



Promoting a Healthy Forest on Your Land

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Figure 1. This healthy longleaf pine (Pinus palustris) stand has been thinned, and understory vegetation has been managed with prescribed burning. Stands such as these have abundant wildlife, diverse vegetation, and help clean our water and air.

Healthy forests provide many public benefits like clean air and water, wildlife and plant habitat, and diverse forest products that help the economy and ecosystem (Fig. 1). Healthy forests also provide individuals with a greater opportunity to achieve their personal objectives such as the production of wood products, recreational or hunting experiences, aesthetic enjoyment, or a variety of other goals. Healthy forests are sustainable and meet owner objectives. Additionally, non-timber benefits are evident in a healthy forest; when trees are healthy, they produce nuts, cones, seeds, canopy, and leaf litter that provide food and habitat for understory plants and wildlife and enrich the soil. We define forest health as the ability of a forest to maintain and perpetuate a constant high quality supply of environmental benefits, products, and a diverse plant and animal community.

A healthy forest means different things to different people, and can be further characterized by how it is managed (for example plantation vs. natural stand) or its age (young vs. mature). Plantation forests are generally more intensively managed, productive (growing more timber per acre), and provide for higher incomes on a more regular basis than a forest that regenerates naturally. Planted forests are generally more uniform (planted in rows), have a greater chance of being fertilized, and are usually harvested sooner than natural stands. Natural, or naturally-regenerated, forests may produce income less frequently and are often less intensively managed. Natural forests vary in composition (different types and ages of trees), and may be primarily managed for wildlife, aesthetics, or non-timber benefits (for example, protecting watersheds, providing habitat or food for wildlife, or helping facilitate nutrient cycling).

The health of your forest is important if you produce income from forestland or simply enjoy its beauty, wildlife, and other amenities. Neglect (even if benign), unpredictable weather events, and insects and disease can hinder a forest's ability to provide all the benefits that accrue from healthy forests. Exotic insects, wildfire, diseases, and storms and ice have caused widespread declines in forest health. One recent example, the redbay ambrosia beetle and laurel wilt, have killed millions of redbay trees along the southeastern U.S. coast, and are threatening other tree species as well as avocado production. The emerald ash borer is now present in the southeastern U.S. and causes complete mortality of ash trees. Past southern pine beetle outbreaks have caused millions of dollars and millions of acres of tree damage. Although forest health problems can discourage forest landowners, most solutions are reasonable and can be accomplished in the course of typical maintenance actions. Practicing sound forest management promotes forest health! A forest management plan is the first place to start, as knowing the steps for proper forest management and proper forest protection are oftentimes very compatible and key to attaining a healthy forest.

Forest health begins with the health needs of a single tree. A forest containing one unhealthy tree does not jeopardize the health of an entire forest. However, on occasion, an unhealthy tree can, if left alone, lead to problems throughout the forest. For example, lightning can damage a single tree by cracking the stem and

breaking through important protection mechanisms in the bark and trunk. When a tree is wounded in this manner, it releases odors that attract insects. These insects can attack the damaged tree, and may spread to healthy neighbor trees, contributing towards an unhealthy, insect-infested forest. Similarly, a forest may have a canopy of extremely healthy trees, but have a very unhealthy ground-cover dominated by exotic plants, such as Chinese privet or kudzu. Exotic plants can crowd out native vegetation, depriving it of important nutrients, water and sunlight. This can lead to detrimental changes in plant and animal communities. Removal of the exotic plants often improves forest health, but this may involve a dedicated effort over several years to complete.

There are many ways to profitably manage and improve the vigor of your forests while minimizing the risks. Some are as simple as regularly monitoring your forestland, while others involve planned timber management. With awareness and a little planning, most landowners can promote forest health while minimizing risks along the way to achieving their objectives. As any good doctor knows, prevention is the cheapest and most effective strategy.

Factors that Jeopardize Forest Health

Many factors can reduce or degrade the health of our forests. These include native and exotic pests, past land uses, uncontrollable weather events, long term climate changes, and wildfires.

