Assessment of the Environmental Benefits of Virginia's Forests and Forest Economy

Prepared by the
Virginia Department of Forestry
Dec. 6, 2022

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I. Executive Summary

As directed in the 2022 Acts of the General Assembly, the Virginia Department of Forestry has prepared this assessment of the environmental benefits of the Commonwealth's forests and forest economy. This report is intended to provide a brief overview of the environmental benefits provided by trees and forests, describe threats affecting the provision of those benefits, and share opportunities to increase benefits, particularly related to atmospheric carbon.

Trees and forests are being recognized more and more for the environmental and human health benefits they provide in addition to traditional forest products. Virginia's trees and forests provide critical habitat and crucial benefits such as reduced stormwater and flooding impacts, moderating temperatures, capturing air pollutants, carbon sequestration and storage, and protecting and increasing the supply of clean drinking water. Almost half of all Virginia surface water originates from state and privately owned forestlands.

Today, two-thirds of Virginia is covered in forest and the productivity of these forests has been increasing for decades. Over those past 60 years, the amount of wood being utilized from our forests has doubled while ongoing forest inventories show that these forests are growing far more wood than is being removed. Because wood is made from carbon, forest growth means carbon sequestration. A national assessment found that Virginia ranked third for statewide forest carbon uptake, an amazing result considering Virginia ranks 24th in total forest acres.

While our forests are healthy and productive, they face many threats such as exotic pests and diseases, invasive plant species, weather extremes and climate changes, and lack of natural fire cycles. Trees in developed areas face many of the same environmental challenges as forest trees along with the underlying stress of growing in the built environment. The only existential threat to our forests is from deforestation related to land use change. All these challenges that affect forest health also influence the capacity of the forest to provide environmental benefits.

Because 80 percent of our forests are privately owned and stewarded, it is the individual land management decisions made by over 400,000 individuals, families, and businesses that will have the greatest effect on the health and sustainability of the forest resource. Management options are heavily dependent upon available markets for forest products because timber harvesting provides the financial incentive for forest protection and management for most landowners. Fortunately, forest management and timber harvesting can enhance forest health and the level of environmental benefits they provide.

Utilizing wood and wood-based products supports local and diverse markets for forest products which in turn supports private forest protection, management and retention. Utilizing long-lived wood products such as for building materials also provides for long-term storage of carbon sequestered by trees. Utilizing a natural, sustainable, and renewable product such as wood can further reduce greenhouse gas emissions by reducing the need to use other fossil fuel based or carbon intensive materials.

Sustainable management of our trees and forests, and the increased use of forest products provide the most cost-effective method to support both the environmental and economic health of Virginia as well as the health and well-being of our citizens.

II. Introduction

HB30; Item 108 #4c M.

"The Department of Forestry, with assistance from the Department of Environmental Quality and the Virginia Economic Development Partnership, shall prepare an assessment of the environmental benefits of Virginia's forests and its forest economy. This assessment shall include, but not be limited to, (i) the air quality benefits, including the sequestration of greenhouse gases, provided by Virginia's forests and timberlands; (ii) the economic activities that promote the growth and health of Virginia's forests and timberlands, including the use of active forest management and the production and use of products derived from forest resources; and, (iii) other such environmentally beneficial aspects of Virginia's forests, timberlands, and forest economy as the Department may identify. The Department shall present its findings to the Chairs of the House Committee on Agriculture, Chesapeake and Natural Resources and the Senate Committee on Agriculture, Conservation, and Natural Resources no later than December 1, 2022."

Trees and forests are increasingly being cited as important tools for addressing climate change impacts. This is good news for the Commonwealth because Virginia has a long history of using trees to meet the needs of our society. We are entering a new age where our trees and forests are being counted on to provide more than just wood and fiber.

Trees and forests provide a host of environmental and human health benefits as well. Even the provision of forest products provides longer lasting benefits enabling us to replace other energy-intensive materials. This report is intended to provide a brief overview of the environmental benefits provided by trees and forests, describe threats affecting the provision of those benefits, and share opportunities to increase benefits, particularly related to atmospheric carbon.

Today, two-thirds of Virginia is covered in forest and the productivity of these forests has been increasing for decades. With proper management, our forests have proven to be sustainable providers of critical environmental services while at the same time providing a renewable resource of wood fiber. This success is due to the diversity of forest types in Virginia as well as having a mosaic of forest ages and stand conditions across the landscape.

Our forests are constantly changing, whether due to natural events like storms or infestations, or from human intervention or the natural cycle of forest stand succession. This ever-shifting mosaic of forest conditions provides for resilience as well as an abundance of habitats for all the plant and animal species that live there.

The impact of human activity on our forests cannot be overstated. It would be difficult to find any forest stand in Virginia that has not been significantly guided to its current condition by direct or indirect manmade influence. Largescale impacts include the loss of tree species due to exotic insects and diseases, the exclusion of natural forest fires, past timber practices, modern intensive pine management, and changes in climate and weather patterns.

All these changes that affect forest health also influence the capacity of the forest to provide environmental benefits. The future condition of the forest, and its ability to provide valuable public services will be determined by human activity as well because eighty percent of our forests statewide are privately owned and managed by over 400,000 individuals, families, and businesses. It is the individual land management decisions made by these landowners that will have the greatest effect on the health and sustainability of the forest resource.

