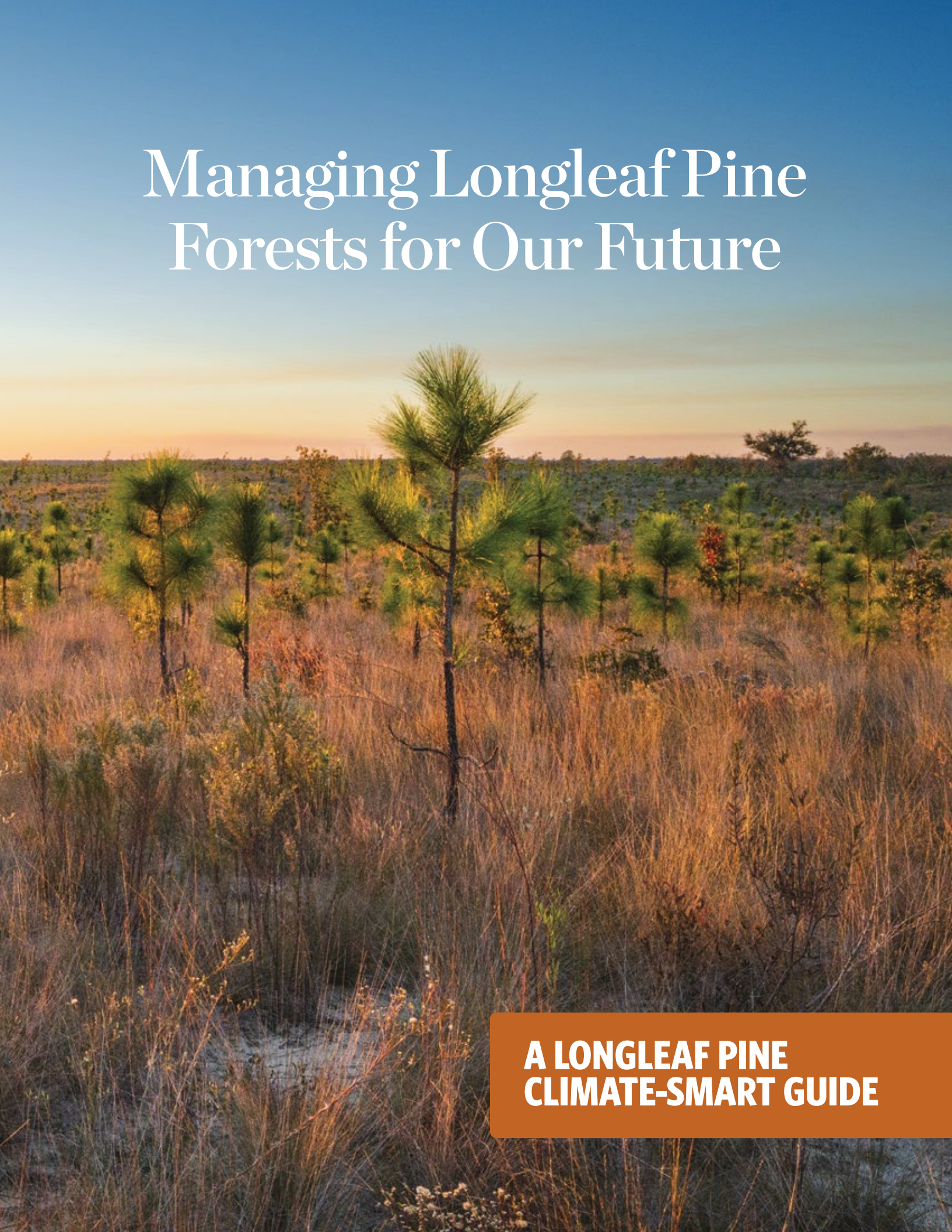
Managing Longleaf Pine Forests for Our Future



A LONGLEAF PINE CLIMATE-SMART GUIDE

Why this Climate-Smart Guide?

In a region shaped by fires, floods, droughts, hurricanes and other wind events, longleaf pine is a species built to thrive in harsh and variable conditions. Restoring native longleaf pine forests is an ecologically and economically important strategy for preparing southern forests and the people that depend on those forests for a challenging climate future.

As forest landowners and managers, it is important to know the best options for land management practices that will meet your objectives, reduce personal risk, and contribute positive outcomes to mitigate climate change and ensure that plants and animals continue to thrive. This is what we mean by climate-smart.

This guide shares a range of forest management practices for longleaf pine forests to help landowners make decisions to optimize their forest benefits. All of our forest management decisions have impacts beyond our land boundaries. Maintaining healthy forests can improve wildlife habitat, provide cleaner air and water, maintain water supplies, and mitigate the effects of a changing climate.

AUTHORS

Colette DeGarady
The Nature Conservancy

Thomas O'Halloran, Ph.D.
Baruch Institute of Coastal Ecology & Forest Science, Clemson University

Lisa Lord
The Longleaf Alliance

Lucas Clay
Extension Associate, Climate Smart Forestry, Cooperative Extension Service, Clemson University

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The Nature Conservancy

CLIMATE-SMART GROWN IN SC

THE LONGLEAF ALLIANCE

HISTORY

Longleaf Pine: A Southern Icon

The Southeast was once dominated by longleaf pine (*Pinus palustris*) forests, sprawling across 90 million acres from eastern Texas to southern Virginia. These expansive forests evolved over centuries, finely tuned to the natural lightning fires and other disturbances that shaped and sustained this ecosystem. Native American tribes were integral to the maintenance and management of longleaf pine forests using fire to clear land for crops, improve hunting, and reduce pests.