Native pests are those that naturally occur in the U.S. Major pests of pine forests include the southern pine beetle and *Ips* beetles. These insects are attracted to the chemicals given off by wounded or unhealthy trees. The southern pine beetle, in particular, is a forest pest capable of major forest damage and tree mortality (Fig. 2). Defoliators (insects that eat leaves) such as the gypsy moth and tent caterpillars are common pests on hardwood trees. Most defoliators do not kill trees, but many years of defoliation can result in decreased tree health, as the loss of leaves or needles can affect a tree's ability to produce food.

Exotic pest plants and insects are mostly associated with recent disturbances, and have typically come from other parts of the world. Exotic species can have negative impacts on native trees, outcompeting native plants, and changing water and nutrient cycles, and ultimately caus-

ing mortality. Important exotic plants in the southeastern U.S. are kudzu, cogongrass, and Chinese privet. These plants can grow over vast areas, and choke out native vegetation (Fig. 3), including trees. Exotic insects of concern include the redbay ambrosia beetle and emerald ash borer, both of which can kill trees very quickly.

Past **land management practices** like farming/grazing and logging operations where proper practices were not used can also have a detrimental effect on the health of the forest. The deforestation of our Eastern forests in the 19th and early 20th centuries for agricultural production in the absence of proper conservation measures led to excessive erosion, loss of topsoil, or detrimental soil structure in many parts of the south (Fig. 4).

High-grading, another past land management practice is the practice of harvesting the largest, often best quality trees and leaving the small and lower quality trees. High-grading is prevalent in stands with mixed (multiple different) species and continues today as "diameter-limit cutting." When repeated, high-grading results in stands of slow-grow-



Figure 2. The southern pine beetle (*Dendroctonus frontalis*) is capable of killing thousands of trees if outbreaks occur. In this photo from the Sabine National Forest in Texas, the gray loblolly pine (*Pinus taeda*) trees in the middle are dead, the red trees closer to the outside are recently killed, and the yellow trees are dying. In this case, the southern pine beetle outbreak appears to be expanding outwards in all directions.



Figure 3. Cogongrass (*Imperata cylindrica*) is a non-native weed capable of outgrowing native vegetation and taking over large areas. The trees in this photo will likely survive, but will have to compete with the cogongrass for water and nutrients, and probably won't grow as quickly as they normally would.



Figure 4. Soil erosion, in this case from poor drainage that caused deep gullies and washed away much of the topsoil, can create difficult growing conditions for trees.



Figure 6. When animals are allowed to graze so much so that the grass cannot grow fast enough, the land can become damaged and may not grow back. This can lead to soil erosion, especially if it occurs on a slope, as grass or other vegetation will no longer be able to buffer flowing water after a rain.

ing trees, often comprised of less valuable timber species and reduced stem quality.

Excessive logging damage occurs when logging machinery rubs against standing trees that are not part of the timber sale (Fig. 5). This often results in large wounds on the stems of “leave” trees, which can lead to insect attack and disease infection.

Destructive grazing by livestock can result from overgrazing, or not allowing pastures the time or energy to regrow (Fig. 6). Poor grazing practices can lead to an influx of weed species, soil erosion, soil compaction, and pasture degradation.

“Off-site” tree species not well-suited to a site can become very stressed and unhealthy. For example, some trees do not grow well on very wet sites, while others do not grow well on very dry sites. Selecting species for the wrong

site stresses trees, and stressed trees are much more susceptible to insects and diseases than are unstressed trees. Growth and productivity are better when trees are not stressed.

Weather events include lightning, high winds, snow and ice damage, and flooding. These can have devastating effects on trees and forests. Lightning can lead to large injuries (Fig. 7), while wind, snow, and ice (Fig. 8) can cause trees to bend and ultimately snap. Injured trees often attract bark and wood-boring insects, which can potentially lead to additional trees being attacked.

