LANDSCAPE MANAGEMENT PLAN

STATE OF TENNESSEE

AMERICAN FOREST FOUNDATION

TN Department of Agriculture | Forestry

CERTIFIED TREE FARM — WOOD, WATER, WILDLIFE, RECREATION

SOUTHERN FORESTRY CONSULTANTS

Landscape Management Plan Creation

Plan Development and Composition

The Tennessee Department of Agriculture Division of Forestry (TDF), in conjunction with Southern Forestry Consultants, Inc. (SFC), developed the original components, outlines, structure, and drafts of the Landscape Management Plan (LMP) and the associated geodatabase. TDF and SFC also worked cooperatively to evaluate and incorporate edits, comments, and modifications that resulted in the final LMP and geodatabase. Publication of this document is provided by the Tennessee Department of Agriculture Division of Forestry through a grant from the U.S. Department of Agriculture Forest Service.

Natural Resource Professional Support Committee

TDF consulted regularly with staff from the American Forest Foundation (AFF) to seek their input on various thematic, structural, and scientific components through multiple drafts of this LMP. Additionally, TDF staff facilitated access to and procurement of publicly available geospatial data during the development of the geodatabase.

Additional Stakeholders

TDF also sought input from a variety of additional stakeholders with expertise in the natural resources, planning, certification, and regulatory disciplines. Like the Support Committee, these additional stakeholders did not necessarily endorse all components of the LMP, nor does TDF imply a consensus was reached. These additional stakeholders included:

- American Forestry Foundation
- Association of Consulting Foresters
- Environmental Systems Research Institute
- Evergreen Packaging
- Forest Stewards Guild
- Hood Container Corporation
- Huber Engineered Woods
- International Paper Company
- Land Trust for Tennessee
- National Association of Conservation Districts
- Oak Woodlands and Forests Fire Consortium
- Open Space Institute
- Packaging Corporation of America
- Quail Forever
- Quality Deer Management Association
- Resolute Forest Products
- Shortleaf Pine Initiative
- Southeastern Grasslands Initiative
- Tennessee Association of Conservation Districts
- Tennessee Department of Environment and Conservation
- Tennessee Farm Bureau
- Tennessee Forestry Association
- Tennessee Forestry Commission
- Tennessee Wildlife Federation
- Tennessee Wildlife Resources Agency
- The Nature Conservancy
- Thompson Appalachian Hardwoods
- Timberland Investment Resources
- University of Tennessee Knoxville Agricultural Extension
- U.S. Fish & Wildlife Service
- USDA Forest Service
  - USDA Forest Service Forest Inventory and Analysis
  - Non-Timber Forest Products
- USDA Natural Resources Conservation Service
- WestRock Company

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1. Introduction

1. INTRODUCTION

A landscape management plan (LMP) is a vital and innovative tool, offering a wide array of benefits and opportunities to landowners, foresters, and other natural resource professionals, state and federal agencies, conservation partners, and others. Specifically, this LMP can:

- Help family landowners overcome one of the biggest barriers to participating in forest certification and landowner assistance programs by eliminating the need for every landowner to develop and maintain an individual management plan.
- Support coordination of action on landscape-scale priorities across ownerships.
- Provide participating landowners with access to the benefits of the Forest Stewardship Program (FSP) and American Tree Farm System (ATFS) certification.
- Establish and strengthen relationships between landowners and their foresters.
- Be used by diverse forestry specialists, including TDF Foresters, consulting foresters, and industrial foresters.
- Be implemented adaptively across an array of conditions, landowner objectives, and ownerships. Although arranged as a single document, the chapters are designed to support each other and to be used flexibly as forest conditions and objectives change.
- Illustrate practical silvicultural systems to manage family woodlands sustainably, achieve landscape conservation goals, and conform to American Forest Foundation (AFF) Standards of Sustainability through a variety of strategies and approaches for forest ecosystems specific to the Tennessee landscapes.
- Utilize the best available science and resources provided at the federal, state, and local levels through a program developed and maintained geospatial database.
- Support the efforts of foresters from across sectors to work with previously unengaged landowners and promote conservation initiatives.
- Optimize grant funding at the local, state, and national level for conservation initiatives on private land.
- Preemptively address threats to at-risk species through habitat protection.
- Provide additional access to certified materials for timber industry partners.

This LMP is designed to complement and align with federal, state, and local laws. Resources in this LMP do not override local forestry regulations that may not be addressed directly in this plan.

Forest management plans have long been a principal component of traditional family woodland owner programs in the United States. Management plans are a requirement for forest certification and landowner assistance programming and, because the individual plans are costly for both landowners and foresters to develop, they are often the biggest barrier to family landowner engagement. In addition, recent research suggests that the development of individual landowner forest management plans has only moderate to minimal impact on family woodland owner behavior. Rather, it is the accompanying engagement with or receiving technical advice from a natural resource management professional that provides the motivation and support landowners need to act. Additionally, individual management plans do not offer a means for inspiring, understanding, and coordinating important conservation strategies across family ownerships. By setting motivating goals at the landscape level, we are creating another call to action that allows us to engage more

landowners. We know that values like forest health are important to landowners and this allows us to set aspirational goals for the landscape that line up with that motivation. The planning process remains critical to sustainable forest management. However, there is a need for a more cost-effective approach that reflects what is known about what will effectively encourage family landowner behavior and support coordinated efforts to address the critical landscape-scale conservation needs and opportunities. Drawing on emerging research, models used in Scandinavia, and techniques used by some American consulting firms, the landscape plan reduces the barrier for family landowners to become involved in conservation activities and streamlines the American Tree Farm System® (ATFS) certification process. This approach maintains the credibility required for ATFS certification while providing landowners with the essential technical support to ensure long-term sustainable management. Finally, it also offers a mechanism for coordinating landscape scale priorities across family owners of varying acreage.

The American Forest Foundation (AFF), in conjunction with numerous natural resource partners, has therefore developed this Landscape Management Plan (LMP) to address landowner and landscape-level objectives within the state of Tennessee. More specifically, this plan incorporates and supports all portions of the following site-specific and landscape level considerations that are applicable to family woodland landowners (in no particular order):

- AFF 2021-2025 Standards of Sustainability for Forest Certification (Standards)
- Forest Stewardship Program National Standards and Guidelines (Standards)
- Tennessee Forest Stewardship Program
- Tennessee Statewide Forest Resources Strategy (Forest Action Plan)
- Tennessee State Wildlife Action Plan
- Natural Resources Conservation Service
- United States Department of Agriculture (USDA) National Woodland Owner Survey (NWOS) Results and Observations (Butler et al 2016)
- Tennessee Division of Forestry Best Management Practices
- National Register of Historic Places and the Tennessee State Library and Archives

This LMP will be revised and updated periodically to reflect changing dynamics with the specific forest resources and on the landscape broadly. Similarly, it is critical to monitor landowners' management to ensure congruence between the plan and continuity across the assemblage of landowners. This could be combined with routine monitoring as required under certification, such as routine inspections.

1.1. Forest Resource Professionals

This LMP relies on the experience, skills, and thoughtful professionalism of foresters and other natural resource managers. The relationships they build with family woodland owners are central to the success of this LMP and to achieving the shared aims of delivering conservation impact.

As the Society of American Foresters (SAF) describes within the preamble to its code of ethics:

"Service to society is the cornerstone of any profession. The profession of forestry serves society by fostering stewardship of the world's forests. Because forests provide valuable resources and perform critical ecological functions, they are vital to the wellbeing of both society and the biosphere."

The role of forest resource professionals includes passing along their experience and expertise regarding the complex relationships among air, water, climate and weather, trees, flora and fauna, ecosystem processes, and anthropocentric considerations. The consultation and advice provided by forest resource professionals is commonly provided to landowners and/or their agents interested in managing their forestland. Landowners can utilize the services of a forest resource professional to manage and monitor vendors and contractors performing silvicultural management activities on the land. Forestry resource professionals also can assist landowners with contracts and the maintenance and retention of appropriate records and documentation relating to forest management activities and certification. Furthermore, landowners can gain advice regarding taxes, estate planning, and relevant laws, regulations, and ordinances under the guidance of a forest resource professional. This LMP was developed as a resource for these professional foresters to assist in landowner engagement, identification and characterization of landowner site specific features and objectives, and the identification and management of local forest types.

Various professional organizations and certification bodies, including state forester registration boards, SAF, and the Association of Consulting Foresters (ACF), provide membership standards and requirements to ensure qualified, responsible, and ethical application of forestry principles. The ATFS also recognizes the importance of these forestry professionals by establishing specific eligibility requirements and recertification standards of all ATFS inspectors.

The Tennessee Technical Service Provider Search Tool (divided into East and West Tennessee) is a listing provided to assist landowners in finding forest management service providers. This database includes forest management consultants, tree seedling nurseries, and other vendors and forest product buyers. Also, landowners may make use of the excellent resources provided by the TDF, such as the Consulting Forester Directory or Master Logger Database.

1.2. Adaptive Management

All silvicultural systems, management activities, and implementation measures provided in this LMP are predicated upon a narrow window of site, weather, time, and market conditions. Changes and variability associated with these conditions can have significant impacts on the timing, feasibility, and success of all silvicultural implementation operations. For example, the decision of when and how to harvest timber could vary tremendously based on recent weather conditions and market conditions. As severe weather events such as wind, ice, and fire can devastate the local timber industry, landowners may need to investigate assistance for recovery efforts in the form of available cost-share programs. The Emergency Forest Restoration Program (EFRP) offered by USDA's Farm Service Agency (FSA) inspects land for eligible damage and provides payments to owners of private forests to restore qualified forests damaged by disasters. In the past, Tennessee FSA has approved EFRP funding for forest management, forest roads, bridges, and culverts. Some entities may offer a timber tax credit for eligible timber owners impacted by natural disasters. Federal tax laws provide for casualty loss and income tax considerations/deductions as a result of natural disasters.

Landowners must also be knowledgeable of procedures e following natural disasters that impact their forests. A timely salvage of the downed timber is essential to maintaining a healthy forest operation, as downed timber attracts harmful forest pests and prevents future reforestation efforts. These forest pests, if attracted by the downed timber, could rapidly spread throughout a pine stand (Gandhi et al., 2019). If the timber stand is moderately (30-50% trees blown over or broken) or heavily (>50%) damaged, it may be necessary for affected

trees to be removed for salvage. Another benefit of the removal of affected timber is the decrease in the risk of wildfires due to the accumulated downed fuel load.

It is important for landowners to know potential disasters and how to manage their land in the event of such a disaster. In Tennessee these include tornadoes, other wind events, earthquakes, and flooding. Additional information concerning forestry cost-share programs can be found in Section 7.1.1 Conservation Incentives. There you can find guidance for evaluating damaged trees, forest health issues, tax issues, steps post-hurricane, and attempting to salvage timber.

Forest landowner objectives could significantly impact the target forest type and the silvicultural implementation methods needed to meet those goals and objectives. Inherently, silvicultural operations have some flexibility on the timing of implementation to more effectively meet the narrow window of conditions to achieve the desired result. Harvesting operations and regeneration efforts could vary significantly when focused on meeting different landowner's objectives like maximizing revenue or conserving rare species. The tolerance to shift operations slightly increases the feasibility of meeting the established goals and objectives. Therefore, this management plan should not be viewed as an unchangeable text, but rather a living document dependent on constant evaluation, refinement, and modification for success.

1.3. 2021-2025 American Tree Farm System Standards of Sustainability within the LMP

The American Tree Farm System's (ATFS) Standards promote the health and sustainability of America's family forests. These standards are a tool to help woodland owners be effective stewards of the land as they adaptively manage renewable resources; promote environmental, economic, and social benefits; and work to increase public understanding of sustainable forestry. The standards are based on international sustainability metrics and North American guidelines for sustainable forest management and serve as the basis for the ATFS certification program. The ATFS certification program is internationally endorsed by the Programme for the Endorsement of Forest Certification (PEFC™). Landowners following these standards are recognized as ambassadors for exemplary woodland stewardship.

Each of the eight standards of sustainability address aspects of sustainable forest management. Moving from general to specific, each standard incorporates performance measures and indicators to illustrate conformance. All components of each standard apply to every property certified under the ATFS Standards.

These standards, performance measures and indicators are presented with links to the specific section of the LMP where they are addressed:

ⓘ In the event an element is discussed in multiple forest types, only the location in the first forest type where the element is discussed is linked below.

STANDARD 1 Commitment to Practicing Sustainable Forestry

Performance Measure 1.1 Landowner shall have and implement a written forest management plan consistent with the size of the forest and the scale and intensity of the forest activities.

- **Indicator 1.1.1** Management plan shall be active, adaptive and embody the landowner's current objectives, remain appropriate for the land certified, and reflect the current state of knowledge about natural resources and sustainable forest management.
- **Indicator 1.1.2 (a)** Management plans shall describe current forest conditions, landowner's current objectives, management activities aimed at achieving landowner's objectives, document a feasible strategy for activity implementation, and include a map accurately depicting significant forest-related resources.
- **Indicator 1.1.2 (b)** The forest management plan shall demonstrate consideration of the following resource elements: forest health, soil, water, wood and fiber production, threatened or endangered species, special sites, invasive species, and forests of recognized importance. Where present and relevant to the property, the plan shall describe management activities related to these resource elements.
- **Indicator 1.1.2 (c)** Where present, relevant to the property and consistent with landowner's objectives, the plan preparer should consider, describe, and evaluate the following resource elements: fire, wetlands, desired species, recreation, forest aesthetics, biomass, and carbon.
- **Indicator 1.1.3** The landowner should monitor for changes that could interfere with the management objectives as stated in the management plan. When problems are found, reasonable actions are taken.

How the LMP covers this section:

- This LMP serves as the written management plan for all participating landowners in the state of Tennessee. This plan provides the necessary flexibility to be active and adaptive to the variety of landowner objectives and related management activities available to the landowners in this state, regardless of the size and scale of their property. As noted in the links included throughout this section, this LMP addresses each of the ATFS Standards.
- A secure database includes all the necessary spatial information to support sustainable forest management in the area. In addition to general information of the region (soils, hydrologic information, the presence or absence of T&E species, etc.), each landowner participating in this program can have specific information related to their tree farm stored on this database by a forester or an ATFS inspector. Maps can be generated from this database by a forester or ATFS inspector, or upon request by the landowner or a third-party assessor.

STANDARD 2 Compliance with Laws

Performance Measure 2.1 Landowner shall comply with all relevant federal, state, county, and municipal laws, regulations, and ordinances governing forest management activities.

- **Indicator 2.1.1** Landowner shall comply with all relevant laws, regulations, and ordinances and will correct conditions that led to adverse regulatory actions, if any.
- **Indicator 2.1.2** Landowner should obtain advice from appropriate qualified natural resource professionals or qualified contractors who are trained in and familiar with relevant laws, regulations, and ordinances.

How the LMP covers this section:

- All landowners certified under this LMP agree to meet all federal, state, and local regulations. Understanding that while mistakes may occur in carrying out forest management activities, landowners must be committed to correcting inadvertent violations. A pattern of willful violation of relevant laws, regulations, or ordinances is not acceptable. If there is evidence of past nonconformance, then the landowner must show proof of a good-faith effort to remedy the nonconformance. If the matter is tied up in court, then the landowner is only disqualified when a final adverse judgment is rendered, and the landowner refuses to comply with the ruling.
- Compliance with all relevant (applicable) laws can be verified by a tiered process:
  - Step 1 – Observation of conditions on the subject property
  - Step 2 – The landowner's verbal or written claim of legal compliance
  - Step 3 – Research with the state Department of Natural Resources, local Natural Resource Conservation Service office or State Forestry Commission offices
  - If Step 1 and Step 2 do not raise any issues, then the qualified ATFS inspector or third-party assessor is not required to employ Step 3.

STANDARD 3 Reforestation and Afforestation

Performance Measure 3.1 Reforestation or afforestation shall be achieved by a suitable process that ensures adequate stocking levels.

- **Indicator 3.1.1** Reforestation or afforestation shall achieve adequate stocking of desired species reflecting the landowner's objectives, within five years after regeneration harvest, or an appropriate time frame for local conditions, or within a time interval as specified by applicable regulation.

How the LMP covers this section:

- Under the silvicultural systems outlined in this LMP, information is provided on the different strategies to achieve success in reforestation and afforestation efforts. The state of Tennessee does not specify a specific required stocking level post-harvest, so landowners operating under this LMP agree to achieve adequate stocking of desired species based on their objectives within five years after harvest. ATFS inspectors will document these efforts within the 021 inspection form to ensure conformance.

STANDARD 4 Air, Water, and Soil Protection

Performance Measure 4.1 Landowner shall meet or exceed practices prescribed by state forestry BMPs that are applicable to the property.

- **Indicator 4.1.1** Landowner shall implement specific state forestry BMPs that are applicable to the property.
- **Indicator 4.1.2** Landowner shall minimize road construction and other disturbances within riparian zones and wetlands.

Performance Measure 4.2 Landowner shall consider a range of forest management activities to control pests, pathogens, and unwanted vegetation.

- **Indicator 4.2.1** Landowner should evaluate alternatives to pesticides for the prevention or control of pests, pathogens, and unwanted vegetation to achieve specific management objectives.
- **Indicator 4.2.2** Pesticides used shall be approved by the Environmental Protection Agency (EPA) and applied, stored, and disposed of in accordance with EPA-approved labels and by persons appropriately trained, licensed, and supervised.

Performance Measure 4.3 When used, prescribed fire shall conform with landowner's objectives and pre-fire planning.

- **Indicator 4.3.1** When used, prescribed fire shall conform with the landowner's objectives and state and local laws and regulations

How the LMP covers this section:

- All landowners certified under this LMP agree to meet or exceed all Tennessee Best Management Practices (BMPs) for Forestry, even those that are voluntary, which are applicable to the property. When planning management activities that will cause any soil disturbance or require chemical application, Tennessee's BMPs for Forestry should be consulted and applicable BMP methods employed. No field evidence of BMP implementation is expected where no management activity has occurred. However, if the property shows evidence of water quality impairment that is not caused by the landowner's or designated representative's actions, the landowner is strongly encouraged to have plans for remediation. Some BMPs, such as those that are guidelines to enhance a desired species, should only apply where relevant to the property. Activities in riparian zones and wetlands shall comply with applicable BMPs. BMP manuals are generally quite detailed on recommended practices for road construction and other disturbances of riparian zones. If there is a point of confusion, the landowner or designated representative is advised to consult with a qualified natural resource professional who is experienced in forest road design and installation. Landowners should specify with qualified contractors that BMPs must be adhered to. In all cases, the primary concern is to avoid contaminating watercourses that are adjacent to the forest activity.

STANDARD 5 Fish, Wildlife, Biodiversity, and Forest Health

Performance Measure 5.1 Forest management activities shall protect habitats and communities occupied by threatened or endangered species as required by law.

- **Indicator 5.1.1** Landowner shall confer with natural resource agencies, natural resource heritage programs, qualified natural resource professionals, or review other sources of information to determine occurrences of threatened or endangered species on the property and their habitat requirements.
- **Indicator 5.1.2** Forest management activities shall incorporate measures to protect threatened or endangered species on the property.

Performance Measure 5.2 Landowner should address the desired species and/or desired forest communities when conducting forest management activities, if consistent with landowner's objectives.

- **Indicator 5.2.1** Landowner should consult available and accessible information on management of the forest for desired species and/or forest communities and integrate it into forest management.

Performance Measure 5.3 Landowner should make practical efforts to promote forest health.

- **Indicator 5.3.1** Landowner should make practical efforts to promote forest health, including prevention, control, or response to disturbances such as wildland fire, invasive species and other pests, pathogens, or unwanted vegetation, to achieve specific management objectives.

Performance Measure 5.4 Where present, forest management activities should maintain or enhance forests of recognized importance (FORI).

- **Indicator 5.4.1** Appropriate to the scale and intensity of the situation, forest management activities should incorporate measures to contribute to the conservation of identified FORI.

How the LMP covers this section:

- The LMP database provides valuable information about the fish, wildlife, biodiversity, and forest health of the program area. The database includes spatial information about where there are known occurrences of threatened and endangered species, the regional soil types, and documented areas of invasive species incursion. Foresters and ATFS inspectors can also use the database to include information specific to a tree farm regarding forest health, such as additional species composition or treatment information.
- Landowners operating under this LMP should walk their property with a qualified natural resource professional to identify occurrences of threatened and endangered species on or near their property. Landowners are also encouraged to work with natural resource professionals to identify possible occurrences of any disease, invasive species or pest outbreak on their property and discuss the range of recommended management techniques to address these issues. This LMP also outlines the variety of native and exotic pest species that landowners may interact with in this region, as well as tactics to address these issues.
- Integrated pest management (IPM) is an excellent approach to controlling, suppressing, or preventing pests and can take many forms. Preventative measures, efforts to improve forest health, or protect the property from injurious organisms are often the most practical and effective approaches. Pesticide applications may be used when other control measures are ineffective or impractical. While landowners and designated representatives are urged to take feasible actions to address pests, pathogens, and unwanted vegetation, third-party assessors are advised that, in some cases, there may be no feasible options for controlling a pest or outbreak due to severity, scale, and timing of onset. When herbicides are used, landowners are required to follow EPA regulations.
- When conducting prescribed burns, landowners operating under this LMP shall follow all regulations and are encouraged to work with qualified professionals. Additional information about burning based on forest type is included in the following sections.
- Landowners are encouraged to maintain records of forestry related activities for at least three years.

STANDARD 6 Forest Aesthetics

Performance Measure 6.1 Landowner should manage the visual impacts of forest management activities consistent with landowner objectives, the size of the forest, the scale and intensity of forest management activities and the location of the property.

- **Indicator 6.1.1** Forest management activities should apply visual quality measures compatible with appropriate silvicultural practices.

How the LMP covers this section:

- Forest aesthetics considerations can be incorporated into management planning with little cost to the landowner. Employing forest aesthetics considerations into the management plan can produce a much more visually appealing experience for owners, their guests, and passers-by. This LMP addresses aesthetic issues relevant to each of the common forest types in the region in their respective sections.

STANDARD 7 Protect Special Sites

Performance Measure 7.1 Forest management activities shall consider and maintain any special sites relevant on the property.

- **Indicator 7.1.1** Landowner shall make a reasonable effort to locate and protect special sites appropriate for the size of the forest and the scale and intensity of forest management activities.

How the LMP covers this section:

- Special sites of biological and geological significance may be identified through consultation related to the identification of FORIs and threatened or endangered species and communities (within Standard 5). In addition to publicly recognized special sites, landowners may designate sites of personal significance to them, such as a spot their grandparents cherished.
- Landowners or designated representatives shall identify special sites on management plan maps and, where appropriate, on the ground. Some landowners may choose not to identify some special sites to protect these sites from vandalism or overuse. Landowners or designated representatives shall make efforts to protect any known special sites, especially during forest management activities. These efforts may include creating a vegetation buffer, fencing the area, or otherwise distinguishing it from surrounding areas. Because special sites are often in the ground, measures may be taken to control erosion and limit soil disturbance. Landowners and designated representatives are advised to review their special sites map and protection plan with qualified natural resource professionals and qualified contractors assisting in forest management activities. After harvests, landowners and designated representatives are encouraged to follow up to ensure adequate protection.

STANDARD 8 Forest Product Harvest and Other Activities

Performance Measure 8.1 Landowner should use qualified natural resource professionals and qualified contractors when contracting for services.

- **Indicator 8.1.1** Landowner should seek qualified natural resource professionals and qualified contractors.
- **Indicator 8.1.2** Landowner should engage qualified contractors who carry appropriate insurance and comply with appropriate federal, state, and local safety and fair labor rules, regulations, and standard practices.
- **Indicator 8.1.3** Landowners should retain appropriate contracts or records for forest product harvests and other management activities to demonstrate conformance to the standards.

Performance Measure 8.2 Landowner or designated representative shall monitor forest product harvests and other management activities to ensure they conform to the landowner's objectives.

- **Indicator 8.2.1** Harvest, utilization, removal, and other management activities shall be conducted in compliance with the landowner's objectives and to maintain the potential of the property to produce forest products and other benefits sustainably.

How the LMP covers this section:

- When conducting forestry activities, landowners must ensure that their actions and those taken on their behalf are in conformance with both the landowner's objectives and the ATFS Standards. To safeguard from liability risks and protect their assets, landowners are encouraged to work with qualified natural resource professionals and contractors and review the Standards before planning management activities. If the landowner's objectives do not specify directives as to harvest, utilization and removals, regional norms and accepted practices are expected.
- Examples of forestry activities requiring review for AFF Standards compliance:
  - Harvest operations including timber and nontimber products
  - Site preparation and reforestation
  - Forest road construction and maintenance
  - Mineral extraction
  - Hunting and fishing
  - Invasive species control
  - Pest management
- Landowners are encouraged to discuss liability issues with their insurance agent and their attorney to gain a perspective on appropriate insurance minimums that they might require of contractors. When agreeing upon the terms of the contract, landowners and designated representatives are encouraged to stipulate that contractors must follow all relevant laws and regulations and should specify that appropriate BMPs must be adhered to. A qualified natural resource professional can help with this process.
- Other contract specifications might include:
  - Protection of special sites or habitats

  - Adherence to labor laws
  - Requirements for adequate insurance
  - Protection of soil and water integrity
  - Residual tree damage
  - Forest road maintenance and restoration
  - Fence and gate protection and/or restoration
  - Litter control
  - Hazardous material spill prevention and clean-up
- Generally, landowners are encouraged to retain contracts or records for management activities for three years.

1.4. Forest Stewardship Program Standards within the LMP

The federal Forest Stewardship Program (FSP) and Tennessee's Forest Stewardship Program encourage long-term stewardship of important state and private forest landscapes by assisting landowners to more actively manage their forest and related resources. The FSP aids owners of forestland and other lands where good stewardship, including agroforestry applications, will enhance and sustain the long-term productivity of multiple forest resources and produce healthy, resilient forest landscapes. Special attention is given to landowners in landscape areas identified by State Forest Action Plans and those new to, or in the early stages of, managing their land for multi-resource stewardship principles. The program provides landowners with professional planning and technical assistance to keep their land productive and healthy. Assistance offered through the FSP also provides landowners with enhanced access to other USDA conservation programs, forest certification programs, and forest product and ecosystem service markets. Participation in the FSP is open to any non-industrial private forest landowners who are committed to active management and stewardship of their forested properties for at least ten years. The FSP is not a cost-share program. Cost-share assistance for plan implementation may be available through other programs.

The FSP Standards were addressed and evaluated during the completion of this LMP. More specifically, to provide an LMP that is multi-resource in scope and adequately comprehensive with respect to forest ecosystem management, the following plan element discussions are linked:

ⓘ In the event an element is discussed in multiple forest types, only the location in the first forest type where the element is discussed is linked below.

- Soil and water
- Biological diversity
- Range
- Agroforestry
- Aesthetic quality and desired timber species
- Recreation
- Wood and fiber production
- Fish and wildlife
- Threatened and endangered species
- Forest health and invasive species

- Conservation-based estate planning and legacy planning information
- Archeological, cultural, and historic sites
- Wetlands
- Fire
- Carbon sequestration and climate resilience
- Forests of Recognized Importance (FORI)

1.5. A Forester's Field Guide for Using the Landscape Management Plan with Landowners

This guide is designed as a resource for foresters in using the landscape management plan to effectively aid landowners, while streamlining administrative and related elements of landowner engagement.

The landscape management plan is designed as a tool that foresters and other natural resource professionals may use to support landowners in their on-the-ground engagement. It allows for economical access to programs that provide recognition of their stewardship and technical assistance and resources. While coordination with a landowner will likely be conversational, this field guide provides forest resource professionals a more structured approach to ensure all components of the LMP are addressed to meet certification standards. For instance, in some scenarios the initial meeting may occur on the phone, in the office, or on another landowner's property. It is important to capture pertinent information about the property in question, its history, size, and location, and the general goals and objectives of the landowner. The information you obtain during this initial conversation will help you prepare for your meeting on the landowner's property.

Step ❶ Preparing to Meet the Landowner

- Use the current LMP geodatabase to locate and characterize the landowner's property
  - Develop location and soils maps which may also be used to aid determination of applicable forest types.
  - Identify additional property characteristics (e.g., special sites, listed species potential, invasive concerns).
  - Determine current forest type(s) and acreage, which may be verified during onsite consultation.
- Review typical landowner and landscape objectives for the existing forest types anticipated on the property.

Step ❷ Meeting the Landowner

- Identifying Objectives
  - Discuss the objectives of the landowner during the initial conversation and/or during onsite follow-up.
  - Probe each objective to ensure you understand the underlying motivations and goals for the property. The landowner may have multiple objectives or difficulty articulating objectives as they are described in the LMP. A clear understanding of the landowner's objectives streamlines the process to meet those objectives.

- Review and suggest other objectives and how they may also meet the landowner's underlying goals.
  - Determine if any correlations or commonalities exist with the landowner's objectives to support wider conservation goals. The landowner may be unaware of specific landscape objectives, leading to a re-evaluation of landowner objectives. Some landowners may not be interested in or have objectives that share commonalities with landscape objectives. In either scenario, landowners are not required to commit to any landscape objectives or requirements.
  - Based on the review of the landowner and potential landscape objectives, and the analysis of current site conditions, determine target forest type(s) and the forest resources available to the landowner. Target forest type(s) could be different or the same as the current forest type on the property.
  - Based upon landowner objectives, potential landscape objectives, target forest type(s), and the geodatabase review, identify an actionable strategy using the silvicultural systems identified in the LMP (by forest type) to meet the objectives.
  - Provide advice, contacts, and technical support to the landowner for the implementation of the identified silvicultural systems. Encourage the landowner to document and retain records of the activities occurring on the property.

Step 3 After the Visit

- Contact the landowner to provide answers to any questions you were unable to answer during the visit and to prompt for additional questions. Provide support and encouragement to implement the activities identified during the meeting. This follow-up is recommended for one week to one month following the meeting.
- Complete and process any paperwork or certification submittals required.
- Using a landscape management plan makes follow-up support to landowners even more important. The LMP method depends on the relationship and engagement of the landowner and forest resource professional to meet the criteria for certification. This LMP allows landowners the flexibility to adaptively manage the property based on the results of silvicultural operations, gaining additional information (e.g. listed species), changing ecological or market conditions, and especially changing landowner and landscape objectives. Therefore, following up with the landowner not only promotes their engagement in active management but also allows them to modify their strategies to meet these other dynamic conditions.
- Make a note in the relevant system of when follow-up should occur.
- Contact the landowner within an acceptable time frame to schedule a visit, assess activities implemented, determine if any changes have occurred to objectives, and if personal circumstances or the property have changed. Depending on the forest type and the silvicultural systems selected, a longer period between contact with the landowner may be appropriate. Optimistically, the landowner should be contacted annually to promote and foster their engagement in the active management of their property. This type of follow-up is strongly encouraged.
- Provide additional advice and technical support to the landowner as needed.

This guide also can be utilized for landowners with an existing or outdated plan. The same process should be followed when replacing the existing or outdated plan, although much of the information needed for the initial step (1) may have already been completed. Additionally, the existing plan can be used during a review of the

landowner's objectives, forest types and resources, and implementation activities. The additional information found in this LMP, and the geodatabase will then be used to supplement and replace the existing plan.

1.6. A Landowner's Field Guide for Using the Landscape Management Plan

This guide is designed as a resource for landowners in using the landscape management plan to effectively interact with foresters, while streamlining administrative and related elements of engagement.

The landscape management plan is designed as a tool that foresters and other natural resource professionals may use to support landowners in their on-the-ground engagement that allows for economical access to programs that provide recognition of their stewardship and technical assistance and resources. While a landowner's interaction with a forester will likely be conversational, this field guide provides landowners additional knowledge of the process and a more structured approach to ensure all components of the LMP are addressed to meet certification standards. For instance, in some scenarios the initial meeting may occur on the phone, in the office, or on another landowner's property. The information you obtain during this initial conversation will help you prepare for the meeting with the forester on your property.

Step ❶ Preparing to Meet the Forester

- Use the current LMP geodatabase (if accessible) to locate and characterize the natural features present on your property or have these features in mind.
  - Identify additional property characteristics (e.g., special sites, listed species potential, invasive concerns) that may need to be discussed with the forester.
  - Determine current forest type(s) and acreage.
- Review Typical Landowner and Landscape Objectives for the existing forest types anticipated on your property.

Step ❷ Meeting the Forester

- Identifying Objectives
  - Discuss the objectives you have for the future management of your property during initial conversation and/or during onsite follow-up.
  - Develop a method to communicate your objectives clearly to the forester. You may have multiple objectives or may need to phrase the objectives as they are described in the LMP.
- Review and discuss potential landscape objectives with the forester (if applicable) to determine if any correlations or commonalities exist with the objectives to support wider conservation goals. The forester may suggest possible landscape objectives that would be applicable to your specific situation or the properties or location of your land.
- Based on the review of your personal and potential landscape objectives, and the analysis of current site conditions, work with the forester to determine a target forest type(s) and the forest resources needed and available for this/these specific objective(s). Target Forest type(s) could be different or the same as the current forest type on the property.

- Based upon the objectives that you have for your land, potential landscape objectives, target forest type(s), and the geodatabase review may be applicable. Landowners should work with the forester to identify an actionable strategy using the silvicultural systems identified in the LMP (by forest type) to meet the objectives.

Step 3 After the Visit

- Contact the forester with any questions that may have been unanswered during the visit or that may have arisen since your last communication. This follow-up is encouraged to occur one week to one month following the meeting.
- The LMP method depends on the relationship and engagement of the landowner and forest resource professional to meet the criteria for certification. This LMP allows landowners the flexibility to adaptively manage the property based on the results of silvicultural operations, gaining additional information (e.g., listed species), changing ecological or market conditions, and especially changing landowner and landscape objectives. Therefore, following up with the forester not only promotes engagement in active management but also allows modification of management strategies to meet these other dynamic conditions.
- Expect the forester to be in contact within one year to schedule a follow-up visit, assess any activities implemented, determine if any changes have occurred to objectives, and determine if personal circumstances or the property have changed. This type of follow-up is highly value to ensuring completion of any land management goals. Ask any additional questions and bring up any new concerns as needed. Depending on the forest type and the silvicultural systems selected, a longer period between contact with the forester may be appropriate. This level of contact should occur at least annually to encourage active, thoughtful management of the property.

This guide also can be utilized for landowners with an existing or outdated plan. The same process should be followed when replacing the existing or outdated plan, although much of the information needed for the initial step (1) may have already been completed. Additionally, the existing plan can be used during a review of the landowner's objectives, forest types and resources, and implementation activities. The additional information found in this LMP, and the geodatabase will then be used to supplement and replace the existing plan.

2. Ecoregions (Level lll)

2. ECOREGIONS (LEVEL III) AND ASSOCIATED FOREST TYPES

The Environmental Protection Agency (EPA) has developed ecoregions to group the continental United States into areas where the type and quality of environmental resources, including biotic and abiotic factors, are generally similar. These resources can include patterns and similarities between geology, soils, vegetation, climate, hydrology, wildlife, and other comparative categories. This division of resources is generated from the research of Omernik (1987) as well as mapping created from collaboration among EPA regional offices, other federal agencies, and state agencies.

Ecoregions are classified into a 4-level Roman numeral scheme, with Level I being the broadest ecoregion category with 12 ecoregion divisions, and Level IV being the most specific with 967 ecoregion divisions nationwide. For this LMP, the 105 ecoregions contained in the Level III classification were deemed to be specific enough to address the management requirements across the state.

Tennessee contains 8 Level III and 25 Level IV ecoregions within its borders (Figure 1). From east to west, these Level III ecoregions and their associated Level IV ecoregions are: Blue Ridge Mountains (Southern Igneous Ridges and Mountains, Southern Sedimentary Ridges, Limestone Valleys and Coves, Southern Metasedimentary Mountains), Ridge and Valley (Southern Limestone/Dolomite Valleys and Low Rolling Hills, Southern Shale Valleys, Southern Sandstone Ridges, Southern Dissected Ridges and Knobs), Central Appalachians (Cumberland Mountains), Southwestern Appalachians (Cumberland Plateau, Sequatchie Valley, Plateau Escarpment), Interior Plateau (Western Pennyroyal Karst, Western Highland Rim, Eastern Highland Rim, Outer Nashville Basin, Inner Nashville Basin), Southeastern Plains (Blackland Prairie, Flatwoods/Alluvial Prairie Margins, Southeastern Plains and Hills, Fall Line Hills, Transition Hills), Mississippi Valley Loess Plains (Bluff Hills, Loess Plains), and Mississippi Alluvial Plain (Northern Mississippi Alluvial Plain). Although certain Level IV ecoregions may exhibit an important distinction in ecology of Tennessee, the Level IV ecoregions were too specific for a LMP designed to focus on landscape-level functions and difference. Therefore, the Level III ecoregions were selected as the focus of the LMP. For additional information on the ecoregions of Tennessee and their associated waterways, landforms, and land uses, consult the Tennessee State Forest Action Plan.

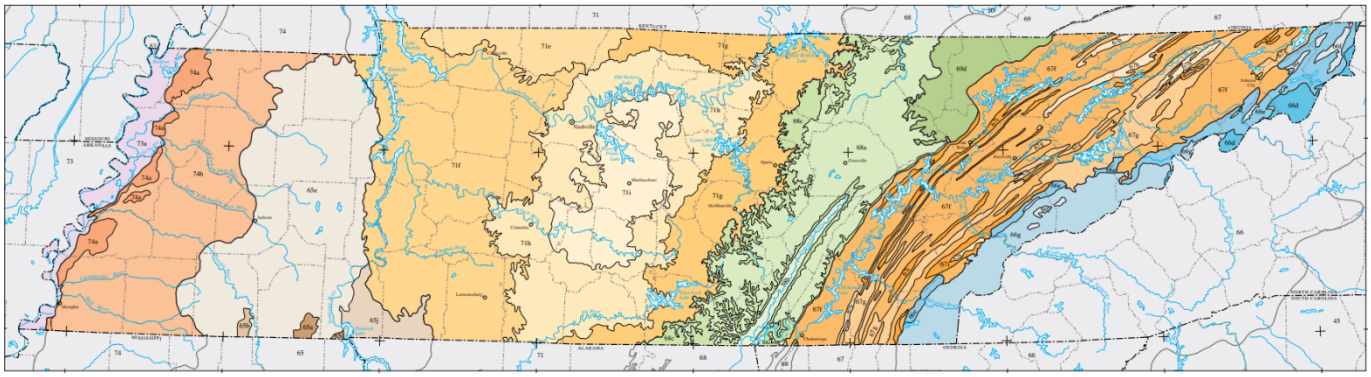


Figure 1. The 8 Level-III Ecoregions of Tennessee

Tennessee is composed of varying levels of plains, mountains, and valleys. In general, the eastern portion of the state consists mainly of mountainous terrain that begins to transition to a plateau and eventually low-lying

plains as you move west. A brief description of characteristics for each Level III ecoregion follows. Geospatial analysis of the geodatabase layers listed in Section 2 provide insight into features that are present within a landowner's parcel. The boundaries of each ecoregion can be displayed with all natural and environmental features shown overlaid in order to give the landowner information about their land as well as the surrounding ecoregion. This information will alert the landowner to any potential listed species or sensitive forest features present in or around their property.

Ecoregions are an important and distinct division of the landscape that take into consideration geographical landforms, natural features (soils, vegetation, etc.), species populations, climate, and other environmental factors. It is important for landowners to realize the properties of the ecoregion in which they are located, as these features will be more or less applicable to certain landscape and/or landowner objectives and may drive the consideration of how to manage one's property.

While landowner objectives are somewhat standard across the different ecoregions, and landowners may have similar goals independent of their location, some landscape objectives vary more greatly depending on the ecoregion. For example, if the landscape objective identified by the landowner is to support healthy forest products, the ecoregion will influence the types of forest products to develop. While pine forest products and the mills that process them are more prevalent in the SP and MVLP ecoregions, the BR ecoregion specializes in hardwood chips and other hardwood products. The location of the land will assist in determining the most reasonable goals for the forestland.

If a goal is to protect wildlife populations and species, those objectives will differ by ecoregion. As seen in Table 1, species have a certain niche and preferred environment. For instance, a landowner interested in preserving and enhancing habitat for the Carolina northern flying squirrel (*Glaucomys sabrinus coloratus*) should have land located in the BR or R&V where the landscape provides the proper high-elevation forest needed for this species to exist. Trying to provide habitat for this species within the MVLP would provide no benefit as it is out of their range. In addition to a landowner's independent efforts to protect species and their related habitats, conservation initiatives have a geographic range for application.

The landscape objective of ecological restoration also varies by ecoregion. The shortleaf pine community is a good restoration example. Many landowners in the BR, R&V, and CA ecoregions own mountainous land that was historically populated by native shortleaf pine communities. Since shortleaf pine also can meet aesthetic, recreation, legacy planning, and revenue objectives, many landowners are interested in its restoration. Landowners in the MVLP or MAP ecoregions, however, would not have this option due to the unsuitable habitat outside of shortleaf range. Other restoration opportunities may be available in these ecoregions.

2.1. Blue Ridge

The Blue Ridge (BR) ecoregion is unique in many aspects. It is part of the Blue Ridge Mountain chain that intersects the extreme eastern side of Tennessee and includes parts of Blount, Carter, Cocke, Greene, Jefferson, Johnson, McMinn, Monroe, Polk, Sevier, Sullivan, Unicoi, and Washington Counties. While being one of the smaller ecoregions within the state, the BR is home to many different species unique to this area. In fact, the southern Blue Ridge is one of the richest regions for biodiversity within the eastern United States. See Table 1 for the federally listed species present within the Blue Ridge ecoregion. Species ranges were taken from U.S. Fish and Wildlife Service (USFWS) data and analyzed geographically through map graphics within ArcPro.

Information regarding the forest types inhabited by these species can be found in Section 5.1.4 Wildlife Management and Protection and Biodiversity. Most of this ecoregion has mostly forested slopes; cool, clear streams; and topographically rugged terrain. The BR substrate includes a wide range of metamorphic, acid rocks with occasional inclusions of mafic and ultramafic rocks.

Within the ecoregion, tree species range from oak forests and northern hardwoods to spruce-fir forests and hemlock, with the topographic relief of the ecoregion providing habitat for many species found nowhere else within the southeastern U.S. The BR ecoregion is primarily recognized for its diversity in hardwood varieties. Upland hardwood forest types are dominant with mesic hardwood forest (including cove forest), oak/hickory mixed, and pine/hardwood mixed being the most prevalent. These habitats occur in association with hardwood slope forests and other topographic features, and include beech gap forests, mountain cove forests, and Appalachian oak forests. Pine is found to a lesser extent, although some instances of loblolly pine/hardwood and shortleaf pine/hardwood forest types can be found. Habitats at lower elevations within the BR are similar ecologically to the adjacent Ridge and Valley ecoregion.

2.2. Ridge and Valley

The Ridge and Valley (R&V) ecoregion, also known as the Great Valley in Tennessee, is a relatively low landscape stretching from southern New York down to central Alabama between the Blue Ridge Mountains and the Central/Southwestern Appalachians. The R&V largely represents a landscape transition from the gradual inclines of the surrounding landscapes. In Tennessee, the R&V includes parts of Anderson, Blount, Bradley, Campbell, Carter, Claiborne, Cocke, Grainger, Greene, Hamblen, Hamilton, Hancock, Hawkins, Jefferson, Knox, Loudon, Marion, McMinn, Meigs, Monroe, Morgan, Polk, Rhea, Roane, Sevier, Sullivan, Unicoi, Union, and Washington Counties. There are roughly parallel ridges and valleys within this ecoregion that vary in widths, heights, and geologic composition. The presence of limestone in the R&V has led to the creation of numerous springs and caves. Due to this abundance of aquatic features, the R&V is known for is aquatic diversity and supports multiple rare fish species. Land cover is mixed within this ecoregion, as forests comprise approximately half of the total area and other landscapes (coves, valleys, etc.) are prevalent as well. See Table 1 for the federally listed species present within the Ridge and Valley ecoregion.