Turpentine tree at Sandy Island Preserve in South Carolina © TNC

During the colonial era, European settlers exploited longleaf forests for timber and naval stores, such as turpentine and pitch. As the demand grew, the turpentine industry boomed in the late 19th and early 20th centuries. In a process called boxing, a deep pocket was cut into the tree to extract resin, which was then processed into turpentine, rosin, and other products. The straight, tall trunks of longleaf pine made it a preferred choice for ship masts, leading to extensive logging. Agriculture and the introduction of other tree species also contributed to the loss of longleaf pine forests. By the 20th century, fire suppression policies, driven by public safety concerns and property protection, influenced the historical fire regime essential for longleaf pine regeneration. Without frequent, low-intensity fires, other tree species and vegetation began to encroach altering the forest composition. At its lowest point, only about 2.9 million acres of longleaf pine forests remained, and much of that was degraded.

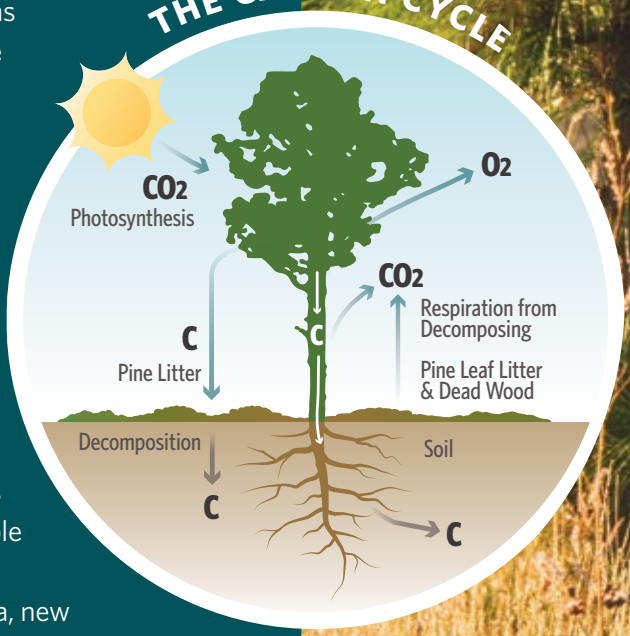
America's Longleaf Restoration Initiative (ALRI) emerged in 2009 as a collaborative effort of partners who work together to restore and conserve longleaf pine forests. ALRI aims to create functional and sustainable longleaf ecosystems that encompass the full range of ecological, economic, and social values. Since its inception, the initiative has successfully reversed the decline of longleaf acreage. Currently, 5.2 million acres of longleaf pine forests exist and that number continues to trend upward.

Landowners can participate in the restoration of this iconic southern forest for its economic and ecological benefits.

IMPORTANCE OF FORESTS

Forests are the lungs of the world, breathing in atmospheric-warming carbon dioxide, while exhaling oxygen for humans and animals to breathe.

While mature, intact forests have tremendous ecological value, our need for fiber and wood products dictates that large areas of forest are managed to include some harvesting. Active forest management provides jobs and contributes significantly to the economy. Forests also help cool the planet by buffering atmospheric temperatures and removing and holding vast quantities of carbon dioxide gas – an excess of which is driving global climate change. While managing forests sustainably so that this renewable natural resource is available in perpetuity is a centuries-old idea, new emphasis on improving the climate with more resilient forests that serve the greater needs of society is driving interest in climate-smart forestry.



CLIMATE-SMART FORESTRY

Climate-smart forestry is an extension of sustainable forestry, where the priority is on adapting forests to climate change so that they can help mitigate climate change while providing benefits to people and nature. Given potential tradeoffs, the priority is placed on sequestering and storing carbon for the long term.

Activities designed to mitigate climate change focus on slowing fossil fuel emissions (carbon sources) and enhancing natural storage in plants and soils (carbon sinks). Given the amount of carbon already in the atmosphere and depending on the intensity of efforts to reduce carbon emissions over the next few decades, we can expect anything from inconvenient to severe climate effects to unfold in the near future. In all aspects of life, it is important to plan to adapt, or change our behaviors and systems, to continue to function under expected future conditions. In the case of forestry, adapting to climate change means managing for anticipated future conditions, which could include hotter temperatures, more extreme periods of flood and drought, more intense storms, and sea level rise.

Climate adaptation strategies can include making forests resistant or resilient to potential disturbances.

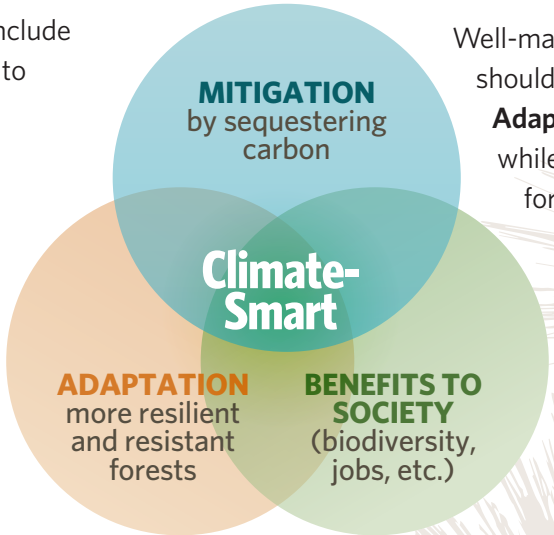
RESISTANT FORESTS

A resistant forest is managed to withstand a particular disturbance. For example, forests maintained with frequent prescribed fire will be more resistant to catastrophic wildfires because fuel loads are reduced.

