Forests of Virginia:
Importance, Composition, Ecology, Threats, and Management

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Most land in Virginia is in rural use. Of the 25.3 million acres in the commonwealth, 8.3 million (33 percent) are used for agriculture and 15.8 million (62 percent) are forested (VDOF 2014). That amounts to 95 percent of the land base.

This reading focuses on land in forest use. It will help you understand the importance of Virginia's forests, their composition, and the ways ecological and human factors influence them. You will also learn about forest management and the roles agencies and citizens play in the stewardship of this land.

The Importance of Forests

We all depend on and benefit from the forest every day, whether we know it or not. The trees, shrubs, plants, animals, and soil that make up forests provide you, your neighbors, and your region with a host of ecological, social, and economic benefits.

Ecological Benefits

The ecological benefits forests provide are also known as ecosystem services or nature's values. One such ecological benefit is improved air quality. The leaves of trees and shrubs reduce air temperature by direct shading and respiration. The lower temperatures reduce the chemical reactions that form ozone pollution, and they also reduce the need for artificial air conditioning (thus reducing energy demands). Plants also remove air particulates such as dust, smoke, and ash.

Additionally, through photosynthesis, forests remove carbon from the atmosphere and provide long-term carbon storage. The commonwealth's 15.8 million acres of forests store approximately 1.2 billion metric tons of carbon, which is equivalent to 37 years of Virginia emissions (Birdsey and Lewis 2002). While the trees are alive, they continue to store carbon. In addition, if they are harvested and made into a long-lasting product such as furniture, the carbon stays stored in the wood.

Another ecological benefit forests provide is clean water. Forests improve water quality by removing pollutants before they enter nearby streams. Leaves — both live leaves on branches and dead leaves on the ground — reduce the momentum of rainfall. This

Figure 1. Forests adjacent to waterways reduce sedimentation, stabilize stream banks, and provide shade for aquatic wildlife.

minimizes soil disturbance and prevents soil particles from dislodging and moving into streams. The roots of trees and other woodland vegetation also slow the movement of water, reducing soil erosion and increasing infiltration. Water in the soil is either used by plants or recharges groundwater supplies (Paul 2011).

Trees that line streams are particularly important for protecting water quality. These buffer trees keep the water cool for aquatic wildlife, stabilize stream banks, and provide habitat. Cleaner water means safer and more enjoyable recreational activities too (Paul 2011).

A fourth ecological benefit of forests is that they provide habitat for wildlife. Many wildlife species depend on forests for food, water, shelter, and space. The exact mix of birds, mammals, fish, and other critters will vary from one property to the next depending on many factors, including the type and age of trees in the forest, the size of the forest, and the characteristics of neighboring properties.

These are some examples of the many ecological benefits forests provide. In Virginia, these benefits along with others are valued at $12 billion annually (Paul 2011).

Social Benefits

Humans are inherently connected to the natural landscape. Some of the social benefits of trees are obvious: they provide fruits and nuts, create shade, reduce glare, and are aesthetically pleasing.

They provide less obvious benefits as well. Green space in urban areas can lower health care costs by encouraging physical activity. It can promote a sense of community because people see each other and interact more. Studies have shown that surgery patients with a view of trees heal faster than those without (Ulrich 1984). And proximity to green space can increase property values (Kane and Kirwan 2009).

Economic Benefits

In addition to environmental and social benefits, Virginia's forests provide economic benefits. Forestry is the third-largest industry in Virginia, contributing $17 billion a year to the economy and approximately 104,000 jobs. Forestry accounts for 3 percent of employment and 2 percent of the gross domestic product in Virginia. In 2010-11, Virginia landowners sold $257 million of standing timber (Rephan 2013).

Major Forest Types in Virginia

Virginia's 15.8 million acres of forests are varied and diverse. The variety of forest types across Virginia reflect our diverse physiography. From the sandy, low-elevation soils of the Coastal Plain to the dry rocky soils on the southwestern slopes of the Appalachian Mountains, Virginia has one of the most diverse landscapes in the East (Fleming et al. 2013). Most forests in this area have been heavily influenced by man-made disturbances such as fire, logging, farming, and introduced species, all of which have altered the forests' composition and structure.

Figure 2. Wood from Virginia forests is used to make many different products, including (a) lumber, (b) pellets, (c) veneer, flooring, plywood, and specialty items such as musical instruments.

A few areas in Virginia can be considered old-growth. Characteristics of old-growth forests include minimal human disturbance, presence of old trees (150 or more years in eastern forests), diverse structure (trees of many different ages, heights, diameters, and species), presence of coarse woody debris (from trees that have died and are decaying on the forest floor), and snags (dead standing trees).

Approximately 230,000 acres of forests in Virginia can be classified as old-growth. Most of these are on the George Washington and Jefferson national forests in the western portion of the commonwealth.

Oak-Hickory

The most common forest type in Virginia is oak-hickory, accounting for 9.7 million acres (61 percent) of the forestland (Rose 2015). The specific species of oaks and hickories will depend on climate, soils and topography. While the primary canopy species are oaks and hickories, there are many other species present as well.

