MISSOURI SHORTLEAF PINE UTILIZATION ASSESSMENT

Prepared for the Forest and Woodland Association of Missouri
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PREPARED BY

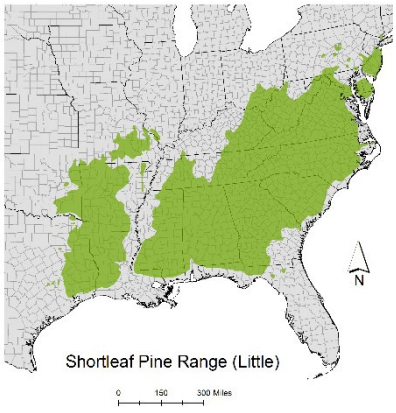
RENEWABLE RESOURCE SOLUTIONS

INTRODUCTION

Shortleaf pine (*Pinus echinata*) has the broadest geographic range of any southern pine species, spanning 22 states from southeastern New York to eastern Texas. Historically, Missouri's forests were dominated by this resilient species, covering an estimated 6.6 million acres prior to European settlement. Today, only a small portion of shortleaf pine remains, primarily within the southern portion of the state (Dey, 2022).

Grandin Mill Pond
Photo Credit: Griffith, H. M. (ca. 1907). The State Historical Society of Missouri-Columbia

In the late 1800's into the early 1900's, the arrival of rail to Missouri's forests started a "lumber boom", when large overstory pines – critical for seed regeneration – were harvested to support the rapid expansion of infrastructure state and nationwide. The heavy harvest, loss of seed sources, and land-use changes drastically reduced shortleaf pine acreage across its range. This decline has fundamentally altered Missouri's forest composition, with various oaks and other hardwoods supplanting pine-dominated ecosystems (Stambaugh & Muzika, 2001).



Shortleaf Pine | Historical Native Range
Map by: Weaver (n.d.), Southern Regional Extension Forestry

Recognizing the urgency of restoration, the Shortleaf Pine Initiative (SPI) was launched in 2013 as a collaborative effort to address the species' decline across its range. The SPI represents a broad range of public and private organizations as well as key state and federal agencies currently working in the shortleaf pine ecosystem. The SPI's 2016 "Shortleaf Pine Restoration Plan" established a framework for restoring shortleaf pine populations through optimum restoration strategies, increased coordination among shortleaf proponents and maximizing the effectiveness of ongoing efforts. Shortleaf pine seeds germinate best on bare soils, and when forests don't burn frequently or are not harvested periodically, leaf and needle litter accumulate to depths which hinder shortleaf pine establishment. In Missouri, the success of restoration efforts is constrained by limited markets which inhibit the harvest of shortleaf pine. Despite its historical and ecological significance, shortleaf pine accounts for only 5% of Missouri's annual timber harvest, underscoring its underutilization and the need for expanded harvesting and market development.

In today's markets, shortleaf pine is often viewed as a financial burden rather than an asset. Inconsistent pricing, weak demand, and limited processing infrastructure have made harvesting shortleaf economically unviable for many timber harvesters, who often face harvesting costs that exceed potential sale prices. As a result, forest managers report few bids on timber sales with a significant pine component, leading to scenarios where shortleaf pine is either left standing or felled to meet silvicultural objectives, but then left to lay on the harvest site. Without expanded markets, this valuable resource remains underutilized, hindering both forest health and economic opportunities.

As a leading advocate for sustainable forestry in Missouri, the Forest and Woodland Association of Missouri (FWAM) initiated the development of this "*Missouri Shortleaf Pine Utilization Assessment*" to address these challenges and create sustainable opportunities for shortleaf pine utilization.

Components of the Missouri Shortleaf Pine Utilization Assessment

This FWAM-led assessment serves as a critical resource for private landowners, loggers, forest product manufacturers, and policymakers by identifying strategic opportunities to expand shortleaf pine markets and address key challenges. To support a targeted approach, it is structured into three key components:

RESOURCE ASSESSMENT

A synopsis of the historical and ecological significance of shortleaf pine in the state and the restoration challenges associated with its sustainability. Utilizing USDA Forest Inventory and Analysis and project partners Missouri's shortleaf pine inventory, the shortleaf pine resource is characterized by current distribution, ownership, age structure, diameter class, operability, and projected growth over the next 30 years.

MARKET ASSESSMENT

An in-depth analysis of Missouri's forest industry capacity, wood utilization trends, growth-to-drain ratios and resource potential under various harvest scenarios It also examines the mechanical and physical properties of Missouri-grown, non-plantation shortleaf pine lumber. Potential forest products markets from shavings to mass timber are explored. In addition, the assessment presents opportunities for industry collaboration, including the potential for developing a state-wide branding initiative: *Missouri Shortleaf Pine – Strength Rooted in Tradition*.

BUSINESS PLAN

A sample business plan presenting the expansion of a shavings packaging facility into a manufacturing facility to procure local shortleaf pine and produce shavings in-house to their markets across the country. The business plan includes information on supply needs, processing equipment, labor requirements and production volumes.

ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

The *Missouri Shortleaf Pine Utilization Assessment* serves as a comprehensive and strategic resource for the Forest and Woodland Association of Missouri (FWAM), federal and state agencies, loggers, sawmills, and secondary wood product manufacturers by identifying key opportunities to expand markets for Missouri-grown shortleaf pine. This report provides data-driven insights to drive targeted growth in shortleaf pine manufacturing, empowering stakeholders to enhance economic viability, strengthen forest management, and improve industry competitiveness while supporting multi-tiered landscape restoration and ecological objectives.

Shortleaf Pine Harvest | Mark Twain National Forest Timber Sale

Photo Credit: Ross, H. (2024). Renewable Resource Solutions, LLC. [Unpublished photographs].

FWAM initiated this study with the Missouri Department of Conservation, the L-A-D Foundation, and the Mark Twain National Forest to address market constraints and the underutilization of Missouri's shortleaf pine resource. By evaluating current and emerging market trends, industry capacity, and production feasibility, this assessment provides a clear roadmap for investment, innovation, and sustainable market expansion. Strengthening markets will, in turn, support state-led priorities – such as those outlined in Missouri's Comprehensive Conservation Strategy (CCS) – while advancing broader landscape restoration goals, such as those established in the Shortleaf Pine Initiative (SPI) "Shortleaf Pine Restoration Plan." By integrating these objectives, this assessment presents a strategic framework that balances economic growth, forest restoration, and the long-term sustainability of Missouri's shortleaf pine resource.

KEY FINDINGS

Missouri's Shortleaf Pine Resource & Historical Context

Shortleaf pine (*Pinus echinata*) is Missouri's only native pine species, historically covering over 6 million acres before widespread logging, fire suppression, and land-use conversion in the late 19th and early 20th centuries (MDC, 2020). As of 2023, only a small percentage of those acres remain, primarily in the southern portion of the state.

Missouri's shortleaf pine forests historically supported a thriving timber industry, providing raw materials for construction, furniture, and railroad ties. The Grandin Sawmill, once the largest in the U.S., processed shortleaf pine to help support the demand for construction timber and other forest products for booming populations in eastern and port cities (Dey, 2022).

Ecological Importance & Forest Management Challenges

Shortleaf pine forests play a vital role in enhancing biodiversity, providing critical wildlife habitat, improving watershed stability, and contributing to carbon sequestration (U.S. Forest Service, 2020). Unlike many hardwood species, shortleaf pine is resilient to frequent fire, making it an essential component of fire-adapted ecosystems.

Without periodic fire or active management, hardwoods such as oak and hickory outcompete shortleaf pine, limiting its regeneration. Leaf litter exceeding 2.5 inches in depth prevents shortleaf pine germination, further inhibiting natural regeneration. Prescribed burning, mechanical site preparation, and sustainable harvesting practices are necessary to maintain and restore shortleaf pine forests. Burning and harvesting operations expose mineral soil, providing the optimal conditions for shortleaf pine seed germination.

Forest Resources & Industry Impact

Missouri encompasses approximately 14.9 million acres of timberland which is largely concentrated in the southern portion of the state – identified in this assessment as the Ozark and Southeast regions. Most of Missouri's timberlands (71%) are privately owned - including 143,880 acres on the L-A-D Foundation's Pioneer Forest. The Mark Twain National Forest accounts for 9% and state-owned lands 4%. The remaining timberland is held by "other" ownerships (local municipalities, other federal agencies, etc.).

Missouri's forest products industry plays a critical role in the state's economy, supporting thousands of jobs, generating significant tax revenue, and contributing billions in economic output. In 2023, the forest products, wood, lumber, paper, and related industries contributed $11.7 billion to Missouri's economy and supported approximately 37,500 jobs with a combined payroll exceeding $2.7 billion and generate $920 million in total tax revenue (Treiman, 2024).

Shortleaf Pine Availability & Harvest Potential

While most land is privately owned, most of the shortleaf pine trees are on federal lands; there are 71.6 million shortleaf pine trees in the state and 35.6 million (50%) of them are on National Forest System lands. Those trees contain 1.41 billion cubic feet of wood, and of that, 1.15 billion cubic feet is in sawlog material.

The majority of shortleaf pine trees are in middle-aged stands (61-90 years), representing 53.6% of total growing stock. In contrast, early-stage recruitment (0-30 years) is just 3.5%, indicating a potential regeneration bottleneck.

Nearly 77% of the shortleaf pine trees are pole timber and fall within the 5-12.9" range, with the most trees in the 9.1-10" d.b.h range. Shortleaf pine reaches merchantable sawtimber size at 9 inches d.b.h., with the highest concentration of trees occurring at this threshold. The decline in tree count occurring between 9 and 15 inches is likely attributed to selective harvesting, whereas reductions beyond 15 inches are more likely due to site limitations and natural mortality.

Shortleaf pine is dispersed across various terrains and its accessibility could be limited by buffers around open surface waters, steep slopes, and small parcel sizes which would likely impact the economic feasibility of timber harvesting. Considering these limitations, at least 75% of the volume is readily available for harvest.

MISSOURI'S SHORTLEAF PINE RESOURCES (FIA, 2019)

71.6 Million

SHORTLEAF PINE TREES

50% shortleaf pine trees are located within the Mark Twain National Forest (35.6 million trees)

1.41 Billion

CUBIC FEET OF SHORTLEAF PINE

with 1.15 billion cubic feet of sawlog material

90%

OF SHORTLEAF PINE SAWLOGS ARE IN THE OZARK AND SOUTHEASTERN REGION

total of 1.02 billion cubic feet

MISSOURI'S SHORTLEAF PINE RESOURCES ARE

75% Accessible

when considering accessibility limitations of open surface water buffers, steep slopes, and small parcel sizes

56%

OF SHORTLEAF PINE ARE MIDDLE-AGED STANDS

shortleaf pine growing stock is concentrated between 61-90 years old

77%

OF SHORTLEAF PINE IS POLE TIMBER

the shortleaf pine resource is largely pole timber (5-12.9" d.b.h. range), with most trees in the 9.1-10" d.b.h range

MISSOURI'S SHORTLEAF PINE GROWTH

36.9 Million

CUBIC FEET OF SHORTLEAF SAWTIMBER GROWTH PER YEAR

and 1.3 million cubic feet/year of growth in other size classes

3.03 Billion

CUBIC FEET OF SHORTLEAF SAWTIMBER VOLUME IN 30 YEARS

PROJECTED 30-YEAR SUSTAINABLE HARVEST VOLUMES

CURRENT HARVEST RATE

3.0 Million

Cubic Feet of Shortleaf Growing Stock

HARVEST 2% OF STANDING VOLUME

9.3 Million

Cubic Feet of Shortleaf Growing Stock

HARVEST 3% OF STANDING VOLUME

1.25 Billion

Cubic Feet of Shortleaf Growing Stock

Growth Trends & Sustainability

Annual growth of shortleaf pine sawtimber is estimated at 36.9 million cubic feet per year and non-sawlog material is estimated at 1.3 million cubic feet annually. Given these growth rates, the volume of the sawlog material is expected to approximately double in 30 years to 3.03 billion cubic feet if current harvest rates continue.

Growth-to-drain ratios indicate the balance between timber growth and removals, with a ratio greater than 1 signifying growth exceeding harvest and less than 1 indicating a net loss of volume. At current annual harvest levels, county-level growth-to-drain ratios remain highly variable and erratic, with some counties showing substantial growth with no removals, highlighting underutilized timber resources.

To assess sustainable harvest levels, two scenarios were analyzed:

- Harvesting 2% of standing volume over 30 years resulted in growth exceeding removals in most counties, yielding growth-to-drain ratios between 0.55 – 3.15 and annual harvest volumes ranging from ~259,000 – 1.4 million cubic feet at the county level. Total harvest volume at this level would be 9.3 million cubic feet.

- A projected harvest of 3% of the standing volume over 30 years indicated that removals would slightly outpace growth. Under this scenario, annual harvest volumes would range from ~340,000 - 1.8 million cubic feet, totaling 1.25 billion cubic feet harvested over 30 years.

These findings indicate the substantial volume potentially available for use and emphasize the need for strategic harvest planning to ensure long-term sustainability of the forest and the forest products industry.

Forest Industry Production

Missouri's forest products industry is primarily focused on hardwood lumber production, with limited softwood production occurring. However, hardwood lumber manufacturers increasingly face challenges in selling softwood logs from mixed timber sales. Additionally, the state's forest products manufacturing facilities have been in decline, mirroring national industry trends.

In 2022, Missouri's total roundwood production was 2.6 million cubic feet, with 94% attributed to hardwoods. Despite having in-state softwood resources, Missouri imports approximately 55,000 tons of roundwood annually, including shortleaf pine, as reported by manufacturing facilities during site visits. This highlights an opportunity to increase utilization of locally available shortleaf pine within existing markets.

Lumber Strength Study

While plantation-grown pine varieties dominate the modern timber market, there is an opportunity to separate Missouri-grown shortleaf pine from plantation-grown shortleaf pine as a sustainable and high-performance lumber resource. The mechanical properties of southern yellow pine (SYP) wood from plantation pines are known to be inferior to those from old growth forests, where trees grow slower, though there is no data specifically on Missouri-grown shortleaf pine. A study was conducted to assess the mechanical properties of shortleaf pine lumber sourced from non-plantation forests in Missouri through a combination of non-destructive and destructive tests.

Recommendations for Market Development

To maximize the **economic and ecological benefits** of shortleaf pine restoration, the following strategies are recommended:

Missouri-Grown Shortleaf Lumber
Photo Credit: Renewable Resource Solutions, LLC. (2025).

1. **Expand Market Utilization:** The versatility of shortleaf pine makes it well-suited for structural timber, engineered wood, and biomass energy applications. Diversifying its market potential will ensure logs of various sizes and quality, as well as processing residues, can be utilized effectively.

2. **Enhance Processing Infrastructure:** Current softwood production capacity would need to be increased to accommodate a large pine market expansion. Investments in milling, drying, and transportation facilities is essential to improve efficiency and create new economic opportunities for shortleaf pine. Addressing the capacity of softwood processing and kiln drying capacity is critical for expanding utilization. Hardwood sawmills could consider transitioning their equipment and sawing strategies to encompass both hardwood and softwood, allowing for enhanced production flexibility and output potential.

3. **Strengthen Industry Collaboration:** Establishing stronger partnerships between loggers, mill owners, conservation groups, and policymakers is essential for coordinated industry expansion. Many industry members reported operating in isolation, limiting opportunities for infrastructure growth. The independent spirit of Missouri's forest industry members can be harnessed toward the common goal to collaboratively market shortleaf pine with a branding initiative, such as "*Missouri Shortleaf Pine – Strength Rooted in Tradition.*" Securing funding to build a Missouri Wood Innovation Team through the U.S. Forest Service's Wood Innovation Program is a next step to developing this coalition.

4. **Expanded Markets**
   - **Biomass, Energy & Bioproducts:** Increase utilization of chips, shavings, pellets, and wood flour for renewable energy and bioproduct applications.
   - **Infrastructure Applications:** Develop markets for highway guardrails, signposts, timber bridges, cross ties, and marine applications, leveraging shortleaf pine's durability and structural properties.
   - **Engineered & Industrial Wood Products:** Promote the use of shortleaf pine for pallets, mass timber, and industrial wood products, aligning with national trends in sustainable building materials.
   - **Lumber & Architectural Applications:** Increase demand for high-quality lumber and architectural wood pieces, emphasizing Missouri-grown shortleaf pine's sustainability and aesthetic appeal.

CONCLUSION

Missouri's shortleaf pine resource is a valuable yet underutilized economic and ecological asset. Through strategic management practices and targeted market expansion, stakeholders can drive economic growth while ensuring the long-term sustainability of this vital forest ecosystem. Collaboration among industry leaders, landowners, and policymakers will be essential to building a resilient and competitive shortleaf pine market in Missouri. This executive summary highlights key insights from the assessment, providing a high-level overview of the resource's potential. The full report offers a comprehensive analysis, including regional data breakdowns, growth projections, and industry resources to support informed decision-making and strategic development.

MISSOURI SHORTLEAF PINE UTILIZATION

RESOURCE ASSESSMENT

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INTRODUCTION

This **Resource Assessment** is part of the broader *Missouri Shortleaf Pine Utilization Assessment*, a resource initiated by the Forest and Woodland Association of Missouri (FWAM) in partnership with the Missouri Department of Conservation, the L-A-D Foundation, and the Mark Twain National Forest to address the market barriers limiting shortleaf pine utilization. Recognizing the need to strengthen existing markets and uncover new opportunities for this underutilized species, FWAM and its partners developed the Assessment as a comprehensive resource for government agencies, loggers, sawmills, and secondary producers.

By providing key data on Missouri-grown shortleaf pine, the report highlights targeted areas for product manufacturing growth and underscores how expanding these markets can foster sustainable forestry practices, boost economic development, and enhance ecological resilience throughout the state.

The *Missouri Shortleaf Pine Utilization Assessment* brings together extensive data and analysis to guide sustainable shortleaf pine management. This **Resource Assessment** details the species' historical significance, current distribution, ownership patterns, and growth projections, while the **Market Assessment** explores current industry capacity, supply-and-demand dynamics, potential product lines, and forest product manufacturing trends. It also examines opportunities for a collaborative branding initiative. The **Business Plan** proposes a targeted example of industrial expansion.

BACKGROUND

The Importance of Shortleaf Pine Restoration in Missouri

Shortleaf pine (*Pinus echinata*) is Missouri's only native pine species, historically covering over 6 million acres prior to widespread logging, fire suppression, and land-use conversion in the late 19th and early 20th centuries (MDC, 2020). Today, only 163,500 million acres remain, primarily within the Ozark and Southeast regions. (Moser et al, 2025) Restoring shortleaf pine forests is critical due to their ecological, economic, and historical significance.

Ecological Benefits

Shortleaf pine forests provide essential habitat for a diverse array of wildlife, including species of conservation concern such as the pine warbler (*Setophaga pinus*) and red-cockaded woodpecker (*Dryobates borealis*). These forests also enhance biodiversity, improve watershed stability, and contribute to carbon sequestration (U.S. Forest Service, 2020). Unlike many hardwood species, shortleaf pine is resilient to frequent fire, making it an essential component of Missouri's fire-adapted ecosystems. Restoring shortleaf pine forests will enhance resilience to climate-related stressors, including prolonged droughts, invasive pests, and increased wildfire risk (MDC, 2020). Shortleaf pine's deep root system and drought tolerance make it particularly well-suited for maintaining healthy forest ecosystems amid changing environmental conditions.

Figure R1: NLCD Class Maps

(USDA Forest Service. April 2024. NLCD 2021 Land Cover)

Figure R1.1: Missouri Land Cover by NLCD Class

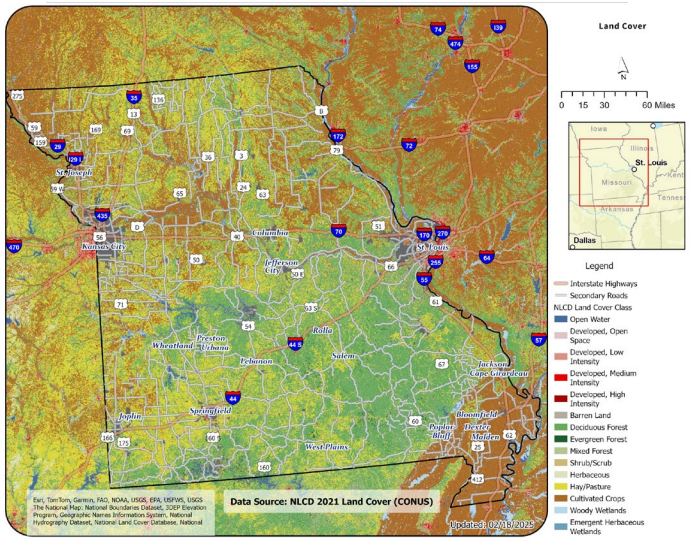
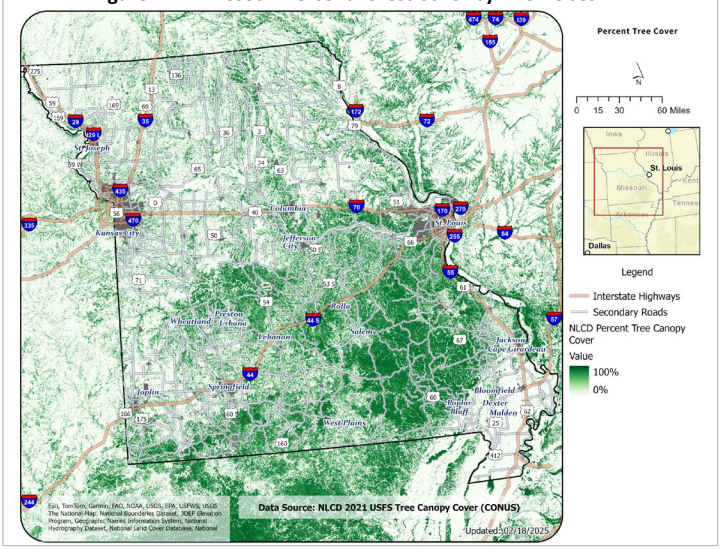


Figure R1.2: Missouri Percent Forest Cover by NLCD Class



Economic Potential

While shortleaf pine currently represents only 5% of Missouri's annual timber harvest, it holds substantial economic value (Song & Aguilar, 2015). Increased market demand for shortleaf pine products could drive investment in processing facilities, stimulate local employment, and create value-added opportunities for landowners. Developing infrastructure for milling, drying, and engineered wood products would further bolster its economic footprint.

Historical & Cultural Significance

Historically, Missouri's shortleaf pine forests supported a thriving timber industry, providing raw materials for construction, furniture, and railroad ties (MDC, 2020). In the 1800's, Missouri was home to the Grandin Sawmill, the largest in the country, which processed 285,000 board feet of timber a day at its peak. Lumber produced was used to build Midwest and Eastern port cities and the railroads that transported their goods to the rest of the country. However, widespread overharvesting and inadequate replanting led to a dramatic decline in acreage. Today, restoration efforts seek to re-establish these forests for both their historical value and their potential to sustain future timber industries.

Collaborative Forest Landscape Restoration Program (CFLRP) – Pine-Oak Woodlands Restoration

The Mark Twain National Forest (MTNF) is the only National Forest in Missouri. As such, all datapoints attributed to the National Forest in the state can be assumed to be MTNF-managed lands (U.S. Forest Service [USFS], 2021).

The MTNF encompasses 1.5 million acres across 20 counties in Missouri, with 99% (1,332,037 acres) of ownership located within the four southern regions where shortleaf pine is prevalent (USFS, 2021).

Shortleaf Pine Forest Type Acreage

As demonstrated in **Figure R2**, MTNF holds 63.2% (137,459 acres) of Missouri's total 217,377 shortleaf pine forest type acreage (U.S. Forest Service [USFS], 2019), and regionally holds:

- 100% of the shortleaf pine acreage in the Southwest and St. Louis regions (total of 19,346 acres)
- 80% in the Southeast region (40,330 acres)
- 53% in the Ozark region (77,782 acres)

This substantial ownership demonstrates MTNF's pivotal role in managing Missouri's shortleaf pine resources. The forest's management policies significantly impact shortleaf pine resource availability and its role as a potential source for Missouri timber markets.

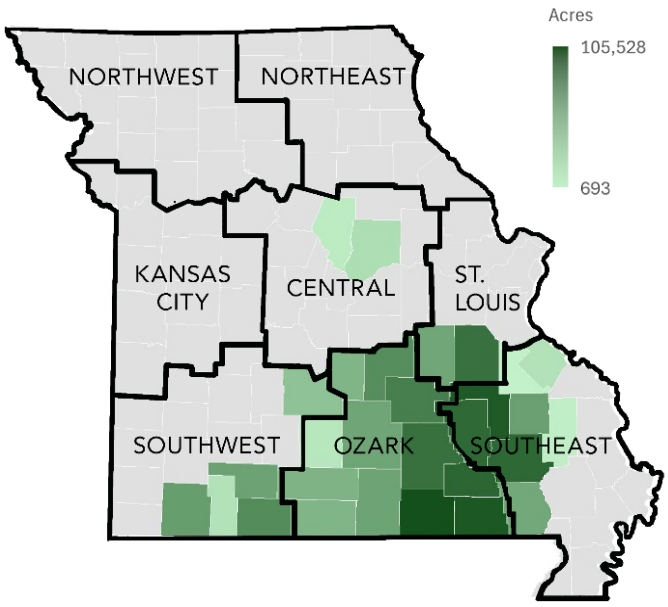
Implementation of the CFLRP on the MTNF

Between 2012 and 2019, the Mark Twain National Forest (MTNF) achieved significant progress in restoring pine-oak woodlands and shortleaf pine ecosystems, with direct economic and ecological impacts that continue to influence Missouri's shortleaf pine management through the "Collaborative Forest Landscape Restoration Program" (MTNF-CFLRP). These efforts underline the MTNF's pivotal role as the state's only National Forest and a critical steward of its forest resources.

The "CFLRP - Pine-Oak Woodlands Restoration Program" was established in 2009 through the

Figure R2: Mark Twain National Forest Acres by County and Region

Mark Twain National Forest Acreage (U.S. Forest Service, 2019)



Mark Twain National Forest Acreage by Region and County

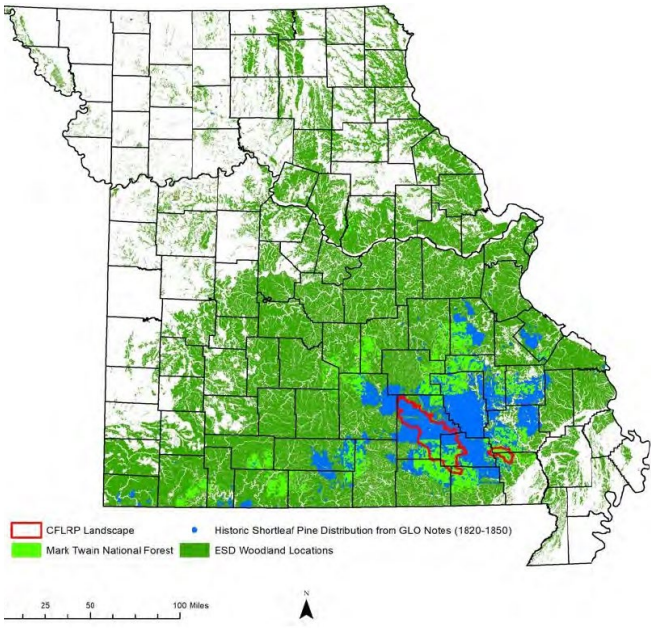
Total Self-Reported Acres (U.S. Forest Service, 2021) and Total Shortleaf Pine Acres (USFS, 2019)

	2021 Total MNTF Acreage by County (Forest Service, 2021)	2019 Total Shortleaf Pine Acreage by County (Forest Service, 2019)	% Shortleaf Pine Acreage Owned by MTNF
Central	**16,842**	**-**	**-**
Boone	4,178	-	-
Callaway	12,664	-	-
Ozark	**710,319**	**147,627**	**53%**
Carter	91,377	15,625	58%
Dent	74,621	6,699	50%
Douglas	41,112	3,823	78%
Howell	50,932	10,602	86%
Oregon	105,528	7,471	100%
Phelps	65,080	2,942	100%
Pulaski	39,443	-	-
Ripley	100,629	3,332	39%
Shannon	84,255	10,158	32%
Texas	50,168	17,130	44%
Wright	7,174	-	-
Southeast	**392,546**	**50,404**	**80%**
Bollinger	1,718	7,734	0%
Butler	48,168	4,639	100%
Iron	99,057	2,942	100%
Madison	53,156	6,182	100%
Reynolds	89,409	9,111	83%
St. Francois	693	2,942	100%
Ste. Genevieve	10,369	-	-
Wayne	89,976	14,514	97%
Southwest	**96,352**	**11,901**	**100%**
Barry	54,940	6,455	100%
Laclede	30,986	5,447	100%
Stone	10,426	-	-
St. Louis	**132,820**	**7,445**	**100%**
Crawford	49,719	669	100%
Washington	83,101	6,776	100%
Grand Total	**1,507,224**	**137,459**	**63%**

Omnibus Public Land Management Act, aiming to promote collaborative, science-based ecosystem restoration on priority forest landscapes. (Song & Aguilar, 2015). Seven major landholding entities partnered to restore approximately 126,000 acres (Song & Aguilar, 2015) of this globally imperiled shortleaf pine and oak bluestem woodland by marketing small-diameter biomass and restoring the historic fire regime *(Missouri Department of Conservation [MDC], 2020).*

Collaborative Forest Landscape Restoration Program – Pine-Oak Woodlands Restoration

Photo Credit: MDC, 2020



The focal area for the restoration project's local economic impacts consisted of nine counties (Ozark region: Carter, Reynolds, Shannon, Texas, Wright Southeast region: Butler, Oregon, Ripley, Wayne) with primary wood processing facilities near the project area.