© Kevina Casaletto

RESILIENT FOREST

A resilient forest is managed to recover from a disturbance. Stands managed with multi-aged silvicultural systems typically recover quicker than even-aged stands, particularly if only one age class is impacted by a disturbance. Maintaining species and structural diversity is also an excellent strategy for achieving climate resilience.



Well-managed longleaf pine forests should excel with respect to **Adaptation** and **Benefits to Society** while providing **Mitigation** in the form of resilient and long-lasting stores of carbon.

WHY ARE LONGLEAF PINE FORESTS CLIMATE-SMART?

© John Moore

Longleaf pine forests sequester and store significant quantities of carbon relative to other land cover types. Longleaf pine also provide resistance to fire and insect and disease outbreaks and can provide resilience to climate change, including periodic drought. Combined with all the co-benefits to society, the strength of longleaf pine is the stability of long-term carbon storage.

Longleaf pine forests that are managed as open, diverse, multi-aged stands can more naturally provide adaptation and benefits to society.

ECOLOGICAL BENEFITS

Insect and Disease Resistance

As a species, longleaf pine is known to be relatively resistant to insect and pathogen outbreaks.

Windstorm Resistance

Research on storm impacts and experimentation indicates that longleaf pine can be more resistant to uprooting and breakage than other southern yellow pines, such as loblolly and slash pines.

Wildfire Resistance

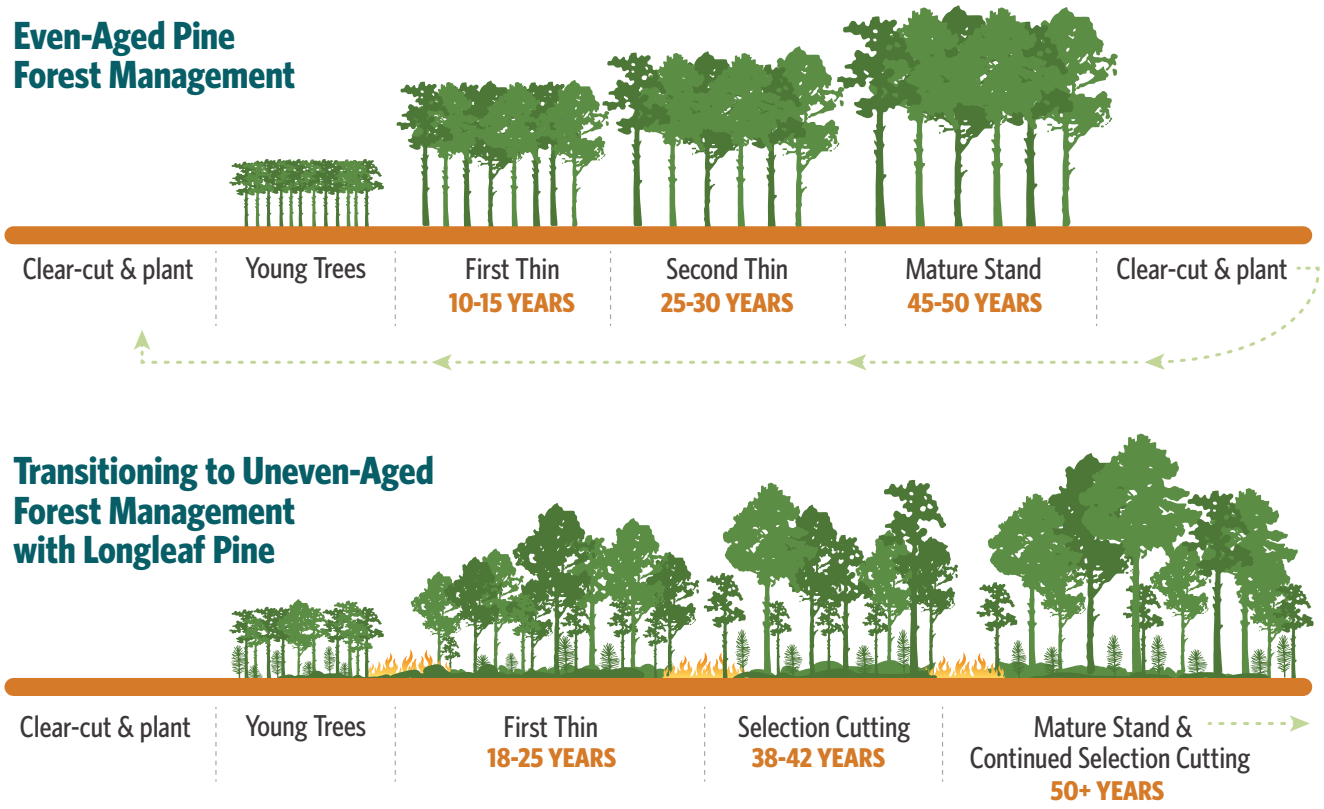
By managing fuel loads with frequent prescribed fire, longleaf pine stands are less prone to catastrophic wildfires.

Water Resource Benefits

Managing stands at low densities can reduce competition among trees for soil moisture and reduce tree vulnerability to drought. Additionally, less combined evapotranspiration from trees in low density stands allows for more runoff and groundwater recharge, which increases water quantity in streams and rivers.

Benefits for Wildlife and Plants

Because longleaf pine forests have steeply declined, many of the wildlife species found within the ecosystem are imperiled. Fire-maintained groundcover can be highly diverse and beneficial to a wide variety of animals including pollinators, quail, wild turkey, and other wildlife.