Wildfire, if severe enough, will injure, stress or kill trees (Fig. 9). These trees, if they survive, will be left susceptible to various types of insects and diseases. Insect damage after a fire may result in tree death. Also, very hot fires can kill tree roots, damage the soil, and hinder its ability to support new growth.



Figure 5. Damage from logging equipment can scrape the bark off trees, causing large wounds that may be infected by fungi or attacked by bark and woodboring insects.



Figure 7. Trees struck by lightning don’t always die, but the wounds created can attract bark and woodboring insects. These insects may colonize the tree, and are capable of infecting the tree with fungi.



Figure 8. During storms, snow and ice can accumulate in tree tops and cause stems to break. In this stand in South Carolina, several trees have snapped because the tops became too heavy from ice accumulation during a storm in 2014.



Figure 9. Uncontrolled wildfire can destroy everything in its path. Wildfires in Georgia in 2007 burned over 500,000 acres and destroyed nine homes.

What Can Be Done to Achieve a Healthy Forest?

Since it is very difficult and expensive to treat forest health issues in a forest – especially insect and disease infestations – prevention strategies are best. Prevention should be practical and cost-effective. Often, professional foresters are well-qualified to assist you in making decisions to promote your forest’s health. Foresters who work with public and private agencies such as consulting firms are often well versed in forest health prevention strategies. Follow the three M’s: Monitor, Modify, and Manage. Prevention steps include:

- **Monitor** your forest for evidence of insect or disease infestations or other forest health issues often. When potential problems are observed, use control techniques to minimize the spread of many insects and diseases and/or salvage affected stems. Monitoring will also help you know when certain silvicultural treatments are needed, like fertilization, prescribed burning, or thinning.
- **Modify** your decisions about reforestation (including species selection), site preparation techniques, seedling grading and handling and proper planting technique to be specific to the soils, history and location of the forest in order to ward off potential insect and disease outbreaks.
- **Manage** your trees to sustain a healthy, vigorous forest. Thin trees to prevent over-stocked and over-mature conditions that can stress forests. Address any health issues quickly to prevent spread to other trees.

UNDERSTAND YOUR FOREST & ITS POTENTIAL HEALTH PROBLEMS:

Understanding forest health requires that you know what natural resources are present and their condition. These resources include trees, soils, vegetation, water resources, and wildlife. Understanding site limitations begins with a thorough knowledge of soils, as it is the best way to determine a forest’s potential growth, productivity and its susceptibility to pests and disease. Some important questions to ask regarding soils are:

- **What are the major soil types of my forests?** What does that mean for tree

growth? Certain soils have better drainage than others, so tree roots won’t be submerged after hard rain events. Some soils have a hard clay layer just below the surface, and this may impact seedling’s ability to grow roots. Sometimes, soils need to be “ripped” prior to planting to break the clay layer so tree roots can grow to deeper depths.

- **What are the conditions of my soils?** Are they eroded or compacted? Growing on these types of soils can stress and weaken trees. Are there deep washed-out-gullies? Roots of nearby trees may be exposed by running water and erosion. Are they wetlands? Submerged roots don’t

have the ability to obtain oxygen. All of these conditions can make trees more susceptible to pests and diseases.

- **Are my timber species well-suited for my soils?** Remember to consider soil limitations and tree condition. Certain types of trees will grow better on certain types of soils. For instance, longleaf pine tends to grow better on deep, sandy soils than loblolly pine.
- **What is the growth potential of trees on my soils?** This is referred to as “site index” (SI) and it is the predicted height of a tree species at a given age, usually 25 or 50 years. The higher the SI for a species, the taller the trees will grow and the

greater the production. Site Index varies among soil types and locations, and it is important to be aware of the capabilities of a site and plant with tree species that have the best chance to grow and perform well.