- MDC (2015) indicated that 40% of Missouri wood mills were located within the nine counties at the time the MTNFP-CFLRP report was drafted and produced a wide variety of wood products, such as lumber, pallets, poles, ties, cants, pulpwood, charcoal, and firewood.
- The MTNF-CFLRP was located on about 4% of these nine counties' timberland base, consisting of hardwood tree species (57%) and shortleaf pine (43%) (Song & Aguilar, 2015).

Ecological and Economic Impacts of the CFLRP

The Economic Impacts of the Mark Twain CFLRP Project (2012–2019) highlight the program's dual ecological and economic benefits, emphasizing their correlation with shortleaf pine management. As noted within the 2020 Missouri Comprehensive Conservation Strategy, "restoration [of shortleaf pine and oak bluestem woodland] at this scale is helping to protect important target bird species addressed in the Missouri Bird Conservation Plan as well as many other taxonomic groups, to promote natural vegetation characteristics, and to stimulate the local economy" *(MDC, 2020).*

Forest Productivity and Growth: While the project led to an estimated increase of 14% in merchantable tree volume per acre and 20% in sawtimber volume, the report does not specifically isolate changes in shortleaf pine volume. The expected merchantable and sawtimber volumes of standing trees in 2019, as compared to 2012, were predicted to be about 5% lower if MTNF-CFLRP had not been implemented (Song & Aguilar, 2015).

Mark Twain National Forest | Orion Sale: 2024 Shortleaf Pine Harvest Operation

Photo Credit: Ross, H. (2024). Renewable Resource Solutions, LLC. [Unpublished photographs].

Local, Regional, and Statewide Economic Impacts: The $20 million invested in MTNF-CFLRP implementation over the 2012-2019 period was expected to support an average of 138 local jobs and generate $34 million in labor income in the regional nine-county economy, generating about $9.2 million in federal and state tax revenues. With consideration that some of the activities on project lands would have still occurred if the project were not implemented, the net impacts of the MTNF-CFLRP were estimated at 84 jobs, $21 million of labor income, $28 million of value added, and a total of $101 million output value (Song & Aguilar, 2015).

Economic Impact of Increase in Timber Volume

Using the available data from the Economic Impacts of the Mark Twain CFLRP Project as detailed above, we can estimate the economic benefits of increasing resource volume achieved through strategic management and shortleaf pine/oak bluestem woodland restoration efforts. These estimates provide a framework for understanding how prioritizing shortleaf and associated forest cover type restoration contributes to job creation, economic value, and tax revenue. With this, the net economic benefits associated with each 1% increase in timber volume can be estimated:

- **Jobs Created:** 84 jobs / 14% increase = 6 jobs per 1% increase
- **Value Added to the Economy:** $28 million / 14% increase = $2 million per 1% increase
- **Tax Revenue Generated:** $9 million / 14% volume increase = $0.64 million per 1% increase

While these values are speculative, they provide insight into how restoration investments can translate into tangible local, regional, and statewide economic and ecological benefits. Refining these findings and applying them to broader shortleaf pine landscapes across Missouri could:

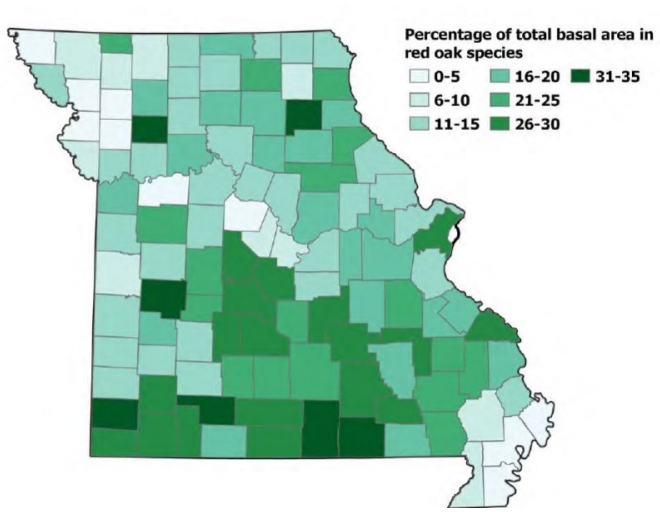
- Justify increased public and private investment by demonstrating strong economic multipliers,
- Encourage incentive programs for private landowners to engage in active shortleaf pine management,
- Highlight the tax revenue benefits to state and federal agencies, and
- Promote sustainable timber market expansion based on restoration-driven volume increases.

By continuing to refine these metrics and apply them across different management scenarios, stakeholders can develop optimized funding models for shortleaf pine restoration across Missouri to better understand how ecological restoration and management equates tree growth to economic growth.

Opportunities for Landscape Collaboration | Red Oak Decline and Shortleaf Pine Restoration

One of the most significant insect and disease threats currently affecting Missouri's forests and woodlands is red oak decline, characterized by widespread mortality in red oak group trees (*Quercus* spp.), including northern red oak (*Quercus rubra*), black oak (*Quercus velutina*), and scarlet oak (*Quercus coccinea*). The decline results from a complex interplay of factors, including the advanced age of these trees, infestations of red oak borers (*Enaphalodes rufulus*), armillaria root rot (*Armillaria* spp.), and prolonged drought conditions (MDC, 2020).

Percent of Total Basal Area in Red Oak Group Species on Forestland, Missouri, 2019. Includes all species in both the other red oak and select red oak species groups.
Photo Credit: MDC, 2020



Missouri's forests contain a substantial proportion of red oak species, making the effects of this decline widespread and impactful. Many red oak group trees are currently growing on sites that historically supported shortleaf pine. Prior to the widespread deforestation of the late 19th and early 20th centuries, shortleaf pine occupied extensive areas in the Missouri Ozarks.

As red oak decline continues to progress, an opportunity exists to restore shortleaf pine to sites where it historically thrived. However, this process requires intensive forest management strategies, including timber harvesting, selective thinning, prescribed fire, and tree planting. Despite these challenges, restoring shortleaf pine can provide numerous

ecological benefits, including increased biodiversity, improved forest resilience, and enhanced habitat for species such as pine warblers (*Setophaga pinus*) and brown-headed nuthatches (*Sitta pusilla*). Furthermore, a more diverse forest structure can mitigate the risk of widespread tree mortality in the event of future insect or disease outbreaks, such as the anticipated spread of the spongy moth (*Lymantria dispar*), which poses a significant threat to oak forests (MDC, 2020).

According to the U.S. Forest Service's Climate Change Tree Atlas, future habitat suitability for many oak species is expected to remain stable or decline, whereas conditions for shortleaf pine are projected to improve. As a result, reintroducing shortleaf pine into Missouri's forests may help create more resilient woodlands capable of adapting to changing environmental conditions (U.S. Forest Service, 2020).

The Importance of Shortleaf Pine Management for Wildlife

Shortleaf pine plays a critical role in supporting diverse wildlife populations across Missouri's forested landscapes. Its unique ecological characteristics, including fire-adaptive traits and the ability to grow in various stand conditions, create habitat diversity that benefits numerous species throughout different successional stages (Masters, 2007). Effective management of shortleaf pine woodlands not only enhances biodiversity but also addresses key conservation priorities outlined in Missouri's Comprehensive Conservation Strategy (CCS), including the protection of species of greatest conservation need, the restoration of fire-dependent ecosystems, and the promotion of sustainable forestry practices that balance economic and ecological goals (MDC, 2020).

Plant Succession and Community Succession Model

Photo Credits: Masters, R. E., 2007

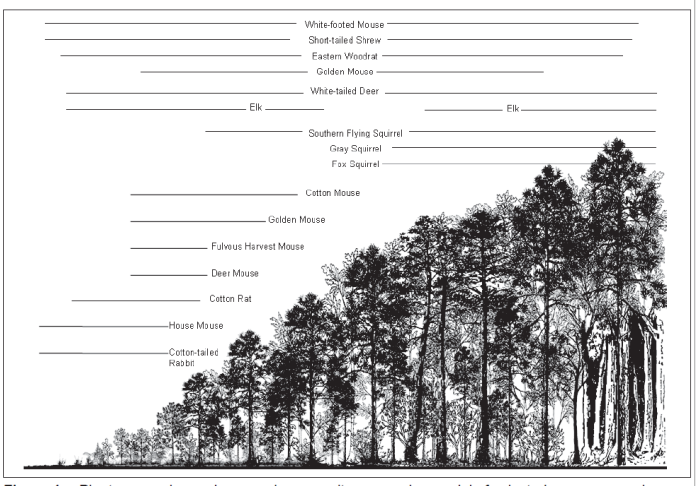


Figure 1.—Plant succession and mammal community succession model of selected common species occurrence associated with different stages of succession in the absence of fire. Horizontal lines indicate only the presence of the named species at a particular successional stage. Based on Atkeson and Johnson (1979), Tappe and others (1994, 2004), Masters and others (1998, 2002).

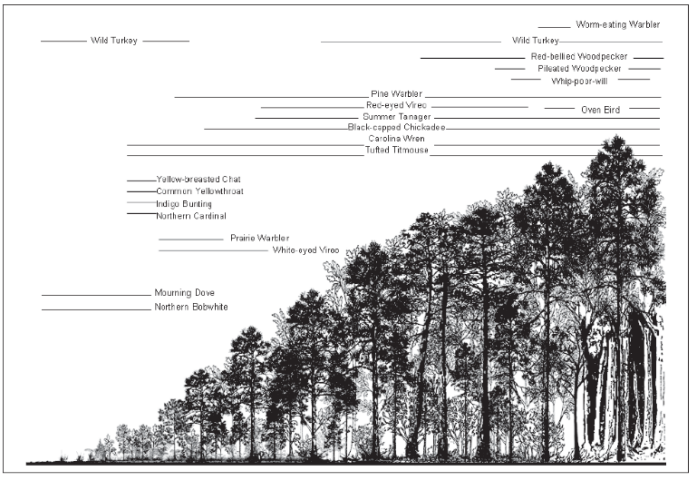


Figure 3.—Plant succession and breeding bird community succession model of selected common species occurrence associated with different stages of succession in the absence of fire. Horizontal lines indicate only the presence of the named species at a particular successional stage. Based on Johnston and Odum (1956), Meyers and Johnson (1978), Wilson and others (1995), Jennelle (2000), and Masters and others (2002).

Alignment with Missouri's Conservation Priorities

Shortleaf pine restoration and management directly support Missouri's CCS by contributing to multiple priority conservation themes. Specifically, shortleaf pine management aligns with:

- **Species and Natural Systems Health and Conservation:** The CCS emphasizes the importance of maintaining diverse and resilient natural communities that support Missouri's flora and fauna. Shortleaf pine woodlands provide critical nesting and foraging habitats for numerous species, including those identified as species of greatest conservation need, such as the northern long-eared bat (*Myotis septentrionalis*) and Bachman's sparrow (*Peucaea aestivalis*) (MDC, 2020).
- **Fire-Dependent Ecosystem Restoration:** The suppression of fire in Missouri's forests has led to declines in fire-adapted species and habitat degradation. Shortleaf pine ecosystems evolved with frequent, low-intensity fires, which maintain open understory conditions necessary for

many ground-foraging and nesting wildlife species (Masters, 2007). The reintroduction of prescribed fire in shortleaf pine management enhances habitat quality for various ground-nesting birds and other species (MDC, 2020).

- **Soil and Water Conservation:** Naturally vegetated riparian areas, help reinforce streambank stability, filter sediments, and improve water quality, which aligns with conservation objectives for watershed health (MDC, 2020), pp. 135-136) By reducing soil erosion and enhancing infiltration, these forests play a role in protecting aquatic habitats, which benefit freshwater mussels, amphibians, and fish species such as the Ozark hellbender (Crypt*obranchus alleganiensis bishopi*) (MDC, 2020).
- **Sustainable Forestry and Economic Benefits:** The CCS prioritizes balancing economic forestry operations with ecological sustainability. Shortleaf pine management supports this goal by promoting high-value timber production while maintaining habitat diversity. Selective thinning and uneven-aged management strategies enhance stand structure and growth while preserving habitat for key wildlife species (MDC, 2020).

Wildlife Benefits Across Successional Stages

Shortleaf pine forests provide essential habitat for a wide range of wildlife species, with stand structure and composition influencing species presence at various stages of forest development.

Successional Stage	Age Class	Wildlife Potential	Species Potential
Stand Initiation	**0–10 Years**	Attracts species reliant on open areas, such as early-successional birds, deer, and small mammals benefiting from herbaceous growth.	Bobwhite quail, wild turkey, white-tailed deer, eastern cottontail rabbit.
Sapling and Pole Stage	**11–30 Years**	Provides cover for small mammals and foraging opportunities for deer, ground-nesting birds, and early-successional species.	Northern bobwhite, prairie warbler, indigo bunting.
Young Mature Forest	**31–50 Years**	Supports prairie warbler, northern bobwhite, and other grass-shrub habitat species as understory diversity increases.	Eastern bluebird, field sparrow, red fox.
Mature Forest	**51–80 Years**	Offers critical habitats for cavity-nesting birds, such as the red-cockaded woodpecker, and increases understory flora diversity.	Red-cockaded woodpecker, eastern gray squirrel, barred owl, pileated woodpecker.
Late Successional Forest	**81+ Years**	Dense canopy and structural diversity attract bats, larger mammals, and species reliant on older forest characteristics, such as pileated woodpeckers.	Northern long-eared bat, big brown bat, black bear, pileated woodpecker.

(Masters, 2007; MDC, 2020)

The presence of shortleaf pine in mixed oak-pine and pine-grassland ecosystems further enhances biodiversity by maintaining a fire-adapted understory rich in native grasses and forbs, which serve as critical forage and cover for wildlife. Periodic prescribed burns, a key component of shortleaf pine management, sustain these open woodland conditions, benefiting pollinators, reptiles, and small mammals (MDC, 2020).

Conclusion

The management of shortleaf pine in Missouri is essential for enhancing wildlife habitat, maintaining ecosystem resilience, and addressing conservation priorities outlined in the Missouri CCS. By incorporating prescribed fire, promoting structural diversity, and ensuring sustainable forestry practices, shortleaf pine restoration efforts can support a wide range of species while also providing economic benefits. Given the historical decline of shortleaf pine across Missouri's landscape, proactive management strategies are necessary to restore and maintain this vital ecosystem for future generations.

VECTOR CONCERNS AND ISSUES

Ips Bark Beetles

Ips bark beetles (*Ips* spp.), commonly known as engraver beetles, are a significant concern for shortleaf pine (*Pinus echinata*) forests in Missouri. These small, reddish-brown to black beetles range from 3 to 6 millimeters in length and are distinguishable by the concave depression at the end of their elytra, which is bordered by spines. They primarily infest stressed or weakened trees affected by environmental factors such as drought, storm damage, or poor stand management. While healthy trees are more resistant, large *Ips* populations can overwhelm tree defenses, leading to mortality (USDA Forest Service, 2011).

Shortleaf pine mortality due to *Ips* bark beetles often occurs in clusters of dying trees, ranging from a few individuals to several dozen. Affected trees typically exhibit reddish-brown needles before succumbing to the infestation. Although *Ips* beetles are frequently the primary cause of mortality, additional stressors, such as root diseases and extreme weather events, can exacerbate their impact (MDC, n.d.).

The beetles' life cycle begins when males bore into the bark to establish a nuptial chamber, releasing aggregation pheromones that attract females. After mating, females create egg galleries where they deposit eggs. The larvae hatch and feed on the phloem, disrupting the tree's ability to transport nutrients and ultimately leading to death if the infestation is severe (Southern Forest Health, n.d.).

Ips bark beetles pose a persistent threat to shortleaf pine forests in Missouri, particularly in stressed or poorly managed stands. Preventative management through silvicultural practices, proper stand maintenance, and continuous monitoring remains the most effective approach in mitigating their impact. By employing integrated pest management techniques, forest managers can reduce the risk of widespread beetle infestations and maintain the health of Missouri's shortleaf pine forests.

Southern Pine Beetle (Dendroctonus frontalis Zimmermann)

The southern pine beetle (*Dendroctonus frontalis Zimmermann*) is one of the most destructive pests of pine forests in the southeastern United States, with significant infestations occurring in states such as Arkansas and Texas. The beetle's range also extends westward into Arizona and New Mexico and further south into Mexico (PalletOne, n.d.). Although less prevalent in Missouri compared to other southeastern states, its presence poses a potential threat to the state's pine resources. The beetle primarily targets species such as shortleaf pine and loblolly pine (*Pinus taeda),* which is also found in Missouri's forests (University of Florida Entomology, 2023).

While Missouri has not experienced widespread outbreaks of the southern pine beetle, its history of devastating infestations in neighboring states underscores the need for proactive management. During an outbreak, the beetle can rapidly kill thousands of acres of pine, leading to significant economic and ecological consequences. In areas where the beetle is established, it has caused extensive damage by tunneling beneath the bark, disrupting the tree's ability to transport nutrients and water (University of Florida Entomology, 2023). Given its potential for rapid population growth and tree mortality, continuous monitoring remains essential.

Preventative measures play a critical role in managing the southern pine beetle. One of the most effective strategies is the use of silvicultural practices that improve stand resilience. Thinning dense pine stands can enhance tree vigor and reduce the risk of infestation. Additionally, prescribed burning and maintaining species diversity within forests can help lower stand susceptibility. The Southern Pine Beetle Prevention Program, a joint effort between the USDA Forest Service and the Southern Group of State Foresters, has provided landowners with cost-share assistance since 2003 to implement these preventative measures (PalletOne, n.d.).

In 2017, the Missouri Department of Conservation (MDC) initiated a monitoring effort in collaboration with the USDA Forest Service. As part of this study, five pheromone-baited traps were deployed in various shortleaf pine stands in Shannon County from mid-July through August. While no southern pine beetles were captured during this period, continued monitoring is necessary to detect early signs of potential infestations (PalletOne, n.d.). These efforts align with broader regional initiatives that track beetle populations and predict potential outbreaks, enabling timely intervention and management strategies.

ASSESSMENT METHODOLOGY

DETERMINING THE ASSESSMENT AREA

Regions

The Missouri Department of Conservation (MDC) organizes the state into eight administrative regions to facilitate conservation efforts and resource management. This resource analysis utilizes MDC regional divisions where applicable for data compilation and analysis. Below is a list of the eight MDC regions and their respective counties.

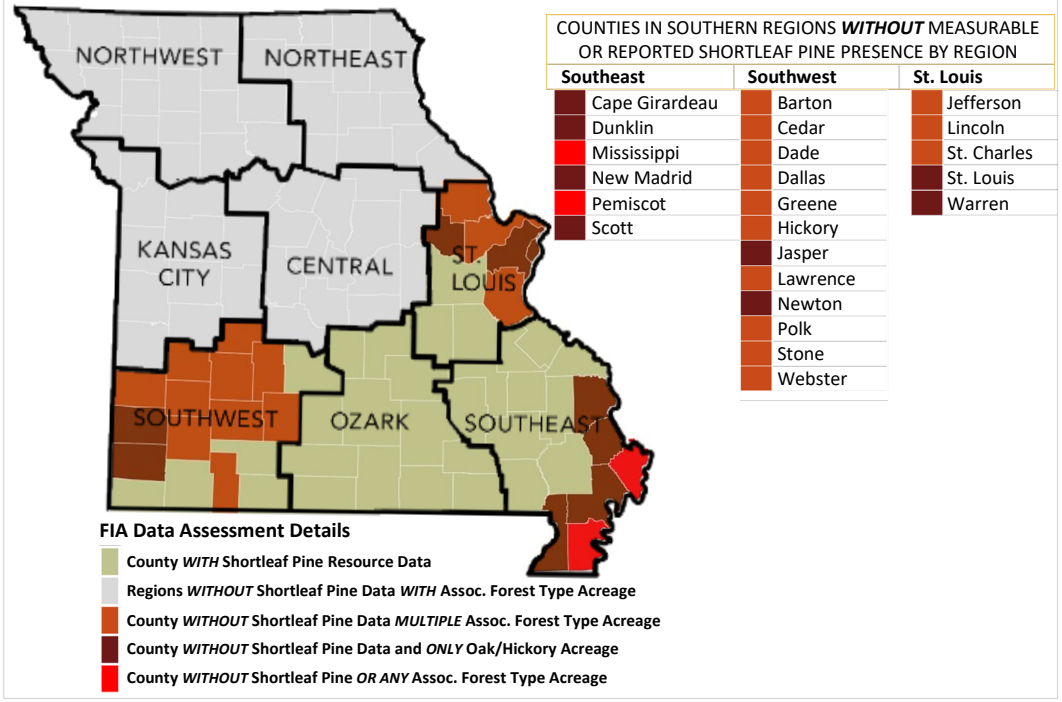
Table R1: Assessment Area Regions

Central	Kansas City	Northeast	Northwest	Ozark	Southeast	Southwest	St. Louis
Audrain	Bates	Adair	Andrew	Carter	Bollinger	Barry	Crawford
Boone	Benton	Clark	Atchison	Dent	Butler	Barton	Franklin
Callaway	Cass	Knox	Buchanan	Douglas	Cape Girardeau	Cedar	Jefferson
Camden	Clay	Lewis	Caldwell	Howell	Dunklin	Christian	Lincoln
Cole	Henry	Macon	Carroll	Oregon	Iron	Dade	St. Charles
Cooper	Jackson	Marion	Chariton	Ozark	Madison	Dallas	St. Louis
Gasconade	Johnson	Monroe	Clinton	Phelps	Mississippi	Greene	Warren
Howard	Lafayette	Pike	Daviess	Pulaski	New Madrid	Hickory	Washington
Maries	Pettis	Putnam	DeKalb	Ripley	Pemiscot	Jasper	
Miller	Platte	Ralls	Gentry	Shannon	Perry	Laclede	
Moniteau	St. Clair	Randolph	Grundy	Texas	Reynolds	Lawrence	
Montgomery	Vernon	Schuyler	Harrison	Wright	Scott	McDonald	
Morgan		Scotland	Holt		St. Francois	Newton	
Osage		Shelby	Linn		Ste. Genevieve	Polk	
Saline		Sullivan	Livingston				
			Mercer				
			Nodaway				
			Ray				
			Worth				

Figure R2 illustrates the MDC regions and highlights counties ***with and without reportable shortleaf pine data based on the most recent shortleaf pine species-specific*** Forest Inventory and Analysis (FIA) datasets available at the time of this report (USFS, 2019). Of Missouri's 114 counties, only two—Mississippi and Pemiscot in the Southeast region—lacked reportable shortleaf pine data or documented acreage within any associated cover types (oak/hickory, oak/pine, or other Eastern softwood). This figure, and the data therein, is explored in greater detail later in this assessment.

Figure R3: Resource Assessment Area

Number of growing-stock trees (at least 5" d.b.h.), in trees, on timberland of Missouri, by Species, by County
(U.S. Forest Service, 2019)



NOTE: It is important to consider that, while the lack of species-specific data is notable, it does not necessarily indicate an absence of shortleaf pine resources. FIA estimation methodologies, such as sampling intensity adjustments, stratification processes, and reporting thresholds, can influence data representation. For instance, counties that lack sufficient sample representation due to low sampling rates or estimation adjustments, and plots classified as inaccessible, outside boundaries, or without measurable shortleaf pine are often excluded from

FIA outputs.

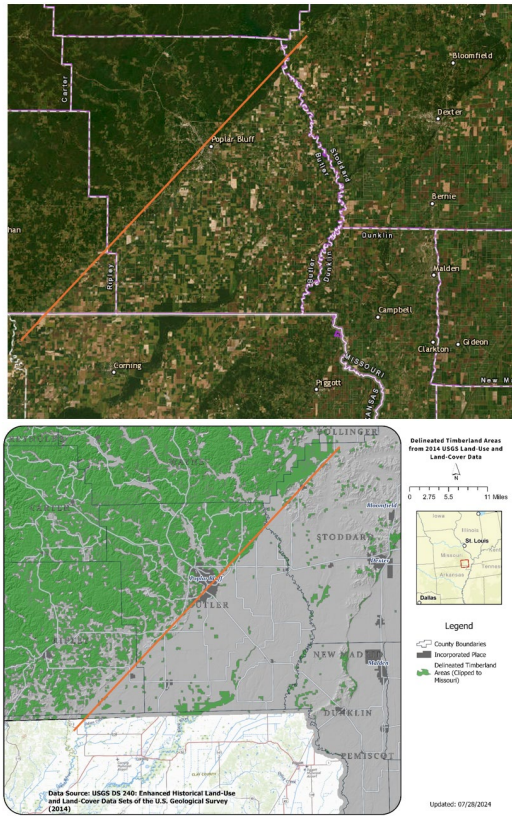
GEOSPATIAL METHODOLOGY

Geospatial features were analyzed using ArcGIS Pro 3.2.2. To estimate marginal harvest areas, a timberland model was constructed based on USDA Forest Service Forest Inventory and Analysis (FIA) data. While the constructed timberland model did not perfectly replicate the FIA timberland dataset, it was deemed a close approximation. Validation of the model was conducted through state- and county-level comparisons with the FIA EVALIDator 2.1.3. Additional verification involved overlaying the timberland model in ArcGIS Pro with aerial imagery of the corresponding geographic regions, ensuring alignment and accuracy in delineated timberland areas.

Initial attempts to construct the timberland model were done using the 2021 National Land Cover Data (NLCD) published by the U.S. Geological Survey. However, when converting the 2021 NLCD from its original raster format to polygons, the estimated timberland acreage value for the state of Missouri was calculated to be 16,457,898 acres, which was 1,594,309 more acres than reported by the FIA EVALIDator 2.1.3 database (14,863,589 acres). Ideally, the estimated timberland acres calculated by the timberland model would be closer in value to the FIA database values. Subsequently, a 2014 Land Use and Land Cover Data Set from the U.S. Geological Survey (USGS) was located. This 2014 data set was already in polygon format and did not require the steps to convert the raster data to polygon data. The timberland data needed to be in polygon format to overlay the other layers listed in **GIS Table 4** and calculate acreage values.

Using the 2014 USGS Land Use and Land Cover datasets, the estimated timberland across all of Missouri was calculated to be 15,054,220 acres, which is only 190,631 acres greater than the 14,863,589 acres reported by the FIA EVALIDator database. Because the 2014 USGS data produced estimates closer in value to the FIA EVALIDator data, the 2014 data set was used instead of the 2021 USGS dataset.

Comparison of the timberland acres generated by the ArcGIS Pro timberland model to the FIA EVALIDator data was the validation method. Verification of the timberland model was accomplished by visual comparison of forest patterns from aerial imagery to delineations of forested areas generated by the ArcGIS Pro timberland model. **GIS Figure 1** demonstrates one of the verification techniques. Aerial imagery (A) of southeast Missouri shows a clear delineation of timberland area that extends diagonally across Butler County. The output from the timberland model (B) also shows this same pattern and confirms that the model is accurately displaying timberland patterns that occur on-the-ground.



GIS Figure 1: Example of model verification displaying (A) 2023 aerial imagery of southeast Missouri and (B) the output of timberland areas from the ArcGIS Pro timberland model. Image A is a screenshot sourced from The Missouri Map, accessible via the Missouri Spatial Data Information Service.

Marginal Harvest Areas

In consultation with forestry staff from the Missouri Department of Conservation and the Forest and Woodland Association of Missouri, it was determined that the three features listed in **GIS Table 1** would be used to define marginal harvest acres.

GIS Table 1: Marginal Harvest Area Definitions

Marginal Harvest Area	Definition
Open Water Buffer	75 feet from shore of water features: streams, rivers, lakes, ponds, other open water bodies, etc.
Steep Slopes	Areas with slopes equal to or greater than 30%
Small Land Ownership Parcels	Parcels of land equal to and less than 40 acres in size.

The identification of marginal harvest areas was achieved using several geospatial tools and processes available within ArcGIS Pro. These tools, outlined in **GIS Table 2**, were integral to analyzing and defining features such as open water buffers, steep slopes, and small land ownership parcels. By leveraging the capabilities of ArcGIS Pro's geoprocessing tools, a detailed and accurate spatial analysis was conducted to identify areas that meet the criteria for marginal harvesting.

GIS Table 2. Key ArcGIS Pro Geoprocessing Tools and References

Tool/Process	Description	ArcGIS Pro Reference Link
Buffer (Analysis)	Creates buffer polygons around features for spatial proximity analysis.	pro.arcgis.com/en/pro-app/latest/tool-reference/analysis/buffer.htm
Export Data	Enables exporting selected features or datasets to various formats.	pro.arcgis.com/en/pro-app/latest/help/data/geodatabases/overview/export-data.htm
Overlay Layers (GeoAnalytics Desktop)	Performs spatial overlays for analyzing relationships between layers.	pro.arcgis.com/en/pro-app/latest/tool-reference/geoanalytics-desktop/overlay-layers.htm
Raster to Polygon (Conversion)	Converts raster data to polygon features for vector analysis.	pro.arcgis.com/en/pro-app/latest/tool-reference/conversion/raster-to-polygon.htm
Select Features Using Attributes	Allows selection of features based on attribute criteria.	pro.arcgis.com/en/pro-app/latest/help/mapping/navigation/select-features-using-attributes.htm
Slope Function	Calculates the rate of maximum change in elevation over a surface.	pro.arcgis.com/en/pro-app/latest/help/analysis/raster-functions/slope-function.htm
Summarize Within (Analysis)	Aggregates data within specified boundaries for statistical summaries.	pro.arcgis.com/en/pro-app/latest/tool-reference/analysis/summarize-within.htm

Note: These tools and processes are part of the geospatial workflow documented in the ArcGIS Pro resources page, which provides access to all referenced tools and additional resources. Visit https://www.esri.com/en-us/arcgis/products/arcgis-pro/resources for details.

