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Trees and Water

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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. 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: water quality; aquatic habitat; water quantity; and the interactions among water, climate, and energy use. This article provides a basic introduction to Virginia's trees and a foundation for assessing the connections between water and trees. Scientific names of all species mentioned are listed in Appendix 1 at the end of this article.

Tree Basics

Along with other plants that reproduce by seeds (some plants reproduce by spores, not seeds), trees are classified into two groups, based on whether or not 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; their seeds are not inside a fruit (the term means naked seeds) but are typically borne in cones, so most gymnosperms can also be called conifers (cone- bearing trees); pines, spruces, and firs are gymnosperms and conifers (Table 1).

Table 1. Typical characteristics of angiosperms and gymnosperms.

Angiosperms (flowers, with seeds in fruits)	Gymnosperms (no flowers, with 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, maples	Familiar examples: pines, spruces, firs

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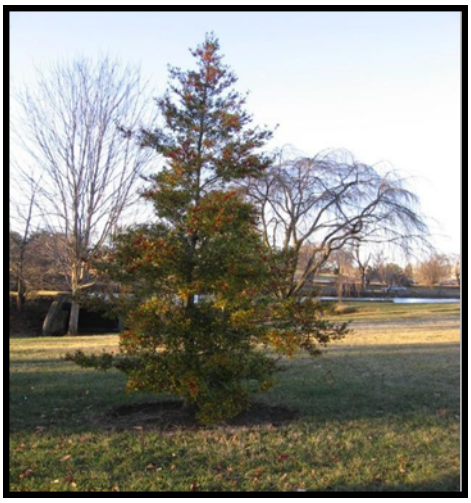
Most **deciduous** trees (those that shed all their leaves in autumn) are angiosperms, and most **evergreen** trees (which do lose their leaves but not all of them at once in a given season) are gymnosperms; there are, of course, exceptions (Figures 1a and b). Deciduous, flowering trees often are referred 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 (Seiler et al., 2008). Finally, flowering trees are often called broadleaf trees, because their leaves are relatively wider than the needles found on many conifers.

a.

b.



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

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. The National Wildlife Federation's (NWF) Field Guide to Trees (Kershner et al., 2008) lists 15 forest types that naturally occur in the United States (excluding Hawaii), ranging from the boreal forests of Canada and Alaska to the southeastern coastal plains forests of the Atlantic coast. The next section looks more closely at the kinds of forests and trees found in Virginia.

Trees and Forests in Virginia

Three main forest types are found in Virginia (Kershner et al., 2008). First is the **eastern deciduous forest**, characterized by high diversity of mostly deciduous species (perhaps 200 native species) with relatively few conifers. Second, is the **southern oak-hickory-pine forest**, widely occurring in the Piedmont areas of southeastern states and differing from the eastern deciduous forest by having more species and a greater abundance of pines. Third is the **southern coastal plains forest**, characterized by pines in upland areas with deciduous trees along waterways and in other low, moist areas.

According to the 2017 State of the Forest report for Virginia (VDOF, 2017), more than 16 million acres of the state, or about 62 percent, were classified as **forestland** (which is commonly defined as land at least 10 percent 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 percent (12.7 million acres) were hardwood or hardwood-pine forests (mostly oak-hickory forests), and 21 percent (3.2 million acres) were pine forests (with over 65 percent of the pine acres in managed pine plantations). Bottomland hardwoods occupied 5 percent of Virginia's forestland, and deciduous forests dominated by maples, American beech, and birches occupied 2 percent.

The VDOF identifies the most common Virginia trees 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 (VDOF, 2010).

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

Top Ten Virginia Trees by Number (2010)	Top Ten Virginia Trees by Volume (2010)
Red maple	Yellow-poplar
Loblolly pine	Loblolly pine
Yellow-poplar	Chestnut oak
Sweetgum	White oak
Blackgum	Red maple
Virginia pine	Northern red oak
American holly	Virginia pine
White oak	Sweetgum
Chestnut oak	Scarlet oak
Flowering dogwood	Black oak

Source: 2010 State of the Forest, Virginia Department of Forestry

VDOF's 2017 report noted that several native Virginia trees are suffering substantial decline due to insect infestations. Traditional pests such as gypsy moth and southern pine beetle have been declining while more recent threats, such as the emerald ash borer, invasive weeds, and thousand cankers disease of black walnut, have been on the rise. In general, invasive species remain a significant threat to forest health (VDOF, 2017).

Water's Influences on Trees

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 percent 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 through cell division and stem elongation.

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 also lose water at the same time. This tradeoff between carbon and water drives the plant's circulatory system and cools plant leaves through vaporization, where heat energy is released to the environment.

Water in trees and other plants is also needed to maintain pressure in cells that supports leaves and other non-woody plant parts; without sufficient pressure from water, plant cells lose the structure needed to function properly. Wilting is a common response to inadequate water pressure in plant leaves or stems (Figure 2).

Figure 2. Rhododendron leaves wilting under dry conditions.
Photo by: Alan Raflo, Virginia Tech.

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.

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 reported that the wave of gypsy moth outbreaks that occurred during the drought between 2005 and 2008 resulted in 114,000 acres of severe defoliation in 2008. The lack of water combined with high temperatures contributed to the death of many trees that were already stressed by insects. According to the VDOF, the gypsy moth numbers were much reduced after the excessively wet spring and summer of 2009, which allowed a naturally occurring virus to take over and subdue the moth population, including a steady decline in 2010 and 2011.

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 of 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. 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.

1. Pines

Virginia pine can be found throughout the state 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 sites.

2. Maple

Silver maple is commonly found in the Appalachian region 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 Ridge and Valley and Appalachian Plateau regions. Unlike the silver maple, it 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.

3. Blackgum and Water Tupelo

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

4. Oaks

Twenty-six species of oaks are native to Virginia. Several of these oaks are on the list of Top Ten Virginia Trees by Volume (VDOF, 2010). This diversity of oak species shows a variety of preferences and tolerances for water conditions. Post oak, for example, can be found throughout most of the state, but 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 along waterways such as streams and swamps. 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 reaches best growth on north and east slopes —in cooler, moister areas. In contrast, scarlet oak would typically be found on drier, rockier parts of mountain slopes.

Trees Providing Direction

In recent years, Virginians who follow news about water, the environment, or their local community may have seen headlines highlighting trees and water in the news. 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. Travelers booking flights online may have been asked if they wish to offset their carbon footprint by making a contribution to help plant trees; these trees will absorb the greenhouse gas carbon dioxide, which is emitted during the flight, and store it in the form of wood.

Photo by: Alan Raflo, Virginia Tech.

In these and other ways, trees are being recognized as part of the solution for an array of issues connected to water. Virginia has a rich diversity of tree species that both are influenced by water conditions and in turn 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.

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Additional Resources

The National Tree Benefit Calculator can be used to determine the impact and contribution trees make to property values, energy, storm water, and carbon and air quality. This Benefit Calculator is available online at http://www.treebenefits.com/calculator/index.cfm (as of 01/10/18).

United States Department of Agriculture's **Interpreting Wetland Indicator Status** provides a list of trees in the US and indicates their levels of need and tolerance for water. This list is available online at http://plants.usda.gov/wetinfo.html
(as of 01/10/18).

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Appendix 1. Scientific names of tree species mentioned.

Common Name	**Scientific Name**
American beech	*Fagus grandifolia*
American holly	*Ilex opaca*
Baldcypress	*Taxodium distichum*
Blackgum (or Black tupelo)	*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 tulipfera*