Virginia Cooperative Extension
Virginia Tech • Virginia State University
www.ext.vt.edu

Trees and Water

Authored by Sanglin Lee, Former Intern, Virginia Water Resources Research Center, Virginia Tech; Alan L. Raflo, Research Associate, Virginia Water Resources Research Center, Virginia Tech; and Jennifer Gagnon, Associate Extension Specialist, Department of Forest Resources and Environmental Conservation, Virginia Tech

Introduction

Since at least the late 1800s, scientists and forest managers in the United States have recognized that forests have strong influences on water resources (Hewlett 2003). Today the connections between forests and water are widely reported in the news media, promoted by natural resource agencies, and investigated by specialists such as hydrologists, dendrologists, foresters, forest biologists, and water managers. Tree structures and functions influence at least four major areas of water-resources concerns: (1) water quality, (2) aquatic habitat, (3) water quantity, and (4) the interactions among water, climate, and energy use. This publication provides a basic introduction to Virginia's trees and a foundation for assessing the connections between water and trees. Scientific names of all tree species mentioned are listed in appendix 1.

Tree Basics

(Except as otherwise noted, the information in this section is based on the following references: Conway 2013; Pallardy 2008; Virginia Department of Forestry (VDOF) 2020; and Weikert 2022.)

Along with other plants that reproduce by seeds (some plants reproduce by spores, not seeds), trees are classified into two groups, based on whether they produce flowers. **Angiosperms** are flowering plants, with seeds inside fruits that develop from the flowers. Oaks, hickories, and maples are all angiosperms. **Gymnosperms** do not have flowers and their seeds are typically borne inside cones, not fruits (the term means naked seeds). Most gymnosperm species are also called conifers. Pines, spruces, and firs are examples of trees that are gymnosperms and conifers (table 1).

Most **deciduous** trees (those that shed all their leaves in autumn) are angiosperms, and most **evergreen** trees (which do lose their leaves but not all of them at once in a single season) are gymnosperms. There are, of course, exceptions (figures 1a and 1b). Deciduous, flowering trees often are referred to as hardwoods and evergreen conifers as softwoods, because the wood of conifers is typically (but not always) lighter and softer than wood from deciduous trees. Finally, flowering trees are often called broadleaf trees because their leaves are relatively wider than the needles found on many conifers.

Table 1. Typical characteristics of angiosperms and gymnosperms.

Angiosperms (Flowers with seeds in fruits)	**Gymnosperms** (No flowers, seeds in cones)
Usually deciduous	Usually evergreen
Known as hardwoods	Known as softwoods
Broad leaves	Needle-like or scale-like leaves
Familiar examples: oaks, hickories, and maples	Familiar examples: pines, spruces, and firs

Several hundred species of trees are found in North America. These trees are either native to this continent or **naturalized**, that is, originating in some other area but having become widespread and capable of reproducing outside of cultivation. Each species has a **range**, or the broad area in which temperature, rainfall, and other environmental conditions allow the species to grow and reproduce. Of course, planted individuals can be found far outside of a species' native range. For example, the Rocky

Mountain native, blue spruce, is often planted in Virginia.

Within their native ranges, certain tree species typically occur together in identifiable **forest types and forest type groups**. The USDA Forest Service's *Forest Atlas of the United States* (2022) identifies 140 forest types in the continental United States (excluding Hawaii).

Figures 1a and 1b. Baldcypress (a) is a non-evergreen (deciduous) conifer. American holly (b) is a flowering evergreen tree. (Alan Raflo, Virginia Tech)

These types are organized into 28 forest type groups, and seven of those groups are found in Virginia: oak-hickory (comprising over 60% of Virginia's forests); elm-ash-cottonwood; loblolly-shortleaf pine; longleaf-slash pine; maple-beech-birch; oak-gum-cypress; and oak-pine. With a wide range of habitats, Virginia has a wide diversity of forest types. The next section looks more closely at the kinds of forests and trees found in Virginia.

Trees and Forests in Virginia

As of 2023 (VDOF 2023), more than 16 million acres in Virginia, or about 62%, were classified as **forestland,** which is commonly defined as land at least 10% stocked by forest trees of any size, or formerly having such tree cover, and not currently developed for non-forest use. Of these forestland acres, 79% (12.7 million acres) were hardwood or hardwood-pine forests (mostly oak-hickory forests), and 21% (3.2 million acres) were pine forests, with over 65% of the pine acres in pine plantations. Bottomland hardwoods occupied five percent of Virginia's forestland, and deciduous forests dominated by maples, American beech, and birches occupied two percent.

As of March 2024, the Flora of Virginia mobile app listed 399 native species of broad-leaved trees and shrubs, 20 native species of needle-leaved trees and shrubs, about 140 non-native broad-leaved species, and two non-native needled leaved species as occurring in Virginia. The VDOF (VDOF 2024) identifies the most common Virginia tree species in two ways: by estimates of the number of individual trees and by estimates of the volume occupied (in cubic feet). Table 2 shows the top ten Virginia trees by number and by volume.

Water's Influence on Trees

(Except as otherwise noted, the information in this section is based on the following references: Kramer and Boyer 1995; and Pallardy 2008.)