Even-aged forest management with conventional, short-rotation forestry produces less diversity and ecological benefits and releases more carbon to the atmosphere over time. Transitioning to uneven-aged forest management with longleaf pine provides a more diverse forest stand, benefiting wildlife and providing more consistent carbon stores for the long-term.

Longleaf forests have a rich and complex history that is interwoven into the fabric of the southeastern U.S. These systems have significant historical, cultural, and spiritual value for many people. Noteworthy progress has been made in recent years in restoring longleaf pine on both private and public lands. A significant component of the modern climate-smart movement is addressing the needs of underserved landowners, to increase knowledge and access to resources for establishing and maintaining longleaf forests. A primary goal of this guide is to make information on managing longleaf pine, and all its associated benefits, available to more people to empower them to participate and benefit in the ecological, climatic, and economic benefits of the landscape-scale longleaf pine restoration initiative.

Climate-smart forestry emphasizes carbon storage as a central goal. While several studies have highlighted the potential for rapidly growing species such as loblolly pine to provide maximum carbon storage, there are drawbacks to that approach. While fast growing loblolly or slash pine stands, for example, may excel at sequestering carbon during the growth stage, clearcutting, the traditional method of harvesting even-aged stands, disturbs the soil and promotes several years of carbon release by the forest, even if trees are planted and start to quickly reestablish. Subsequently, short rotation management is not likely to promote as much soil carbon storage as longer rotations or less intensive harvesting techniques.

The typical management techniques and characteristics of an intensively managed even-aged stand for carbon sequestration creates substantial tradeoffs in adaptation and societal benefits. Monoculture forests that lack plant and animal diversity are susceptible to disease and pest outbreaks and have little aesthetic or cultural value. Multi-aged forest management of longleaf pine naturally provides a healthy balance of the three tenets of climate-smart forestry: mitigation, adaptation, and societal benefits.

Climate-Smart Longleaf Pine FOREST MANAGEMENT PRACTICES FOR LANDOWNERS

The practices selected for this guide are core management practices that put longleaf pine forests on the path to being climate-smart and improve desired outcomes from forest management.

The recommended practices described in this guide are also aligned with practices selected by the Natural Resources Conservation Service (NRCS) as climate-smart and help support more resilient forests with increased ecological benefits.

Based on landowner preferences and interests, forest management can involve trade-offs. For example, establishing a more open longleaf pine forest can support a diversity of wildlife and plants and increase water quantity at the cost of lower carbon sequestration. Conversely, denser forests may reduce species diversity and water availability to streams and rivers but increase carbon capture. The goal of this guide is to recommend climate-smart practices in longleaf pine forests that provide multiple benefits.

1 Avoided Conversion

DESCRIPTION: An important climate-smart practice is to avoid converting existing mature longleaf pine forests to other land uses, which results in a significant loss of forest carbon. Forests are better at storing and capturing carbon than any other land use and the benefits from the forest are additive over time.

Avoided conversion offers many benefits, including climate mitigation, wildlife habitat conservation, and bolstered resilience. Preventing forest conversion to other non-forested land uses such as agriculture or development helps to maintain carbon sinks that absorb and store atmospheric carbon dioxide. Avoided conversion also protects existing habitat, which provides essential resources needed by plants and animals, many of which are already threatened or endangered due to habitat loss and fragmentation of longleaf pine across the range.

PRACTICE CONSIDERATIONS

- A **conservation easement** is a voluntary legal tool that can be used to protect your land for future generations. Conservation easements can keep your land from being converted to other uses or being subdivided, while still allowing you to own and manage your land. An easement is a multi-generational and permanent decision that requires careful thought and planning. Land Trusts are available to assist by walking you through the legal process and familiarizing you with tax and other benefits. The Land Trust Alliance (www.landtrustalliance.org) as well as other agencies and conservation organizations in your area can assist with finding a qualified land trust for your needs.
- A **Forest Management Plan** can help to communicate your intent for the land based on your objectives to your family, consulting forester or other technical service providers.

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2 Reforestation and Afforestation

DESCRIPTION: Reforestation is replanting longleaf pine on land that was recently harvested for timber or "cutover". **Afforestation** usually refers to planting longleaf pine on land that wasn't forest such as cropland or pasture.

Reforestation and afforestation provide important benefits for wildlife and adaptation to climate change through habitat restoration and carbon sequestration. As trees grow, they absorb carbon dioxide from the atmosphere, mitigating the impacts of climate change. Restoring or establishing forests in degraded or previously deforested areas creates new habitat for wildlife, including at-risk, threatened or endangered species or those that have declined due to habitat loss or fragmentation and supports long-term survival of wildlife populations. Reforestation and afforestation also provide services to people—moderating temperatures, reducing soil erosion, and filtering and storing water. This can mitigate the impacts of extreme weather events such as floods and droughts, which are becoming more frequent and severe.

PRACTICE CONSIDERATIONS

- The majority of longleaf pine seedlings are container grown or plugs. A 6" or longer plug allows for better root development and the ability to adjust planting depth, which is key to success when planting longleaf.
- Nurseries often have a limited supply of longleaf pine seedlings, so place your order early in the summer well in advance of planting in the winter.
- Establishing seedlings in agricultural fields and pastures presents challenges such as competition from pasture grasses and agricultural weeds, excessive nutrients, root diseases, and compacted soil. Adequate site preparation can help address these obstacles and help prevent the use of even more chemicals in the future.
- Effective site preparation involves reducing competing vegetation, creating an environment where seedlings can access increased moisture and nutrients, and can have space to grow in a way that facilitates the early return of prescribed fire. Site preparation require adjustments according to site-specific factors such as moisture levels, soil composition, past usage, and current vegetative cover. Minimizing inputs related to site preparation will help reduce costs, and impacts on the environment such as carbon emissions.
- When hiring planters for longleaf pine, make sure that they have had successful experience planting longleaf pine. Don't be afraid to ask your planting contractor questions.
- In the spring post-planting, be sure to spot-check seedlings for survival, health, and development and assess the need for competition control.