Open Water Buffer

A 75-foot buffer around open water features occurring on timberland areas was modeled. This 75-foot buffer is a median value of stream management zone sizes as defined in Missouri's Best Management Practices (BMPs) (Missouri Department of Conservation, 2020) for timber harvesting. The published BMPs use slope to determine the exact buffer size, but there is a minimum 50-foot stream management zone for most streams, and for third-order streams, a minimum of a 100-foot buffer is required.

GIS Table 3: National Hydrography Dataset Sources

Flowlines (NHDFlowline_1)	Waterbody (NHDWaterbody)	Area (NHDArea)
336 = canal/ditch 460 = stream/river	390 = lakepond 436 = reservoir	312 = bayinlet 336 = canalditch 364 = foreshore 398 = lockchamber 460 = streamriver

Geospatial data from the U.S. Geological Survey's National Hydrography Dataset (NHD) was used to generate the 75-foot water buffers. The three NHD shapefiles utilized were the Flowlines, Waterbody, and Area as described in **GIS Table 3**. In preparing the NHD shapefiles for analysis, the first step was to ***Select*** and ***Export*** each of the identified attributes for each of the three respective NHD shapefiles. Once the relevant attributes were exported to a new NHD shapefile, each new shapefile was then overlaid using the Overlay Layers on the delineated timberland areas. A 75-foot buffer was then applied using the ArcGIS Pro ***Buffer (Analysis)*** geoprocessing tool. Estimation of acreage for the buffer areas was done with the ***Summarize Within (Analysis)*** tool.

Steep Slopes

Mechanical harvesting timber on steep slopes can contribute to soil erosion and present rollover hazards for timber harvesting equipment such as rubber-tired log skidders and feller bunchers. It was determined, in consultation with Missouri natural resource managers, that slopes of 30% and greater would be considered as part of the marginal harvest areas. The slope of hillsides, across all timberland areas in Missouri, was calculated using digital elevation model (DEM) data for the state of Missouri. The DEM data from the Missouri Spatial Data Information Service was in raster form and had a resolution of 2 arc-seconds, which is approximately 60 meters. An arc-second represents the distance of latitude traversed on the earth's surface.

The ***Slope Function (Analysis)*** of the ArcGIS Pro ***Raster Function*** Toolset was used to identify and select areas with slopes equal to or greater than 30%, followed by converting the selected raster data to polygons. Once in polygon form, the slope feature layer was overlaid on the timberland model, and acreage values of the steep slope areas occurring within the timberland areas were summarized with the ***Summarize Within (Analysis)*** tool.

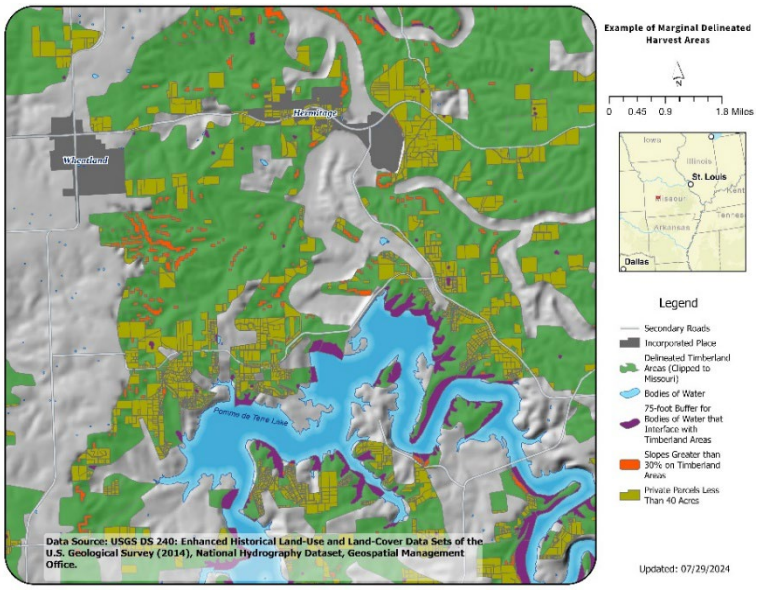
Small Land Ownership Parcels

Mobilization of mechanized timber harvesting equipment to new harvest areas often requires the use of trailers to haul the equipment. From a business operations standpoint, the mobilization process removes the equipment from any profit-generating activities until the equipment arrives at the new harvesting site. To help minimize the number of times that equipment needs to be mobilized, many logging contractors will prefer to only harvest areas that have a minimum acreage size. In consultation with the Missouri Department of Conservation, it was determined that parcels equal to and less than 40 acres in size should be considered part of the marginal acres analysis.

Identification of parcel size was done using 2018 Missouri Homeland Infrastructure Foundation-Level Data. As with the water buffer and steep slope analysis processes, the parcel data was overlaid on the timberland model, and parcels of 40 acres or less were summarized from within the delineated timberland areas.

Marginal Harvset Areas GIS Mapping Summary

Collectively, an example of how the water buffers, steep slope areas, and small land ownership parcels were displayed and verified in the ArcGIS Pro timberland model is presented in **GIS Figure 2**.



GIS Figure 2: Example of delineated Marginal Harvest Areas that overlay on Timberland Areas in Hickory County, MO.

GIS Table 4: Geographic Information Systems Spatial Data Parameters

Feature	Data File	Source	Values Used
Flowlines	NHDFlowline_1	USGS The National Map (Missouri NHD Flowline_1)	ftype: 336 = canal/ditch, 460 = stream/river.
Open Water	NHDWaterbody	USGS The National Map (Missouri NHD Waterbody)	ftype: 390 = lakepond, 436 = reservoir.
Stream Area	NHDArea	USGS The National Map (Missouri NHD Area)	ftype: 312 = bayinlet, 336 = canalditch, 364 = foreshore, 398 = lockchamber, 460 = streamriver.
Missouri Landowner Parcels	Parcel_Residential_poly_HIFLD_2018	Geospatial Management Office – Homeland Infrastructure Foundation-Level Data (Account Required)	Parcels less than or equal to 40 acres.
Timberland Data	g36088, g36090, g36092, g36094, g37088, g37090, g37092, g37094, g38090, g38092, g38094, g39090, g39092, g39094, g40090, g40092, g40094	USGS DS 240: Enhanced Historical Land-Use and Land-Cover Data Sets of the U.S. Geological Survey (2014)	LUCODE: 41 (Deciduous forest land), 42 (Evergreen forest land), 43 (Mixed forest land), 61 (Forested wetland).
Slopes	1990_60m_dig	Missouri Elevation Data - Missouri Spatial Data Information Service	N/A
Missouri State Boundary	MO_State_Boundary	Administrative Boundaries – Missouri Spatial Data Information Service	N/A
Missouri County Boundaries	MO_County_Boundaries	Administrative Boundaries – Missouri Spatial Data Information Service	All
Forest Products Manufacturers	2024_Q1_Forisk_North_American_Ind_Cap_DB_Shape	North American Mill Capacity Databse – Forisk Consulting (Account Required)	Status: Open

MISSOURI'S FOREST RESOURCE

Missouri's forestland and timberland resources are foundational to the state's ecological and economic vitality, with shortleaf pine occupying a pivotal role. This section evaluates the **2019 FIA Summary Data derived from the Forest Inventory and Analysis (FIA) EVALIDator tool** (USFS, 2019), which provides comprehensive forest resource metrics, including acreage, operability, stand type composition, size, age and ownership patterns. By analyzing this dataset - the most recent available for the state of Missouri at the time of the research - key insights are identified to support sustainable forest management and market development for shortleaf pine. These findings highlight critical opportunities to bolster forest health, restore ecosystems, and expand the economic potential of Missouri's forestry sector.

The FIA resource data can be categorized into two primary forest types, forestland and timberland, each defined by specific criteria established by the USDA FIA program (U.S. Forest Service [USFS], 2023):

- **Forestland** refers to areas with at least 10% canopy cover of trees, including land capable of natural regeneration and areas not subject to non-forest uses such as intensive grazing, urban development, or recreation.
- **Timberland** is a *subset* of forestland that specifically excludes reserved areas and is capable of producing at least 20 cubic feet of wood per acre annually. Reserved areas, such as wilderness zones or parks where harvesting is restricted, are not included in timberland classifications.

To effectively analyze the current and future shortleaf pine resources within the framework of sustainable forest management and industry development, this report focuses on timberland data.

Methodology and Sources

This assessment integrates 2019 FIA data (USFS, 2019), advanced geospatial analyses as outlined in the Geospatial Methodology section, and supplementary datasets from regional forestry partners (where noted). Note that FIA inventories are extensive inventories that provide reliable estimates for large areas. As data are subdivided into smaller and smaller areas, such as a geographic unit or a county, the sampling errors increase and the reliability of the estimates goes down. The greater allowance for sampling error in smaller areas reflects the decrease in sample size as estimation area decreases.

The subsections of this assessment are designed to provide a detailed evaluation of Missouri's timberland resources, focusing on the metrics most relevant to sustainable forest management and economic development:

- **Timberland Acreage**: Highlights the total area of timberland across Missouri, with a breakdown by region and county, emphasizing regions like the Ozarks and Southeast, which dominate timberland distribution.
- **Operability and Marginal Harvest Areas**: Examines factors influencing harvest feasibility, such as steep slopes, proximity to water, and small parcel sizes. These constraints are analyzed alongside the availability of shortleaf pine growing stock within operable and marginal areas.
- **Stand Type Composition**: Categorizes timberland by dominant tree species, including oak-hickory, oak-pine, and loblolly-shortleaf pine groups, to understand the ecological and economic value of mixed forest stands.
- **Timberland Ownership Patterns**: Evaluates the distribution of timberland by ownership category (private, state, federal), noting that private landowners manage over 80% of the state's timberland, making them essential stakeholders in sustainable forestry.
- **Shortleaf Pine Ownership**: Analyzes the number of shortleaf pine trees across ownership types, underscoring the importance of private landholdings in supporting Missouri's shortleaf pine ecosystem.
- **Volume**: Estimates the volume of shortleaf pine growing stock and sawtimber on the forest and potentially available for harvest to support expanded markets.

FORESTLAND AND TIMBERLAND ACREAGE

FORESTLAND ACREAGE

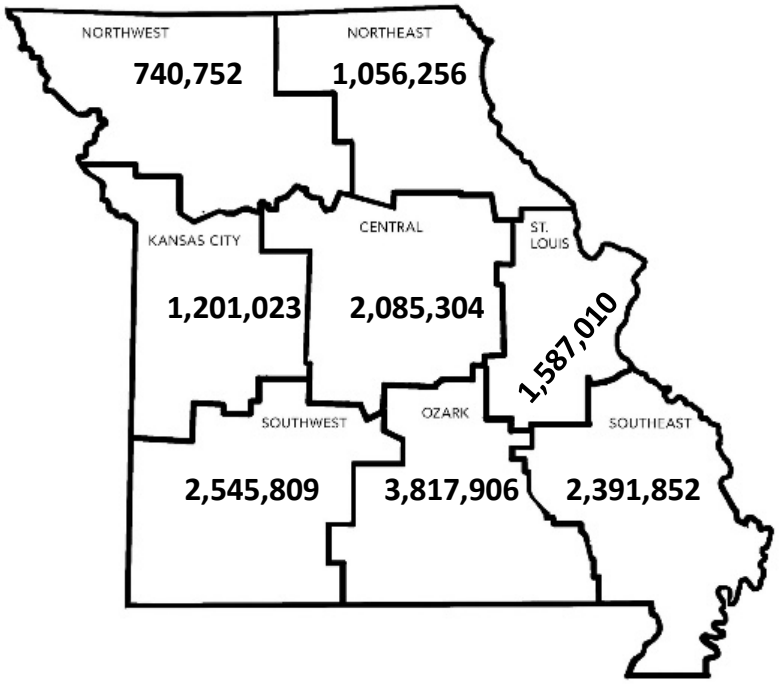
Missouri's forestland, as defined by the FIA program (U.S. Forest Service, 2023), represents the broadest category of the state's forest resources. Forestland encompasses areas with at least 10% canopy cover of trees, regardless of size, including those capable of natural regeneration or designated for artificial regeneration. This classification also includes transition zones between heavily forested and non-forested lands, provided they meet the minimum canopy cover threshold. Additionally, forestland accounts for unimproved roads, trails, streams, and clearings within forested areas if these gaps are less than 120 feet wide. Forestland also includes areas that historically met the canopy criteria but no longer do, as evidenced by stumps, snags, or other remnants of past tree cover, provided these areas are expected to regenerate. Importantly, forestland does not include areas subject to non-forest uses, such as regular mowing, intensive grazing and recreation activities that prevent natural tree regeneration and succession.

Forestland Acreage in Missouri

Missouri contains over **15.4 million acres of forestland** (USFS, 2019). The Ozark region, with its dense and diverse forest ecosystems, accounts for the largest share of forestland acreage, followed closely by the Southeast region. **Figure R3** illustrates the distribution of forestland across Missouri, highlighting the state's regions and the total forestland acreage within each.

Figure R3: Forestland Acres in Missouri by Region and County

Area of forest land, in acres of Missouri, all live stocking by county
(USFS, 2019)



Purpose of Including Forestland Data

While reserved and low-productivity areas account for only **3.65% of forestland**, these lands are essential for conservation and biodiversity. Although this report details timberland (actively managed areas suitable for wood production), forestland data is included for the following reasons:

1. **Ecological Context:** Capturing the full extent of Missouri's forestland provides a more complete understanding of the role forests play in ecosystem services, including carbon storage, wildlife habitat, and watershed protection.
2. **Baseline for Comparison:** The distinction between forestland and timberland highlights the proportion of forested acres suitable for active management versus those designated for conservation or lower productivity.
3. **Policy & Land Management Insights:** Including forestland data informs land-use planning and conservation efforts, enabling strategies to expand sustainable forestry practices or address ecological restoration needs.

TIMBERLAND ACREAGE

Timberland, as classified by the FIA program, refers to unreserved forestland capable of producing at least 20 cubic feet of wood per acre annually from trees classified as timber species (USFS, 2023). This classification excludes areas such as national parks, conservation zones, and low-productivity lands, ensuring that timberland data reflects actively managed, merchantable forests.

With **14.9 million acres of timberland**, timberland represents **96.4% of the state's total forestland**. This high percentage of productive lands underscores the importance of timber to public and private landowners across the state.

Merchantable Timber Harvest Operation
Photo Credit: Ross, H. (2024). Renewable Resource Solutions, LLC. [Unpublished photographs].

Geographic Distribution of Timberland

Figure R4 illustrates the distribution of Missouri's **14,863,589 timberland** acres (USFS, 2019), highlighting the dominance of the southern regions in forest coverage and resource availability. The map depicting timberland acreage by county underscores a clear concentration of forested land in the southern half of the state, where diverse forest composition and extensive coverage create a cornerstone for Missouri's forestry economy. The southern part of the state holds 2/3 of Missouri's total timberland acreage (10 million acres), the four southernmost regions are a critical hub for timber production and forest industry development efforts.

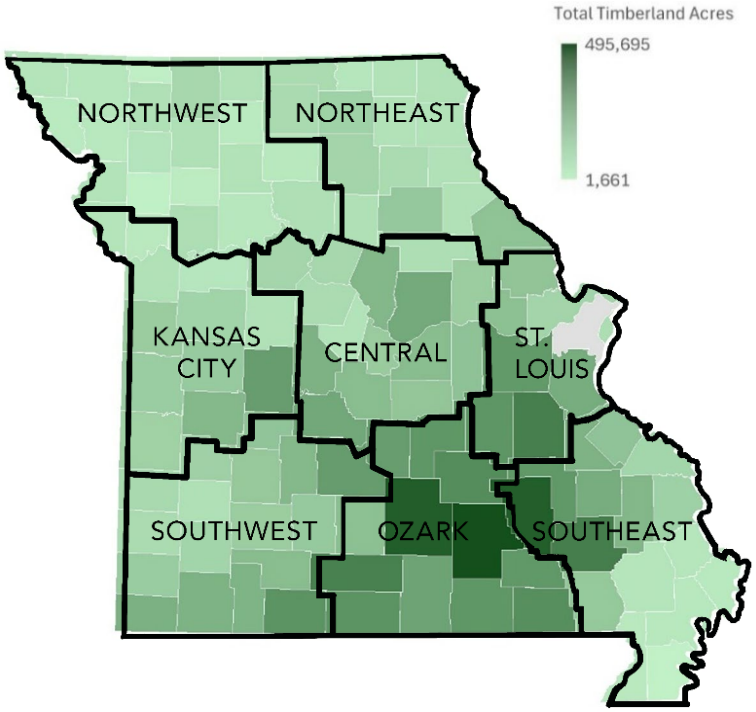
- **Ozark Region:** With 3.7 million acres, the Ozark region holds the largest total timberland acreage in the state. Notably, Shannon County has 495,695 timberland acres - more than any other county.

- **Southwest, Southeast, and St. Louis Regions:** Together, these regions account for 6.27 million acres of timberland - Southwest (2.5 million acres), Southeast (2.3 million acres), and St. Louis (1.54 million acres).

In contrast, the four northernmost regions collectively encompass only 1/3 of the state's timberland acreage (4.9 million acres), significantly less than their southern counterparts. Geographic and ecological constraints, such as soil composition and land use patterns, limit the expansion of dense timberland in these areas. This reinforces the critical importance of Missouri's southern forests in sustaining the state's timber economy and ecological health.

Figure R4: Timberland Acreage Distribution in Missouri by Region and County

Area of timberland, in acres of Missouri, all live stocking by county (USFS, 2019)



Acres of Timberland by Region and County

Table R2 provides a comprehensive breakdown of Missouri's timberland acreage by Region and County. By structuring the data at both region and county level, the table enables a more precise analysis of resource availability and potential for timber production at the local level.

Table R2: Acres of Timberland in Missouri by Region and County

Area of timberland, in acres of Missouri, all live stocking by county (USFS 2019)

STATEWIDE TOTAL: 14,863,589

Central	1,982,078
Audrain	59,522
Boone	175,833
Callaway	218,372
Camden	225,798
Cole	118,193
Cooper	67,266
Gasconade	144,420
Howard	78,085
Maries	135,257
Miller	163,702
Moniteau	44,292
Montgomery	112,169
Morgan	194,069
Osage	161,317
Saline	83,785

Kansas City	1,168,372
Bates	110,913
Benton	256,609
Cass	114,906
Clay	25,284
Henry	120,088
Jackson	49,373
Johnson	90,615
Lafayette	34,258
Pettis	50,630
Platte	42,264
St. Clair	173,179
Vernon	100,252

Northeast	1,042,418
Adair	96,605
Clark	51,318
Knox	47,216
Lewis	46,744
Macon	87,391
Marion	49,260
Monroe	127,771
Pike	146,176
Putnam	66,313
Ralls	49,269
Randolph	53,896
Schuyler	36,471
Scotland	46,510
Shelby	68,524
Sullivan	68,954

Northwest	729,121
Andrew	28,797
Atchison	41,326
Buchanan	43,824
Caldwell	16,057
Carroll	33,716
Chariton	57,182
Clinton	6,116
Daviess	52,482
DeKalb	40,170
Gentry	53,677
Grundy	24,077
Harrison	78,653
Holt	23,484
Linn	30,416
Livingston	47,758
Mercer	49,026
Nodaway	35,258
Ray	60,191
Worth	6,908

Ozark	3,664,652
Carter	271,829
Dent	307,823
Douglas	342,057
Howell	239,512
Oregon	277,486
Ozark	288,218
Phelps	278,219
Pulaski	256,068
Ripley	301,306
Shannon	495,695
Texas	453,676
Wright	152,763

Southeast	2,268,303
Bollinger	178,160
Butler	128,778
Cape Girardeau	99,101
Dunklin	25,138
Iron	273,133
Madison	209,396
Mississippi	27,658
New Madrid	29,462
Pemiscot	1,661
Perry	85,346
Reynolds	451,023
Scott	35,342
St. Francois	190,469
Ste. Genevieve	142,489
Stoddard	38,450
Wayne	352,700

Southwest	2,460,060
Barry	192,666
Barton	72,274
Cedar	98,371
Christian	161,912
Dade	51,961
Dallas	175,162
Greene	112,718
Hickory	139,970
Jasper	66,310
Laclede	258,061
Lawrence	88,585
McDonald	198,433
Newton	113,995
Polk	126,364
Stone	189,569
Taney	288,478
Webster	125,233

St. Louis	1,548,584
Crawford	280,256
Franklin	269,494
Jefferson	211,253
Lincoln	138,258
St. Charles	87,228
St. Louis	60,083
Warren	152,038
Washington	349,974

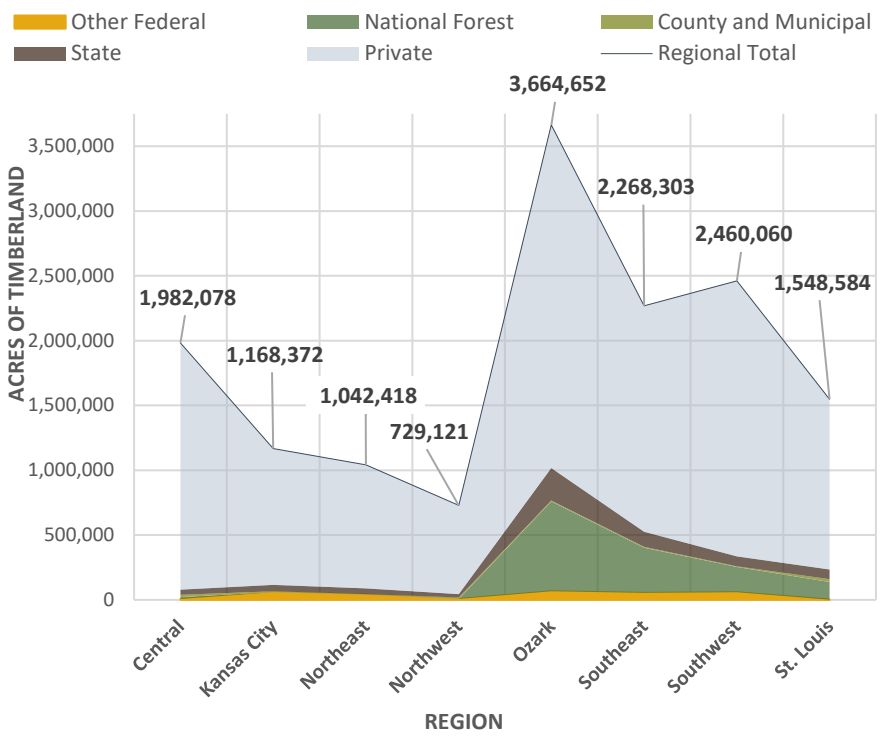
Acres of Timberland by Ownership

Ownership patterns influence forest management strategies, timber production, and conservation priorities. Understanding who owns Missouri's timberland is essential for identifying opportunities for sustainable management, private landowner engagement, and public land conservation.

As **Figure R5** shows, Missouri's timberland spans approximately 14.86 million acres, distributed among private, state, national forest, and other federal land holdings.

Figure R5: Regional Timberland Acreage Ownership by Forest Type Group

Acres of Timberland by Stand Type by Ownership by County – Area of timberland, in acres of Missouri, by Forest type group, by ownership, by county (USFS, 2019)



- **Private ownership** dominates Missouri's timberland, accounting for 10.48 million acres statewide. The largest private timberland holdings are in the Ozark (2.65 million acres), Southeast (1.74 million acres), and Southwest (2.12 million acres) regions, underscoring the pivotal role of private landowners in shaping the state's forestry economy.
- **National Forest** constitutes 1.37 million acres, with the highest concentration in the Ozark region (693,570 acres), reinforcing the importance of shortleaf pine markets to successful federal forest management, conservation, and timber production programs.
- **State** owned timberlands represent 651,242 acres, with the largest holdings in the Ozark (248,513 acres) and Southeast (115,033 acres) regions, further supporting the need for expanded shortleaf pine markets to facilitate management.
- **Other federal lands**, including lands managed by agencies such as the U.S. Fish and Wildlife Service and the Department of Defense, total approximately 232,889 acres statewide.

Implications for Forest Management

Missouri's predominantly private timberland ownership structure presents both challenges and opportunities for forest management. Given that over 70% of the state's timberland is privately owned, engaging private landowners in sustainable forestry initiatives is essential for maintaining long-term timber supply and ecosystem health. The regional distribution of timberland acreage when considered through the lens of ownership underscores the importance of private landowners, particularly in the southern regions, where the highest concentration of commercial timberland is located. Additionally, the distribution of public timberlands in key forestry regions highlights the role of state and federal agencies in supporting sustainable management practices and the feasibility of sustaining a shortleaf pine market in the state.

Acres of Timberland by Age Class and Forest Type Groups

Understanding timberland age class distributions is critical for evaluating forest structure, growth dynamics, and long-term sustainability. FIA defines stand age as: "A stand descriptor that indicates the average age of the live dominant and codominant trees in the predominant stand-size class of a condition." (USFS, 2023). Age class data helps determine stand composition and maturity, harvest cycles, and ecological succession.

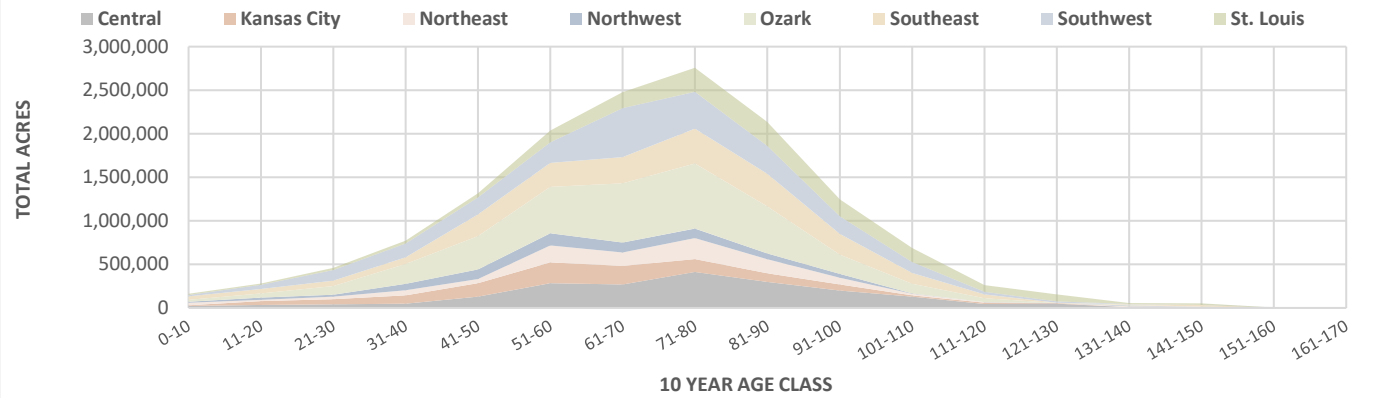
Two FIA-derived datasets were used to provide insight into Missouri's timberland age structure: **Regional Timberland Acreage by 10-Year Age Class** and **Regional Timberland Acreage by 50-Year Age Class and Forest Type Group.** FIA defines ***Forest Type*** as a classification determined by the predominant tree species that account for the greatest share of live-tree stocking, while ***Forest Type Groups*** aggregate similar forest types that share closely associated species or site requirements (USFS, 2023). By integrating these two data perspectives, it is easier to compare species-level and landscape-level data (volumes, geographic location, etc.).

Trends in Regional Timberland Age Class Distribution by 10-Year Age Class

Figure R6 illustrates the distribution of timberland acreage by 10-year age class across Missouri's regions, revealing a pronounced peak in the mid-age classes (61-80 years). Across the state, timberland is predominantly composed of older age classes, with limited regeneration in younger stands, indicating a potential decline in forest recruitment and early successional habitat. Only 13.9% of timberland (901,534 acres) is younger than 31 years, highlighting low recent regeneration rates. Age class patterns underscore the need for targeted forest management strategies to promote regeneration and ensure that merchantable timber volumes can sustain the demands of Missouri's forest product industry well into the future.

Figure R6: Regional Timberland Acreage by 10-Year Age Class

Acres of Timberland by 10-year Age Class – Area of timberland, in acres of Missouri, by Stand age 10 yr classes, by County (USFS, 2019)



Stand Age	Central	Kansas City	Northeast	Northwest	Ozark	Southeast	Southwest	St. Louis	Total
0-10 yrs	22,202	10,053	26,072	12,467	22,337	38,639	17,874	13,275	**162,920**
11-20 yrs	32,702	47,140	14,889	23,803	46,710	52,335	47,018	14,439	**279,038**
21-30 yrs	42,706	58,528	26,853	24,384	96,996	64,560	120,678	24,872	**459,576**
31-40 yrs	50,339	92,344	59,141	73,052	228,876	77,248	159,828	30,876	**771,705**
41-50 yrs	130,285	154,298	45,461	110,827	382,263	250,735	195,290	47,021	**1,316,180**
51-60 yrs	284,240	237,906	195,635	137,515	535,225	273,721	236,879	136,437	**2,037,558**
61-70 yrs	269,695	212,025	154,047	113,742	681,571	299,659	564,585	180,790	**2,476,114**
71-80 yrs	413,425	147,925	240,690	108,437	747,072	400,527	422,523	276,772	**2,757,371**
81-90 yrs	297,040	102,562	158,337	69,134	537,535	377,080	320,128	273,480	**2,135,295**
91-100 yrs	198,611	71,328	75,509	43,404	223,637	238,604	200,013	196,254	**1,247,359**
101-110 yrs	131,160	13,747	16,961	3,917	111,158	123,087	125,612	162,693	**688,336**
111-120 yrs	45,091	13,508	8,760	1,515	43,305	43,791	27,716	79,047	**262,734**
121-130 yrs	48,259	7,010	1,036			2,827	13,611	82,397	**155,140**
131-140 yrs	7,445		13,374	6,923	5,024	7,718	5,654	8,316	**54,454**
141-150 yrs	8,878		5,654		2,942	17,772		15,648	**50,893**
151-160 yrs								6,267	**6,267**
161-170 yrs							2,651		**2,651**
Total	**1,982,078**	**1,168,372**	**1,042,418**	**729,121**	**3,664,652**	**2,268,303**	**2,460,060**	**1,548,584**	**14,863,589**

Trends in Regional Timberland Age Class Distribution by 50-Year Age Class and Forest Type Group

Table R3 reviews the regional and statewide timberland acreage distribution by 50-year age class by forest type group, providing a broader perspective on the long-term structural and compositional dynamics of Missouri's timberland. This approach complements the finer-scale analysis of 10-year age classes reviewed above by highlighting key trends in stand maturity, forest succession, and forest type group-specific prevalence and longevity.