Northeast facing slopes are relatively cool and moist and thus have a greater capacity to grow plants. These more productive sites, in much of Virginia, will have a mix of northern red and white oak, as well as mockernut, shagbark, and pignut hickories. Yellow-poplar (also known as tulip poplar or tulip tree) grows in coves where the soil is very rich and deep. These are especially prominent in the fall, when pockets of bright yellow are visible. On the drier, rockier, more fire-prone, southwest-facing slopes, oaks will be mainly chestnut and scarlet. More pines will be present on these slopes as well. In both cases, a myriad of other species will be found, including American elm, maples, and black walnut.

Oak-Pine

Oak-pine forest types account for about 1.7 million acres (11 percent) of the forest in Virginia. Although oak-hickory forests typically have a pine component, in oak-pine forests, 25 to 50 percent of the trees are pine (VDOF 2014). Oak-pine forests provide great habitat for wildlife. The hardwood trees provide mast (hard seeds such as acorns), while the pines (evergreens) provide winter cover. Pine species common to this forest type include pitch, Table Mountain, Virginia, shortleaf, and loblolly. Other hardwood species found in this forest type include blackgum, hickories, and yellow-poplar.

Since most pine species in Virginia need full sunlight to regenerate and grow, these forests, if left undisturbed, will eventually become mixed hardwood forests, with the pines becoming a smaller and smaller component over time. This is a result of the hardwood canopy closing in and shading the forest floor, making it too dark for pine regeneration. Regular disturbances, such as fire, harvesting, or insect and disease outbreaks, are required to perpetuate this forest type.

Figure 3. The exact mix of species found in an oak-hickory forest varies by climate, soils, and topography.

Figure 4. Oak-pine forests require periodic disturbances to persist. Here, a wildfire has opened up the hardwood forest canopy, allowing regeneration of shade-intolerant pines, such as Table Mountain and Virginia.

Pine

Approximately 3 million acres (20 percent) of Virginia's forest are pine (VDOF 2014). Native species include loblolly, longleaf, pitch, shortleaf, Table Mountain, Virginia, and eastern white. Historically, longleaf pine was much more common in the southeastern corner of Virginia, and shortleaf pine was more common throughout the state. However, significant harvesting followed by replacement with other species has resulted in both being currently considered diminished species. The Virginia Department of Forestry is working to restore shortleaf and longleaf pine with cost-share programs that will help interested landowners re-establish them.

Just over 1 million acres (35 percent) of the pine acreage is from natural regeneration; the other 1.9 million acres (65 percent) has been planted (VDOF 2014). Most of the pine planted east of the Blue Ridge is loblolly. West of the Blue Ridge, most of the pine planted is eastern white. While there has been some debate over the ecological value of pine plantations, studies show that these forests provide critical early successional habitat for many wildlife species and can support a diverse array of understory vegetation (Haywood et al. 2003). Additionally, they provide wood products and fiber to help meet increasing demand.

Figure 5. Most pine planted east of the Blue Ridge is loblolly. Young pine plantations such as this one provide critical habitat for early successional wildlife species such as bobwhite quail and woodcock.

Figure 6. West of the Blue Ridge, eastern white is the main species of planted pine. The tips of young eastern white pine are used to make wreaths and other holiday decorations. Mature trees are used for lumber.

Bottomland Mixed Hardwood

Bottomland hardwoods occur throughout Virginia on rich alluvial soils (flood plains) along streams; in low-lying wet areas, backwater, and headwater swamps; and along minor drainages. Acreage of this forest type has remained stable at 790,000 acres since 2001 (VDOF 2014).

Bottomland hardwood forests have a high diversity of both plant and animal species and are one of the most biologically important habitats in North America (Fleming et al. 2013). The actual species composition of this forest type varies greatly from the oak-gum-cypress swamps of the Coastal Plain (major species include swamp chestnut oak, cherrybark oak, sweetgum, willow oak, overcup oak, Atlantic white cedar, bald cypress, water tupelo, sweetbay, swamp tupelo, and red maple) to the flood plain forests along the New River (major species include American sycamore, American elm, green ash, hackberry, red maple, and boxelder).

Figure 7. The diverse species mix in bottomland hardwood forests not only protects water quality but also provides high-quality wildlife habitat.

Forest Structure and Ecology

These broad forest types can be broken down further into forest communities. A forest community is one dominated by trees (one or more species) growing in a specific area in association and mutual interaction with one another and with a complex of other plants and animals (Barnes et al. 1998).

Forest Structure and Composition

The structure of a forest community (i.e., how the trees are arranged vertically and horizontally) can range from simple to complex. Typically, a forest consists of an overstory (the largest trees which form the main canopy), a midstory (generally a brushy layer composed of saplings and woody species such as rhododendron), and an understory (which includes herbaceous plants, grasses, and tree seedlings).

Forests can be even-aged, two-aged, or uneven-aged (multi-aged). In an even-aged forest, most of the trees are approximately the same age. Even-aged forests can result from either natural or artificial regeneration. A plantation, where all the trees were planted in a relatively short period of time, is an example of an even-aged stand that was artificially regenerated. Areas that have had large-scale beetle or gypsy moth kills can have naturally regenerated even-aged forests. In two-aged forests, there are two distinct age classes of trees present — generally an overstory of parent trees and an understory of regeneration. Uneven-aged forests have the most complex structure and have at least three to four distinct age classes. A forest can begin as even-aged and over time develop into an uneven-aged forest because of small-scale disturbances, as discussed in the Succession and Disturbances section. Old-growth forests typically have uneven-aged structure.