The R&V is characterized mainly by its abundance of upland habitat due to its topography. Species composition is very similar to the Southern Appalachians with a greater abundance of bottomland hardwood habitats due to riverine presence (i.e., Tennessee River). Wetland environments within this ecoregion are generally limited to the bottom of slopes and stream beds. Historic species commonly found in these stream bank habitats include beech (*Fagus grandifolia*), yellow-poplar (*Liriodendron tulipifera*), and sugar maple (*Acer saccharum*)/red maple (*Acer rubrum*), while slopes contain white oak (*Quercus alba*), chestnut oak (*Quercus montana*), and various hickory species (*Carya spp*.). The summits and plateaus of the R&V are dominated by oak/hickory and mixed oak (*Quercus*)/pine (*Pinus*), with shortleaf pine (*Pinus echinata*) the dominant pine species. Bottomland forest types are limited to mostly major rivers within the region and can contain tree species more typical of a coastal plain. Overall forest types of Tennessee present in the R&V are dominated by mesic hardwood forest (including cove forest), oak/hickory mixed, and pine/hardwood mixed.

2.3. Central Appalachians

The Central Appalachians (CA) ecoregion is a high, rugged, mountainous landscape that stretches northeast-southwest from northeastern Tennessee to central Pennsylvania. The CA largely represents a peak-elevation landscape that is higher in elevation and more mountainous than the surrounding R&V to the east and SA to the west. In Tennessee, the CA is includes parts of Anderson, Campbell, Claiborne, Morgan, Roane, and Scott Counties. A mixed mesophytic forest dominates the lower mountain and high hill areas, whereas tops of mountains consist of a more specialized, higher-elevation forest complete with conifers. Agriculture is rare in this ecoregion due to the topographic relief. The level IV portion of the CA that exists in Tennessee—the Cumberland Mountains—is mostly forested. Soils in this ecoregion are generally well-drained, acidic, and underlain by limestone bedrock, providing little value for crops. See Table 1 for the federally listed species present within the Central Appalachians ecoregion.

The CA is characterized by its abundance of upland habitat. Wetlands within this ecoregion are generally limited to the bottom of slopes and stream beds. Historic species commonly found in stream bank habitats include beech (*Fagus* spp.), yellow-poplar (*Liriodendron tulipifera*), and sugar maple (*Acer saccharum*)/red maple (*Acer rubrum*), while slopes contain white oak (*Quercus alba*), chestnut oak (*Quercus montana*), and various hickory species (*Carya* spp.). The summits and plateaus of the CA are dominated by oak/hickory and mixed oak/pine, with shortleaf pine (*Pinus echinata*) as the dominant pine species. Due to the mostly upland habitat within the CA, the bottomland forest types are not as present within this ecoregion. However, bottomland forest habitat may be found along the major rivers of the region. Many forest compositions are found throughout the CA, with mesic hardwood forest (including cove forest), oak/hickory mixed, and pine/hardwood mixed being the most prevalent.

2.4. Southwestern Appalachians

The Southwestern Appalachians (SA) ecoregion is a low mountainous landscape that stretches northeast-southwest from Kentucky to Alabama with the majority of this ecoregion in the center of Tennessee. The SA largely represents a landscape transition from the gradual inclines of the Interior Plateau in Kentucky and Tennessee bordering the western portion of the SA to the more mountainous Ridge and Valley and Central Appalachians ecoregions present along the eastern and northern borders. In Tennessee, the SA includes parts of Bledsoe, Coffee, Cumberland, Fentress, Franklin, Grundy, Hamilton, Lincoln, Marion, Morgan, Overton, Pickett, Putnam, Rhea, Roane, Scott, Sequatchie, Van Buren, Warren, and White Counties. Most of the ecoregion is low elevation mountains with a mixture of rolling hills. The portions of the SA that exist in Tennessee—the Plateau Escarpment, Cumberland Plateau, and Sequatchie Valley—are mostly forested. Soils in this ecoregion are generally well-drained, acidic, and underlain by limestone bedrock, providing little value for crops. The predominant land cover of the SA is mostly hardwood forests, with mixed forested wetlands dominating deeper ravines and slopes and mixed oak-shortleaf pine stands present on summits or plateaus. See Table 1 for the federally listed species present within the Southwestern Appalachians ecoregion.

The SA is characterized by its abundance of upland habitat Wetland environments within this ecoregion are generally limited to the bottom of slopes and stream beds. Historic species commonly found in these stream bank habitats include beech (*Fagus* spp.), yellow-poplar (*Liriodendron tulipifera*), and sugar maple (*Acer saccharum*)/red maple (*Acer rubrum*), while slopes contain white oak (*Quercus alba*), chestnut oak (*Quercus montana*), and various hickory species (*Carya* spp.). The summits and plateaus of the SA are dominated by oak

and mixed oak/pine, with shortleaf pine (*Pinus echinata*) as the dominant pine species. Bottomland forest habitat may be found along the major rivers of the region. Multiple different forest types are found within the SA, with mesic hardwood forest (including cove forest), oak/hickory mixed, and pine/hardwood mixed being the most prevalent.

2.5. Interior Plateau

The Interior Plateau (IP) ecoregion is topographical transition between the Southwestern Appalachians and Southeastern Plains. This ecoregion consists of some irregular hills to the east that become a flatter plain region on the western border with broad interstream regions. is the IP includes parts of Bedford, Benton, Cannon, Cheatham, Clay, Coffee, Davidson, Decatur, DeKalb, Dickson, Fentress, Franklin, Giles, Grundy, Hardin, Henry, Hickman, Houston, Humphreys, Jackson, Lawrence, Lewis, Lincoln, Macon, Marshall, Maury, Montgomery, Moore, Overton, Perry, Pickett, Putnam, Robertson, Rutherford, Smith, Stewart, Sumner, Trousdale, Van Buren, Warren, Wayne, White, Williamson, and Wilson Counties. The ecoregion is a mixture of open hills, irregular plains, and tablelands where it exists in Tennessee. Streams in the IP are extremely varied depending on the topography and relief, giving the ecoregion the most diverse fish fauna in Tennessee. In flatter portions of the IP, land use is a mixture of natural forest, pine plantations, pasture, and cropland. See Table 1 for the federally listed species present within the Interior Plateau ecoregion.

The IP is characterized mainly by gradual transition from mountains to plains, which provides a great variety of upland and wetland habitat. Wetland environments within this ecoregion are generally limited to the bottom of slopes and stream beds in the eastern portion, while broader river basins can be found as the IP moves west. Historic species commonly found in these stream bank/bottomland hardwood habitats include beech (*Fagus* spp.), yellow-poplar (*Liriodendron tulipifera*), and sugar maple (*Acer saccharum*)/red maple (*Acer rubrum*), while eastern slopes contain white oak (*Quercus alba*), chestnut oak (*Quercus montana*), and various hickory species (*Carya* spp.). The summits and plateaus of the IP are dominated by oak/hickory mixed and pine/hardwood mixed, with shortleaf pine (*Pinus echinata*) as the dominant pine species. An additional species association is found in limestone rich areas within the IP, where cedars (*Juniperus* spp.) can be found in glade habitats and cedar/hardwood mixed forests with hardwood species that tolerate the basic environment. Also, more so than the mountainous environments to the east, the central portion of Tennessee has notable areas of mixed pine species and single species dominated pine stand forests.

2.6. Southeastern Plains

The Southeastern Plains (SP) ecoregion exists between the Interior Plateau and the Mississippi Valley Loess Plains and consists of some irregular plains with broad interstream regions. In Tennessee, the SP includes parts of Benton, Carroll, Chester, Decatur, Fayette, Gibson, Hardeman, Hardin, Haywood, Henderson, Henry, Madison, McNairy, Wayne, and Weakley Counties. The SP contains greater elevations and relief than the Mississippi Valley Loess Plains to the immediate west, but less than the hilly Interior Plateau ecoregion to the east. A certain Level IV ecoregion of the SP, the Transition Hills north of the Alabama/Mississippi border, contain characteristics of both the Interior Plateau and the SP Level III ecoregions. Streams are generally low-gradient and consist of sandy substrate. Historically, the land cover within this portion of the SP was dominated by forest, although transitions over time have yielded a mixture of forest, pasture, cropland, and isolated areas of urban development. See Table 1 for the federally listed species present within the Southeastern Plains ecoregion.

2.7. Mississippi Valley Loess Plains

The Mississippi Valley Loess Plains (MVLP) ecoregion borders the Mississippi Alluvial Plain to the west and Southeastern Plains to the east. This ecoregion consists of some irregular plains, rolling hills, and bluffs. In Tennessee, the MVLP includes parts of Crockett, Dyer, Fayette, Gibson, Hardeman, Haywood, Lauderdale, Madison, Obion, Shelby, Tipton, and Weakley Counties. The ecoregion is a mixture of natural forest, pine plantations, pasture, and cropland, with agriculture serving as the dominant land use in Tennessee. The western portion contains the Bluff Hills Level IV ecoregion with its deep, silty, and erosive soils, while the eastern portion has soils with a smoother substrate. Cropland dominates the eastern section, while the western section is southern mesophytic forest composed mainly of hardwoods (beech, southern magnolia, and American holly). See Table 1 for the federally listed species present within the Mississippi Valley Loess Plains ecoregion.

The MVLP supports a wide range of different forest types and natural communities. While the eastern portion has been largely converted to pasture and cropland, oak/hickory mixed and bottomland hardwood forest types are still present. The flat topography and fertile soils of the region make good habitat for both upland and bottomland forest types, with the bottomland forests occurring mainly in riparian areas. Some varying pine forest types are found in the eastern portion of the MVLP. The varying topography of the western Bluff Hills Level IV ecoregion supports a wide variety of microenvironments due to the changes in height. Oak/hickory mixed is still the dominant forest type, although mesophytic forests and isolated tupelo-cypress mixed forests are also present.

2.8. Mississippi Alluvial Plain

The Mississippi Alluvial Plain (MAP) ecoregion is a large landscape that borders the entire Mississippi River, where it drains all or part of 31 states and 2 Canadian provinces. In Tennessee, the MAP includes parts of Dyer, Lake, Lauderdale, Shelby, and Tipton Counties. The majority of the ecoregion is floodplain, with river terraces, swales, and levees providing topographic relief. Soils are generally fine-textured and poorly drained. This ecoregion was historically covered by bottomland forest before a majority was cleared to convert to cropland through levees that restrict the natural flow of the Mississippi River. Areas between the levees are a unique bottomland hardwood habitat known as battures and contain flood-tolerant hardwood species. See Table 1 for the federally listed species present within the Mississippi Alluvial Plain ecoregion.

The MAP is characterized mainly by its abundance of bottomland hardwood forest types as well as its subtype tupelo-cypress. Due to the flood-generated silty soils and frequent flooding regime, the different pine-dominated and upland forest types are not present to a notable degree.

3. Hydrologic Categories

3. HYDROLOGIC CATEGORIES

The United States Geological Survey (USGS) developed the hierarchical system of Hydrologic Unit Codes (HUCs) to categorize and group waterbodies and watersheds of the U.S. There are 4 main levels of HUCs within the United States, ranging from the broad 2-digit regions to the 8-digit cataloging units, more commonly known as sub-basins. Sub-basins can then be further subdivided into 10-digit watersheds and 12-digit sub-watersheds. For the purpose of this LMP, the 4-digit subregions were deemed appropriate to address the management requirements and landscape differences across the state.

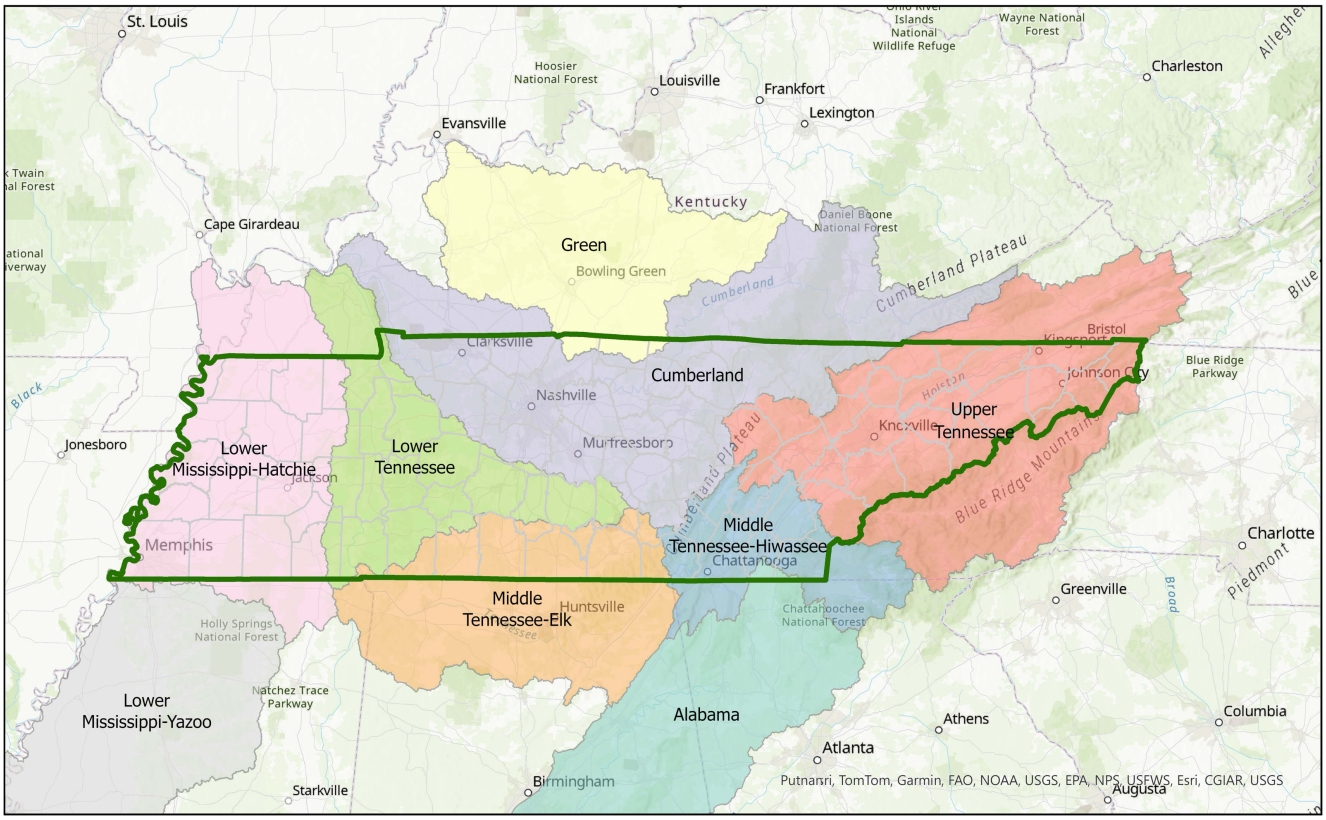
Tennessee contains all or part of 9 identified 4-digit subregions: 0315-Alabama, 0511-Green, 0513-Cumberland, 0601-Upper Tennessee, 0602-Middle Tennessee-Hiwassee, 0603-Middle Tennessee-Elk, 0604-Lower Tennessee, 0801-Lower Mississippi-Hatchie, and 0803-Lower Mississippi-Yazoo. Within these subregions, Tennessee has 59 distinct 8-digit watersheds. These 8-digit HUCs, as mentioned above, represent too specific an area for a Landscape Management Plan due to the lack of large-scale landscape differences between these divisions. These 8-digit HUCs can be viewed through the geodatabase tool (see Section 9). Also, geospatial analysis of the geodatabase layers listed previously in Section 2 will provide insight into features that may be present within a landowner's parcel. The boundaries of each HUC, 2-to-16-digit, can be displayed with all natural and environmental features shown overlaid to give the landowner information about their land as well as the surrounding watershed.

Within the different watersheds of Tennessee, multiple watershed initiatives exist. These initiatives are largely focused on providing technical assistance to landowners to increase awareness about the connection between healthy forests and a healthy water supply as well as assisting foresters and landowners to implement sustainable and safe forest management practices. A significant initiative in Tennessee is the Tennessee Healthy Watershed Initiative (THWI). This initiative is a collaboration among federal, state, and nonprofit organizations (i.e., Tennessee Department of Environment and Conservation (TDEC), Tennessee Valley Authority (TVA), The Nature Conservancy, and West Tennessee River Basin Authority) that work together to maintain and improve Tennessee's watersheds. Since the THWI's establishment in 2011, numerous projects have resulted, including the establishment of an education and demonstration center at the James E. Ward Agricultural Center in Lebanon. This center focuses on implementing innovative "green" infrastructure BMPs to improve water quality. Another project restored a channeled stream to its original form of a meandering stream with associated bottomland hardwood habitat in Jackson. Other projects within the initiative are upcoming and should be investigated by interested landowners.

The National Water Quality Initiative (NWQI) is a NRCS initiative applicable to forestlands throughout the U.S. The NWQI offers financial and technical assistance to forest landowners who are interested in improving water quality as well as aquatic habitats if their land falls within priority watersheds with impaired streams. A focus of the program is to provide conservation measures to landowners that will effectively control and trap nutrient and manure runoff, thereby decreasing nutrient loads to already-impaired stream habitats. In Tennessee, the priority watersheds are in two watersheds (Nolichucky River and Caney Fork River) covering parts of seven counties (DeKalb, Greene, Putnam, Smith, Washington, White, and Wilson), and include the Muddy Fork, Big Limestone Creek, Falling Water River Middle, Falling Water River Upper, Center Hill Lake, Hickman Creek, and

Calfkiller River Middle 12-digit HUCs. These watersheds encompass areas in both northeast and central Tennessee and are mostly forested, with agricultural land comprising anywhere from 10% to 60% depending on the 12-digit HUC. Enrolling in this program provides financial assistance while also improving water quality within the state.

Figure 2. 4-digit Hydrological Units for Tennessee



Disclaimer: This map is not intended as legal representation of property boundaries and is provided for informational purposes only.

TN Department of Agriculture | Forestry

Map by: P.M.M. - 1/31/2024

HUC 04 TN

- 0315,Alabama
- 0511,Green
- 0513,Cumberland
- 0601,Upper Tennessee
- 0602,Middle Tennessee-Hiwassee
- 0603,Middle Tennessee-Elk
- 0604,Lower Tennessee
- 0801,Lower Mississippi-Hatchie
- 0803,Lower Mississippi-Yazoo

0 50 100 Miles

4. Common Tennessee Forest Types

4. COMMON TENNESSEE FOREST TYPES

This section discusses the common forest types and general stand conditions natural resource professionals may encounter while working with landowners in Tennessee. Since this LMP is forestry specific, forest type is defined here as a classification of forests by dominant overstory species or group of species (e.g., shortleaf pine or mixed hardwoods). Forest type is not to be confused with the term natural community because each forest type may contain multiple natural communities. Likewise, a given natural community may be dominated by a variety of forest type species.

Referring to NatureServe online database may be useful in meeting landowner objectives as it provides detailed natural community descriptions, species lists, and other information on all the natural communities of Tennessee. Tennessee natural communities associated with the LMP's Common Tennessee Forest Types are discussed within each respective forest type section. Refer to Table 4 for a listing of the common, dominant overstory species by associated LMP forest type. For this table, the respective species composition for the different forest types was found within NatureServe. Multiple community groups of Tennessee comprise each LMP Forest Type (i.e., the Bottomland Hardwoods Forest Type contains South-Central Interior Large Floodplain, South-Central Interior/Upper Coastal Plain Flatwoods, etc.). Also, the forest type hardwood monocultures pertain to areas of one vastly dominant species and not a variety, so it is not given in the table.

This section will also highlight the landscape objectives for each forest type. Since some objectives are not applicable across all forest types within Tennessee, they will be further discussed following the forest type they related to.

4.1. Oak/Hickory Mixed

The oak/hickory mixed (OHM) forest type represents a mixture of hardwood tree species with little to no presence of pine species. The associated natural communities according to NatureServe include, with the main group in text and applicable subgroups in parentheses: Appalachian-Northeastern Oak-Hardwood-Pine Forest and Woodland (Allegheny-Cumberland Dry Oak Forest and Woodland, Central and Southern Appalachian Montane Oak Forest, Southern Appalachian Oak Forest), Southern and South-Central Oak-Pine Forest and Woodland (East Gulf Coastal Plain Northern Dry Upland Hardwood Forest, East Gulf Coastal Plain Northern Loess Plain Oak-Hickory Upland, Southern Interior Low Plateau Dry-Mesic Oak Forest), and Southern Mesic Mixed Broadleaf Forest (East Gulf Coastal Plain Northern Loess Bluff Forest, Southern Coastal Plain Limestone Forest), to a degree. This forest type is variable depending on location and found throughout the state. For instance, the OHM association in the eastern and central portions of the state is typically located in more hilly terrain, which supports an entirely different subset of oaks and hickories than the more moderate topography found on loess bluffs overlooking the Mississippi River in western Tennessee. This community is similar in composition to other mesophytic, and riparian forests found throughout the state. Soils within upland mixed hardwoods are typically sub-xeric and acidic, varying from quite sandy to clayey depending on where they are found in Tennessee and the surrounding habitat. See Table 2 for a listing of the common tree species for the upland hardwoods forest type.

In comparison to the sparse, pine-dominated upland forest types, OHM forests usually have longer timber rotations and a more complex management due to typical hardwood degradation found statewide. Soils,

productivity, and timber quality vary greatly across these hardwood sites. OHM forests dominated by shade-intolerant species, such as oaks, growing on productive soils can produce quality timber products, while forests dominated by shade-tolerant species, such as red maple or certain hickories, growing on sub-xeric soils produce mostly low-value products such as hardwood pulpwood and fuelwood. Although not usually regarded as fire tolerant or dependent, research has shown that fire applied at the beginning of an OHM rotation has increased more valuable shade-intolerant species such as oaks. These forests are important for wildlife because of the annual mast production they provide through their acorns and nuts. These forests also allow the flexibility to manage for timber while also meeting aesthetic and wildlife objectives.

4.2. Mixed Pine Species

While the majority of Tennessee forestry is based on being one of the country's largest producers of hardwood timber, pine species comprise 1.2 million acres of forest and increase the state's natural diversity as well as its diversity within the timber market. Pines can occur in monoculture plantations or mixed with other pine species in nature. The typical pine species found in Tennessee plantations are loblolly and shortleaf, while other species such as eastern white pine, Virginia pine, table mountain pine, and pitch pine can be found in monoculture stands depending on the habitat. The associated natural communities according to NatureServe include Southern and South-Central Oak-Pine Forest and Woodland with the subgroup Southern Appalachian Low-Elevation Pine Forest. Loblolly pine is a popular pine forest community throughout Tennessee due to its ability to grow as a generalist across many different habitats. Although loblolly is considered the pine timber king of Tennessee, other species have varied levels of success as managed plantations. For example, the Virginia pine occurs on soils of high acidity and has been used to stabilize strip-mined areas due to its hardiness, while eastern white pine is prized in the log home and Christmas tree industries (UT Agricultural Extension 2005). Refer to Table 4 for a listing of the common species comprising the mixed pine forest type.

In mesic and wet flatwoods, loblolly can be found in variably mixed stands, with little to no hardwood midstory in managed stands. On upland pine and upland mixed woodland sites loblolly can be found growing alongside shortleaf pine, southern red oak (*Quercus falcata*), and hickory (*Carya* spp.) among other hardwoods. As mentioned previously, there are many economic and ecological incentives for landowners to manage for pine. Along with the commercial benefits of pine forests, many endemic wildlife game species of Tennessee utilize loblolly or shortleaf pine forests due to their open stand structure. In Tennessee these include deer, squirrels, bobwhite quail, and wild turkey. Frequent, low intensity prescribed fire is essential for maintaining and restoring this ecosystem and its diversity. For more information on the management of these pine forests, refer to Section 7.

4.2.1. Single-Species Dominated Pine Stands

While Tennessee is mainly hardwood-dominated, there are two pine species prevalent enough in monoculture stands to warrant discussion—loblolly and shortleaf pine. These are also the two species most likely to be found in actively managed plantations statewide. The different management considerations related to each of these will be discussed in Silvicultural Systems.

4.2.1.1. Loblolly Pine

Loblolly pine grows in several types of wetlands and their ecotones but thrives in productive clay uplands. It shares upland pine sites in variably mixed stands with shortleaf pines, southern red oak (*Quercus falcata*), and

hickory (*Carya* spp.) among other hardwoods. Loblolly is occasionally found sparsely on mesic and wet flatwoods sites, particularly adjacent to wetlands. It is considered offsite on sandhills, scrubby flatwoods, and well-drained sandy soils, but can be found marginally on these sites. Loblolly pine is susceptible to ice, pine beetle, and fire damage, and is not very drought tolerant.

Loblolly is the most important commercial species in Tennessee. It is economically valuable and a key ecological component in upland pine and several wetland natural communities. It is often planted in dense, productive plantations with genetically improved seedling stock. Loblolly is often even-aged-managed on revenue-maximizing short rotations, as it does not live as long as other pine species. It is generally managed on shorter rotations for pulpwood, oriented strand board and chip-n-saw, however it can be managed on longer rotations for high-value products such as saw timber, poles, and ply logs. Additionally, revenue and conservation objectives can be balanced or achieved individually through loblolly pine management.

4.2.1.2. Shortleaf Pine

Shortleaf pine is not as commercially productive as loblolly in Tennessee. While it was once the dominant pine species in eastern Tennessee, it is now present only as remnant groups on the Cumberland Plateau, Appalachians, and Ridge and Valley landscapes (UT Agricultural Extension 2005). Shortleaf pine is most productive on the dry ridgetops of central and eastern Tennessee, where it is more suited than loblolly. Other than littleleaf disease, shortleaf pine exhibits relatively strong disease and insect resistance. Shortleaf seedlings and saplings readily sprout from the base following excessive fire damage, making it more fire resistant than loblolly.

Shortleaf mostly occurs scattered in natural, uneven-aged, mixed hardwood-pine stands. Planted stands are uncommon but can be managed in appropriate soils. Shortleaf pine is shade intolerant and is best suited for even-aged management, providing landowners the option of managing intensively to maximize revenue with short rotations. It is generally found growing in natural stands that produce pulpwood and oriented strand board products. On the limited, better Tennessee shortleaf sites, it can produce chip-n-saw, sawtimber, and ply logs. Larger shortleaf pine can also be used by the federally listed red-cockaded woodpecker (*Picoides borealis*) as nest trees.

4.3. Pine/Hardwood Mixed

Pine/hardwood mixed (PHM) forest type is a combination of uneven-aged, natural forest types which includes multiple upland natural communities. The associated natural communities according to NatureServe include, with the main group in text and applicable subgroups in parentheses: Appalachian-Northeastern Oak-Hardwood-Pine Forest and Woodland (Southern Appalachian Montane Pine Forest and Woodland) and Southern and South-Central Oak-Pine Forest and Woodland (Southern Appalachian Low-Elevation Pine Forest). Refer to Table 4 for a listing of the common, dominant overstory species comprising the pine/hardwood mixed forest type.

The natural communities within PHM are each similar in silvicultural operability to other xeric sites in Tennessee. This forest type is found state-wide within the uplands of Tennessee, and species composition within this forest type varies based on hydrology and elevation. For instance, on the dry, well-drained ridgetops, shortleaf pine will associate better with hardwood species than loblolly pine, while loblolly can be found more

prevalently in more hydric locations. These forests usually result from long-term fire exclusion and are often found within the ecotone where bottomland forests and upland pine forests meet. Upland pine is collectively represented and covered within the mixed pine species forest type section.

PHM forests have lower timber productivity than pure loblolly or shortleaf stands due to the interspersed hardwood species and generally are not actively managed, aside from upland pine. Some PHM forests, such as a shortleaf pine/hardwood system, may be actively managed within Tennessee due to its fire dependance. However, not all PHM systems are fire dependent. Soils, productivity, and timber quality vary greatly across these sites. PHM forests produce pine products similar to loblolly pine dominated forests, as well as low-value products such as hardwood pulpwood and fuelwood. These forests usually have understories dominated by shade tolerant hardwoods which are best suited for uneven-aged management. PHM forest types allow the flexibility to manage for timber while also meeting aesthetic and wildlife objectives.

Of special note, cedar/hardwood mixed (CHM) forest type is typically an even-aged, natural forest type which can be found in multiple larger natural communities of Tennessee. The even-aged nature of this system is commonly due to succession of old field habitats. The associated natural communities according to NatureServe include, with the main group in text and applicable subgroups in parentheses: Appalachian-Northeastern Oak-Hardwood-Pine Forest and Woodland (Appalachian-Northeastern Chinquapin Oak-Red-cedar Alkaline Forest and Woodland) and Eastern North American Ruderal Forest (Eastern North American Native Ruderal Forest). Refer to Table 2 for a listing of the common, dominant overstory species comprising the cedar/hardwood mixed forest type.

The CHM forest type is limited to xeric sites in Tennessee. A common location for CHM forests is along more open areas with warmer exposures, which tend to be along ridgetops and midslope areas composed of limestone and exposed rock. This forest type is found statewide within the uplands of Tennessee, and it differs from other hardwood associations through the usual presence of dry, calcium-rich parent soils formed from the erosion of parent rock. Only certain hardwood species can tolerate the calcareous environment, with chinkapin oak, bitternut hickory, red hickory, and white ash joining the red cedar as species able to tolerate these conditions. These forests usually result from long-term fire exclusion and are generally found within the ecotone where mixed hardwood forests transition into high elevations or more rocky habitat.

CHM forests have lower timber productivity than oak/hickory mixed or pine/hardwood mixed forests due to the lack of commercially valuable species, and thus they generally are not actively managed. They are not fire tolerant or dependent, aside from upland mixed woodland portions of the forest. These forests usually have understories dominated by exposure-tolerant sedges and grasses.

4.4. Other Mixed Hardwood

Other mixed hardwood (OMH) communities represent a mixture of widely varied hardwood tree species with little to no presence of pine species. As there are other types of hardwood-dominated forest types covered within this LMP, this group will mainly serve to cover those hardwood forests that may not best apply to the other hardwood forest types (i.e., oak/hickory mixed, mesic hardwood forest, etc.). This forest type is variable depending on location and found statewide, with the majority in the montane forests of the Southwestern Appalachians in eastern Tennessee. This community is similar in composition to other mesophytic, and riparian forests found throughout the state. Soils within upland hardwoods are typically sub-xeric and acidic, varying

from quite sandy to clayey depending on where they are found in Tennessee and the surrounding habitat. See Table 2 for a listing of the common tree species for the other mixed hardwood forest type.

In comparison to the pine-dominated upland forest types, OMH forests usually have longer timber rotations requiring little management. Soils, productivity, and timber quality vary greatly across these sites. OMH forests dominated by shade-intolerant species, such as oaks growing on productive soils are capable of producing quality sawtimber. OMH forests dominated by shade-tolerant species, such as red maple, growing on sub-xeric soils produce mostly low-value products such as hardwood pulpwood and fuelwood. Although not usually regarded as fire tolerant or dependent, research has shown that fire applied at the beginning of an OMH rotation can increase more valuable shade-intolerant species. These forests are important for wildlife because of the annual mast production they provide. They also allow the flexibility to manage for timber while also meeting aesthetic and wildlife objectives. The associated natural communities according to NatureServe include, with the main group in text and applicable subgroups in parentheses: Southern Mesic Mixed Broadleaf Forest (Southern Mesic Beech-Oak-Mixed Deciduous Forest, Southern Coastal Dry Oak Forest), Appalachian-Interior-Northeastern Mesic Forest (Appalachian-South Central Interior Mesic Forest, Appalachian-Northeast Mesic Forest), Southern Mesic Beech-Oak-Mixed Deciduous Forest, Piedmont-Coastal Plain Oak Forest and Woodland, South-Central Interior Alkaline Forest and Woodland, and Eastern North American Native Ruderal Forest.

4.5. Mesic Hardwood Forest

The mesic hardwood (MH) forest grouping is quite diverse, including multiple species of broad-leafed deciduous trees. This forest type is composed of predominantly hardwood forests that are typically found on deep lowland soils or protected landscapes such as lower mountain slopes or coves (The Nature Conservancy 2020). This forest type is most prevalent in eastern Tennessee. MH forests are characterized by significant biodiversity in the plant and animal species they support, with as many as 30 different canopy species supported (Hinkle et al. 1993).

Soils of MH habitats in eastern Tennessee reflect the underlying parent rock material of the surrounding landscape and are mostly composed of Inceptisols and Ultisols. Forests that are located near the bottom of rocky slopes may contain loose stony material consisting of sandstone, siltstone, and/or limestone depending on local bedrock and the slope's steepness. These deep rock materials give rise to some of the richest and most productive MH forests. The vegetation of these MH forests varies depending on the region and surrounding topography, as the climax community for slopes may be different from those at the base of slopes (Hinkle et al. 1993). Regardless of location, the dominant species are typically composed of a mixture of oaks, yellow-poplar, chestnut, maples, and beech.

If MH forests are left undisturbed with the right conditions, or are properly managed to create regenerative oak forests, they can grow to great heights and be a very productive source of hardwood timber. Various hardwood forest products can be produced from the MH forest type, and these forests can also harbor important non-timber forest products (NTFPs), such as ginseng. Associated natural communities according to NatureServe include, with the main group in text and applicable subgroups in parentheses: Southern Mesic Mixed Broadleaf Forest (East Gulf Coastal Plain Northern Loess Bluff Forest, East Gulf Coastal Plain Northern Mesic Hardwood Slope Forest, Southern Coastal Plain Limestone Forest) and Appalachian-Interior-Northeastern Mesic Forest

(South-Central Interior Mesophytic Forest, Southern and Central Appalachian Cove Forest, Southern Appalachian Northern Hardwood Forest).

4.6. Cove Hardwood Forest

A subsection of MH deserving a greater description is cove hardwood forests (CHF), as this micro-forest type is prevalent in eastern Tennessee. Cove habitats are topographically distinct uneven-aged communities usually found under 5000 ft. in elevation in either a V-shaped valley between ridges, a concave portion of a great ridge feature, or north-and-east facing toeslopes (NatureServe 2020). The position of CHF at the base of slopes lends to highly fertile soils where slight topographical differences can cause shifts in the dominant vegetation (Forest Stewards Guild 2019). CHF are typically sheltered by their surroundings, which creates a protected environment where mesic hardwoods can flourish. Due to this shelter provided, CHF boast diverse hardwood overstory species that can rival that of any other Tennessee habitat. Along with the timber resources provided by CHF, a broad array of NTFPs and plentiful recreational and wildlife protection opportunities exist within coves.

Within CHF, two distinct forest types exist within the Appalachians and Blue Ridge Mountains—acidic cove forests and rich cove forests. The key differentiator between the two types is the soil composition, as rich coves contain highly fertile soil to support overstory and abundant understory growth and are usually found at the base of slopes while acidic coves can be found up slopes and mixed among rocky habitat that causes increased soil acidity and less primary production. A different subset of trees inhabit each type, with acid-tolerant species such as red maple and eastern hemlock found in acidic coves while buckeye, white ash, and basswood along with other moisture-loving species found in rich coves (Forest Stewards Guild 2019). Rich coves may also provide certain NTFP opportunities for landowners, as valuable understory species such as bloodroot (*Sanguinaria canadensis*) and ginseng (*Panax quinquefolius*) may be found in their understory. The associated cove communities according to NatureServe include Appalachian-Interior-Northeastern Mesic Forest with the Southern and Central Appalachian Cove Forest subgroup.

4.7. Bottomland Hardwoods

Bottomland hardwood (BH) communities are river swamps generally found along streams and rivers throughout the southeast and south-central United States, although sometimes they can be found in depressions such as Carolina bays or pocosins. These habitats are generally lacking in slope due to their presence within the broad, flat floodplains of their associated hydrologic feature. Additionally, BH communities within eastern Tennessee usually exhibit increased ranges of topography compared to the western Tennessee plains regions, resulting in a more narrow floodplain. Due to their presence in floodplains, BH soils typically consist of alluvial sediment ranging from clay to sand depending on the features (size, water velocity, etc.) of the nearby waterway. All species within BH communities are dependent on occasional flooding, with the flooding regime determining which species are best adapted for each habitat.

In comparison to the pine-dominated upland forest types, BH forests have somewhat limited access. On shorter rotations, BH forests produce mostly low-value products such as hardwood pulpwood and fuelwood. On longer rotations, BH forests can produce high value sawtimber and veneer products. Harvests should maintain natural waterflow patterns and consider the regeneration of the next forest from seed, seedling, or stump sprouts. BH forests exist from small-and-large-scale disturbances, and those dominated with shade-tolerant hardwoods

have usually been high-graded over time (Messina and Conner, 1998). BH allows the flexibility to manage for timber while also meeting aesthetic and wildlife objectives.

The associated natural communities according to NatureServe include, with the main group in text and applicable subgroups in parentheses: Central Hardwood Floodplain Forest (South-Central Interior Large Floodplain, South-Central Interior Small Stream and Riparian), Central Hardwood Swamp Forest (Cumberland Seepage Forest, South-Central Interior/Upper Coastal Plain Flatwoods, South-Central Interior/Upper Coastal Plain Wet Flatwoods), and Southern Coastal Plain Floodplain Forest (East Gulf Coastal Plain Large Floodplain Forest, East Gulf Coastal Plain Small Stream and River Floodplain Forest, Mississippi River Bottomland Depression, Mississippi River High Floodplain (Bottomland) Forest, Mississippi River Low Floodplain (Bottomland) Forest, Mississippi River Riparian Forest). After conferring with a group of natural resource professionals from Tennessee, it was determined that for the purpose of landscape management within this plan, the BH designation should have a single forest type subheading of tupelo-cypress mixed to best match what is dominant throughout Tennessee.

Of special note, tupelo-cypress mixed communities are relatively small, isolated wetlands embedded within bottomland hardwood forests or also various upland, pyrogenic natural communities. Pond or bald cypress (*Taxodium distichum* or *Taxodium ascendens*) and swamp or water tupelo (*Nyssa sylvatica* var. *biflora* or *Nyssa aquatica*) are relatively slow-growing and dominate this forest type together or in pure stands. Bald cypress and water tupelo are usually found in deep-water swamps along the coastal plain, while pond cypress and swamp tupelo are usually found in deep-water swamps along elevated rivers. Water tupelo and bald cypress become dominant with increasing hydroperiods along rivers. Because of its thicker, fire-resistant bark, pond cypress becomes dominant in isolated ponds, stringer swamps, and black rivers located in more pyrogenic natural communities (Messina and Conner, 1998). Isolated ponds have a hydroperiod that lasts most of the year, with tupelo-dominated ponds having a longer hydroperiod than pond cypress-dominated. Pond cypress-dominated stringer swamps occur along intermittent streams that only flow following heavy rainfall. They occur on relatively unproductive organic muck, wet sand, and peat soils. These typically even-aged forest types can be managed sustainably by using Tennessee's BMPs for Forestry.

Cypress/tupelo ponds can contain various mixed hardwoods including bays (*Persea* spp., *Magnolia virginiana*), red maple (*Acer rubrum*), holly (*Ilex* spp.), beech (*Fagus* spp.), and various hydric oaks (*Quercus* spp.). Cypress-dominated ponds and stringer swamps generally occur within pine flatwoods and sand hills, while tupelo-dominated ponds generally occur within upland pine natural communities.

In comparison to the pine-dominated upland forest types, these tupelo-cypress mixed forests have relatively low timber productivity and value and are not usually actively managed on most private lands. However, silvicultural opportunities exist within these communities. Cypress-dominated ponds and stringers are shade intolerant and best suited for even-aged management. Gum ponds (tupelo-dominated isolated depressions) are shade tolerant and also managed even-aged. The tupelo-cypress mixed forest type allows the flexibility to manage for timber while also meeting aesthetic and wildlife objectives. These forests produce mostly low-value products such as hardwood pulpwood, fuelwood, and cypress mulch. Mature cypress stands can produce saw logs used for various ornamental products such as trim and furniture.

5. Landscape Objectives

5. LANDSCAPE OBJECTIVES

Forest management objectives are generally classified as landowner or landscape level objectives. Landscape level objectives are identified on a national, state, or ecoregional level and provide the greatest benefit for forested ecosystem restoration, maintenance, and enhancement.

The landscape level objectives highlighted in this document are important to all forest types and should be considered for each landowner. They are summarized in this section rather than included in the forest types discussion due to their uniform applicability across all forest types. Some of the landscape level objectives were derived from the Tennessee Forest Action Plan and some were taken from a stakeholder group including various forest resource professionals and governmental agencies within Tennessee. Many of the objectives overlap. Individual strategies and actions to address the following objectives can be found in the Tennessee Forest Action Plan .

After determining a landowner's objectives, forest resource professionals can identify the landscape level objectives that the landowner's objectives support. Landowner and landscape level objectives can be the same (e.g., hydrologic protection and conservation) or provide opportunities to support and enhance each other. For example, a landowner may consider their primary objectives forest health, wildlife management, and ecological restoration. Through forest management activities to promote these objectives, the landowner could also be supporting landscape objectives like wildlife habitat management, rare plant and animal protection, non-native and invasive species management, and in some cases utilization of prescribed fire and hardwood enhancement.

5.1. Support Healthy Forest Products Industry

This LMP promotes maintaining a healthy forest products industry in Tennessee through sustainable forest management practices. This can be achieved through carefully planned timber harvests and timely site preparation and reforestation. Certification through the American Tree Farm System (ATFS) also encourages sustainable forestry and adds value to timber markets. Many forest products companies need certified wood to compete globally, so third-party certification through ATFS or other certifying bodies contribute to their success.

Tennessee's BMPs for Forestry also support a healthy forest products industry by protecting and enhancing water and soil quality. By voluntarily practicing safe, responsible, and sustainable forestry practices, over-regulation is avoided and timber markets thrive. Implementation of BMPs can also lead to retention or increase of carbon present in the forest. TDF contributes to carbon sequestration in Tennessee with their retention and active management of healthy and productive state-owned forestland.

5.2. Watershed Protection and Restoration

Tennessee contains several significant watersheds including the Tennessee, Mississippi, Cumberland, Sequatchie, Elk, and Conasauga Rivers. Well-managed forests protect these watersheds and ensure clean waterways and drinking water, as well as healthy aquatic habitats. Protecting these hydrologic features is a landscape-wide objective and may also be utilized by private landowners as a landowner objective.

Healthy creeks, streams, and rivers are dependent on healthy, forested stream banks, often referred to as riparian buffers. These buffers offer many benefits to individual landowner's property and also to the overall health of the entire watershed and everyone living downstream. These buffers can help stabilize eroding stream banks, filter out sediment and chemicals before they reach the waterway, help recharge groundwater, preserve, or improve wildlife and aquatic habitat, and add scenic and economic value. Buffers can also help reduce flooding by absorbing high-velocity stream flows and can help regulate the water temperature of streams (TDF).

NRCS, as mentioned in Section 3.0 Hydrologic Categories, strives to protect watersheds in need of improvement. In order to ensure these watersheds continue to provide high-quality water resources, TDF treats forests surrounding water bodies as buffers and a source of protection. When these forests are converted to urban areas or impervious surfaces, the quality and quantity of these hydrologic features is negatively impacted. However, opportunities exist within Tennessee to establish, preserve, expand, and restore forested areas along waterways and riparian habitats. Some of these opportunities include protecting forested karst recharge areas and forested riparian zones from development ensuring the protection and maintenance of watersheds critical to public drinking water supplies, and restoring forest cover in agricultural and urban areas, especially along riverine habitats.