Young longleaf pine thrive among mature trees, demonstrating successful regeneration and forest ecosystem resilience.© Lisa Lord

© Lisa Lord

3 Longleaf Pine Forest Regeneration

DESCRIPTION: Seedlings can be added to an area through **natural regeneration**, **gap planting**, and **underplanting**. Natural regeneration utilizes the existing seed-bearing longleaf trees on site as the seed source for regeneration. Loblolly or slash pine forests can also be gradually converted over time by creating ¼ to ½ acre openings or gaps and planting the openings with longleaf. These gaps mimic natural disturbances. Underplanting is planting under an existing loblolly or slash pine forest and is most successful when the forest is adequately thinned to allow seedlings enough sunlight and space to grow. Both gap planting and underplanting require careful attention and frequent burning to control competition from the regeneration of the residual mature stand.

Managing for multi-aged forests presents unique opportunities for carbon sequestration, wildlife habitat enhancement, and adaptation to climate change. Unlike even-aged management, which promotes a single age class until the forest is ready to be regenerated, other forms of management maintain a more diverse age structure within the forest. Multi-aged silvicultural systems tend to promote structural complexity that supports a wide variety of wildlife species while maximizing carbon storage potential for the long term. Additionally, a multi-layered canopy structure enhances resilience to climate-related stressors, such as insect outbreaks and soil erosion. This contributes to the long-term adaptation of the ecosystem to changing environmental conditions.

PRACTICE CONSIDERATIONS

- Establishment costs of natural regeneration are low. Labor, equipment, and disturbance is minimal, but this method can require more time, effort, and planning.
- Longleaf cone crops vary from year to year. The speed of natural regeneration will depend on the size of the masting event.
- Controlling loblolly pine regeneration when underplanting with longleaf can be very challenging. Loblolly pine trees are prolific seeders. Establishing a fire management program is your most valuable tool for controlling unwanted regeneration. Chemical control may also be warranted in combination with fire.

4 Forest Stand Improvement

DESCRIPTION: Forest stand improvement involves changing the structure, composition, or density of the existing trees in a stand to achieve objectives such as increasing carbon sequestration, improving forest health or productivity, managing water yields, improving or creating wildlife or pollinator habitat, or reducing wildfire risk. These improvements can provide landowners with the flexibility to market some trees while moving towards a more desirable stand structure that benefits wildlife.

Several forest management practices are available to landowners who would like to use forest stand improvements to meet their objectives:

Enhancing groundcover through forest management

This practice involves using overstory or understory treatments to improve groundcover structure and composition. Methods can include both chemical and mechanical treatments to improve species diversity, structure or overall forest health. This methodology is commonly utilized to remove volunteer hardwood and other undesirable species from the canopy or sub-canopy to shift toward a longleaf pine dominant forest with a diverse understory of native grasses and forbs.

Midstory reduction with mechanical thinning. © TNC

Reducing the midstory

This is a practice designed to control competing woody vegetation in mature or mid-rotation stands when competition is sufficient to negatively affect the growth and development of target species or the understory quality. In addition to potentially improving growth and vigor of the longleaf trees, this practice also can be beneficial for reducing wildfire risk and improving the groundcover structure and composition, which is beneficial for wildlife and burning. For managed longleaf pine, fire or herbicide is generally applied within a year following the first thinning to control hardwoods and competing pines.

Changes in forest structure or density can help improve the quality of the groundcover and attract pollinators. © Lydia O'Halloran

Reducing stand density

Reducing stand density helps to create an open forest structure and retain desired species in the canopy through practices such as thinning or single tree selection. Reducing stand densities reduces competition for resources among trees and allows sunlight to the forest floor to maintain and promote grasses and forbs. Working with a knowledgeable forester is important to prevent shifting the stand to an overall lower quality state by removing the best trees, an outcome known as 'high-grading' that should be strictly avoided.

Creating patch openings to improve structural diversity

This practice involves creating patches that mimic natural disturbances. The size, shape, and arrangement of the patches can be variable based on the landowner's wildlife objectives, geography, or the species that are being managed.

Forest stand improvement in longleaf pine forests can yield an array of benefits including carbon sequestration, wildlife habitat, and forest adaptation. By reducing tree density, more sunlight reaches the forest floor, promoting groundcover which enhances the forest's capacity to sequester carbon as plants photosynthesize and store carbon in their biomass and the soil. Increased groundcover diversity also provides a broader range of habitats for wildlife, supporting a richer array of species.

Reducing tree density also can improve the resilience of longleaf pine forests to climate change by increasing forest health and tree vigor. Allowing more space for individual trees to better utilize limited resources reduces competition among trees, making stands more resistant to wildfires and less vulnerable to the impacts of drought. This adaptability is crucial in mitigating the effects of climate change, as stands with lower tree densities are better equipped to withstand changing environmental conditions.

PRACTICE CONSIDERATIONS

- Forest stand improvements can be highly variable and tailored to each property, which can inherently make them more complex. It's important to work with a consulting forester who has experience with longleaf forests.
- Practices that affect the distribution of trees can improve forest structure, while forest composition can be improved by removing and manipulating the species. Managing stocking rates and altering distribution can also help reduce wildfire risk and hazards.
- Herbicides may be necessary following the mechanical treatments mentioned above if fire alone isn't effective. Herbicides should be carefully selected for the species targeted for removal.
- When considering where to create patch openings, use openings where the trees are at a risk of mortality or failure, low in crown vigor, poor in stem form and quality, or less desirable species are present.