Help is Available! Soil information is readily available through your county (or "District") Natural Resources Conservation Service (NRCS) office. They can help you identify and interpret your soil information. A service forester with your state forestry agency or a private consulting forester can assist you in understanding the species suitability and growth potential of your soils (contact information is listed in the back page of this publication). Additionally, most soil surveys are available on the NRCS website: <http://www.nrcs.usda.gov/wps/portal/nrcs/soilsurvey/soils/survey/state/>. Once there, select your state, then select your county.

Additional forest resource information can be obtained by having a consulting forester visit your forest. Pertinent forest resource questions include:

- **What are the dominant tree species for each forest stand?**
- **How old are the dominant trees in the forest canopy?**
- **What is the present stand condition?**
For example, are there slow growing species, or crowded trees that will increase the risk of insects or disease?
- **Are there any current disease or insect problems?**
- **Are exotic plants a potential threat?**
If so, what are the recommended control measures?

DEVELOP A FOREST MANAGEMENT PLAN:

Proactive forest management promotes forest health and reduces risks. You will need a management

plan for your forests in order to develop active management steps that will likely be required to return your forest to desirable conditions. A written management plan includes an assessment of the condition of the forest and outlines how to accomplish your management goals for your land. State forestry agency personnel, and consulting and/or registered foresters can develop management plans.

A good management plan contains:

- A statement of your goals and objectives for your forestland.
- A map or aerial photograph showing property and stand boundaries, access points, and important features such as roads, water bodies, and structures.
- A forest description, including soil types, site index, number of acres, tree species, stand age, stocking, average height, tree condition, and health and topographic information. A management plan may also include more specific inventory data such as timber volumes and values.
- A timetable of prescribed forest management activities, including thinning, final harvesting, regeneration plans, wildlife practices, and treatment plan for problems such as insects, disease, or exotic plants.

An excellent source of information regarding forest management is the Forest*A*Syst website: www.forestasyst.org. This site allows you to specify your management objectives, and combine this information with site-specific environmental data to assemble a written forest management plan.

MANAGE FOR GOOD FOREST HEALTH AS A PART OF YOUR PLAN

A proper management plan should address specific practices that promote forest health and reduce risks. One or more of the following practices may be recommended:

- Promote regeneration of desirable species suited to soil type while avoiding overstocking (too many trees per acre).
- Thinning to maintain adequate growing space for trees.
- Employ practices that protect water quality and soil productivity, including harvesting practices.
- Use prescribed fire where feasible to reduce fuel loading and reduce risk from catastrophic wildfire, remove understory competition, and improve habitat for wildlife.
- Remove or cull diseased trees.
- Control exotic plants that hinder desirable plant and wildlife species.

MONITOR FREQUENTLY!

Forests should be inspected annually (or better yet, quarterly) in times of stress to identify forest health problems. An insect pest such as the southern pine beetle can take over quickly. Monitoring during different seasons is more informative than at one time during the year, as it gives you the opportunity to see things that may not be evident year-round. Inspection for specific pests should be done on a schedule that's appropriate to the problem. When scouting for pests, one dead tree may not be cause for concern, but several dead or dying trees may warrant a closer look. Thinning crowns on individual trees throughout the stand may reflect poor site conditions or drought, but a patch of trees with thinning crowns may indicate a pest problem. Inspection for storm damage should be done soon after a storm event. Salvage value diminishes with time and damaged or downed trees can serve as hosts for insect pests.

Landowners can access resources from the Internet to become familiar with insect and disease symptoms. Several such sources are listed on the last page of this publication. For a list of

Table 1. Online resources for forest health potential threats, monitoring schedules, and symptoms.