Rural landowners have historically been able to justify investing in forestland and afford ongoing forest ownership and management expenses using the revenue generated from occasional timber harvests. In this way, the utilization of timber supports the protection, management, and retention of forestland. Fortunately, thoughtful forest management, including timber harvesting can also enhance the capacity of the forest to provide other environmental benefits.

Recognizing and accounting for the environmental services that our forests also provide is opening new revenue streams for landowners. We are just beginning to tap into the tremendous potential of trees to address environmental issues while at the same time providing the natural, renewable resource that is wood.

III. Status of the Forest Resource

Thanks to collaborative efforts between the USDA Forest Service and the Virginia Department of Forestry we can perform routine assessments of many different aspects of our forests. The longest running and most intensive of those efforts is the national Forest Inventory and Analysis (FIA) program. FIA functions as a sort of national "tree census" that provides critical status and trend information to resource managers, policy makers, investors, and the public utilizing routine measurements of the forest around fixed points on both public and private forest lands across the nation. In Virginia, we re-measure one-fifth of the inventory points each year so that the entire state is re-measured every five years. This provides an excellent assessment of how the forest is growing on a statewide and regional basis.

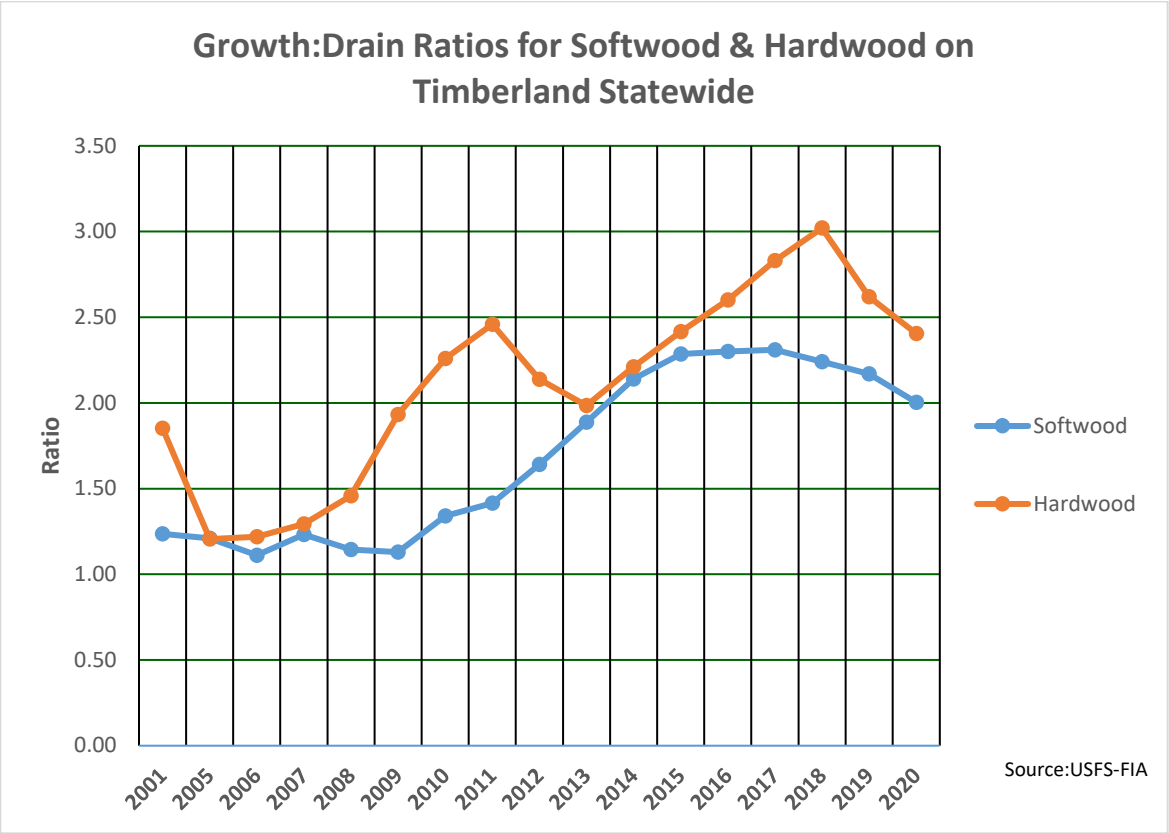
One important use of this data is to evaluate the sustainability of our forests from a timber production standpoint (because wood is made of stored carbon, this measure also provides a basis for estimating the amount of carbon being sequestered and stored in our trees). This is expressed as the Growth to Drain Ratio (GDR), how much the forest is growing compared to how much is being harvested or dying on an annual basis. A GDR of greater than one indicates that the volume of wood being added through tree growth exceeds the amount of wood being harvested or lost to mortality or damage.

The following graph shows a long-term trend where Virginia forests are growing more than twice as much wood than is being removed. The forests of Virginia are a sustainable resource, and they have the potential to provide even greater levels of benefits.

In Virginia we have another source of information on the productivity of our forests. Virginia's primary wood using facilities such as sawmills pay an annual Forest Products Tax based on the volume of wood that they procure as raw material.

Their annual reporting provides sixty years of data on the amount of Virginia wood being utilized. Over those past 60 years, the amount of wood being utilized from our forests has doubled.

In the past 20 years, covered in the GDR chart below, our wood utilization has increased by roughly 40 percent while tree growth has increased at an even faster pace.