In the 2010 Forest Action Plan (FAP), TDF outlined eight watersheds within the state as priority watersheds and began a pilot program with the USDA Forest Service to help restore riparian buffers in these areas. The program provided public and private landowners with native trees for planting along these buffers to reestablish forest cover. These plantings were usually initiated through the design of a planting plan. Efforts by landowners and civic groups led to restoration of buffers on a wide variety of public and private landscapes. Although this program is no longer offered, it provided the foundation for the development of a Tennessee Urban Riparian Buffer Handbook. Additionally, the Community Riparian Restoration Program administered by the University of Tennessee raises awareness and understanding of riparian buffer systems. This resource can be used to plan riparian buffer tree planting endeavors.

The 2020 Forest Action Plan also highlights the role riparian forests play in protecting water quality. In the Enhancing Forest Health and Resiliency objective, the plan outlines eight action steps under the strategy to expand reforestation, conservation, and protection efforts of forestlands along riparian zones, floodplains, and in source water watersheds.

5.3. Forest and Wildlife Health and Sustainability

Tennessee's forests face many threats, with changes in land-use the leading cause of loss in forest cover. Forests, their ecosystems, and natural resources can be conserved through conservation easements, sustainable forest management, and habitat management.

One objective of the Tennessee Forest Action Plan (FAP) is to enhance and restore forest health and resiliency. Within this statewide landscape objective there are certain strategies that are designed to improve and sustain the health and resiliency of Tennessee forests into the future. A discussion of certain key points, strategies, and actions from the FAP that apply within the LMP follow and can also be found throughout the document in various landowner and landscape objectives.

Strategy 1. Strengthen forest health monitoring, treatment, prevention, and management of forests that are threatened by invasive forest pests and plant species.

Action 1. Use technology such as light detection and ranging (LiDAR) imagery, unmanned aerial vehicles, and Geographic Information Systems (GIS) to increase the efficiency of forest health monitoring efforts.

Action 2. Secure and sustain funding for current and future strike teams to implement forest health treatments.

Action 3. Support initiatives, such as Firewood Scout and Don't Move Firewood, to create awareness of non-native invasive pests in urban and rural areas.

Action 4. Help initiate and support private sector service-based industries, such as invasive species consulting firms, to implement applicable forest management prescriptions.

Action 5. Diversify the age structure and species composition of the forest by utilizing science-based forest stand regeneration practices.

Action 6. Maintain tree growth by utilizing science-based forest stand intermediate treatments.

Action 7. Ensure forest management recommendations made by conservation professionals include appropriate measures that exclude, limit, or eradicate non-native forest pests (diseases, plants, and animals).

Action 8. Develop or support initiatives to maintain or restore historic diversity within ecoregions by maintaining or reestablishing native forest tree species like the shortleaf pine and white oak initiatives.

Action 9. Encourage and support native plant inventories and studies on state and private forestlands where native plant species knowledge is lacking.

Action 10. Increase the capacity to provide forest landowners with comprehensive, multi-resource forest management planning.

Strategy 2. Maintain or re-establish fire-adapted ecological communities.

Action 1. Build capacity in Tennessee's prescribed fire program and Tennessee's Prescribed Fire Council to better provide objective-driven services and increased education and awareness of the role of prescribed fire in forest management.

Action 2. Establish and track annual accomplishments for prescribed fire in the state of Tennessee.

Action 3. Develop and implement a statewide Memorandum of Understanding (MOU) for all federal, state, and non-government partners to combine resources to collaboratively implement prescribed fire.

Action 4. Encourage the Prescribed Fire Council to champion advancing fire science, partnering with entities such as TDF, The Nature Conservancy, University of Tennessee, the Oak Woodlands, and Forests Fire Consortium, and Consortium of Appalachian Fire Managers and Scientists.

Strategy 3. Expand reforestation, conservation, and protection efforts of forestlands along riparian zones, floodplains, and in source water watersheds.

Action 1. Engage conservation partners to ensure that appropriate species and quantity of trees are being grown to address the resource need.

Action 2. Increase tree planting in strategically prioritized riparian zones and floodplains.

Action 3. Develop and support initiatives to establish or maintain forest cover that protects public water supply watersheds and streams, such as programs funded by the Farm Bill and the National Fish and Wildlife Foundation.

Action 4. Engage in broader partnerships within and across Tennessee state borders to achieve larger floodplain and riparian restoration goals.

Action 5. Increase awareness of the benefits of forested watersheds and wetlands for providing sustainable and high-quality drinking water.

Action 6. Ensure landowners receive applicable technical assistance in identifying opportunities to create, enhance, and maintain riparian buffers.

Action 7. Establish forested corridors at landscape scale with more intact riparian zones and mixed hardwood corridors.

Action 8. Increase acreage of conserved and properly managed forestlands in source water watersheds.

Strategy 4. Support participation of private forest landowners across a wider range of ownership types and sizes in carbon markets.

Action 1. Engage extension agencies to develop outreach and educational programs to teach private forest landowners and corporations about the co-benefits of carbon projects and forest management.

Action 2. Educate decision-makers and policymakers on the potential of carbon projects to provide economic opportunities to rural communities.

Action 3. Evaluate carbon projects on publicly owned property that can demonstrate carbon programs while providing economic value to rural communities.

Action 4. Implement forest carbon programs like Family Forest Carbon Initiative that enable landowners who own less than 2,000 acres of forestland to participate in carbon markets (see Regional Initiatives for more information on this program).

Strategy 5. Support research and monitoring efforts which track changes to forest composition.

Action 1. Utilize and build upon existing data such as those procured and analyzed by USFS Forest Inventory and Analysis (FIA) program to understand composition shifts to help inform forest management activities.

Action 2. Explore and incorporate forest composition monitoring tools such as satellite imagery and forest disturbance mappers.

Strategy 6. Design and implement forest management prescriptions to achieve healthy and resilient forests.

Action 1. Support silviculture research that explores the impact of various planting or natural regeneration patterns and species mixtures on ecosystem resilience, productivity, and carbon storage.

Action 2. Educate forest landowners and conservation professionals on the benefits of mixed forest plantings or natural regeneration that result in long term forest health and resiliency.

Action 3. Promote federal and state cost-share programs that encourage mixed plantings, timber stand improvement, and natural regeneration.

Action 4. Promote research and implementation of cave and karst BMPs in forest management operations.

Strategy 7. Support efforts to increase the number of certified forests and the availability of certified logs and wood products.

Action 1. Educate private forest landowners and private forest consultants on the different certification systems, such as Sustainable Forestry Initiative, American Tree Farm, and Forest Stewardship Council.

Action 2. Investigate opportunities to incentivize private forest landowners to pursue third-party certification.

Action 3. Support the use of Landscape Level Management forest management plans to allow more private forest landowners to enter third-party certification systems.

When examining the wildlife aspect of its forested habitat, Tennessee is home to many rare species found only in this region and contains several global populations. Tennessee forests provide vital habitat to many imperiled plant and animal species. Table 2 shows listed species (threatened, endangered, and at-risk) found in the forested habitats of Tennessee by LMP forest type. This table was created using the United States Fish and Wildlife Service's list of Threatened and Endangered Species of Tennessee as well as the Tennessee Natural Heritage Program Rare Plant List 2021. Not all listed Tennessee species from the list are shown, only those with the potential to utilize some portion of forested habitat within their life cycle. These habitats were then associated with each LMP forest type. Additional information on current listing status for each species can be found in the geodatabase.

In addition to the federally endangered or threatened species present in Tennessee, the Tennessee 2015 State Wildlife Action Plan (SWAP) further delineates Tennessee's species and classifies some as falling within the category of Species of Greatest Conservation Need (SGCN). The species were determined by creators of the Tennessee SWAP using the following criteria:

i. G1-G3 NatureServe rarity rank; federally listed as endangered, endangered by similarity of appearance, threatened, threatened by similarity of appearance, proposed endangered, proposed threatened, or candidate species for listing; or state listed as endangered, threatened, or deemed in need of management; OR
ii. Special concern species due to declining trends, or otherwise vulnerable due to endemic, limited, disjunct, or peripheral status in the region; OR
iii. Special consideration due to:
    a. Partners in Flight score of 22 or higher
    b. National Shorebird Prioritization Score of 4 or higher
    c. National Wind Coordinating Collaborative category of "high"
    d. Being a keystone species within a biodiversity hotspot or part of a globally significant aggregation of species
    e. Species is strongly dependent upon ecological processes often interrupted across the landscape

These SGCN were then divided into tiers (1-4) based on the type of species. Overall, the 2015 Tennessee SWAP designated 1,499 species as being SGCN (931 animals and 568 plants). These species represent the focal point

moving forward into the future of Tennessee's natural environment. While these species are too numerous to be listed individually in this document, they can be found in the appendices of the SWAP.

5.3.1. Working Lands for Wildlife

One major initiative throughout the nation is the program of Working Lands for Wildlife (WLfW). Established through NRCS and funded through EQIP, this program assists landowners in voluntary conservation efforts for threatened species. NRCS provides financial and technical support to participants who voluntarily make certain improvements to their working lands to facilitate improvement of these species' habitat. This initiative has proven successful in helping conserve more than 7.1 million acres of wildlife habitat nationwide and has benefitted species such as the greater sage-grouse and New England cottontail. In Tennessee, there are multiple target species and habitats of the WLfW program, including the bobwhite quail, golden-winged warbler, and hellbender salamander.

The northern bobwhite (*Colinus virginianus*) is a focus of the Bobwhite Quail Restoration Project. The northern bobwhite is typically an edge" dweller, living where woodlands and crop fields intersect and taking cover under brush. Modern land use has decreased the bobwhite's population by more than 80% in the past 60 years. Now, bobwhite depend on early successional grassland, shrubby areas, and pine or oak savannas through the eastern Unites States. Research has shown that closed canopy or unburned stands provide poor quality habitat for bobwhites, and that forest thinning and frequent prescribed fire help to promote both savanna habitats as well as high bobwhite quail populations. Through this WLfW program, NRCS is providing technical and financial assistance for landowners to improve their land to attempt to create this necessary habitat, such as establishing field borders and buffer strips, thinning mature forest stands to create diverse and shrubby understory, and integrating native plants into pasture plantings. The habitat created for the northern bobwhite is also beneficial for other woodland species, including turkeys, white-tailed deer, rabbits, bog turtles, and various types of songbirds.

A second species of focus is the golden-winged warbler (*Vermivora chrysoptera)*, a nationally identified target species of the WLfW partnership. The golden-winged warbler requires younger forest stands and shrubland for nesting. That habitat is being increasingly replaced by aging forests or large trees within the warbler's breeding range largely due to a lack of fires and unsustainable forestry practices. This shift in mature forests has caused the warbler to have a 66% population loss since the 1960s. To combat this decline, land owners have voluntarily worked with NRCS to develop and implement conservation plans to create high-quality early successional habitat on their property, often in conjunction with programs that recognize these benefits for other species like the American Bird Conservancy, Pheasants Forever, and National Turkey Federation. NRCS offers technical and financial assistance for the voluntary conservation of the golden-winged warbler through targeting the removal of trees and invasive weeds, while tailoring conservation efforts to meet the structure of the landowner's property. Habitat restored for the golden-winged warbler also benefits many other songbird and game species.

A final WLfW program within Tennessee focuses on protection of the eastern hellbender (*Cryptobranchus alleganiensis*), the largest salamander in North America. This species is unique to North America in its size, potentially reaching 2 feet in length. While hellbenders were previously common in the eastern United States, continuing water quality degradation and loss of habitat have caused their numbers to decline. NRCS is focusing restoration efforts for the hellbender's population in North Carolina, Virginia, and Tennessee. In Tennessee,

these focal areas occur distinctly within Blount, Bradley, Hickman, Jackson, Knox, Lawrence, Lewis, McMinn, Monroe, Overton, Polk, Putnam, Sevier, and Wayne Counties and represent the last remaining known hellbender occurrences within those watershed systems. NRCS offers free technical and financial assistance to assist landowners in implementing a variety of protectionary practices to benefit the hellbender as well as other species. Some examples of some of these practices are livestock grazing management, reducing agricultural runoff, removal of barriers that impede instream flows, and installing riparian forest buffers.

5.3.2. Non-Native and Invasive Species and Nuisance Species Management

There are many non-native invasive plant (NNIP) and non-native invasive animal (NNIA) species in the state of Tennessee. These species are a major threat to forest health. Table 3 provides a list of the most common non-native and invasive species (NNIS) and nuisance species that impact forest management, using the Tennessee Invasive Plant Council's (TN-IPC) Invasive Plants of Tennessee. Additionally, there are numerous native species which can function as nuisance species when their abundance and distribution impact historic and healthy forest conditions. For example, the absence of wildfires and the lack of prescribed burning in some areas creates conditions where fetterbush (*Lyonia lucida*) and Chinese tallow tree (*Triadica sebifera*) limit forest regeneration, increase wildfire risk, and reduce biodiversity. Forest resource professionals can accurately assess which native species are a nuisance, inhibiting the achievement of landscape objectives. Management and control of NNIS and nuisance species is often most successful when it is integrative and adaptive (Miller et al 2015).

The TN-IPC has identified the following plant species as established invasive threats reported in more than 10 Tennessee counties:

tree of heaven (*Alianthus altissima*)
mimosa (*Albizia julibrissin*)
garlic mustard (*Alliaria petiolata*)
alligator weed (*Alternanthera philoxeroides*)
hairy jointgrass (*Arthraxon hispidus*)
Hungarian brome (*Bromus inermis*)
Asian bittersweet (*Celastrus orbiculatus*)
spotted knapweed (*Centaurea stobe*)
sweet autumn clematis (*Clematis terniflora*)
Chinese yam (*Dioscorea polystachya*)
autumn-olive (*Elaeagnus umbellata*)
burning bush (*Euonymus alatus*)
winter creeper (*Euonymus hederaceus*)
Japanese knotweed (*Fallopia japonica*)
English ivy (*Hedera helix*)
hydrilla (*Hydrilla verticillata*)
bicolor lespedeza (*Lespedeza bicolor*)
Chinese lespedeza (*Lespedeza cuneata*)
Chinese privet (*Ligustrum sinense*)
Japanese honeysuckle (*Lonicera japonica*)
Amur bush honeysuckle (*Lonicera maackii*)
purple loosestrife (*Lythrum salicaria*)
Japanese stilt grass (*Microstegium vimineum*)
Chinese silver grass (*Miscanthus sinensis*)
Asian spiderwort (*Murdannia keisak*)
Brazilian watermilfoil (*Myriophyllum aquaticum*)
Eurasian watermilfoil (*Myriophyllum spicatum*)
princess tree (*Paulownia tomentosa*)
beefsteak plant (*Perilla frutescens*)
common reed (*Phragmites australis*)
kudzu (*Pueraria montana*)
Bradford pear (*Pyrus calleryana*)
multiflora rose (*Rosa multiflora*)
wine raspberry (*Rubus phoenicolasius*)
Johnson grass (*Sorghum halepense*)
Japanese meadowsweet (*Spiraea japonica*)
coltsfoot (*Tussilago farfara*)
common periwinkle (*Vinca minor*)
Chinese wisteria (*Wisteria sinensis*),
Japanese wisteria (*Wisteria floribunda*)

In addition to the established species, there are emerging threat species such as cogongrass (*Imperata cylindrica*) and Japanese climbing fern (*Lygodium japonicum*) that are federally listed noxious weeds and represent a potential future threat to Tennessee's natural communities if not controlled. While not yet drastically affected by cogongrass, Tennessee is on the advancing front on the infestation across the Southeast. It was eradicated in Henderson County following isolated detections there. Currently, cogongrass can be found in border states including Alabama and Mississippi. Landowners in the vicinity of these cogongrass infestations are being made aware of the importance of its control and are advised to notify TDF if cogongrass is found on their property.

Another major threat to natural communities within Tennessee is the emerald ash borer (EAB) (*Agrilus planipennis*). This beetle is responsible for the death or decline of tens of millions of ash trees in the United States and has been confirmed in 35 states, ranging from Maine to Georgia and as far west as Nebraska (USDA APHIS 2021). Larvae of this beetle feed on the tissue between the bark and sapwood of the tree, creating tunnels which are visible if the bark is peeled back. These tunnels disrupt the transport of nutrients, causing branch dieback and eventually killing the tree. The emerald ash borer was first detected in Tennessee in 2010 and has since been confirmed in 65 counties, which is approximately 60% of the state (EDDMaps 2019). The USDA attempted to prevent spread of EAB by quarantining areas where it was known to exist. This practice ended in 2020. Although quarantine of the EAB has been suspended, the most effective way to control EAB populations is to limit the geographical movement of firewood.

The hemlock woolly adelgid (HWA) (*Adelges tsugae*) is another non-native pest known to affect Carolina and eastern hemlock by sucking sap from the base of foliage. While these insects are very small, they create a cottony covering in the winter which can be visible on the foliage of infected trees. Trees usually decline and succumb from carbohydrate loss after five to seven years of infestation This insect has decimated the eastern hemlock population of the Appalachian cove forests from Maine to Georgia and stretching into eastern Tennessee. Tennessee now has 43 counties with infestations (Tennessee Department of Agriculture). To preserve the most aesthetically and ecologically valuable trees, systemic insecticides must be periodically applied.

The European spongy moth (ESM) (*Lymantria dispar*) is another significant threat to Tennessee's forests. The ESM is most dangerous to trees in its caterpillar form, as the caterpillars have a large appetite for greater than 300 species of trees and shrubs. Caterpillars can work to defoliate the majority of a tree, leaving the tree more susceptible to other diseases, pests, and environmental stressors (USDA APHIS 2020). While Tennessee does not contain established ESM populations at this time, its progression is actively monitored due to the threat it poses to Tennessee's timber resources.

5.3.2.1. Prevention and Monitoring

Prevention is the key first step. Landowners and managers can limit the spread of NNIP's by minimizing ground disturbance activities and inspecting silvicultural and agricultural equipment for cleanliness prior to entering and departing property. Spread of NNIA's can be minimized by avoiding the transport of these species from one property to another, mainly through fencing and avoiding firewood movement. Don't Move Firewood offers additional information to prevent the transport of insects or disease through firewood. Even through strong prevention measures, birds, weather, and other modes of spread will occur.

Monitoring can take place during routine work or recreational activities on the property. It is important to have species identification skills and resources to aid in monitoring. Early detection allows for rapid, aggressive treatment before infestations become established and spread throughout the property.

5.3.2.2. Documentation and Planning

Documentation of new and existing infestations with GPS coordinates, GIS mapping, or location notes assist in the treatment and monitoring of infestations. Infestations can be marked with flagging, paint, or other means. Documentation is also beneficial to ensure any pesticides used are approved by the Environmental Protection Agency (EPA) and applied, stored, and disposed of in accordance with the labels and by persons appropriately trained, licensed, and supervised.

NNIS and nuisance species management plans can be developed to treat minor and major infestations. Integrated pest management is adaptive, aggressive and may include:

- Infestation occurrence and treatment documentation
  - Good record keeping
  - GIS mapping of new and existing
- Treatment plan and schedule
  - Frequency, seasonality, and methods
  - Combination of treatment methods typically most effective
- Monitoring plan and schedule
  - Frequency and locations
- Adjust retreatment methods and monitoring as needed
- Repeat this cycle until control is achieved

5.3.2.3. NNIP and nuisance plant treatment methods

- Chemical
  - Ground: broadcast or isolated treatment
    - Foliar, cut stump, hack-n-squirt, injection, basal bark, soil spot (grid)
    - Backpack and hand sprayers; ATV, farm tractor, skidder-mounted sprayers
  - Aerial: broadcast by helicopter
- Mechanical: broadcast or isolated
  - Hand-pull, chop, mow, mulch
- Prescribed fire: broadcast
  - Dormant or growing season

5.3.2.4. NNIA treatment methods

- Feral hogs
  - Do not transport onto property and prohibit hunting lessees from doing so.
  - Install property boundary fencing.

- Promote year-round aggressive hunting and trapping.
  - Licensed contract trappers available
- Practice careful game species food plot crop selection.
- Consultation and additional information are available from USDA Wildlife Services.

5.3.2.5. Nuisance animal treatment methods

- White-tailed deer (if unwanted)
  - Modify and increase deer harvest to control population abundance and sex ratios.
  - Install property boundary fencing.
  - Install exclusionary fencing around young plantations and regeneration areas.
  - Time logging activities and use uneven aged stands to provide continual availability of browse and forage options.
- Beaver
  - Do not transport onto property and prohibit hunting lessees from doing so.
  - Monitor all water sources and potential impoundment locations for activity.
  - Promote year-round aggressive hunting and trapping.
    - Licensed contract trappers available
  - Destroy any dams or impoundments in conjunction with trapping and harvesting efforts.
  - Consultation and additional information is available from USDA Wildlife Services.

5.3.2.6. Biological Control

Per the USDA Forest Service's Forest Health Technology and Enterprise Team (FHTET), a biological control is the reduction of an organism's population density through use of its natural enemies. The FHTET recognizes biological control as being one of the most effective and cost-efficient long-term approaches for managing widespread NNIS infestations. This involves utilizing natural enemies (parasites, predators, herbivores, and pathogens) to reduce the population of hosts, whose abundance influences the population levels of natural enemies (USDA-FS 2016). Biological control can be used as a component within a comprehensive Integrated Pest Management program (van Lenteren 2012). For example, some areas under this LMP have utilized grazing goats to control kudzu infestations.

In some scenarios, biological control may also be used for native vegetation management such as utilizing goats as an alternative to herbicide, mechanical, or prescribed fire treatments (USDA-NRCS 2015). However, the use of prescribed grazing in these scenarios can be less selective from a species standpoint, impacting both desirable and undesirable species (USDA-NRCS 2015). Despite good intentions, rigorous environmental risk assessments, and standards and guidelines for the import, export, shipment, evaluation, and release of biological controls, it is still possible for these species to become ecologically problematic in forest settings (van Lenteren 2012).

5.3.3. Degraded Hardwood Enhancement

In Tennessee, most forests are composed of hardwoods that over time have become degraded in some way. A major factor in this hardwood forest degradation is the historically limited market for small, low-value trees.

Larger trees may be "high-graded" out of the stand selectively, with the incorrect assumption that the small trees remaining will replace the larger trees removed as the next round of merchantable timber. In reality, the remaining trees were likely the same age as those harvested and can never reach that level of quality due to a lack of competition producing smaller crowns and weaker trees. Further, measures are not taken toward stand improvement in the interim following the harvest. Degraded hardwood stands may also result from fire, insect, or disease damage, or a poor choice of site for the stand, not just anthropogenic mismanagement. A cycle of mismanagement has produced degraded hardwood stands that are a mixture of degraded remnants of previous harvests, a certain amount of desirable species regrowth, and a large contingent of smaller shade-tolerant trees that are not desirable for timber production and crowd out young target tree species (Clatterbuck 2006).

In the wake of this silvicultural mismanagement, degraded forest stands are prevalent throughout much of Tennessee. The effort and cost required to restore these stands can be great, and, depending on the current market for degraded wood products such as pallets, ties, chips, and pulpwood, may be cost prohibitive for an agency or landowner. However, this issue of degraded stands is becoming more widely recognized and their product market is becoming stronger, so degraded hardwood stands have recently become a focal point in the Tennessee forestry community.

Depending on the condition of the specific site and the objective of the landowner, there are three options for the management of degraded stands: rehabilitation, regeneration, or no action. Rehabilitation refers to the improvement of an existing stand to the point where it no longer exists in a degraded condition, while regeneration involves the creation of an entirely new stand that will have the opportunity to grow into a balanced stand. The key factor in deciding whether to rehabilitate or regenerate a hardwood stand is whether acceptable growing stock (AGS; trees of commercial value that are capable of reproducing) exists within the current stand. If so, the stand could be a candidate for rehabilitation. If not, regeneration of the site is the best route moving forward (Clatterbuck 2006).

McGee (1982) provides a helpful checklist for first evaluating and then prescribing a treatment plan for a degraded hardwood timber stand. Depending on the option chosen, various silvicultural systems from the ones present in Sections 7.1-7.6 may or may not be applicable. As degraded hardwood restoration is at the forefront of timber management in Tennessee, each section and subsection that follows will describe how that particular practice could be used within the framework of either rehabilitation or regeneration.

5.3.3.1. Oak Health Threats

In the recent years, oaks (*Quercus* spp.) of various species have begun to die off in significant numbers across Tennessee. Known as oak decline, the syndrome is not the cause of a single insect or disease but is deemed to be the product of interactions between forest pests and the trees' environment. While the disease can affect species within both the red and white oak groupings, the red oak grouping is the most prevalent of the oaks affected (Wargo et al. 1983). White oak is an important commercial species within the Tennessee timber industry due to its use in creating barrels for bourbon distilleries.

Once a tree becomes defoliated or stressed due to environmental factors, it is more susceptible to the effects of insects and diseases. In its weakened state, the tree may succumb to the secondary factor. The agents most commonly associated with the propagation of oak decline following the initial symptoms are the disease

Armillaria rot (*Armillaria mellea*) and the insect twolined chestnut borer (*Agrilus bilineatus*), while the pathogen *Phytophthora quercina* has also been linked to oak decline. Armillaria rot attacks the roots and causes them to girdle the tree (wrap and choke the main stem) over time. The twolined chestnut borer's larvae feed underneath the bark of trees that are already weakened. While a tree's decline may take several years, it is first noticed as dieback on branch tips and then yellowing of the leaves or leaf loss prior to autumn (Wargo et al. 1983).

Proper maintenance of forest stands is essential to combat the effects of oak decline. Steps that can be taken for commercial stands include removing dying trees to ensure twolined chestnut borer populations do not increase and thinning stands to keep trees growing vigorously and to decrease the competition for resources. Landscape oaks should be mulched properly to retain their moisture fertilized as necessary to combat nutrient deficiencies.

The FAP outlines a goal of reducing losses of forestland values due to oak decline. That following strategies are given as means to accomplish this goal:

- Diversify the age structure and species composition of the forest by utilizing science-based forest stand regeneration practices.
- Maintain tree growth by utilizing science-based forest stand intermediate treatments.
- Expand markets for hardwood forest products, including biomass, biofuels, and urban waste wood.
- Develop proactive monitoring processes for early detection of forest health problems.
- Conduct and publish more research on the causation factors of oak decline.

Sudden oak death (SOD) is also a potential threat to oak species. It is a fairly new disease, as it was first reported in California in 1995 and spread to Georgia through the transport of certain camelias in the 2004. Out of a total of 59,000 potentially infected plants that were shipped to Georgia, 49,000 were sold before the Georgia Forestry Commission (GFC) was aware of the disease's presence (GFC 2019). Due to this shipment, SOD has now been positively identified in 17 nurseries throughout Georgia. SOD is a fungus, *Phytophthora ramorum*, that causes a bleeding canker on the tree's side which continues to grow until eventually girdling the tree. This girdling eliminates the tree's ability to transport water from the roots to the crown, which can cause leaf spot and twig dieback. Of the oaks present in Georgia, it has been shown that red oak and pin oak are particularly susceptible to the fungus. GFC is continuing to sample native vegetation surrounding suspected nursery sites, and no native plants have yet to be infected within Georgia or any of its neighboring states. However, Tennessee is listed as having a severe risk of sudden oak death (Kelly et al. 2004). It is important that landowners assist in the early detection of this disease and proactive monitoring of Tennessee's oak species to prevent spreading.

5.3.3.1.1. White Oak Loss

In the recent years, oaks (*Quercus* spp.) of various species have begun to die off in significant numbers across Tennessee. Known as oak decline, the syndrome is not the cause of a single insect or disease but is deemed to be the product of interactions between forest pests and the trees' environment. While the disease can affect species within both the red and white oak groupings, white oak (*Quercus alba*) is the most prevalent of the white oaks affected (Wargo et al. 1983). White oak is an important commercial species within the Tennessee timber industry due to its use in creating barrels for bourbon distilleries.

Once a tree becomes defoliated or stressed due to environmental factors, it is more susceptible to the effects of insects and diseases that on their own would not kill an oak; however, the tree in its weakened state may succumb to the secondary factor. The agents most commonly associated with the propagation of oak decline following the initial symptoms are the disease Armillaria rot (*Armillaria mellea*) and the insect twolined chestnut borer (*Agrilus bilineatus*). Armillaria rot attacks the roots through rotting them and causing them to girdle the tree (wrap and choke the main stem) over time, while the twolined chestnut borer's larvae feed underneath the bark of trees that are already weakened. While the tree's decline may take place over several years, it is first noticed as dieback on branch tips and then yellowing of the leaves/leaf loss prior to autumn (Wargo et al. 1983).

Proper maintenance of forest stands is essential in combating the effects of oak decline. Steps that can be taken for commercial stands include removing dying trees to ensure twolined chestnut borer populations do not increase and thin stands to keep trees growing vigorously and decrease the amount they have to compete for resources. Landscape oaks should be mulched properly to retain their moisture and also given fertilizers as necessary to combat nutrient deficiencies.

5.3.4. Forest Fragmentation and Parcelization

A landscape objective of new focus is managing urban sprawl and its associated wildland-urban interface, especially the fragmentation and parcelization of the forest that results. Fragmentation of the forest is the division of continuous forested tracts into smaller patches, while parcelization is the division of the forest into smaller parcels that are more likely to be developed into non-forestland uses. Effects of forest fragmentation and parcelization include the introduction of barriers to the movement of native animal (Harris 1998) and plant species, degradation of native habitats (Belisle et al. 2001; Burke 2000; Cam et al. 2000), degradation of water quality, and the introduction of non-native plant and animal species (Harris 1988).

This increasing threat of forest fragmentation in Tennessee can be attributed to increasing population growth statewide, especially with a large portion of the population leaving urban areas and moving into the rural frontier. Conversion of land into non-forested land uses is a major threat to the Tennessee forestry landscape, as well as to forestry jobs, air quality, water quality, and biodiversity of the landscape. Some of the impacts to the forestlands due to forest fragmentation and parcelization, as well as strategies to combat these challenges follow.

5.3.4.1. Water

The conversion of forestland to urban use poses a threat to the sustainability of Tennessee's water quality and quantity. With less forestland to effectively process rainfall, impervious urban surfaces generate an increase in storm runoff and streamflow that can lead to increased erosion and sedimentation rates and overbank flooding. Pollutants and fertilizers are able to reach larger water bodies through flow over impervious surfaces. Also, development in rural areas tends to occur near the headwaters of streams and rivers, which may affect all of Tennessee's many aquatic species located downstream that are susceptible to pollutants and changes in water composition or temperature.

In the 2020 Forest Action Plan, urban and riparian forests are prioritized as solutions to protecting and conserving clean water. In the Maintaining and Improving Connected Landscapes objective, there are four actions steps under the strategy *Increase and maintain canopy cover in urban and riparian areas to protect water quality and establish resilient urban and riparian forests*.

5.3.4.2. Biodiversity

Some species have been able to adapt over time to the gradual encroachment of urbanization into their rural habitats and the changes to the natural resources they require. Others are much more susceptible to changes in or around their habitat. These species require management to help prevent further population declines due to encroachment of anthropogenic effects and their subsequent habitat loss. For example, a species that once populated shortleaf and loblolly pine savannas, such as the red-cockaded woodpecker, has found its populations become threatened as habitat has been lost and degraded due to urban growth and development and the conversion of forests to plantations.

The previous Tennessee FAP (2010-2020) outlined a goal of keeping intact and maintained forested landscapes. The following strategies were given as means to accomplish this goal:

- Increase the capacity to provide forest landowners with comprehensive, multi-resource forest management planning.
- Develop continuing education programs for private consulting foresters to encourage preparation of forest stewardship plans that address forest health, intermediate stand practices, aesthetics, and non-native invasives.
- Establish forested N-S corridors at the landscape scale with wider riparian zones and mixed hardwood corridors.
- Improve ecological health by establishing connectivity between local, state, and federal public-owned properties where practical.
- Expand markets for hardwood forest products, including biomass, biofuels, and urban waste wood.
- Educate state and local planning officials on development issues at the wildland-urban interface.
- Develop and implement or support information and education programs that publicize benefits of urban and rural forests.

This goal of both maintaining and improving connected landscapes within Tennessee is further reiterated through strategies and actions outlined in the current (2020-2030) FAP, as keeping forested landscapes intact remains a high priority moving into the future. These current, updated strategies are found on pg. 71-73 of the FAP.

Strategy 1. Strategically connect rural and urban working forests.

Action 1. Encourage strategic land acquisitions and approaches that keep working forests productive and connected.

Action 2. Collaborate with conservation organizations and agencies to encourage alignment and synchronization of strategic plans and use of science-based forest connectivity models (e.g., TNC's Resilient Land Mapping Tool).

Action 3. Develop working groups or communication platforms to share information and updates on land acquisition and how active forest management can improve connectivity.

Action 4. Support research and utilize the best available science to determine location and best approaches to ensure landscape connectivity.

Strategy 2. Aggregate small-forested parcels (e.g., cooperatives) to improve economies of scale for forest operations and market shares.

Action 1. Identify geographic areas in Tennessee where timber and non-timber forest cooperatives will be most successful.

Action 2. Identify existing or emerging programs or leaders who can facilitate landowner participation.

Action 3. Partner with University of Tennessee Extension to develop outreach and educational and collaborative programs.

Strategy 3. Increase and maintain canopy cover in urban and riparian areas to protect water quality and establish resilient urban and riparian forests.

Action 1. Utilize current and emerging science to create action and protection plans to plant appropriate tree species in appropriate locations.

Action 2. Utilize remote-sensing technology and models to identify urban areas where strategic tree planting can mitigate the effects of flooding and stormwater runoff.

Action 3. Continue to build community engagement and programs to create and maintain green infrastructure.

Action 4. Create, enhance, and maintain riparian buffers.

Strategy 4. Reduce future environmental and social stressors caused by the impacts of urbanization in areas with accelerated urban growth.

Action 1. Utilize urban growth models such as SLEUTH and the Impervious Surface Stress Index to prioritize forest conservation activities and aid in land-use planning.

Action 2. Educate urban foresters and municipal planners to understand the connection between trees and human health.

Action 3. Collaborate with forestry and wildlife professionals to identify high-value forests and habitat and develop effective forest avoidance, minimization, and mitigation strategies for development.

5.3.5. Forest Ecological Restoration

Ecological restoration has been defined as the intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity, and sustainability (Society of Ecological Restoration 2004). These activities are performed on ecosystems that have been degraded, damaged, transformed, or destroyed as the result of direct or indirect anthropogenic activities (Society of Ecological Restoration 2004). The enhancement and restoration of native ecosystems is often a complex and iterative process that requires adaptation and engagement. Integrated natural resource management planning, including forest management, is essential for the successful attainment of ecosystem restoration and biodiversity objectives in many Tennessee ecosystems. This landscape objective of ecological restoration may also serve as a private landowner objective.

In Tennessee, the majority of forests encountered are composed of hardwoods that over time have become degraded in some manner or fashion. A major factor in this hardwood forest degradation is the historically limited market for small, low-value trees; larger trees have been "high-graded" out of the stand selectively, with

the incorrect assumption that the small trees remaining in the stand will replace the larger trees removed as the next round of merchantable timber. In reality, many of the remaining trees were likely the same age as those harvested and will now never reach that level of quality due to the lack of competition that produced smaller crowns and overall weaker trees. Further, measures are not taken toward stand improvement or stand regeneration in the interim following the harvest. Degraded hardwood stands may also be due to the result of fire, insect, or disease damage, or poor site conditions for the stand, not just anthropogenic mismanagement. A cycle of mismanagement has produced degraded hardwood stands that are a mixture of degraded remnants of previous harvests, a certain amount of desirable species regrowth, and a large contingent of smaller shade-tolerant trees that are not desirable for timber production and crowd out young target tree species (Clatterbuck 2006).

In the wake of this silvicultural mismanagement, degraded forest stands are prevalent throughout much of Tennessee. The effort and cost required to restore these stands can be great and, depending on the current market for degraded wood products such as pallets, ties, chips, and pulpwood, may be entirely cost prohibitive for an agency or landowner. However, this issue of degraded stands is becoming more widely recognized and their product market is becoming stronger, so degraded hardwood stands have become a focal point as of late in the Tennessee forestry community.

Depending on the condition of the specific site and the objective of the landowner, there are three options for the management of degraded stands: rehabilitation, regeneration, or no action. Rehabilitation refers to the improvement of an existing stand to the point where it no longer exists in a degraded condition, while regeneration involves the creation of an entirely new stand that will have the opportunity to grow into a balanced stand. The key factor in deciding whether to rehabilitate or regenerate a hardwood stand is whether acceptable growing stock (AGS; trees of commercial and desirable species that are capable of increasing in value and volume and are or can become viable crop trees) exists within the current stand. If so, the stand could be a candidate for rehabilitation; if not, regeneration of the site is the best route moving forward (Clatterbuck 2006).

McGee (1982) provides a helpful checklist for first evaluating and then prescribing a treatment plan for a degraded hardwood timber stand. Depending on the option chosen, various different silvicultural systems from the ones present below in Sections 7.1-Section 7.6 may or may not be applicable. As degraded hardwood restoration is at the forefront of timber management in Tennessee, each section and subsection below within the Silvicultural Systems section describe how that particular practice could be used within the framework of either rehabilitation or regeneration.

5.3.6. Fire Management

As with any forest habitat, especially in the South with frequent lightning strikes in the summer, Tennessee forests are susceptible to wildfires. Tennessee averaged approximately 1,123 wildfires per year, which collectively burned greater than 270,000 acres of forestland from 2007 to 2019 (FAP 2020). Primary sources of these wildfires are debris burning that escapes control as well as other human sources such as powerlines, smoking, campfires, and other various means. TDF has instituted measures to attempt to combat these wildfires, including the regulation of outdoor burning from October 15 to May 15 as well as the Tennessee Department of Agriculture's Agricultural Crime Unit aggressively enforcing wildfire laws.

Wildfire is also a significant part of Tennessee's natural environment, with some ecosystems and forest types that have adapted to fire and are dependent on it for their existence. This is commonly accomplished through use of prescribed burns that mimic this natural fire regime. Every year in Tennessee, nearly 45,000 acres of forest in the federal, state, and private sectors are burned for the purpose of landscape management.

Recently, certain factors have increased both the threat of wildfire within Tennessee forests as well as potential severity. Residents are currently building homes closer to forest edges due to the movement from cities, creating a wider Wildland-Urban Interface (WUI). Urbanization of previously forested land, increasing levels of forest fuels, and certain restrictions that reduce the use of prescribed burning all contribute to wildfires having an even greater potential to negatively impact Tennessee forests. Issues related to this increasing level of WUI taken from the 2010 FAP include:

- Pressure to reduce debris burning in suburban and rural environments.
- The increasing value of homes, which results in larger expectations for fire protection services.
- Increasing the need to include Firewise USA® principles in planning and development of new and existing communities.
- Improved collaboration among groups and agencies to resolve issues of common concern.
- The growing need for fire prevention education of citizens.
- Continuous monitoring of fire ordinances and laws for effectiveness.
- Pressure from interest groups to expand or restrict the use of controlled burning.

In response to WUI expansion, TDF encourages communities to adopt Fire Adapted Community concepts and associated Community Wildfire Protection Plans (CWPPs). CWPPs analyze each community's issues within the WUI and propose strategies for mitigating them. Upon completion of a CWPP, Tennessee communities are eligible for national recognition through the Firewise USA® program. Firewise USA® educates homeowners to reduce their wildfire risk. As of 2020, 29 communities across 12 counties within Tennessee had achieved designation as Firewise USA® communities. Additional information concerning Firewise USA® in Tennessee can be found online.

The 2020 FAP further expounds on this focus of protecting urban communities from the impacts of fires that originate in the forests or wilderness of Tennessee. In examining fire patterns within the state, significant areas of at least moderate WUI risk classifications exist across Tennessee with dense pockets of high risk evident in eastern Tennessee's mountainous terrain. In that region, firefighting activities can be difficult and more costly due to topographic challenges. The FAP outlines multiple strategies and actions to improve wildfire protection within Tennessee communities.

Strategy 1. **Develop and implement fire management activities to reduce the frequency and severity of wildfire.**

Action 1. Develop and implement new strategies, programs, and tools for management of forests within the wildland-urban interface to mitigate risks associated with wildfire.

Action 2. Invest in strategic communication and marketing plans promoting the benefits of wildfire hazard mitigation.

Action 3. Support technological advancements and opportunities to collect and analyze the naturally dynamic impacts of treatments to natural resources, communities, and important infrastructure.

Action 4. Garner political and financial support in recognition of current state and future needs for securing the necessary resources for on-the-ground treatments and information/outreach.

Action 5. Solicit multi-disciplined, multi-agency support for collaborative approaches to protect communities, natural resources, and important infrastructure.

Action 6. Invest in organizational expansion to manage increasing workforce demands.

Action 7. Develop a framework for a regional and state-based wildfire hazard mitigation council to address landscape-level mitigation issues affecting Tennessee citizens.

Action 8. Encourage at-risk communities to engage in community-level fire prevention planning.

Action 9. Educate state and local planning officials on development issues within the wildland-urban interface.

Action 10. Partner with the Tennessee Emergency Management Agency (TEMA) to identify grant programs and funding resources to prioritize and support wildfire mitigation project proposals statewide.

Strategy 2. **Improve community wildfire resilience through Fire Adapted Community activities.**

Action 1. Improve community hazard risk awareness by utilizing the Wildfire Risk Assessment Portal, which will provide a standard risk assessment.

Action 2. Use risk assessments to develop additional CWPPs statewide.

Action 3. Leverage federal hazard mitigation program funding in collaboration with partners to update hazard mitigation plans, identify disaster-risk reduction opportunities, and implement hazard reduction projects, which will reduce risk to vulnerable communities and landscapes.

Action 4. Work with homeowner associations, community groups, and homeowners to identify and mitigate home ignition hazards.

Action 5. Identify and work with communities to update CWPPs that are five years old or older.

Strategy 3. **Improve and increase emergency responder capacity in priority communities.**

Action 1. Continue to provide cost-share programs that pay for equipment to boost first responder resources.

Action 2. Partner with the local fire departments to map out response radius to identify gaps or overlaps in first responder zones.

Action 3. Collaborate with fire departments, TEMA, and other organizations to provide annual wildfire prevention and suppression training.

Action 4. Organize and execute annual training drills that simulate wildfire deployment actions from a multitude of emergency response agencies.

5.3.7. Climate Change

A significant issue identified through collaboration with various Tennessee forest professionals and stakeholders is the effects of climate change on Tennessee forests. Climate change in the upcoming years could significantly impact the amount of carbon sequestered by forests, water quality and quantity, species distribution within forests, and the loss of forested land to catastrophic wildfires (Tennessee Forest Resource Assessment 2010). It is predicted that all of Tennessee's ecoregions could be impacted by climate change due to the loss of biomass from tree decline and mortality through the year 2100.

While forests have historically adapted to increasing temperatures (3.6 to 5.4-degree Fahrenheit increases over several thousand years), the prediction for the coming century involves temperatures potentially rising 2.7-10.4 degrees in just that period (Shugart et al 2003). It is anticipated that managed and natural forests may respond differently to these increased temperatures if they respond at all. If temperatures change significantly enough, species will either have to adjust to the new normal conditions, move generally northward, or go locally extinct (Woodward 1987). Some of the forest responses could be earlier leafout and flowering as well as a change in the distribution of plant and animal species (Cayan et al. 2001, Chmielewski and Roter 2001, Kelly and Goulden 2008). The primary abiotic limiting factors on forest productivity are temperature, water availability, and radiation. Any climate change and its effect on forests will depend on fluctuations in one of these factors, with the results still unknown (Backlund et al 2008).