Southern pine beetle	http://southernforesthealth.net/insects/southern-pine-beetle
	http://entnemdept.ufl.edu/creatures/trees/southern_pine_beetle.htm
	http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_042840.pdf
	http://www2.ca.uky.edu/entomology/entfacts/ef443.asp
Emerald ash borer	http://www.emeraldashborer.info
	http://southernforesthealth.net/insects/emerald-ash-borer
	http://na.fs.fed.us/fhp/eab/
Redbay ambrosia beetle and laurel wilt	http://www.freshfromflorida.com/Divisions-Offices/Plant-Industry/Agriculture-Industry/Pests-Diseases/Laurel-Wilt-Disease
	http://southernforesthealth.net/fungi/laurel-wilt
	http://www.ncforestservice.gov/forest_health/forest_health_laurelwiltfaq.htm
	http://www.forestry.alabama.gov/LaurelWilt.aspx?bv=3
Gypsy moth	http://southernforesthealth.net/insects/gypsy-moth
	http://www.fs.fed.us/ne/morgantown/4557/gmoth/
	http://www.na.fs.fed.us/SPFO/pubs/fidls/gypsymoth/gypsy.htm
	http://www.vdacs.virginia.gov/plant&pest/moth.shtml
Cogongrass	http://southernforesthealth.net/weeds/cogongrass
	http://www.cogongrass.org/
	http://www.invasivespeciesinfo.gov/plants/cogongrass.shtml
	http://www.freshfromflorida.com/Divisions-Offices/Florida-Forest-Service/Our-Forests/Forest-Health/Invasive-Non-Native-Plants/Cogon-Grass
	http://www.nps.gov/plants/alien/fact/imcy1.htm
Chinese privet	http://plants.usda.gov/plantguide/pdf/pg_lisi.pdf
	http://southernforesthealth.net/weeds/chinese-privet
	http://ipm.ifas.ufl.edu/environmental/Chinese_privet.shtml
	http://www.invasiveplantatlas.org/subject.html?sub=3035

some major potential threats to forest health, suggested monitoring schedules, and the symptoms, see Table 1.

TIMBER HARVESTING CAN IMPACT FOREST HEALTH

Poor logging practices can undo years of good management and

reduce the condition and potential of forests. Trees damaged by machinery can attract insects and disease, and logging debris can increase wildfire risks. Since the majority of the forest's root system is in the top 12" of soil, improper use of equipment on fragile soils or logging during wet weather can drastically reduce the growth

potential of future forests due to soil compaction and "rutting." Hire a consulting forester to act as your agent and include provisions in the contract to monitoring logging jobs at least daily during logging activity. For more information on selling your timber, please see the resources page of this publication.

Summary

Forest health begins with the health of a single tree, and the goal should be to strive to maintain or improve forest conditions through responsible management and planning. Forest health is partly dependent on the landowner's management objectives, land history, and current environmental conditions. Past land use, past forest management and harvesting decisions, presence or absence of natural disturbances, and

many other factors have shaped your forest. If your forest is healthy and vigorous, then it will be able to meet your wildlife, recreation, and timber production needs. Many insects and diseases can be prevented or controlled by minimizing damage to tree stems, thinning stands to maintain vigor, and selecting the right species for your soils. In addition, proper timing of your forest management steps also helps prevent and minimize risks. When you are ready to harvest, carefully planned timber harvesting, reforestation and stand management

will help you sustain or restore your forest resources for the future.

A healthy forest is an achievable goal. Obtain professional assistance and manage to prevent and minimize loss. Despite numerous factors that can't be controlled (such as drought, wildfires, and storm damage), a forest landowner can manage their land to reduce their risks from disturbances and maximize their forest health. Our collective efforts can make our forests healthier, more productive and keep them sustainable.

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Figure 3: Charles T. Bryson, USDA Agricultural Research Service, Bugwood.org

Figure 4: USDA Forest Service Southern Research Station, Bugwood.org

Figure 5: Robert L. Anderson, USDA Forest Service, Bugwood.org

Figure 6: R.L. Hamblen, Bugwood.org

Figure 7: Stephen F. Austin State University, Bugwood.org

Figure 8: David Coyle, University of Georgia, Bugwood.org

Figure 9: Georgia Forestry Commission, Bugwood.org

Resource Information

For the location and phone numbers of state agencies in the southeastern U.S. providing forestry assistance and information, see the following websites:

Alabama Forestry Commission: <http://www.forestry.alabama.gov/>

Arkansas Forestry Commission:
<http://forestry.arkansas.gov/Pages/default.aspx>

Florida Forest Service: <http://www.floridaforestservice.com/>

Georgia Forestry Commission: <http://www.gatrees.org/>

Kentucky Division of Forestry:
<http://forestry.ky.gov/Pages/default.aspx>

Louisiana Department of Agriculture and Forestry:
<http://www.ldaf.state.la.us/>

Mississippi Forestry Commission: <http://www.mfc.ms.gov/>

North Carolina Forest Service: <http://www.ncforestservice.gov/>

Oklahoma Forestry Services: <http://www.forestry.ok.gov/>

South Carolina Forestry Commission:
<http://www.state.sc.us/forest/>

Tennessee Division of Forestry:
<https://www.tn.gov/agriculture/section/forests>

Texas A&M Forest Service: <http://texasforestservice.tamu.edu/>

Virginia Department of Forestry: <http://www.dof.virginia.gov/>

For the location and phone numbers of University Extension personnel in the southeastern U.S. providing forestry assistance and information, see the following websites:

Alabama Cooperative Extension System:
<http://www.aces.edu/main/>

University of Arkansas Cooperative Extension Service:
<http://www.uaex.edu/>

University of Florida's Institute of Food and Agricultural Sciences (UF/IFAS):
<http://solutionsforyourlife.ufl.edu/>

University of Georgia Extension: <http://extension.uga.edu/>

Kentucky Cooperative Extension Service:
<https://extension.ca.uky.edu/>

Louisiana Cooperative Extension Service:
<http://www.lsuagcenter.com/>

Mississippi State University Extension Service:
<http://extension.msstate.edu/>

North Carolina Cooperative Extension:
<https://www.ces.ncsu.edu/>

Oklahoma Cooperative Extension Service:
<http://www.oces.okstate.edu/>

Clemson Cooperative Extension (South Carolina):
<http://www.clemson.edu/extension/>

University of Tennessee Extension:
<https://extension.tennessee.edu/>

Texas A&M AgriLife Extension: <http://agrilifeextension.tamu.edu/>

Virginia Cooperative Extension: <http://www.ext.vt.edu/>

To locate a consulting forester:

Association of Consulting Foresters:
<http://www.acf-foresters.org/acfweb>

Click on "Find a Forester", then select your state in the "People Search – Public" search page.

For more information on how to select a consulting forester, go to:

<http://msucare.com/pubs/publications/p2718.pdf>

<http://texashelp.tamu.edu/011-disaster-by-stage/pdfs/recovery/ER-038-Selecting-a-Consulting-Forester.pdf>

<http://www.uaex.edu/environment-nature/forestry/FSA-5019.pdf>

For more information on selling your timber, go to:

<http://www.ncsu.edu/woodlands/woodwise/timber.pdf>

<http://www.gfc.state.ga.us/resources/publications/SellingYourTimber.pdf>

<http://www.mfc.ms.gov/selling-your-timber.php>

https://vttechworks.lib.vt.edu/bitstream/handle/10919/24648/VCE420_160_2004.pdf?sequence=1&isAllowed=y

<http://extension.missouri.edu/p/G5051>

For information on recognition and control of exotic plants, go to:

<http://southernforesthealth.net/weeds>

<http://nps.gov/plants/alien/>

<http://se-eppc.org/>

<http://www.bugwood.org/weeds/forestexotics.html>

<http://www.invasivespeciesinfo.gov/plants/main.shtml>

For specific information regarding forest health issues, including storm damage, pests, and disease, go to:

<http://southernforesthealth.net/>

<http://www.nps.gov/yose/learn/nature/forest-pests.htm>

<http://www.forestpests.org/>

http://ncforestservice.gov/forest_health/forest_insects.htm

<https://www.arborday.org/trees/health/issues.cfm>

<https://www.tn.gov/agriculture/article/ag-forests-storm-damage>