WORKING WITH A CONSULTING FORESTER

A consulting forester plays a crucial role in assisting landowners with defining their objectives, developing a forest management plan, and implementing forestry activities. Their expertise extends to providing valuable insights into the timber market, overseeing timber sales and harvests, and offering a diverse range of services including surveying, boundary marking, wildlife management, prescribed burning, and guidance on incentive or market-based programs. Foresters use various fee structures, including hourly or daily rates, service-based fees, or negotiated revenue shares.

The fees charged by consulting foresters are an investment that ensures peace of mind. This investment often pays off for landowners through enhanced forest productivity, increased timber sale prices, and improved overall forest health and wildlife habitat. Landowners should verify the credentials and references of a consulting forester before engaging their services.

In certain states, practicing forestry is restricted to individuals who are either Registered Foresters or working under the supervision of a Registered Forester. It is important to verifying the qualifications of a consulting forester to ensure compliance with state or regulatory standards.

© Tiffany Woods

5 Extending Rotations of Existing Stands

DESCRIPTION: This practice involves extending harvest time beyond when a stand would normally be harvested. Extending the time trees are on the landscape in a forest offers numerous ecological benefits, namely enhancing carbon sequestration capabilities within forests. Prolonging growth accumulates more biomass and effectively traps more carbon dioxide from the atmosphere. This will also help to conserve wildlife habitats through greater diversity and complexity, including the groundcover. This habitat richness also supports and bolsters wildlife populations. Allowing forests to mature over longer periods supports increased resilience to environmental challenges and stressors.

PRACTICE CONSIDERATIONS

- Understand the potential ecological impacts of extending rotations on your longleaf pine forest. Consider factors such as wildlife diversity, habitat quality, and resilience to disturbances.
- Clarify your objectives and evaluate the current health and vigor of your longleaf pine trees. Extending rotations may increase susceptibility to pests, diseases, and other stressors so it is important to understand the factors that affect forest health. Burning is key to maintaining a healthy longleaf forest and decreasing fuel accumulation that might lead to catastrophic fires.
- Assess the potential for natural regeneration of longleaf pine and groundcover species under extended rotations. Ensure that adequate seed sources are available for regeneration from the existing trees.
- Evaluate the impact of extended rotations on timber productivity and economic returns. Understand your market and possible product specification, as it is quite possible to outgrow your market. Consider the trade-offs between short-term financial gains and long-term benefits of maintaining older trees. Alternative income streams may become especially advantageous when extending rotations.

6 Transitioning from Even-aged to Uneven-aged Forests

(see graphic on page 5)

DESCRIPTION: Managing an uneven-aged forest can help landowners achieve several objectives. There are several techniques for converting single-aged stands to multi-aged. Often timber is removed periodically through single-tree or group selection cutting. In forests managed with single-tree or group selection systems, trees are maintained in various age classes. The gaps or openings created when trees are removed during selection cutting allows for regeneration to occur naturally.

If the existing forest is not longleaf, the gaps or openings can be planted with containerized longleaf. This can continue to provide income, wildlife habitat, and carbon storage. Lower quality trees can be removed while retaining the higher quality trees.

The varied canopy structure and diverse understory vegetation resulting from uneven-aged management creates a mosaic of habitats, supporting a diverse array of wildlife species. Uneven-age management also enhances forest resilience.

PRACTICE CONSIDERATIONS

- Despite the methodology used for conversion, competition control likely will likely be needed for unwanted pine or oak regeneration. Understand the recent fire history and consider the timing, frequency, seasonality, and intensity of burning to achieve control.
- Mechanical thinning or herbicide treatments might also be needed in addition to burning. When using herbicides, be sure to use a selective prescription that doesn't kill or damage the desired understory species.
- It is important to discuss your desired objectives with your consulting forester to help find the right logger to achieve your goals.

7 Prescribed Burning

DESCRIPTION: Prescribed burning is an effective tool for maintaining longleaf forests over time and helps to maintain productivity and health of the forest. Longleaf seedlings in the grass stage are very fire tolerant. Seedlings can survive burning if they have been in the ground for at least a full growing season and are vigorous. However, longleaf can be vulnerable to fire when it is going through active height growth or "candling" around March or April. Benefits of prescribed burning include fuel reduction, promoting groundcover diversity, improving wildlife habitat, improving wood quality by pruning lower branches, and controlling insects and diseases.

Frequent, low-intensity prescribed fire mimics the historical fire pattern in which longleaf forests evolved. It also promotes biodiversity, improves wildlife habitat and groundcover quality, and can help to control invasive species. Many plant species, especially in fire-adapted ecosystems like longleaf, rely on periodic fires to regenerate and thrive. By reducing accumulated vegetation and allowing sunlight to reach the forest floor, prescribed fire creates conditions that promote high-quality groundcover.

Prescribed fire contributes to adaptation in the face of climate change by reducing the risk of catastrophic wildfires and enhancing forest resilience. As climate change leads to more frequent and intense wildfires in the southeast, prescribed fires can help mitigate these risks by reducing fuel loads.

PRACTICE CONSIDERATIONS

- Seasonality, intensity, scale, and frequency of burning are factors that influence the outcomes and should be considered before burning to help meet your objectives for your land.
- Prescribed fire can be applied during the growing season or dormant season depending on your objectives. Growing season burning is often the most beneficial for controlling unwanted competition and improving wildlife habitat.
- To find a reputable prescribed burner, contact your state forestry agency or ask your consulting forester.