Water quality and quantity could be altered by increased temperatures and a change in the amount of carbon dioxide. Increased temperatures will cause increased soil temperature, increased evaporation, and therefore possibly more arid soils. This alteration may cause species to migrate north where conditions are more favorable. Also, stream temperatures may have already risen in some western U.S. streams, leading to a decreased dissolved oxygen value and decreased water quality from heightened aquatic flora growth (Backlund et al 2008).

Climate change may also increase the potential for large wildfires due to increased temperatures and possible reductions in available water capacity. Forest fire seasonal severity has the potential to increase from 10 to 30%in the coming decades (Backlund et al 2008).

Climate change in Tennessee may have a significant effect on forest species as well (Tennessee Wildlife Action Plan 2010). It is anticipated that terrestrial forests would experience a mixed reaction to climate change. Drought-tolerant habitats (glades, dry upland forests, open woodlands, and savannas) may actually fare better as temperatures increase in the future. However, terrestrial mesic and bottomland forests would be at greater risk species alteration as the temperature increases and precipitation decreases. Species may be forced to relocate or adapt to the changing habitat conditions. One strategy for trees may be to move northward in latitude and upward in elevation due to these anticipated rising temperatures (Woodall et al. 2009).

The changing species compositions in Tennessee's forests may also affect the forest products that the forest can sustain. If oaks are more affected by climate change than maples, the type of products produced from hardwood forests can dramatically shift and foresters and landowners must prepare to adapt their management. The change in pine forest composition within the state is harder to predict. While warmer temperatures could allow loblolly pine to become more prevalent within Tennessee, the potential for pests such as southern pine beetle rises as well, and infestations could intensify by a factor of 2.5 to 5 (Gan 2004).

TDF has made it a priority through the FAP to ensure that the state responds and adapts to climate change. To aid in these endeavors, TDF has created various strategies.

- Goal: Respond and adapt to climate change.
  - Strategies:
    - Improve ecological health by establishing connectivity between local, state, and federal public owned properties where practical.
    - Stop and reverse the spread of non-native invasive pests in urban and rural areas.
    - Support research for measuring impacts of climate change on forestland and adapt management strategies accordingly.
    - Build awareness of the possible effects to forests as climate change occurs.

5.3.7.1. Carbon Sequestration

Along with the many other benefits provided by forests, forest habitat can also provide the important climatic benefit of carbon sequestration. Carbon sequestration is the trapping and storage of atmospheric carbon dioxide by trees and is viewed as essential to offset the carbon dioxide produced by burning fossil fuels (i.e., manufacturing, car emissions, etc.). Forests can also improve air quality by removing pollutants and reducing energy usage, which can further reduce the amount of carbon pollution from utility companies. As climate change continues to impact our world, monetizing forest carbon through private landowner participation in the sequestration market provides the opportunity for landowners to make money while benefiting society. As a majority of the land within Tennessee in particular, and the South as a whole, is privately owned, there is the potential for private forest owners to create a sizeable impact through their actions. If landowners can be financially compensated by retaining forests on their property (earning monetary carbon credits), they will be more likely to resist their lands succumbing to future development. Active forest management and carbon sequestration projects can exist in the same forest. In fact, actively managing a forest for healthy, productive trees improves its ability to sequester carbon.

While forests are the most efficient natural carbon sink (absorber), carbon sequestration doesn't end with private landowners and their forests. Urban forests can help in the carbon market by cooling the urban environment, reducing the amount of energy (carbon dioxide emission) required for cooling energy, as well as absorbing and storing carbon produced in these urban areas. TDF estimates that energy saved through tree shading (avoided carbon emissions) totals $3.7 million annually across the state.

6. Landowner Objectives

6. LANDOWNER OBJECTIVES

Forest management objectives generally fall into two primary levels of classification: Landowner objectives and landscape level objectives. Landowner objectives are those considerations important to a landowner. Achievement measures the relative success or failure of the management in their perspective. These objectives can be used by forest resource professionals to provide, design, and implement services important to the landowner. Landowner objectives are often easily determined because they are common to all forest types (e.g., aesthetics and recreation). Landowner objectives may also change or adapt after becoming aware of landscape level objectives.

Generally following the determination of a landowner's objectives, forest resource professionals can identify the landscape level objectives that the landowner's objectives support. Landowner and landscape level objectives can be the same (e.g., hydrologic protection and conservation) or provide opportunities to support and enhance each other. For example, a landowner may consider their primary objectives forest health, wildlife management and ecological restoration. Through forest management activities to promote these objectives, the landowner could also be supporting landscape objectives like wildlife habitat management, rare plant and animal protection, non-native and invasive species management, and in some cases utilization of prescribed fire and hardwood enhancement. Another helpful exercise in determining landowner objectives is to examine a time span for the objectives and how this time will affect goals for managing the land. Longer-term goals such as managing for a timber harvest may require different considerations than short-term goals such as removing a patch of invasives on the property.

A general description of each potential landowner objective is discussed relative to its application towards forest management. Each landowner objective is also discussed relative to its application within each forest type in the Common Tennessee Forest Types Section.1

6.1.1. Aesthetics

Landowners seek a certain look and feel from the visual appearance of their forests. Forest aesthetics spark a sense of personal landowner pride, stewardship, privacy, and even adventure. Many landowners maintain and enhance their forest aesthetics for their family, community, neighbors, and passers-by to enjoy. Forest management activities that are consistent with the size of the forest, the scale and intensity of forest management activities, and the location of the property tend to increase the aesthetic value.

Forest resource professionals can assist landowners with implementing and managing silvicultural practices to increase aesthetic value of the property. Over the course of time, a wide range of aesthetic objectives can be accomplished with the suite of silvicultural tools within this LMP. Even though many silvicultural tools may produce immediate and temporary results that decrease aesthetic value, the consistent application, and long-term results of these operations produce enhanced overall aesthetic value of the forest. For example, the short-term visual conditions produced following a prescribed fire may have minimal aesthetic value, however the resultant functional and aesthetic changes in species composition and midstory and nuisance species control becomes evident in just weeks following the burn. Furthermore, the aesthetic condition of consistently burned forestlands increases rapidly with each subsequent prescribed fire event. Likewise, the long-term aesthetic value gained from performing timber thinning operations far outweigh the short-term optics following

harvesting operations. Landowners are rewarded with a sense of pride when their hard work and investment in management activities results in aesthetic accomplishments.

6.1.1.1. Hardwood Forest Aesthetics

Hardwood forests have high quality, varying aesthetics across different forest types. The overstory diversity of hardwood forests provides character and variety compared to pine-dominated forests. While upland slope forests and mountainous peaks in the BR and R&V ecoregions provide relatively steep topography and vegetation that are common to areas far north within the United States, the aesthetic qualities of mixed floodplains mainly exist in the rivers, creeks, and streams that punctuate mixed floodplain forest types' overstory diversity and uneven-aged structure.

Tupelo-cypress mixed forests have their own high-quality aesthetics, with a unique form from buttress-based stems and cypress extending knees from their roots. They are often draped with Spanish moss. This gives them a pleasantly eerie and prehistoric look that is quite unique across the landscape. Cypress is one of the few deciduous conifers in the world and turns a stunning auburn in the fall before dropping needles. Swamp tupelo also changes to red in the fall, providing an even more dramatic splash of color.

Most uplands in Tennessee are hardwood-dominated forests that are natural, uneven-aged, and possess a lot of character. These aesthetic characteristics lure landowners into excluding silvicultural management in these forests, especially those presently in a desired future condition. Thus, upland hardwood forests are often treasured for their regionally unique character and beauty.

Silvicultural systems can be used to maintain and enhance aesthetics. Forest operations should be planned with aesthetics in mind to ensure these objectives are met. For example, when clearcutting hardwood stands, a strip of hardwoods can be left as a buffer against adjacent high visibility areas such as roadways or neighboring homes. These forested strips can be managed as an even-aged forest on a cutting cycle that ensures the adjacent stand they are buffering is forested before they are clear-cut, or they can be managed as an uneven-aged forest and passively managed on the same cutting cycle as the even-aged stand they are buffering.

6.1.1.2. Pine Forest Aesthetics

Well-managed pine forests often meet some landowners' objective for aesthetics. Mature stands that have been prescribed burned or thinned have an open, park-like structure with large, well-formed pines and little-to-no midstory. Stands with native groundcover typically have lush green grasses, herbaceous plants, and shrubs in the spring following prescribed fire and a sea of wildflowers in the fall. Young stands with quality groundcover managed with the LMP's appropriate silvicultural tools have the potential for the same stand structure and aesthetics with time.

Silvicultural systems can be used to maintain and enhance aesthetics. Forest operations can be planned with aesthetics in mind to ensure these objectives are met. For example, when clearcutting a pine stand, a strip of pines can be left as a buffer against adjacent high visibility areas such as roadways or neighboring homes. Or during thinning operations, logging decks can be placed within the stand interior, away from roadways. These forested strips can be managed as an even-aged forest on a cutting cycle that ensures the adjacent stand they

are buffering is forested before they are clear-cut, or they can be managed as an uneven-aged forest and passively managed on the same cutting cycle as the even-aged stand they are buffering.

6.1.2. Forest Health Management

Maintaining and promoting forest health is a primary landowner concern and objective. Many landowners not actively managing their forests initially contact a forest resource professional regarding forest health issues.

Various cost-share programs, grants, and services aid Tennessee landowners in taking preventative measures to avoid devastating outbreaks and infestations. Silvicultural systems such as timber harvest, prescribed burning, and non-native invasive species treatments are also available to landowners to improve forest health.

Non-native invasive species such as tree of heaven and feral hogs can cause significant ecological and economic damage to Tennessee forests. Native forest pests such as southern pine beetle are also a potential threat. Several native diseases, such as fusiform rust and pitch canker, and non-native diseases, such as oak and laurel wilt, also cause damage across multiple forest types. These pests and diseases as well as others known to affect Tennessee forests will be addressed by species type for pines and by hardwood grouping. Additional information concerning the multiple invasive pests affecting Tennessee forests can be found through the TDF Forest Health webpage. While the following sections provide a short background of major issues, the referenced source is the best resource for additional information.

6.1.2.1. Hardwood Forest Health Management

Common issues with hardwood forest types in Tennessee are insect defoliators, insect borers, and certain fungal and bacterial pathogens. The most common defoliators of trees within Tennessee are spongy moths (formerly known as gypsy moths) and their caterpillars, canker worms, and forest tent caterpillars. These insects commonly appear in early spring just after leaf formation, and generally just cause a loss of growth for that growing season. Mortality sometimes occurs on the weakest trees when defoliations occur in consecutive years. Canker worms are usually found with the Piedmont ecoregion or west and rarely impact more than a few acres. Spongy moths feed on leaves from a wide variety of different hardwood species, such as oak, hickory, beech, birch, and willow, and can eat 60-100% of a tree's leaves. While spongy moths do not currently have established populations within Tennessee, extensive monitoring for this pest is necessary to prevent significant damage from large-scale outbreaks in the future. Forest tent caterpillars are native throughout the United States and are usually found in the bottomland hardwood forests located in the ecoregions west of the IP and can defoliate thousands of acres. Management of insect defoliators varies depending on pest and infestation level. On a small scale (for yard trees or culturally important trees) pruning of infested branches or properly timed insecticide application can be effective. On a large scale in a managed forest setting, pruning and chemical treatment is often impractical, so promoting tree vigor through proper silvicultural techniques is important in protecting against defoliators.

Within the insect borer category of pests, a major threat to natural communities within Tennessee is the emerald ash borer (EAB). This species is described in Section 5.3.2 Non-Native and Invasive Species (NNIS) and Nuisance Species Management. Additional threats within this class of pests are the two-lined chestnut borer and granulate ambrosia beetle. The two-lined chestnut borer is a half-inch long slender black beetle that lives under the bark of oaks or chestnuts in long cylindrical tunnels. Adults of this species typically attack oaks already declining or weakened by drought or stressors. The granulate ambrosia beetle is even smaller, approximately

the size of the date on a penny. It bores into a variety of hardwood species, leaving behind toothpick-like protrusions of sawdust from bore holes. Leaving these trees untreated can lead to wilting, branch dieback, reduced growth, and often death. The University of Tennessee Extension provides further information concerning this species.

Laurel wilt is primarily a fungal disease of the laurel family (*Lauraceae*), which includes such Tennessee species as sassafras (*Sassafras albidum*) and common spicebush (*Lindera benzoin*). Infected trees will eventually have their water conducting tissues blocked, causing their leaves to abruptly wilt soon after leaf formation in early spring. It can only be slowed by actions such as limiting transport of firewood. This disease will likely eventually eliminate most red bay trees in the coastal southeastern United States and will greatly affect Tennessee species as well. The fungal disease typically starts from a wound caused by an insect (usually its main disease vector the redbay ambrosia beetle) or equipment, but once started, it likely transmits from tree to tree via root grafts. If the bark of infected trees is peeled back, dark blue or black staining of the water-conducting tissues can be seen and can be characteristic of this vascular wilt disease. Suspect oak wilt, a similar disease that affects oaks instead of the laurel family, if young, healthy red oaks are suddenly dying. Sanitation and severing root grafts with a vibratory plow are two methods used for its control.

Thousand cankers disease is a pathogen that destroys the black walnut tree (*Juglans nigra*). In Tennessee, these trees are commercially important due to their nut production and their wood, which is used in various products. The disease is spread to a tree through its injection from a small twig beetle as it burrows into the cambium tissue. Repeated fungal infections by multiple beetles kill branch and trunk tissue over time, usually within two or three years of the first infection. As cures for thousand cankers disease have yet to be identified, the early detection and removal of infected trees is the primary method to manage the disease. Other prevention measures endorsed by the Tennessee Department of Agriculture include sourcing local firewood , not moving firewood outside the state, and monitoring local walnut trees for signs of infestation or distress.

Sudden oak death (SOD) is an emerging concern for Tennessee, as it was first reported in California in 1995 and was spread to Georgia through the transport of camelias in 2004. Out of a total of 59,000 potentially-infected plants that were shipped to Georgia, 49,000 were sold before Georgia was aware of the disease's presence (Georgia Forestry Commission 2019). Due to this shipment, SOD has now been positively identified in 17 nurseries throughout Georgia. SOD is a fungus, *Phytophthora ramorum*, that causes a bleeding canker on the tree's side which continues to grow until eventually girdling the tree. This girdling eliminates the tree's ability to transport water from the roots to the crown, which can cause leaf spot and twig dieback. Of the oaks present in Georgia, it has been shown that red oak and pin oak are particularly susceptible to the fungus. The Georgia Forestry Commission is continuing to sample native vegetation surrounding suspected nursery sites and no native plants have yet to be infected within Georgia. However, Tennessee is listed as having a severe risk of sudden oak death (Kelly et al. 2004). It is important that landowners assist in the early detection of this disease to prevent spreading, as there is no effective treatment to cure affected oaks. Also, it is necessary to ensure that any nursery-grown saplings used for replanting are sourced from certified nurseries.

An additional emerging insect threat to Tennessee forests is the spotted lanternfly (*Lycorma delicatula*). This species has been found in Virginia and other states that border Tennessee. While the lanternfly can feed on a variety of tree species, including many important to Tennessee, fruit trees and vines such as apples, hops, and grapes are catastrophically affected. Larvae feed by sucking the sap from host trees, while the adults tend to focus on the previously mentioned fruit trees and vines. Adults also secrete sticky fluid when feeding, which

can cause mold to form either on plants or in the soil beneath (USDA APHIS Pest Alert). The spotted lanternfly is limited in how far it can move on its own through flight. However, infected wood or items containing their masses can spread these Pest greater distances.

Two other looming threats to Tennessee forests are the Asian longhorned beetle and the gold-spotted oak borer. While these species are not currently found throughout Tennessee, their presence within the state in the future could be catastrophic to the hardwood population. Further information on the Asian longhorned beetle and gold-spotted oak borer can be found at these sites, respectively:
https://nyis.info/invasive_species/asian-longhorned-beetle/
www.nps.gov/yose/learn/nature/upload/pest-oak-borer-alert.pdf.

Despite potential insect and disease threats, with appropriate seedling and site selection and release and thinning regimes, hardwoods generally have minimal issues following successful establishment.

If any forest diseases or pests are suspected, contact TDF for a consultation.

6.1.2.1.1. Degraded Hardwood Restoration

In Tennessee, the majority of forests encountered are composed of hardwoods that over time have become degraded in some manner or fashion. A major factor in this hardwood forest degradation is the historically limited market for small, low-value trees; larger trees have been "high-graded" out of the stand selectively, with the incorrect assumption that the small trees remaining in the stand will replace the larger trees removed as the next round of merchantable timber. In reality, the remaining trees were likely the same age as those harvested and will now never reach that level of quality due to a lack of competition producing smaller crowns and overall weaker trees. Further, measures are not taken toward stand improvement in the interim following the harvest. Degraded hardwood stands may also be due to the result of fire, insect, or disease damage, or a poor choice of site for the stand, not just anthropogenic mismanagement. A cycle of mismanagement has produced degraded hardwood stands that are a mixture of degraded remnants of previous harvests, a certain amount of desirable species regrowth, and a large contingent of smaller shade-tolerant trees that are not desirable for timber production and crowd out young target tree species (Clatterbuck 2006).

In the wake of this silvicultural mismanagement, degraded forest stands are prevalent throughout much of Tennessee. The effort and cost required to restore these stands can be great, and, depending on the current market for degraded wood products such as pallets, ties, chips, and pulpwood, may be entirely cost prohibitive for an agency or landowner. However, this issue of degraded stands is becoming more widely recognized and their product market is becoming stronger, so degraded hardwood stands have become a focal point as of late in the Tennessee forestry community.

Depending on the condition of the specific site and the objective of the landowner, there are three options for the management of degraded stands: rehabilitation, regeneration, or no action. Rehabilitation refers to the improvement of an existing stand to the point where it no longer exists in a degraded condition, while regeneration involves the creation of an entirely new stand that will have the opportunity to grow into a balanced stand. The key factor in deciding whether to rehabilitate or regenerate a hardwood stand is whether acceptable growing stock (AGS; trees of commercial value that are capable of reproducing) exists within the

current stand. If so, the stand could be a candidate for rehabilitation; if not, regeneration of the site is the best route moving forward (Clatterbuck 2006).

McGee (1982) provides a helpful checklist for first evaluating and then prescribing a treatment plan for a degraded hardwood timber stand. Depending on the option chosen, various different silvicultural systems from the ones present below in Sections 7.1-Section 7.6 may or may not be applicable. As degraded hardwood restoration is at the forefront of timber management in Tennessee, each section and subsection below within the Silvicultural Systems section describe how that particular practice could be used within the framework of either rehabilitation or regeneration.

6.1.2.2. Pine Forest Health Management

The most destructive insect pests to loblolly pine are southern pine beetles (SPB), Ips beetles, and black turpentine beetles (BTB). Loblolly is the preferred host for SPB. It is usually not a significant issue in younger, well-managed stands. However, damage can be severe in overstocked and senescent stands, especially if other stressors occur (i.e. drought, lightning strikes, fire stress). Once a severe outbreak occurs, it can spread to adjacent, well-managed, younger stands. Outbreaks are cyclical and range from a few spots across a stand to hundreds of acres. Pine sawflies are also a major defoliator of loblolly pines, capable of causing the complete loss of foliage on small trees. Ips beetles and BTB are less aggressive and cause damage on an annual basis, usually following summer drought, and their attacks rarely exceed more than 3/10th of an acre. Ips beetles and BTB are typically secondary pine pests and can colonize trees that have already been weakened by previous SPB infestations. SPB and Ips beetles both carry spores of and can be a vector of a blue stain fungus that clogs the tree's water conducting tissue, making most attacks along the trunk lethal. BTB does not have the lethal blue stain fungus and pines can survive after being attacked.

Maintaining health and vigor among your pines is the most economical way of reducing loss from bark beetles. Pines exhibiting these qualities will have plenty of room and resources to grow, have 33-40%live crowns (crown length/total tree length), and are free of disease along their trunks. Foresters sustain these attributes in pine plantations by removing pines that do not exhibit these qualities while retaining pines that do. Suppressing understory competition can be just as effective at increasing pine health and vigor as thinning. Foresters control this competition in pine plantations through prescribed burns, herbicides, or thinning by machine or hand. Those practices ensure resources are available for the pines that can most utilize them, and that there is enough internal water pressure/turgor to drown attacking beetles, even during times of environmental stress.

Pitch canker and fusiform rust are fungal diseases affecting pines and are most problematic when affecting the main trunk, disrupting the uptake of water and nutrients, and causing increased susceptibility to a bark beetle attack. Pitch canker is known for its heavy resin exudation and affects all pine species throughout Tennessee. Fusiform rust is known for its galls that create a weak spot along the trunk, which continues to grow with the tree and produces orange spores every spring. This rust also increases the tree's susceptibility to wind damage. Resistance to both diseases is being developed in planting stock with much success.

The most detrimental disease to shortleaf pine is littleleaf disease. Littleleaf can be identified through the yellowing of needles and the appearance of needles bunching unnaturally at twig tips, as well the tree's production of excessive cones as a stress response to the infection. Infection is common on poorly drained sites, on nutrient-poor soils, and following root damage and drought. Littleleaf mostly occurs in 30 to 50-year-

old stands and seldom in stands younger than 20 years old. It can result in slow growth and high mortality. Proper shortleaf pine site selection and appropriately timed thinning or clearcutting can reduce chances of infection with littleleaf.

Tip moths, pine sawflies, and pales weevils and pitch-eating weevils can be problematic in young pine stands. Tip moths damage the terminal shoots on young pine seedlings, which can result in loss of growth and deformity of the tree. Pine sawflies are a major defoliator of young pine saplings, capable of causing the complete loss of foliage on small trees. Loblolly pine sawflies attack shortleaf pine. Pales and pitch-eating weevils usually cause issues in newly planted stands if planted too soon after harvest. Reforestation of stands harvested after July should not be done the next planting season or, if done, should use seedlings that have been treated with insecticides.

Loblolly and shortleaf pine cannot tolerate prescribed fire until the bark thickens, and they reach 10 to15 feet tall, depending on fuel load. Loblolly pine forests may be burned with prescribed fire every two to four years to maintain and restore the natural communities in which it is dominant and to enhance wildlife habitat, improve aesthetics, reduce vegetative competition, reduce fuel loads, and stimulate rare plants. They are susceptible to crown and inner bark scorch, especially in younger stands.

Despite these potential insect and disease issues, with appropriate seedling and site selection and release and thinning regimes, pines generally have minimal issues following successful establishment.

If any of the aforementioned diseases or pests are suspected, TDF should be contacted for a consultation. See the non-native invasive species section for additional information about threats to Tennessee forests.

6.1.3. Conservation

For this LMP, conservation is defined as the process of maintaining a natural resource or forested ecosystem for perpetual use. This definition inherently associates conservation with the proper use of ecological processes to maintain the forested ecosystem. The term conservation is generally credited to Gifford Pinchot, who served as President Teddy Roosevelt's head of the U.S. Forest Service in the early 20th century (Trefethen 1975).

Some landowners have a conservation objective because they would like to see their forest ownership remain intact and capable of being passed down from generation to generation. Landowners with a conservation objective may also consider other consumptive-use objectives like revenue generation or hunting and fishing recreation.

Conservation and legacy planning are both founded upon the desire to ensure future use of a natural resource. Many landowners seek to achieve a balance between conservation and legacy planning objectives by utilizing silvicultural tools to mimic ecological processes (conservation) and restricting human activities outside their interests (legacy planning).

All forest types can be managed in a conservation-oriented manner. This can be accomplished using multiple-use management by balancing utilization and protection of timber, wildlife, rare plants, recreation, and hydrology.

Many pine forests and some hardwood forests are fire dependent and require frequent application of prescribed fire or a herbicide treatment for ecological maintenance. Few hardwood forest types are fire dependent, although some may benefit from fire-related management techniques.

Managed sites within the forest that demonstrate a high conservation value (like FORIs or critical habitat), as well as representative areas of the forest types that are found in the forest management unit, should be identified, protected, and, where possible, enhanced. The sites may contain one or more of the following values: diversity of species, ecosystems and habitats, ecosystem services, ecosystems at landscape level, cultural values, and geologic or topographic features of value to the landowner. Conservation of the particular type(s) of forest areas found within the forest management unit is essential in protecting the forest's natural resources for this and future generations. Locating these high conservation value sites is aided by use of the LMP Geodatabase and the NatureServe Explorer (https://explorer.natureserve.org/), a GIS-based tool that provides locations of rare and protected plants, animals, and ecosystems of the United States.

Once a high conservation value site or representative forest area is located within a landowner's property, strategies, and actions to maintain these areas should follow state and federal guidelines. One component of active management may be the periodic monitoring or evaluation of the landowner strategies effectiveness. Although landowners are encouraged to conduct their own periodic monitoring of the high conservation value areas on their property, their assessments as a whole are not authoritative or effective in determining the efficacy of such measures. As the scale of monitoring high conservation value areas is quite large, the applicable local, state, and federal entities hold ultimate responsibility for this task.

6.1.4. Economic Return

Sources of forest-based revenue in Tennessee are diverse and can be derived from each forest type. Some landowners choose to balance revenue with other objectives while others prioritize revenue as their primary objective and livelihood.

6.1.4.1. Timber Management

There are strong, diverse timber markets in Tennessee, allowing landowners to manage their forest resource on short or long rotations for a wide variety of pine or hardwood products. Paper, lumber, and over 5,000 different timber-based, life-sustaining products are produced through Tennessee timber markets (Tennessee Division of Forestry 2020). This flexibility and economic potential in timber markets allows for restoration, revenue, and investment. A current timber price report by quarter is available through the Timber Update.

Landowners must always consider economy of scale in timber management. Forest landowners often retain portions of their land in natural ecosystems and habitats, where regulatory considerations, economies of scale, and silvicultural systems indicate this is the best management approach. For instance, adherence to BMP standards encourage the retention of a forested buffer along existing stream channels.

Factors affecting economies of scale are stand acreage; forest product type, size, and quality; and distance from a related forest product mill. Loggers incur costs whenever they move their equipment from one tract to another, which makes larger tracts and stands with high value forest products closer to the mill more attractive. As a result, landowners should consider having forested stands no less than 20 acres in size, and landowners

with smaller stands may need to manage timber in conjunction with another stand or with an adjacent landowner.

Timber can be sold per unit or as a lump sum sale. Most thinnings are sold as a per unit basis, where the contract states a price per ton for each product removed. Lump sum sales usually involve final harvests or stands where the take trees have been marked. The University of Tennessee Extension service has several resources available on this topic (https://fwf.tennessee.edu/timber-sales/).

There are many practices available to help with timber management including thinning, clearcutting, and natural and artificial regeneration. Even-aged and uneven-aged management can be utilized for any of Tennessee's forest types. However, uneven-aged management has a number of tenets and concerns which must be addressed to maintain an uneven-age. (Guldin et al. (1991) and information is provided by Clatterbuck, W.K., Stringer, J.W.; Tankersley, L. 2010). Uneven-aged management is usually limited to aesthetically sensitive areas or areas facing other constraints such as threatened and endangered species. The ease of implementation and various group sizes make even-aged management a common choice.

Native species are preferred in the management of wood plantations in Tennessee. Due to multiple factors, including evolutionary adaptations to endemic soils, climate, and weather-related threats, native species comprise the vast majority of Tennessee nursery stock, are required by most cost-share programs, and are the preference of local markets and mills.

6.1.4.2. Non-Timber Forest Products

Tennessee's forests provide a variety of non-timber forest products (NTFP) and uses for revenue. These are wide-ranging and include black cohosh, honey, silvopasture, forest farming, ginseng, Fraser firs, and mountain laurels. These markets can provide landowners with revenue between timber harvests or may be the main source of revenue generation from their forests (Chamberlain and Predny 2003).

6.1.4.3. Non-Forest Associated Land Uses

Some revenue-generating options should be considered with caution due to disadvantages associated with them. Forests should remain classified as forests to ensure that certification is met. The following land uses may prevent or cause loss of ATFS certification.

1. Eco-tourism through opening private land to public access for a fee
    a. Canoe, kayak, and boat rentals and tours along the many scenic waterways adjacent to Tennessee's forests
    b. Hunting leases
2. Mining for aggregate materials
    a. Sand, clay, stone, and gravel
        i. Need local permitting
        ii. Will alter local hydrology and cause ecological impacts
3. Mineral and gas leases
4. Oil, gas, and electric Right-of-Way and easement leases
    a. Can be positive or negative, depending on how the land is maintained
5. Timberland real estate

   a. May involve land development or forestry/agriculture
   b. Can conflict with ATFS and FSP Standards
6. Conversion of the forested land from a forested state (natural or plantation-style plantings) to an unnatural tree plantation containing non-native or exotic tree types.

Some instances of forests being converted to non-forested land uses are acceptable under various standards.

1. The area concerned is small (the total area to be converted to a non-forested land use is no more than 5% of the total forest management unit
2. This conversion clearly benefits long-term nature conservation.
3. This conversion causes no damage or threat of damage to high conservation value areas.

6.1.4.4. Timber Tax

No matter the reason for deriving revenue from one's forest, all landowners must consider timber taxes. The timber tax code is extensive and can be confusing for landowners whose goal is to simply manage property for periodic financial gain. These taxes are dependent on a variety of factors and situations (Wang 2018).

6.1.4.4.1. Timber Property Types

In calculating timber taxes, it is first necessary to determine the type of property in question, as this governs how taxes are determined. Properties may be classified as personal use (lands used for personal enjoyment instead of profit), investment property (lands used mainly for the generation of profit from growing timber or appreciating assets), or business property (lands that experience regular, active, and continuous timber activities to make a profit). These varying property types are impacted differently by taxes. For example, if the land is personal use and not engaged for profit, losses to trees are not tax deductible.

6.1.4.4.2. Deductions of Timber Expenses and Taxes

Timber expenses and tax deductions are calculated differently depending on the property type in question. For timber on a business property, if one is materially participating in the business, expenses such as forester, accountant, or attorney fees; precommercial thinning, firebreak maintenance, vegetation and competition control; insect, disease, or fire control; or depreciation from equipment used are all fully deductible through Form 1040. If the property is an investment, however, starting in the 2018-2025 cycle, timber expenses are no longer deductible on an annual basis and can be applied as "Carrying Charges" to the timber basis and deducted following timber sales. State and local property taxes on these investment properties are still deductible on an annual basis using a Schedule A form or can be applied as carrying charges. Also, Tennessee has an agricultural use tax exemption for farmers, foresters, or other agricultural land users.

6.1.4.4.3. Timber Basis and Depletion Deduction

Timber basis is the amount one paid for the timber when purchasing the property. If the property was inherited, the timber basis is the timber's fair market value on the previous owner's date of death. This original timber basis from these two scenarios can change as capital improvements are made to the land or as depletion, amortization, or depreciation are deducted from the timber basis (Megalos et al 2016). Certain timber management and operation expenses may be capitalized as "Carrying Charges" to the timber basis and recovered upon timber sales. Depletion deductions are deductions against the timber basis upon timber sale.

These deductions reflect the removal of timber from the property and provide a way to calculate the timber basis that remains on the property. Another type of depletion could be the loss of timber to a casualty event such as hurricane, fire, earthquake, tornado, etc. This type of depletion is also tax deductible, calculated by the difference of the fair market value of the timber immediately before and after the casualty.

6.1.4.4.4. Reforestation Costs

Reforestation costs may be tax deductible as well. Landowners can deduct up to $10,000 per year for land designated as qualified timber property. If it costs more than $10,000 per year for reforestation, the cost may be deducted over the span of 84 months (amortized). Trusts, however, are only eligible to use the amortization method. The amount deducted cannot also be expensed as a timber basis or vice versa.

6.1.4.4.5. Cost-Share Payments

Cost-share programs are of great value to many landowners, and some applications of cost-share can be excluded from your income. Part or all of a qualified cost-share payment received can be excluded from income if it was used for capital expenditure including purchases of land, timber, or equipment, expenditures for bridge or road construction, or expenses for tree planting or seeding (Jones and Jacobson 2000). Qualified federal programs that accept income exclusion are the Forest Health Protection Program, Healthy Forests Reserve Program, Conservation Reserve Program, Conservation Stewardship Program, Partners for Fish and Wildlife Program, Wildlife Incentives for Nongame and Game Species, and Environmental Quality Incentives Program. There are also multiple state programs that qualify for exclusion, depending on the state. The Tennessee Agricultural Enhancement Program (TAEP) is an incentive to avoid or minimize negative environmental and water quality impacts when conducting forestry.

6.1.4.5. Tennessee Greenbelt Law

If a landowner plans on using a farm for legitimate agricultural activities (excluding wholesaling, retailing, or processing of farm products), the Tennessee Greenbelt Law may be applicable and could save the landowner money in taxes. The law was established through the Agricultural, Forest, and Open Space Land Act of 1976 to encourage the preservation of agricultural, forest, and open space land. A property appraiser determines the actual use of the property and whether it may qualify for the Greenbelt Law. This law allows the farm to be taxed based on its current use property value instead of its development value, which is usually much higher. This stipulation enables the property owner to pay a significantly lower amount of property taxes. It also prevents development and resulting land conflicts or stimulation of land speculation. More information on this benefit can be found here: https://comptroller.tn.gov/boards/state-board-of-equalization/sboe-services/greenbelt0.html.

6.1.4.6. Long-Term Investment

Another way to generate economic return from timberland is to use the land as a long-term investment. In the past, the economic return of treating timberland as an investment has compared favorably with stocks while providing more financial stability (King 2019). The U.S. timber investment performance is monitored by the National Council of Real Estate Investment Fiduciaries (NCREIF) Timberland Index. Returns through timber investment as monitored by this index have shown that, over the previous 20 years, timberland-generated profits are nearly equal to those gained by equity investments through the S&P 500 while encountering less than half of the volatility.

There are a few main reasons that a landowner may choose to use their timberland as an investment. First, timberland value tends to rise with inflation, thereby hedging the risk of devaluation by inflation and keeping timber prices stable relative to the index. Secondly, trees continue to grow in volume over time, as well as value, completely independent of the current economic state. Therefore, if the timber market is currently in an unfavorable state, the trees can remain in the ground to retain their value until the prices become more favorable. However, postponing the first thinning of a young pine stand can have negative effects on the stand's long-term growth and internal rate of return. A third, more intrinsic, value of timberland as an investment is that the land can be enjoyed recreationally while waiting to make a profit.

Regardless of the reasons for using timberland as a long-term investment, the property must be managed properly to produce the most and best-quality timber possible. A forester can assist in the management of timberland through a multitude of forest and silvicultural management techniques, as discussed in Section 7.

6.1.5. Wildlife Management and Protection

Tennessee is rich in both game and non-game wildlife species. Many landowners are interested in managing, conserving, and protecting these species and their habitat. Simply conserving forestland is a form of wildlife habitat protection. Some landowners wish to take a more active wildlife management role by maintaining, enhancing, and restoring wildlife habitat and its components including food, cover, water, and space.

Private lands in the state of Tennessee provide valuable habitat to imperiled species such as Carolina northern flying squirrel, Northern long-eared bat, grey bat, and a host of various creek and stream fish species. Many silvicultural tools are available to maintain, enhance, and restore habitat for game and non-game species including prescribed fire, timber harvests, groundcover restoration, food plots, and wildlife openings.

The natural resource professional and landowner can make efforts to protect any imperiled species and their habitat prior to some silvicultural activities. The LMP Geodatabase and associated resources can be used to locate any known imperiled species on a property. Although not an exhaustive list, if imperiled species and/or their habitats are located, the following protection measures can be used:

- Limited mechanical entry
- Increased management activity (prescribed fire, thinning, etc.)
- Restricted pesticide use
- Residual tree maintenance
- Buffer zone establishment and maintenance
- Hunting or fishing limitations
- Signage or marking of the habitat area
- Communicate sensitive habitat/species locations in contracts and to contractors

In addition to the aforementioned protection measures, the landowner may also choose to enhance habitat where the species is known and visible. This may include removing nuisance and invasive species or, depending on the species' preferred habitat, participating in ecological restoration efforts. State and federally listed plant species are not legally required to be protected unless there is a federal funding nexus on the site or additional landowner objectives require protection. While it is recognized that protection of endangered or threatened plants may not be legally required, many landowners choose to do so as a part of their land management.

Additionally, some standards may ask landowners to take measures to protect any endangered or threatened species. Also, foresters who assist the landowners should make note of these species as a standard practice.

The natural resource professional and landowner should plan and implement silvicultural activities with regard to known and visible species and their habitats. Additionally, guidelines for the protection of certain USFWS Threatened and Endangered (T&E) species can be found through the Environmental Protection Agency's (EPA) threatened and endangered pesticide use guidelines, as well as the USFWS's Landowner Tools site. The LMP Geodatabase and associated resources can be used to locate any known imperiled species occurrences on a property. Although not an exhaustive list, if T&E species and/or their habitats are located, the following protection measures can be used:

- Institution of conservation zones or protected areas where size and location of the zones conform to national and local legislation and are sufficient to guarantee the continuing presence of the identified species. Conservation zones have been identified and marked on maps and, where necessary, on the ground in a way that is visible when entering the zone; and
- Reduced harvesting methods to protect nesting and breeding sites.

Tennessee has some of the best hunting opportunities in the Southeast in terms of acreage and game quality and quantity. Hunting and revenue from hunting leases are particularly popular landowner management objectives. White-tailed deer, wild turkey, bobwhite quail, and ducks are commonly hunted and managed. Wildlife conservation practices may include managing healthy game species populations through hunting programs and hunt leases. Revenue from leases to hunting clubs or individuals can be used to improve and protect habitat.

6.1.5.1. Hardwood Forest Wildlife Habitat Management and Protection

The hardwood forest types and their associated natural communities provide excellent wildlife habitat management and protection opportunities. Many game and imperiled species utilize hardwood forest types for mast, browse, or cover throughout the year. Game species are actively managed on private lands while non-game species are managed to a lesser extent. For effective management recommendations, resource professionals need to know the specific game or non-game species that are most desirable for the landowner.

Hunting is a common wildlife management objective in the hardwood forest types, particularly for white-tailed deer, wild turkey, and gray squirrels. Hunting leases are used to manage healthy game populations while also generating revenue to help pay for management activities such as NNIS.

Hardwood habitat objectives can be met with various silvicultural systems. For example, creating small group selection clearcuts for wildlife openings will diversify habitat and create edge. Many game and non-game species will benefit from these activities including white-tailed deer, wild turkey, and within more hydric environments, waterfowl, and wading birds such as the great blue heron.

Wildlife habitat protection objectives can be met through legacy planning practices. The more hands-off preservation approach can be used to protect non-game species in healthy, fully functioning hardwood forests. However, active management with NNIS monitoring and treatment is the minimum requirement to maintain this forest type and its habitat components.

6.1.5.2. Pine Forest Wildlife Habitat Management and Protection

The pine forest types and their associated natural communities provide excellent wildlife habitat management and protection opportunities. Many game and imperiled species can be found within pine forests. Game species are more commonly actively managed on private lands while non-game species are managed to a lesser extent. While some wildlife species can benefit from one single management technique or practice, most species have unique habitat requirements and must be managed accordingly. Identifying any specific game or non-game species that are desirable will be helpful for the resource professional.

Hunting is a common wildlife management objective in pine forests, particularly for wild turkey, bobwhite quail, and white-tailed deer. These species benefit from a frequently fire-maintained open, grassy groundcover, with low shrubs and little-to-no midstory. They also prefer a relatively lower overstory density, which helps provide more sunlight to the desired groundcover. Hunting leases are used to manage healthy game populations while also generating revenue to help pay for pine management activities or annual land taxes.

Pine habitat objectives can be met with various silvicultural systems. For example, thinning planted pine stands to a lower overstory density or creating small clearcuts to diversify habitat and create edge, generally improve wildlife habitat. Many game and non-game species native to pine forests will benefit from these activities including white-tailed deer, wild turkey, bobwhite quail, and fox squirrels.

Wildlife habitat protection objectives can be met through legacy planning practices. The more hands-off preservation approach can be used to protect non-game species in healthy, fully functioning pine forests. However, active management with thinning and/or prescribed fire at a minimum is required to maintain this forest type and its habitat components.

6.1.6. Recreation

Many landowners enjoy a variety of active and passive outdoor recreation, from hiking their woods and wildlife viewing to hunting and driving off-highway vehicles. Those who live onsite may recreate on their forests daily, others may live elsewhere and only visit during hunting season.

Pine forests, hardwood forests, rivers and lakes, flatland, and mountainous terrain are all popular recreational areas in Tennessee. The mosaic of green, seasonal blossoms, the splendor of autumn colors, and the blue skies and stark wintertime silhouettes of deciduous trees provide a scenic backdrop for a variety of recreational activities including:

- Hunting
- Geocaching
- Bicycling
- Off-highway vehicle (OHV) use
- Horseback riding
- Wildlife viewing and birding
- Camping
- Hiking
- Environmental education
- Water sports

6.1.7. Legacy Planning

Some landowners have a legacy planning objective because they would like to see their forest ownership remain intact and capable of being passed down for generations. The protection of the forested ecosystem from conversion to development, fragmentation, and/or degradation from alternate uses (e.g., mining) is a benefit of the legacy planning objective yet can also benefit the conservation objective.

Landowners who treat their forestland as an untouched preserve and do not actively manage their forest may observe changes in forest type composition more quickly due to succession to other species. However, some of Tennessee's forest types such as shortleaf pine, loblolly pine, and shortleaf/hardwood mixed, are fire dependent and at a minimum require active management with thinning, prescribed fire, release, or equivalent successional and fuel reduction measures for ecological maintenance.

Conservation and legacy planning are both founded upon the desire to ensure future use of a natural resource. Many landowners seek to achieve a balance between conservation and legacy planning objectives by utilizing silvicultural tools to mimic ecological processes (conservation) and restricting human activities outside their interests (legacy planning).

Pine forests are fire dependent and require frequent application of prescribed fire at minimum for ecological maintenance. These forests are not conducive to preservation-oriented, single-use management. Preservation of pine forests without maintenance will result in long-term succession to hardwood forest.

Some hardwood forest types are more conducive to preservation-oriented, single-use management than pine and other potentially fire-dependent forest types. However, the lack of active management and landowner engagement may cause a decline in overall forest health and productivity, as well as potential ATFS de-certification.

6.1.7.1. Filing Types

The different ownership forms in which forest property is held is important from a tax standpoint. Additionally, if the forest property is counted as a business, the type of business chosen can also affect the tax structure of the property. Non-tax factors can also influence the business type chosen, such as forest management goals, the property's size, consideration of the owner's family, and the potential income needed from the property. The final decision of which ownership form a property should take is dependent on an analysis of these and other factors. Some characteristics of selected ownership types are discussed below, while an overview of the different types available can be found through The Forest Landowners Guide to the Federal Income Tax, Chapter 12 - Form of Forest Land Ownership and Business Organizations.

Basic Ownership Types

Sole Ownership

Sole ownership is the most basic form of timber property ownership and is composed of one owner controlling every aspect of the property management. This provides the greatest amount of control over the property. A benefit of this ownership type is profit or loss from the business endeavors can be accounted separately from the owner's other income sources.