Like all living things (except viruses), trees are made up of cells that consist largely of water. In fact, water makes up as much as 90% of the

leaves and other tree tissues during periods of growth. Because of this, the availability of water is crucial to a tree's ability to grow.

As it does in other organisms, water in tree cells provides a solvent that contains and transports the many substances needed for biochemical reactions. Water is itself involved in many of these reactions, particularly in photosynthesis, the process whereby green plants convert light energy into carbon-based chemical energy (or food). When plants absorb carbon through leaves for photosynthesis, they lose water at the same time. This tradeoff between carbon and water drives the plant's circulatory system and cools plant leaves through evaporation, where heat energy is released to the environment. Water in trees and other plants is also needed to maintain turgidity to support leaves and other non-woody plant parts. Without this turgidity, plant cells lose the structure needed to function properly. Wilting is a common response to inadequate turgidity in plant leaves or stems (figure 2).

Table 2. Most common tree species in Virginia by number of stems and volume.

By Number of Stems	By Volume
Loblolly pine	Red maple
Yellow-poplar	Loblolly pine
Chestnut oak	Yellow-poplar
White oak	Sweetgum
Red maple	American holly
Northern red oak	Black gum
Sweetgum	White oak
Scarlet oak	Virginia pine
Virginia pine	Hornbeam
Eastern white pine	Chestnut oak

Structures in trees combine with certain physical properties of water to move water and dissolved substances throughout a tree. Water molecules, which tend to stick to other water molecules, are absorbed by the roots and pulled through thin tubes inside the tree into stems and leaves through a process called **capillary action**. Water properties of tension and cohesion are necessary for this action.

Figure 2. Rhododendron leaves wilting under dry conditions. (Alan Raflo, Virginia Tech)

Water is an important factor in how trees respond to insect pests, diseases, and plant competitors. Effects on trees from these threats can be more severe if trees are already stressed by inadequate water. In turn, drought can be harder on trees that are already suffering from insects or diseases. VDOF (2010) reported that the wave of spongy moth outbreaks that occurred during the drought between 2005 and 2008 resulted in 114,000 acres of severe defoliation. The lack of water combined with high temperatures contributed to the death of many trees already stressed by insects.

As noted above, water, along with temperature and other environmental conditions, is a key factor in determining the range of tree species. A sugar maple, for example, would not thrive in the southwestern U.S. deserts, where species of mesquite trees live. But water availability is also a key factor in determining tree **distribution** --- that is, where within the range populations of a given species are actually found. Areas of Virginia range from being consistently wet, such as wetlands found throughout the state but particularly in Tidewater, to relatively dry south-facing mountain slopes in western Virginia. Trees are found in all these areas, with some requiring really wet or really dry conditions in order to survive, and others preferring certain conditions but able to survive in a wide variety of circumstances. The following are some examples of how tree distribution is related to water availability, using various species from the VDOF Top Ten Virginia Trees and other trees from their related groups (VDOF 2024).

Pines

Virginia pine can be found throughout the state (except the southeastern corner) in dry conditions and would not be found in wetlands. On the other hand, pond pine is normally found within a limited area in southeastern Virginia and can only grow on moist-to-wet sites.

Maples

Silver maple is commonly found in western Virginia and along the southern border of the state. Silver maple grows better in wetter conditions, so native trees are most commonly found along stream banks, flood plains, and lake edges. Like the silver maple, sugar maple is also commonly found in the western regions of the Ridge and Valley and Appalachian Plateau. Unlike the silver maple, sugar maple thrives in moist but well-drained soils, which is why it would not typically be found on river bottoms. A third example, red maple, is different from the other two in that it is naturally found across Virginia and can live in a wide variety of sites, from very dry to wet conditions. These three and other species of maple are found planted in all parts of Virginia, including in sites with conditions different from their preferred natural habitat.

Black Gum and Water Tupelo

Black gum, also known as black tupelo, is found throughout Virginia and can live in a wide range of conditions from very wet to relatively dry. In contrast, water tupelo is found in a very limited area of the state, mostly on the coast of the southern border. Its natural habitat is near water, such as deep rivers and coastal swamps.

Oaks

According to the Flora of Virginia app, 27 species of oaks are native to Virginia. These species have a variety of preferences and tolerances for water conditions. Post oak, for example, can be found throughout most of the state, but it needs rocky and sandy ridges or dry woodlands to thrive. In contrast, water oak is commonly found only in the southeast coastal areas of Virginia near waterways and swamps or on moist uplands. Other oak species respond to water in more subtle ways, such as growing at various elevations and aspects. For example, northern red oak is found throughout Virginia, but it thrives in well-drained soils and fertile coves and grows best on north and east slopes, areas that are cooler and moister. In contrast, scarlet oak would typically be found on drier, rockier parts of mountain slopes.