Figure 8. Even-aged forests occur after large-scale disturbances such as clearcuts or wildfires. Both (a) pine and (b) hardwood forests can be even-aged. In fact, the majority of hardwood forests in Virginia are considered to be even-aged.

The composition of a forest community adds to its structural complexity. Some forest communities are monocultures, meaning there is one dominant tree species in the overstory. An example of a monoculture is a loblolly pine plantation. Although there may be many different species in the understory, the main canopy is almost entirely loblolly pine. The composition of a mixed-species canopy is determined by the growth characteristics of the species involved. Shade tolerance is an example of a growth characteristic that affects species composition.

Shade tolerance is the ability of a species to survive and grow under limited light conditions. Some species are very shade-intolerant and need high levels of light to thrive. These are generally pioneer or early successional species, which come in after a disturbance. Examples include Virginia pine, black locust, loblolly pine, shortleaf pine, black cherry, yellow-poplar, and black walnut. Many of the commercially important species in the southeastern United States are shade-intolerant.

In contrast are the shade-tolerant species, which are able to persist under low light conditions. Tolerant species include eastern hemlock, dogwood, maples, and American beech. Some species, however, are intermediately tolerant, and although they can survive in the shade, they respond with rapid growth to increases in light. Examples of intermediately tolerant species include eastern white pine, most oaks, white ash, and hickories.

The location of the forest, availability of seed sources, past management practices, wildlife, insects, and diseases can also significantly impact the composition and structure of forest communities.

(a)
(b)
(c)

Figure 9. Yellow-poplar seedlings (a) are shade-intolerant, needing full sunlight to thrive. On the other hand, maples and beech seedlings (b) are shade-tolerant and do fine in shade. In between are intermediately tolerant species, such as oaks and eastern white pine (c).

Succession and Disturbances

Forest communities are always changing. Even old-growth forests, which are generally considered to be systems in equilibrium, are undergoing succession. Succession is the gradual process of one plant community replacing another one over time (in the absence of major disturbances; Barnes et al. 1998). Disturbances, both natural and man-made, alter successional patterns, generally setting the forest community back to an earlier point in forest development.

Small-scale disturbances such as individual tree mortality, lightning strikes, and blowdowns occur frequently and change forest composition and structure slowly and subtly. Large-scale (forest-replacing) disturbances such as wildfires or extensive windthrow (from hurricanes) occur infrequently but change forest composition and structure drastically and immediately. Native insects can cause large-scale disturbances as well. For example, southern pine beetles can kill thousands of pine trees in a single growing season. Suppression of small-scale disturbances (for example, small wildfires) may predispose the forest to a much larger disturbance (such as a forest-replacing wildfire) because of fuel buildup.

How a disturbance affects a forest depends on the age and species of the trees at the time of the disturbance — larger, older trees are more susceptible to disturbances such as wind damage than younger trees, while younger trees are more susceptible to disturbances such as fire. Some pine species, such as longleaf pine, are more tolerant of fire than others, such as Virginia pine.

Large-Scale Disturbances

Hurricanes, ice storms, and intense wildfires are among the more common forest-replacing disturbances in Virginia. These disturbances can kill large acreages of trees, setting succession back to the regeneration stage. After a major disturbance, there are four distinct stages of forest development (succession):

1. **Forest initiation** immediately follows a large-scale disturbance. In this stage, smaller herbaceous plants quickly begin to occupy the growing space and woody stems eventually begin to dominate.
2. **Stem exclusion** occurs when woody stems begin to fully occupy the growing space. Trees begin to compete with each other for limited resources, and weaker trees are suppressed and eventually die.
3. **Understory re-initiation** begins as small-scale disturbances become frequent. The strongest competitors from the stem exclusion stage begin to die. This opens up canopy gaps, which allows the regeneration of a second cohort of trees to begin.
4. **Complex** (old-growth) forests occur when there is a relative balance between new growth production and death and decay (Smith et al. 1997; Barnes et al. 1998).

The age at which a forest reaches any one of these stages depends on the location, site, and species. For instance, in a loblolly pine plantation, the stem exclusion stage can occur at age 5. In an unmanaged hardwood forest, it might not occur until the trees are much older.