Co-Ownership

Co-ownership represents the undivided ownership of property by two or more persons. This form of ownership is often used as a simpler form of more complex business arrangements, and transfer of a co-ownership at death can often be completed easily and inexpensively. A potential disadvantage to this ownership type is that business transactions must have the approval of both parties, as one owner does not have autonomy and control. The most common types of co-ownership are Tenancy in Common, Joint Tenancy, and Tenancy by the Entirety.

Business Ownership Types

Limited Liability Company

A way that forest owners can create a preserved property to pass down through generations is the creation of a corporation including a Limited Liability Company (LLC). There are four different mechanisms to keep properties intact and in the family for future generations: family partnership, closely held S-corporation, qualified trust for conservation purposes, or an LLC (McEvoy 2003). Having forestland under an LLC reduces federal tax liability and strives to ensure that the property is less likely to be divided by heirs in the future. An LLC offers a level of flexibility to landowners, as the LLC can be dedicated to any purpose, including investment, business, conservation, or any combination of motives. LLCs can also offer the benefits similar to the three other aforementioned mechanisms for property ownership: the liability protection of a corporation, pass-through taxation aspects of a partnership, and the ability to limit ownership in the family forest provided by a closely held S-corporation. Also, LLCs can grow as a family does, as the founders of the LLC can set either fractional family membership, having more than one membership class, or having no limitations on the number of owners.

With this ability of an LLC to set membership classes to distribute responsibility within a family, it is less likely that the property will be split by heirs over time. If a property is split once, the likelihood of it being further split and developed is much greater than if the entire property remains intact under the LLC mechanism. The LLC can allow family members to share in the receipt of both tangible and intangible forest benefits, but without the strain of any one family member feeling the burden to continue the family's property legacy. In essence, the LLC treats the family not as separate entities with one member bearing the majority of the responsibility, but as a company that leaves generations to enjoy the benefits of forests with fewer hassles. An LLC also provides the added benefit of qualifying for different cost-share programs that require a single Employer Identification Number (EIN) for tax purposes.

Further information for creating and registering a business in Tennessee for property ownership can be found at the Tennessee Secretary of State website.

Partnerships

Partnerships are an association of two or more people who conduct a business for profit as co-owners. States have developed their own legality as to what constitutes a partnership. Oral partnership agreements are not considered legally binding everywhere so it is important to have all details of the agreement in writing. The contributions of the partners to the partnership do not have to be equal. Assets that enter the partnership or are purchased within the partnership become property of the partnership. Some common considerations within partnerships are unlimited liability, minors as partners, and taxation of partnerships.

Corporations

A corporation is a separate legal entity that has most of the rights of an individual, while being owned by its shareholders and governed by a stakeholder-elected board of directors. The most notable feature of a corporation is the limited liability falling to the shareholders, as legal actions against a corporation are covered through the corporate assets while shareholder assets are protected. A Subchapter S Corporation is restricted by various limitations, including the limiting of members to 100.

6.1.7.2. Forest Legacy Challenges

Estate Planning

Most nonindustrial private forestland in the United States is owned by individuals, married couples, family estates and trusts, or other types of family groups (Siegel et al. 2009). Within private forestland ownership, the estate tax structure is in a constant state of flux, presenting potential danger for estates with substantial forestland holdings. If estate planning is not conducted properly, risks such as forced liquidation of family forestland holdings or the severe fragmentation or disruption of forestland are real possibilities.

As a private forest landowner approaches retirement or faces the possibility of death, certain issues regarding the future of their land must be addressed. There are multiple costs and aspects to consider if retiring or dying with an unprepared future for forestland holdings, such as transfer costs, unexpected heirs, the continuity of forestland management, and keeping forested land from becoming liquidated or parcelized. The U.S. Forest Service developed the publication Estate Planning for Forest Landowners: What Will Become of Your Timberland? to provide guidelines for nonindustrial private forest owners concerning the application of estate planning techniques to their properties.

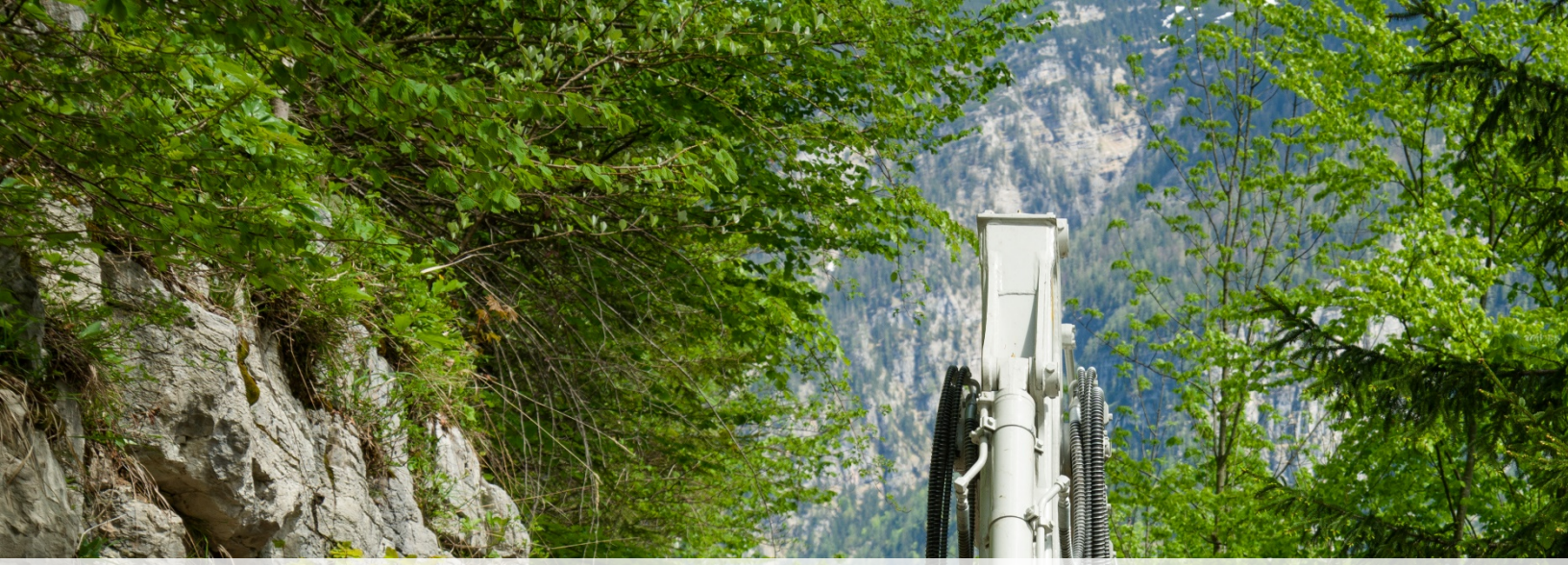
Heirs' Property

Another potential challenge when dealing with forest legacy planning is the issue of heirs' property. Heirs' property is any land or associated dwellings that are owned jointly by descendants of a deceased person whose estate proceedings were not handled in probate court (Watts Law Firm PA, 2019). After the Civil War, many former slaves purchased or were deeded land throughout Tennessee. When these lands were passed down to descendants, the property rights for many lands were passed down orally and no written contract was devised. Due to this ambiguity of ownership and lack of written contract, the land in question may be considered heirs' property.

An often-overlooked aspect of heirs' property is that the land in question does not just belong to the family that resides on or pays taxes on the land, but to all heirs regardless of their location. This creates a land management challenge, as some descendants may wish to sell their portion of the land while others may wish to maintain ownership. Further complicating the matter is each new generation further skewing the family tree. If one particular branch of the family has more descendants, they own a larger portion of the property.

The ideal solution to heirs' property issues is to have all heirs gather to discuss preferences regarding the property and to agree on how to handle the land. If the lineage of the original landowner is unknown, research must be conducted to determine each heir of the property and their share. Title to the property can be cleared by one party's renunciation of property ownership or the transfer of their share to another heir. If no agreement

can be reached among the heirs, litigation is an option. Once a cleared title is owned by a party, there is the freedom to build a home, mortgage the property, sell timber, or conduct other activities on the land.



7. Silvicultural Systems

7. SILVICULTURAL SYSTEMS

Silviculture is the art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet the diverse needs and values of landowners and society such as wildlife habitat, timber, water resources, restoration, and recreation on a sustainable basis. This is accomplished by applying different treatments such as thinning, harvesting, planting, pruning, prescribed burning and site preparation. Intermediate treatments (including thinnings and releases) are designed to enhance growth, quality, vigor, and composition of the stand after establishment or regeneration and prior to final harvest. Regeneration treatments (regeneration harvesting) are applied to mature stands to establish a new age class of trees. Regeneration methods, packaged with subsequent intermediate treatments, are known as silvicultural systems. Silvicultural systems are classified based on the practices utilized for stand regeneration. In this document we will consider two types of silvicultural systems: even-aged and uneven-aged. The science of silviculture includes a specific nomenclature to identify regeneration and intermediate treatments. Each section in this chapter attaches the classical nomenclature of silviculture to practices that apply specifically to Tennessee forests.

Silvicultural practices are available to Tennessee forest resource professionals to meet various landowner objectives and utilize forest resources. Common methods used in this region are discussed but there may be others available. One or a combination of these practices may be used to meet single or multiple objectives. Landowner objectives and budget ultimately may determine which practices are employed. As Tennessee is a diverse state with varying forest stand compositions, a majority of these silvicultural systems may be more specific to a species group (i.e., shade intolerant tree species) than others. Local contractor availability, timber and NTFP markets, project scale, regulations, site conditions, climate, the degree of planning and scheduling, and other factors also influence decisions when determining which silvicultural practices will efficiently and effectively meet landowner objectives. Before conducting a timber harvest, it's imperative to develop a forest management plan and have the timber basis established so that capital gains taxes only apply to the net gains, not the gross timber sale.

In order to meet the objectives of the Federal Clean Water Act "to restore and maintain the chemical, physical and biological integrity of the Nation's waters," Tennessee has adopted Best Management Practices (BMPs) for forestry operations. Tennessee's BMPs for Forestry are practical nonregulatory guidelines to construct roads, log landings, and skid trails to minimize the environmental impact of forest management activities. BMPs offer a flexible, preventive, and nonregulatory approach to protecting water quality during forestry operations. They are designed to be low-cost, practical, and easily applicable to all forestry operations. The Guide to Forestry Best Management Practices in Tennessee serves as a reference guide for those who work in the forest, own forestland, or are concerned about forest management practices and their effect on the environment. It is designed to assist foresters, loggers, and land managers with each aspect of BMP installation. Topics include forest road design, construction, and maintenance; special considerations for streamside management zones; timber harvesting and site preparation; and wetlands. While forestry BMPs deal specifically with practices to protect water quality, implementation of these guidelines will also help enhance and protect timber and non-traditional forest products resources, rare plant and animal species and habitat, aquatic ecosystems, and air quality during timber harvesting operations. Historical and cultural resource protection and recreation management should also be considered when planning and engaging in silvicultural operations. These BMPs

are critical to the protection of lands and the communities they support. Conversion of forestland from peatland, wetlands, and other hydric systems should be evaluated judiciously. If sites are wetlands or other hydric systems, special consideration should be taken to ensure that harvesting timber does not result in water depletion of a previously undrained soil. Tennessee's BMPs for Forestry provide guidance on acceptable activities and associated permits relative to timber harvesting in wetlands.

The descriptions of general Tennessee forest type provide information related to their respective harvest and profitability. Each forest type is examined for its preferred management method (i.e. even-aged), length of growth rotation, site suitability for commercial species, and further options beyond commercial harvesting (i.e. aesthetics, wildlife). Annual harvest levels (which may be referred to as annual allowable cut or annual yield) should be determined based on the silvicultural systems described in this LMP and should be informed by current stand conditions and other factors. Harvest rates and volumes should support forest productivity at the property and landscape level that can be sustained in the medium and long-term. In instances where there is no difference between different forest types in respect to the silvicultural practice, only the forest types that differ will be further explained.

Each silvicultural practice as detailed in this chapter's introduction may impact both timber products as well as NTFPs. As detailed in Section 7.2.3.1 Silviculture for Non-Timber Forest Products, various silvicultural tools can be used to promote certain NTFPs within various stages of forested land. If management of a forest stand involves also considering impacts to NTFPs, Assessment of Nontimber Forest Products in the United States Under Changing Condition provides various strategies to maximize the potential of success.

Before applying any type of silvicultural practice to a stand, the landowner must first understand their objectives and what they hope to accomplish with their land. This preference determines the proper combination of silvicultural activities to utilize and the timeframe to achieve the desired future condition within each separate timber stand. Landowners, in consultation with their forester, must then take stock of the current stand condition and develop a prescription to reach goals. Examples of goals that may arise through development of a stand management prescription may include regenerating desired species; controlling species composition or density; reducing susceptibility to insects, fire, and disease; protecting any potential nontimber value; or various other goals.

7.1.1. Rehabilitation vs Regeneration

The most fundamental decision in determining appropriate silvicultural practices for a specific stand is determining the need for broad management activity categories of rehabilitation (intermediate stand improvements) or stand regeneration. The majority of the silvicultural practices discussed in Section 7 can apply to one of these two situations (Marquis and Jacobs 1989). In Tennessee, most forests are composed of hardwoods that over time have become degraded in some manner or fashion. A primary factor in this hardwood forest degradation is the historically limited market for small, low-value trees; larger trees have been "high-graded" out of the stand, with the incorrect assumption that the small trees remaining in the stand will replace the larger trees removed as the next round of merchantable timber. In reality, the remaining trees were likely the same age as those harvested and will never reach that level of quality due to suppression from larger trees resulting in smaller crowns and overall weaker trees. As further measures are not taken toward stand improvement in the interim following the harvest the stand remains in a less productive, degraded condition. Degraded hardwood stands may also be due to the result of fire, insect, or disease damage, or poor site/stand

relationships, not just anthropogenic mismanagement. A cycle of mismanagement has produced degraded hardwood stands that are a mixture of degraded remnants of previous harvests, a certain amount of desirable species regrowth, and a large contingent of smaller shade-tolerant trees that are not desirable for timber production and crowd out young target tree species (Clatterbuck 2006).

In the wake of the activities described above, degraded forest stands are prevalent throughout much of Tennessee. The effort and cost required to restore these stands can be great, and, depending on the current market for degraded wood products such as pallets, ties, chips, and pulpwood, may be entirely cost prohibitive for an agency or landowner. However, this issue of degraded stands is becoming more widely recognized and their product market is becoming stronger, so facilitating diverse, competitive, sustainable forest products markets to utilize degraded hardwood stands remains a high priority in Tennessee's forestry community.

Depending on the condition of the specific site and the objective of the landowner, there are three options for the management of degraded stands: rehabilitation, regeneration, or no action. Rehabilitation refers to the improvement of an existing stand to the point where it no longer exists in a degraded condition, while regeneration involves the creation of an entirely new stand that will have the opportunity to grow into a balanced stand. The key factor in deciding whether to rehabilitate or regenerate a hardwood stand is whether acceptable growing stock (AGS; trees of commercial value that are capable of reproducing) exists within the current stand. If so, the stand could be a candidate for rehabilitation; if not, regeneration of the site is the best route moving forward (Clatterbuck 2006).

McGee (1982) provides a helpful checklist for first evaluating and then prescribing a treatment plan for a degraded hardwood timber stand. Depending on the option chosen, various silvicultural systems from the ones present below in Sections 7.1-Section 7.4 may or may not be applicable. As degraded hardwood stand restoration is at the forefront of timber management in Tennessee, each section and subsection below will describe how that particular practice could be used within the framework of either rehabilitation or regeneration.

7.1.2. Salvage

Silvicultural practices, including regeneration practices and intermediate treatments, can be used to facilitate salvage harvests after forest stands have been damaged. Salvage applications can apply to wildfires; climatic events such as tornadoes, wind events, and ice storms; and forest health issues such as southern pine beetle outbreaks.

The primary purpose of a salvage harvest is to utilize as much of the damaged timber resource as possible prior to mortality and a complete loss of merchantability. Salvage is also used to maintain or enhance forest health and aesthetics. Sometimes secondary objectives become primary or attainable following a catastrophic event. For example, restoration and recreation goals may get realigned, allowing for management accomplishments to result from what first appears to be a bad situation.

Salvage operations typically involve clearcuts but that is not always the case. A salvage operation can entail evaluating an impacted stand and thinning damaged timber while maintaining the relatively healthy trees. There can be a forest health risk involved in the determination to clearcut or thin damaged timber. This determination is situation and site-specific and should be made following careful evaluation.

Salvage harvest operations can be used in pine stands as well as hardwoods. A variety of natural and anthropogenic factors could cause the need for a salvage harvest.

7.2. Silvicultural Practices

7.2.1. Thinning

Thinnings are intermediate silvicultural practices used in Tennessee to meet various objectives such as revenue, aesthetics, wildlife, and restoration. The type and timing of thinning are dependent on landowner objectives, market conditions, and stand and site conditions. Thinnings involve stand-specific evaluations and decisions that should be made by a forester. There are also site-specific BMPs for Forestry related to thinning harvests, particularly in wetlands and streamside management zones.

- **Low thinning:** Removes overtopped trees and those in subordinate canopy positions and creates few gaps in the main canopy except when applied at high intensity. Low thinnings simulate natural mortality by cutting smaller trees that would die first. Growth is focused on trees in the upper-canopy positions.
- **Crown thinning:** Removes trees from middle and upper crown positions to open the canopy and favor the most promising dominant and codominant trees.
- **Selection thinning:** Removes dominant trees to favor smaller trees of at least reasonable vigor. Selection thinnings are utilized when dominant trees consist entirely or mostly of low-value species or have poor stem quality.
- **Mechanical thinning:** Removes trees within a fixed spacing interval, or by strips within fixed distances. Mechanical thinnings leave a residual stand of some predetermined spatial arrangement and are often arbitrary in other respects.
- **Crop tree release (free thinning)**: Favors only the crop trees, in many cases leaving the remainder of a stand unthinned. In applying a crop tree release, criteria must first be set for selecting crop trees based upon a combination of species, crown position, bole quality, and spacing interval.

7.2.1.1. Hardwood Forest Type

Thinnings in hardwood stands, regardless of type, are designed to allocate growth on residual trees to increase growth and value. While such thinnings may be used to harvest healthy, desirable trees to meet revenue objectives for a landowner, thinnings in hardwoods are fundamental in rehabilitating stands that have been damaged by previous harvests. Nyland (2006) gives four steps needed in the rehabilitation of degraded stands, with a chief component being to protect the desirable trees to be kept and promote their growth through the removal of poor or undesirable trees. This removal of trees helps to facilitate a healthier growing condition for desirable trees with less competition for sunlight and nutrients (Clatterbuck 2006).

7.2.1.2. Pine Forest Type

Regardless of thinning type, maintaining a healthy live crown ratio (crown length/total tree length) in a pine stand is a driving element to consider when deciding when to thin. Most first thinnings are done when the average crown ratio is 50% and then are maintained with an average crown ratio of 33% moving forward. Natural, over-dense pine stands greater than 20 years old with average crown ratios less than 20% should be

considered for a final harvest, since the residual trees likely will not have enough crown to benefit from the thinning. Ultimately the timing and/or need for specific products is driven by available forest markets.

Planted loblolly pine on productive sites generally requires a first thinning around age 13-15, a second thinning around age 18-22, and a final harvest beginning around age 30-32. The first thinning will usually come sooner for wildlife management and later for products such as poles and pilings, and subsequent thinnings generally take place every 5 to 7 years in planted and natural stands.

Mechanical thinnings are well suited to help manage pine stands. These harvests typically involve row thinning individually or in combination with other thinning types mentioned in the introduction to this chapter. Mechanical thinnings can take on several forms, including 3rd row thinnings (every third row removed), 5th row thinnings (every 5th row removed) each with or without additional individual tree thinning of the residual rows. Row thinnings combined with individual tree thinning of residual rows provides the greatest benefit to improving stand health, aesthetics, and growth. Thinning of the residual rows can be marked by a forester or the forester can mark a 1+ acre demonstration area to calibrate the logger to make tree removal decisions. In these situations, communicating expectations and periodic checks of the logger's work are necessary to ensure thinnings are implemented as intended.

Natural pine stands can be thinned similar to planted stands, but instead of rows being removed, strips referred to as corridors are removed. The type of thinning can impact future harvesting strategies—the closer the thinned rows are, the fewer trees will be left for the next harvest. Depending on the initial and desired residual densities, first thinnings in young, over-dense stands will usually have 12' wide corridors removed for every 12-24' wide corridor of leave trees. A 40% corridor thinning will have 12' wide corridors removed for every 18' wide corridor of leave trees. Individual tree thinnings are appropriate for second thinnings and later, or within older stands in combination with a corridor thinning. In older, sawtimber-sized stands, a standard practice is to remove 12-20' wide corridors every 50-60'. Operator select or having remove trees marked by a forester is appropriate to additionally thin corridors. Marking natural stands allows more control over residual quality. If wildlife, aesthetics, or biodiversity are primary objectives, stands should be thinned to a lower density than if economic return is the main objective. If managing for multiple uses, a moderate density can be used.

Young pine stands overstocked with natural regeneration (>1,000 stems per acre) should have a pre-commercial thinning by hand prior to age 10. The TDF's SPB Initiative offers cost-share assistance for these thinnings. For young, overstocked stands growing on productive soils and greater than 40 acres in size, a corridor thinning or fuelwood chipping at age 15-20 can take the place of a pre-commercial thinning. The economies-of-scale and available markets play a large role in these thinnings. Fuelwood markets do not currently exit in Tennessee. Such markets are available south of Tennessee and efforts are underway to develop the market within the state and to encourage out-of-state fuelwood markets to utilize Tennessee resources.

Many landowners may choose not to thin mature even-aged and two-aged pine stands when their desired future condition has been met. They enjoy the benefits of this mature stand structure, such as high-quality wildlife habitat, aesthetics and recreational opportunities. Other landowners may choose to occasionally lightly thin their mature pine for revenue, forest health, and maintaining overstory composition. See the forest health section for the risks associated with managing mature pine.

7.2.1.3. Pine/Hardwood Mixed Forest Type

The preferred practice in mixed pine/hardwood stands is to thin marked trees for removal. Due to their variable nature, marking these stands allows for more control over thinning density and stem quality. A marking guide considering characteristics for desired residual species should be developed during planning. Logger operability should be considered during marking.

Thinning from below, utilizing a hardwood pulpwood or fuelwood chipping harvest, is sometimes done in loblolly pine/hardwood mixed forests since the hardwoods are primarily in the understory. Many landowners may choose not to thin pine/hardwood mixed forests as their stands are already in the desired condition. They enjoy the benefits of this forest type's structure such as high-quality wildlife habitat, aesthetics, and recreational opportunities. Other landowners may choose to occasionally lightly thin their stands for revenue, forest health, and maintaining overstory composition.

7.2.1.4. Edge Feathering

Various thinning practices can be used to create edge feathering, a technique to create forest edges that gradually transition from forest to the surrounding habitat, especially if the adjacent land is managed land such as pasture or cropland. Within this practice, three different zones are created with each containing increased levels of thinning (75% thinned, 50% thinned, 25% thinned) moving from the forest edge into the forest (Kentucky Habitat How-To's 2019). This method of thinning creates a gradual transition from larger trees in the forest to smaller grassy vegetation, while establishing habitat for wildlife species that need brushy cover for nesting. This method is best applied to edges with a southern or western aspect that receive direct sunlight. A broader edge between forest and pasture or cropland gives more room for these species to establish a home and is a technique utilized in bird-friendly forestry.

7.2.2. Regeneration Harvests

Regeneration harvests provide for stand regeneration. Trees become established from seeds, sprouts, planting and/or advanced regeneration. Two broad categories of regeneration harvests are recognized—even-aged creates stands of essentially one age class of trees, and uneven-aged creates stands of three or more age classes. Situations where regeneration harvests apply to general forest types or forest products production are also discussed.

Even-aged harvesting practices are utilized to manage shade intolerant pine and hardwood tree species for timber and other objectives. In most Tennessee timber markets, on most soils, timber revenue is maximized through even-aged management for pulpwood and sawtimber production.

The goal of even-aged management is to create gaps of various sizes in the forest that provide full sunlight to the ground to favor the establishment of the most desirable shade-intolerant tree species. Timing of tree removal, either through one stand entry or partial removals over time, and gap size are determined by tree species silvics, management objectives, and forest products markets. Larger gaps created by one stand entry (clearcut) facilitate economic efficiencies for forest harvesting operations and favor wildlife species that require open expanses of early successional habitat. Smaller gaps (patch clearcut) and/or techniques that remove trees in several stand entries over time (shelterwood, seedtree, two-aged) are more appropriate in situations where

aesthetics are a primary management objective and favor wildlife species that require some level of forest structure to thrive.

Uneven-aged management involves cutting trees in all size classes or in small groups to achieve a preplanned distribution of diameters and to create stands with an uneven-aged structure. This method is best suited for shade-tolerant species that have the ability to regenerate and grow in the shade, such as American beech and sugar maple. When uneven-aged management is continually applied to stands containing intolerant species, composition will gradually shift to more shade-tolerant species.

High-grading and diameter-limit cutting are often touted as uneven-aged management. These abusive cutting practices of "taking the best and leaving the rest' are not true regeneration methods and are not to be construed as variations of uneven-aged management. The practices are not directed toward obtaining regeneration and cutting does not occur in all size classes to maintain an uneven-aged structure. The assumption of taking the big trees to allow the little trees to grow perpetuates the development of advanced-aged, poorly formed, shade-tolerant trees that result in a progressively less-valuable stand.

There are few commercially valuable shade-tolerant tree species in Tennessee. Most species valuable for revenue and wildlife —including pines, yellow-poplar, oaks, and hickories—range from intolerant to intermediate in tolerance of shade and require some direct sunlight for successful seedling establishment and continued development. The light available to the forest floor in the small openings created by uneven-aged management practices simply is not enough to ensure successful regeneration of the most valued tree species. Therefore, uneven-aged methods of reproduction are not recommended for most tree species in Tennessee (Clatterbuck 1992).

Regeneration harvests can be utilized for species conversion within a timber stand to meet various objectives or may reflect a change in objectives. Many pine/hardwood mixed forests were historically dominated by shortleaf pine. In these situations, clearcutting can be used to remove offsite pine/hardwood mixed stands and then replanting can follow with the appropriate pine species.

There are site-specific BMPs for Forestry for regeneration harvests, particularly in wetlands and streamside management zones (SMZ). The size and shape of harvests should be considered if wildlife and aesthetics are also objectives. Timing and seasonality are also crucial when considering harvesting in wetlands or wet upland sites. Mat logging is a technique utilized to minimize soil and hydrological impacts in these hydric forest types (Bottomland Hardwoods). Non-harvest buffers or retention strips can be used along roads and highways to reduce negative aesthetics associated with regeneration harvests.

7.2.2.1. Even-aged regeneration harvests:

Designed to remove all trees at once or over a short period of time to produce a new stand with trees very close in age. Typically leads to a forest of shade-intolerant species.

- **Clearcut – Natural Regeneration:** Removes all existing trees except smaller seedlings and saplings of desirable reproduction. Establishment of the new stand will depend on existing seed, seedlings, and stump sprouts.
- **Clearcut – Artificial Regeneration:** Removes all existing trees but the establishment of the new stand will depend on planting seedlings of desired species and spacing that meets management

objectives. While not a harvesting treatment, afforestation, or the establishment of trees on previously treeless areas or areas that have been in a non-forest use for an extended period of time, is similar to artificially regenerating a recently harvested stand. Establishing successful plantings require attention to several key elements, including proper species selection, seedling quality, proper planting technique, and short- and long-term control of competing vegetation.

- **Patch clearcut:** Cuts groups of trees in an individual stand (USDA Reforestation Glossary 2019). This method can help create varying habitat within a forest stand while promoting natural regeneration within the small openings in canopy cover (Zielke and Bancroft 1999). The small patch cuts are managed as individual stand. True patch clearcutting regenerates the entire stand through multiple entries over a relatively short period of time.
- **Two-aged:** Cuts remove most trees with a limited number of canopy trees remaining uncut. Species composition of regenerated trees will be similar to a clearcut. In many situations the residual stand is managed to ensure an older age class of trees is always on site. Regeneration of the harvested area is dependent on existing seed, seedlings, and stump sprouts.
- **Seedtree:** Cuts remove most of the trees in one cut while leaving a limited number of desirable trees to provide seed for regeneration. Seedtrees can be left alone, in small groups, or in narrow strips. The residual seedtrees can be harvested once regeneration is established.
- **Shelterwood:** Cuts utilize a series of 2 or more treatments and/or cuts over approximately 10 to 15 years. The treatments and cuts are designed to shelter desired regeneration until it has developed to the point of being able to compete with non-desirable species. After the regeneration is well established, a subsequent harvest may remove some or all the shelterwood trees. Regeneration of the harvested area is dependent on existing seed, seedlings, and stump sprouts.
- **Mid-Story Removal – Modified Shelterwood:** Takes out mid-story trees and shrubs without creating gaps in the upper canopy. The diffuse light conditions created will allow established seedlings of desirable species to increase in size while restraining development of undesirable species dependent on full sunlight for growth. Canopy trees can be harvested in one or several cuttings once desirable regeneration is large enough to compete with undesirable regeneration upon exposure to full sunlight. Depending on site conditions, establishment of desired regeneration can take 5 to 15 years. Regeneration of the harvested area is dependent on existing seed, seedlings, and stump sprouts.

7.2.2.2. Uneven-aged regeneration harvests:

Designed to periodically harvest trees of all ages to maintain a broad age class distribution. A greater number of trees are maintained in the smaller age class than in each of the next older age classes. Typically leads to a forest composed of shade-tolerant species.

- **Single Tree Selection:** Removes individual trees of all sizes during periodic cuts, creating gaps in the canopy that help other trees regenerate and grow. This method will require periodic harvests and detailed recordkeeping to ensure that the appropriate trees are left to maintain stand health and management objectives. This method tends to develop stands dominated by shade-tolerant trees.
- **Group Selection:** Removes trees in relatively small groups throughout the stand, creating gaps in the tree canopy that allow desirable trees to regenerate. Regeneration of the harvested area is dependent on existing seed, seedlings, and stump sprouts.

7.3. Regeneration

Regeneration is a core tool of sustainable forestry. Reforestation strategies come to play after a regeneration harvest is conducted (refer to Section 7.3 for types of regeneration harvests). The goal is to successfully establish tree species appropriate for the site while meeting landowner objectives. This process involves careful planning and selection of artificial or natural regeneration, species, seedlings, density, site preparation, planting method, and release. Each of these elements are dictated by landowner objectives, site conditions, current and forecasted timber markets, budget, and other factors.

The initial step of regeneration is to decide on an appropriate regeneration harvest, using the methods described in Sections 8.1.2 and 8.2.3.2. Throughout site preparation and then regeneration, desirable species should be favored while taking care to control problem midstory species.

7.3.1. Artificial vs Natural Regeneration

A selection between artificial and natural regeneration must be made during the stand and property-level silvicultural planning process. This selection is driven by landowner objectives and site-specific circumstances. There are pros and cons to each reforestation strategy.

Table 1. Comparison summary of artificial and natural regeneration methods of reforestation.

	Pros	Cons
Artificial	More productive timber management	More expensive: seedling and planting costs
	Better stand development: form, growth	Rows may decrease aesthetics during early rotation
	More control over seedling quality through improved genetics: growth rate, disease resistance, form	More heavy equipment entry required: soil compaction, effect on rare plants
	Control over planting density and spacing	
	More conducive to high production management	
	Less likely to require pre-merchantable thinning (cost)	
	Can be used for species conversion	
	Less fire exclusion time due to faster growth	
Natural	Less expensive: no seedling and planting costs	Less productive timber management
	More regeneration sources are available: seed stored in duff, advanced regeneration, stump sprouts	Poorer stand development: form, growth
	Less heavy equipment entry: soil compaction, effect on rare plants	Less control over regeneration source and quality
	Lack of rows may increase aesthetics	Less control over seedling density and spacing

	Pros	Cons
	Even-aged stands can be converted to stands with more structure (ex: two-aged stand)	Cannot control cone/seed production
	More fire exclusion time due to slower growth	More expensive: may require single or multiple pre-merchantable release thinnings

7.3.1.1. Artificial Regeneration

Artificial regeneration generally occurs after a regeneration harvest and site preparation during the following winter months between December and March. If site preparation includes chemicals, it is best not to plant too soon after application. Planting too soon after bedding or subsoiling can have negative consequences as well, since seedlings are more likely to be buried. Waiting after 2-4 inches of rainfall will allow soil settlement prior to planting. Table 1 provides a summary of the advantages and disadvantages of artificial and natural regeneration.

Artificial regeneration typically involves planting seedlings in rows that are spaced at a desired density. A spacing of 8' X 10' indicates seedlings are 8' apart within 10' rows. However, a random or natural pattern can be established with hand planting. High survival rates depend on selecting appropriate species for the site, adequate site preparation, the availability of high-quality seedlings, good competition control of other species, suitable planting method, proper care of seedlings and natural factors such as climate and pests. A seedling survival check should be conducted following the first growing season to determine if the stand was successfully established, to document initial stocking, and decide if supplemental planting is required to achieve desired stocking. To ensure a manageable stand, a minimum density of 300 trees per acre should be obtained after the first growing season.

Planting density is an important consideration and is dependent on landowner objectives, available markets, budget, site conditions, cost-share requirements, and other factors. The soil productivity, hydrology, and natural community should be accurately evaluated during artificial regeneration planning. A density is selected that meets primary objectives such as timber, wildlife, aesthetics, and recreation. If timber management is an objective, a relatively higher density may be chosen.

If timber management is not an objective, lower planting densities may also help meet wildlife, rare plant, and aesthetic objectives. However, due to tree biology and physiology, planting at too low of a density will result in aesthetic tradeoffs and a stand of short, shrub-like trees with excessive limbs. They will never develop into tall, straight, well-formed trees. A medium, balanced density that meets multiple objectives can also be considered.

7.3.1.1.1. Hardwood Species

Artificial regeneration of hardwoods is a more difficult endeavor than that of pine, but successful plantings of oak and other hardwoods is achievable through attention to detail. There are many variables that can affect regeneration success, including poor planting practices, poor seedling quality, seedling damage from animals, and the planted hardwoods' inability to deal with competition following establishment (Clark 2020). If trying to plant hardwood seedlings, it should be noted that hardwood seedlings require maintenance of a dominant position throughout stand development for survival; previous site preparation methods must have first

occurred to ready the site (Forest Practice Guidelines for Tennessee 1995). Guidelines for planting bareroot hardwood seedlings can be found through the University of Tennessee Extension's Guidelines for Planting Seedlings.

7.3.1.1.2. Pine Species

Available forest products markets should affect density. Landowners in good pulpwood markets should consider taking advantage of them by planting at a density that ensures the earliest merchantable first thinning. Spacings of 8' X 10', 10' X 10' or 12' X 12' are common in Tennessee, although other spacings may be more applicable. Landowners with small stands may want to consider planting fewer trees to postpone the first thinning, but the trees will likely be more merchantable with larger diameters and more height. Attaining 90+% survival rates with pine species can be achieved with careful reforestation planning and execution. Landowners should establish their own standard for survival prior to planting, given the site conditions. Planting a few extra seedlings for insurance towards a desired stocking density may also be worthwhile.

7.3.1.1.3. Hand Planting vs Machine Planting

Hand planting

Hand planting is the most common method of tree seedling planting used in Tennessee. Refer to Table 2 for more information on this method and a comparison with machine planting.

***Machine** planting*

Machine planting involves two main methods-- open land planting with a rubber-tired tractor or V-blade planting. Open land planting requires a cleaner site, hence more mechanical site preparation. This is due to limitations of the planting machine and the rubber-tired farm tractor commonly used to pull it. V-blade machine planting is not commonly used in Tennessee. This technique uses the same planting machine, but is pulled behind a bulldozer with a large, heavy-duty V-shaped blade that clears large debris and creates a vegetation-free strip for seedlings to be planted. V-blade planting can accommodate rougher sites and does not require as much mechanical site preparation. V-blade is essentially planting and site preparation in-one, but costs more than open land planting. V-blade planting is particularly useful on large acreages, on acreages where planting access is difficult, or where chemical site preparation methods have already been performed. On wetter sites, V-blade planting can result in planting seedlings in a trench, which can lead to high mortality and poor growth of the surviving seedlings. Refer to Table 2 for more information on machine planting. Any of these planting methods can be used to plant pine species.

Table 2. Comparison summary of hand and machine planting methods of artificial regeneration.

	Pros	Cons
Hand Planting	Less expensive than machine planting	More potential for human-caused error (i.e., J or L rooting, seedling depth and packing issues, etc.)
	Can plant rough sites without raking	Inexperienced crews require more supervision
	Experienced, supervised crews have similar quality and consistency to machine planting	
	Less groundcover impact and soil compaction	
	Easier to plant any pattern for natural look	
	Can use for under-planting thinned stands	
	Can plant any softwood or hardwood species; bare root or containerized seedlings	
	Can be used on hills and steep topography	
Machine Planting (Open land & V-Blade)	Less human-caused error (i.e., J or L rooting, seedling depth and packing issues)	More expensive than hand planting
	Generally, more consistent than hand planting	Open land planting requires cleaner site/more mechanical site preparation
	Requires less supervision	More groundcover and soil impacts, especially V-blade
	Can plant any pine species, bare root, or containerized seedlings	Harder to plant natural pattern
	V-blade requires less site preparation	Cannot under-plant thinned stands
	Ensures straighter rows for easier management	Harder to plant hills and steep topography

7.3.1.1.4. Seedlings

This section will focus primarily on artificial regeneration methods with pine seedlings. Large-scale artificial reforestation with hardwood species is less common than with pine species throughout Tennessee, as most hardwood stands are naturally regenerated. Seedling cost and management considerations often lead many landowners to use natural regeneration practices for large-scale hardwood regeneration efforts. However, hardwood and cypress seedlings are available in local nursery markets, mainly in bareroot form. The East Tennessee Nursery offers bare root hardwood and pine seedlings. Hardwoods are more commonly planted on a smaller scale, focusing on wildlife management; for example, planting white oaks adjacent to food plots to enhance hunting programs. Cypress is often planted near pond edges for wildlife or aesthetics and small-scale

wetland restoration. If hardwood seedlings are planted, it is best to plant larger seedlings as these have a faster growth rate and mast production (Clark 2020).

Containerized vs Bare Root

Containerized seedlings

Containerized seedlings are considered better quality and have increased survival rates but are more expensive. Containerized seedlings are more resilient during transport and storage and can be kept longer once lifted if properly stored in a refrigerated trailer. Loblolly, shortleaf, and Virginia pine seedlings may be available with various genetic improvements, such as growth rate, form, and disease resistance. Improved, containerized loblolly pine seedlings are more expensive than bare root and are preferred if planting budget allows.

Bare root seedlings

Bare root seedlings, in comparison, can have average lower survival rates, require immediate planting once lifted, and are very vulnerable during transport and storage, yet are less expensive. Due to the cost savings of bare root seedlings land managers are able to reforest larger areas more diversity than natural regeneration can provide. Bare root seedlings are very sensitive to warmer temperatures, dry air, and direct sunlight. Bare root seedlings can have comparable survival to containerized with proper planting technique (depth, angle, and packing), adequate site preparation, storage, and handling. For example, certain pine bareroot seedlings may fare better in excessively well-drained sands.

Whether pine or hardwood, there are steps landowners can take to achieve a higher seedling survival rate, including planting in the late fall or early winter, planting on cooler days to avoid drying of roots, storing seedlings properly and protecting them during transport to the site, treating the seedlings properly at the planting site, planting using the best method, and conducting a survival check of the seedlings once planted. Additional information on each of these aspects can be found in Mercker (2005).

Both seedling types' survivability increases exponentially if planted as soon as possible after lifting, stored in a refrigerated cooler, and/or kept under seedling tarps in the shade prior to planting.

7.3.1.1.5. Afforestation

Tennessee has a long history of agricultural production of crops like corn, tobacco, wheat, and cotton. These sectors have shifted in recent decades, resulting in land-use conversions to timber and cattle production. Many landowners' plant various pine or hardwood species on old pasture and cropland sites within the state.

Many of these sites were heavily fertilized or grazed and still contain high nutrient loads, especially those with heavy clay soils. This causes many stands to develop poor form and excessive limbs and forks. This effect tends to be localized and more severe in heavy soils and where cattle were fed. Landowners managing their pine for timber products generally are not concerned with these issues. If nutrient loads are not excessive, this can have a positive fertilization-like effect on growth rates and timber production.

Sites that were previously used for pasture or cropland require scalping and/or ripping (subsoiling) prior to beginning the afforestation process as discussed in the site preparation section.

7.3.1.2. Natural Regeneration

Natural regeneration is a system of regenerating a stand of trees using natural reproduction by the trees already existing in the stand, and typically involves new seedlings, advanced seedlings, and stump resprouts (Cunningham and Walkingstick 2016). Most species respond best to certain methods of regeneration, so research into the desired outcome of a stand is recommended before beginning the natural regeneration process (Clatterbuck 2006). Pine, hardwood, and cypress stands can be naturally regenerated to meet various objectives.

While natural regeneration is the most common method of hardwood regeneration, it can be challenging to conduct natural regeneration with oaks. If oak advanced regeneration is not present (more than four feet tall), oaks will be outcompeted by other faster-growing species (Clatterbuck 2006). This will result in oaks not being able to reach a dominant stage within the stand and future objectives will fail. This challenge is worth the risk, however, as oaks are valuable for a multitude of wood products, as shelter, habitat, and food for wildlife species, and as providers of valuable aesthetic and environmental benefits (Cunningham and Walkingstick 2016).

Existing pine stands can be naturally regenerated to meet various objectives. Some natural pine stands may have been historically high-graded and a decision must be made on whether to clearcut and start over by planting higher quality genetics or naturally regenerate and hope for the best.

The different pine species have different annual windows of seed production. Loblolly produces seed annually, usually peaking in October. Shortleaf seed production peaks in October but produces bumper crops every 3-6 years. Planning for natural regeneration of pine entails evaluating the cone crop the prior spring and carefully timed site preparation prior to fall seed catch. Natural regeneration of pine species requires careful planning and coordination.

Following are considerations on utilizing natural regeneration processes relative to the different types of regeneration harvests.

Clearcut

Pine forest types

A clearcut harvest can serve as a form of site preparation. On sites with a history of prescribed fire or light fuel loads, site preparation may simply entail a carefully timed prescribed burn. Prescribed burning in spring to early summer will prepare the seed bed by scarifying the soil, promoting seed catch. Conducting prescribed burns near seed dispersal should be avoided, as seed predation will be greater due to less groundcover. Some understory regrowth is desirable, so the seeds are not completely exposed to predators. In stands with heavy fuel loads, a single site preparation burn will likely not be adequate. Establishing a fire regime and reducing fuel loads over time can allow for a successful site preparation burn in the future, or a combination of site preparation methods can be used with prescribed fire to achieve natural regeneration sooner.

If adequate seed or seedlings will not be present after harvest, a seed tree harvest should be considered.

Hardwood forest types

A carefully timed clearcut harvest typically serves as site preparation when attempting to naturally regenerate hardwood stands. Fire applied at the beginning of an Upland Hardwood rotation can increase more valuable shade-intolerant species such as oaks. Other forms of site preparation previously discussed may also be utilized. High-graded hardwood stands can be clearcut and naturally regenerated to start over and improve timber quality and aesthetics.

7.3.1.2.1. Shelterwood

Hardwood Species

In hardwood stands that need regeneration where the most valuable species are intermediate in shade tolerance, shelterwood harvests can be appropriate. Shelterwood practices favor intermediate shade tolerant hardwood species dependent on advanced regeneration for success. Timing of successive cuts is dependent on the presence of adequate number and size of advanced regeneration seedlings.