This analysis shows the prevalence of loblolly-shortleaf pine and key associated forest type groups of oak/hickory, oak/pine, and other Eastern softwood (SFTWD) as discussed in more detail in the "Shortleaf Pine Acreage and Ownership Distribution" section, but also reveals trends in forest composition, maturity, and age-related species diversity.

Table R3: Regional Timberland Acreage by 50-Year Age Class and Forest Type Group

50-Year Age Class by County and State – Area of timberland, in acres of Missouri, by Forest type group, by Stand age 50 yr classes, by County (USFS, 2019)

Stand Type and Age	Central	Kansas City	Northeast	Northwest	Ozark	Southeast	Southwest	St. Louis	Total
Elm/ash/cottonwood	**199,769**	**235,459**	**141,347**	**147,703**	**66,219**	**157,015**	**115,424**	**101,548**	**1,164,484**
0-50 years	56,240	105,089	10,362	50,796	21,252	89,146	43,684	27,776	**404,347**
51-100 years	135,424	123,633	130,985	95,392	44,967	67,868	70,127	72,151	**740,548**
101-150 years	8,104	6,737	-	1,515	-	-	1,613	1,621	**19,589**
Loblolly/shortleaf pine	-	-	-	-	**147,627**	**57,790**	**11,901**	**7,445**	**224,763**
0-50 years	-	-	-	-	31,713	16,367	-	2,951	**51,031**
51-100 years	-	-	-	-	110,766	36,122	9,251	3,313	**159,452**
101-150 years	-	-	-	-	5,148	5,301	-	1,180	**11,629**
151-170 years	-	-	-	-	-	-	2,651	-	**2,651**
Maple/beech/birch	**17,326**	-	-	**5,202**	**6,910**	**31,196**	**188**	**36,601**	**97,424**
0-50 years	-	-	-	-	-	6,540	188	-	**6,728**
51-100 years	10,316	-	-	5,202	3,405	20,857	-	36,601	**76,382**
101-150 years	7,010	-	-	-	3,505	3,799	-	-	**14,314**
Oak/gum/cypress	**1,637**	**37,576**	-	**9,953**	**11,067**	**40,444**	**52,340**	**7,445**	**160,462**
0-50 years	-	1,832	-	6,923	-	21,109	13,164	-	**43,028**
51-100 years	1,637	35,744	-	3,030	11,067	19,335	33,022	-	**103,834**
101-150 years	-	-	-	-	-	-	6,154	7,445	**13,599**
Oak/hickory	**1,587,488**	**846,428**	**841,321**	**526,261**	**3,119,964**	**1,753,311**	**1,901,555**	**1,225,455**	**11,801,783**
0-50 years	147,827	238,935	125,716	146,814	625,030	296,093	333,984	70,899	**1,985,298**
51-100 years	1,213,942	579,965	669,822	368,607	2,351,766	1,272,759	1,402,744	833,093	**8,692,697**
101-150 years	225,719	27,527	45,784	10,840	143,168	184,460	164,827	315,196	**1,117,521**
151-170 years	-	-	-	-	-	-	-	6,267	**6,267**
Oak/pine	**99,536**	**41,690**	**31,604**	**14,397**	**239,861**	**159,659**	**264,453**	**119,414**	**970,614**
0-50 years	32,214	10,237	13,846	14,397	45,142	15,326	94,706	10,357	**236,223**
51-100 years	67,322	31,453	17,758	-	184,111	142,699	169,747	86,398	**699,488**
101-150 years	-	-	-	-	10,609	1,635	-	22,659	**34,903**
Other Eastern SFTWD	**69,790**	**5,788**	**7,281**	**13,035**	**51,762**	**54,134**	**95,319**	**44,979**	**342,088**
0-50 years	35,421	4,838	7,281	13,035	32,804	24,183	36,082	15,149	**168,792**
51-100 years	34,370	950	-	-	18,959	29,951	59,237	29,831	**173,296**
Other hardwoods	-	-	**5,654**	**3,030**	-	-	**5,816**	-	**14,500**
0-50 years	-	-	-	3,030	-	-	5,816	-	**8,847**
51-100 years	-	-	5,654	-	-	-	-	-	**5,654**
Total	**1,982,078**	**1,168,372**	**1,042,418**	**729,121**	**3,664,652**	**2,268,303**	**2,460,060**	**1,548,584**	**14,863,589**

Regional Timberland Acreage Composition by All Forest Type Groups

The composition of stand types across Missouri's timberland is a critical factor in evaluating shortleaf pine availability, operability, and long-term forest management potential. Missouri's timberland encompasses a diverse mix of shortleaf pine, oak, and other softwood and hardwood species (USFS, 2023).

Figure R8 and Table R4 provide a breakdown of timberland acres by forest type group, detailing regional and county-level distributions. According to FIA data, timberland in Missouri is classified into multiple stand type groups based on species composition and stocking levels (USFS, 2019).

These classifications are essential for understanding shortleaf pine's distribution within mixed stands, as well as for assessing its role in Missouri's broader forest landscape. By analyzing acres of timberland by Forest Type Group as shown in **Table R4**, shortleaf pine can be evaluated on where it occurs most frequently, how it contributes to different stand structures, and what implications this has for resource availability and management strategies.

Figure R4: Regional Timberland Acreage Composition by Forest Type Group

Acres of Timberland by Stand Type Group – Area of timberland, in acres of Missouri by Forest type group, All live stocking by county (USFS, 2019)

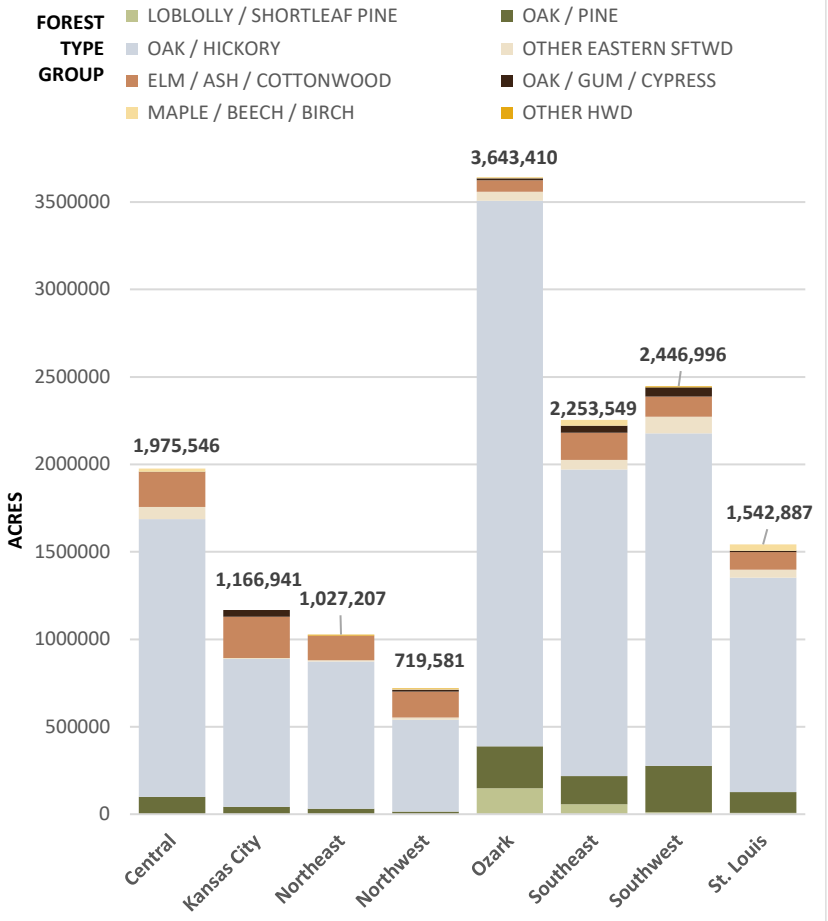


Table R4: Acres of Timberland by Region, County, and Forest Type Group

Acres of Timberland by Stand Type Group – Area of timberland, in acres of Missouri by Forest type group (USFS, 2019)

Region	Elm/ ash/ cottonwood	Loblolly/ shortleaf pine	Maple/ beech/ birch	Oak/ gum/ cypress	Oak/ hickory	Oak/ pine	Other eastern SFTWD	Other HWD	Total
Central	199,769	0	17,326	1,637	1,587,488	99,536	69,790	0	**1,982,078**
Kansas City	235,459	0	0	37,576	846,428	41,690	5,788	0	**1,168,372**
Northeast	141,347	0	0	0	841,321	31,604	7,281	5,654	**1,042,418**
Northwest	147,703	0	5,202	9,953	526,261	14,397	13,035	3,030	**729,121**
Ozark	66,219	147,627	6,910	11,067	3,119,964	239,861	51,762	0	**3,664,652**
Southeast	157,015	57,790	31,196	40,444	1,753,311	159,659	54,134	0	**2,268,303**
Southwest	115,424	11,901	188	52,340	1,901,555	264,453	95,319	5,816	**2,460,060**
St. Louis	101,548	7,445	36,601	7,445	1,225,455	119,414	44,979	0	**1,548,584**
Total	**1,164,484**	**224,763**	**97,423**	**160,462**	**11,801,783**	**970,614**	**342,088**	**14,500**	**14,863,588**

Note on Excluded Stand Types:

Exotic hardwood, exotic softwood, White/red/jack pine group, and nonstocked areas were not included in Table 3 due to their limited volumes across Missouri. The only county within the state with Hardwood Exotic Species was Pulaski County in the Ozark Region (2,984 acres). Callaway County in the Central Region (643 acres) was the only occurrence of Exotic Softwood. The White/red/jack pine group was identified in two locations: 512 acres in Perry County (Southeast) and 2,346 acres in Warren County (St. Louis). Nonstocked areas were excluded as they represent timberland with less than 10% stocking of all live trees (U.S. Forest Service, 2023), which typically include recently harvested, burned, or windthrow-damaged stands that have not yet regenerated to 10% threshold and are currently non-contributing to the immediate timber supply.

Basal Area per Acre of Shortleaf Pine and Associated Major Species Group Growing Stock

Understanding the basal area per acre of shortleaf pine and two key associated "major species groups" provides valuable insight into forest stocking levels, stand density, and timber productivity. The Forest Inventory and Analysis Glossary describes basal area as, "The cross-sectional area of a tree stem/bole (trunk) at the point where diameter is measured, inclusive of bark. Basal area is calculated for trees 1.0 inch and greater in diameter and is expressed in square feet. For timber species, the calculation is based on diameter at breast height (d.b.h.). When the basal areas of all trees in a stand are summed, the result is usually expressed as square feet of basal area per acre" (USFS, 2023).

The data in **Table R5** assesses the basal area of growing-stock trees (at least 5 inches d.b.h.) in square feet per acre across Missouri's timberland, categorized by other softwoods, pines, and shortleaf pine specifically. The mean basal area per acre is provided regionally for each associated species group.

Statewide and Regional Trends

- **Ozark Region:** Shortleaf pine basal area averages 6.7 ft² per acre, showing a strong presence in the region, with some counties like Carter (15.2 ft²) and Texas (15.5 ft²) contributing substantially to the region's total.
- **Southeast Region:** Reports a lower overall average shortleaf pine basal area (3.2 ft² per acre), with Butler (11.5 ft²) and Reynolds (9.4 ft²) reporting significantly higher values.
- **Southwest and St. Louis Regions:** These areas show a mixed distribution, with counties like Washington (10.1 ft²) maintaining a stronger presence, while others, such as Franklin (0.6 ft²), report minimal shortleaf pine stocking.

Implications for Forest Management

Basal area distribution highlights key shortleaf pine growing regions while also identifying areas requiring strategic management to sustain future timber availability. Ensuring balanced stocking levels through active management and regeneration efforts will be crucial for maintaining the long-term sustainability of Missouri's shortleaf pine forests. Research from Rogers (1983) provided specific models for achieving desired future conditions for shortleaf pine forests, emphasizing the need to align canopy closure and basal area with specific age classes to achieve silvicultural objectives. This study highlights the significant impact of age, density management, and thinning practices on shortleaf pine growth and product suitability.

Table R5: Basal Area of Growing Stock per Acre on Timberland by Region, County, and Associated Species Group

Basal area of growing-stock trees (at least 5 inches d.b.h.), in square feet, on timberland of Missouri, by Species group - Major Group, by All live stocking, by County // Area of timberland, in acres of Missouri, all live stocking by county Basal area divided by Acres of timberland (USFS, 2019)

	Other Softwoods	Pines	Shortleaf Pine
Ozark	**1.0**	**6.7**	**6.7**
Carter	0.0	15.2	15.2
Dent	0.5	6.6	6.6
Douglas	0.8	3.9	3.9
Howell	0.1	8.7	8.7
Oregon	0.4	6.4	6.4
Ozark	3.3	4.2	4.2
Phelps	1.5	1.2	1.2
Pulaski	2.2	0.3	0.3
Ripley	0.4	8.1	8.1
Shannon	0.3	10.3	10.3
Texas	1.7	15.5	15.5
Wright	1.1	0.1	0.1
Southeast	**1.1**	**4.7**	**3.2**
Bollinger	0.0	5.6	5.6
Butler	0.1	11.5	11.5
Iron	0.7	4.9	4.9
Madison	2.3	7.2	7.2
Perry	1.1	0.7	0.7
Reynolds	0.4	9.4	9.4
St. Francois	6.7	0.9	0.7
Ste. Genevieve	5.4	0.8	0.8
Stoddard	-	25.8	0.7
Wayne	0.6	9.2	9.2
Southwest	**2.6**	**0.6**	**0.6**
Barry	5.5	4.0	4.0
Christian	4.6	1.1	1.1
Laclede	1.3	3.2	3.2
McDonald	0.6	0.7	0.7
Taney	7.5	0.9	0.9
St. Louis	**3.0**	**1.7**	**1.4**
Crawford	1.1	0.2	0.2
Franklin	5.7	1.1	0.6
Washington	2.5	10.1	10.1

Shortleaf Pine and Associate Group Acreage

Acres of Short Leaf Pine and Associate Forest Type Groups

Shortleaf pine, while prominently found within the **loblolly/shortleaf pine forest type group**, may also be a significant component of other forest type groups, including **oak-hickory, oak-pine, and other eastern softwoods** (Lister, 2024, email communication). Understanding the distribution of these forest type groups is critical for assessing shortleaf pine availability and developing targeted management and market strategies.

Table R6 provides an expanded look at how these forest type groups are distributed across Missouri's timberland:

- **The Ozark region contains 3.56 million acres** of timberland across the four forest type groups, equating to **46.4%** of total acreage where shortleaf pine may occur. It is the largest contributor to Missouri's total shortleaf pine availability.

- **The Southeast has 1.92 million acres** across these four stand type groups, equating to **25%** of total acreage where shortleaf pine may occur. As such, this region remains a critical forestry area for shortleaf pine and mixed hardwood-pine forest management.

- **The Southwest region totals 1.07 million acres**, representing **13.9%** of the total acreage where shortleaf pine may occur.

- **The St. Louis region** encompasses **840,268 acres**, equating to **11%** of the total acreage where shortleaf pine may occur.

Figure 9 visualizes the data presented in **Table 6**, illustrating the county and regional distribution of shortleaf pine and associated forest type group acreage.

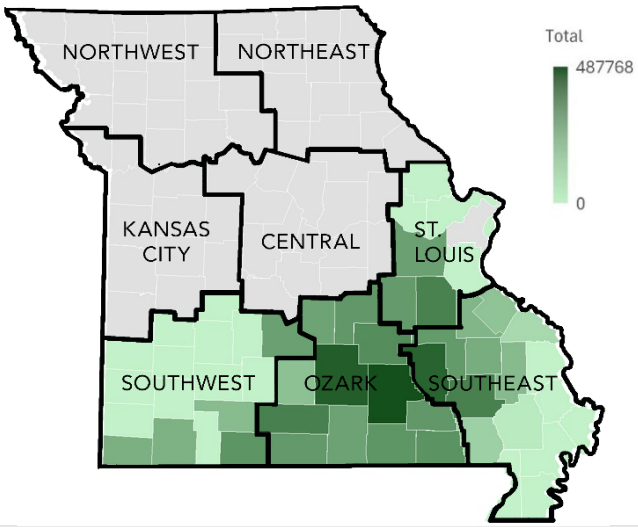
Table R6: Acres of Timberland by Forest Type Groups Which Contain Shortleaf Pine as Associates by Region and County

Acres of Timberland by Stand Type Group – 0003 Area of timberland, in acres of Missouri, by Forest type group, by County (USFS, 2019)

	Loblolly/ shortleaf pine	Oak/ hickory	Oak/ pine	Other E. SFTWD	Total Acres
Statewide	**224,763**	**6,327,338**	**673,319**	**161,328**	**7,386,748**
Ozark	**147,627**	**3,119,964**	**239,861**	**51,762**	**3,559,214**
Carter	26,924	211,912	29,303		**268,139**
Dent	13,448	266,249	17,646	7,050	**304,393**
Douglas	4,881	309,795	17,005	6,988	**338,669**
Howell	12,359	217,635	8,060		**238,054**
Oregon	7,471	251,370	16,686		**275,527**
Ozark		203,951	39,895	22,223	**266,069**
Phelps	2,942	240,977	18,574	5,684	**268,177**
Pulaski		226,687	6,890		**233,577**
Ripley	8,565	264,012	10,894		**283,471**
Shannon	31,800	424,396	31,572		**487,768**
Texas	39,236	373,655	33,306		**446,197**
Wright		129,323	10,031	9,817	**149,171**
Southeast	**57,790**	**1,646,399**	**159,659**	**54,134**	**1,917,982**
Bollinger	7,734	156,907	1,494		**166,135**
Butler	4,639	70,756	24,450		**99,845**
Iron	2,942	242,035	8,955	6,974	**260,906**
Madison	6,182	172,626	25,074	2,942	**206,824**
Perry		71,895		1,861	**73,756**
Reynolds	11,041	378,743	36,366	5,061	**431,211**
St. Francois	2,942	131,818	12,948	29,948	**177,656**
Ste. Genevieve		111,968	28,301	359	**140,628**
Stoddard	7,385	13,867			**21,252**
Wayne	14,926	295,784	22,071	6,988	**339,769**
Southwest	**11,901**	**857,050**	**164,580**	**35,752**	**1,069,283**
Barry	6,455	151,103	23,905	9,447	**190,910**
Christian		124,233	30,743	6,935	**161,911**
Laclede	5,447	219,934	13,556	3,245	**242,182**
McDonald		188,035	6,661	1,665	**196,361**
Taney		173,746	89,714	14,460	**277,920**
St. Louis	**7,445**	**703,925**	**109,218**	**19,680**	**840,268**
Crawford	669	251,307	3,297	5,106	**260,379**
Franklin		199,382	41,576	1,861	**242,819**
Washington	6,776	253,236	64,346	12,713	**337,071**

Figure R5: Distribution of Shortleaf Pine and Associate Forest Type Group Acres

Acres of Timberland by Stand Type Group – Area of timberland, in acres of Missouri, by Forest type group, by County (USFS, 2019)



Short Leaf Pine Forest Type Acreage

The following section reviews the acreage of shortleaf pine in Missouri. For FIA sourced data, forest type is defined as "a classification of forest land named for the tree species that forms the plurality of live tree stocking,". FIA reported species-specific acreage refers to the total timberland area where a designated tree species, such as shortleaf pine, is the predominant live species cover (USFS, 2023).

Regional Shortleaf Pine Acres by Ownership Type

Ownership distribution plays a critical role in shaping the management, accessibility, and market feasibility of Missouri's shortleaf pine forests. This section examines the total shortleaf pine acreage, which is exclusively located within the four primary assessment regions - Ozark, Southeast, Southwest, and St. Louis as demonstrated in **Figure 10**. Understanding ownership patterns is essential for evaluating resource availability, informing market engagement strategies, and guiding policy considerations that impact sustainable timber management.

A survey of private landowners by the MDOC showed that landowners are largely willing and able to plant and manage shortleaf pine seedlings and that they do not expect a financial gain from doing so within their lifetimes (Reitz & Gwaze, 2010).

As summarized by region in **Figure R10** and detailed in **Figure R11**, a total of **217,377 shortleaf pine acres** are distributed across National Forest, Private, and State ownership categories (USFS, 2019).

- **National Forest lands** hold the majority of shortleaf pine acreage (137,459 acres), representing 63.2% of Missouri's shortleaf pine acreage. This ownership is most significant in the Ozark (77,782 acres) and Southeast (40,330 acres) regions.

  National Forest System staff on the Mark Twain National Forest have identified shortleaf pine as a challenge to managing timberlands. Having shortleaf pine on a sale has been an impediment to selling timber sales and meeting silvicultural and harvest goals.

- **Private lands** account for 62,685 acres (28.8%) of Missouri's shortleaf pine acreage, with the Ozark region (54,541 acres) containing the largest privately held concentration.

- **State-owned lands** encompass 17,233 acres (7.9%) of Missouri's shortleaf pine acreage, with the highest distribution in the Ozark (15,304 acres) and Southeast (1,930 acres) regions.

Figure R6: Distribution of Shortleaf Pine Dominant Acres

Acres of Timberland by Forest Type – Area of timberland, in acres of Missouri, by Ownership all classes, by Forest type, by County (USFS, 2019)

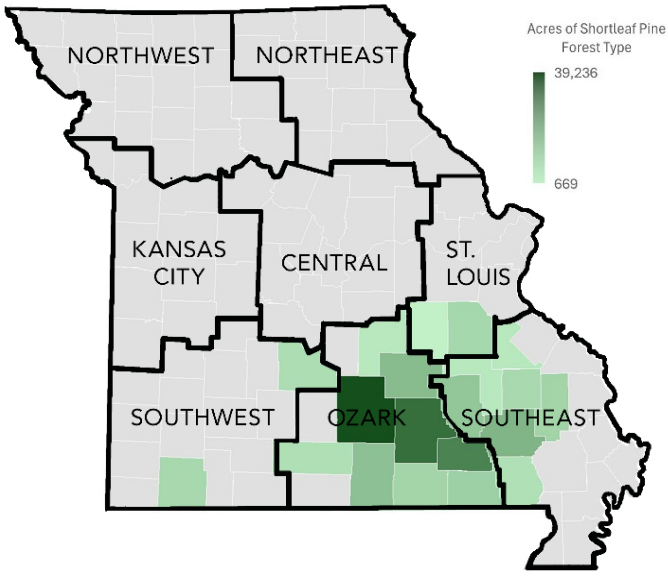
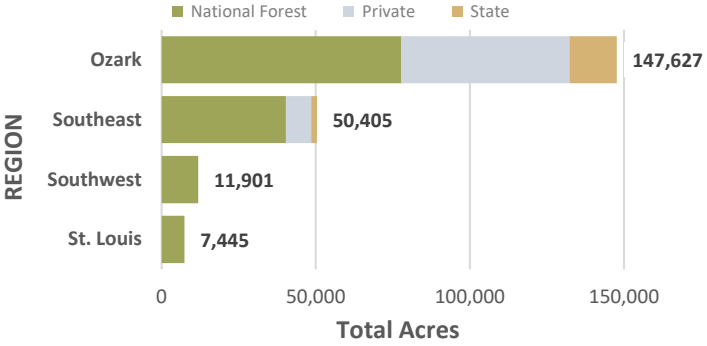


Figure R7: Regional Shortleaf Pine Acres by Ownership Type

Acres of Timberland by Forest Type – Area of timberland, in acres of Missouri, by Ownership all classes, by Forest type, by County (USFS, 2019)



Shortleaf Pine Overstory | L-A-D Foundation Randolph Tract
Photo Credit: Ross, H. (2024). Renewable Resource Solutions, LLC. [Unpublished photographs].

L-A-D Foundation Randolph Tract
Though this tract was cut in 1946, over 1,000 legacy seed trees were left scattered through the tract. A series of fortunate events led to the re-establishment of pure and mixed stands of shortleaf pine in its place. Pioneer has been taking care of these trees for decades and has focused on the area for a concentrated study of shortleaf pine regeneration and management (L-A-D Foundation, 2008).

Pioneer Forest Acreage Composition

Pioneer Forest is owned by the L-A-D Foundation, who is recognized for its longstanding commitment to sustainable forestry. While acreage by forest type is not reported, this privately owned 143,880-acre forest in the Missouri Ozarks represents a significant and unique forest management unit that warrants a distinct analysis when evaluating privately owned acreage with a shortleaf pine component.

The forest is primarily composed of oak and shortleaf pine. Since the early 1950s, Pioneer Forest has implemented uneven/single-tree selection harvesting to promote continual forest cover and natural regeneration. This method fosters structural diversity, enhances long-term forest health, and ensures a consistent supply of high-quality timber (L-A-D Foundation, n.d.). In 2009, the Pioneer Forest started utilizing prescribed fire management techniques as a means to reduce woody species encroachment, restore fire-adapted landscapes (including the natural regeneration of shortleaf pine), and enhance resilience to changing climatic conditions (L-A-D Foundation, 2023). Their Pine-Oak Woodland Ecological Management Area, including the Virgin Pine/Randolph Tract, stands as a microcosm for management that preserves mature trees while fostering shortleaf pine and associated woodland plant species regeneration (L-A-D Foundation, n.d.).

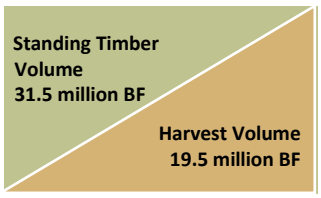
Though FIA data can provide a statewide perspective on acreage, ownership distribution, and species composition and volumes, analyzing Pioneer Forest separately is critical due to its well-documented management history. As one of Missouri's most extensively studied private forests, Pioneer Forest offers seven decades of data on growth rates, stand structure, and harvest impacts under a single-tree selection model. Unlike FIA data, which aggregates various ownership types, management strategies, and stand conditions, Pioneer Forest serves as a controlled case study for assessing how specific forest management practices can influence timber productivity, cover type, and ecological function over time in the state's most shortleaf pine-dense regions (L-A-D Foundation, 2023).

The 2022 Pioneer Forest Continuous Forest Inventory (CFI), completed in early 2023, marked its 15th inventory cycle. The CFI showed a standing volume of 6,560 per acre or 31.5 million board feet. The annual growth rate is reported as 219 board feet per area, approximately 3.2 million board feet across the forest. Importantly, current growth far exceeds harvest levels, as only 19.5 million board feet were harvested in FY23 (of which shortleaf pine accounted for 652,281 board feet, indicating a net-positive timber growth rate (L-A-D Foundation, 2023).

In terms of species composition, while red oak volume declined slightly and white oak volume increased, shortleaf pine volume remained stable at 29%, consistent in 2022 with the 2017 inventory (L-A-D Foundation, 2023). Although this represents a 3% decline from 32% in 2007, total shortleaf pine volume was only 10% of total forest volume in the 1957 inventory, reflecting significant long-term gains (L-A-D Foundation, 2008).

Shortleaf Pine Sapling from Prescribed Fire |L-A-D Foundation Randolph Tract
Photo Credit: Ross, H. (2024). Renewable Resource Solutions, LLC. [Unpublished photographs].

FY23 Pioneer Forest Volume & Harvest Rates
(L-A-D Foundation, 2023)



Forest Growth and Volume Trends

The CFI data from Pioneer Forest, which has been maintained since 1952, indicates a consistent increase in board foot volume per acre over time. Between 2002 and 2007, board foot volume per acre rose by 313 board feet, demonstrating sustained forest growth despite regional drought conditions (L-A-D Foundation, 2008). This trend has persisted, with sawlog volume per acre reaching 6,560 board feet in 2022, an increase of 746 board feet from 2017. The observed growth has been attributed to a combination of selective harvesting, natural regeneration, and favorable growing conditions (L-A-D Foundation, 2023).

By analyzing Pioneer Forest shortleaf pine volume trends, this study highlights how strategic management influences stand dynamics and timber sustainability. **As Table R7** illustrates, Pioneer Forest has experienced steady increases in timber volume across key stand cover types over the past decade, reinforcing the long-term viability of its single-tree selection management approach. The data shows a notable upward trend in the volume of red oak, white oak, and shortleaf pine - three of the dominant timber species in the region. Specifically, **shortleaf pine volume increased by 31% from 2012 to 2022** (Kuhn, 2024). These findings suggest that Pioneer Forest's management practices are not only sustaining timber resources but also actively enhancing productivity over time.