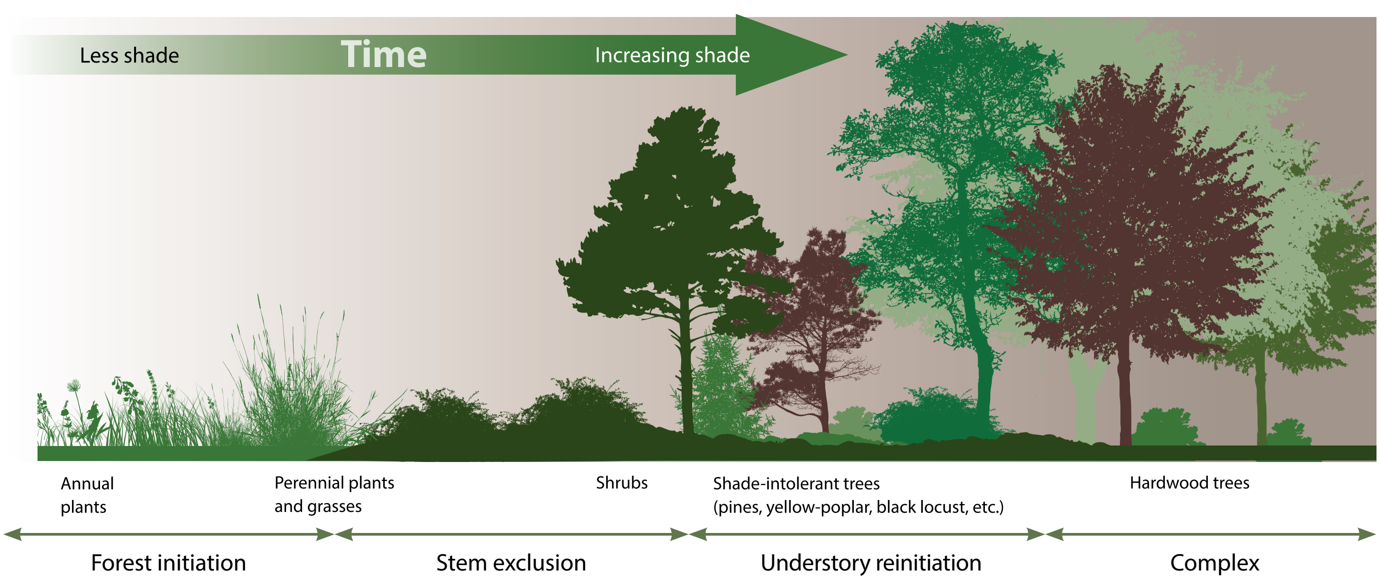

Figure 10. Succession is the gradual process of one plant community replacing another over time. Ideally, all phases of forest succession are available across a landscape. Illustration by Communications and Marketing, College of Agriculture and Life Sciences, Virginia Tech.

Figure 11. A wildfire is an example of a large-scale natural disturbance. These types of disturbances occur infrequently and allow shade-intolerant species to regenerate.

Figure 12. An individual tree killed by a lightening strike is an example of a small-scale disturbance. These types of disturbances occur frequently and allow intermediately shade-tolerant species to regenerate.

Small-Scale Disturbances

The creation of canopy gaps by small-scale disturbances plays a major role in altering forest community structure and composition. Gaps form as individual or small groups of trees die. The microclimate within gaps can be very different from the microclimate under the intact canopy. When a gap forms, there is an increase in the amount of sunlight reaching the forest floor, which encourages the growth of shade-intolerant species. In the case of a small gap, however, if the surrounding forest is young and vigorously growing, the crowns of the surrounding trees will take advantage of the opening and expand into the gap, potentially preventing development of shade-intolerant species.

Additionally, there can be an increase in soil moisture inside a gap due to a decline in leaf area (hence, a decline in rainfall interception by leaves). The increased soil moisture can increase growth of species in the gaps. However, as with crown growth, the root systems of the neighboring trees will also grow into the opening to take advantage of the increased soil moisture. Depending on the size of the gap, other environmental factors may also be altered. In large gaps, summer temperatures can be much higher than in the surrounding forest. Wind and snow patterns can also be affected by gap formation (Smith et al. 1997).

Forest structure and composition are complex and ever-changing. Knowledge of the basic terminology and processes helps to describe a forest at a given point in time and to make predictions on how the forest can develop over time. This is useful for forest management planning.

However, not all disturbances are created equally. Some disturbances can negatively impact natural forest functions, as discussed in the next section.

Threats Affecting Forests in Virginia

Many of the threats to Virginia's forests are not unique to the commonwealth; most U.S. forests face similar problems. Some of the biggest threats to forests in Virginia are exotic invasive species, parcelization and fragmentation, development, climate change, and historical mismanagement. These cause changes in forests above and beyond what the natural and intentional man-made disturbances already discussed above do.

Exotic invasives

Plants, insects, diseases, and animals that thrive and spread vigorously outside their native ranges are known as exotic invasive species. Often, exotic invasive insects and diseases outcompete native species because they have no natural predators outside of their native habitat. Exotic invasive plant species are often fast growers and can outcompete native vegetation by simply shading it out. This can change the species composition of a forest (from native to non-native), which can alter ecosystem function, change forest structure, decrease productivity, and decrease biodiversity.

While some exotic species were accidentally introduced to the United States, others were intentionally introduced as beneficial species. For example, kudzu was brought to the country and promoted for erosion control, forage, and ornamental uses. Unfortunately, kudzu grows very well in the southeastern U.S. and now covers up to 7 million acres (Britton, Orr, and Sun 2002), displacing many native species.

In general, exotic invasive plant species are prolific seeders and/or root sprouters. For example, a single female tree-of-heaven (*Ailanthus altissima*, also known as the paradise tree, stink tree, or ailanthus) can produce more than 300,000 seeds in one year and sprouts prolifically when cut down (Rhoades and Block 2002). Many exotic invasives have light seeds that are easily disseminated by wind. Additionally, many are adapted to a wide range of site conditions (soil moisture, light, nutrient availability) and grow rapidly.

The Virginia Department of Conservation and Recreation's List of Invasive Alien Plant Species identifies 38 highly invasive plant species (including grasses, shrubs, and trees), and 90 total invasive plant species, many of which are found throughout Virginia. On its website, VDCR defines highly invasive plant species as those that pose "a significant threat to native species, natural communities, or the economy" (VDCR 2015). Visit www.dcr.virginia.gov/natural-heritage/invsppdflist for a complete list of these species.