Mid-story removal, or modified shelterwood, removes mid-story trees and shrubs without creating gaps in the canopy. The resulting diffuse light conditions favor intermediate-shade tolerant species such as red and white oak.

Pine Species

In general, pine species require full sunlight for establishment. Shelterwood harvests create more shade than is appropriate for pine establishment. White pine is somewhat intermediate in shade tolerance and shelterwood harvests can be appropriate if the over-wood is removed in a timely manner.

7.3.1.2.2. Seed Tree

Seed tree practices are appropriate for wind-disseminated light-seeded tree species. Most pine species fit into this description. Residual seed tree stocking and spacing is approximately 10-30 square feet per acre or about 10-20 trees per acre. A good cone crop is important using this method to ensure adequate seed catch. Seed trees should be the highest quality in terms of crown size, form, and health and vigor. Compared to other methods, seed tree harvests may have little value in promoting oak regeneration. Oaks have various factors such as their slow-growing seedlings and sporadic acorn production that make them poor candidates for this method. Seed tree methods are not necessary for regenerating yellow poplar. Yellow poplar seed are stored in forest litter for several years and will germinate and grow on appropriate sites when full sunlight conditions are created.

7.3.1.2.3. Group Selection

Hardwood Species

Group selection in hardwood forests can promote the establishment of light-demanding, moderately tolerant species (Forest Practice Guidelines for Tennessee 1995). Group selection is essentially a series of micro-clearcuts within a forest that creates a small area (0.25 – 0.5 acres) that will proceed in regeneration similarly to a clearcut forest (Cunningham and Walkingstick 2016). The openings provided by this type of harvest also create a mosaic of various-sized opening and habitats for a wide variety of wildlife.

Pine Species

Group selection is less commonly used to naturally regenerate pine forest types. The opening size is critical to ensure adequate seed coverage. If openings are too large, the interior portions may not regenerate adequately. Regardless, if regenerating pine or hardwood species, group selections can be conducted independently but are more commonly made in combination with a stand-wide thinning. Group selections can be beneficial to wildlife since they create edge and a juxtaposition of habitat.

7.3.1.2.4. Single Tree Selection

Single -tree selection does not create enough sunlight to favor valuable species such as oak and hickory. In turn, shade-tolerant species such as maple, beech, and elm thrive in these shady habitats and will outcompete the desirable species for resources (Cunningham and Walkingstick 2016).

7.3.2. Site Preparation

Adequate site preparation is required to achieve high survival rates and successfully establish a new stand of timber. The following methods can be used in various forest types for natural or artificial regeneration. Site conditions, landowner objectives, and budget drive this selection. Target vegetation to control includes herbs, grasses, non-crop pines, woody shrubs, and hardwood species. Site preparation is broken into three categories: chemical, mechanical, and prescribed fire. These methods can be used individually or in combination. Site preparation treatments generally take place in the spring and summer months.

Vegetative competition varies across sites and the appropriate site preparation technique(s) should be selected to adequately control it. Vegetative competition control prior to planting increases the stand establishment success. With adequate site preparation, various hardwood species, loblolly and shortleaf pine will initiate fast, early vertical growth.

7.3.2.1. Chemical Site preparation

The use of herbicides over mechanical treatments in site preparation has increased over time for a variety of reasons, including increased machinery and fuel costs, increased chemical specificity, the ability of herbicides to kill the entire root of unwanted hardwoods, and the minimal impact of herbicides on soils (UF IFAS Extension 2009). Herbicide is applied based on the recommended site preparation label rate for the target and crop species and site conditions. The appropriate herbicide and chemical site preparation technique is selected to effectively target the primary woody and herbaceous vegetative competition. Site preparation herbicide is typically applied aerially by helicopter or through ground application using the broadcast or banded techniques**.** There are site-specific BMPs for Forestry related to site preparation, particularly in wetlands and streamside management zones.

The use of herbicides in chemical site preparation offers some benefits, but also has shortcomings. Herbicides can effectively provide longer-lived control of competing vegetation, which leads to an increased economic return for the landowner. Their application usually does not affect the soil of a site, meaning that soil compaction does not occur, and the soil is protected. However, some chemical applications may be remnant in the soil for long periods and damage subsequent plantings. They can also control exotic or invasive species relatively effectively. However, there are also disadvantages to choosing chemical site preparation, with chief among them being the cost depending on the brand used. Herbicides may also present a problem if used

without caution, as surface runoff or spills can have unintended effects on surrounding vegetation. If herbicides are to be used in forestry practices on the landowner's property, all pesticide requirements and regulations must be followed. For Tennessee, the Department of Agriculture is the state authority, while the EPA maintains its national authority on pesticide use. There are also site-specific BMPs for Forestry related to site preparation, particularly in wetlands and streamside management zones.

Each herbicide has different characteristics that allow it to be used in specific situations and to target specific forms of vegetation. The active ingredient present within the herbicide has the greatest influence on the effectiveness, as it is the portion of the herbicide that negatively affects the desired vegetation (Osiecka et al. 2005). A listing of common active ingredients, along with the species targeted by the herbicide, the species resistant to the herbicide, and the proper application period can be found through the NC State 2017 Quick Guide to Forestry Herbicides Used for Softwood and Hardwood Site Preparation and Release as well as Site Preparation and Competition Control Guidelines for Hardwood Tree Plantings . It is important to consult a professional forester prior to herbicide use to ensure correct application.

Chemical site preparation techniques and application methods are varied, depending on the species present and the desired outcome of the chemical application. Herbicide labels give the types of application methods registered for each herbicide. Factors such as tract size, stand density and structure, the application rate, and the proper application timing are also essential to determine before selecting the proper herbicide (Osiecka et al. 2005). Common techniques for the application of herbicides follow this section. Also reference Manual Herbicide Application Methods for Managing Vegetation in Appalachian Hardwood Forests for the chemical composition of and application methods for various herbicides.

7.3.2.1.1. All Herbicide Spray Application Types

Broadcast

Broadcast applications involve herbicide being spread out over an entire area. This method of treatment is accomplished either through the air by helicopter, or more rarely aircraft, or on the ground through the use of machine-mounted or hand-held equipment. This is the general method utilized for site preparation but may also be utilized for conifer release or weed control.

Band

Band applications are similar to broadcast treatments in their general application method but are applied in strips or along rows of planted trees with ground-based equipment. This method is as effective as using broadcast for herbaceous weed control in young pine plantations and may also provide a significant cost savings if used properly. Annual weeds are usually more effectively controlled by this method compared to perennial weeds.

Spot

Spot applications are applied as needed to smaller areas or even individual stems, typically with hand-held spraying devices to ensure greater accuracy. If the proper species are targeted with this method, the reduction of unwanted species can be obtained at less cost. However, these types of treatments are typically very labor intensive and can only be justified as a method within areas containing a small number of unwanted species.

Directed Spray

Directed spray is a form of spot treatment used primarily for conifer release and occasionally weed control. The spray from hand-held spray units can be effectively directed only to the foliage being targeted while avoiding crop or plantation trees. In addition to spraying, herbicide can be applied through this method by wiping directly onto the target species with a wick applicator.

Basal Bark Spray

The basal bark application method involves spraying intact bark with a herbicide. This application type is best utilized with ester formulations with an oil carrier. With basal bark spraying, small stems can be treated by thinline spraying (herbicide applied in a narrow band 6-24 inches above stem base) or full basal (spray-to-wet) spraying (spraying the entire lower 12-20 inches of the plant to the point of runoff). Basal bark spraying can be done throughout the year as long as the bark is dry.

Hack and Squirt

The hack and squirt application method involves cutting or drilling into the sapwood of the tree and immediately applying herbicide to the interior of the cut. This application method is most effective for treating larger-diameter trees and requires the herbicide to be water soluble and not in an ester formulation. Hack and squirt can be done most of the year, but it is less effective before and during the spring flush.

Injection

The injection method is similar to hack and squirt, except it does not involve cutting into the tree prior to application. Herbicide in this method is injected directly into the tree's interior through use of a special device. The application timing for this method is similar to hack and squirt.

Cut Stump

The cut stump application method involves application of a herbicide to the outer edge of a freshly cut stump. This method is most effective on woody species that are known to resprout after they are cut down.

Grid Application

The grid application method involves using a grid pattern when applying soil-active herbicide to an entire area. The grid pattern and the rate of herbicide application is dependent on the soil's texture and woody species composition of the site. This method can be used for conifer release as well as site preparation, particularly on sites with a high density of unwanted woody vegetation.

Spot-Around

The spot-around application method involves the application of granular soil-active herbicide to an area around the trunks of the trees to be preserved. Herbicide application within this method can be in small spots or a small area. This method prevents woody and herbaceous vegetation from overcrowding the target tree species.

Individual Stem

The individual stem (basal soil) application method involves the application of specific herbicides to the soil directly adjacent to the stems of targeted woody species.

7.3.2.2. Mechanical Site preparation

There are many mechanical site preparation methods to choose from. Some can be used on various sites, while others have very site-specific applications. For example, there are very specific rules governing site preparation within a wetland. While the following methods can be used with establishing pine and hardwood forest types, they are more commonly used in artificial pine regeneration.

7.3.2.2.1. Bedding

Bedding is not a common practice in Tennessee but can have applicability in some wetter sites in the western part of the state. Bedding is used on flat, wet sites to elevate the roots of seedlings and promote respiration and growth. There are various bedding machines that create beds of different heights depending on the moisture level of the site. Some wet sites are difficult or impossible to successfully artificially regenerate without beds. Bedding is appropriate for timber management objectives but can have long-term negative impacts on desirable groundcover, aesthetics, and hydrology. Bedding should be oriented so surface water drainage is not blocked. Bedding machines are pulled behind farm tractors, bulldozers, or more commonly, skidding machines, depending on horsepower requirements and site conditions. Bedding is typically done during the driest months of the year, September, and October. For more information on bedding, go to: https://www.ncforestservice.gov/publications/Forestry%20Leaflets/FM06c.pdf

7.3.2.2.2. Roller drum chopping

Roller drum chopping is effective on flat to slightly rolling sites to reduce woody and herbaceous competition, but the technique is mostly used to help facilitate planting access on sites with thick competing cover resulting from 3-5 growing seasons. Chemical site preparation in conjunction with roller drum chopping will deliver the best results when compared to roller drum chopping alone. There are various sizes of roller drum choppers with various lengths of blades. The appropriate equipment is selected based on site conditions (i.e., soil moisture, topography, etc.) and vegetation size and density. Many chopping machines can be filled with varying levels of water to achieve different degrees of vegetative impacts. For example, a site with light, herbaceous vegetation may not require the chopper to be filled, while it may be appropriate to chop a heavy woody shrub site with a full drum. Choppers are pulled behind bulldozers or skidding machines, depending on horsepower requirements and site conditions.

Scalping and Ripping or Subsoiling

Scalping and ripping or subsoiling usually only takes place on old pasture and cropland sites during afforestation. Scalping peels back thick, matted turf grass, creating a vegetation-free strip to plant seedlings. Ripping or subsoiling is used in compacted soils, particularly clay. Subsoil must be at least 14” deep to improve root development.

7.3.2.2.3. Root Raking and Piling

Root raking and piling with an optional pile burn is a common site preparation method used to reduce debris for mechanical planting. Usually only large surface material is raked for silvicultural use, not stumps and roots. The piles may be left or burned, depending on objectives, budget, and burning regulations. Care and research of burning regulations should be undertaken prior to a pile burn.

7.3.2.2.4. Mowing and Mulching

Mowing and mulching can be effective mechanical site preparation in stands to be naturally regenerated, especially those with heavy fuel loads and lack of prescribed fire history. Mowing can reduce the fuel load and allow for safer, more effective site preparation burns. It can also help increase herbicide coverage through removing large grasses and herbaceous weeds.

7.3.2.2.5. Harrowing or Disking

Harrowing or disking can be used on relatively clean sites or those that have been raked or burned to create vegetation-free strips to plant seedlings.

7.3.2.2.6. Shearing

Shearing involves a heavy bulldozer equipped with an oversized V-blade or KG-blade that shears off stumps and other vegetation and debris. This material is then piled with root rakes and typically burned. This creates a very clean planting site, ideal for establishing a pine straw stand. Shearing is most often used with bedding that occurs following the site being stagnant for a long period of time. If the tractor is large enough, it can shear and bed at the same time, but most often it takes two tractors, one shearing in the front and one bedding in the rear. Shearing can also be used during groundcover restoration, converting clearcut timber to pasture or cropland, or shearing strips within thick competing cover to allow planting access.

7.3.2.2.7. Logging

Logging impacts to understory vegetation can be utilized as part of a broader site preparation plan, especially when carefully timed. In heavy fuels and understory, logging acts as an initial fuel reduction treatment that can be followed up by chemical, mechanical, and/or prescribed fire site preparation.

7.3.2.2.8. Anchor Chain or Dragging

Anchor chain or dragging is an efficient way to remove dense stands of trees and shrubs (Doerr et al 1986). This method involves pulling a heavy anchor chain (~7000 lbs.) 100-500 feet between 2 bulldozers in a V- or J-shaped loop. Steel bars may be welded to individual chain links in to increase scarification within the soil. Dragging requires high-power machinery and is not as effective on young, supple plants. This method is less commonly used in Tennessee and typically relegated to site prep following a devastating event such as a hurricane.

7.3.2.3. Prescribed Site Preparation Burn

Prescribed fire can be used solely or in combination with other site preparation methods. It is becoming less and less common to prescribe site preparation burns following mechanical and chemical site preparation in Tennessee, although in certain circumstances the practice may be helpful. Site preparation burns typically take place in the late summer or early fall once fuels have cured, and prior to winter planting.

If timber management is not an objective, a winter site preparation burn alone, and prior to planting, may be adequate to establish a loblolly stand. Survival rates will likely be lower compared to more intensively prepped sites.

7.4. Release

Different types of release are used to improve composition in young stands by removing inferior trees, thereby releasing the desired trees from competition.

- **Cleanings:** Applied during the sapling stage of stand development to remove competition of overtopping trees and favor trees of better species and quality. In cleanings, the competing trees and preferred trees are of comparable age. Generally, cleanings work best in young stands while the preferred trees still have sufficient vigor to respond to release.
- **Weedings:** Remove mainly herbaceous plants and shrubs that overtop or interfere with desirable young trees during the seedling stage of stand development. Generally, weedings are follow-up treatments on sites that develop dense herbaceous plants and shrub cover after artificial regeneration.
- **Liberation cuttings:** Often used to remove cull and unmerchantable trees that were left after a timber harvest. Removing this residual material provides for increased growth of established regeneration.

Early and mid-rotation release treatments are common in pine management and less common in pine/hardwood mixed forest types within Tennessee. Chemical, mechanical, and prescribed fire are the three primary types of treatments used to release desirable species from vegetative competition and promote timber production through increased vertical and diameter growth and good form. Target vegetation to control includes herbs, grasses, non-crop pines, woody shrubs, and non-crop hardwood species. These treatments may take place in planted or natural pine stands.

7.4.1. Chemical

Early-and-mid-rotation herbicide release treatments targeting vegetative competition are utilized where additional competition control is required. This is sometimes due to insufficient site preparation. Herbicide is applied based on the recommended release label rate for the target and crop species and site conditions. The appropriate herbicide and chemical release method are selected to effectively target the primary herbaceous and woody vegetative competition. Targeted ground applications are conducted using broadcast, banded, or spot (grid) spraying techniques with skidder, farm tractor, ATV, or backpack sprayers. Aerial broadcast applications are conducted by helicopter over larger areas.

7.4.1.1. Herbaceous Weed Control

Herbaceous weed control is mostly utilized in recently planted pine forests. In the spring just after planting, herbicides are applied over the top of pines using various methods including broadcast, band, and spot spraying techniques. Proper herbicides, rates, and timing suppresses herbaceous weed growth, while increasing pine growth and survival.

7.4.1.2. Woody Brush and Residual Undesirable Trees

Woody brush and residual undesirable trees may also be controlled using a chemical herbicide application and treatment. Selective herbicides can be used in planted pine stands. More directed techniques such as band and spot spraying, can be effective in hardwood plantings. This treatment type can be used in situations where dense woody brush establishes after artificial regeneration or over-topping residual cull and unmerchantable trees must be removed to release desired reproduction.

7.4.2. Mechanical

Early and mid-rotation mechanical release treatments targeting vegetative competition are utilized where additional competition control is required. This is sometimes due to insufficient site preparation. These treatments can include mowing, chopping, mulching, and the use of hand tools. All four actions can be used for early-rotation release with caution to avoid damaging young trees.

7.4.3. Prescribed Fire

Prescribed fire can be used as an early rotation release in shortleaf pine stands after year two, since shortleaf pines readily resprout after fire. Prescribed fire is an effective competitive management tool in pine stands beginning at year two. Broadcast prescribed burning serves as a mid-rotation release in loblolly stands.

7.4.4. Premerchantable Thinning

Pre-merchantable thinning is common in overstocked, naturally-regenerated pine stands. These treatments reduce competition and promote proper stand development. They can also be used to improve aesthetics, wildlife habitat, and forest health. Pre-merchantable thinning is costly, but the TDF's SPBI offers cost-share assistance for this practice. If there is enough material per acre, a fuelwood chipping operation can substitute and generate revenue or break even. Merchantable thinning is a release treatment in older stands and discussed in the timber harvest section.

7.5. Prescribed Fire

7.5.1. Hardwood Forest Types

Aside from the previously discussed upland pine natural community (loblolly and shortleaf pines), pine/hardwood mixed forests or hardwood forests can also be fire dependent systems. Their ecotones also burn along with their adjacent fire-dependent uplands. Burning these ecotones is crucial for the many rare species found there. Mixed forests with an adequate pine component will carry fire. Pure hardwood stands only entirely burn within narrow fire weather conditions.

Research has also shown that certain hardwood types, particularly oak-dominated communities as seen in the mountainous regions of Tennessee, can benefit from prescribed burning although they are not necessarily fire-dependent (Van Lear et al. 1999). As fire was gradually removed from oak-dominated and other upland hardwood communities, shade-tolerant species began to dominate the understory and then the overstory as disturbance allowed them access to sunlight. On better quality sites, frequent burning has been seen to create oak-favorable environments by removing shade-tolerant understory species. This creates a bare forest floor that promotes oak regeneration through burying of acorns by squirrels and blue jays and reduces soil moisture, keeping oaks at an advantage over mesophytic shade-tolerant species such as birch, maple, or hickory. Some potential scenarios where prescribed fire could benefit an oak stand include: a mature forest with no oak advance reproduction, a mature forest with abundant small oak advance reproduction, a stand with uneven-aged management, a savanna or degraded woodland restoration, or a forest in the stand initiation stage after the final shelterwood removal or clearcut,. As evidenced by these examples, the use of prescribed fire on hardwood stands is increasing in these forest management practices across the Southeast (Dey and Schweitzer

2018). A forester should be contacted before burning to prescribe the proper management technique for individual stands.

Certain factors must be considered when burning in oak-dominated upland hardwood forests. Oaks can tolerate higher-intensity burns than shade-tolerant species due to their sprouts originating deeper in the soil and greater energy for sprouting stored in their roots (Brose and Van Lear 1998). Therefore, a high intensity burn at the beginning of a stand's origination will help to favor oak regeneration. Oaks have the greatest amount of energy storage in the roots during the dormant season, making this a favorable time to conduct burns to promote oaks.

As prescribed burning within hardwood forests is dependent on a variety of factors, it is essential to consult a resource professional prior to attempting a burn. This consultation can provide further information on how and when the burn will be the most effective for a specific purpose. While prescribed fire can be a great benefit to hardwood forests, it can also cause significant damage when used improperly. Among the different types of fire injury that can occur are total tree mortality, stem top-kill, and bole wounding and decay. Even if trees are not necessarily physically harmed by burning, charring on trunks may cause timber buyers or loggers to either reject the timber or only use a portion of the tree. Both instances cause the loss of value from a landowner's hardwood timber. For additional information on the types of injury caused by fire to hardwood (mainly oak) forests, reference Dey and Schweitzer (2018).

Bottomland hardwood (BH) forest types are not fire dependent and burn infrequently, with cypress-dominated ponds slightly more frequent than gum-dominated. However, their ecotones generally burn along with the fire-dependent uplands they are embedded within. Burning these ecotones is crucial for the many rare species found there. The interior portions of BH forests generally contain thick duff and muck layers, which rarely burn. If it is an objective to reduce the understory or midstory of one of these ponds with fire, the soil needs to be moist. During drought, humic soils within BH forest types can burn for months and cause serious smoke management and safety issues.

7.5.2. Pine Forest Types

Tennessee's natural communities were shaped for centuries through fires started by lightning, Native Americans, and settlers. Prescribed fire is a key land management tool used to maintain and restore the fire dependent natural communities of Tennessee by mimicking historical, natural fire regimes and resetting succession. Prescribed fire is safely and responsibly applied to ecosystems to achieve various land management objectives such as aesthetics, wildlife habitat, and biodiversity.

Prescribed fire plays a critical ecological maintenance and restoration role in pine forests, mimicking historic natural fires. Without fire, pine forests would succeed to hardwood forests in most cases.

Shortleaf and loblolly pine are fire tolerant once the bark thickens and they reach about 10-15 feet tall, depending on fuel load. Loblolly and shortleaf pine should all be burned every one-to-three years to maintain and restore the natural communities in which it is dominant and to enhance wildlife habitat, improve aesthetics, reduce vegetative competition, reduce fuel loads, and stimulate rare plants.

7.5.3. Advantages of Prescribed Fire

There are many benefits to using prescribed fire to meet land management objectives. This practice reduces fuel loads, which directly lowers the risks and hazards associated with catastrophic wildfires. If a wildfire occurs in an area with a history of prescribed fire, the intensity and severity of that wildfire will be substantially less compared to areas without.

Prescribed fire opens the mid and understories by consuming overgrown vegetation and dead fuels. This stimulates many species of grasses, forbs, and herbs. The result is an open, lush, scenic understory that is aesthetically pleasing. Stands maintained with prescribed fire have more plant and wildlife biodiversity compared to fire-suppressed stands. Even old field sites planted with pines develop a more diverse understory compared to those without fire. This diverse, open understory is also beneficial to many species of wildlife which require this fire-maintained structure. Likewise, allowing fire to burn through isolated and ephemeral wetlands within forest stands is beneficial for diversity in those natural communities.

Prescribed fire increases the nutrient content of forage species and the mast productivity of species such as blueberry (*Vaccinium spp*.). Pines and other plant species receive a post-burn flush of nutrients through increased nutrient cycling. Wildlife prefer this nutrient-dense and mast-rich understory.

Landowners also enjoy this fire-maintained understory for the improved access and beautiful, open views it provides. This enhances recreational activities such as hunting, wildlife viewing, and hiking. Prescribed fire also reduces many forest pests. This improves outdoor recreational experiences and helps reduce the spread of tick-borne illnesses such as Lyme disease and rocky mountain spotted fever.

7.5.4. Disadvantages of Prescribed Fire and Ways to Mitigate

Inappropriately applied prescribed fire can reduce growth rates and lead to mortality in pine and hardwood stands. Excessive heat can scorch crowns and cause damage to feeder roots and inner bark. Excessive scorch alone may slow growth and cause isolated mortality. When excessive scorch is combined with other stress factors such as poor soil quality, offsite species, overstocking, and drought, widespread mortality may occur (FDACS 2012-2019). Southern pine beetle *(Dendroctonus frontalis*), ips beetle (*Ips* spp.), and/or black turpentine beetle (*Dendroctonus terebans*) outbreaks are more likely to occur following excessive scorch.

There are ways to mitigate these negative impacts. Cool, dormant season burns can be utilized until fuel loads are reduced, especially in long-unburned stands. Thick duff layers can be reduced slowly over time by only burning following precipitation to avoid damaging feeder roots. Appropriate firing techniques should be selected considering overstory species, stand structure, burn objectives, desired fire intensity and severity, fuels (type, loading, structure), and weather conditions.

Fire is inherently dangerous, so a certain level of risk comes along with conducting prescribed burns. Tied to that risk is the liability if a burn does not go as planned, leading many landowners to avoid prescribed burning. Landowners have the option to hire a state or private contractor to conduct their burning. Tennessee has strong prescribed fire statutes which protect safe, responsible prescribed burn managers (Tennessee Prescribed Burning Act, Tennessee Code Annotated Title 11, Chapter 4, Part 10). Much of prescribed burning revolves around the weather and even with careful planning and forecasting, the weather can change. Most other preparation and implementation factors can be controlled. Burn planning is crucial and may include:

- Physical description of terrain and fuels
- Management goals and objectives
- Thorough burn prescription development
- Weather forecasting and observations
- Smoke management and screening
- Staffing and other resource needs
- Notification of neighbors, the public, and local emergency responders
- Contingency and emergency plan development
- Map of burn unit and surrounding area
- Post burn evaluation

Documentation and record keeping of prescribed fire planning and activities is encouraged.

7.5.5. Methods of Prescribed Fire

7.5.5.1. Broadcast Burning

The act of burning acreage to meet various objectives is referred to as broadcast burning. Broadcast burning includes burning uplands or wetlands and is the most common type of prescribed fire. Broadcast burning is used to meet various objectives including fuel reduction, ecological maintenance and restoration, wildlife habitat management, aesthetics, and imperiled species management.

7.5.5.2. Site Preparation Burns

Site preparation burning is a form of broadcast burning that prepares sites for artificial or natural regeneration. Site preparation burns reduce vegetative competition, improve access and operability for planting, and scarify the soil for seed catch. They also meet some of the same objectives as broadcast burning.

7.5.5.3. Pile Burns

Pile burning is a form of site preparation burning. Large post-harvest debris within clearcuts are raked into scattered piles and burned. The objective is reducing logging slash to improve access and operability for machine planting. Pile burning is not used to reduce vegetative competition. A site preparation burn may incorporate pile burning. When pile burning it is essential to manage the smoke production adequately to prevent adverse smoke effects.

7.5.6. Fire Return Intervals

Fire return interval is the average period between fires under the presumed historical fire regime based on pre-European interactions between fire, vegetation, topographical, and climate dynamics. Determining the appropriate fire return interval at the burn unit level is vital to a successful burn program and key to introducing prescribed fire in appropriate intervals through time.

7.5.7. Seasonality

Seasonality plays an important role in a prescribed fire program and should be carefully considered to help meet specific objectives. Seasonality should be varied over time, avoiding burning the same stands during the same season.

Historically in Tennessee, most natural fires were caused by lightning and occurred mainly during the early growing season when storms, high winds, and low relative humidity were the most common. Many plant species adapted to this seasonality and require fire in the spring or summer months to reproduce. Growing season prescribed fire promotes a higher density of grasses, forbs, and herbs, and lower density of woody species such as gallberry, largeleaf gallberry (*Ilex coriacea*), and hardwoods. Growing season burns also reduce fuel loads quicker and result in delayed woody regrowth. If wildlife management is the focus, growing season burns often result in excellent habitat. If isolated wetlands such as cypress ponds or depression marshes need woody species reduction, a spring burn is ideal.

However, growing season burns are challenging due to increased potential for scorch caused by higher ambient temperatures. Growing season prescribed burns are best suited to sites with lighter fuel loads or those with a history of prescribed fire. Additionally, not all historic fires occurred during the growing season. The southern pine beetle's main dispersal is in the spring when trees are already drought stressed. Adding additional stress caused by the heat of a prescribed burn may lead to an outbreak. Pines are also susceptible to mortality caused by crown scorch during spring due to bud elongation.

Dormant season burns generally occur when vegetation is dormant, as the name implies, which promotes more woody species stems per acre and less grass, forb, and herbaceous ground cover. However, more legumes respond to dormant season fires than growing season fires. Dormant season burns safely and slowly lighten fuel loads, but post-burn woody regrowth occurs faster, since they have the whole growing season to recover. Dormant season burns are generally easier to conduct due to cooler temperatures, less intense fire behavior, consistent winds, and higher fuel and soil moisture. Pine trees are in dormancy during the winter months so impacts from scorch are not as dramatic but should still be kept to a minimum. There are generally more available burn days in dormant season. There is less potential for dormant season burns to stress pines or lead to mortality issues.

Dormant season burns are ideal for sites with heavier fuel loads or those little-to-no burn history. For example, reintroducing fire to a dense pine plantation with a 30-year rough (i.e., time since the last burn) would be most successful using a dormant season burn. If desired, burning can be transitioned to the growing season after one to two initial dormant burns. If wildlife management, groundcover, and biodiversity are not objectives, but timber management is, dormant season prescribed fire is a better fit. A dormant season burn can substitute for a scheduled growing season burn if winter conditions are more favorable, avoiding missing an entire year.

7.5.8. Fire Weather

One of the most important considerations in planning and conducting a prescribed burn is fire weather. Burn prescriptions contain a section with desired, forecasted, and actual fire weather for a burn unit. The U.S. Forest Service's Guide for Prescribed Fire in Southern Forests is an excellent resource for burn managers in the region and contains recommendations and detailed descriptions of the following fire weather factors (Wade and Lunsford 1989).

Fire weather has some relevant terms that help to explain atmospheric conditions related to prescribed burns.

- Relative humidity (RH) is the amount of moisture in the air in relation to the air temperature. RH is the main factor for spotting potential and affects fire intensity and fuel availability. Various fuel sizes are affected differently by RH. Fine fuels like grasses and leaves are more responsive to RH. They absorb and release moisture much faster compared to the slower responses of heavier fuels like branches and logs. RH is a factor in whether a fuel will burn and how well it will burn.
- Temperature is the hotness or coldness of the air or a substance and is a factor in RH, fire intensity, scorch potential, and live fuel moisture.
- Wind speed and direction affect fire intensity, rate of spread, smoke management, and spotting potential.
- Dispersion index is a measure of atmospheric stability which is directly related to smoke and heat lift. It also affects scorch potential.
- Live fuel moisture is a measure of the amount of moisture in live vegetation. This affects fuel volatility, availability, and fire intensity.
- Days since last rain affect live fuel moisture, fire intensity, drought indices, and the ability of natural firebreaks such as hardwood stands or wetlands to hold fire.
- The Keech-Byram Drought Index (KBDI) is an indicator of drought severity and may help determine if a prescribed burn can take place. It measures soil and duff layer moisture assuming there are eight inches of moisture available to vegetation in a saturated soil. During burn planning, KBDI can help indicate how wet duff layers and wetlands might be.

7.5.9. Prescribed Burning Regulations

Prescribed burning in Tennessee must be carried out according to the local and state rules and regulations. The Tennessee Division of Forestry and Tennessee Division of Air Pollution Control govern fire and smoke management, respectively. Tennessee Code Annotated, T.C.A. 11-4-Part 10, known as the Tennessee Prescribed Burning Act, identifies prescribed fire as a landowner right and a land management tool benefiting the safety of the public, the environment, and the economy of Tennessee. The Tennessee Prescribed Burning Act goes on to identify certified prescribed burn manager training, planning, and implementation requirements, which if adhered to, increase overall safety, and provide the greatest environmental benefits. The Act indicates that prescribed burning in accordance with the law shall: require a written burn plan be prepared, signed, and followed by the certified prescribed burn manager; require that the certified prescribed burn manager maintain the burn plan in the manger's records, and possess the plan on site during the burn; require a certified burn manager be on site and supervising the burn; require the certified prescribed burn manager to directly observe and coordinate the lighting of the fire to initiate the burn process; require a burning permit be obtained from the Division of Forestry as required in T.C.A. 39-14-306; and require the burn be considered in the public interest and not constitute a public or private nuisance.

To become a certified prescribed burn manager, an individual must successfully complete a training program which includes blended self- study and classroom portions, a written exam, and a live fire demonstration depending on weather. The course is geared toward people with varying degrees of prescribed burn experience and understanding. They must also provide documentation of practical experience in prescribed burning. In addition, they must agree to conduct all burning in compliance with all applicable laws and ordinances. Upon successful course completion, students are certified for up to three years and must maintain currency through

a combination of continuing education and demonstrated prescribed burning experience with adherence to regulations within the Prescribed Burning Act. The Tennessee Division of Forestry governs rules pertaining to Tennessee's Certified Prescribed Fire Manager program under Tennessee Effective Rules chapter 0080-07-06. For additional information about prescribed burning tools, tips, regulations, and training in Tennessee visit TNWildlandFire.gov

7.5.10. Prescribed Fire Assistance

The Tennessee Division of Forestry provides several services related to prescribed burning for a fee. These services include plan preparation, firebreak installation, prescribed burning, standby services, equipment loan, and on-site burn assistance. Several private consulting foresters also offer prescribed burning as a service.

Financial assistance to help cover the costs associated with prescribed burning is sometimes available through the Environmental Quality Incentives Program. Contact your local NRCS office to apply for these funds. Funds are also available through the Tennessee Agricultural Enhancement Program and Southern Pine Beetle Initiative. Contact your local area forester to learn more.

7.6. Fertilization

Fertilization can improve nutrient-poor soils within Tennessee. Loblolly pines on flatwood sites respond to fertilization. Fertilization uptake is dependent on soil composition (i.e., sand versus clay, drainage) among other factors. Bedding on some poorly drained flatwood sites will sometimes make more nutrients available, reducing the need to fertilize. Excessive fertilization may lead to fusiform rust issues and cause trees to retain limbs longer, both contributing to the degradation of their form. Fertilizer label rates, material safety data sheets, and Tennessee's BMPs for Forestry provide additional guidance on application procedures and rates.

8. Forest Management Assistance Programs

8. FOREST MANAGEMENT ASSISTANCE PROGRAMS

The following forest programs are resources from all forest types in the LMP and may be considered for each landowner. They are summarized here rather than in the forest types discussion due to their relative uniform applicability across all forest types. The forest resources particular to each forest type are given in Section 4.2.

8.1. Conservation Incentives

There are several programs and markets available to landowners that can provide rewards and incentives for their conservation efforts. The most widely used programs are cost-share programs. Additional initiatives that may be applicable in certain circumstances are given in Section 8.1.2.

Providing Agency	Program Title
USDA Natural Resources Conservation Service Farm Service Agency National Initiatives	Conservation Reserve Program Emergency Forest Restoration Program Agricultural Conservation Easement Program Emergency Watershed Protection Program Environmental Quality Incentives Program Conservation Stewardship Program National Water Quality Initiative Regional Conservation Partnership Program Shortleaf Pine Initiative Working Lands for Wildlife (Eastern Hellbender, Conasauga River Aquatic Species) Wetlands Reserve Program National Bobwhite Conservation Initiative Tennessee Healthy Watershed Initiative
Tennessee Division of Forestry Tennessee Department of Agriculture Tennessee Wildlife Resources Agency Tennessee Wildlife Federation Regional Initiatives	Forest Stewardship Program Agricultural Resources Conservation Fund Tennessee Agricultural Enhancement Program Tennessee Nonpoint Source Grant Program White Oak Initiative Bobwhite Quail Initiative Forestry for Wildlife Partnership The Land Trust for Tennessee Landowner Assistance Program Southern Pine Beetle Initiative Tennessee Stream Mitigation Program

Providing Agency	Program Title
	Habitat Conservation Program
	Farm Wildlife Habitat Program
	Forest Legacy Program
	Elk and Duck River Watershed Forest and Buffer Initiative

Some landowners sign conservation easements ensuring long-term protection. Landowners can enter their property into a conservation easement agreement through various entities such as the The Nature Conservancy or a local land trust such as The Land Trust for Tennessee. A list of all Land Trust Alliance members operating within Tennessee can be found online at www.findalandtrust.org/. Conservation servitudes vary, but most ensure the land is never developed while allowing the landowner to continue management activities such as timber harvests, and in return they receive a property tax break. This option also allows many landowners a strategy during estate planning. Some landowners may also be available to earn credits on private mitigation banking markets through the enhancement or restoration of wetlands and/or threatened and endangered species habitat.

8.1.1. Conservation Incentives Within Ecoregions

Conservation is essential to maintain the abundant natural resources found in Tennessee. There are multiple conservation initiatives (CI) at work in the state that are focused on protecting these resources. The following section explains the components that involve or affect forested habitat or species located within these habitats. It should be noted that this section may not be an entirely comprehensive list of all conservation incentives available to landowners within Tennessee. Research should be personally conducted in conjunction with a forester consultation in order to discern whether other CIs may be available to landowners.

8.1.1.1. Natural Resources Conservation Initiatives and Programs

The United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) administers the Environmental Quality Incentives Program (EQIP) to provide financial and technical assistance to forestry producers to address natural resource concerns and deliver environmental benefits such as improved water and air quality, conserved ground and surface water, reduced soil erosion and sedimentation, and improved or created wildlife habitat. Through this program, NRCS provides guidance and financial resources to implement environmental improvements. EQIP is available throughout all ecoregions in Tennessee. Depending on where your land is located, any number of 200 different forest and farm-focused land improvement practices may be available. Some of these various EQIP practices can be found in subsequent sections of the LMP.

The USDA Farm Service Agency (FSA) administers the Conservation Reserve Program (CRP). Since its inception in 1985, CRP is the largest private-lands conservation program in the United States. Through this program, farmers agree to accept a yearly rental payment and participate in cost-share of up to 50% to remove lands deemed environmentally sensitive from production and instead plant species to improve environmental quality and health. The contract length for lands enrolled in CRP vary from 10 to 15 years, with the long-term goal of reestablishing valuable land cover to improve water quality, prevent soil erosion, and reduce wildlife habitat loss. The CRP has multiple initiatives for landowners, ranging from habitat buffers for upland birds to the bottomland timber establishment on wetlands, which is applicable in Tennessee's wetland forested habitats.

As an example, an initiative geared toward private landowners with land within either the Elk River or Duck River Watersheds is the Elk and Duck River Watershed Forest and Buffer Initiative, administered by the Tennessee Forestry Association (TFA) in partnership with other agencies. This initiative encourages the establishment and maintenance of riparian buffers on private land within either of the two watersheds in parts of Bedford, Benton, Coffee, Franklin, Giles, Grundy, Hickman, Humphreys, Lewis, Lincoln, Marshall, Maury, Moore, Perry, and Williamson Counties. To qualify for the potential $1,700 per acre financial incentive, landowners must plant riparian forest buffers on eligible land. For previously established buffer lands, additional funds may be available to treat invasive species present. Additional information concerning this initiative can be found here.

An aquatic initiative benefiting Tennessee is the National Water Quality Initiative (NWQI). Through this program, NRCS provides financial and technical assistance to landowners interested in improving the quality and habitat of impaired streams. In Tennessee, the two watersheds meeting the criteria to be classified as priority watersheds are the Nolichucky River Watershed in East Tennessee and the Caney Fork River Watershed in Middle Tennessee. These are two 8-digit HUCs that contain a combined 7, 12-digit HUCs warranting their own designation. Most land types surrounding these watersheds is forest, with pasture and other habitat interspersed. A main method of improving these watersheds is the control of nutrient and manure runoff. This control may be accomplished through assistance installing cover crops, filter strips, and tailwater recovery systems, which will aid landowners in protecting natural resources voluntarily while also receiving a profit. In Tennessee, the above-mentioned priority watersheds are found in the Blue Ridge, Ridge and Valley, Southwest Appalachians, and Interior Plateau ecoregions.

A forest-based restoration initiative that is present throughout multiple southern states is the Shortleaf Pine Initiative (SPI). The SPI is a program designed to address the multiple threats facing the increasingly imperiled shortleaf pine forest (Shortleaf Pine Restoration Plan, 2016). Recently, factors such as pine beetle outbreaks, changes in timber management practices and land use, and altered fire regimes have contributed to the decline of this specific ecosystem. In 2013, the SPI was formed to address these issues through policy formed by key federal and state agencies from the 22 states affected by shortleaf pine decline. Shortleaf pine restoration depends on site-specific efforts by regional practitioners and partners to educate landowners interested in restoration on their lands. These efforts include the demonstration of shortleaf pine restoration practices, the sharing of technical information, and the promotion of site-based conservation. This initiative is available throughout all Tennessee ecoregions except the Mississippi Alluvial Plain.

A wildlife-focused conservation initiative within Tennessee is the National Bobwhite Conservation Initiative (NBCI). The NBCI is a 25-state effort to restore bobwhite quail to America's landscape. The NBCI is focused on developing an ever-evolving strategy to approach bobwhite revival on a landscape scale as opposed to the small-scale, individual farm-based approach previously utilized. Through the NBCI Technical Committee, representatives from the 25 states can lend their biological and scientific research, and private conservation expertise to the protection and restoration of bobwhite quail. Methods for promoting the reestablishment of the species include advancing the establishment of native grasses and flowers along cropland and rural land edges to promote habitat connectivity, converting up to one-third of existing pasture to native grasses beneficial to cattle and bobwhite, and managing pine and other forests to promote forest habitat connectivity. The NBCI is available to landowners with appropriate acreage and suitable habitat that qualify for a NBCI Focal Area where quail populations can be studied. NBCI provides coordination, design, training, data management, reporting tools, and nationwide outreach. All ecoregions within Tennessee can qualify under the NBCI.

Another wildlife-focused initiative is the Partners for Fish and Wildlife Program established by the U.S. Fish and Wildlife Service. Through this program, as well as its collaboration with American Forest Foundation, the Alabama/Tennessee Habitat Improvement Initiative was founded to provide technical assistance to private landowners in the two states. Multiple state agencies within Alabama and Tennessee share the goal of improving occupied, terrestrial, and aquatic habitat within north Alabama and south-central Tennessee to support at-risk species. An additional goal is to scout the potential development of projects on private lands within this region. To be eligible for this program, Tennessee landowners must have at least one at-risk species currently or previously documented on or adjacent to their property in an eligible county and be implementing or have plans to implement sustainable forestry BMP practices. If they meet the criteria, landowners will be provided resources and cost-share funds to complete various practices consistent with the particular species' management plan, along with other benefits.

8.1.1.2. State Conservation Initiatives and Programs

The Tennessee Forest Stewardship Program (FSP) gives forestry assistance to private landowners while increasing public awareness concerning wise forest utilization and management. A goal of the program is to use landowner goals and feedback to create a detailed plan for managing their privately-owned forestland. Through TDF, free, on-the-ground assistance is provided by natural resource and forestry specialists. These professionals help create the landowner's personalized stewardship plan based on their objectives.

Certain items needed to qualify for the program, along with additional information, can be found online at www.tn.gov/content/tn/twra/wildlife/habitat/programs-and-grants.html.

The Tennessee Agricultural Enhancement Program (TAEP) was established in 2005 to provide cost-share assistance to farmers and forest landowners to support the long-term investment into Tennessee farms, forests, and communities. Once enrolled in the program, farmers and forest and landowners are able to maximize profits, adapt to changing market dynamics, improve the safety and efficiency of their operation, and positively impact their surrounding communities. From 2005-2019, more than $185 million has been invested into more than 60,000 separate projects. TAEP is available through the Tennessee Department of Agriculture and specific funding is available for forest landowners and loggers through Forestry TAEP.

The Southern Pine Beetle Initiative(SPBI), is a federally-funded cost-share program administered by TDF. SPBI is designed to mitigate future forest loss from southern pine beetles for non-industrial private forest landowners through management of pine density. The program emphasizes prevention and restoration practices to y make pine stands more resilient to beetle infestations and ensure the stand will reach merchantable size before becoming overly dense. Private landowners, joint landowners, and non-profit organizations may qualify. The SPBI consists of cost-share programs designed to re-establish stands already affected, as well as improve stands to make them more resilient to potential outbreaks. All counties and ecoregions are eligible for the prevention practices, and the restoration practices involving plantings for all pine species. Additional information can be found online at:
www.tn.gov/content/tn/agriculture/forests/landowners/financial/southern-pine-beetle-cost-share-for-landowners.html.