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8 Groundcover Restoration

DESCRIPTION: This practice involves planting seeds or plugs to restore or enhance the existing groundcover. Groundcover restoration can also include planting for pollinators. Groundcover can be improved within a stand, restored in an area that was previously under another land use like an agricultural or fallow field, or planted as a buffer strip between forest stands and agricultural sites.

Restoring longleaf groundcover, which includes diverse plants and grasses, offers a comprehensive approach to carbon sequestration, wildlife habitat enhancement, and adaptation benefits. Longleaf pine groundcover sequesters carbon efficiently, primarily through extensive root systems. Groundcover plants contribute to soil carbon accumulation, fostering a healthy forest to effectively capture and store atmospheric carbon dioxide. Groundcover in longleaf forests also provides crucial habitat for wildlife species including bobwhite quail and eastern wild turkeys.

PRACTICE CONSIDERATIONS

- Native groundcover may return on its own after a thinning based on what already exists on the site. Before planting it may be advantageous to burn to stimulate the soil seed bank to see what species return and determine if planting additional groundcover is necessary.
- Site preparation is extremely important, especially in sites that were previously occupied by sod-forming or cool-season grasses, which can be difficult to control once the new groundcover is established. Sites may require multiple years or seasons to control weeds before planting.
- It is often beneficial for wildlife to include native warm-season grasses and three early, three mid, and three late flowering species. Monitor the site post-planting to see if additional weed control is required.
- Be patient. It often takes several years to establish native groundcover from seeds. The Natural Resources Conservation Service (NRCS) defines the restoration a success "when the planting is providing at least 80% canopy cover, visually estimated, and that the resultant cover consists primarily of the early, mid, and late blooming species planted for pollinators."
- Be wary of insecticides which can be harmful to the insects that are being drawn to the area. If insecticides must be used in adjacent agricultural areas, mitigate the effects on insects by using techniques such as creating buffers that avoid or capture drift.
- There are companies in the southeast that sell native seeds and can help with seed selection and mixing, site preparation and planting techniques using specialized equipment such as no till drills.

clockwise from top left: Planting plugs at Piney Grove Preserve in VA. © Colette DeGarady; © Lisa Lord; © Linda Fish

from left: Cogongrass can hinder longleaf management when growing within a stand. © Emma McKee; Feral hogs cause the release of carbon into the atmosphere from their soil and plant disturbance. © Linda Fish

9 Invasive Species Removal

DESCRIPTION: Removing invasive plant or animal species (often non-native) through chemical, mechanical or other methods can have a positive impact on forest health. Invasive plants often outcompete or shade out native vegetation while invasive animals, such as feral hogs, can be destructive to plants, other animals, and soils.

Removing invasive species offers multiple benefits for carbon sequestration, wildlife habitat restoration, and adaptation to climate change. Invasive species such as cogongrass and Chinese privet outcompete native vegetation, and degrade habitat quality and forest health, reducing carbon storage capacity and diminishing resilience. Allowing longleaf pine forests to thrive invasive-free enhances the forest's ability to capture and store atmospheric carbon.

Restoring native plant communities creates more suitable wildlife habitat, food availability, and connectivity for wildlife populations, promoting biodiversity and forest resilience in the face of climate change.

Removing invasive species enhances climate change adaptation. Healthy forests are better equipped to withstand the impacts of climate-related stressors, and native vegetation is more resilient and better adapted to local environmental conditions. Restoring the natural balance within a longleaf forest maintains important ecological processes such as nutrient cycling, soil stabilization, and water regulation, which are essential for forest function and the long-term adaptation of plants and animals.

PRACTICE CONSIDERATIONS

- Areas that are heavily infested with invasive plant species may take repeated treatments over several seasons or years to remove completely from the site.
- Recommendations have been developed for methods to successfully control various invasive species. Consider methods that will cause the least amount of damage to native species that may be important for carrying fire, providing wildlife habitat, and stabilizing soil. There are many selective herbicides available. Always read the label before application.
- Heavy infestations also may require revegetation or reestablishment due to ground disturbance and insufficient beneficial species.
- To learn about invasive species in your area check state invasive species lists and websites or contact your local Cooperative Extension Service.

10 Silvopasture

DESCRIPTION: Silvopasture is an agroforestry practice that deliberately integrates livestock, forages and forests on the same parcel of land. Adding trees to an otherwise open grazing pasture increases carbon storage. Understory plants provide forage for livestock and mature overstory provides shade. Silvopasture in longleaf pine forests may help maintain understory plant biodiversity, promote pollinator and wildlife habitat, limit mid-story woody species growth, build soil health, and maintain water quality. Landowners may benefit from reduced management costs when practicing silvopasture because grazing can help control unwanted woody growth and invasive species. Revenue may also be generated from both the trees and the livestock.

PRACTICE CONSIDERATIONS

- Landowners may choose to plant longleaf pine in existing pasture or plant forages into existing longleaf pine forests. Best timing of livestock introduction will vary based on current conditions and individual landowner goals.
- Active management is key to the success of this agroforestry mitigation strategy. Both trees and forages require appropriate planting rates to support livestock.
- Trees should be at least 10 years old before introducing livestock.
- Basal area recommendation for your property should be obtained from your consulting forester.
- Additional planted forages such as native warm season grasses may benefit livestock if naturally seeded understory plant species establishment is inadequate.
- Livestock stocking densities will depend on forage and/or understory plant quality and quantity.
- Rotational grazing is recommended between stands of longleaf pine to maintain landscape heterogeneity and promote understory biodiversity.
- Grazing may reduce the prescribed fire interval needed on your property and should be determined with the advice of a consulting forester or technical service provider.