Exotic invasive insects, diseases, and animals have characteristics similar to invasive plant species in that they are able to reproduce rapidly and prolifically. The hemlock wooly adelgid, gypsy moth, emerald ash borer, and chestnut blight are some examples of exotic invasive insects and diseases that have had (and are having) devastating impacts on Virginia's forests. Feral hogs are an example of an exotic invasive animal that is a major problem throughout most of the U.S., and they are becoming a problem in parts of Virginia. Photos of all types of invasive species are available at www.bugwood.org.

(a) (b) (c) (d)

Figure 13. Exotic invasive species can be (a) plants (wine raspberry), (b) insects (gypsy moth), (c) diseases (chestnut blight; photo courtesy of Linda Haugen, USDA Forest Service), or (d) animals (wild hogs; photo courtesy of Vladimir Dinets, University of Miami) and can negatively impact the natural function of ecosystems.

Parcelization and Fragmentation

Parcelization is the process by which land is subdivided into increasingly smaller units. This often occurs when land is passed down through generations. For example, a 100-acre farm belongs to a family with four children. The parents divide the land equally and each child receives 25 acres. Each child then has two children of their own, who each receive 12.5 acres, and so on through the generations. Eventually a large plot of land becomes many small plots under separate ownership.

As long as all the children keep the land as forest, it is parcelized but still functions as a forest at the landscape level. Problems occur when adjacent landowners value their land for other uses. Some might value the land for forestry and/or wildlife, while others desire to realize immediate financial benefit by selling or developing their portion of the property. As individual parcels are converted to nonforest uses, the landscape becomes a fragmented matrix of different uses, such as a subdivision next to a working forest with a hunting lease. Fragmentation affects the function of the forest systems at the landscape level and reduces land-use options for the future.

Fragmentation also limits the type of forest management tools that can be used. For example, prescribed fire may not be an acceptable management tool in a forest surrounded by residential development due to smoke and safety concerns. Timber harvesting and the noise and machinery associated with it could be controversial among residents who bought homes overlooking a forest. This takes the work out of a working landscape.

As forests become fragmented and people move out to the urban-wildland interface, there are more encounters between humans and wildlife, which could be dangerous (for example, ticks) or problematic (for example, deer eating gardens), and more chances for loss of property from a wildfire in the neighboring forest.

Development

Perhaps the most significant outcome of parcelization and fragmentation is the loss of agriculture and forestland to development. According to the Virginia Department of Forestry (VDOF 2014), more than half a million acres of forestland have been converted to other uses since 1997. If current development trends continue, it has been projected that Virginia will lose a million acres of forest in the next 25 years. Real estate cycles clearly affect the rate of rural land loss to development, but the overall trend clearly reflects a decline in rural acreage. In a society with increasing demands for wood-based products, this is not a sustainable trend.

Aside from the ecological problems this creates, there are also social and economic problems. For instance, development pressures increase the value of forest and farmland, which in turn increases property taxes. This makes it difficult for even the best-intentioned forest landowner to keep growing trees. Fortunately, some localities in Virginia have programs that help reduce the tax burden for some forest landowners, but not everyone qualifies for these programs or knows about them.

(a)

(b)

Figure 14. In many areas of Virginia, (a) large acreages of forestland are being parceled and sold off. More often than not, this leads to fragmenting and development (b), which can have a negative impact on traditional forest and wildlife management practices.

Climate Change

Climate change is likely to have a significant influence on Virginia's forests by the end of this century. Increasing temperatures, changing rainfall patterns, increases in extreme weather events, increases in atmospheric carbon dioxide, and increases in nitrogen deposition are all factors associated with climate change that will alter forests both directly and indirectly. For example, higher temperatures could lead to the extirpation of red spruce, balsam fir, and eastern hemlock, all of which are near the environmental limits for their ranges where they occur in Virginia. In another example, higher temperatures already are lengthening the growing season, giving invasive insects and diseases more time to find and colonize trees. At the same time, the higher temperatures create more stress in the trees, making them more vulnerable to attack (Vose, Peterson, and Patel-Weynand 2012).

The use of sound forest management practices are a key factor in keeping our forests resilient in the face of these threats.

Objectives are specific actions landowners can take to help them achieve their goals. Typically, objectives are associated with a timeline. Professional foresters help landowners develop their objectives based on their management goals.

For example, if a landowner's goal is to improve the health of their forest, the objectives could include the following:

- **Plant species best suited for the site. Trees planted outside their natural range or on unsuitable sites are generally weak and unhealthy.**
- **Monitor the condition of the forest. Periodically walk through the forest, especially after severe weather such as ice storms, hurricanes, and tornadoes. While some level of damage is natural and acceptable, if there is excessive damage, landowners might want to conduct a salvage cut to remove severely damaged trees before further damage from insects and disease occurs.**
- **Use prescribed fire. Forests in the Coastal Plain are typically burned every three to five years. In the mountains, prescribed fires are less frequent.**
- **Reduce the risk of wildfire. Actions such as salvage logging, thinning, and prescribed burning reduce fuel loads and help reduce the risk of a wildfire damaging the woods.**
- **Control exotic invasive species. Annual monitoring for exotic invasives can help stop an invasion before it gets out of hand.**

Historical Practices

Many of the hardwood forests in the Appalachians have been high-graded. A high-grade is often presented to the landowner as a select or diameter-limit cut. The landowner is told that the biggest and most valuable trees are the oldest trees, and removing them will not only maximize income from the timber sale, but it will also free up the young, small trees so they can grow into big trees. This sounds reasonable, but in reality, size isn't a good indicator of tree age. Two trees can be the exact same age, but due to genetics, disease, or microsite conditions, one tree could be twice the size of the one next to it. Many of the small trees are exactly the same age as the merchantable trees. In a high-graded forest, after the merchantable trees are removed, the remaining forest is composed of poor quality, often diseased and weak trees — an unhealthy forest.