Table R7: Pioneer Forest Stand Cover Types and Volume

Cover type volume estimates for Pioneer Forest. [Unpublished report] (Kuhn, 2024)

Species	2012 bf/acre	2017 bf/acre	2022 bf/acre
Red Oak	1831	2,356	2,409
Shortleaf Pine	***1451***	***1,621***	***1,899***
White Oak	991	1,270	1,605
Hickory	178	221	263
Post Oak	81	102	115

Projected Trends and Considerations

Species Composition and Management Adjustments

Historically, Pioneer Forest was dominated by shortleaf pine and white oak, but past logging practices favored red oak, leading to changes in species composition (L-A-D Foundation, 2008). Over time, oak regeneration has declined, as shade-tolerant species such as maple, black gum, and dogwood have increased in abundance. This shift has negatively impacted the recruitment of white and red oak, as these shade-intolerant species struggle to establish in dense understory conditions (L-A-D Foundation, 2023). To address these challenges, forest managers have implemented targeted midstory thinning and canopy gap creation strategies, allowing more sunlight to reach the forest floor and improve oak regeneration potential (L-A-D Foundation, 2023). The Pioneer Forest will remain a forest to reference when looking to show how managing to improve species that have a strong market (oak) can strengthen and enhance the shortleaf pine forest type/volume potential as well.

Ecological Management Plan

In response to ongoing forest health concerns, the first-ever Ecological Management Plan for Pioneer Forest was completed in 2023. This plan identifies priority resource areas and management strategies aimed at improving biodiversity, habitat quality, and forest resilience. One of the key components of this plan is a natural features inventory, which will guide future conservation efforts by identifying ecologically significant areas requiring specialized management. Additionally, the plan emphasizes the use of prescribed fire as a tool for maintaining shortleaf pine ecosystems, reducing competition from encroaching hardwood species, and enhancing overall forest structure (L-A-D Foundation, 2023).

SHORTLEAF PINE RESOURCES

This Shortleaf Pine Resources section focuses on species-specific data reported in FIA dataset.

Key Definitions of This Section

Forest Inventory and Analysis Glossary of Terms (U.S. Forest Service, 2023)

RESOURCE DEFINITIONS

Gross Stump Wood	The volume of wood in the stump portion of a tree, from the ground level up to the merchantable bole height. Represents the residual wood volume left after harvest.
Growing Stock	All live trees of commercial species that meet min. merchantability standards. These trees must have at least one solid 8-foot section, be reasonably free of form defect, and a min. of 34% merchantable volume
Merchantable Bole	The portion of a tree from a 1-foot stump to a 4" top diameter outside bark, meeting merchantability standards. Excludes branches and non-merchantable upper portions.
Sawlog	A log meeting min. standard for diameter, length, and defect, including being at least 8 feet long, sound and straight, and with a min. diameter inside bark of 6" for softwoods and 8" for hardwoods
Sawtimber Sawlog Wood	The portion of live sawtimber trees that includes the part of the bole between a 1-foot stump and sawlog top, defined as the point where the diameter outside bark is 7" for softwoods and 9" for hardwoods
Seedlings	Live trees smaller than 1.0" d.b.h./d.r.c., with a height of at least 6" for softwoods and 12" for hardwoods
Standing Dead Trees	A tree at least 1" d.b.h., have an unbroken bole of at least 4.5 feet, and lean less than 45 degrees from vertical
Stem-Top Wood	The wood of a tree above the merchantable height (or above the point on the stem 4" diameter outside bark.

MEASUREMENT AND CLASSIFICATION DEFINITIONS

Diameter Class	A metric that categorizes trees based on their d.b.h. into classes of a specified range. Diameter classes commonly begin and continue in 2" increments. Each class represents and is named after the approx. mid-point (e.g. 6-" class = trees 5 through 6.9" in diameter).
Number of Trees	The total count (number) of trees within a specified category, offering a quantitative measure of forest composition and dynamics. Tree counts are based on field measurements collected from systematically located sample plots, which represent specific areas of forest. FIA extrapolates these counts to larger areas using expansion factors and stratified sampling techniques, ensuring estimates reflect forest diversity and conditions accurately (U.S. Forest Service, 2018).

Identifying Zero Values

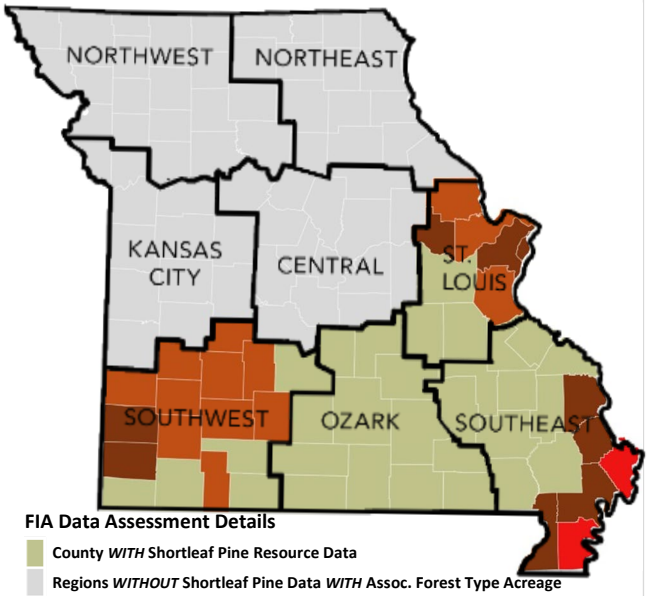
Due to the species-specific nature of these tables and charts, the regions and counties identified in **Figure R12** that had ***no reported shortleaf pine data across all species-specific datasets*** ("zero values") and as such do not appear in the data tables or charts within the "Shortleaf Pine Resources" section.

While the lack of species-specific data is notable, it does not necessarily indicate an absence of shortleaf pine resources. FIA estimation methodologies (i.e. sampling intensity adjustments, stratification processes, reporting thresholds, etc.) can influence data representation. Counties lacking sufficient sample representation due to low sampling rates or estimation adjustments and plots classified as inaccessible, outside boundaries, or without measurable resources are often excluded from FIA datasets. Also, shortleaf pine volumes or characteristics below measurable thresholds are not reported, even if the resource exists (USDA Forest Service, 2018).

It is therefore critical to consider additional factors, such as the cover type acreage of key shortleaf pine associate forest type groups: oak/hickory, oak/pine, and other Eastern softwood. Figure 10 takes this variable into consideration. The following provide some additional details on the findings when reviewing the FIA Data Forest Cover Type data:

Figure R8: Shortleaf Pine Resources Assessment Area

Number of Shortleaf Pine by Ownership Categories All Classes by County – Number of growing-stock trees (at least 5 inches d.b.h.), in trees, on timberland of Missouri, by Ownership all classes, by Species, by County (USFS, 2019)



COUNTIES IN SOUTHERN REGIONS ***WITHOUT*** MEASURABLE SHORTLEAF PINE PRESENCE OR REPORTED TOTALS BY REGION

Southeast	Southwest	St. Louis
Cape Girardeau	Barton	Jefferson
Dunklin	Cedar	Lincoln
Mississippi	Dade	St. Charles
New Madrid	Dallas	St. Louis
Pemiscot	Greene	Warren
Scott	Hickory	
	Jasper	
	Lawrence	
	Newton	
	Polk	
	Stone	
	Webster	

Counties *WITH* Shortleaf Pine Resource Data

All 61 counties within Missouri's northern regions - Central, Kansas City, Northeast, and Northwest - did not have any reported resource data in shortleaf pine-specific FIA datasets; however, FIA reports all have acreage of oak/hickory associated cover type.

Regions *WITHOUT* Shortleaf Pine Resource Data but *WITH* Associate Forest Type Acreage

All 61 counties within Missouri's northern regions - Central, Kansas City, Northeast, and Northwest - did not have any reported resource data in shortleaf pine-specific FIA datasets; however, FIA reports all have acreage of oak/hickory associated cover type. NOTE: 28 of the 61 counties in the northern regions also showed acreage of at least one additional associated forest type group.

County *WITHOUT* Shortleaf Pine Data but *MULTIPLE* Associate Forest Type Acreage

23 of the 53 counties within Missouri's southern regions (located in the Southeast, Southwest, and St. Louis region) did not have any reported resource data in shortleaf pine-specific FIA datasets; however, FIA reports they ***did*** have acreage of oak/hickory ***and*** acreage of at least one additional associate forest type group.

County *WITHOUT* Shortleaf Pine Data but *ONLY* Oak/Hickory Acreage

8 of the 53 counties within Missouri's southern regions (located in the Southeast, Southwest, and St. Louis region) did not have any reported resource data in shortleaf pine-specific FIA datasets. When reviewing acreage of associate forest type groups, these counties ***only*** had acreage in the oak/hickory associate forest type.

County *WITHOUT* Shortleaf Pine Data *OR* Associate Forest Type Acreage

2 counties within Missouri's southern regions (**Mississippi and Pemiscot** in the St. Louis region) did not have any reported resource data in shortleaf pine-specific FIA datasets ***or*** acreage in any associate forest type.

Number of Shortleaf Pine

The number of shortleaf pine trees across Missouri's timberland provides critical insights into the species' distribution, regeneration trends, and resource availability.

Tracking shortleaf pine counts by ownership and tree classification - including growing stock, standing dead, and seedlings - helps assess regeneration success, mortality rates, and timber supply. This data enables forest managers and stakeholders to evaluate sustainability, identify market opportunities, and guide targeted management strategies.

In all datasets reviewing the number of shortleaf pine, the following counties consistently showed as a "zero" valuation. As such, they are excluded from table data withing this subsection.

Number of Shortleaf Pine by Ownership

Table R8 presents the number of shortleaf pine trees on timberland across Missouri, segmented by ownership categories: National Forest, Private, and State.

Shortleaf pine distribution across Missouri varies significantly by ownership, with public and private lands playing critical roles in sustaining the resource.

- **National Forests** have the largest share of shortleaf pine, with 35.5 million trees (49.7% of the statewide total).
- **Private lands** hold 31.2 million trees (43. 6%).
- **State lands** account for 4.7 million trees (6.7%).

The well-known regional variation in resource distribution is demonstrated in the fill map below Table 8, with a clear shortleaf pine concentration spanning across the Ozark (41.9 million trees) and Southeast (20.7 million trees) regions. Upon review of data, it was noted that the **Ozark and Southeast regions contain nearly 90% of all shortleaf pine trees statewide** (62.6 million trees). When evaluating the data of the two-region area as a collective, the prevalence of National Forest and Private lands and their nearly 50/50 split of the resource in this area becomes clear:

- **National Forests**: 30 million trees (48%)
- **Private lands**: 28.6 million trees (45%)

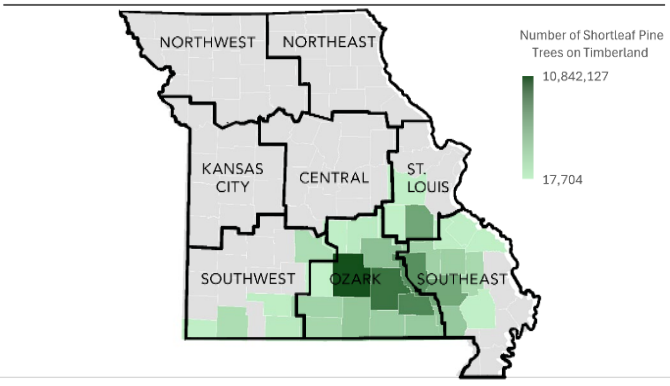
This distribution highlights the potential for coordinated management and necessity of collective industry efforts across both ownership types to ensure the long-term sustainability of Missouri's shortleaf pine resource.

Table R8: Number of Shortleaf Pine by Ownership, Region, and County

Number of Shortleaf Pine by Ownership Categories All Classes by County – Number of growing-stock trees (at least 5 inches d.b.h.), in trees, on timberland of Missouri, by Ownership all classes, by Species, by County (USFS, 2019)

Region	National Forest	Private	State	Total
Total	**35,564,743**	**31,233,798**	**4,762,288**	**71,560,830**
Ozark	**20,256,034**	**18,482,704**	**3,178,358**	**41,917,096**
Carter	3,574,995	2,848,770	680,798	**7,104,563**
Dent	1,999,775	1,297,093		**3,296,868**
Douglas	1,098,718	867,657		**1,966,376**
Howell	1,979,555	885,901		**2,865,456**
Oregon	1,951,760	463,366		**2,415,126**
Ozark	519,208	1,166,951		**1,686,159**
Phelps	483,436			**483,436**
Pulaski	138,125			**138,125**
Ripley	1,624,022	1,022,817		**2,646,839**
Shannon	3,602,260	2,354,498	2,497,560	**8,454,318**
Texas	3,266,478	7,575,650		**10,842,127**
Wright	17,704			**17,704**
Southeast	**9,713,398**	**10,119,920**	**908,349**	**20,741,667**
Bollinger		1,646,534		**1,646,534**
Butler	1,531,161	1,143,584		**2,674,745**
Iron	805,285	1,327,494		**2,132,779**
Madison	1,111,422	1,151,597		**2,263,019**
Perry		117,028		**117,028**
Reynolds	2,578,641	3,091,226	882,518	**6,552,385**
St. Francois	194,739			**194,739**
Ste. Genevieve		128,619		**128,619**
Stoddard		88,890		**88,890**
Wayne	3,492,150	1,424,947	25,831	**4,942,928**
Southwest	**2,759,717**	**204,720**	**675,581**	**3,640,018**
Barry	1,320,943			**1,320,943**
Christian	79,757	169,163		**248,920**
Laclede	1,359,016			**1,359,016**
McDonald		35,557	106,671	**142,228**
Taney			568,911	**568,911**
St. Louis	**2,835,594**	**2,426,455**		**5,262,049**
Crawford	61,930			**61,930**
Franklin		119,918		**119,918**
Washington	2,773,665	2,306,537		**5,080,202**

Distribution of Number of Shortleaf Pine Trees on Timberland



Number of Shortleaf Pine by Type, Region, and County

Table R9 illustrates the number of shortleaf pine trees in Missouri's timberlands, categorized into three tree classifications: growing stock, standing dead, and seedlings. Statewide totals indicate that Missouri's shortleaf pine resource includes 71.5 million growing stock trees, 5.3 million standing dead trees, and 376.6 million seedlings.

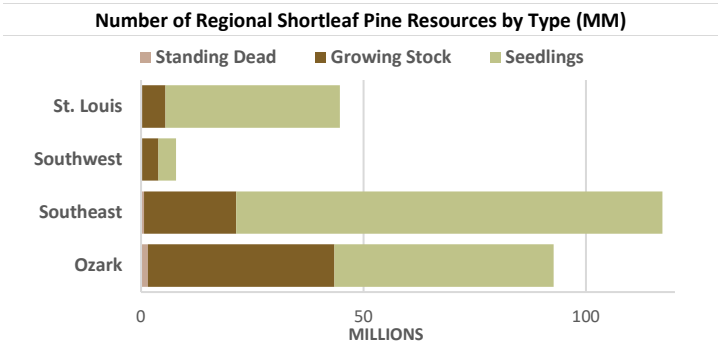
- The **Ozark region** contains the highest number of growing stock trees (41.9 million), representing 58.6% of the statewide total, with 49.2 million seedlings (13.1%).
- While the **Southeast region** only has 20.7 million growing stock trees (29.0%), it leads in seedling density with 95.7 million trees (25.4%), indicating regeneration potential.
- The **Southwest and St. Louis regions** collectively contain 8.9 million growing stock trees (12.4%), with lower seedling counts relative to the Ozark and Southeast regions.
- The statewide ratio of seedlings to growing stock trees is approximately 5.3:1, reinforcing the importance of seedling survival to ensure sustained resource availability.

The data highlights Missouri's robust shortleaf pine resource, particularly in the Ozark and Southeast regions, reflecting strong availability and regeneration potential. Counties such as Shannon and Texas in the Ozark region, with substantial growing stock and seedling counts, stand out as critical hubs for both current resource availability and future growth.

Table R9: Number of Shortleaf Pine by Type, Region, and County

Number of growing-stock trees / Number of standing dead trees (at least 5 inches d.b.h.), in trees, on timberland of Missouri, by Species, by All live stocking, by County; 0046 Number of live seedlings (less than 1 inch d.b.h./d.r.c.), in seedlings, on timberland of Missouri, by Species (seedling), by All live stocking, by County (USFS, 2019)

Region	Growing Stock	Standing Dead	Seedlings
Total	**71,560,830**	**5,292,351**	**376,577,415**
Ozark	**41,917,096**	**1,552,666**	**49,276,011**
Carter	7,104,563	197,104	12,571,877
Dent	3,296,868	125,157	2,030,328
Douglas	1,966,376	79,757	2,738,678
Howell	2,865,456	99,213	1,698,757
Oregon	2,415,126	56,921	1,123,839
Ozark	1,686,159		17,496,346
Phelps	483,436	35,407	
Pulaski	138,125		
Ripley	2,646,839	133,298	1,015,344
Shannon	8,454,318	346,721	8,528,796
Texas	10,842,127	479,086	2,072,045
Wright	17,704		
Southeast	**20,741,667**	**650,279**	**95,761,647**
Bollinger	1,646,534	40,613	2,023,611
Butler	2,674,745	63,806	4,932,245
Iron	2,132,779	33,186	10,061,295
Madison	2,263,019	223,143	30,340,770
Perry	117,028		
Reynolds	6,552,385	98,929	12,396,727
St. Francois	194,739	17,704	11,246,984
Ste. Genevieve	128,619	15,951	1,589,630
Stoddard	88,890		
Wayne	4,942,928	156,947	23,170,385
Southwest	**3,640,018**	**237,787**	**4,010,317**
Barry	1,320,943	35,407	
Christian	248,920	15,951	198,704
Laclede	1,359,016	79,757	3,811,613
McDonald	142,228		
Taney	568,911	106,671	
St. Louis	**5,262,049**	**205,444**	**39,240,732**
Crawford	61,930		
Franklin	119,918		
Washington	5,080,202	205,444	39,240,732



The Southeast region, led by counties like Madison and Reynolds, appear to demonstrate strong regeneration success with high seedling numbers. In contrast, the Southwest and St. Louis regions exhibit limited overall resource availability, with Washington County as a significant outlier, containing most of the St. Louis region's growing stock and all of its seedlings.

The number of standing dead trees in counties like Washington (St. Louis) and Shannon (Ozark) may represent potential forest health challenges in those regions. Additionally, counties like Pulaski (Ozark) and Barry (Southwest) with low seedling to growing stock ratios may show localized regeneration gaps.

Shortleaf Pine Growing Stock

Number of Shortleaf Pine Growing Stock by 2" Size Class

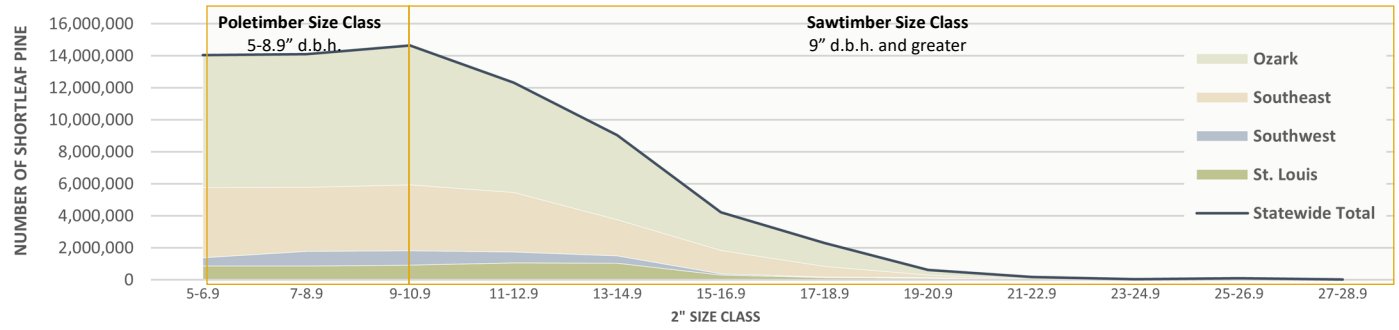
Reviewing the distribution of shortleaf pine growing stock across Missouri's timberland by 2" Size Class provides insight into forest structure, growth trends, and future timber supply. This data is critical for understanding merchantable timber distribution and potential sawtimber availability.

Figure R13 demonstrates that of the 71.6 million shortleaf pine trees in Missouri, nearly 77% (55 million trees) fall within the 5.0-12.9-inch range. When looking at this range from a regional perspective, this range accounts for 76.8% (32.2 million trees) of the 41.9 million trees in the Ozark region and 84.8% (17.6 million trees) of the 20.7 million trees in the Southeast Region.

Shortleaf pine reaches merchantable sawtimber size at 9" d.b.h., so it is reasonable to speculate that the apex within Figure 10 - and the gradual decline from 9 to 15 inches - is largely driven by selective harvesting, while the decline from 15 inches upward is more likely due to growth limitations, competition, and natural mortality factors.

Figure R9: Number of Shortleaf Pine Growing Stock Trees by 2" Size Class by County

Number of growing-stock trees (at least 5 inches d.b.h.), in trees, on timberland of Missouri, by Diameter class: 2-inch class to 41, by Species, by County (USFS, 2019)



	5-6.9	7-8.9	9-10.9	11-12.9	13-14.9	15-16.9	17-18.9	19-20.9	21-22.9	23-24.9	25-26.9	27-28.9	Total
Total	**14,028,331**	**14,096,486**	**14,638,247**	**12,324,058**	**9,042,174**	**4,223,197**	**2,285,264**	**609,042**	**176,536**	**33,655**	**86,135**	**17,704**	**71,560,830**
Ozark	**8,281,183**	**8,318,732**	**8,711,261**	**6,874,861**	**5,287,162**	**2,382,334**	**1,460,283**	**322,283**	**141,504**	**33,655**	**86,135**	**17,704**	**41,917,096**
Carter	1,566,535	2,003,562	1,439,286	864,280	657,344	359,285	120,370	31,903	15,951		46,047		7,104,563
Dent	692,121	744,340	738,989	372,557	468,207	116,542	132,209	31,903					3,296,868
Douglas	622,059	351,494	294,121	226,172	207,369	97,461	95,709	15,951		15,951	40,088		1,966,376
Howell	492,276	409,447	541,611	566,180	496,248	226,825	83,262	31,903	17,704				2,865,456
Oregon	507,928	379,402	378,399	336,499	399,627	282,406	76,377	54,488					2,415,126
Ozark	258,230	410,429	298,351	215,972	219,476	96,127	171,622	15,951					1,686,159
Phelps	100,965	51,359	155,828	86,766		17,704	70,814						483,436
Pulaski	35,407		35,407	35,407	15,951	15,951							138,125
Ripley	311,071	310,283	413,788	461,285	439,698	353,970	216,560	90,576	49,607				2,646,839
Shannon	1,977,878	1,748,093	1,785,335	1,396,681	853,315	341,003	282,951	17,704	15,951	17,704		17,704	8,454,318
Texas	1,716,714	1,910,323	2,630,146	2,295,358	1,529,926	475,059	210,408	31,903	42,291				10,842,127
Wright				17,704									17,704
Southeast	4,377,200	**4,011,624**	**4,110,191**	**3,708,052**	**2,259,245**	**1,458,776**	**648,355**	**152,273**	**15,951**				**20,741,667**
Bollinger	267,225	254,545	408,988	501,845	213,932								1,646,534
Butler	853,106	453,723	592,300	371,857	147,068	152,273	31,903	72,516					2,674,745
Iron	531,787	475,464	362,578	199,945	329,382	76,020	157,602						2,132,779
Madison	299,107	454,153	405,571	510,035	299,797	276,651	17,704						2,263,019
Perry	39,009		39,009	39,009									117,028
Reynolds	1,550,032	1,174,318	1,192,057	1,025,293	705,009	664,523	241,153						6,552,385
St. Francois			106,222	53,111	35,407								194,739
Ste. Genevieve		44,805		44,805			39,009						128,619
Stoddard		88,890											88,890
Wayne	836,933	1,065,726	1,003,466	962,152	528,650	289,309	160,983	79,757	15,951				4,942,928
Southwest	510,382	**920,090**	**893,484**	**687,443**	**464,005**	**86,766**	**42,291**	**35,557**					**3,640,018**
Barry	246,098	350,568	210,691	240,842	219,634	53,111							1,320,943
Christian	63,806	58,242		42,291	42,291		42,291						248,920
Laclede	129,364	226,825	505,009	297,639	166,523	33,655							1,359,016
McDonald	35,557			71,114				35,557					142,228
Taney	35,557	284,455	177,785	35,557	35,557								568,911
St. Louis	859,567	**846,039**	**923,311**	**1,053,702**	**1,031,761**	**295,322**	**134,336**	**98,929**	**19,081**				**5,262,049**
Crawford			15,482	30,965	15,482								61,930
Franklin					39,973	79,945							119,918
Washington	859,567	846,039	907,829	1,022,737	976,307	215,377	134,336	98,929	19,081				5,080,202

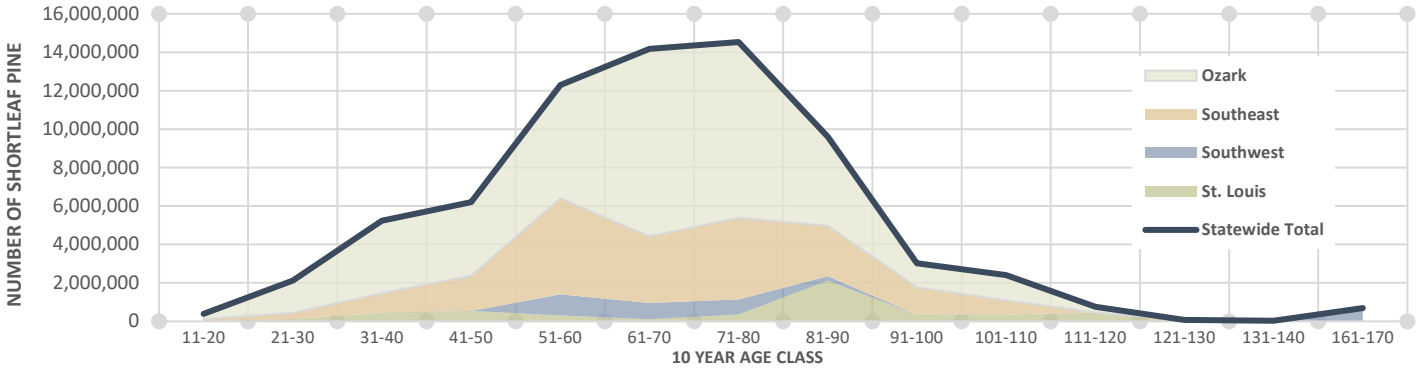
Number of Shortleaf Pine Growing Stock by 10-Year Age Class, Region, and County

Reviewing the distribution of shortleaf pine growing stock by 10-year age class provides critical insights into forest recruitment, stand dynamics, and long-term resource sustainability. Understanding how shortleaf pine trees are distributed across age classes helps inform management strategies and provides an additional means of understanding current resource data and provide context for evaluating resource potential.

As demonstrated in **Figure R14**, shortleaf pine growing stock in Missouri follows a distinct age-class distribution pattern, with notable concentrations in younger and middle-aged stands. Nearly 39% of all shortleaf pine in the state (27.3 million trees) are between 51 and 80-years old, reflecting the well-established merchantable size as detailed in the review of Growing Stock Trees by 2" Size Class. Trees up to 40-years old account for approximately 19% (7.7 million trees) and are an indication of regional stand regeneration success rates.

Figure R10: Number of Shortleaf Pine Growing Stock Trees by 10-Year Age Class, Region, and County

Number of growing-stock trees (at least 5 inches d.b.h.), in trees, on timberland of Missouri, by Stand age 10 yr classes, by Species, by County (USFS, 2019)



	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	101-110	111-120	121-130	131-140	161-170	Total
Total	**388,266**	**2,124,208**	**5,232,752**	**6,210,400**	**12,304,782**	**14,177,598**	**14,534,242**	**9,607,836**	**3,023,454**	**2,406,995**	**756,459**	**76,020**	**31,903**	**685,914**	**71,560,830**
Ozark	**284,266**	**1,690,382**	**3,779,938**	**3,834,291**	**5,904,075**	**9,749,660**	**9,155,082**	**4,632,881**	**1,254,897**	**1,307,708**	**292,015**		**31,903**		**41,917,096**
Carter	30,522	88,518	920,586	661,654	1,820,421	2,257,204	862,365	17,704	40,613	404,977					7,104,563
Dent		462,593	237,338	88,518		78,711	623,550	1,533,413	272,745						3,296,868
Douglas	253,744	53,111	395,845	175,885	303,496	377,051	251,541	113,413	42,291						1,966,376
Howell			845,813	574,254	167,700	870,141	255,224	67,310	53,111				31,903		2,865,456
Oregon			70,814		381,617	781,623	469,210	414,739	175,284	121,838					2,415,126
Ozark					423,342	649,747	400,878	148,387		63,806					1,686,159
Phelps						47,854			63,806	371,775					483,436
Pulaski									31,903		106,222				138,125
Ripley				53,111	161,697	803,724	530,705	394,918	357,373	345,311					2,646,839
Shannon		1,086,159	1,256,431	1,442,370	86,660	1,007,504	1,938,586	1,410,201	40,613		185,793				8,454,318
Texas			53,111	838,499	2,559,142	2,876,100	3,805,320	532,797	177,159						10,842,127
Wright							17,704								17,704
Southeast	**104,000**	**309,902**	**997,012**	**1,838,182**	**4,995,603**	**3,469,279**	**4,230,350**	**2,623,247**	**1,428,877**	**745,216**					**20,741,667**
Bollinger				84,849	871,268	527,966				162,451					1,646,534
Butler					737,457	1,076,090	350,750	223,321	287,127						2,674,745
Iron	88,518		35,407	262,757	127,274	300,445	629,696	203,064	385,975	99,643					2,132,779
Madison		106,222	19,081	58,673	350,933	462,593	869,038	203,064	193,416						2,263,019
Perry								117,028							117,028
Reynolds	15,482	19,081	942,524	1,015,338	574,013	843,094	2,067,721	621,099	436,329	17,704					6,552,385
St. Francois					194,739										194,739
Ste. Genevieve						39,009		44,805	44,805						128,619
Stoddard		88,890													88,890
Wayne		95,709		416,564	2,139,919	220,080	313,145	1,210,867	81,225	465,418					4,942,928
Southwest					**1,097,622**	**847,232**	**785,928**	**223,321**						**685,914**	**3,640,018**
Barry					1,097,622			223,321							1,320,943
Christian						31,903	217,017								248,920
Laclede						673,102								685,914	1,359,016
McDonald						142,228									142,228
Taney							568,911								568,911
St. Louis		**123,925**	**455,802**	**537,928**	**307,482**	**111,427**	**362,882**	**2,128,386**	**339,681**	**354,072**	**464,444**	**76,020**			**5,262,049**
Crawford			61,930												61,930
Franklin							79,945	39,973							119,918
Washington		123,925	393,872	537,928	307,482	111,427	282,937	2,088,414	339,681	354,072	464,444	76,020			5,080,202

Number of Shortleaf Pine Growing Stock by 30-Year Age Class Intervals, Region, and County

The rotation age for shortleaf pine in Missouri varies based on management objectives and site conditions. For instance, Rogers and Sander (1985) examined intermediate thinning in a Missouri shortleaf pine stand over a 30-year period, providing insights into growth rates, thinning practices, and management strategies to optimize timber production. Their findings emphasized the importance of maintaining stand densities through periodic thinning, particularly at 10-15-year intervals, to sustain growth and minimize competition (Rogers & Sander, 1985).