We have a third measure of forest activity in Virginia provided by our timber harvest water quality inspection program. Virginia's industry-leading notification law requires that every timber harvest be reported to VDOF, and this enables the agency to monitor every harvest to ensure that sediment is kept out of our streams and water bodies. Based on this program we know that the number of timber harvests and the acres of forest harvested have been decreasing steadily for 10 years.

This shows that the increased timber production has come from fewer acres, another indication of the increasing productivity of our forests. This can be attributed to two major factors; one is increasing tree growth due to better forest management. The second is better utilization of the material on a given acre because of new markets for forest products that enable more of the trees and more of each tree to be utilized.

We unfortunately do not have a history of measuring the status of the trees in our cities and towns. Urban and community tree inventories are limited and infrequent.

In most places where we do have data the news is not positive. Many communities record stagnant or declining tree populations and declines in the condition of the urban forest as well.

Like with other forms of infrastructure, municipal budgets are not keeping up with tree maintenance or replacement.

Remote sensing data is ushering in a new era of urban tree surveying. Being able to measure the extent of tree canopy from above rather than counting trees from the sidewalk has greatly increased our understanding of the status of the urban forest. Of course, this data reflects a similar story of declining tree coverage and uneven distribution of trees between different communities.

IV. Environmental Benefits of Trees and Forests

Trees and forests are being recognized more and more for the environmental and human health benefits that they provide in addition to traditional forest products. Virginia's trees and forests provide critical habitat and crucial benefits such as carbon capture and storage, reduced stormwater and flooding impacts, moderating temperatures, and filtering air pollutants. Measuring the value of these forest functions and services is an emerging science.

Much of the following information on the economic value of environmental forest functions comes from the i-Tree suite of tools developed by the USDA Forest Service (www.itreetools.org/tools). This research is the culmination of decades of work to help us understand how individual trees – and entire forests – interact with the physical environment to benefit people. Using high-resolution imagery (1-meter) land cover data from the Chesapeake Bay program and the i-Tree model, we can begin to place dollar value estimates on some of the benefits provided by Virginia's forests.

Values from improved air quality and reduced temperatures

The i-Tree analysis estimates that Virginia's trees capture 540 tons of chemicals that form pollutants such as ozone and particulate matter for an annual benefit of $212 million in avoided health costs. By shading hot surfaces, trees keep communities cooler thus reducing the conversion of some air pollutants such as nitrogen dioxide into ground-level ozone. Trees also capture small particulate matter on their leaves or capture pollutants through gas exchange, effectively removing these substances from the atmosphere.

There are additional benefits of avoided sick days or lost school days too. For example, it's estimated that 549 annual hospital admissions are avoided each year in Virginia thanks to trees cleaning our air.

Even at the neighborhood level, trees reduce pollutants. Studies show that those living in well-treed neighborhoods suffer less respiratory illnesses such as asthma (Rao et al. 2014). There are 39,784 less acute respiratory symptoms and 8,903 less asthma exacerbation incidences…all because of trees.

Trees provide shade in the hotter months that help reduce the "heat-island" effect caused by buildings and pavement that reflect energy as heat. In colder months, trees serve as a windbreak by slowing the winter winds and reducing overall heating costs. Both result in burning less fossil fuels to generate electricity for cooling and heating. Trees and forests provide Virginia residents an estimated $231 million in annual energy saving benefits (*Nowak et al 2017*).

Reduced stormwater, flooding and water pollution

Tree roots and the forest floor soak up rainfall like a sponge, holding it in place and allowing it to soak into the ground and recharge groundwater. Since at least half of all Virginians depend on clean groundwater for their drinking water wells, recharging our aquifers is critical. Every year, Virginia's forests soak up enough rainfall to fill 25,400 Olympic-sized swimming pools saving $150 million in avoided treatment costs. These avoided costs are based on price that it costs the treatment plant to treat a given volume of water. In many cases, here in the US we have combined sewer systems where roadway runoff (and other stormwater runoff) makes its way into the sanitary sewer system and must be treated. In this way the cost of treating a gallon of sewer water is a useful estimate of the cost of managing a gallon of stormwater.

Forests play a significant role in Virginia's ability to meet its water quality benchmarks in the Chesapeake Bay Agreements/Total Maximum Daily Load mandated for two third of Virginia's Chesapeake Bay communities. Forest buffers along riparian corridors filter out sediment and nutrients that contribute to poor water quality, while shading and cooling water for fish and supporting healthy shellfish, crabs and oysters in coastal rivers and bays.

When trees are lost, runoff increases. For example, one inch of rain falling on an acre of pavement releases 27,000 gallons of runoff; that same amount of rain falling in a forest will capture most of that water, releasing only 750 gallons of runoff.

Drinking Water

Abundant clean water, for drinking, outdoor recreation, fishing and irrigation of crops, is important to all citizens of the Commonwealth. Protection and management of forested watersheds are paramount to source water protection efforts. Much of Virginia's population receive drinking water from surface water flows that run over and through state- and privately-owned forests (SPF). "About 47.4% of all Virginia surface water originates on SPF lands". Virginia's surface water provides drinking water to about 52 percent of the population (approximately 4.3 million people). In addition, Virginia's SPF supplies an additional 5.9 million people in 196 communities in 13 surrounding states (*Liu, Ning et al. 2020*). Adding the water that originates on the 1.4 million acres of the George Washington and Jefferson National Forest in Virginia would significantly increase this amount.