Forest Management

Silviculture is the art and science of tending a forest system to meet specific objectives. It is an art because it is not a one-size-fits-all science. Often the answer to the question, "How should I manage my forest?" is "It depends." How to best manage a forest depends on what the owner's goals are. A goal is the big picture or a general statement about how an owner wants the land to look in the future. Landowners' goals vary greatly depending on their backgrounds, interests, resources (time, money) and land (acreage, location, productivity). Examples of common landowner goals include

- Improving the health of the forest.
- Harvesting timber and regenerating the forest.
- Providing quality habitat for wildlife.
- Identifying and protecting special sites.

Silviculture is also a science. Years of research have been conducted on how to best manage forests, be they naturally regenerated or artificially regenerated, pine or hardwood. A sound management plan will be based solidly in the science of silviculture.

A silvicultural system is a plan of action that includes all management activities during the life of a forest, including site preparation, regeneration, intermediate treatments such as thinning, and harvesting. Silvicultural systems differ from simple harvests in that they plan for the future of the forest, not just for the removal of trees (Johnson and Smith 1998, Smith et al. 1997).

Silvicultural systems can be active, passive, or somewhere between the two extremes. Active management involves high inputs (fertilization, weed control, release operations, use of genetically

(a)

(b)


Figure 15. Silvicultural practices enhance forest health and productivity. This clearcut (a) will soon be replanted with loblolly pine seedlings, while this seedtree cut (b) will rely on natural loblolly pine regeneration.

improved trees), while passive management involves very modest inputs. Actively managed forests tend to produce large timber quickly, while extensive systems tend to focus on other objectives (for example, biodiversity).

Following is a discussion of silvicultural systems used in Virginia. Each of these systems can vary in management intensity. To gain a better understanding of these different systems, read Virginia Cooperative Extension publication 420-405, "Principles of Regeneration Silviculture in Virginia," and visit the website www.forestandrange.org. Under the Learning Options tab for forestry, the Visual Guide to Timber Harvesting provides 360-degree photos of forests before and after different silvicultural systems have been applied.

Seedtree and Shelterwood

Two systems that create even-aged forests are seedtree and shelterwood. In the seedtree system, two harvests are conducted. The seed cut reduces the density of the residual overstory to 10-20 trees per acre, which allows more sunlight to reach the forest floor and prepares the seedbed. The remaining overstory trees provide seed to naturally regenerate the forest. Once regeneration is well-established, the overstory trees are removed in a final harvest — the removal cut. However, there are some variations to this method in which the overstory trees are left on-site. This creates a two-aged forest.

The shelterwood system requires three harvests. The first harvest is called a preparatory cut and is much lighter than a seed cut. The preparatory cut reduces the overstory density modestly, allowing more sunlight to reach the forest floor and removing undesirable species. This gradual reduction in density allows the residual trees to become more wind-firm before the density is further reduced in the seed cut. Like the seedtree system, once adequate regeneration is established, the overstory trees are removed.

There are several advantages to the seedtree and shelterwood silvicultural systems. First, relying on natural regeneration is inexpensive. Second, leaving the seedtrees on-site for several years ensures adequate regeneration while they continue to grow and increase in value. Finally, many landowners find these systems more aesthetically pleasing because there are always trees on-site (Johnson and Smith 1998, Smith et al. 1997).

Selection

The selection silvicultural system mimics naturally occurring small-scale disturbances. This name, unfortunately, is very similar to select cut (diameter limit cut or high-grade), but in practice it is quite different. Selection takes into account the future health and productivity of the forest. Selection systems can either be single-tree or group. In a single-tree selection system, individual trees are removed to create small openings in the canopy. Intermediately shade-tolerant species can naturally regenerate in these openings. In a group selection system, groups of trees are removed to create larger canopy openings and encourage the growth of more shade-intolerant species (such as oaks). In both systems, the worst trees are harvested and the best trees are left behind. The goal is to improve the quality of the forest with each successive harvest. Selection silviculture creates uneven-aged (multi-aged) forests that have at least three different age classes represented (Johnson and Smith 1998; Smith et al. 1997).

Clearcut

Although not appropriate for all situations, clearcuts have a place in forests where the growth of shade-intolerant species is desired (recall that species such as loblolly pine and yellow-poplar need full sunlight to grow). This can best be achieved by a silvicultural clearcut. Please note, this is not the same as a commercial clearcut. In a commercial clearcut, the best trees are taken, and the poorly formed, diseased, suppressed trees are left on-site. These conditions are not suitable for adequate regeneration of shade-intolerant species due to shade from the residual trees. The remaining overstory trees have little or no value and if left, will develop into a poor-quality forest.

In a silvicultural clearcut, all trees — regardless of quality — are removed from the site. This leaves a clean site that is easy to plant, and promotes healthy, robust regeneration of shade-intolerant species. Clearcuts mimic naturally occurring large-scale disturbances such as wildfires or hurricanes.