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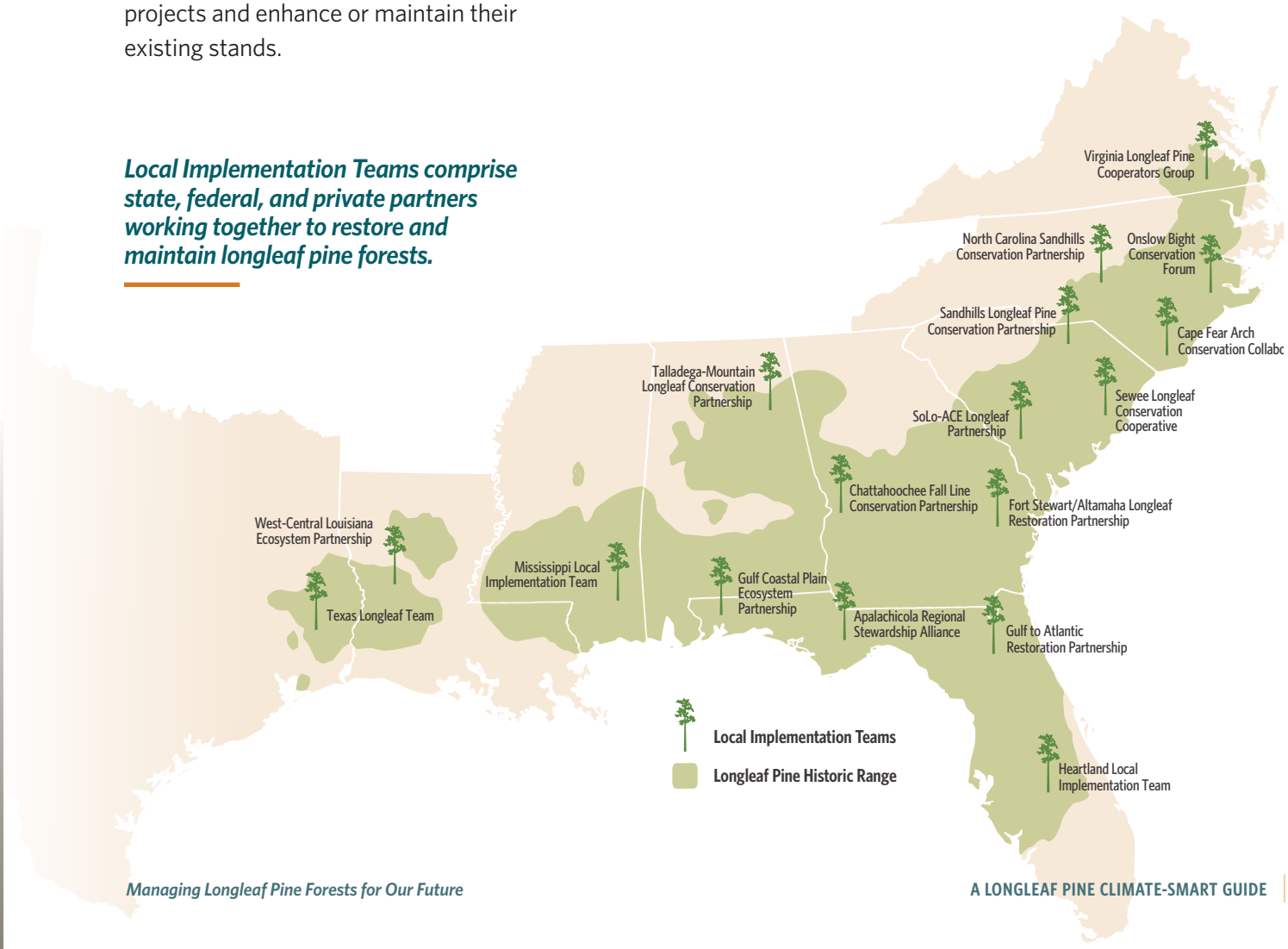
RESOURCES & FUNDING OPPORTUNITIES

Landowners incur costs when practicing active longleaf forest management, but financial assistance and incentive programs are increasingly available to help landowners with the costs of firebreaks, burning, establishment, midstory hardwood reduction, and other climate-smart practices mentioned in this guide. Resources vary by region, state, and county and year to year as new funding becomes available. Participation requirements are different for each program. Agencies often offer technical assistance to help landowners gain the knowledge, tools, and resources to establish new stands or implement new projects and enhance or maintain their existing stands.

Agency/Program	Provides Technical Assistance	Provides Financial Assistance	Website
USDA Natural Resources Conservation Service	Yes	Yes	www.nrcs.usda.gov/programs-initiatives/
ALRI Longleaf Local Implementation Teams (Map below)	Can share all longleaf resources specific to that LIT	Can share all longleaf resources specific to that LIT	americaslongleaf.org/local-implementation/
The Longleaf Alliance	Yes	Yes	longleafalliance.org
Climate-Smart Grown in SC	Yes	Yes	www.climatesmartsc.org
Texas Climate Smart Forestry Initiative	Yes	Yes	tfsweb.tamu.edu/climatesmart.aspx

** List of resources as of the printing of this guide.*

Local Implementation Teams comprise state, federal, and private partners working together to restore and maintain longleaf pine forests.



SCAN TO VIEW THIS GUIDE ONLINE:

The Nature Conservancy

CLIMATE-SMART GROWN IN SC

THE LONGLEAF ALLIANCE