The Tennessee Wildlife Resources Agency (TWRA) implemented the Farm Wildlife Habitat Program (FWHP) to fund qualified projects that may not be eligible for national USDA funding, especially practices that assist a

landowner in implementing habitat projects. This program provides 75% cost-share reimbursement with a limit of $2,000 for practices geared toward restoring and managing native species habitats. Species that occupy grasslands, shrublands, and early successional forests (such as bobwhite quail, ruffled grouse, woodcock, etc.) are the main target species for restoration within the program, with projects such as hedgerow/thicket development, forest edge thinning, restoration of fallow fields, and various other means to achieve habitat restoration. Additional information on the FWHP, including information for application, can be found online at www.tn.gov/content/tn/twra/wildlife/habitat/programs-and-grants.html.

The Sustainable Forestry Initiative (SFI) has been in place in Tennessee since 2020, when all 168,359 acres of the state's 15 state forests became SFI-certified. Its main objective is to support responsible forestry and ensure harvesting promotes and provides sustainability into the future for Tennessee landowners. In the past, this program has helped train loggers and foresters, provided information and support concerning forestry practices to family landowners, used SFI-endorsed wood procurement practices, and assured customers that their production of paper products come from sustainably managed forests. While the SFI is a worldwide program with 242 program participants in North America, some states have their own local SFI Implementation Committees. Highlights of the Tennessee SFI program include the promotion of forestry BMPs, participating in outreach to local private landowners, and educating 331 loggers in pursuit of Master Logger Program certification in 2019.

The Tennessee Forest Legacy Program (TFLP) is currently conserving more than 35,000 acres across the state. The main goal of the program is to protect private, working forests that are currently threatened with conversion to non-forestland uses. TFLP actively works to identify and maintain fully operational forests that are facing threats of conversion and enter them into perpetual protection. In order to qualify for the program, target forestland must have a current Forest Stewardship Plan that identifies all land management objectives and land resources. Additional resources and information related to enrollment in this program are located here.

8.2. Ecosystem Services

Forests provide ecosystem services to society that are wide ranging and difficult to value. These ecosystem services include clean air and water, carbon sequestration, aquifer recharge, climate resiliency, and biodiversity. There are currently few significant markets for these services in Tennessee, but they may develop in coming years. One notable exception is the Tennessee River Gorge Trust. This program is starting to place some of its properties into the carbon offset market and is now committed to monitoring and inventorying the trees within these properties to ensure that carbon stocks remain level for the next 100 years. The Tennessee River Gorge Trust did this to support a process aimed at reducing greenhouse emissions. Other companies may be able to cost-share tree planting or reforestation activities in exchange for carbon credits, which would help to offset cost. Georgia, California, Maine, and Oregon are the states that have developed a carbon credits system, with more expected to follow. More information on this system can be found online at www.conserve-energy-future.com/carbon-credits.php. The Nature Conservancy is also entering the carbon sequestration sector, offering various plans geared toward promoting the continued sequestration of carbon to offset global carbon dioxide emissions.

8.3. Historical and Cultural Sites

Many private lands contain various historical and cultural resources, also known through the American Tree Farm System as special sites. Therefore, forest management activities are often developed to consider and maintain the sites on a property. Landowners may be aware of these sites, or their locations may be documented and mapped with federal, state, or local agencies and organizations. Forest resource professionals could discuss known sites with landowners. If the landowner is unaware of any sites or the land is newly acquired, there are many resources available to review potential recorded sites such as the National Register of Historic Places or the State Historic Preservation Office through the Tennessee State Library and Archives and local historical societies and museums.

The Tennessee State Library and Archives and local historical organizations have limited resources but may be able to assist with locating or interpreting potential significant sites and local preservation laws. Sites listed by these organizations reflect a determination of a site's significance to the history of a community, state, or nation and should be protected as required by federal, state, or local laws. *Non-listed sites of personal significance to the landowner may also be protected.* The Historical Structures and Cemeteries layers within the LMP geodatabase can also be used to provide information on site-specific historic and cultural resources.

In addition, the property can be reviewed on the ground through visual reconnaissance by the landowner or forest resource professional, within a reasonable scale relative to property acreage and accessibility. Those individuals are encouraged to make reasonable efforts to locate and protect special sites appropriate for the size of the forest and the scale and intensity of forest management activities. Protection of historical and cultural sites during land management activities can be considered during planning, contract development, monitoring, and follow-up inspections. These sites can be designated on the ground with vegetative buffers, flagged or blazed trees, fencing, or signage and communicated to contractors and sub-contractors.

Landowner considerations for determining whether to designate an unlisted site may include:

- **Significance**:
  - Site has made a significant contribution to the broad patterns of our history.
  - Associated with the lives of significant persons of the past.
  - Embodies distinctive characteristics of a type, period, or method of construction, or represents the work of a master, or possesses high artistic values, or represents a distinguishable entity whose components may lack individual distinction.
  - Yielded or likely to yield information important in history or pre-history
- **Age**: Minimum 50 years old
- **Integrity**:
  - Site must retain its historical physical integrity with character-defining features still present.
  - Building, structure, or landscape feature must be relatively unchanged.
  - Archeological site must be relatively undisturbed, with its patterns and layers of artifacts relatively intact.
  - Traditional cultural site must be recognizable to today's affiliated cultural group, evidenced through tradition, and still used or revered today.
- **Personal Significance**: Such as a location, structure or artifact with a family importance or meaning

Special sites of biological or geological significance and sensitivity may be determined through consultation to identify threatened or endangered species and natural communities. Cultural and historical resources can be mapped and marked on the ground to aid general protection, documentation, and monitoring efforts. However, some landowners may wish to keep these sites unmarked and unmapped to avoid attracting attention that could lead to vandalism, theft, or degradation.

Historic, cultural, and special sites may include:

- Native American burial grounds, camps, middens, mounds, etc.
- Historic dwellings, structures, foundations, barns, wells, cattle dipping vats, ruins, cemeteries, bridges, etc.
- Geological formations, sinkholes, limestone bluffs or outcroppings, caves, spring heads, springs, etc.
- Rare plant populations, pitcher plant bogs, champion trees, bear dens, etc.

8.4. Recreation

Tennessee's geography and variability of different habitats, ranging from the western alluvial plains to the Appalachians and Blue Ridge mountains, provide a wide range of recreation opportunities through its natural areas. Tennessee's forests are popular places to recreate due to their unique topography, biological diversity, and the potential activities. Landowners can enjoy personal and family recreational use or lease their land as a means of revenue generation. If leasing land for hunting, it is important to purchase liability insurance for the property to protect your liability in the event of an accident. Many interest groups may provide advice or programs on managing for recreation opportunities. Additionally, easement programs may coordinate or include public access in their terms. Potential recreational activities include:

- Hunting
- Fishing
- Off-highway vehicle use
- Eco-tourism a
- Wildlife viewing and birding
- Hiking
- Bicycling
- Horseback riding
- Camping
- Environmental education
- Geocaching
- Paddling

8.5. Aesthetics

From a towering upland hardwood stand with rolling open understories to a lush, mixed bottomland hardwood forest to the unique landscape of the mountains, the wide range of forest types, topography, and aquatic features throughout Tennessee provide unique forest aesthetic values. The forests themselves vary from open, oak/hickory-dominated rolling hills to rocky outcrops to rich bottomland forests. East Tennessee boasts Appalachian Mountain hardwood forests transitioning into the Blue Ridge Mountains on the state's eastern border. These dense forests are composed of many northern species, especially at higher elevations, providing a different aesthetic than the relative flatness of the state's central plateau as it tapers to the plains of West Tennessee, where the cypress-lined rivers and ponds have their own prehistoric beauty.

Tennessee is quite diverse in its topography due to its stretching from prominent mountain ranges to the Mississippi River. It has rolling sand and clay hills in the Piedmont, steep-head spring ravines, slope forests, and high river bluffs. Various aquatic features such as forested wetlands, lakes, ponds, rivers, streams, and springs are visual highlights of the state's forests. These are present naturally throughout the region and add character to a property; so much so that many landowners choose to enhance their property's aesthetics by creating ponds and waterbodies. These forest aesthetic considerations not only provide beautiful views but also a sense of privacy, adventure, and landowner pride. Many associated programs support aesthetics.

8.6. Forests of Recognized Importance

Forests of recognized importance (FORIs) represent globally, regionally, or nationally significant large landscape areas of exceptional ecological, social, cultural, or biological values. These forests are evaluated at the landscape level, rather than at the stand level, and are recognized for a combination of unique values, rather than a single attribute. FORIs may include landscapes with exceptionally high concentrations of one or more of the following:

- Protected, rare, sensitive, or representative forest ecosystems such as riparian areas and wetland biotopes.
- Areas containing endemic species and critical habitats of multiple threatened or endangered plants and animals, as identified under the Endangered Species Act (ESA) or other recognized listings.
- Recognized large-scale cultural or archeological sites including sites of human habitation, cities, burial grounds, and in situ artifacts.
- Areas containing identified and protected water resources upon which large metropolitan populations are dependent.
- Areas containing identified unique or geologic features including geysers, waterfalls, lava beds, caves, or craters.

While landowners are encouraged to contribute to or support the values that led to the FORI designation of the area, the FORI designation does not compel the landowner to take any actions.

8.6.1. FORI Designation Within Region

In the United States, because of their significance, FORIs have generally been identified and protected by federal or state governments or are under conservation easement by an environmental nonprofit organization. There is currently no state or federal agency that regulates FORIs on private forestlands in the United States. Several conservation organizations have identified areas that they believe are exceptional, yet there remains no single central clearinghouse of information regarding such forested landscapes.

To support and facilitate identification of these resources within this project, AFF worked with the Support Committee to develop a list of FORIs within the state while consulting the Tennessee Forest Action Plan and area conservation priorities. The Support Committee decided that Tennessee has no designated FORI.

8.7. Forest Products

8.7.1. Fish and Wildlife

The forests and associated aquatic ecosystems of Tennessee provide habitat for a wide array of game and non-game fish and wildlife, including several imperiled species (Table 2). These forests can be managed to enhance, restore, and protect the valuable habitats these species call home. These species may be managed for various objectives such as conservation, legacy planning, or recreation. Present listed species can be documented, mapped, and monitored.

The recommendations in Tennessee's BMPs for Forestry to protect water quality could also be used to compile strategies and considerations for managing and protecting these species and their habitat during silvicultural operations, such as using flagging, paint, or signage during harvest operations, regular active monitoring and following up with post-harvest inspection(s).

Hardwood forests provide habitat to hundreds of game and non-game species including bobwhite quail, wild turkey, and deer. They are also home to several rare species including the bald eagle, Indiana bat, gray bat, Carolina northern flying squirrel, and others (Table 2). Hardwood forests also provide habitat for their own collection of game and non-game species.

8.7.2. Timber Products

The merchantability of a stand of trees, whether planted or natural, pine or hardwood, will depend on acreage and volume, local timber markets, and mill product specifications. The LMP Geodatabase can be utilized to locate and contact local mills and calculate haul distance. Mills in Alabama, Georgia, Mississippi, Missouri, North Carolina, Kentucky, and Virginia purchase these products from Tennessee landowners (Mathison and Schnabel 2009).

The value of timber is based on the value of the products that can be made from them. This is dictated by size (height and diameter), species, local topography, and quality of the trees. While some southern states are heavily pine dominant in their forest product output, Tennessee is one of the top five hardwood lumber producing states (English et al. 2004) with a specialty in sawtimber boards, hardwood flooring, and pencils. Markets in and around Tennessee currently include these following products:

- **Sawtimber:** Hardwood, Some Pine
  - Grade – staves, veneer, lumber
  - Industrial (Low-Grade) – pallet wood, railroad ties, mine timbers
- **Pulpwood:** Pine, Some Hardwood
- **Veneer:** Hardwood, Some Pine
- **Pole and Piling:** Pine
- **Mulch:** Hardwood and Cypress
- **Fuelwood:** Hardwood and Pine
  - chips/pellets
  - firewood

- Various Hardwood Products: mats, small diameter saw timber, shavings, bedding

Like any other commodity, timber experiences price fluctuation according to supply and demand, as well as quality.

Sawtimber is complicated in its nomenclature. There are three recognized methods of computing the number of board feet in a given tree. Called log rules, these are tables estimating the amount of lumber that can be cut from trees of various sizes. The Doyle Log Rule is the commonly accepted measurement standard in Tennessee for scaling hardwood sawtimber logs. The Scribner Log Rule was developed based on the diameter at the small end of a log and tends to overscale large logs while underscaling small logs (Bond 1999). The third rule, International Quarter-Inch, may actually be the most accurate but has never gained much acceptance in the state. Typically, a good estimate for sawlog value based on each region of Tennessee can be found through TDF. Sawtimber volume is usually quoted in thousands of board feet (MBF).

The price paid for standing timber is called stumpage. This is the amount the landowner is paid in a timber sale. Stumpage will be expressed as dollars per cord, dollars per ton, or dollars per thousand board feet. The amount the timber brings at the mill is called the delivered price. The delivered price will be higher than the stumpage price because it includes the cost of logging and hauling.

An 18-wheel truck and trailer can haul about 25 tons of timber. This is the equivalent of about 9.3 standard cords of pine pulpwood or chip-n-saw. If the load is sawtimber or veneer size, the truck can haul about 3.3 MBF.

8.7.2.1. Hardwood Forest Products

Trees in the sawtimber product class are cut into lumber and waste material is converted into chips for fuel or paper production. Sawtimber is measured in tons or board feet and its value is heavily dependent on tree quality. In Tennessee, sawtimber is split into two basic categories: grade sawtimber and low grade (industrial) sawtimber.

- Grade Sawtimber: Usually a larger diameter and better quality than industrial sawtimber, grade sawtimber is typically converted to veneer, staves for barrel production, high-quality lumber
- Industrial (Low Grade) Sawtimber

To produce veneer, the tree is converted into continuous sheets of thin wood using a long lathe. This is used in the manufacture of plywood and furniture, depending on the type of tree. Veneer is measured in tons or board feet and its value is heavily dependent on tree quality. For valuation purposes, most veneer quality trees are considered sawtimber.

All the primary timber product groups can be harvested from pine/hardwood mixed, upland hardwood, and bottomland hardwood forest types including pulpwood, chip-n-saw, sawtimber, and fuelwood. Forest age and site quality affect which products can be produced, with older forests growing on good soils having the most potential of producing the most valuable products. Bottomland hardwood forests are sometimes managed for hardwood pulpwood, especially if hardwood pulpwood prices are high. Mature pine/hardwood mixed forests, where hardwood makes up the understory, will produce hardwood pulpwood along with pine sawtimber.

Tupelo-cypress mixed forests are commonly managed for lower value products such as hardwood pulpwood, cypress mulch, sawtimber, and fuelwood.

8.7.2.2. Pine Forest Products

Pulpwood is the second most abundant form of timber in Tennessee behind hardwood sawtimber (Mathison and Schnabel 2009). Typically, softwoods (pines), pulpwood trees are chipped into small pieces, chemically treated, and made into paper. This product can be found in tree-length and clean chip forms and is usually sold by the cord or the weight of the wood in pounds (Bond 1999).

Poles and pilings are used to hold vertical loads and must be straight. Eligible trees have straight, cylindrical trunks free of limbs and defects for at least 32', and trunk sweep should not exceed 1" for every 10' of trunk length. The demand for poles and pilings and their sizes is highly variable, and ultimately, the buyer of those product classes determines whether a tree is a pole or piling tree. For valuation purposes, most pole and piling quality trees are considered sawtimber.

Timber is considered pre-merchantable if it is too small in diameter and/or height for one of the products above. All the primary timber product groups can be harvested from pine/hardwood mixed forests. These pine forests also allow for fuelwood harvests, especially utilizing natural regeneration and hardwood reduction treatments. With its fast, early growth, loblolly and shortleaf pine are sometimes managed for lower value, short rotation products such as pulpwood. Each pine species can generally be managed for longer rotation products such as sawtimber, poles and pilings, and veneer.

8.7.2.3. Bioenergy and Biofuels

Tennessee is a main source of biofuels, as it is the leading ethanol-producing state in the Southeast (US Dept of Energy). As such, Tennessee leaders are committed to the future protection of natural resources and the environment through the increased production and use of biofuels for energy needs. In February 2006, an Executive Order by Governor Phil Bredesen established the Alternative Fuels Working Group. This group consisted of the commissioners of the Departments of Agriculture, Economic and Community Development, Environment and Conservation, General Services, Health, and Transportation. Along with this, the governor issued an executive order to encourage the development of biofuel refueling stations at pre-existing gas stations.

While biofuels have traditionally consisted of ingredients derived from soybeans, corn, animal fats or byproducts, or other crop or animal-based sources, the industry is beginning to shift and incorporate more plant and tree-based materials (cellulose, hemicellulose, lignin). These compounds are harvested from woody biomass and fermented to derive what is needed for biofuel construction. While both hardwood and softwood can be used for these processes, research suggests that they may be different in the ease with which their compositions become biofuel. In looking toward the future of the market, it is anticipated that current mills may begin to transition to biofuel and biodiesel processing in the near future. This shift in power source makes biofuels a legitimate potential market for landowners to explore as they determine how to process their timber (Pu et al. 2007).

If there is an interest in the emerging market of the production of biofuel and biodiesel, the Biodiesel Laws and Incentives in Tennessee resource provides additional information.

8.7.3. Non-Timber Forest Products

Many non-timber forest products (NTFP) opportunities exist within forests, including pine straw, silvopasture, ginseng cultivation, beekeeping, and various native fruit or other edibles harvests. NTFPs exist to a certain scale within hardwood forests as well. Pine/hardwood mixed, upland hardwood, mixed floodplain, tupelo-cypress mixed, and cottonwood, sycamore, birch provide opportunities for beekeeping and fruit harvests, while tupelo-cypress mixed forest types provide opportunities for the collection of cypress knees as well.

8.7.3.1. Silviculture for Non-Timber Forest Products

The majority of NTFPs that are gathered come from natural populations and are not regulated by a professional management system. However, there are silvicultural systems that may be used to address the logistics of incorporating management for NTFPs into the overall management strategy for a landowner, as either a primary or secondary source of production and income. If the NTFP management is used as secondary production, the inclusion of NTFP management into an overall forest management strategy can help produce both economically and ecologically healthy forests due to the structural, compositional, and functional diversities needed to produce these NTFPs (Chamberlain et al. 2018). Silvicultural treatments fall into two overall groups: intermediate treatments, which promote existing stand improvement and development, and regeneration treatments, which create a favorable environment for the establishment of a new timber stand.

Both of these treatments can be used to promote NTFP management while accomplishing overall silvicultural goals for the stand. Intermediate treatments can be adjusted in their frequency and intensity to meet the needs of certain NTFPs present on or desired for the stand. For example, treatments can be lowered in frequency or intensity to keep shade in the forest and ensure that certain NTFP—such as mushrooms—don't lose the shade needed for their proliferation. Conversely, if yellow poplar is desired as a NTFP, thinning the stand can increase remaining trees' surface area and produce a greater abundance of poplar bark. Regeneration treatments can also plan for NTFP production from the ground up. If a certain NTFP is desired on the stand, the specifications of the stand (canopy gap size, tree spacing, period of canopy removal) can be altered from the first planning steps to meet both NFTP and other forest product goals (Chamberlain 2018). Additional information concerning NTFP proliferation within forests that are silviculturally managed can be found in Dr. Chamberlain's paper here.

8.7.3.1.1. Hardwood-Specific Forest Types

Cypress knees

Tupelo-cypress mixed forests produce knees that can be cut and used for art and craft purposes. This is non-commercial and on a small-scale

Ginseng

American ginseng (*Panax quinquefolius*) has become a popular export from southern forests, mainly to China for use in medicines. Ginseng is native to hardwood forests from the Midwest to Maine but is predominantly located in the Appalachian and Ozark Mountain regions. The plant is recognized by its bright red berries and is usually found at the base of slopes in hardwood forests (USFWS 2020). In Tennessee, ginseng is licensed through two different forms of legislation: the Ginseng Dealer Registration Act of 1983 (TCA Title 62 Chapter 28) and the Ginseng Harvest Season Act of 1985 (TCA Title 70 Chapter 8). In Tennessee, approximately 50 ginseng dealers are permitted annually to export an average of 15,500 pounds of wild ginseng. This program

serves to monitor and protect the abundance of wild ginseng for future harvests while also providing technical assistance to licensed ginseng growers and dealers within the state (Tennessee Department of Environment and Conservation 2020).

8.7.3.1.2. Pine-Specific Forest Types

Pine straw

Pine straw is the most valuable and desirable as it produces long, resilient, attractive needles ideal for landscaping. However, other species of pine may also be utilized. Pine straw raking for landscaping material is more common in certain regions of Tennessee than others, so it is important to check the markets where you live. A bonus of pine straw is that it can be harvested while the timber is still pre-merchantable, providing landowners with early returns on their stand establishment investment (i.e., site preparation and reforestation costs). Raking is generally initiated at crown closure (year 10) and ceases following first thinning (year 18-20). This period of raking usually coincides with the stand's crown lifting via shade. If landowner objectives are focused on maximizing revenue, they may wish to forego thinning and rake straw beyond economic or biological thinning age, clearcutting for pulpwood at age 22-25 and starting over. If landowner objectives are varied and involve thinning, the stand should be thinned at economic or biological thinning age (year 20-22) to promote proper stand development.

Traditional pine straw raking reduces or eliminates the native groundcover with annual herbicide and mowing and removal of coarse woody debris. This prevents impurities from being mixed in with the pine straw and allows for efficient raking. The result is a monoculture of the pine species, drastically reducing the quality of wildlife habitat. However, a more conservation-oriented form of pine straw management has been developed which entails raking the pine straw from the top of native groundcover and avoids frequent herbicide and mechanical treatments (NWF 2015), which might be a better fit for landowners balancing pine straw revenue with timber, wildlife, and aesthetic objectives. This approach will likely not include annual raking and may generate less revenue but splitting a stand in two sections and raking one section per year is one approach to gain annual revenue.

Pine straw stands are often fertilized to produce more pine straw, promote tree growth, and avoid depleting soils. Pine straw raking can be rewarding yet requires a lot of work to be successful. Planning and site selection begins prior to stand establishment. Visit "Pine Straw – A Profitable Agroforestry Enterprise" and "Lifting Longleaf Pine Straw: An Option to Balance Income and Wildlife" for more information.

Silvopasture

All hardwood and pine habitat is conducive to silvopasture. Silvopasture is an agroforestry practice combining livestock, forage, and timber management within the same land management unit (Hamilton 2008). This system provides landowners various combinations of options to manage forage (hay, etc.), livestock (cattle, etc.), and pine straw for short-term revenues while managing their timber for high-value products (poles and sawtimber) on longer rotations. Properly managed silvopasture systems also allow farms to be more profitable by diversifying revenue sources and cutting feed costs. However, landowners should be willing and able to actively manage the forage, livestock, and timber components.

The open forage areas within the management unit allow for biodiversity, enhancing cool season grasses while also allowing for warm season grass production. The areas with timber provide shade to livestock. This open,

relatively low-density stand structure enhances aesthetics, property values, and recreational opportunities. This system also promotes wildlife populations and provides habitat for wild turkey and quail. The combination of timber and quality forage also prevents erosion and improves water quality and hydroperiod.

Silvopasture provides economic security by reducing risk through diversification of products. However, prior to establishing a new silvopasture system, local land-use, cost-share, and tax regulations should be reviewed. Forestry and agriculture may have different land use and zoning regulations which may be tied to separate tax structures. Some states consider silvopasture cost sharable through Environmental Quality Incentives Program (EQIP). Landowners should investigate their qualifications through the program.

Silvopasture is generally easier to establish in existing timber stands, which already have trees with good form that can be thinned or clearcut to provide corridors of adequate width that support forage production. Converting existing pastures can be difficult when having to exclude existing livestock from the developing stand. Silvopasture supports less livestock than pasture since it is simultaneously supporting viable timber and livestock production.

Visit Silvopasture: Establishment & management principles for pine forests in the Southeastern United States" for more information (Hamilton 2008).

8.7.3.1.3. Pine and Hardwood Forest Types

Honey

Beekeeping and honey production are common within either pine or hardwood forests. Honey production can provide annual short-term revenues. Landowners can conduct beekeeping as a hobby, produce and sell honey themselves, sell their honey to larger producers and distributors, or lease their lands to honey producers. Properties with a diverse stand composition in terms of overstory and understory species and uplands and wetlands can potentially generate honey revenue nearly year-round. Upland and wetland forests are marketable for apiary leases. However, this is not particularly lucrative and is often done by bartering honey for leased land.

Beekeeping and honey production, especially the introduction of bees into the state, is covered by the Tennessee Code of Laws and the Tennessee Apiary Act of 1995. In order to protect this industry from pests and unwanted species of honeybees, the state requires apiary registration. Additional resources and professional association affiliation can be found through the Tennessee Beekeepers Association.

Fruits

Two of the main edible fruits found within Tennessee forests are persimmon (*Diospyros virginiana*) and pawpaw (*Asimina triloba*). Persimmon is native to the eastern United States and can be found in a variety of different habitat settings. The persimmon fruit is usually harvested in the fall following a few frost events and can be used in a variety of different dishes (Proffitt 2017). Pawpaw is an interesting species, as it represents the only American member of a tropical plant family and is the largest edible fruit in North America. The pawpaw is an understory tree that likes shade and moist soils, often being found in floodplains. The fruit is used in a variety of ways when harvested (Matthews 2017).

Also, hawthorn (*Crataegus* spp.) can be collected from mixed bottomland and upland forests and is often made into a jelly. Blueberry, blackberry, and other native fruits grow in several forest types, but are limited in their commercial harvest from forest settings. However, landowners may enjoy harvesting small quantities from their land for personal use. Other Non-Timber Forest Products include:

Medicinal Native Plants

- Bloodroot
- Black Cohosh
- Christmas Fern
- Goldenseal
- Oriental Bittersweet
- Slippery Elm
- Trillium

Other Edible Products

- Walnuts
- Morels
- Shitake Mushrooms
- Ramps

Ornamental Products

- Burl and Crooked Wood
- Christmas Trees
- Conifer Tips for Garlands
- Grapevines
- Galax
- Conifer Boughs
- Moss
- Mountain Laurel
- Pinecones
- Pine Tree Gum
- Pitcher Plants

Landscape Products

- Firewood
- Pine Bark Mulches

9. Site Specific Characterization through Geodatabase Tools

9. SITE SPECIFIC CHARACTERIZATION THROUGH GEODATABASE TOOLS

To adequately determine the existing conditions present on any reference site evaluated using this LMP, a GIS-can be used. This geodatabase represents the accumulation and organization of the most site-specific geospatial characterization tools that are publicly available within the LMP. The strategic goal of this geodatabase is to provide forest resource professionals with a geospatial tool that presents tabular data helpful in developing forest management goals and recommendations.

9.1. Instructions for Use

This geodatabase will require a geographic information system (GIS) to view, summarize, and manipulate the geospatial and tabular data included. Numerous fee-based and free shareware style geospatial applications are available and accessible for natural resource professionals, including TDF foresters as well as consulting foresters across the state.

The geodatabase is designed to allow the user to calculate and summarize data for each geodatabase layer on the landowner's parcel of property. By selecting the landowner's tract location using publicly-available county tax records, the exact location of the reference parcel can be identified. Multiple parcels can also be selected simultaneously if landowner property boundaries encompass multiple tax parcels. After identifying the referenced property, users can toggle and select between individual and/or multiple geospatial resource layers that will present summarized tabular data for the selected location. For instance, a user could determine the haul distance to specific product mills and develop detailed soil and potential hydrologic impact maps to plan harvesting operations. Likewise, users could quickly determine which potential threatened and endangered species or nearby invasive species could be present on their referenced site.

9.2. Geodatabase Layer Descriptions

The following 19 geospatial layers and aerial imagery layer comprise the LMP geodatabase used for site specific characterization of subject landowner properties. Each layer is referenced by its name within the geodatabase and information is provided about the source layers' name, location, and a brief description of the content found within the layer.

Historical Structures

- Layer Source Name: National Register of Historic Places - 2014, National Park Service Integrated Resource Management Applications (IRMA)
- Description: The National Register geospatial dataset is intended to be a comprehensive inventory of all cultural resources that are listed on the National Register of Historic Places. However, this dataset excludes all features deemed 'restricted' or 'sensitive', such as sensitive archaeological sites. This dataset provides feature geometry representations (point or polygon) and is intended to be supplemented with descriptive attributes maintained by other external database systems such as the National Register Information System which is included in this geodatabase.
- Layer Source Location: https://irma.nps.gov/DataStore/Reference/Profile/2210280

Cemeteries

- Layer Source Name: GNIS TN Cemeteries - 2019, USGS Geographic Names Information System (GNIS)
- Description: This data layer contains cemeteries in Tennessee from the USGS Geographic Names Information System (GNIS). Data was downloaded from the GNIS and cemeteries without latitude and longitude were removed.
- Layer Source Location: https://hub.arcgis.com/datasets/tga::gnis-tn-cemeteries

Wetlands

- Layer Source Name: USFWS National Wetlands Inventory-Polygons-October 2014, USGS
- Description: This data set represents the extent, approximate location, and type of wetlands and deep-water habitats in the conterminous United States. These data delineate the areal extent of wetlands and surface waters as defined by Cowardin et al. (1979). Certain wetland habitats are excluded from the national mapping program because of the limitations of aerial imagery as the primary data source used to detect wetlands. These habitats include seagrasses or submerged aquatic vegetation that are found in the intertidal and subtidal zones of estuaries and near shore coastal waters. Some deep-water reef communities (coral or tuberficid worm reefs) have also been excluded from the inventory. These habitats, because of their depth, go undetected by aerial imagery. By policy, the service also excludes certain types of "farmed wetlands" as may be defined by the Food Security Act or that do not coincide with the Cowardin et al. definition. Contact the service's Regional Wetland Coordinator for additional information on what types of farmed wetlands are included on wetland maps
- Layer Source Location: https://water.usgs.gov/GIS/huc.html

Hydrology/Hydrologic Units

- Layer Source Name: Watershed Boundary Dataset – 2018, USGS; National Hydrography Dataset – 2018, USGS
- Description: The Watershed Boundary Dataset (WBD) and National Hydrography Dataset (NHD) are nationally consistent watershed datasets that are subdivided into 6 levels (12-digit HUCs) and flow paths and are available from the USGS and USDA-NRCS-National Cartographic and Geospatial Center's (NCGC).
- Layer Source Location: www.usgs.gov/core-science-systems/ngp/national-hydrography/access-national-hydrography-products

Listed Species

- Layer Source Name: U.S. Fish and Wildlife Service Environmental Conservation Online System (ECOS) Federally Listed Species Critical Habitat-2019, USFWS
- Description: This data set represents federally-listed species known to be present in each of the counties that make up Tennessee. The Environmental Conservation Online System (ECOS) is a gateway web site that provides access to data systems in the U.S. Fish and Wildlife Service and other government data sources. This central point of access assists service personnel in managing data and information, and it provides public access to information from numerous Service databases. As of Feb. 13, 2015, the data in this report has been updated to use a different set of information. Results are based on where the species is believed to or known to occur. The FWS feels utilizing this data set is a better representation of species occurrence. Note: there may be other federally listed species that are not currently known or expected to occur in this state but are covered by the ESA wherever they are found. Thus, if new surveys

detected them in this state they are still covered by the ESA. The FWS is using the best information available on this date to generate this list. The data is not meant as a substitute for site-specific surveys.
- Layer Source Location: https://ecos.fws.gov/ecp/report/table/critical-habitat.html

Early Detection and Distribution Mapping System

- Layer Source Name: EDDMaps
- Description: Point data of invasive species collected by EDDMaps users.
- Layer Source Location: www.eddmaps.org/tools/

Counties

- Layer Source Name: Counties, Tennessee, Tennessee Department of Transportation
- Description: The county boundary features database was created on behalf of the Tennessee Department of Transportation by members of the Geographic Information Systems Laboratory, Systems Development Institute, The University of Tennessee, Knoxville
- Layer Source Location: www.tngis.org/administrative-boundaries.html

Roads

- Layer Source Name: TRANS Road Segments
- Description: Layers of geospatial data include roads, airports, trails, and railroads. The geospatial data are from selected National Map data holdings and other government sources.
- Layer Source Location: www.sciencebase.gov/catalog/item/5a61c93de4b06e28e9c3bdbb

Soil

- Layer Source Name: Statewide Soil Data, Tennessee
- Description: This dataset contains the boundaries and descriptions of soil types.
- Layer Source Location: https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

Integrated Climate and Land-Use Scenarios Population Projections

- Layer Source Name: ICLUS v2.1.1 Countywide Population Projections, 2020
- Description: The methodology used to produce these projections differs from ICLUS v2.0. The demographic components of change (i.e., rates of fertility and mortality) for ICLUS v2.1 were taken directly from the Wittgenstein Centre Data Explorer. These projections were produced more recently than the Census projections used in ICLUS v2.0 and incorporate more recent observations of population change. SSP2 is a “middle-of-the-road” projection, where social, economic, and technological trends do not shift markedly from historical patterns, resulting in a U.S. population of 455 million people by 2100. Domestic migration trends remain largely consistent with the recent past, however the amenity value of local climate (average precipitation and temperature for summer and winter) is used in ICLUS v2.1.1 to influence migration patterns. The name of the climate model used as the source of future climate patterns is included at the end of the file name (e.g., "GISS-E2-R" or "HadGEM2-ES"). The approach for incorporating climate change into the migration model is described in the ICLUS v2.0 documentation. The SSP5 narrative describes a rapidly growing and flourishing global economy that remains heavily dependent on fossil fuels, and a U.S. population that exceeds 730 million by 2100. ICLUS v2.1 land use projections under SSP5 result in a considerably larger expansion of developed lands relative to SSP2. The

amenity value of local climate (average precipitation and temperature for summer and winter) is used in ICLUS v2.1.1 to influence migration patterns. The name of the climate model used as the source of future climate patterns is included at the end of the file name (e.g., "GISS-E2-R" or "HadGEM2-ES"). The approach for incorporating climate change into the migration model is described in the ICLUS v2.0 documentation. RCP4.5 assumes that global greenhouse gas emissions increase into the latter part of the century, before leveling off and eventually stabilizing by 2100 as a result of various climate change policies. RCP8.5 assumes that global greenhouse gas emissions increase through the year 2100.

- Layer Source Location: https://catalog.data.gov/dataset/iclus-v2-1-1-population-projections

Projected Future Land Use, 2030

- Layer Source Name: ICLUS Version 2 Land Use Projections for the Fourth National Climate Assessment SSP2LUS_v2.1_land_use_southeast_ssp2, 2019
- Description: SSP2 is a “middle-of-the-road” projection of future land use, where social, economic, and technological trends do not shift markedly from historical patterns, resulting in a U.S. population of 455 million people by 2100. Domestic migration trends remain consistent with the recent past. This version of the ICLUS model does not include climate change projections to dynamically update location-specific amenities when calculating migration. These projections will include the “nocc” label in the file name to indicate this difference.
- Layer Source Location: https://catalog.data.gov/dataset/iclus-v2-1-land-use-projections-for-the-fourth-national-climate-assessment-ssp2

World Imagery

- Layer Source Name: ESRI World Imagery, 2019
- Description: This map service presents satellite imagery for the world and high-resolution imagery for the United States and other areas around the world.
- Layer Source Location: www.esri.com/software/arcgis/arcgisonline

National Conservation Easement Database Conservation Easement Boundaries

- Layer Source Name: NCED Easements
- Description: The National Conservation Easement Database (NCED) is the first national database of conservation easement information, compiling records from land trusts and public agencies throughout the United States. This public-private partnership brings together national conservation groups, local and regional land trusts, and local, state, and federal agencies around a common objective. The NCED is an initiative of the U.S. Endowment for Forestry and Communities. The NCED team collaborates on data acquisition and standards with the USGS Core Science Analytics, Synthesis, and Library’s Protected Areas Database of the United States (PAD-US).
- Layer Source Locations: www.conservationeasement.us/interactivemap/

The Nature Conservancy Conservation Easement Boundary

- Layer Source Name: TNC Lands TN
- Description: This dataset includes The Nature Conservancy's properties, preserves, easements, and leases (areas TNC holds a legal interest in). Boundaries are regularly collected from TNC's US State Chapters and are matched with attributes from the TNC legal database. This dataset is regularly provided

to the CBI PAD-US, NCED, and USGS GAP protected area databases, but this dataset provides additional attributes and more frequent updates. Some historic data is included, but the focus is on current holdings.
- Layer Source Locations: www.tnclands.tnc.org/

U.S. Forest Service Forest Administrative Boundaries

- Layer Source Name: Forest Service Administrative Boundaries
- Description: The area encompasses private lands, other governmental agency lands, and may contain National Forest System lands within the proclaimed boundaries of another administrative unit.
- Layer Source Locations: https://data-usfs.hub.arcgis.com/datasets/forest-administrative-boundaries-feature-layer?geometry=-94.323%2C34.289%2C-77.634%2C37.405

Mill Locations

- Layer Source Name: Southeast US Wood Using Mill Locations
- Description: ArcGIS Online layer showing the wood product mills by type within the southern United States.
- Layer Source Locations: https://primary.forestproductslocator.org/mill-map

Tennessee Protected Areas

- Layer Source Name: USGS Protected Areas TN (v. 2.1), 2020
- Description: The USGS Protected Areas Database of the United States (PAD-US) is the nation's inventory of protected areas, including public open space and voluntarily provided, private protected areas, identified as an A-16 National Geospatial Data Asset in the Cadastral Theme. PAD-US is an ongoing project with several published versions of a spatial database of areas dedicated to the preservation of biological diversity, and other natural, recreational, or cultural uses, managed for these purposes through legal or other effective means. The geodatabase maps and describes public open space and other protected areas. Most areas are public lands owned in fee; however, long-term easements, leases, and agreements or administrative designations documented in agency management plans may be included. The PAD-US database strives to be a complete “best available” inventory of protected areas (lands and waters) including data provided by managing agencies and organizations. The dataset is built in collaboration with several partners and data providers. See Supplemental Information Section of this metadata record for more information on partnerships and links to partner organizations. As this dataset is a compilation of many data sets, data completeness, accuracy, and scale may vary. Federal and state data are generally complete, while local government and private protected area coverage is about 50% complete and depends on data management capacity in the state. As the federal and state data are reasonably complete, focus is shifting to completing the inventory of local government and voluntarily provided, private protected areas. The PAD-US geodatabase contains over 25 attributes and 4 feature classes to support data management, queries, web mapping services and analyses: Marine Protected Areas (MPA), Fee, Easements and Combined. The data contained in the MPA Feature class are provided directly by the National Oceanic and Atmospheric Administration (NOAA) Marine Protected Areas Center. The Easements feature class contains data provided directly from the National Conservation Easement Database.) The MPA and Easement feature classes contain some attributes unique to the sole source databases tracking them (e.g., Easement Holder Name from NCED, Protection Level from NOAA MPA

Inventory). The "Combined" feature class integrates all fee, easement and MPA features as the best available national inventory of protected areas in the standard PAD-US framework. In addition to geographic boundaries, PAD-US describes the protection mechanism category (e.g., fee, easement, designation, other), owner and managing agency, designation type, unit name, area, public access, and state name in a suite of standardized fields. An informative set of references (i.e., Aggregator Source, GIS Source, GIS Source Date) and "local" or source data fields provide a transparent link between standardized PAD-US fields and information from authoritative data sources. The areas in PAD-US are also assigned conservation measures that assess management intent to permanently protect biological diversity: the nationally relevant "GAP Status Code" and global "IUCN Category" standard.

- Layer Source Locations: https://hub.arcgis.com/datasets/myUTK::usgs-protectedareas-tn

Wildland-Urban Interface

- Layer Source Name: Tennessee Wildland-Urban Interface, 2018
- Description: This data set depicts the Wildland-Urban Interface data for Tennessee. The data is from the SILVIS Lab. The data has been symbolized based off the WUIFlag10 layer (WUI Status as of 2010).
- Layer Source Locations: hub.arcgis.com/datasets/bc751b7c5bb244a3b56279c10684f987_0

Disturbance Data - 2020

- Layer Source Name: LANDFIRE Disturbance Data_2020
- Description: LANDFIRE's (LF) Annual Disturbance products provide temporal and spatial information related to landscape change. Annual Disturbance depicts areas of 4.5 hectares (11 acres) or larger that have experienced a natural or anthropogenic landscape change (or treatment) within a given year. For the creation of the Annual Disturbance product, information sources include national fire mapping programs such as Monitoring Trends in Burn Severity (MTBS), Burned Area Reflectance Classification (BARC) and Rapid Assessment of Vegetation Condition after Wildfire (RAVG), 18 types of agencies contributed "event" perimeters (see LF Public Events Geodatabase), and remotely sensed Landsat imagery. To create the LF Annual Disturbance products, individual Landsat scenes are stacked and made into composites representing the 50th percentile of all stacked pixels (band-by-band) to reduce data gaps caused by clouds or other anomalies. Composite imagery from the specified mapping year, the two prior years, and the following year serve as the base data from which change products such as the Normalized Differenced Vegetation Index (dNDVI), the Normalized Burn Ratio (dNBR), and the Multi-Index Integrated Change Algorithm (MIICA) (Jin et al. 2013) are derived. Image analysts collectively use these datasets (separately or in combination) to isolate the true change from false change (commission errors). False changes can be attributed to many anomalies but are mostly caused by stark differences in annual or seasonal phenology, and/or artifacts in the image composites. Fire-caused disturbances sourced from MTBS may contain data gaps where clouds obscure the full burn scar from being mapped. Models trained from pre-fire and post-fire Landsat data are used to fill these gaps. The result is continuous severity and extent information for all MTBS fire disturbances. MTBS pixels derived from gap filling techniques, such as modeling, are noted as such in the Annual Disturbance attribute table. Smaller fires that do not meet the size criteria set forth by MTBS may be attributed using Burned Area (BA), informed from Landsat Level-3 science products and only available in the lower 48 states. Causality and severity information assigned to a disturbance are prioritized by source, with the highest priorities reserved for fire mapping programs (MTBS, BARC, and RAVG) followed by user-contributed events contained in the LF Events Geodatabase, and lastly, Landsat image-based change.

- Layer Source Locations: https://landfire.gov/version_download.php

Tennessee Forest Action Plan Priority Areas – 2020-2030

- Layer Source Name: Tennessee FAP Priority Areas
- Description: The Tennessee Department of Agriculture Division of Forestry, in cooperation with the Tennessee Chapter of The Nature Conservancy, released the 2020 Tennessee Forest Action Plan. All 50 states are required by federal law to develop and update a Forest Action Plan every ten years in order to be eligible to receive funds under the Cooperative Forestry Assistance Act administered by the U.S. Forest Service. This plan provides a comprehensive assessment of the condition of Tennessee's forest resources, risks and challenges associated with forest health and resiliency, and strategies for protecting, conserving, and enhancing this vital resource for our citizens and visitors. The 2020 Tennessee Forest Action Plan builds on the state's inaugural 2010 Forest Resource Assessment and Strategy with four objectives: enhancing forest health and resiliency, expanding market diversification, maintaining and improving connected landscapes, and strengthening wildfire resilient communities. The Plan's priority areas are driven by three foundational data layers: USDA Forest Service's Forests to Faucets to characterize the effect of forests on the quantity and quality of surface drinking water, USDA Forest Service's Forest Inventory and Analysis Carbon Inventory, and The Nature Conservancy's Resilient and Connected Landscapes.
- Layer Source Locations: https://tndof.maps.arcgis.com/home/item.html?id=496f76c6402d4c36bd2167691e1330bb&sublayer=0

Table 3. Common tree species by LMP Forest Type.