Suspended sediments, clouding of water (turbidity) and temperature impacts are all potential concerns. Increased sedimentation raises filtering costs for drinking water, increases flooding potential by filling up streambeds and chokes irrigation systems. Fish habitats can be altered by improper management activities. Removing shade from critical riparian or streamside areas can increase water temperatures thus affecting fish and other aquatic life.

The entire food chain in, and near, streams can be impacted and damaged by deforestation and improper land management activities.

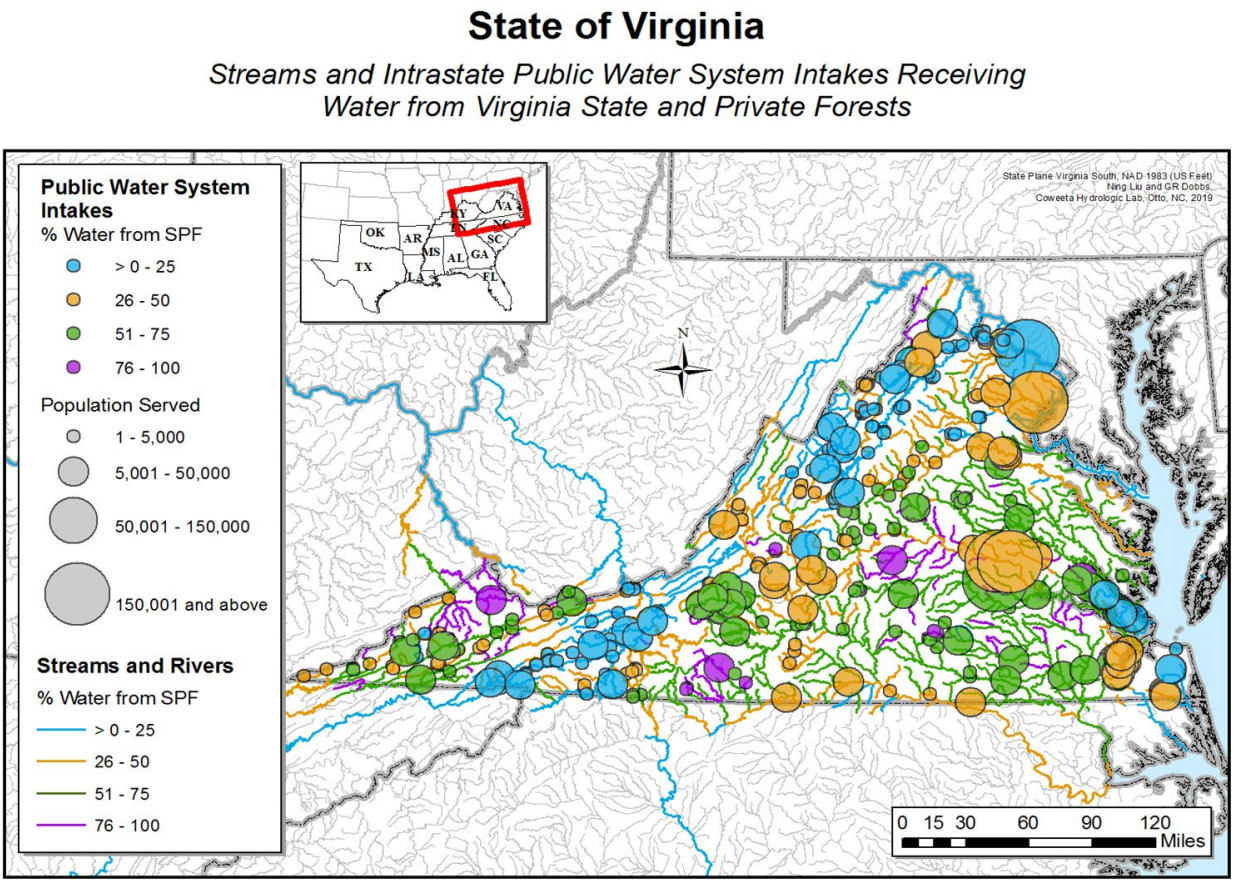


Figure 2. Liu, Ning et al. p. 197 2020)

Increasingly, public water utilities are beginning to acknowledge the positive impacts from forested watersheds and green infrastructure projects. Forests minimize water treatment costs by keeping source water clean. The cleaner the source water is, the less treatment it needs, and the less money is spent by water treatment facilities.

Seven U.S. cities avoided between $725,000 and $300 million in annual water treatment costs and between $25 million and $6 billion in capital costs by investing in the protection and sustainable management of watersheds that deliver urban water supplies.

When green infrastructure is managed responsibly and used with traditional infrastructure, it reduces utility operation costs, improves traditional water system performance, increases predictability of water supply, and generates ecosystem services for the enjoyment of communities in the watershed. As an example, the New York City Watershed Protection Program saved the city more than $6.5 billion by investing in natural infrastructure in the Catskill-Delaware watershed, instead of building a new filtration plant. The program injected $100 million into the rural economy in the upper reaches of the watershed through funding to landowners and contractors for practices that improved water quality.

Carbon Sequestration and Storage

Forest ecosystems in the United States store approximately 60 percent of our carbon, this is in both live and dead trees (McKinley et al., Sept.2011). It is estimated that the total carbon in U.S Forests is 58,720 MMT (million metric tons). Soils comprise 54 percent, aboveground biomass 26 percent, forest litter 6 percent, deadwood 5 percent and belowground biomass 5 percent *("Land-Use Change, and Forestry" in U.S. National Greenhouse Gas Inventory, EPA 430-R-20-002 April 2020*). As of 2019, the U.S Environmental Protection Agency declared that "forest land, harvested wood products, woodlands and urban trees within the land sector collectively represent the largest net carbon sink in the US, offsetting more than 11% of total greenhouse gas emissions" (*U.S. EPA, Inventory of greenhouse gas emissions and sinks 1990-2019 EPS 430-R-21-005*).