Understanding Growth Rate and Age for Shortleaf Pine

Pulpwood and Young Stands	**11-30 Years**	During this stage, trees exhibit rapid height growth but are generally too small for sawtimber. Thinning in this cohort focuses on promoting robust growth and preparing stands for future sawtimber production (Rogers, 1983).
Sawtimber Transition	**31-50 Years**	Trees in this range begin producing higher-quality wood suitable for sawtimber, making thinning practices vital to encourage uniformity and minimize defects (Rogers & Sander, 1985). These intermediate age classes bridge pulpwood and sawtimber production.
Mature Sawtimber	**51-80 Years**	Optimal sawtimber production occurs in these age classes. Managing basal area progressively higher during thinning will utilize growing space and maximize yield (Rogers, 1983).
Over-Mature Stands	**81+ Years**	Potentially still valuable for sawtimber, these older trees are at risk of volume loss. Harvests should focus on regeneration and transition to younger cohorts (Rogers & Sander, 1985).

Table R10: Number of Shortleaf Pine Growing Stock by 30-Year Age Class Intervals, Region, and County

Number of growing-stock trees on timberland of Missouri, by Species (seedling), by All live stocking, by County (USFS, 2019)

	0-30 YRS	31-60 YRS	61-90 YRS	91-120 YRS	121-170 YRS	TOTAL
Total	**2,512,474**	**23,747,934**	**38,319,676**	**6,186,908**	**793,837**	**71,560,830**
Ozark	**1,974,647**	**13,518,303**	**23,537,623**	**2,854,619**	**31,903**	**41,917,096**
Carter	119,040	3,402,662	3,137,272	445,590	0	7,104,563
Dent	462,593	325,856	2,235,674	272,745	0	3,296,868
Douglas	306,855	875,226	742,005	42,291	0	1,966,376
Howell	0	1,587,767	1,192,675	53,111	31,903	2,865,456
Oregon	0	452,431	1,665,572	297,122	0	2,415,126
Ozark	0	423,342	1,199,012	63,806	0	1,686,159
Phelps	0	0	47,854	435,581	0	483,436
Pulaski	0	0	0	138,125	0	138,125
Ripley	0	214,808	1,729,347	702,684	0	2,646,839
Shannon	1,086,159	2,785,461	4,356,292	226,406	0	8,454,318
Texas	0	3,450,752	7,214,217	177,159	0	10,842,127
Wright	0	0	17,704	0	0	17,704
Southeast	**413,902**	**7,830,797**	**10,322,876**	**2,174,092**	**0**	**20,741,667**
Bollinger	0	956,117	527,966	162,451	0	1,646,534
Butler	0	737,457	1,650,161	287,127	0	2,674,745
Iron	88,518	425,438	1,133,205	485,618	0	2,132,779
Madison	106,222	428,687	1,534,695	193,416	0	2,263,019
Perry	0	0	117,028	0	0	117,028
Reynolds	34,563	2,531,875	3,531,914	454,033	0	6,552,385
St. Francois	0	194,739	0	0	0	194,739
Ste. Genevieve	0	0	83,814	44,805	0	128,619
Stoddard	88,890	0	0	0	0	88,890
Wayne	95,709	2,556,483	1,744,093	546,644	0	4,942,928
Southwest	**0**	**1,097,622**	**1,856,481**	**0**	**685,914**	**3,640,018**
Barry	0	1,097,622	223,321	0	0	1,320,943
Christian	0	0	248,920	0	0	248,920
Laclede	0	0	673,102	0	685,914	1,359,016
McDonald	0	0	142,228	0	0	142,228
Taney	0	0	568,911	0	0	568,911
St. Louis	**123,925**	**1,301,212**	**2,602,695**	**1,158,196**	**76,020**	**5,262,049**
Crawford	0	61,930	0	0	0	61,930
Franklin	0	0	119,918	0	0	119,918
Washington	123,925	1,239,283	2,482,778	1,158,196	76,020	5,080,202

Grouping the reported number of shortleaf pines by 30-year cohorts allows for a clearer picture of the current and future resource. This coincides with the stand level growth and yield prediction system developed by Murphy & Farrar (1985) and within the *Silvics of North America: Volume 1. Conifers,* which states that optimal volume yields of Missouri's shortleaf pine stands were indicated when thinned to about 90 ft²/acre or above at age 51 within (Lawson, 1990).

As illustrated in **Table R10**, the reported number of Missouri's shortleaf pine growing stock trees is concentrated in middle-aged stands (61-90 years), with 53.6% (38.3 million trees) of the total resource. Early-stage recruitment (0-30 years) is significantly lower at just 3.5% (2.5 million trees), indicating regeneration but may not be at levels needed to sustain long-term productivity.

- **Ozark Region:** holds 58.6% (41.9 million trees) of the total; with nearly 56.1% (23.5 million trees) in the 61-90-year range and only 4.7% (1.97 million trees) in the youngest (0-30 year) category.
- **Southeast Region**: contains 29.0% (20.7 million trees) of the total; with nearly 49.8% (10.3 million trees) in the 61-90-year range and only with 2.2% (413,902 trees) in the 0-30-year category.

Volume of Shortleaf Pine Resources

This section reports on the volume of shortleaf pine resources which provide understanding of timber availability and commercial potential. Volume was examined for the whole tree including cubic feet of merchantable bole wood and sawlog volume as well as international ¼" rule of sawlog volume. Stem-top wood and stump wood volumes are presented for consideration in tertiary and biomass markets.

Understanding the Use of Cubic Feet and Board Feet (International ¼" Rule) in Sawtimber Measurement

Within this section, shortleaf pine sawtimber is measured in both cubic feet and board feet to provide a comprehensive view of current and projected forest volume and utilization potential. By using both measurements, we can evaluate total forest productivity (Cubic Feet) and commercial processing potential (Board Feet) for different stakeholder groups.

- Cubic Feet is the primary metric used to measure the total merchantable bole volume of growing stock. Including this metric in gross annual growth calculations allows for the extrapolation of sawlog growth and non-sawlog qualifying volumes, offering insights into how much of the resource is *potential* sawtimber volume.
- Board Feet represents the volume of sawn lumber that can be recovered from a tree under the International ¼" Rule, making it a key metric for sawtimber markets and mill yield predictions.

Volume of Shortleaf Pine Resources

As **Table R11** shows, Missouri's total reported shortleaf pine volume is 1.41 billion cubic feet. Of that, sawlog volume accounts for 82% (1.15 billion cubic feet (CF)). Additionally, the reported volume report shows 30.6 million cubic feet of stem-top wood and 52.1 million cubic feet of stump wood. Regional volumes are highlighted here:

- **Ozark:** 836.4 million CF merchantable growing stock, 691.4 million CF sawlog volume
- **Southeast:** 405.5 million CF merchantable growing stock, 329.8 million CF sawlog volume
- **Southwest:** 56.9 million CF merchantable growing stock, and 42.9 million CF of sawlog volume
- **St. Louis:** 106.6 million cubic feet and 90.4 million CF sawlog volume

Table R11:Volume of Shortleaf Pine Resources on Timberland by Region, County, Type

Net Merchantable bole wood volume of growing-stock trees (at least 5 inches d.b.h.), in cubic feet // Gross stem-top (above 4-inch top diameter) wood volume of live trees (timber species at least 5 inches d.b.h.), in cubic feet // Net sawlog wood volume of sawtimber trees, in cubic feet // Net sawlog wood volume of sawtimber trees, in board feet (International ¼-inch rule) // Gross stump wood volume of live trees (timber species at least 5 inches d.b.h.), in cubic feet, on timberland of Missouri, by Species, by County (USFS, 2019)

	Merchantable Bole Volume (CF) of Growing Stock Trees	Volume (CF) of Stem-top wood of Living Trees	Gross stump wood volume (CF) of live trees	Sawlog Volume (CF) of Sawtimber Trees	Sawlog Volume (BF) of Sawtimber Trees
	Cubic Feet of SL Pine Bole Wood	Cubic Feet of SL Pine Tops (Above 4 inch)	Cubic Feet of SL Pine Stump Wood	Cubic Feet of SL Pine Sawlog	INT'L ¼" Rule Board Feet of Sawlog
Total	**1,405,342,769**	**30,593,561**	**52,109,173**	**1,154,612,349**	**4,436,470,715**
Ozark	**836,382,531**	**17,629,645**	**30,812,008**	**691,364,895**	**2,644,031,725**
Carter	117,314,329	3,189,137	4,541,494	89,428,854	355,758,985
Dent	59,797,284	1,352,084	2,247,648	48,519,439	185,312,279
Douglas	38,815,375	825,713	1,467,588	33,481,273	138,790,931
Howell	66,830,404	1,247,848	2,362,363	57,015,887	211,905,789
Oregon	59,724,180	1,018,832	2,033,290	51,626,765	182,648,762
Ozark	39,200,378	646,417	1,382,895	33,260,175	123,882,312
Phelps	12,051,829	230,298	394,679	10,449,572	34,984,767
Pulaski	2,398,929	46,456	92,770	2,092,047	8,322,807
Ripley	86,363,901	927,032	2,831,709	78,522,734	284,381,354
Shannon	154,510,536	3,817,695	5,722,403	123,698,572	460,280,038
Texas	198,957,966	4,322,576	7,720,016	162,896,742	656,403,480
Wright	417,421	5,557	15,153	372,836	1,360,221
Southeast	**405,472,105**	**9,386,532**	**14,837,274**	**329,818,195**	**1,233,301,190**
Bollinger	33,883,157	889,330	1,208,703	26,424,736	88,519,816
Butler	44,559,298	1,418,726	1,663,818	34,821,751	133,621,128
Iron	39,151,040	930,682	1,492,575	31,900,071	123,333,535
Madison	44,458,985	942,690	1,673,313	36,172,124	140,440,788
Perry	1,405,279	38,375	64,525	1,210,497	5,670,412
Reynolds	130,952,323	2,783,839	4,743,884	108,903,802	404,201,842
St. Francois	4,099,574	67,168	153,094	3,565,825	13,782,193
Ste. Genevieve	3,530,522	37,086	128,756	3,017,626	12,415,257
Stoddard	528,867	53,183	30,807	-	-
Wayne	102,903,060	2,225,453	3,677,799	83,801,763	311,316,219
Southwest	**56,922,007**	**1,593,242**	**2,343,234**	**42,979,472**	**187,201,420**
Barry	19,904,859	594,538	827,724	15,287,418	66,601,856
Christian	5,372,903	103,460	200,198	4,536,987	17,497,720
Laclede	20,242,887	523,515	874,577	15,613,276	70,917,013
McDonald	4,148,469	54,048	156,307	3,873,570	18,099,644
Taney	7,252,889	317,681	284,429	3,668,221	14,085,186
St. Louis	**106,566,125**	**1,984,142**	**4,116,657**	**90,449,787**	**371,936,381**
Crawford	1,178,572	19,790	61,696	1,057,618	5,355,408
Franklin	4,009,306	18,580	162,281	3,858,801	18,454,766
Washington	101,378,248	1,945,772	3,892,680	85,533,368	348,126,206

OPERABILITY/MARGINAL HARVEST AREAS

As part of the analysis of timberland in Missouri, accessibility and operability were evaluated using datasets from the 2019 FIA Summary Data derived from the Forest Inventory and Analysis (FIA) EVALIDator tool (USFS, 2019). This assessment focused on identifying marginal harvest areas impacted by physical and logistical constraints. In collaboration with forestry staff from the MDOC and the FWAM, three key features were established to define marginal harvest acres, as detailed in **GIS Table 1 of the Geospatial Methodology Section**: (1) Buffer zones of 75 feet from surface water features, (2) Areas with a grade of 30% or more, and (3) parcels 40 acres in size and smaller.

This framework ensures a balanced approach to identifying marginal harvest areas while balancing operability while considering environmental objectives. To further illustrate the spatial factors influencing marginal harvest areas, **Figures R15 and R16** provide a statewide perspective on critical constraints, including the distribution of unbuffered lakes and streams and the extent of privately owned parcels greater than or equal to 40 acres.

Figure R15 illustrates the statewide distribution of perennial streams and lakes in Missouri, highlighting unbuffered surface water features. This map provides valuable insights into the geographic extent and density of water resources across the state, which play a crucial role in defining marginal harvest areas through the implementation of buffer zones.

Figure R16 depicts areas of privately owned parcels that are greater than or equal to 40 acres in size. These larger parcels are key components of operable timberland, as smaller parcels often present logistical challenges for sustainable forest management.

Figure R12: Unbuffered Lakes and Streams

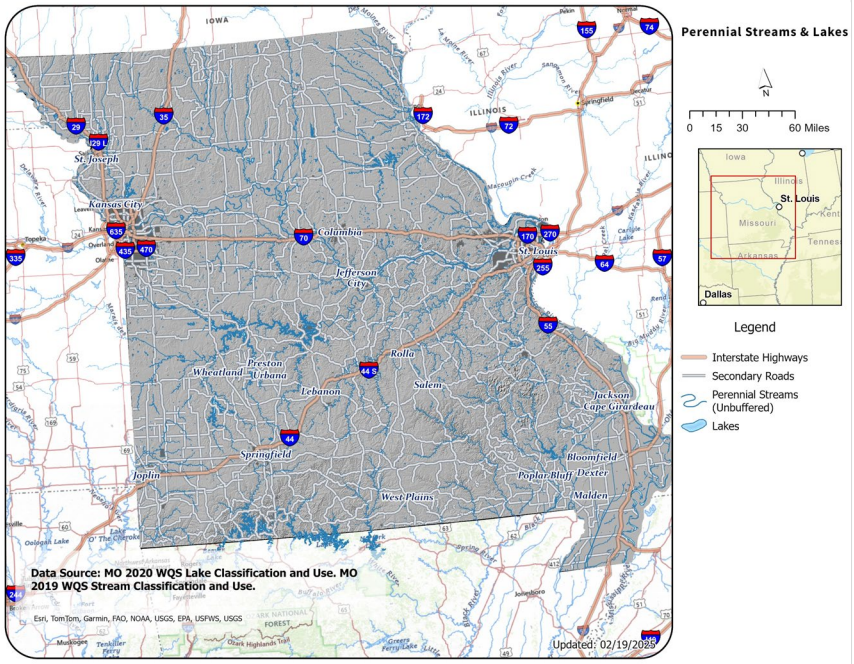
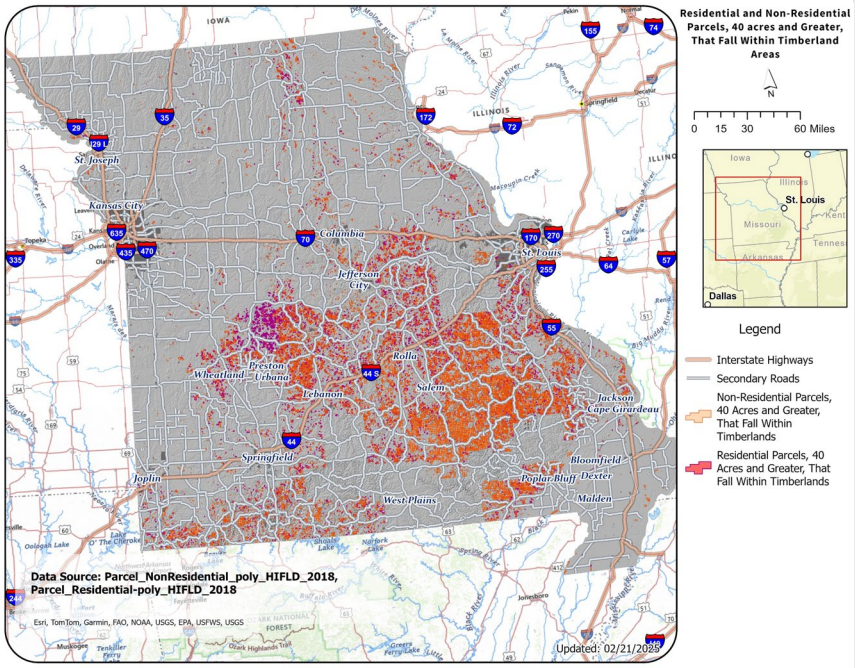


Figure R12: Privately Owned Parcels Greater Than or Equal to 40 Acres



Regional and Statewide Considerations for Marginal Acres

While Missouri has a considerable and well-distributed shortleaf pine resource, operability challenges - such as steep slopes, water buffers, and small parcel sizes - impact accessibility to significant portions of timberland. These constraints must be carefully considered when evaluating both statewide timber supply and regional harvesting feasibility.

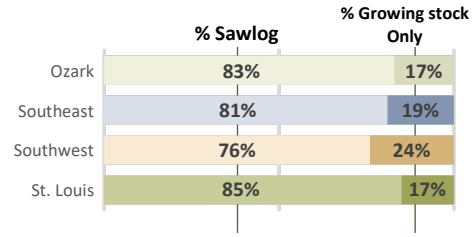
To accurately assess the impact of marginal acres on Missouri's shortleaf pine resource, this analysis evaluates both growing stock and sawlog volumes. ***Growing stock volume*** represents the total merchantable timber, including trees that may require further growth or management to reach full commercial potential. ***Sawlog volume***, in contrast, reflects the harvest-ready portion of the resource, meeting commercial specifications for immediate processing (USFS, 2023). By measuring both, this assessment provides a dual perspective—one that accounts for long-term sustainability while also evaluating short-term operability in Missouri's timber supply.

While this resource analysis details the volume of the shortleaf pine resource availability in considerably more detail in section "Volume of Shortleaf Pine Resources", it is important to note that sawlog volume accounts for approximately 82% of shortleaf pine growing stock statewide (USFS, 2019), indicating both short-term and long-term harvest potential.

Growing stock volume: Refers to the cubic-foot volume of sound wood in growing stock trees with a diameter at breast height (d.b.h.) of at least 5 inches. This includes wood from a 1 foot stump to a minimum 4 inch top diameter outside bark along the central stem.

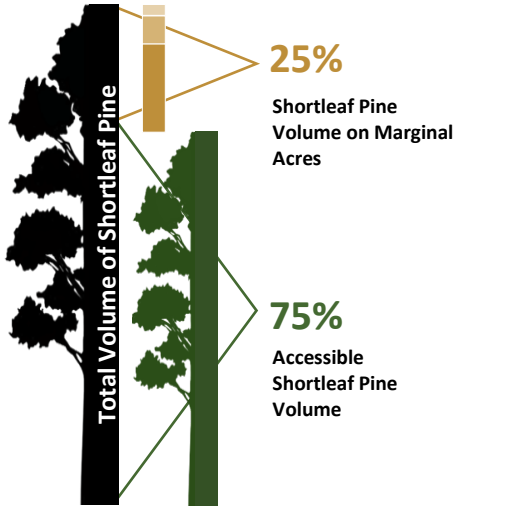
Sawlog volume: Represents timber currently meeting minimum commercial specifications, including logs that are at least 8 feet long, sound and straight, with a minimum diameter inside bark of 6 inches for softwoods or 8 inches for hardwoods, or meeting regional standards for size and defect.
(USFS, 2023)

SHORTLEAF SNAPSHOT: Regional Shortleaf Sawlog Conversion
Percentage of Volume of Sawlog & Growing Stock Only



Understanding Missouri's Growing Stock and Sawlog Volume Availability

Figure R13: Statewide Percentage of Shortleaf Pine Volume on Marginal Acres (CF)
(U.S. Forest Service, 2019)

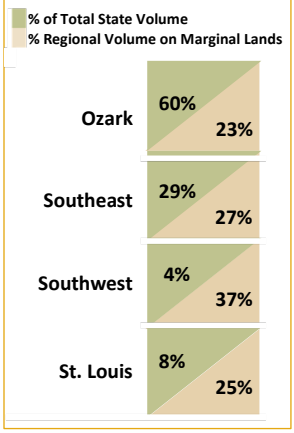


Noteable volumes of both growing stock and sawlogs are within marginal harvest areas. Two percent of volume is within surfae water buffer zones, 17% is on slopes of 30% grade or greater, and 6% is on parcels of 40 acres or less in size. This data helps identify challenges that may affect operability, market availability, and long-term planning.

As illustrated in **Figure R17**, a total of potentially 25% of the statewide shortleaf pine volume is located on acreage impacted by marginal constraints, meaning that at least 75% of the reported resource volume is feasibly accessible for traditional harvesting operations. **Figure R17** represents both growing stock and sawlog volume, as volumes of each were nearly identical across the marginal area types.

Timber volume was assessed on each marginal area constraint individually, so there could be overlaps of the volume reported between the three types of marginal areas, indicating that 75% of the total volume is a conservative estimate.

SHORTLEAF SNAPSHOT: Volume Distribution and Marginal Acre Impact



Regional Shortleaf Pine Availability

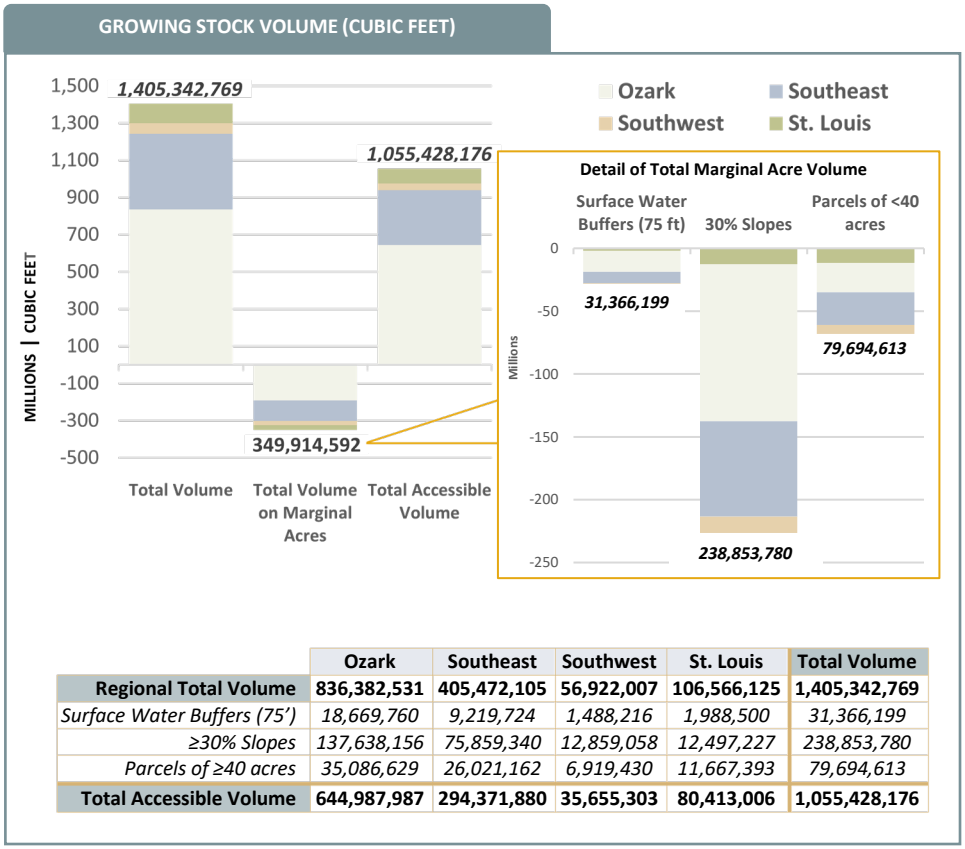
While the statewide percentages for both growing stock and sawlog volumes located on acreage impacted by marginal constraints were consistent, there is notable variability when considering shortleaf pine volume distribution and regional marginal acre impact.

The **Ozark and Southeast regions together contain 88.3%** of Missouri's **1.4 billion cubic feet** of shortleaf pine growing stock (USFS, 2019). However, 23% of the volume in the Ozark region and 27% of the volume in the Southeast region is impacted by marginal harvest considerations, equating to 302.5 million cubic feet of shortleaf pine being restricted by accessibility constraints. Additionally, while the Southwest region holds only 4% of the total growing stock volume, nearly 37% of its timberland is impacted by marginal conditions, providing more insight on the feasibility of accessing a consistent and commercially viable shortleaf pine resource from this region.

Key Observations from Comparing Growing Stock and Sawlog Volume Tables

Figures R18-R20 provide a detailed assessment of how marginal acre constraints impact growing stock and sawlog volume across regions with a shortleaf pine resource. These figures utilize one of two key measurement types - cubic feet (CF) and the International ¼" Rule - to quantify shortleaf pine growing stock and sawlog volumes. By analyzing both metrics, these figures allow stakeholders to compare total resource volume with actual sawmill yield potential, supporting more informed projections and feasiblity assessments.

Figure R14: Regional Shortleaf Pine Growing Stock Volume on Marginal Acres



	Ozark	Southeast	Southwest	St. Louis	Total Volume
Regional Total Volume	**836,382,531**	**405,472,105**	**56,922,007**	**106,566,125**	**1,405,342,769**
Surface Water Buffers (75')	*18,669,760*	*9,219,724*	*1,488,216*	*1,988,500*	*31,366,199*
≥30% Slopes	*137,638,156*	*75,859,340*	*12,859,058*	*12,497,227*	*238,853,780*
Parcels of ≥40 acres	*35,086,629*	*26,021,162*	*6,919,430*	*11,667,393*	*79,694,613*
Total Accessible Volume	**644,987,987**	**294,371,880**	**35,655,303**	**80,413,006**	**1,055,428,176**

Figures R18 and R19 report shorleaf pine growing stock and sawlog volumes (respectively).

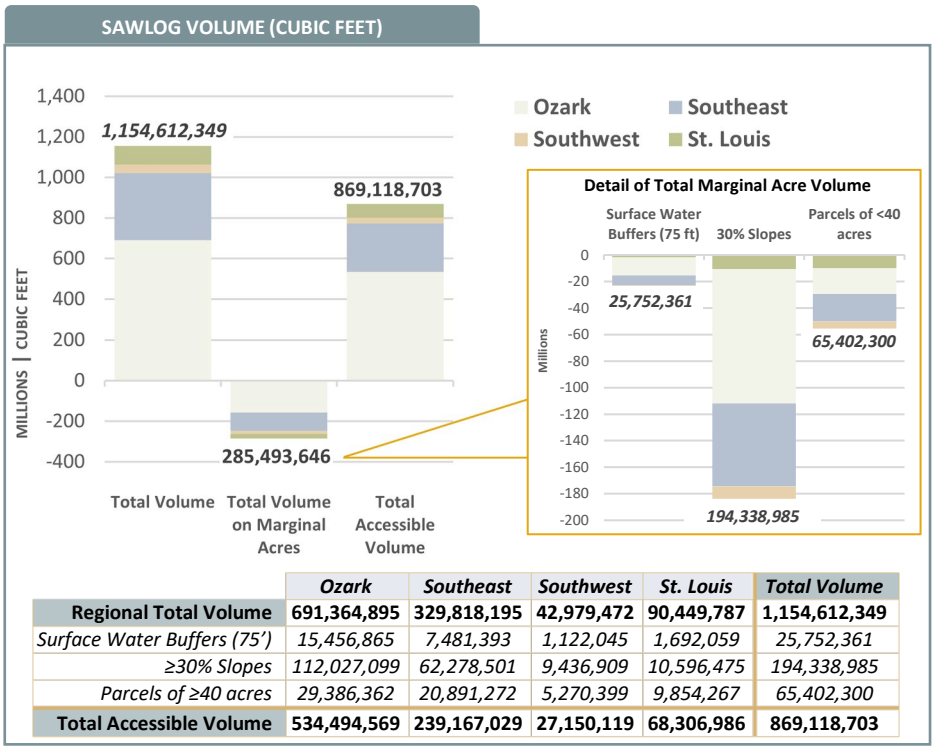
Figure R20 reports shortleaf pine sawlog volumes in International 1/4" Rule. This unit of measure is used to estimate the amount of lumber that can be sawn from a log, accounting for sawmill kerf (waste from the saw blade), taper, and processing inefficiencies (Purdue University Extension, n.d.). This rule provides a more practical assessment of the usable sawlog volume, offering insights into how much commercially viable lumber can be expected.

While the statewide percentages of marginal acre impacts remain relatively consistent between growing stock and sawlogs, there are notable regional differences to consider when evaluating harvest feasibility and market stability.