Common Name	Scientific Name	Oak-Hickory Mixed	Cedar-Hardwood Mixed	Other Mixed Hardwood	Mesic Hardwood Forest	Bottomland Hardwoods	Mixed Pine	Pine-Hardwoods Mixed
box elder	*Acer negundo*			X		X		
red maple	*Acer rubrum*	X		X	X	X		X
silver maple	*Acer saccharinum*			X		X		
sugar maple	*Acer saccharum*	X	X	X		X		X
mountain maple	*Acer spicatum*	X	X	X				
yellow buckeye	*Aesculus flava*			X	X			
yellow birch	*Betula alleghaniensis*	X	X	X	X			X
black (sweet) birch	*Betula lenta*	X		X	X			X
river birch	*Betula nigra*			X		X		X
American hornbeam	*Carpinus caroliniana*	X		X	X	X		X
water hickory	*Carya aquatica*				X	X		
bitternut hickory	*Carya cordiformis*	X		X	X	X		X
pignut hickory	*Carya glabra*	X		X	X		X	X
shellbark Hickory	*Carya laciniosa*				X	X		
red hickory	*Carya ovalis*	X		X	X			X
shagbark hickory	*Carya ovata*	X		X	X	X		X
mockernut hickory	*Carya tomentosa*	X		X	X			X
sugarberry	*Celtis laevigata*			X		X		

Common Name	Scientific Name	Oak-Hickory Mixed	Cedar-Hardwood Mixed	Other Mixed Hardwood	Mesic Hardwood Forest	Bottomland Hardwoods	Mixed Pine	Pine-Hardwoods Mixed
hackberry	*Celtis occidentalis*			X		X		
eastern redbud	*Cercis canadensis*	X	X	X				X
flowering dogwood	*Cornus florida*	X	X	X	X	X	X	X
swamp dogwood	*Cornus foemina*					X		
persimmon	*Diospyros virginiana*			X	X	X		X
American beech	*Fagus grandifolia*	X		X	X	X		X
white ash	*Fraxinus americana*	X		X	X	X		X
green ash	*Fraxinus pennsylvanica*					X		X
blue ash	*Fraxinus quadrangulata*	X	X	X				X
honey locust	*Gleditsia triacanthos*	X		X				X
American holly	*Ilex opaca*	X		X	X	X		X
black walnut	*Juglans nigra*	X		X		X		X
eastern red cedar	*Juniperus virginiana*	X	X	X				X
mountain laurel	*Kalmia latifolia*	X		X				X
sweetgum	*Liquidambar styraciflua*	X		X	X	X		X
yellow-poplar	*Liriodendron tulipifera*	X		X	X	X		X
cucumber magnolia	*Magnolia acuminata*			X	X			
bigleaf magnolia	*Magnolia macrophylla*			X	X			

Common Name	Scientific Name	Oak-Hickory Mixed	Cedar-Hardwood Mixed	Other Mixed Hardwood	Mesic Hardwood Forest	Bottomland Hardwoods	Mixed Pine	Pine-Hardwoods Mixed
sweet bay	*Magnolia virginiana*			X	X	X		X
water tupelo	*Nyssa aquatica*					X		
swamp tupelo	*Nyssa biflora*					X		
black tupelo	*Nyssa sylvatica*	X		X	X	X		X
American hop hornbeam	*Ostrya virginiana*	X		X	X			X
sourwood	*Oxydendrum arboreum*	X		X	X			X
shortleaf pine	*Pinus echinata*						X	X
table mountain pine	*Pinus pungens*						X	X
pitch pine	*Pinus rigida*						X	X
eastern white pine	*Pinus strobus*		X		X		X	X
loblolly pine	*Pinus taeda*				X		X	X
Virginia pine	*Pinus virginiana*						X	X
American Sycamore	*Plantanus occidentalis*			X	X	X		
eastern cottonwood	*Populus deltoides*					X		
black cherry	*Prunus serotina*				X	X		
white oak	*Quercus alba*	X		X	X	X		X
swamp white oak	*Quercus bicolor*					X		
scarlet oak	*Quercus coccinea*	X		X			X	X

Common Name	Scientific Name	Oak-Hickory Mixed	Cedar-Hardwood Mixed	Other Mixed Hardwood	Mesic Hardwood Forest	Bottomland Hardwoods	Mixed Pine	Pine-Hardwoods Mixed
southern red oak	*Quercus falcata*	X		X			X	X
overcup oak	*Quercus lyrata*					X		
bur oak	*Quercus macrocarpa*			X		X		
blackjack oak	*Quercus marilandica*	X		X				X
swamp chestnut oak	*Quercus michauxii*					X		
chinkapin oak	*Quercus muehlenbergii*	X	X	X				X
chestnut oak	*Quercus montana*	X		X	X		X	X
water oak	*Quercus nigra*	X		X				X
cherrybark oak	*Quercus pagoda*	X		X		X		X
pin oak	*Quercus palustris*			X		X		
willow oak	*Quercus phellos*			X		X		
northern red oak	*Quercus rubra*	X		X	X			X
shumard oak	*Quercus shumardii*	X	X	X				X
post oak	*Quercus stellata*	X	X	X				X
black oak	*Quercus velutina*	X		X				X
black willow	*Salix nigra*					X		
sassafras	*Sassafras albidum*	X		X				X
cypress	*Taxodium sp.*					X		X

Common Name	Scientific Name	Oak-Hickory Mixed	Cedar-Hardwood Mixed	Other Mixed Hardwood	Mesic Hardwood Forest	Bottomland Hardwoods	Mixed Pine	Pine-Hardwoods Mixed
northern white cedar	*Thuja occidentalis*		X	X	X			
white basswood	*Tilia americana*			X	X			
eastern hemlock	*Tsuga canadensis*			X	X			
winged elm	*Ulmus alata*	X	X	X	X			X
American elm	*Ulmus americana*	X		X			X	X
slippery elm	*Ulmus rubra*			X		X		
September elm	*Ulmus serotina*	X		X				X

Table 4. Federally threatened and endangered species present within the Tennessee Level III Ecoregions.

Species	Blue Ridge	Ridge and Valley	Central Appalachians	Southwestern Appalachians	Interior Plateau	Southeastern Plains	Mississippi Valley Loess Plains	Mississippi Alluvial Plain
Alabama lampmussel					X	X		
Alabama moccasinshell	X	X						
amber darter	X	X						
American hart's-tongue fern				X				
Anthony's riversnail	X	X	X	X				
Appalachian elktoe	X	X						
Appalachian monkeyface (pearlymussel)	X	X	X		X			
barrens topminnow	X	X	X	X	X	X	X	X
birdwing pearlymussel		X	X			X		
blackside dace		X	X	X				
blue Ridge goldenrod	X	X						
blue shiner	X	X						
bluemask darter				X	X			
boulder darter					X			
Braun's rockcress					X			
Carolina northern flying squirrel	X	X						
Chucky madtom		X						

Species	Blue Ridge	Ridge and Valley	Central Appalachians	Southwestern Appalachians	Interior Plateau	Southeastern Plains	Mississippi Valley Loess Plains	Mississippi Alluvial Plain
clubshell			X		X	X		
Conasauga logperch	X	X						
Coosa moccasinshell	X	X						
cracking pearlymussel	X	X	X		X	X		
Cumberland bean (pearlymussel)	X	X		X	X			
Cumberland darter			X					
Cumberland elktoe			X	X	X			
Cumberland monkeyface (pearlymussel)	X	X		X	X			
Cumberland pigtoe				X	X			
Cumberland rosemary			X	X	X			
Cumberlandian combshell	X	X	X	X	X			
diamond darter					X			
Dromedary pearlymussel		X	X	X	X			
duskytail darter	X	X	X	X				
eastern black rail							X	X
fanshell		X	X	X	X	X		
fat pocketbook								X
finelined pocketbook	X	X						

Species	Blue Ridge	Ridge and Valley	Central Appalachians	Southwestern Appalachians	Interior Plateau	Southeastern Plains	Mississippi Valley Loess Plains	Mississippi Alluvial Plain
finerayed pigtoe	X	X	X	X	X			
fluted kidneyshell	X	X	X	X	X			
Georgia pigtoe	X	X						
goldline darter	X	X						
gray bat	X	X	X	X	X	X		X
green blossom (pearlymussel)	X	X	X					
Guthrie's ground-plum					X			
indiana myotis	X	X	X	X	X	X	X	X
large-flowered skullcap		X		X				
laurel dace		X	X	X				
leafy prairie-clover					X			
littlewing pearlymussel		X		X	X			
Morefields leather flower				X	X			
northern long-eared bat	X	X	X	X	X	X	X	X
orangefoot pimpleback	X	X	X	X	X	X		
ovate clubshell	X	X						
oyster mussel	X	X	X	X	X			
painted snake coiled forest snail				X	X			

Species	Blue Ridge	Ridge and Valley	Central Appalachians	Southwestern Appalachians	Interior Plateau	Southeastern Plains	Mississippi Valley Loess Plains	Mississippi Alluvial Plain
pale lilliput (pearlymussel)				X	X			
Pallid sturgeon							X	X
pink mucket	X	X	X	X	X	X		
Price's potato-bean				X	X	X		
purple bean		X	X	X				
pygmy madtom	X	X						
rabbitsfoot	X	X			X	X		
rayed bean	X	X			X			
ring pink (mussel)	X	X	X		X	X		
Roan Mountain bluet	X	X						
rock gnome lichen	X	X						
rough pigtoe	X	X	X	X	X	X		
rough rabbitsfoot		X	X					
royal marstonia (snail)				X				
Ruth's golden aster	X	X						
sheepnose mussel	X	X	X		X	X		
shiny pigtoe		X	X	X	X			
Short's bladderpod					X			
slabside pearlymussel	X	X		X	X	X		

Species	Blue Ridge	Ridge and Valley	Central Appalachians	Southwestern Appalachians	Interior Plateau	Southeastern Plains	Mississippi Valley Loess Plains	Mississippi Alluvial Plain
slackwater darter					X	X		
slender chub		X	X					
small whorled pogonia	X	X		X				
smoky madtom	X	X						
snail darter	X	X		X	X			
snuffbox mussel	X	X	X		X			
southern acornshell	X	X						
southern clubshell	X	X						
southern pigtoe	X	X						
spectaclecase (mussel)	X	X	X	X	X	X		
spotfin chub	X	X	X	X	X	X		
spreading avens	X	X						
spring creek bladderpod					X			
spruce-fir moss spider	X	X						
tan riffleshell			X	X				
Tennessee yellow-eyed grass					X			
triangular kidneyshell	X	X						
trispot darter	X	X	X	X	X	X	X	X

Species	Blue Ridge	Ridge and Valley	Central Appalachians	Southwestern Appalachians	Interior Plateau	Southeastern Plains	Mississippi Valley Loess Plains	Mississippi Alluvial Plain
tubercled blossom (pearlymussel)	X	X		X	X			
turgid blossom		X	X	X	X			
upland combshell	X	X						
Virginia big-eared bat	X	X						
Virginia spirea	X	X	X	X	X			
white fringeless orchid	X	X		X	X			
white wartyback (pearlymussel)		X	X		X	X		
whorled sunflower						X	X	
winged mapleleaf					X			
yellow blossom (pearlymussel)					X			
yellowfin madtom	X	X	X					

Table 5. Rare species of Tennessee by LMP forest type.

Common Name	Scientific Name	Oak/Hickory Mixed	Mixed Pine Species	Pine/ Hardwood Mixed	Cedar/ Hardwood Mixed	Mesic Hardwood Forest	Bottomland Hardwoods
Birds							
whooping crane	*Grus americana*					X	X
Fish							
amber darter	*Percina antesella*					X	X
Barrens topminnow	*Fundulus julisia*					X	X
blackside dace	*Phoxinus cumberlandensis*					X	X
bluemask darter	*Etheostoma akatulo*					X	X
blue shiner	*Cyprinella caerulea*					X	X
boulder darter	*Etheostoma wapiti*					X	X
Chucky madtom	*Noturus crypticus*					X	X
Conasauga logperch	*Percina jenkinsi*					X	X
Cumberland darter	*Etheostoma susanae*					X	X
diamond darter	*Crystallaria cincotta*					X	X
duskytail darter	*Etheostoma percnurum*					X	X
goldline darter	*Percina aurolineata*					X	X
laurel dace	*Chrosomus saylori*					X	X
pallid sturgeon	*Scaphirhynchus albus*					X	X
pygmy madtom	*Noturus stanauli*					X	X

Common Name	Scientific Name	Oak/Hickory Mixed	Mixed Pine Species	Pine/ Hardwood Mixed	Cedar/ Hardwood Mixed	Mesic Hardwood Forest	Bottomland Hardwoods
slackwater darter	*Etheostoma boschungi*					X	X
slender chub	*Erimystax cahni*					X	X
Smoky madtom	*Noturus baileyi*					X	X
snail darter	*Percina tanasi*					X	X
spotfin chub	*Erimonax monachus*					X	X
trispot darter	*Etheostoma trisella*					X	X
yellowfin madtom	*Noturus flavipinnis*					X	X
Invertebrates							
Alabama lampmussel	*Lampsilis virescens*					X	X
Alabama moccasinshell	*Medionidus acutissimus*					X	X
Anthony's riversnail	*Athearnia anthonyi*						X
Appalachian elktoe	*Alasmidonta raveneliana*					X	X
Appalachian monkeyface (pearlymussel)	*Quadrula sparsa*						X
birdwing pearlymussel	*Lemiox rimosus*					X	X
clubshell	*Pleurobema clava*					X	X
Coosa moccasinshell	*Medionidus parvulus*					X	X
cracking pearlymussel	*Hemistena lata*					X	X

Common Name	Scientific Name	Oak/Hickory Mixed	Mixed Pine Species	Pine/ Hardwood Mixed	Cedar/ Hardwood Mixed	Mesic Hardwood Forest	Bottomland Hardwoods
Cumberland bean (pearlymussel)	*Villosa trabalis*					X	X
Cumberland elktoe	*Alasmidonta atropurpurea*					X	X
Cumberland monkeyface (pearlymussel)	*Quadrula intermedia*					X	X
Cumberland pigtoe	*Pleurobema gibberum*					X	X
Cumberlandian combshell	*Epioblasma brevidens*					X	X
dromedary pearlymussel	*Dromus dromas*					X	X
fanshell	*Cyprogenia stegaria*					X	X
fat pocketbook	*Potamilus capax*					X	X
finelined pocketbook	*Lampsilis altilis*					X	X
finerayed pigtoe	*Fusconaia cuneolus*					X	X
fluted kidneyshell	*Ptychobranchus subtentus*					X	X
Georgia pigtoe	*Pleurobema hanleyianum*					X	X
green blossom (pearlymussel)	*Epioblasma torulosa gubernaculum*					X	X
littlewing pearlymussel	*Pegias fabula*					X	X
Nashville crayfish	*Orconectes shoupi*					X	X

Common Name	Scientific Name	Oak/Hickory Mixed	Mixed Pine Species	Pine/ Hardwood Mixed	Cedar/ Hardwood Mixed	Mesic Hardwood Forest	Bottomland Hardwoods
orangefoot pimpleback (pearlymussel)	*Plethobasus cooperianus*					X	X
ovate clubshell	*Pleurobema perovatum*					X	X
oyster mussel	*Epioblasma capsaeformis*					X	X
painted snake coiled forest snail	*Anguispira picta*					X	
pale lilliput (pearlymussel)	*Toxolasma cylindrellus*					X	X
pink mucket (pearlymussel)	*Lampsilis abrupta*					X	X
purple bankclimber	*Elliptoideus sloatianus*					X	X
purple bean	*Villosa perpurpurea*					X	X
purple cat's paw	*Epioblasma obliquata*					X	X
rabbitsfoot	*Quadrula cylindrica*					X	X
rayed bean	*Villosa fabalis*					X	X
ring pink (mussel)	*Obovaria retusa*					X	X
rough pigtoe	*Pleurobema plenum*					X	X
rough rabbitsfoot	*Quadrula cylindrica strigillata*					X	X
royal marstonia	*Pyrgulopsis ogmorhaphe*						X
sheepnose mussel	*Plethobasus cyphyus*					X	X

Common Name	Scientific Name	Oak/Hickory Mixed	Mixed Pine Species	Pine/ Hardwood Mixed	Cedar/ Hardwood Mixed	Mesic Hardwood Forest	Bottomland Hardwoods
shiny pigtoe	*Fusconaia cor*					X	X
slabside pearlymussel	*Pleuronaia dolabelloides*					X	X
snuffbox mussel	*Epioblasma triquetra*					X	X
southern acornshell	*Epioblasma othcaloogensis*					X	X
southern clubshell	*Pleurobema decisum*					X	X
southern pigtoe	*Pleurobema georgianum*					X	X
spectaclecase	*Cumberlandia monodonta*					X	X
spruce-fir moss spider	*Microhexura montivaga*			X			
tan riffleshell	*Epioblasma florentina walkeri (=E. walkeri)*					X	X
triangular kidneyshell	*Ptychobranchus greenii*					X	X
tubercled blossom (pearlymussel)	*Epioblasma torulosa*					X	X
turgid blossom (pearlymussel)	*Epioblasma turgidula*					X	X
upland combshell	*Epioblasma metastriata*					X	X
white wartyback (pearlymussel)	*Plethobasus cicatricosus*					X	X
winged mapleleaf	*Quadrula fragosa*					X	X

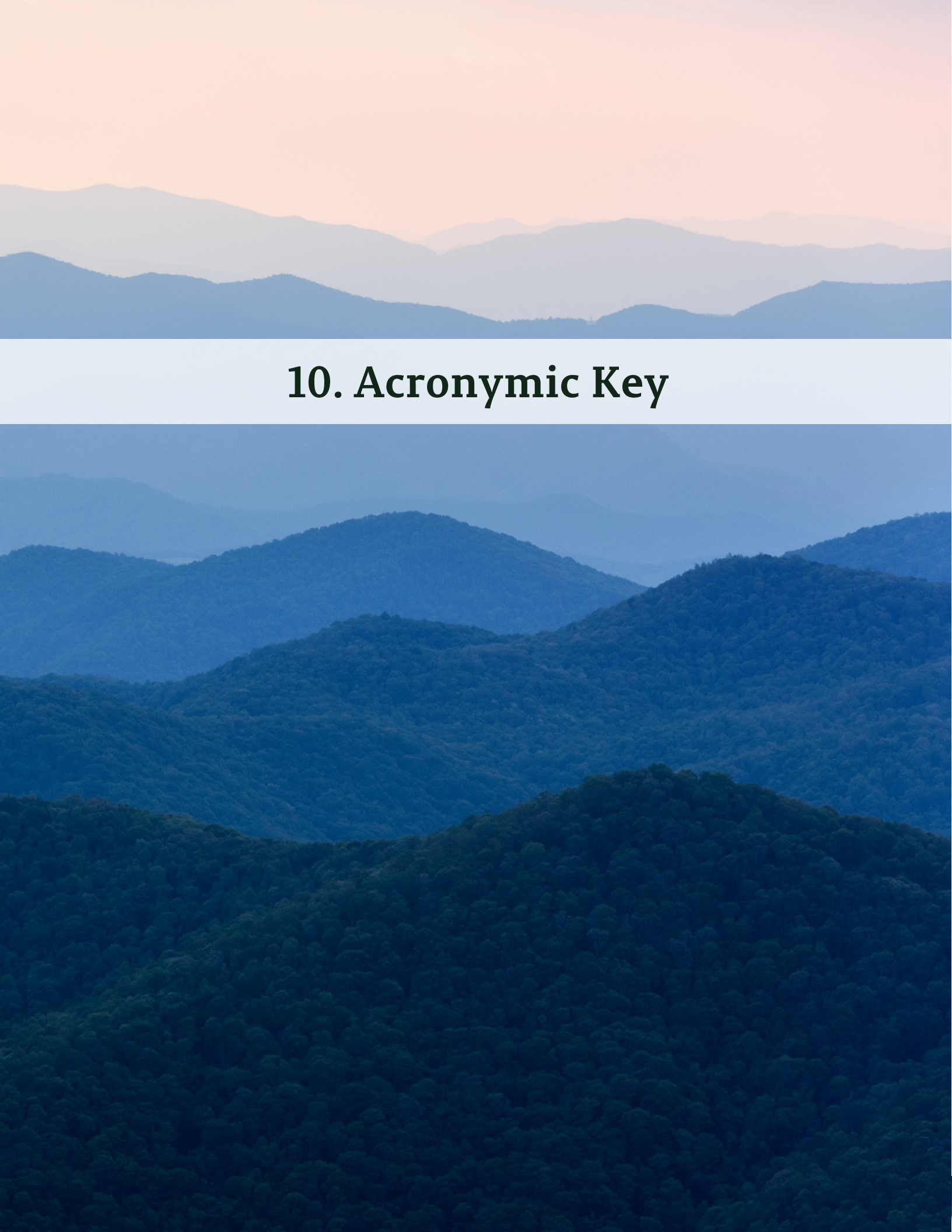
Common Name	Scientific Name	Oak/Hickory Mixed	Mixed Pine Species	Pine/ Hardwood Mixed	Cedar/ Hardwood Mixed	Mesic Hardwood Forest	Bottomland Hardwoods
yellow blossom (pearlymussel)	*Epioblasma florentina*					X	X
Mammals							
Carolina northern flying squirrel	*Glaucomys sabrinus coloratus*			X		X	
gray bat	*Myotis grisescens*	X		X	X	X	
Indiana bat	*Myoti sodalis*	X	X	X	X	X	X
northern long-eared bat	*Myotis septentrionalis*	X	X	X	X	X	X
Virginia big-eared bat	*Corynorhinus (=Plecotus) townsendii virginianus*	X				X	
Plants							
Blue Ridge goldenrod	*Solidago spithamaea*				X		
Braun's rockcress	*Boechera perstellata*				X		
Cumberland rosemary	*Conradina verticillata*					X	X
Hart's-tongue fern	*Asplenium scolopendrium var. americanum*	X			X	X	
large-flowered skullcap	*Scutellaria montana*	X	X	X	X		
leafy prairie-clover	*Dalea foliosa*				X		
Morefield's leatherflower	*Clematis morefieldii*				X		
ovate catchfly	*Silene ovata*	X				X	

Common Name	Scientific Name	Oak/Hickory Mixed	Mixed Pine Species	Pine/ Hardwood Mixed	Cedar/ Hardwood Mixed	Mesic Hardwood Forest	Bottomland Hardwoods
Price's potato-bean	*Apios priceana*					X	X
Pyne's ground-plum	*Astragalus bibullatus*				X		
Roan Mountain bluet	*Hedyotis puepurea var. montana*				X		
Ruth's golden-aster	*Pityopsis ruthii*					X	X
Short's bladderpod	*Physaria globosa*				X		
small whorled pogonia	*Isotria medeoloides*	X	X	X	X		
spreading avens	*Geum radiatum*				X		
Spring Creek bladderpod	*Paysonia perforata*				X		X
Tennessee yellow-eyed grass	*Xyris tennesseensis*				X	X	
white fringeless orchid	*Platanthera integrilabia*					X	X
whorled sunflower	*Helianthus verticillatus*					X	X
Virginia spiraea	*Spiraea virginiana*					X	X
Reptiles							
bog turtle	*Clemmys muhlenbergii*			X		X	X

Table 6. Common Tennessee non-native invasive plant (upland) species list divided by threat level.

Scientific Name	Common Name
Established Threat	
Ailanthus altissima	tree of Heaven
Albizia julibrissin	mimosa, silktree, silky acacia
Alliaria petiolata	garlic mustard
Alternanthera philoxeroides	alligatorweed
Arthraxon hispidus	hairy jointgrass, small carpetgrass
Bromus inermis	Hungarian brome, smooth brome
Celastrus orbiculatus	Asian bittersweet, Oriental bittersweet
Centaurea stobe	Centaurea biebersteinii DC., spotted knapweed
Clematis terniflora	sweet autumn clematis
Dioscorea polystachya	Chinese yam, cinnamon vine, Dioscorea oppositifolia L.
Elaeagnus umbellata	autumn olive
Euonymus alatus	burning bush, winged Euonymus
Euonymus hederaceus	Euonymus fortune, Hand.-Mazz., winter creeper
Fallopia japonica	fleeceflower, Japanese knotweed, Mexican bamboo, Polygonum cuspidatum Seib. & Zucc.
Hedera helix	English ivy
Hydrilla verticillata	Hydrilla, water thyme
Lespedeza bicolor	Bicolor Lespedeza, shrubby bushclover, shrubby Lespedeza
Lespedeza cuneata	Chinese Lespedeza, Sericea Lespedeza
Ligustrum sinense	Chinese privet
Lonicera japonica	Japanese honeysuckle
Lonicera maackii	Amur bush honeysuckle
Lythrum salicaria	purple loosestrife
Microstegium vimineum	Japanese stiltgrass, Nepalese browntop, Nepalgrass
Miscanthus sinensis	Chinese silver grass, Eulalia grass, maiden grass, zebra grass
Murdannia keisak	Asian spiderwort, marsh dayflower
Myriophyllum aquaticum	Brazilian watermilfoil, parrot feather
Myriophyllum spicatum	Eurasian watermilfoil
Paulownia tomentosa	empress tree, princess tree, royal Paulownia
Perilla frutescens	beefsteak plant, Chinese basil, Perilla, Perilla mint
Phragmites australis	Ccommon reed
Pueraria montana var. lobata	kudzu

Scientific Name	Common Name
Pyrus calleryana	Bradford pear, Callery pear
Rosa multiflora	multiflora rose
Rubus phoenicolasius	wine raspberry, wineberry
Sorghum halepense	Johnson grass
Spiraea japonica	Japanese meadowsweet, Japanese Spiraea
Tussilago farfara	coltsfoot
Vinca minor	common periwinkle
Wisteria sinensis	Chinese Wisteria
Wisteria floribunda	Japanese Wisteria
Emerging Threat	
Acroptilon repens	Russian knapweed
Akebia quinata	chocolate vine, five-leaf Akebia
Ampelopsis glandulosa var. brevipedunculata	Amur peppervine, creeper, porcelain berry, wild grape
Arundo donax	elephant grass, giant reed
Buddleja davidii	butterfly bush
Firmiana simplex	Chinese parasol tree, Phoenix tree, varnish Ttee
Heracleum mantegazzianum	giant cow parsnip, giant hogweed
Humulus japonicus	Japanese hops
Imperata cylindrica	cogongrass, Japanese bloodgrass
Liriope spicata	creeping lilyturf, creeping liriope, lilyturf, monkey grass
Lygodium japonicum	Japanese climbing fern
Mahonia bealei	Beale's barberry, leatherleaf Mahonia
Melia azedarach	Chinaberry
Nandina domestica	Heavenly bamboo, Nandina, sacred bamboo
Persicaria perfoliata	Asiatic tearthumb, mile-a-minute weed
Phyllostachys aurea	golden bamboo
Ranunculus ficaria	Fig buttercup, lesser Celandine
Rhamnus cathartica	common buckthorn, European buckthorn, purging buckthorn
Rottboellia cochinchinensis	itchgrass
Salvinia molesta	aquarium water-moss, giant salvinia
Solanum viarum	tropical soda apple



10. Acronymic Key

10. ACRONYMIC KEY

Abbreviation	Name
004 Form	ATFS Inspection Form
ACF	Association of Consulting Foresters
AFF Standards	AFF Standards of Sustainability
AGS	Acceptable Growing Stock
ATFS	American Tree Farm System
ATV	All-Terrain Vehicle
BH	Bottomland Hardwoods
BMP	Best Management Practice
BR	Blue Ridge Ecoregion
BTB	Black Turpentine Beetle
CHF	Cove Hardwood Forest
CHM	Cedar/Hardwood Mixed
CI	Conservation Initiative
CRP	Conservation Reserve Program
CTR	Crop Tree Release
CWPP	Community Wildfire Protection Plans
EAB	Emerald Ash Borer
ECOS	Environmental Conservation Online System
EDRWFBI	Elk and Duck River Watershed Forest and Buffer Initiative
EFRP	Emergency Forest Restoration Program
EIN	Employee Identification Number
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
ESA	Endangered Species Act
ESM	European Spongy Moth
FAP	Forest Action Plan
FSA	Farm Service Agency
FEMA	Federal Emergency Management Agency
FHTET	Forest Health Technology and Enterprise Team
FMV	Fair Market Value
FORI	Forests of Recognized Importance
FRP	Forest Renewal Program

Abbreviation	Name
FSA	Farm Service Agency
FSP	Forest Stewardship Program
FSP Standards	FSP National Guidelines and Standards
FWHP	Farm Wildlife Habitat Program
GIS	Geographic Information System
GPS	Global Positioning System
HUC	Hydrologic Unit Code
IOBC	International Organization for Biological Control
IPM	Integrated Pest Management
KBDI	Keech-Byram Drought Index
LIDAR	Light Detection and Ranging
LLC	Limited Liability Company
LMP	Landscape Management Plan
MBF	Thousand Board Feet of Timber
MH	Mesic Hardwoods
MAP	Mississippi Alluvial Plain
MVLP	Mississippi Valley Loess Plains
NBCI	National Bobwhite Conservation Initiative
NCREIF	National Council of Real Estate Investment Fiduciaries
NIPF	Non-Industrial Private Forest
NNIA	Non-Native Invasive Animal
NNIP	Non-Native Invasive Plant
NNIS	Non-Native Invasive Species
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NTFP	Non-Timber Forest Product
NWF	National Wildlife Federation
NWOS	National Woodland Owner Survey
NWQI	National Water Quality Initiative
OHV	Off-Highway Vehicles
OHM	Oak-Hickory Mixed
OMH	Other Mixed Hardwoods
OSB	Oriented Strand Board
PEFC	Programme for the Endorsement of Forest Certification
PHM	Pine/Hardwood Mixed

Abbreviation	Name
QTP	Qualified Timber Property
RH	Relative Humidity
RV	Ridge and Valley Ecoregion
SA	Southwestern Appalachians Ecoregion
SAF	Society of American Foresters
SFC	Southern Forestry Consultants
SFI	Sustainable Forestry Initiative
SGCN	Species of Greatest Conservation Need
Silviculture BMPs	Tennessee Division of Forestry Best Management Practices for Silviculture
SMZ	Streamside Management Zone
SOD	Sudden Oak Death
SP	Southeastern Plains Ecoregion
SPB	Southern Pine Beetle
SPBI	Southern Pine Beetle Initiative
SPI	Shortleaf Pine Initiative
Support Committee	Landscape Management Plan Development Support Committee
SWAP	State Wildlife Action Plan
T&E	Threatened and Endangered Species
TAEP	Tennessee Agricultural Enhancement Program
TDEC	Tennessee Department of Environment and Conservation
TDF	Tennessee Division of Forestry
TEMA	Tennessee Emergency Management Agency
TFLP	Tennessee Forest Legacy Program
THWI	Tennessee Healthy Watershed Initiative
TSWAP	Tennessee Statewide Wildlife Action Plan
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
USDA	United States Department of Agriculture
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WBD	Water Boundary Dataset
WLfW	Working Lands for Wildlife
WUI	Wildland-Urban Interface

11. Glossary

11. GLOSSARY

The following glossary is adapted from: David Mercker. 2017. A Glossary of Common Forestry Terms. University of Tennessee Institute of Agriculture Extension.

Acre: A land area of 43,560 square feet. An acre can take any shape. If square in shape, it would measure approximately 209 feet per side.

Advance Reproduction: Young trees that are already established in the understory before a timber harvest.

Afforestation: Establishing a new forest onto land that was formerly not forested; for instance, converting row crop land into a forest plantation.

Age Class: The intervals into which the range of tree ages are grouped, originating from a natural event or human-induced activity.

Artificial Regeneration: Revegetating an area by planting seedlings or broadcasting seeds rather than allowing for natural regeneration.

Bareroot Seedlings: Small seedlings that are nursery grown and then lifted without having the soil attached.

Basal Area: measurement used to help estimate forest stocking. Basal area is the cross-sectional surface area (in square feet) of a standing tree's bole measured at breast height (4.5 feet above ground). The basal area of a tree 14 inches in diameter at breast height (DBH) is approximately 1 square foot, while an 8-inch DBH tree is .35 square feet, and a 19-inch DBH tree is 2 square feet. A sum of the basal area when used with the number of trees within a given forest can aid in determining forest stocking recommendations.

Best Management Practices (BMPs): Management practices that are designed to minimize pollutants, including soil, chemical, petroleum products, etc., from entering water bodies.

Biodiversity: The richness and abundance of species and the variety of natural communities in a forest environment. Both the number of species and the number of individuals of each species affect the extent of biological diversity in an area.

Biomass: Plant components that are used as a raw material for processing into energy or fuels.

Bole: The main tree trunk.

Buffer: A strip of trees or other vegetation that is intentionally left undisturbed (or disturbed lightly) in order to mitigate the visual impacts of logging or to minimize pollutants that result from logging from entering adjacent water bodies.

Cambium: The layer of cells beneath the tree bark from which new wood (xylem) and new inner bark (phloem) originate.

Canopy: The uppermost layer in a forest, formed collectively by tree crowns.

Certified Forest: A forest enrolled in a voluntary system that promotes sustainable forest management that is assessed by an independent third party.

Chip-n-Saw: A process, normally with conifers, where small logs are cut in such a way that the outside of the log is converted directly into chips, leaving the inside, square-edged cant which can be used as a post or sawn into lumber.

Cleaning (Weeding): A precommercial practice of freeing seedlings or saplings from competition with shrubs, vines, or other ground vegetation.

Clearcut: A regeneration technique removing all the trees (regardless of size) on an area in one operation. Clearcutting is commonly used to reproduce shade-intolerant species that require full sunlight to germinate and grow well. Clearcutting produces an even-aged stand.

Climax Forest: The final stage of forest succession, usually composed of shade-tolerant species that are self-perpetuating without a disturbance.

Conifer: A cone-bearing tree with needles, such as pine, hemlock, cedar, and fir.

Coniferous: Trees that retain most of their needles during the dormant season.

Coppice: Intentionally cutting trees (normally smaller ones) for the express purpose of causing a trunk to re-sprout.

Cord: A stack of wood that has a gross volume of 128 cubic feet. A cord measures 4 feet by 4 feet by 8 feet and contains approximately 80 cubic feet of solid wood, with the remainder being air space.

Crop Tree: A tree identified to be grown to maturity for the final cut. Usually crop trees are chosen on the basis of *species,* quality, and location relative to other trees and wood markets.

Crown: The living branches and foliage of a tree.

Crown Class: A relative designation of tree *crowns*, broken into distinct layers.

Crown Closure: The point in forest development when the lateral branches from adjacent trees touch, significantly reducing *growing space* and the amount of sunlight that reaches the forest floor.

Cull: A tree or log of merchantable size, which, because of *defect*, is useless for the intended purpose of timber production. Culls can have significant wildlife or aesthetic value.

Diameter at Breast Height (DBH): The outside-of-the-bark diameter of a tree at breast height (4.5 feet above the ground, measured on the uphill side of the tree).

Deciduous: Trees that lose all their leaves during the dormant months.

Defect: That portion of a tree or log that makes it unusable for the intended product. Defects can include knots, rot, crookedness, cavities, stain, cracks, etc. Severe defects cause the log to be classified as a *cull*.

Duff: Various stages of decaying organic matter found on the soil surface.

Endangered Species: A plant or animal vulnerable to extinction in all or a significant portion of its range that has been identified by the secretary of the interior in accordance with the Endangered Species Act (1973).

Even-Aged Management: *Stand* management that is designed to remove (harvest) all trees at one time or over a short period to produce a new stand with trees very close in age. Tree ages usually will range no more than 20% of the projected final *rotation* age.

Exotic Invasive: A *species* that becomes established outside its natural range, forms a breeding population, and becomes a pest that may threaten *biodiversity* of the local ecosystem.

Firebreak: A barrier, either existing prior to or constructed during a fire, from which all or most of the flammable materials have been removed, designed to help firefighters in stopping or slowing fire spread.

Forest Health: A generally observed, somewhat subjective condition whereby the forest is evaluated according to its age, growth, diversity, existence (or absence) of injurious insects, diseases, *exotic invasive* pests, wildlife attributes, aesthetics, degree of resiliency, etc., all of which are weighed against the land management goals.

Forest Inventory: The process of sampling a forest or forest *stand*, used to arrive at an estimate of wood volume and value and/or to make *forest management* recommendations. Forest inventories are also known as forest cruises.

Forest Management: The application of scientific, economic, and social principles to manage a forest for accomplishing specific desired outcomes.

Fragmentation: The breaking up of large forest areas into smaller units either by natural processes or through conversion to other land uses. Natural habitats may become separated into isolated fragments or "islands."

Girdling: The severing of tree phloem and often sapwood that disrupts food and water transport, usually resulting in tree or tissue death.

Group Selection: An *uneven-aged* method of harvesting trees in small groups (usually 1 *acre* or less).

Hardwood: A term describing broadleaf trees, usually *deciduous*, such as oaks, maples, hickories, ashes, cherry, poplar, elms, etc.

Hydric Soils: Soils that experience prolonged periods of water saturation, resulting in low available soil oxygen and negatively impacting growth of many plants.

Integrated Pest Management: Managing forest pests by considering several methods, including cultural, chemical, biological and the use of genetically modified organisms.

Intermediate Treatment: Eliminating immature trees between the stages of *stand* establishment and final stand harvest, to improve the quality of or reduce competition among the remaining trees. In contrast to a harvest cut, an intermediate cut may or may not generate income.

Intermittent Stream: A stream containing water within a well-defined channel and flow in response to seasonal variation in precipitation following a rainstorm or as long as ground water is abundant.

Mast: Tree fruits, either hard (hickories and oaks) or soft (persimmon and cherry).

Mature Forest: A term generally applied in an economic sense to indicate a forest that has attained the desired harvest size or age. The rate of forest growth diminishes once forests mature.

MBF: Abbreviation for thousand board feet, a standard unit of lumber and log volume.

Merchantable: Trees (or their parts) that can be manufactured into a salable product.

Mesic Soils: Soils having ample moisture, neither too wet nor dry, desirable for tree growth.

Midstory: The layer of vegetation existing between the smallest (*understory*) and tallest (*overstory*) plants (normally trees) in a forest.

Monoculture: A forest stand composed of a single species; for instance, a loblolly pine plantation.

Natural Regeneration: Trees that become established as a result of natural seeding or sprouting, as opposed to being planted.

Overstory: That portion of the trees in a stand forming the upper crown cover.

Plantation: A stand established by planting trees.

Plot: An area where data are collected to provide information about the forest. Several plots constitute a cruise.

Prescribed Burn: A fire intentionally set under appropriate weather, soil moisture, wind, and supervision, in order to accomplish specific *silvicultural*, wildlife, or fire-hazard-reduction goals.

Pulpwood: Wood that is cut primarily for the manufacture of paper, fiberboard, or other wood fiber products. Pulpwood is normally small in diameter.

Recruitment: The process of smaller trees growing into larger size classes.

Reforestation: Re-establishing a forest on an area where forest vegetation has been removed.

Regeneration: The process of forest replacement or renewal. Trees become established from seeds, sprouts, planting and/ or *advance reproduction*.

Release Cutting: Improving the composition in young *stands* by cutting inferior trees, thereby releasing the desired trees from competition.

Riparian: Pertaining to the area along the banks of a river, stream, or lake, normally offering some protection from forestry activities via the use of *buffers*.

Rotation: The number of years required to establish and grow trees to a specified size, age, product, or condition of maturity.

Salvage Cut: Harvesting damaged trees (i.e., from tornado or fire) to gain their economic value, often benefitting the *residual stand*.

Sanitation Cutting: A harvest done as a precautionary mechanism to remove potentially highly susceptible trees from oncoming insects or disease before trees become infected by the pest organism.

Scarify: Scratching or cutting a surface, for instance, to disturb the forest floor for *regeneration* or to break down a seed's protective coat for germination.

Selection Harvesting: Harvesting individual trees or small groups (*group selection*) of trees at intervals based primarily on their vigor and age. Trees are removed across all *age classes*. Selection harvesting perpetuates an *uneven-aged stand*, often composed of *shade-tolerant species*.

Shelterwood Harvest: Harvesting trees in a series of two or more operations. Following the first harvest, new *seedlings* grow and become established in the partial shade protection of older trees. Once established, the *overstory* trees are then harvested, yielding an *even-aged stand*.

Silviculture: Applying knowledge of *silvics* to culture the forest. Silviculture is practiced in four stages: establishment, intermediate operations, harvesting and stand/forest protection.

Site Preparation: Process of preparing an area of land for forest establishment. Methods may include mechanical clearing, chemical vegetation control, soil manipulation, mowing, burning, regulating wildlife, etc.

Size Class: A relative designation of trees based on their DBH size.

Seedling - A tree, usually less than an inch in diameter, and no more than 3 feet in height, that has grown from seed (in contrast to a sprout).

Sapling - A small tree, usually between 1 and 3 inches DBH and 15 to 30 feet in height.

Pole - A tree generally 3 to 12 inches DBH.

Sawtimber – A tree greater than 12 inches DBH that can be sawn for lumber.

Slash: Nonmerchantable residue left on the ground after logging, *thinning,* or other forest operations. Includes treetops, broken branches, uprooted stumps, defective logs, and bark. Slash can have certain ecological benefits, such as adding nutrients to the soil or providing wildlife habitat.

Streamside Management Zone (SMZ): A *buffer* strip of trees or other vegetation that is intentionally left (or disturbed lightly) around rivers, streams, lakes, or other bodies of water to protect water quality.

Stand: A recognizable area of a forest that is relatively similar in *species* composition or physical characteristics and can be managed as a single unit. Stands are the basic management units of a forest.

Stand Density: A component of stand *stocking*, or the number of trees in a given area.

Stocking: A relative term indicating the amount of growing space being occupied by trees and the amount of growing space that is available or unoccupied. Although stocking cannot be directly measured, collective factors contributing to stocking guides include basal area per acre, number of trees per acre and average tree diameter. Relative terms, such as *overstocked, fully stocked, or understocked,* are descriptive terms to describe stocking. For best stand growth, stocking should be maintained in the *fully stocked* range.

Succession: The process of one plant community modifying the environment in such a way that favors the establishment and eventual domination of another plant community. One overtakes another, which is then overtaken by another, etc.

Sustainable Forest Management: Use of the forest in such a way that it does not affect the ability to meet future as well as present human needs.

Thinning: Tree removal in an immature forest *stand* that reduces tree *density* and between-tree competition. Proper thinning encourages increased growth of fewer but higher quality trees.

Timber: A term that is loosely applied to a standing tree, felled logs, wood, wood products, or to entire *stands* of trees.

Tree Farm: A privately-owned woodland in which producing *timber* is a primary management goal. May be recognized as a certified forest by the American Tree Farm System.

Timber Stand Improvement (TSI): Applying cultural practices to a forest to improve the composition, *stocking,* and growth of trees to better achieve landownership goals. May be precommercial or commercial.

Understory: That portion of the trees or other vegetation existing below the *midstory* and *canopy* in a forest.

Uneven-Aged Management: Managing a forest by periodically harvesting trees of all ages to maintain a broad age (or size) class distribution. A greater number of trees are maintained in the smaller *age class* than in each of the next older *age classes*. Typically leads to a forest composed of *shade-tolerant species*.

Watershed: An area of land that collects and discharges water into a single stream or other outlet.

Wetlands: Marshes, swamps, and other water-saturated soils. These areas offer important habitat for wildlife, significant support of nutrient cycling in ecosystems, and protection against severe storms and floods.

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