In that same study, Virginia ranked third in the conterminous 49 states for statewide carbon uptake. This is an amazing result considering Virginia ranks 24th in total forest acres. This again speaks to the surplus of wood volume that has been accumulating in Virginia's forests. It is interesting to note that southeastern states make up six out of the top ten states for forest carbon uptake. While many of the western states with large forest footprints rank lower, likely due to wildfire and mortality from insect outbreaks.

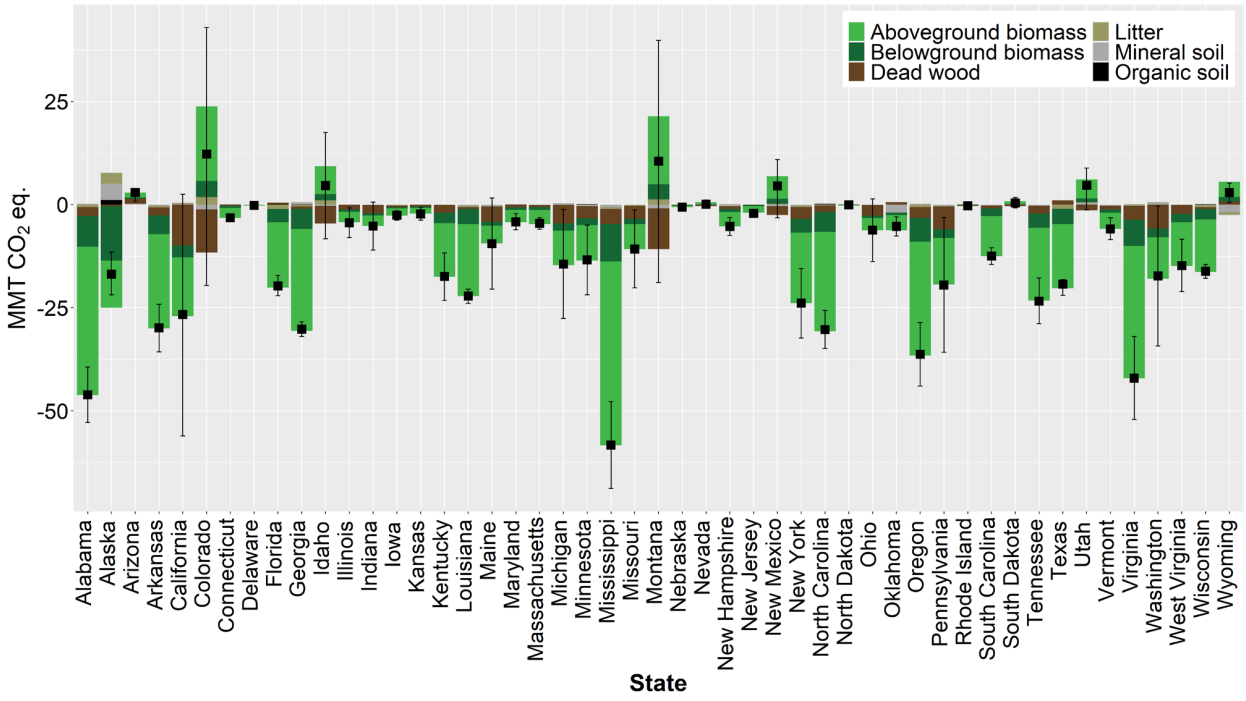


Figure 1. Estimated annual emissions and removals by carbon pool for forest land remaining forest land in each of the conterminous 49 States in 2019 (MMT CO2Eq.). Note that points and uncertainties represented by confidence intervals (95 percent) reflect net flux for all carbon pools in each State. Negative estimates indicate net C uptake (i.e., a net removal of C from the atmosphere). (Domke, Grant M.; Walters, Brian F.; Nowak, David J.; Smith, James, E.; Nichols, Michael C.; Ogle, Stephen M.; Coulston, J.W.; Wirth, T.C. 2021. Greenhouse gas emissions and removals from forest land, woodlands, and urban trees in the United States, 1990–2019.

Resource Update FS–307. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station. 5 p. [plus 2 appendixes]. https://doi.org/10.2737/FS-RU-307.)

Carbon dioxide (CO2) in the atmosphere is necessary for plants and trees to grow. Trees absorb carbon dioxide during photosynthesis, storing carbon and produce oxygen as a byproduct of photosynthesis. Carbon sequestration is the process of removing that carbon from the atmosphere and storing it in a physical element (e.g., a tree).

Based on model outputs, Virginia trees and forests store 550 million tons of carbon overall worth $94 billion of avoided climate change costs. Carbon storage is estimated using the i-Tree using model inputs such as tree species, diameter and height to calculate overall biomass (Chow and Rolfe 1989). The value of carbon storage and benefit is based on the social cost of carbon as reported by the Interagency Working Group on Social Cost of Carbon. Social cost associated with a pollutant (e.g., CO2) refers to an estimate of total (global) economic damage attributable to incremental increase in the level of that particular pollutant in a given year.