One key distinction is that although the Ozark and Southeast regions maintain similar sawlog conversion rates (~82%), they differ significantly in how accessibility constraints are distributed. In the Ozark region, steep slopes account for the largest share of marginal acre impacts, making terrain a primary obstacle to operability. In the Southeast, parcel fragmentation and water buffers play a more substantial role, suggesting that accessibility challenges are more tied to landownership patterns and environmental restrictions rather than terrain alone.

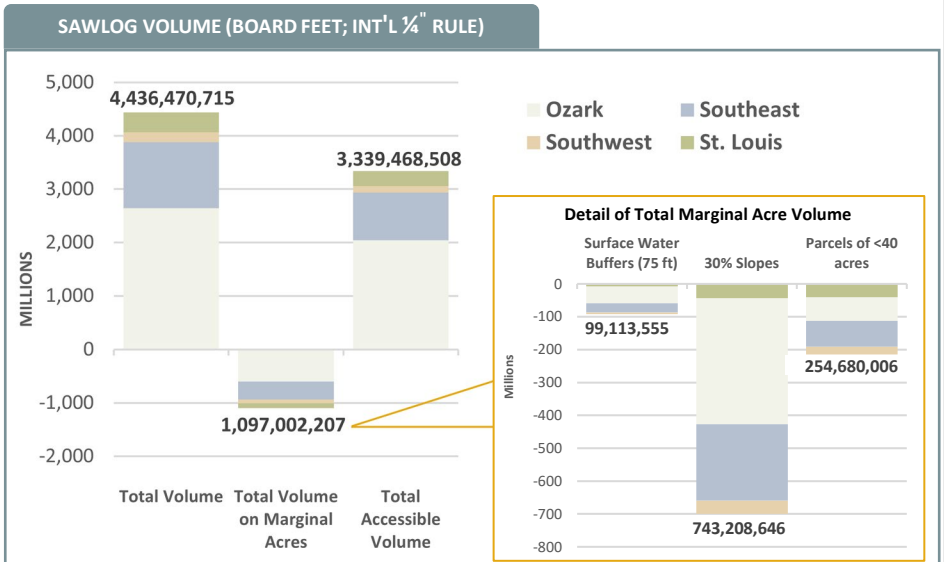
Additionally, while the Southwest region contains the smallest total volume of shortleaf pine, its significantly higher proportion of marginal acres (37%) raises concerns about economic feasibility of most of this resource. In this region, harvesting constraints are not solely caused by limited timber supply, but also fragmented and difficult-to-access stands. This could lead to longer harvest cycles or lower overall utilization rates, reducing the incentive for mills and processors to depend on the region as a source of supply.

Figure R19: Regional Shortleaf Pine Sawlog Volume on Marginal Acres (CF)



	Ozark	Southeast	Southwest	St. Louis	Total Volume
Regional Total Volume	**691,364,895**	**329,818,195**	**42,979,472**	**90,449,787**	**1,154,612,349**
Surface Water Buffers (75')	*15,456,865*	*7,481,393*	*1,122,045*	*1,692,059*	*25,752,361*
≥30% Slopes	*112,027,099*	*62,278,501*	*9,436,909*	*10,596,475*	*194,338,985*
Parcels of ≥40 acres	*29,386,362*	*20,891,272*	*5,270,399*	*9,854,267*	*65,402,300*
Total Accessible Volume	**534,494,569**	**239,167,029**	**27,150,119**	**68,306,986**	**869,118,703**

Figure R15: Regional Shortleaf Pine Sawlog Volume on Marginal Acres (BF)



	Ozark	Southeast	Southwest	St. Louis	Total Volume
Regional Total Volume	**2,644,031,725**	**1,233,301,190**	**187,201,420**	**371,936,381**	**4,436,470,715**
Surface Water Buffers (75')	*59,095,277*	*28,097,948*	*4,932,403*	*6,987,927*	*99,113,555*
≥30% Slopes	*427,052,170*	*232,629,024*	*40,010,500*	*43,516,953*	*743,208,646*
Parcels of ≥40 acres	*112,861,688*	*78,557,692*	*22,980,826*	*40,279,800*	*254,680,006*
Total Accessible Volume	**2,045,022,590**	**894,016,527**	**119,277,691**	**281,151,701**	**3,339,468,508**

These tables highlight that the current accessibility challenges will persist over time, limiting the feasibility of traditional harvesting methods in certain regions and impacting Missouri's shortleaf pine resource potential as a commercially viable species. Expanding harvesting capabilities through targeted infrastructure improvements, innovative logging techniques, and coordinated landowner engagement will be essential to ensuring that Missouri's shortleaf pine resource remains both commercially viable and ecologically sustainable in the long term.

SHORTLEAF PINE RESOURCE GROWTH AND GROWTH PROJECTIONS

This section first reviews the current annual growth of shortleaf pine and then expands on that dataset to provide a projected volume of merchantable growing stock growth as well as growth of sawtimber sawlog wood at 10, 20, and 30-year intervals. The volume of gross annual growth of the reported shortleaf pine resource provides insights into current forest productivity and how that impacts harvest potential and long-term market sustainability. ***Gross annual growth*** refers to the annual increase in volume of trees 5" d.b.h. and larger each year, including growth on trees that survive and those that will later be lost to mortality, harvest, or other factors (USFS, 2023). Gross growth is a key measure of forest productivity and potential timber supply.

CURRENT ANNUAL GROWTH OF SHORTLEAF PINE

The data collected for gross annual growth includes sub-datasets of all growth on merchantable bole wood as well as the sawlog wood volume of sawtimber trees, which is included in the total merchantable bole wood volume.

By examining both categories, it is possible to also extrapolate the growth of non-sawtimber-sized trees by removing the sawlog portion of the total bole growth. This breakdown allows for a more detailed assessment of how much of the growth is already within sawtimber size classes versus trees that are still developing toward merchantability and provides a key indicator of the overall productivity and regenerative capacity of the state's shortleaf pine resource.

Table R12 reviews the gross annual growth of the reported shortleaf pine merchantable bole growing stock in cubic feet (CF) and sawlog wood volume of sawtimber sized trees in both CF and Board Feet (International ¼" Rule).

Statewide Distribution of Growth

Statewide, the gross annual growth of shortleaf pine merchantable bole volume is 38.2 million CF, which includes:

- **Sawlog Wood Merchantable Bole Volume:** 36.9 million CF (96.6% of total merchantable growth)
- **Non-Sawlog Merchantable Bole Volume:** 1.3 million CF (3.4% of total merchantable growth)

Table R12: Gross Annual Growth of Shortleaf Pine Growing Stock and Sawlog on Timberland by Size Class, Region, and County

Average annual gross growth of merchantable bole wood volume of growing-stock trees (at least 5" d.b.h.), in cubic feet // Average annual gross growth of sawlog wood volume of sawtimber trees, in cubic feet// Average annual gross growth of sawlog wood volume of sawtimber trees, in board feet (International ¼" rule), on timberland of Missouri, by Species, by County (USFS, 2019)

	Gross Growth of Merchantable Bole Wood of Growing Stock Trees	Gross Growth of Shortleaf Pine Sawlog Wood Volume of Sawtimber	
	Cubic Feet	Cubic Feet	INT'L ¼" Rule Board Feet
Total	**38,177,130**	**36,920,859**	**131,017,637**
Ozark	**23,865,263**	**22,728,471**	**80,199,164**
Carter	4,155,726	3,543,400	12,226,284
Dent	1,782,987	1,643,555	6,797,061
Douglas	811,388	692,982	2,425,383
Howell	1,953,324	1,975,351	6,145,680
Oregon	1,442,432	1,345,040	5,177,776
Ozark	897,889	733,781	3,260,378
Phelps	240,389	236,568	729,025
Pulaski	107,568	130,610	504,867
Ripley	1,849,124	1,884,893	6,188,734
Shannon	4,361,463	4,121,346	14,412,291
Texas	6,254,239	6,386,471	22,186,765
Wright	8,736	34,473	144,920
Southeast	**10,286,010**	**9,979,297**	**35,835,916**
Bollinger	687,064	728,364	1,829,400
Butler	1,213,706	1,083,041	3,582,733
Iron	994,009	888,189	3,238,695
Madison	1,190,134	1,204,333	4,540,209
Perry	-	-	-
Reynolds	3,630,725	3,485,633	13,091,234
St. Francois	183,193	192,950	633,027
Ste. Genevieve	3,333	22,454	240,899
Stoddard	33,367	-	-
Wayne	2,350,478	2,374,334	8,679,718
Southwest	**1,098,808**	**1,254,698**	**4,346,412**
Barry	358,463	387,357	1,194,386
Christian	93,731	80,356	218,556
Laclede	417,527	485,547	1,785,729
McDonald	45,542	46,885	240,192
Taney	183,545	254,554	907,548
St. Louis	**2,927,049**	**2,958,394**	**10,636,145**
Crawford	70,865	79,153	303,807
Franklin	156,856	155,025	410,990
Washington	2,699,328	2,724,216	9,921,348

Regional and County Distribution of Growth

As evidenced in **Figure R21**, the Ozark and Southeast regions are key areas for shortleaf pine regeneration and future timber supply. These regions combined show nearly 34.2 million CF of annual growth of merchantable bole and sawtimber combined, demonstrating substantial timber production potential. Note the negative growth rates of non-sawlog material in the Southwest and St. Louis regions.

Figure R16: Gross Annual Growth of Shortleaf Pine Growing Stock and Sawlog by Region

Southwest Region

Total Merchantable Bole Growth:
1.1 million CF
Sawlog Volume:
1.25 million CF
Non-Sawlog Volume:
-0.15 million CF

Ozark Region

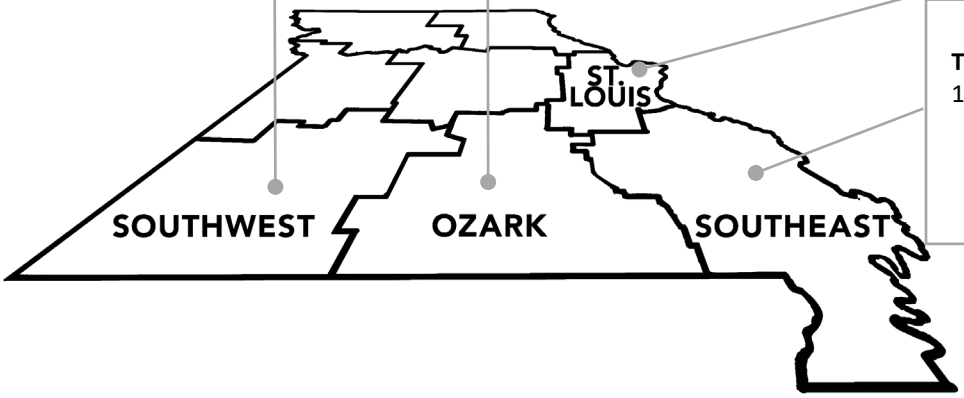
Total Merchantable Bole Growth:
23.9 million CF
Sawlog Volume:
22.7 million C
Non-Sawlog Volume:
1.2 million CF

St. Louis Region

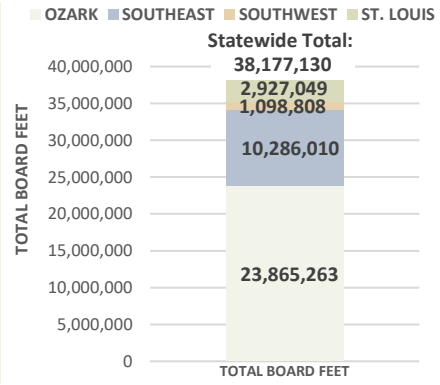
Total Merchantable Bole Growth:
2.93 million CF
Sawlog Volume:
2.96 million CF
Non-Sawlog Volume:
- 0.03 million CF

Southeast Region

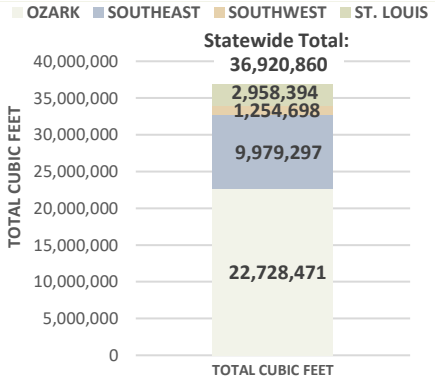
Total Merchantable Bole Growth:
10.3 million CF
Sawlog Volume:
9.98 million CF
Non-Sawlog Volume:
0.32 million CF



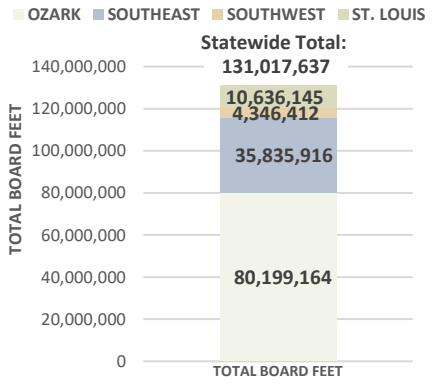
Gross Growth of Shortleaf Pine Merchantable Bole of Growing Stock
(Cubic Feet)



Gross Growth of Shortleaf Pine Sawlog Wood of Sawtimber
(Cubic Feet)



Gross Growth of Shortleaf Pine Sawlog Wood of Sawtimber
(INT'L ¼" Rule Board Feet)



PROJECTED GROWTH OF SHORTLEAF PINE

Understanding the long-term sustainability and future availability of Missouri's shortleaf pine requires projections based on current volume assessments and growth trends. Forest managers and industry stakeholders can make more informed decisions regarding harvest planning by examining projected volume changes for merchantable growing stock and sawlog wood. Projections are provided at 10, 20 and 30-year intervals. While these projections offer valuable insights into future timber availability, it is important to note that they are speculative and assume growth rates remain constant over time. Factors such as stand management practices, natural disturbances, and climate variability may influence actual growth outcomes.

Methodology

Projections are based on the most recent FIA growth data, applying the current annual gross growth rates from to "Year 0" (YR0) current volume as detailed in **Table R11** (Current Volume of Shortleaf Pine Resources) to estimate future values. The growth rate is assumed to remain constant over time, meaning each year's growth is projected forward based on the previous year's adjusted volume.

The projected volume at 10, 20, and 30-year intervals is calculated by applying the current annual gross growth rate iteratively over multiple years.

- *Growth is Compounded:* The volume estimates build upon previous years using a consistent growth rate assumption, meaning YR10 reflects the cumulative effect of 10 years of growth applied to YR0, and so forth for YR20 and YR30.

Understanding Growth Rate and Age for Shortleaf Pine

Example of Projected Growth Calculation

For instance, Missouri's total shortleaf pine growing stock volume at YR0 is 1.4 billion cubic feet. Using the applied growth rate:

- **YR10 Projection:** 1.84 billion cubic feet
- **YR20 Projection:** 2.41 billion cubic feet
- **YR30 Projection:** 3.17 billion cubic feet

This demonstrates how the iterative growth model projects increasing merchantable volume over time, assuming a constant growth rate. Similar calculations are applied at the **regional and county level** for a more granular assessment.

Merchantable Bole of Growing Stock | Projected Volume at 10, 20, and 30 Years

Table R13 outlines projected volume increases based on the assumption of a constant growth rate over time. The projections look at the merchantable bole wood volume of growing-stock trees (at least 5" DBH) in cubic feet.

Statewide Growth Projections

Missouri's total shortleaf pine merchantable bole wood volume of growing stock at YR0 is 1.4 billion cubic feet (CF). At the applied growth rate, statewide volumes increase as follows:

- **YR10 Projection:** 1.84 billion cubic feet
- **YR20 Projection:** 2.41 billion cubic feet
- **YR30 Projection:** 3.17 billion cubic feet

At current growth rates, net bole volumes will more than double in 30 years, increasing from 1.4 billion CF to 3.17 billion CF. This projected increase suggests strong long-term sustainability, reinforcing Missouri's shortleaf pine as a vital resource for timber production.

Regional Distribution of Projected Growth

Regional trends highlight the role of core forested areas in sustaining future shortleaf pine resources:

- **Ozark Region:** Expected to grow from 836 million CF (YR0) to 1.96 billion CF (YR30) with an applied annual growth rate of approximately 2.93%.

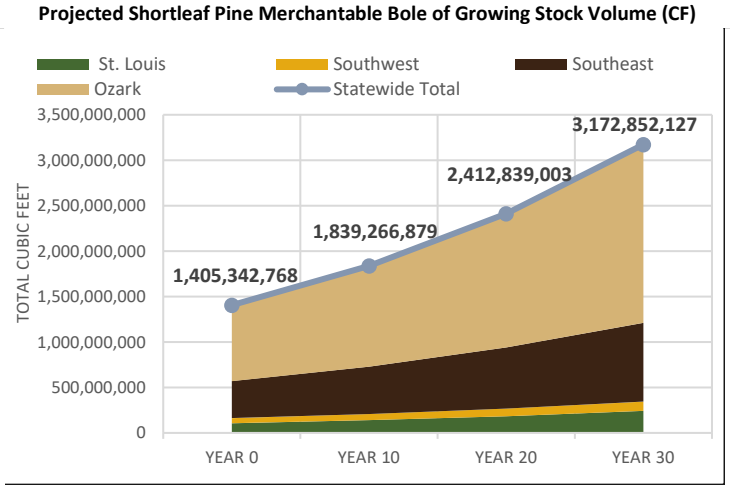
- **Southeast Region:** Projected to increase from 405 million CF (YR0) to 867 million CF (YR30), a 114% increase over 30 years, with an applied annual growth rate of approximately 2.65%.
  - **NOTE:** Perry County did not have reported growth of merchantable bole but did have reported volume; as such, projections are affected.

- **Southwest & St. Louis Regions:** Combined, these regions are expected to grow from 164 million CF (YR0) to 355 million CF (YR30), with an applied annual growth rate of approximately 2.72%.

Table R123: Projected Volume (Cubic Feet) of Shortleaf Pine Merchantable Bole of Growing Stock on Timberland at 10, 20-, and 30-Year Intervals by Region and County

Net merchantable bole wood volume of growing-stock trees (at least 5 inches d.b.h.) // 1208 Average annual gross growth of merchantable bole wood volume of growing-stock trees (at least 5 inches d.b.h.) (U.S. Forest Service, 2019)

	YR0	YR10	YR20	YR30
Total	**1,405,342,769**	**1,839,266,879**	**2,412,839,003**	**3,172,852,128**
Ozark	**836,382,531**	**1,109,141,867**	**1,473,818,974**	**1,962,309,083**
Carter	117,314,329	166,162,390	235,350,106	333,346,629
Dent	59,797,284	80,220,026	107,617,807	144,372,833
Douglas	38,815,375	47,736,641	58,708,355	72,201,792
Howell	66,830,404	89,143,628	118,906,753	158,607,141
Oregon	59,724,180	75,821,516	96,257,535	122,201,632
Ozark	39,200,378	49,163,604	61,659,098	77,330,466
Phelps	12,051,829	14,683,374	17,889,523	21,795,742
Pulaski	2,398,929	3,719,763	5,767,838	8,943,571
Ripley	86,363,901	106,742,385	131,929,390	163,059,539
Shannon	154,510,536	204,103,617	269,614,535	356,152,421
Texas	198,957,966	271,131,441	369,486,379	503,520,299
Wright	417,421	513,484	631,654	777,018
Southeast	**405,472,105**	**521,331,741**	**671,516,213**	**866,580,788**
Bollinger	33,883,157	41,415,870	50,623,213	61,877,481
Butler	44,559,298	58,297,390	76,271,078	99,786,240
Iron	39,151,040	50,307,212	64,642,358	83,062,335
Madison	44,458,985	57,901,277	75,407,881	98,207,653
Perry	1,405,279	1,405,279	1,405,279	1,405,279
Reynolds	130,952,323	172,141,159	226,285,246	297,459,439
St. Francois	4,099,574	6,347,406	9,827,743	15,216,378
Ste. Genevieve	3,530,522	3,563,999	3,597,793	3,631,908
Stoddard	528,867	975,106	1,797,865	3,314,837
Wayne	102,903,060	128,977,044	161,657,756	202,619,237
Southwest	**56,922,007**	**68,948,676**	**83,605,228**	**101,483,906**
Barry	19,904,859	23,794,384	28,443,945	34,002,058
Christian	5,372,903	6,387,319	7,593,258	9,026,882
Laclede	20,242,887	24,827,800	30,451,174	37,348,213
McDonald	4,148,469	4,627,062	5,160,867	5,756,256
Taney	7,252,889	9,312,112	11,955,983	15,350,496
St. Louis	**106,566,125**	**139,844,595**	**183,898,588**	**242,478,350**
Crawford	1,178,572	2,113,193	3,788,980	6,793,685
Franklin	4,009,306	5,884,888	8,637,882	12,678,747
Washington	101,378,248	131,846,514	171,471,726	223,005,918



Sawtimber Sawlog Wood | Projected Volume at 10, 20, and 30 Years

Projected Cubic Feet of Shortleaf Pine Sawlog Wood of Sawtimber Volume at 10, 20, and 30 Years

Table R14 outlines projected volume increases based on the assumption of a constant growth rate over time. The projections look at the net volume (cubic feet) of the sawlog wood of sawtimber trees (measured from stump to a minimum 7" inches top d.o.b. for softwoods) (USFS, 2023).

Statewide Growth Projections

Missouri's total shortleaf pine sawtimber sawlog wood volume at YR0 is **1.15 billion cubic feet (CF)**. At the applied growth rate, statewide volumes increase as follows:

- **YR10 Projection:** 1.58 billion cubic feet
- **YR20 Projection:** 2.18 billion cubic feet
- **YR30 Projection:** 3.03 billion cubic feet

Regional Distribution of Projected Growth

Regional trends highlight the role of core forested areas in sustaining future shortleaf pine sawtimber resources:

- **Ozark Region:** Expected to grow from 691 million CF (YR0) to 1.86 billion CF (YR30), with an applied annual growth rate of approximately 2.97%.
- **Southeast Region:** Projected to increase from 329 million CF (YR0) to 812 million CF (YR30), with an applied annual growth rate of approximately 2.78%.
  - **Note:** Perry County had reported sawlog volume but did not have reported growth, affecting projected growth rates.
- **Southwest & St. Louis Regions:** Combined, these regions are expected to grow from 133 million CF (YR0) to 353 million CF (YR30), with an applied annual growth rate of approximately 2.82%.

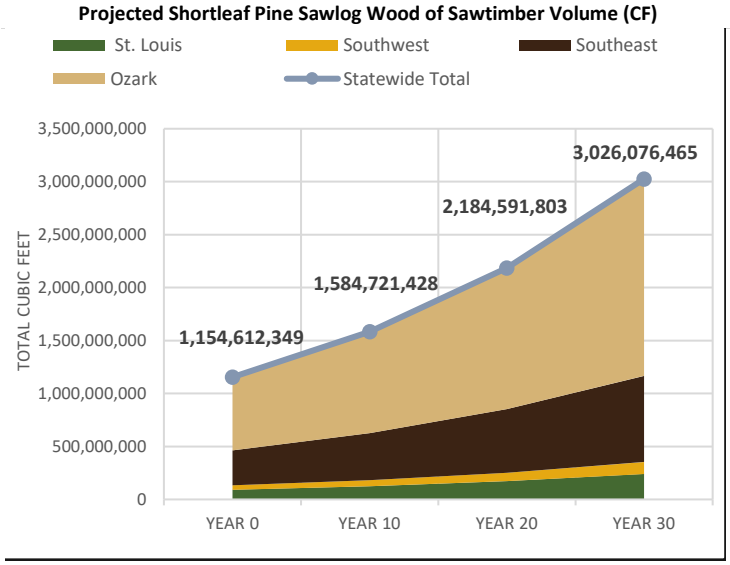
Key Takeaways

At current growth rates, net sawtimber sawlog volume will more than double in 30 years, increasing from 1.15 billion CF to 3.03 billion CF. This projected increase suggests long-term sustainability of the supply for shortleaf pine markets.

Table R14: Projected Volume (Cubic Feet) of Shortleaf Pine Sawlog Wood of Sawtimber on Timberland at 10, 20, and 30 Year Intervals by Region and County

Net sawlog wood volume of sawtimber trees, in cubic feet, on timberland // Average annual gross growth of sawlog wood volume of sawtimber trees, in cubic feet, on timberland (U.S. Forest Service, 2019)

	YR0	YR10	YR20	YR30
Total	**1,154,612,349**	**1,584,721,428**	**2,184,591,803**	**3,026,076,465**
Ozark	**691,364,895**	**957,298,658**	**1,331,441,967**	**1,860,324,500**
Carter	89,428,854	131,896,900	194,532,207	286,911,819
Dent	48,519,439	67,700,603	94,464,648	131,809,309
Douglas	33,481,273	41,093,481	50,436,380	61,903,455
Howell	57,015,887	80,151,591	112,675,220	158,396,171
Oregon	51,626,765	66,768,790	86,351,940	111,678,789
Ozark	33,260,175	41,371,029	51,459,801	64,008,829
Phelps	10,449,572	13,071,397	16,351,044	20,453,563
Pulaski	2,092,047	3,833,384	7,024,141	12,870,757
Ripley	78,522,734	99,543,696	126,192,084	159,974,390
Shannon	123,698,572	171,673,470	238,254,815	330,658,876
Texas	162,896,742	239,291,543	351,513,737	516,365,542
Wright	372,836	902,774	2,185,951	5,293,001
Southeast	**329,818,195**	**444,700,512**	**600,629,094**	**812,654,225**
Bollinger	26,424,736	34,681,532	45,518,286	59,741,141
Butler	34,821,751	47,300,818	64,252,008	87,277,994
Iron	31,900,071	41,981,585	55,249,202	72,709,840
Madison	36,172,124	50,189,764	69,639,606	96,626,768
Perry	1,210,497	1,210,497	1,210,497	1,210,497
Reynolds	108,903,802	149,233,906	204,499,368	280,231,167
St. Francois	3,565,825	6,039,812	10,230,263	17,328,070
Ste. Genevieve	3,017,626	3,249,832	3,499,905	3,769,222
Stoddard	-	-	-	-
Wayne	83,801,763	110,812,765	146,529,959	193,759,527
Southwest	**42,979,472**	**57,793,340**	**79,430,824**	**112,207,179**
Barry	15,287,418	19,633,865	25,216,073	32,385,389
Christian	4,536,987	5,407,707	6,445,531	7,682,531
Laclede	15,613,276	21,207,761	28,806,840	39,128,789
McDonald	3,873,570	4,368,799	4,927,343	5,557,296
Taney	3,668,221	7,175,208	14,035,036	27,453,174
St. Louis	**90,449,787**	**124,928,918**	**173,089,917**	**240,890,561**
Crawford	1,057,618	2,176,558	4,479,316	9,218,351
Franklin	3,858,801	5,721,553	8,483,508	12,578,735
Washington	85,533,368	117,030,806	160,127,093	219,093,475



Projected Board Feet of Shortleaf Pine Sawlog Wood of Sawtimber Volume at 10, 20, and 30 Years

Table R15 outlines projected volume increases based on the assumption of a constant growth rate over time. The projections look at the net volume (board feet; International ¼" Rule) of the sawlog wood of sawtimber trees (measured from stump to a minimum 7" inches top d.o.b. for softwoods) (USFS, 2023).

Statewide Growth Projections

Missouri's total shortleaf pine sawtimber sawlog wood YR0 is measured at 4.44 billion board feet (BF). Using the applied growth rate, statewide projections increase as follows:

- **YR10 Projection:** 5.94 billion board feet
- **YR20 Projection:** 7.99 billion board feet
- **YR30 Projection:** 10.79 billion board feet

Regional Distribution of Projected Growth

Regional trends highlight the role of core forested areas in sustaining future shortleaf pine sawtimber resources:

- **Ozark Region:** Expected to grow from 2.64 billion BF (YR0) to 6.58 billion BF (YR30), with an applied annual growth rate of approximately 2.97%.
- **Southeast Region:** Projected to increase from 1.23 billion BF (YR0) to 2.94 billion BF (YR30), with an applied annual growth rate of approximately 2.78%.
  - **Note:** Perry County had reported sawlog volume but did not have reported growth, affecting projected growth rates.
- **Southwest & St. Louis Regions:** Combined, these regions are expected to grow from 0.56 billion BF (YR0) to 1.28 billion BF (YR30), with an applied annual growth rate of approximately 2.82%.

Key Takeaways

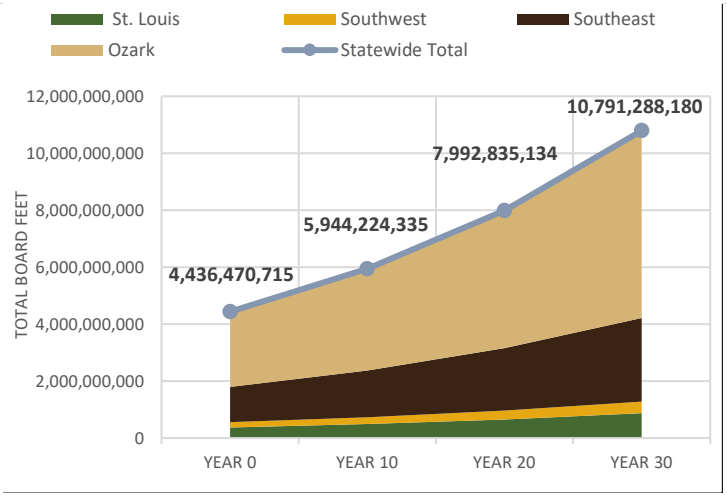
At current growth rates, net sawtimber sawlog volume will more than double in 30 years, increasing from 4.44 billion BF to 10.79 billion BF. This projected increase suggests strong long-term sustainability, reinforcing Missouri's shortleaf pine as a vital resource for timber production and conservation.