Clearcuts can also be a good option in forests that have been high-graded, like many of the hardwood forests in the Appalachians. The density of a residual forest after a typical high-grade is generally too high for good oak regeneration; the species composition of the forest in mountain coves then moves towards more shade-tolerant species, such as striped maple, red maple, beech and rhododendron. In the Piedmont, high-graded forests are often comprised of scarlet oak, chestnut oak, red maple, and occasionally Virginia pine. Depending on your management goals, this may or may not be a problem. If a high quality, diverse, and healthy forest is your goal and adequate desirable advanced regeneration is present (for example, tulip-poplar), and undesirable regeneration (for example, tree-of-heaven) is absent, the best way to rehabilitate a high-graded forest may be to clearcut and start over. After a silvicultural clearcut, the hardwood stumps will sprout and seeds in the soil will germinate, resulting in a vigorous, healthy forest.

A silvicultural clearcut creates an even-aged (one-aged) forest, with all trees in the future forest being approximately the same age. Recall that even-aged forests can either be naturally regenerated (relying on seed fall from nearby trees or stump sprouts) or artificially regenerated (seeds sown or seedlings planted). The method of regeneration used depends on the species, availability of a seed source, size of the clearcut, and management objectives (Johnson and Smith 1998; Smith et al. 1997).

In the Southeast, regeneration in a clearcut develops rapidly; in a short period of time, many people are not able to identify that the site had been clearcut. Clearcutting is not deforestation — it is replacing an older forest with a younger forest.

Intermediate Treatments

In forests, trees compete for light, water, and nutrients. In the eastern U.S., trees primarily compete for light. Intermediate treatments are designed to increase the availability of light (and with that, the other resources). The more active the management plan, the more intermediate treatments are included. Intermediate treatments are applied to the forest between regeneration and final harvest and include activities such as thinning, crop tree release, timber stand improvement, understory competition control, prescribed fire, and fertilization.

Figure 16. Hundreds of thousands of seedlings (hardwood and pine) are grown and planted in Virginia every year. These loblolly pine seedlings are being grown by the Virginia Department of Forestry.

Thinning removes a portion of the trees in a forest, freeing up resources for the remaining trees to increase vigor and growth. Row thinnings are often used in plantations and are nonselective. That is, every second, third, fourth, or fifth row is systematically harvested. Low thinning (thinning from below) removes smaller stems, while high thinning (thinning from above) removes co-dominant trees, freeing up the crowns of the dominant trees. Free thinning focuses on removing slow-growing, diseased, suppressed, or deformed trees from the canopy.

Thinnings are usually conducted in pine forests at around age 15 and in hardwood forests from age 30 to 40. Timber stand improvement work is similar to a selection thinning in that poorly formed, diseased trees or undesirable species are removed, increasing the overall quality of the forest.

Crop tree release is a type of thinning. Crop trees are identified (see the sidebar, What Is a Crop Tree?, for information on how crop trees are chosen) as trees that will remain on-site long-term. Nearby competitors are removed either by mechanical methods such as cutting or girdling (cutting the bark all the way around the tree) or by herbicide application. This increases the availability

Figure 17. Thinning is a type of intermediate silvicultural treatment that reduces the number of trees in a forest. Unhealthy and undesirable trees are usually removed. This gives the remaining trees access to more sunlight, nutrients, and water, resulting in a more vigorous forest.

of resources for the crop tree. These operations can be labor-intensive, time-consuming, and expensive but can contribute significantly to maintaining trees that help landowners meet their goals.

Understory vegetation can also be a serious competitor for trees, particularly seedlings. In forests where timber production is the main management objective, understory vegetation is usually minimized in the early years of the forest. Like thinning, understory competition control reallocates resources to the crop trees. This can be accomplished using herbicides or prescribed fire (depending on the species and size of the trees).

Prescribed fire is a useful and inexpensive management tool for pine forests. Longleaf pine forests can be burned at any age. Fire not only reduces understory vegetation, it also prepares a bare mineral soil seedbed that longleaf pine seeds need for germination. Other species, such as loblolly pine, are susceptible to fire damage until they are old enough to have developed a fire-resistant bark. Table Mountain pine is a species with serotinous cones. This means the cones remain closed (and don't drop their seeds) until exposed to extreme heat such as that generated by a fire. The regeneration of species with serotinous cones is dependent on fire. The use of prescribed fire has been more limited in hardwood

What Is a Crop Tree?

Although there are guidelines for how to select crop trees, there is a lot of flexibility for landowners and foresters in this process. In general, a crop tree is any tree that helps a landowner meet their management goals. For example, if a landowner wants to improve wildlife habitat, crop trees could include mast-producing species, such as oaks, hickories, blackgum, and black walnut, and perhaps even trees with cavities for denning. If a landowner wants to improve aesthetics, crop trees could include species with colorful fall foliage, such as blackgum, dogwood, and sweetgum.

In many cases, a crop tree can help a landowner meet multiple goals. For example, blackgum provides soft mast for wildlife as well as colorful fall foliage. In other cases, though, a certain crop tree may meet one goal while conflicting with another. For example, den trees are excellent for meeting wildlife management goals; however, they are not so good for achieving timber production goals. Landowners using crop tree release should prioritize their management goals and choose their crop trees accordingly.

The number of crop trees on any given acre will vary, depending on tree species, productivity of the site, age of the forest, and the landowner's ability to do the thinning. The more crop trees identified, the more thinning work is required. In mature stands, selecting 20 to 40 uniformly spaced crop trees per acre is common.