V. Threats to the Forests of Virginia

The productivity of our forests at the statewide level masks many underlying conditions that threaten their long-term health and sustainability. There are global issues that impact our forests like climate change and international trade as well as local issues like land development and lack of markets for forest products.

It may be surprising to some that the greatest threats to the forests in Virginia are not from over-harvesting or from wildfires. We have multiple data points that indicate our forests can sustain anticipated timber harvesting. And while Virginia experiences hundreds of wildfires every year, the quick response of the VDOF and our partner firefighters keep most of these fires very small. Even larger fires in Virginia typically do not cause irreparable damage to the forest, wildfires are a greater threat to the people and property that are located in and near the forest.

Threats to the forest fall into two main categories; threats to health, and changes in land use. There is a third category related to markets for forest products that influences the first two. Significant forest health issues in Virginia include the introduction of exotic pests and diseases, the worst of which have nearly eliminated some forest species such as American chestnut and all our species of ash trees. Introduced invasive plant species outcompete native plants for growing space.

Climate change impacts our forests from warmer winter temperatures allowing pests to spread into new areas and from more intense weather impacts from storms, floods, heat and droughts.

Land management practices have also led to unhealthy forest conditions. Our successful efforts to prevent wildfires is hurting many forest species and entire ecosystems that depend on natural fire cycles. We have also not historically been thoughtful about how we manage the hardwood forests that make up eighty percent of the forest. In this case, the growing volume of wood masks the fact that a large portion of our hardwood forests are aging and there is a lack of young trees of desired species to make up the future forest.

Despite the myriad challenges to forest health, the only existential threat to our forests is from deforestation related to land use change. Most of our forests are privately owned and these landowners routinely face choices of how to utilize their land. Statewide, the total acreage of forestland has been holding steady for about ten years. But the statewide number masks loss of forestland in growing residential areas and recent conversions due to industrial scale solar facilities. A recent study found that forest and agricultural lands are the most likely land types to be impacted by solar facilities being built. The authors also found that over half of the acreage disturbed in Virginia for solar panels to date was previously forested lands.

Because our forests are 80 percent privately owned, and because most landowners will want to generate income from their timberland at some point, the presence or absence of markets for timber products has a significant influence on the management of and condition of our forests. The presence of diverse markets for timber in a local area can provide additional financial incentive for landowners to invest in forest retention and management.

On the other hand, a lack of markets creatives a disincentive for landowners to invest in forestland and forest management and can increase the likelihood of conversion to a more profitable land use. Landowners face annual costs associated with management and taxes while often waiting decades for income while assuming long term risks. Landowners need to be reassured of the financial return to justify managing their forest.

Our oak-hickory hardwood forests provide a good example of how these market forces can influence the condition of the forest. For many years we have had strong market demand for mainly the highest quality hardwood trees, of which there are typically a small number on any given acre of forest. There are a greater number of low-value trees that can be sold but at lower profit, and then there are many trees that are not valuable enough to warrant cutting and hauling. This leads to the practice of "take the best and leave the rest." Over time, this degrades the forest. Especially since some of our most valuable hardwood trees are also very beneficial for wildlife.

Lack of diverse forest products markets contributes to poor forest management decisions and provides less incentive for thoughtful and sustainable forest management by private landowners.

Threats to the urban and community forest

Trees in developed areas face many of the same environmental challenges as forest trees along with the underlying stress of growing in the built environment. Urban trees typically have a much shorter lifespan than they would expect in the forest due to limited rooting space, lack of soil nutrients and water, physical damage, and exposure to wind and temperature extremes.

These challenges can be compounded by a lack of intentional and thoughtful planning during development. Too often, protection of existing trees and natural places is not incorporated during design and construction and then trees are added back as an afterthought. Often the trees that are planted are not well suited to the environment, soils or site conditions, and do not have a chance to live long healthy lives or return the greatest level of benefits.

As a feature in the built environment, trees are impacted by the same lack of resources as all the rest of our modern infrastructure. Like streets and sidewalks, urban trees require routine upkeep and eventual replacement, and this requires staffing and equipment and funding. Because trees continually grow – above and below ground – they are often in conflict with the built environment. Addressing these conflicts typically comes at the expense of the tree.

Many communities across Virginia simply lack the experience, resources, and personnel to plant, grow and maintain trees. Even when resources are available, many trees are planted each year by well-meaning homeowners and community members that never flourish because they are unsuited for the conditions in which they are placed. We are also seeing that trees and access to nature is another resource that is lacking in underserved and marginalized communities. The lack of trees – and their many benefits – is one more inequitable consequence of living in historically underserved neighborhoods.

VI. Enhancing the Environmental Benefits of our Trees and Forests

Using forest products supports forest health

While challenging to put a dollar value on shade provision or rainfall interception, the costs of establishing, growing, protecting and managing trees and forests are well established and can be considerable. For forestland, these costs are primarily borne by private landowners.

Eighty percent of our forests statewide are privately owned and managed by over 400,000 individuals, families, and businesses. It is the individual land management decisions made by these landowners that will have the greatest effect on the health and sustainability of the forest resource.

The ownership pattern of the trees in urban and community areas is less well known, but both private and public entities struggle with the costs of establishing and maintaining healthy landscapes. Trees in cities and towns are a part of the infrastructure and face similar funding challenges as the built environment.