Conclusion

In recent years, Virginians who follow news about water, the environment, or their local community, may have seen headlines highlighting trees and water. Streamside hikers may have seen dozens or hundreds of plastic tubes staked in the ground, indicating newly planted trees intended to help improve stream water quality and habitat. Cities are encouraging planting of trees to help reduce storm water runoff and the pollutants it can carry to waterways. Woodland owners in Virginia and nationwide have increasing opportunities to enroll in forest-carbon programs, in which the landowners can be paid for planting or maintaining trees on their property; these trees will absorb the greenhouse gas carbon dioxide and store it in the form of wood (Schons et al. 2024).

In these and other ways, trees are recognized as part of the solution for an array of issues

connected to water. Virginia has a rich diversity of tree species that are influenced by water conditions and affect the quality and quantity of water around them. Increasing awareness of this resource and its water relationships will help provide direction for public and private decisions that will affect landscapes, watersheds, wildlife, communities, and people (figure 3).

Figure 3. Trees are part of the solution for an array of issues connected to the environment. (Alan Raflo, Virginia Tech)

References

Conway, S. 2013. Beyond Pine Cones: An Introduction to Gymnosperms. *Arnoldia.* 70 (4) 2-14. Accessed March 25, 2024. https://arboretum.harvard.edu/arnoldia/arnoldia-archive/.

Hewlett, J.D. 2003. *Principles of Forest Hydrology*. Athens: University of Georgia Press.

Kramer, P. and J. Boyer. 1995. *Water Relations of Plants and Soils*. San Diego, California: Academic Press.

Pallardy, S.G. 2008. *Physiology of Woody Plants*. Burlington, MA: Academic Press.

Schons, S., K. Stephenson, and J. Gagnon. 2024. *An Overview of Forest Carbon Credit Programs in Virginia*. Virginia Cooperative Extension Publication. CNRE-177P.

The Flora of Virginia Project. 2017. *The Flora of Virginia Mobile App*. Accessed March 29, 2024. https://floraofvirginia.org/flora-app/.

USDA Forest Service. 2022. Forest Atlas of the United States. USDA Forest Service Publication FS-1172. Accessed March 29, 2024.https://www.fs.usda.gov/sites/default/files/fs_media/fs_document/Forest-Atals-of-the-United-States.pdf.

Virginia Department of Forestry. 2010. *2010 State of the Forest*. Virginia Department of Forestry Publication P00129. 26p. Accessed April 11, 2024. https://dof.virginia.gov/wp-content/uploads/SOF-2010_pub.pdf

Virginia Department of Forestry. 2020. *Common Native Trees of Virginia: Identification Guide*. Virginia Department of Forestry Publication P00026. 28p. Accessed on April 14, 2024. https://dof.virginia.gov/wp-content/uploads/Common-Native-Trees-ID_pub.pdf

Virginia Department of Forestry. 2023. *State of the Forest*. Virginia Department of Forestry Publication POO129. 27p. Accessed April 11, 2024. https://dof.virginia.gov/wp-content/uploads/SOF_2023.pdf.

Virginia Department of Forestry. 2024. *Virginia's Forest Composition*. Accessed March 29, 2024. https://dof.virginia.gov/forest-markets-sustainability/learn-about-forest-markets-sustainability/virginias-forest-composition/.

Weikert, S. 2022. *Hardwood or Hard Wood?* Penn State Extension Publication. Accessed March 25, 2024. https://extension.psu.edu/hardwood-or-hard-wood.

Additional Resources

Coltrone, V. The Role of Trees and Forests in Healthy Watersheds. 2022. Penn State Extension Publication. Accessed March 21, 2024. https://extension.psu.edu/the-role-of-trees-and-forests-in-healthy-watersheds.

i-Tree. 2024. *MyTree: A Tool for Assessing Individual Trees*. Accessed April 17, 2024. https://mytree.itreetools.org/#/. This tool can be used to assess the benefits of individual trees, including carbon dioxide uptake, air pollution control, and impacts on stormwater.

Virginia Water Radio. Trees and Shrubs Thematic Series. Accessed April 11, 2024. http://www.virginiawaterradio.org/p/trees-and-shrubs-thematic-series.html.

The authors thank Carlos Evia of the Virginia Tech College of Liberal Arts and Human Sciences and Kevin McGuire of the Virginia Water Resources Research Center for their assistance with this publication.

2024 ANR-18NP (CNRE-179NP)

Appendix 1

Scientific names of tree species mentioned.

Common Name	Scientific Name
American beech	*Fagus grandifolia*
American holly	*Ilex opaca*
Baldcypress	*Taxodium distichum*
Black gum	*Nyssa sylvatica*
Black oak	*Quercus velutina*
Blue spruce	*Picea pungens*
Chestnut oak	*Quercus prinus*
Flowering dogwood	*Cornus florida*
Loblolly pine	*Pinus taeda*
Northern red oak	*Quercus rubra*
Pond pine	*Pinus serotina*
Post oak	*Quercus stellata*
Red maple	*Acer rubrum*
Scarlet oak	*Quercus coccinea*
Silver maple	*Acer saccharinum*
Sugar maple	*Acer saccharum*
Sweetgum	*Liquidambar styraciflua*
Virginia pine	*Pinus virginiana*
Water oak	*Quercus nigra*
Water tupelo	*Nyssa aquatica*
White oak	*Quercus alba*
Yellow-poplar	*Liriodendron tulipifera*