Regardless of specific management goals, crop trees should be healthy and have large, vigorous crowns. Each tree should be assessed for its overall contribution towards management goals and its ability to respond to the release treatment.

For more information on selecting crop trees, read the USDA Forest Service publication "Crop Tree Management in Eastern Hardwoods" (Perkey, White, and Smith 1994).

Figure 18. Prescribed fire is an intermediate treatment that is used to help landowners meet their management goals.

Figure 19. When a forest is high-graded, the best, most valuable trees are removed and smaller, poorly formed trees are left. This results in an unhealthy, unsustainable forest. (Photo courtesy of Rich Steensma, Virginia Department of Forestry.)

forests due to the complexity of burning diverse tree species with variable fire tolerances. The use of prescribed fire, however, shows promise for the regeneration and management of oaks.

Actively managed forests can also be fertilized to increase growth. Fertilization in the absence of understory vegetation control can lead to sites that have impenetrable weed growth (for example, greenbrier and blackberry), so fertilization is usually applied following weed control.

Other examples of intermediate treatments can occur annually. For example, monitoring and controlling exotic invasive species is an ongoing process. Maintaining roads and trails to prevent erosion can also be a frequent practice. Pretty much anything done to a growing forest can count as an intermediate treatment.

Site Preparation

Site preparation activities occur after a harvest to ready a site for artificial regeneration. These activities include slash removal (by burning, chopping, shearing, or disking over land that has been harvested), vegetation removal (by burning, applying herbicide, plowing, scalping [removing the top layer of sod], or mowing), reduction of soil compaction (by tilling or scalping), and bedding. These activities make the site easier to plant, create a suitable seedbed for natural regeneration, reduce competition for the new trees, increase rooting depth, and control flooding. These practices can increase survival and growth of seedlings.

When it comes to managing a forest, doing nothing for a time is always an option (this surprises some people). Depending on past management, the forest may be growing optimally to meet the landowner's management objectives. A professional forester can make this determination. Professional assistance is readily available to landowners. State agencies have personnel who can work with forest owners to develop realistic goals and management plans. Additionally, Virginia has a cadre of professional consulting foresters (see www.dof.virginia.gov for a listing), and the forest industry also provides services to landowners.

The Role of State Agencies in the Stewardship of Virginia's Forests

Virginia Cooperative Extension is the community's connection to Virginia's land-grant universities, Virginia Tech and Virginia State University. Through its statewide network of Extension agents and specialists, VCE shares knowledge to help improve the quality of Virginians' lives. In the realm of forestry, VCE provides education through the Virginia Forest Landowner Education Program and through regional forestry and natural resource agents located across the commonwealth. Together they provide short courses, workshops, print materials, and training for private forest landowners and natural resource professionals. Please contact the VFLEP coordinator at 540-231-6391 or jgagnon@vt.edu or visit www.ext.vt.edu and http://forestupdate.frec.vt.edu for more information.

Virginia Department of Forestry is Virginia's state forestry agency and its mission is "to protect 15.8 million acres of forest land from fire, insects and disease, to manage 24 state forests and other state lands totaling 68,626 acres for timber, recreation, water, research, wildlife and biodiversity, and to assist non-industrial private forest landowners through professional forestry advice and technical management programs." Each county in Virginia has an area forester assigned to it. Area foresters help non-industrial private forest landowners determine reasonable management goals and objectives and help to prioritize them. They can write a forest stewardship plan — a management plan for the property — as well as assist landowners with insect and disease problems. A wealth of print

Figure 20. State agencies such as the Virginia Department of Forestry provide assistance to private woodland owners.

Figure 21. Virginia Master Naturalists can educate others about Virginia's forests through opportunities such as the Working Woods Walk at James Madison's Montpelier. (Photo courtesy of Patricia Temples, Virginia Master Naturalist volunteer.)

materials is available as well. VDOF employees assist the Virginia Forest Landowner Education Program and Virginia Cooperative Extension with many of their educational programs, enforce water quality laws and burn bans, and fight wildfires. Visit www.dof.virginia.gov for more information.

There are a number of other state agencies involved in the management of Virginia's natural resources as well. They include the Department of Game & Inland Fisheries, Department of Conservation & Recreation, and Virginia Outdoors Foundation.

Some of their many duties include landowner assistance, wildlife management, protection of special areas and ecosystems, management of state parks, and issuance of conservation easements.

The Role of Citizens in the Stewardship of Virginia's Forests

Virginians are an integral part of forest stewardship simply because they own most of the forests. Of Virginia's 15.8 million forested acres, 10.1 million acres are owned by private individuals and families (VDOF 2014). The forestland owners' land management ethics and skills have a tremendous impact on the overall health and productivity of the forests, which in turn impact the environmental, social, and economic benefits we all enjoy. The importance of these landowners will only increase as development pressures and other threats increase, as our forest base decreases, and as demand for forest products increases.

One of the best actions private landowners can take is to become educated on forest conservation. As mentioned, many educational programs are available in Virginia. And of course, citizen volunteers like you can help educate these landowners, as well as nonland-owning citizens.

For more information on these tools and on managing forests sustainably, please contact the Virginia Forest Landowner Education Program at http://forestupdate.frec.vt.edu, jgagnon@vt.edu, or 540-231-6391.

Knowledge is power when it comes to conserving forests.

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