Given that trees and forests are providing valuable environmental and social benefits, it is incumbent on the Commonwealth to ensure that those entities responsible for our trees and forests have adequate resources and markets to invest in their long-term sustainability.

Historically, rural landowners have been able to invest in ongoing forest ownership and management using revenue generated from occasional timber harvests. This harvesting revenue only accesses a portion of the potential economic value that forests offer. The development of ecosystem services markets is beginning to help capture the full value of forests and are opening new markets for air quality, drinking water and carbon. These new markets acknowledge the public benefits that private forestlands are providing and generate additional revenue to help keep forestland ownership profitable.

Private forest landowners have many reasons for owning and managing forestland, and timber management is not a top priority for most landowners. However, the annual expenses associated with forest ownership means that almost all landowners will need to derive income from their forest. Occasional timber harvests have met this need, and in this way the utilization of timber supports the protection, management, and retention of forestland. Fortunately, thoughtful forest management, including timber harvesting can also enhance the capacity of the forest to provide other environmental benefits.

Habitat improvement provides an excellent example of the additional benefits derived from sustainable forest management. Timber harvesting provides a variety of habitat improvements for a wide range of both plant and animal species. Different species need different types and ages of forested habitat, and many species utilize multiple ages and types of habitats for different purposes throughout the year and their lifespan. In areas where limited or no harvesting occurs for long periods of time, stand structural diversity decreases and large areas revert to closed canopy conditions, limiting the range and diversity of suitable habitats for a variety of species. Even in areas with relatively recent harvesting activity, early successional habitats slowly but inexorably transition to the next successional stage and stand diversity decreases over time. Implementing intentional forest management practices can recreate vital early successional habitat conditions that many species depend on and that are largely absent from our landscape.

Few landowners have the wherewithal to pay out of pocket for large-scale forest management activities. These practices are expensive because they typically cover large areas, require specialized equipment and skilled workers that are willing to do hard work, often in adverse conditions. Most landowners have to rely on income from timber sales to be able to implement practices to protect, manage, and improve their forests.

For this reason, diverse markets for forest products are critical to support forest management. These markets include pine and hardwood sawmills as well as users of wood chips for producing paper products, engineered building products, biochar and burning wood for energy. In turn, many of these primary wood users depend on a secondary market to utilize their residual wood materials such as sawdust, shavings, and tree bark. And all of these wood users depend on the timber harvesting workforce as well as truck drivers.

Sustainable forest management by our private landowners depends on a robust forest products economy that can utilize multiple types of trees, in all parts of the state and that can provide sufficient revenue to support all the elements of the forestry supply chain. The lack of viable markets for any product type in any location threatens the viability of the supply chain and eventually serves as a disincentive to sustainable management. Lack of markets contributes to a lack of forest management which can threaten forest health and reduce their potential benefits. Taken to its furthest extent, lack of markets will cause the loss of loggers and wood haulers from an area, and this will leave the landowners with no contractors to perform management work, even if they have the means and intent to do so. Lack of potential timber income can also increase the risk that landowners will choose to convert forestland to other uses.

Carbon offset from using wood to displace other materials

Utilizing forest products, particularly long-lived materials such as in buildings, provides additional environmental benefits by providing long term storage of the carbon incorporated in the wood as the trees grew and by displacing the use of fossil-fuel intense construction materials such as concrete, steel, aluminum etc. The following chart demonstrates the carbon balance of various common building materials. Utilizing wood from sustainably managed forests where timber harvesting is done in an environmentally sound way and the land is reforested or allowed to regrow naturally can combine carbon sequestration with long term carbon storage and offset the use of less sustainable materials.

Net Carbon (C) Emissions in Producing a Ton of Various Materials

Material	Net Carbon Emissions (kg C/metric ton)[a/] [b/]	Net Carbon Emissions Including Carbon Storage Within Material (kg C/metric ton)[c/]
Framing lumber	33	-457
Medium density fiberboard (virgin fiber)	60	-382
Brick	88	88
Glass	154	154
Recycled steel (100% from scrap)	220	220
Concrete	265	265
Concrete block [d/]	291	291
Recycled aluminum (100% recycled content)	309	309
Steel (virgin)	694	694
Plastic	2,502	2,502
Aluminum (virgin)	4,532	4,532

[a/] Values are based on life cycle assessment and include gathering and processing of raw materials, primary and secondary processing, and transportation.
[b/] Source: USEPA (2006).
[c/] A carbon content of 49% is assumed for wood.
[d/] Derived based on EPA value for concrete and consideration of additional steps involved in making blocks.

Table 1: Information Source https://www.dovetailinc.org/upload/tmp/1581600730.pdf

A research study report by (Gustavsson and Sathre, 2006) suggests wood frame apartment building construction as compared to similar apartment building construction with concrete frames reduces lifecycle net carbon emissions by 110 to 470 kg CO2 per square meter of floor area (IPCC report: https://archive.ipcc.ch/publications_and_data/ar4/wg3/en/ch9s9-4-2-4.html).

A case study from Virginia also suggests that wood products in building can result in net carbon sequestration gained and positive impact on changing climate. The Apex Plaza in Charlottesville features 1.6 million board feet of lumber, which equates to roughly 20-30 acres of forest (for perspective, the forests of the U.S. and Canada grow this much wood in just seven (7) minutes. Based on their calculations, the Apex Plaza will sequester 2,400 MT of CO2, equivalent to about 2.6 million pounds of coal, which is equal to the same amount of GHG emissions as driving 5.9 million miles in a passenger vehicle.

Wood as an energy source

Burning biomass – residual organic forest and agricultural crops – for energy provides a renewable alternative feedstock that can displace burning fossil fuels. Using plants instead of fossil fuels prevents the need for additional carbon to be taken out of the ground and introduced into the atmosphere. Burning biomass releases carbon that was taken out of the atmosphere and temporarily stored in the above ground portion of the plants. This carbon would be released otherwise when the plants decompose or are harvested and consumed for traditional crops. While burning biomass is not carbon free, it can provide a low-carbon and renewable, on-demand energy source to serve as a bridge as we transition to full reliance on carbon-free energy.

In the U.S, biomass accounts for 5 percent of total primary energy use, and globally, biomass is becoming more popular in developing countries to avoid fossil fuel use. The U.S. is a net exporter of biomass; in 2021, the U.S. exported 8 million tons of biomass in the form of wood pellets.

Forestry products constitute more than 85 percent of total biomass used for energy purposes. Forestry-derived biomass, or "woody biomass," can be split into two categories: *primary* and *secondary* feedstocks. Primary feedstocks include tree components like tops/limbs, whole trees cut down during trimming, or misshapen or diseased trees that cannot be used for traditional forestry products and are not considered to be high-quality stocks. Secondary feedstocks include byproducts from wood processing, such as sawdust. Both primary and secondary woody biomass feedstocks are considered to be forestry "leftovers" that would be left to decompose, be burned on site to facilitate new plantings, take up landfill space, or otherwise go to waste.

Using responsibly sourced woody biomass for energy provides another significant benefit as it can improve forest health both directly and indirectly. Indirectly, biomass energy markets support the regional forestry supply chain by providing a market for low value or unusable material which though marginal, can increase the profitability of forest management for private landowners, loggers, contractors, and haulers. This increases the capacity of the forestry workforce available to provide a full range of forest management practices. Biomass also provides a critical outlet for residuals from primary wood processors like sawmills, which cannot operate for long without a way to economically dispose of sawdust, chips, and shavings. Biomass energy markets can directly improve forest health by providing a market for low value trees that need to be removed as part of forest enhancement activities.

In the Western U.S., utilizing woody biomass for energy is being used to support forest thinning to reduce wildfire risk. In Virginia, there is a critical need for markets for removing less desirable and low value hardwood trees from the forest understory to restore our oak-hickory forests. Utilizing forest residuals for energy can also prevent this material from being burned on-site in the forest in preparation for reforestation.

There is concern that using woody biomass will lead to unsustainable timber harvesting or even contribute to deforestation. Practice has shown the opposite to be true as additional markets for forest products actually increase the likelihood that private forestland will stay in forest use. A study commissioned by Forest2Market on timberland in the southern U.S. found that an increase in demand for forest products from 1953 to 2015 did not lead to deforestation.

The study found that the increased demand for forest products caused timber forest removals to increase by 57 percent, but during this same time period, the inventory of wood fiber (measured in cubic feet) increased by 108 percent.

This means that even though more trees were being harvested for products, the forestry sector became more efficient and effective at sustaining productive forestland. The total amount of timberland acres in the area studied increased by 3 percent, indicating that cutting trees down for forest products did not deplete the acreage of productive forestland in the Southern U.S. Additionally, the study found that timberland removal correlates to increased acreage, growth, and inventory of timberland.

Analyses of the relative environmental risks and benefits of burning woody biomass often involve alternative scenarios with little or no timber harvesting. This assumes that atmospheric carbon sequestered and stored in trees will remain there long-term. This is not a realistic alternative in most parts of Virginia where forests are actively managed and timber harvesting is routine. Virginia has historically recorded over 200,000 acres of timber harvests each year. The typical private forest landowner relies on timber revenue at some point, and they do not forego timber harvesting over the long term. They also harvest timber to support other land management goals such as improving habitat.

The low market value of woody biomass makes it unlikely that biomass alone would support a profitable timber harvest. Being able to market biomass contributes to profitability when more valuable trees are being harvested.

Forestry-based biomass can also generate energy through conversion to liquid biofuels, or conversion to gaseous biofuels. Biorefineries to create sustainable aviation fuels from biomass provide another opportunity to replace fossil fuels with a natural and renewable feedstock.

Conclusion

Virginia's trees and forests offer a proven, low-cost, readily available solution to help address multiple environmental issues while at the same time providing a wide range of public benefits. Recognizing and valuing the multiple benefits that trees provide is leading to new markets to further incentivize investment in trees and forests. Sustainable management of our forests is necessary to increase their resilience and private forest landowners are the key to this effort.

Growing new revenue streams for rural landowners based on the environmental benefits provided by their forests, while maintaining timber harvest revenue can create an all-of-the-above forest economy that supports the greatest combination of benefits for the Commonwealth. Trees in cities and towns have an even more direct impact on the health and well-being of the people living in these communities. Especially since we can now demonstrate the inequitable distribution of trees within urban areas where the lack of tree canopy in underserved communities contributes to poor health outcomes. Further investments in trees and tree health in urban areas can now be viewed from a public health perspective.

Utilizing a natural, sustainable, and renewable product such as wood can reduce greenhouse gas emissions by reducing the need to use other fossil fuel based or carbon intensive materials. At the same time, timber harvesting can enhance the health of the forest, create critical habitat, and help to reduce the threat of forest conversion to other land uses. Using more wood, can contribute to doing more good.

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