Table R135: Projected Volume (Board Feet; Int'l ¼" Rule) of Shortleaf Pine Sawlog Wood of Sawtimber on Timberland at 10, 20, and 30 Year Intervals by Region and County

Net sawlog wood volume of sawtimber trees, in board feet (International 1/4-inch rule), on timberland // Average annual gross growth of sawlog wood volume of sawtimber trees, in board feet (International 1/4-inch rule), on timberland (U.S. Forest Service, 2019)

	YR0	YR10	YR20	YR30
Total	**4,436,470,715**	**5,944,224,335**	**7,992,835,134**	**10,791,288,180**
Ozark	**2,644,031,725**	**3,569,895,685**	**4,836,048,644**	**6,576,597,051**
Carter	355,758,985	498,771,279	699,273,384	980,375,746
Dent	185,312,279	265,672,761	380,881,483	546,050,352
Douglas	138,790,931	165,043,685	196,262,232	233,385,868
Howell	211,905,789	282,036,153	375,376,208	499,607,217
Oregon	182,648,762	241,556,624	319,463,444	422,496,764
Ozark	123,882,312	160,631,325	208,281,733	270,067,375
Phelps	34,984,767	42,998,054	52,846,790	64,951,387
Pulaski	8,322,807	14,998,035	27,027,066	48,703,868
Ripley	284,381,354	352,694,745	437,418,212	542,493,742
Shannon	460,280,038	626,502,596	852,753,694	1,160,711,651
Texas	656,403,480	915,246,863	1,276,161,456	1,779,397,588
Wright	1,360,221	3,743,565	10,302,942	28,355,493
Southeast	**1,233,301,190**	**1,643,690,608**	**2,194,544,486**	**2,935,073,665**
Bollinger	88,519,816	108,612,388	133,265,649	163,514,803
Butler	133,621,128	174,095,337	226,829,295	295,536,515
Iron	123,333,535	159,828,314	207,122,013	268,410,065
Madison	140,440,788	193,050,759	265,368,743	364,777,483
Perry	5,670,412	5,670,412	5,670,412	5,670,412
Reynolds	404,201,842	555,939,069	764,638,397	1,051,683,378
St. Francois	13,782,193	21,594,731	33,835,865	53,015,976
Ste. Genevieve	12,415,257	15,045,849	18,233,821	22,097,273
Stoddard	-	-	-	-
Wayne	311,316,219	409,853,749	539,580,291	710,367,761
Southwest	**187,201,420**	**237,256,820**	**306,742,282**	**407,019,938**
Barry	66,601,856	79,557,156	95,032,503	113,518,093
Christian	17,497,720	19,810,309	22,428,542	25,392,813
Laclede	70,917,013	90,939,803	116,615,850	149,541,302
McDonald	18,099,644	20,650,192	23,560,156	26,880,182
Taney	14,085,186	26,299,360	49,105,232	91,687,547
St. Louis	**371,936,381**	**493,381,223**	**655,499,722**	**872,597,526**
Crawford	5,355,408	9,298,849	16,146,030	28,035,114
Franklin	18,454,766	23,001,977	28,669,611	35,733,737
Washington	348,126,206	461,080,397	610,684,080	808,828,674

Projected Shortleaf Pine Sawlog Wood of Sawtimber Volume (BF; Int'l ¼" Rule)



Shortleaf Pine Resources | Summary of Projected Volume at 10, 20, and 30 Years

The projections outlined in this section indicate a strong and sustainable future for Missouri's shortleaf pine resource. Over the next 30 years, the expected increase in merchantable bole wood, sawtimber sawlog volume (cubic feet), and sawtimber sawlog volume (board feet; International ¼" Rule) highlights the resilience of the state's pine forests and their continued role in the regional timber economy.

Key Findings and Implications

- **Substantial Growth Across All Categories**
  The projected increase in shortleaf pine volume across all regions suggests that current forest management practices are supporting long-term resource sustainability.

- **Regeneration and Recruitment are Critical**
  While overall projections indicate positive growth, the continued regeneration of young shortleaf pine stands will be essential to maintaining this upward trajectory beyond the next 30 years.

- **Regional Growth Disparities**
  While the Ozark and Southeast regions dominate shortleaf pine expansion, other regions, such as Southwest and St. Louis, will require strategic management to enhance their growth potential.

- **Data Limitations and Assumptions**
  These projections assume a constant growth rate, but actual trends may vary due to climate change, harvesting practices, land use shifts, and regeneration success. Continued monitoring and adaptive management will be necessary to refine these estimates over time.

Ensuring Long-Term Sustainability

Missouri's shortleaf pine resource is projected to be more than double the amount of sawlog and merchantable volumes over the next 30 years at current growth rates, speaking to the sustainability of building up the markets for the resource and promoting its use. Strategic management efforts will be key to ensuring that this resource remains resilient, productive, and sustainable for future generations.

To secure the long-term future of Missouri's shortleaf pine forests, emphasis should be placed on:

- **Active forest management strategies**, including thinning and prescribed burns to reduce competition and improve stand health.
- **Encouraging natural and artificial regeneration efforts** to sustain the pipeline of young pine stands.
- **Expanding research on regional growth dynamics** to refine future projection models and ensure adaptive forest management.

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MISSOURI SHORTLEAF PINE UTILIZATION

MARKET ASSESSMENT

CONTENTS

INTRODUCTION

This **Shortleaf Pine Market Assessment** is part of the broader *Missouri Shortleaf Pine Utilization Assessment*, a resource initiated by the Forest and Woodland Association of Missouri (FWAM) in partnership with the Missouri Department of Conservation, the L-A-D Foundation, and the Mark Twain National Forest to address the market barriers limiting shortleaf pine utilization. Recognizing the need to strengthen existing markets and uncover new opportunities for this underutilized species, FWAM and its partners developed the Assessment as a comprehensive resource for government agencies, loggers, sawmills, and secondary producers.

Mechanized Logging Operation in Shortleaf Pine Stand
Photo Credit: Ross, H. (2024). Renewable Resource Solutions, LLC. [Unpublished photographs].

By providing key data on Missouri-grown shortleaf pine, the report highlights targeted areas for product manufacturing growth and underscores how expanding these markets can foster sustainable forestry practices, boost economic development, and enhance ecological resilience throughout the state.

The *Missouri Shortleaf Pine Utilization Assessment* brings together extensive data and analysis to guide sustainable shortleaf pine management. Its **Resource Assessment** details the species' historical significance, current distribution, ownership patterns, and growth projections, while the **Business Plan** proposes a targeted example of industrial expansion. The **Market Assessment** presented here explores current industry capacity, supply-and-demand dynamics, potential product lines, and forest product manufacturing trends. It also examines opportunities for a collaborative branding initiative.

The Need for Market Expansion

Missouri's forest products industry is based on the 14.86 million acres of timberland which support a diverse range of commercial applications. Within Missouri's expansive timber resources, shortleaf pine (*Pinus echinata*), the state's only native pine species, once covered more than 6 million acres, but is now reduced to a small portion of that. Despite its decline, shortleaf pine holds substantial economic and ecological potential for Missouri's timber industry.

Historically, Missouri's shortleaf pine played a pivotal role in supporting regional sawmills, construction, and manufacturing. Today, shortleaf pine is substantially underutilized and comprises only 5% of Missouri's annual timber harvest, despite having viable applications across multiple sectors (Missouri Department of Conservation [MDC], 2022).

SHORTLEAF PINE ONLY ACCOUNTS FOR
5% OF HARVEST VOLUMES
IN MISSOURI ANNUALLY
despite a stable resource base and strong industry potential

To revitalize the shortleaf pine market, the Missouri Comprehensive Conservation Strategy (CCS) calls for expanded processing capabilities and enhanced integration into regional supply chains (CCS, 2022). In parallel, the Mark Twain National Forest's Collaborative Forest Landscape Restoration Project (CFLRP) has demonstrated that proactive forest management focused on shortleaf pine restoration can yield substantial economic benefits (Song & Aguilar, 2015). Together, these strategic measures reinforce the case for targeted investments to fully unlock the potential of Missouri-grown shortleaf pine.

Missouri's Competitive Advantage

The state's extensive timberland – concentrated primarily in the Ozark, Southeast, and Southwest regions – provides a stable supply of shortleaf pine resources. In addition, Missouri's central location and existing transportation infrastructure present logistical advantages for accessing regional and national markets.

This assessment integrates resource availability data from the U.S. Forest Service Forest Inventory and Analysis (FIA) program with industry and market information to assess economic feasibility to:

- Identify viable market opportunities for shortleaf pine in traditional and emerging sectors,
- Evaluate supply chain constraints and infrastructure needs for increased milling and processing capacity, and
- Develop a pro forma business model to support investment in shortleaf pine-based enterprises.

Creating A Strategic Path Forward

This report offers a pragmatic, data-driven framework for unlocking the full potential of Missouri's shortleaf pine markets while aligning economic growth with long-term restoration objectives. This strategy synthesizes resource, industry, and market information from federal, state, and private datasets to identify the most promising commercial applications.

In addition to emerging markets such as mass timber, this report offers unique strategies for utilization in traditional markets. For instance, Missouri's abundant post and pole shortleaf pine resource presents a strong opportunity to develop state-level initiatives that harness its excellent mechanical properties for critical highway infrastructure projects (Lebow et al., 2014). Shortleaf pine's ready treatability and its proven success in states like Wisconsin make creating a state-level initiative to utilize Missouri-grown shortleaf posts and poles in highway guardrails, signage, and other load-bearing applications a market with a lot of potential.

As Missouri's only native pine species, shortleaf pine embodies the state's natural heritage and resonates with regional pride and sustainability initiatives. Additionally, its slower growth and tighter grain distinguish it from plantation shortleaf pine produced in other regions, resulting in superior durability, workability, and aesthetic appeal, attributes highly prized in premium, appearance-driven markets. Capitalizing on its unique values, the assessment explores how a dedicated branding initiative can drive demand for Missouri-grown shortleaf pine lumber as a premium product choice for architects, designers, and manufacturers seeking fine-grain, custom millwork, architectural trim, cabinetry, and decking. Anchored by a cohesive message such as "*Strength Rooted in Tradition*," the campaign aims to foster industry collaboration and establish access to new lumber markets.

Beyond infrastructure and branding for premium lumber markets, the assessment explores market opportunities for:

- Mass Timber: Leveraging shortleaf pine's structural attributes to enter the growing mass timber market,
- Wood Pellets: Capitalizing on the biomass potential for renewable energy supply for the global markets, and
- Wood Shavings: Enhancing local processing capacities and creating value-added products for niche markets.

Conclusion

Missouri is well-positioned to reclaim its role as a leading shortleaf pine producer, with strong resource availability, market opportunities, and infrastructure potential. By leveraging public-private partnerships and targeted investments, the state can drive economic growth while promoting sustainable forestry practices. Strategic investments in shortleaf pine markets will help revitalize Missouri's softwood industry while also supporting long-term environmental stewardship and economic resilience.

FOREST PRODUCT MANUFACTURING | ECONOMIC IMPACT

Missouri's forest products industry plays a critical role in the state's economy, supporting thousands of jobs, generating significant tax revenue, and contributing billions in economic output. The Missouri Department of Conservation (MDC) has been tracking the industry's impact over the years, providing valuable insights into the health and sustainability of forest-based businesses. In 2023, the most recent available data, the forest products, wood, lumber, paper, and related industries contributed $11.7 billion to Missouri's economy (adjusted to 2024 dollars). These industries support approximately 37,500 jobs with a combined payroll exceeding $2.7 billion and generate $920 million in total tax revenue, including $148 million in state taxes (Treiman, 2024).

Shortleaf Pine on Landing | Mark Twain National Forest

Photo Credit: Ross, H. (2024). Renewable Resource Solutions, LLC. [Unpublished photographs].

The forest products industry encompasses a diverse range of operations, including logging and sawmill businesses, secondary wood manufacturing, furniture and cabinet production, paperboard manufacturing, and log home construction. Beyond direct employment and revenue generation, the sector also drives secondary economic effects through supply chain interactions and consumer spending. These secondary effects are divided into two key categories: indirect effects, which refer to changes in sales, income, or employment in industries supplying goods and services to forest products businesses, and induced effects, which result from household spending by employees within the sector. The wages earned by workers in logging, milling, and wood product manufacturing are reinvested into housing, utilities, food, and other consumer goods, creating a multiplier effect that stimulates regional economic growth (Treiman, 2024).

Mill Yard | Missouri Pallet Manufacturing Facility

Photo Credit: Ross, H. (2024). Renewable Resource Solutions, LLC. [Unpublished photographs].

Missouri's forest products industry is positioned for continued growth and adaptation, but faces challenges related to mill closures, market consolidation, and shifts in timber demand. Understanding regional industry strengths, infrastructure needs, and future investment opportunities is essential for maintaining competitiveness.

This section analyzes the forest industry's economic impact, covering key topics such as industry employment, regional mill distribution, logging sector trends, softwood and hardwood market demand, and high-production mill capacity. By examining these components, stakeholders can develop strategic initiatives to sustain Missouri's forest economy, expand processing capacity, and strengthen forest management practices moving forward.

FOREST INDUSTRY IMPACT ON MISSOURI'S ECONOMY

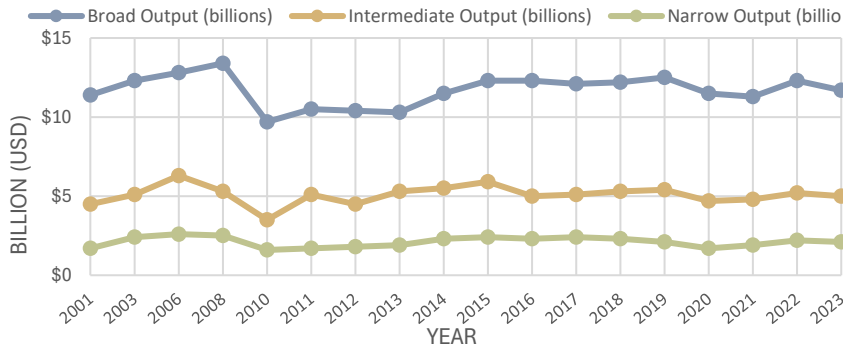
The forest products industry is a critical component of Missouri's economy, providing significant contributions to employment, manufacturing output, and rural development. This industry can be categorized into three economic scopes, each measuring different levels of sectoral contribution (Treiman, 2024): 1) narrow output which includes field and logging operations and primary wood processing mills, intermediate output which includes narrow output plus secondary wood processing companies, and broad output which includes intermediate output plus paper product manufacturing.

Impact of the Forest Product Industry on Missouri's Economy

Figure M1 (Treiman, 2024) shows the total economic impact of the forest products sector in Missouri has fluctuated over the past two decades, with broad output ranging from a low of $9.7 billion in 2010 to a peak of $13.4 billion in 2008 (all figures adjusted to 2024 dollars).

Figure M1: Economic Impact of Forest Industry by Scope | 2001 - 2023

Economic impacts of the forest products industry in Missouri, from 2001 to 2023 in 2024 USD, analyzed using IMPLAN and MDC data (Treiman, 2024).



The underlying data was compiled from multiple sources, including the U.S. Bureau of Economic Analysis, the U.S. Bureau of Labor Statistics, the U.S. Department of Agriculture, and the Missouri Department of Conservation (U.S. Bureau of Economic Analysis et al., n.d.).

The most recent data for 2023 reports a broad industry output of $11.7 billion. Using 2001 as the base year, the industry's performance peaked in 2008 and dipped in 2010 illustrating the variable nature of the industry.

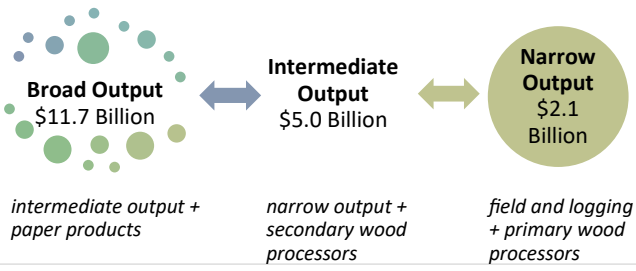
From 2001 to 2023, Missouri's forest products industry has experienced considerable fluctuations; notable trends include:

- The 2008 financial crisis resulted in a sharp decline, with broad output falling by 28% to $9.7 billion by 2010.
- Recovery began in 2011 and by 2014, economic recovery efforts had bolstered the sector, and broad output was $11.5 billion - driven by increased demand for lumber and wood-based products.
- The industry demonstrated resilience during the COVID-19 pandemic, experiencing only a moderate decline in 2020 and 2021 (down to $11.3 billion) before rebounding to $12.3 billion in 2022.
- There was a slight contraction in 2023 to $11.7 billion.

Comparative Industry Performance

Figure M2: 2023 Economic Contribution by Sector Type

Economic impacts of the forest products industry in Missouri in 2023 in 2024 dollars, analyzed using IMPLAN and MDC data (Treiman, 2024)



The intermediate and narrow output segments follow similar trends, reinforcing the interdependence of timber harvesting, processing, and market demand. **Figure M2** highlights the breakdown between the downstream processing industry that exists beyond initial harvesting and milling operations. This reinforces the economic importance of value-added wood products and paper to the economy. The paper products sector adds significant value to the industry. At this time, Missouri timber is not being consumed by the paper sector mill(s) located in the state. These mills produce value-added paper and paperboard products from paper sources not from pulp; however, Missouri timber has historically been supplied in the form of chips to Pheonix Paper in neighboring Kentucky.

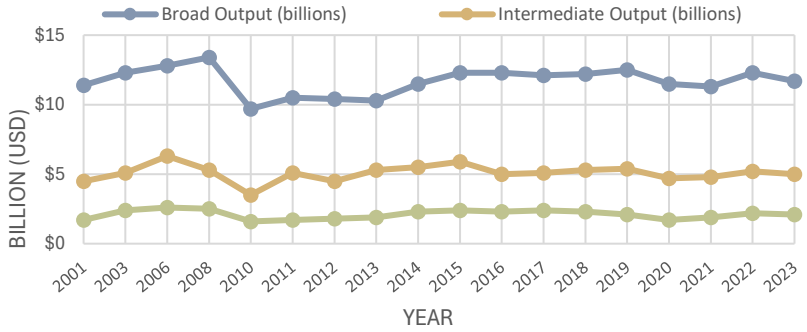
Forest Industry Employment

2001 – 2023 | Historical Forest Products Industry Employment Data

As shown in **Figure M3** (Treiman, 2024), employment in the forest products sector has fluctuated over the past two decades, with broad industry employment ranging from a high of almost 50,000 jobs in 2001 to a low in 2011. Using 2001 as the base year, employment levels have varied from 75% (2012) to 95% (2006) of the base, depending on industry scope. The decline in employment levels post-2006 coincides with broader economic shifts, including the 2008 financial crisis and changing consumer demand.

Figure M3: Forest Industry Employment by Scope | 2001 - 2023

Economic impacts of the forest products industry in Missouri, from 2001 to 2023, analyzed using IMPLAN and MDC data (Treiman, 2024).



The underlying data was compiled from multiple sources, including the U.S. Bureau of Economic Analysis, the U.S. Bureau of Labor Statistics, the U.S. Department of Agriculture, and the Missouri Department of Conservation (U.S. Bureau of Economic Analysis et al., n.d.).

Historical Employment Trends and Workforce Shift

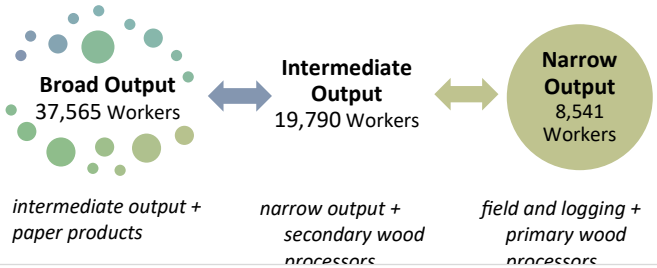
From 2001 to 2023, forest industry employment in Missouri is dynamic, mirroring national economic patterns. Following the recession, broad employment declined from 2006 to 2010. Though employment stabilized between 2015 and 2019, the industry experienced a small decline during the COVID-19 pandemic. Since then, employment levels have remained relatively steady, with broad employment reported at 37,565 jobs in 2023 (Treiman, 2024).

During on-site visits for this assessment, multiple forest product manufacturing facilities reported challenges in both finding and retaining reliable mill workers. Managers cited issues such as timeliness and inconsistent attendance. One facility addressed this obstacle by partnering with a local correctional facility to employ incarcerated individuals who were eligible for work release. The correctional facility provided round-the-clock transportation so workers could cover multiple shifts, and at least one of these employees secured a full-time position at the mill upon their release.

Comparative Workforce Performance

Figure M4: 2023 Employment by Sector Type

Number of workers in the forest products industry in Missouri in 2023, analyzed using IMPLAN and MDC data (Treiman, 2024)



Missouri's forest industry employment trends reflect broader national patterns in forestry and wood manufacturing. Technological advancements have improved labor efficiency, leading to lower employment numbers in logging and processing, even as output levels remain steady.

Figure M4 illustrates a comparison of 2023 employment levels across sectors and highlights the importance of a stabilized primary forest industry to supply the broader forest products sector.

Workforce Stability

The forest products industry is a major employer in Missouri, supporting thousands of jobs in logging, primary wood processing, secondary manufacturing, and paper production. However, frequent closures of individual mills and manufacturing facilities affect local employment levels. As the state's forest industry continues to evolve, ensuring job stability and growth will require sustained investment in manufacturing capacity, workforce training, and innovative hiring practices - such as employing incarcerated individuals who are eligible for work release.

Projected Growth

The forest products industry in Missouri exhibits a mixed but largely promising outlook for 2022 to 2032 based on long-term Forestry & Logging Industry employment projections (Missouri Economic Research and Information Center [MERIC], 2024). While the forestry and logging sector shows substantial growth, certain segments of the wood products manufacturing industry are projected to face slight declines.

Table M1 provides an overview of the industry's projected growth from 2022-2032, highlighting both challenges and opportunities. While a useful cue on the projected health of the state and specific industries, it is important to note that employment projections are based on historic industry employment trends and other factors are analyzed to project future industry employment, with industry staffing patterns used to estimate occupational employment projections.

Table M1: 2022-2032 | Missouri Forest Products Industry Employment Projection

Last Updated: 4/12/2024 (MERIC, 2024)

		Long-Term Employment Projection			
		Employment		Change	
Industry		2022	2032	2022-2032	
Code	Title	Est. Base	Projected	Numeric	%
-	**Total, All Industries**	3,134,123	3,270,283	136,160	4.3
110000	**Agriculture, forestry, fishing and hunting**	**25,213**	**27,621**	**2,408**	**9.6**
113000	*Forestry and logging*	*1,156*	*1,406*	*250*	*21.6*
115000	*Agriculture and forestry support activities**	*3100*	*3488*	*388*	*12.5*
321000	**Wood product manufacturing**	**7,041**	**6,973**	**(68)**	**(1.0)**
321100	**Sawmills and wood preservation**	**2,020**	**1,991**	**(29)**	**(1.4)**
322000	**Paper manufacturing**	**7,101**	**7,357**	**256**	**3.6**

** Industries in the Support Activities for Agriculture and Forestry subsector: provide support services that are an essential part of forestry production, may be performed by the forestry producing establishment or conducted independently as an alternative source of inputs required for the production process for a given forestry industry.*

The occupational projections estimate the number of new, transfer, and exit jobs openings that are expected to occur over the projection period. Events that happen after these projections were made could alter these projections figures.

Projected Logging Industry Employment

The forestry and logging sector (NAICS 113000) is anticipated to grow substantially, with employment projected to rise by 21.6%, from 1,156 jobs in 2022 to 1,406 in 2032 (MERIC, 2024). This increase reflects a higher demand for raw material supply and promises to bolster rural employment.

Projected Wood Products Manufacturing Industry Employment

The Wood Products Manufacturing industry (NAICS 321000) is projected to experience a slight employment decline of 1%, dropping from 7,041 jobs in 2022 to 6,973 by 2032. Similarly, the Sawmills and Wood Preservation sector (NAICS 321100) is expected to decrease by 1.4%. These contractions may stem from technological advances, competitive market pressures, or changing consumer demand.

By contrast, Paper Manufacturing (NAICS 322000) shows a more positive forecast with a projected 3.6% increase in employment, signaling steady demand for paper products (MERIC, 2024). However, national trends may not apply uniformly across Missouri. For example, International Paper has announced plans to close its sheet feeder facility in St. Louis in February 2025.

Mill Yard | Missouri Pallet Manufacturing Facility
Photo Credit: Ross, H. (2024). Renewable Resource Solutions, LLC. [Unpublished photographs].

FOREST INDUSTRY COMPANIES

Logging Industry

Missouri's logging industry plays a crucial role in the state's forest products sector, supporting sustainable timber harvesting and providing raw materials for sawmills, wood product manufacturers, and paper mills. While there is no comprehensive list of logging companies operating in Missouri, the Missouri Consulting Foresters Association maintains a database of loggers and timber purchasers, ensuring that landowners and foresters can connect with harvesters. As reported by the Missouri Consulting Foresters Association (Lohman, personal communication), the most recent version which was last updated in 2017 currently shows approximately 960 timber loggers/timber buyers across the state.

Missouri Training and Certification Programs

Recognizing the importance of well-trained loggers, the State of Missouri has established training and certification programs to enhance logging safety, promote sustainable harvesting practices, and support industry professionalism.

Missouri Master Logger Certification Program

The Missouri Master Logger Certification, managed by the Missouri Logging Council under the Missouri Forest Products Association, is a performance-based program recognizing professional logging companies for their adherence to state-specific best management and best business practices. This is done through third-party audits and approved via an anonymous review process with a Certifying Board consisting of an array of industry stakeholders.

Certified Master Loggers are distributed across Missouri's regions, with notable representation (54%) in the Ozark and Southeast regions combined, in alignment with the state's forest resource density. **Figure M5** shows Missouri Certified Master Logger companies by region. There are 24 certified companies as of this report writing.

The program strengthens industry standards and enhances the economic viability of Missouri's forest products sector through promotion of sustainable forest management, safety, and sound business practices, fostering trust with landowners and the public. It also seeks to improve the relationships between residents, landowners, loggers, mills, and consumers to find a balance between forest resource productivity and sustainability (Missouri Forest Products Association [MFPA], n.d.).

Figure M5: Missouri Master Loggers by Region

Missouri Master Logger Companies as of 2/2025 *(MFPA, n.d.)*

Central	**1**
Burke Sawmill	
Northeast	**2**
A. Brown Logging	
Terry Hicks Logging	
Ozark	**6**
Ferguson Logging	
Frizzell Sawmill & Logging	
Jeff Clark Logging	
LAD Forestry & Farms	
Ron Harper Logging	
Three Oaks Timber LLC	
Southeast	**7**
B & B Timber Company	
Brinkley Wood Products	
Dean Gipson Logging	
Ellington Manufacturing	
J & N Sinn Logging	
Price Sawmill	
Rustic Wood Products, Inc.	
Southwest	**3**
Burke Timber	
D&D Logging	
Turner Logging	
St. Louis	**5**
Adams Logging	
Big River Timber Company	
Jarvis Timber Company, LLC	
Jim's Tree Service	
John Evans Logging	
Total Master Logger Companies	**24**

Professional Timber Harvester (PTH) Program

Since 2000, the Missouri Department of Conservation (MDC) has required loggers to complete the Professional Timber Harvester (PTH) Program before harvesting timber on state-owned land (Northeast Missouri News, 2008). This five-day training session, conducted by the Missouri Forest Products Association (MFPA), provides hands-on instruction on safe, efficient, and sustainable timber harvesting. Many foresters also recommend using professional timber harvesters for private land timber sales as well, to ensure harvesting is conducted responsibly and sustainably. The PTH training program is affiliated with the Safety and Woods Worker (SAWW) Program, which is widely regarded as one of the leading hand felling training programs in the U.S.

Missouri's PTH program plays a critical role in ensuring logging safety and compliance with best management practices (BMPs). PTH-Certified entities must complete annual continuing education (CE) courses to maintain their training credentials. Since 1997, nearly 1,000 individuals have completed the program, with most maintaining their certification through annual (CE) requirements. As of 2024, 530 individuals (Lohman, personal communication), are up to date on PTH certification requirements (MFPA, n.d.).

This count is distinctly lower than the 960 loggers in the Consulting Foresters database, but this number includes only those loggers who are up to date on PTH training credentials. There is no general requirement for loggers to take this training; it is only required to harvest state lands, whereas the list maintained by the Consulting Foresters Association does not have any training requirements.

Harvesting Techniques

Mechanized logging, which utilizes advanced machinery like processors, feller bunchers, and forwarders has transformed the forestry industry by enhancing both efficiency and safety. These machines are capable of quickly cutting and collecting multiple trees, markedly increasing productivity compared to traditional hand-felling methods. The use of mechanized logging improves operational efficiency, allowing for higher timber yields while decreasing costs associated with labor and time (Blinn & Kilgore, 2005).

Despite advancements in mechanization, chainsaw-based hand felling remains common in areas where steep terrain or sensitive forest conditions make large machinery impractical (Blinn & Kilgore, 2005). Manual felling also allows for precise tree selection, especially in uneven-aged management systems where minimizing soil disturbance and protecting remaining trees is a priority. Additionally, traditional methods can be more flexible for small-scale operations or where the capital outlay for mechanized equipment is not financially feasible (MDC, 2014).

Nevertheless, many Missouri loggers are transitioning to mechanized harvesting. Most companies now employ cable or grapple skidders - if not forwarders - and some have incorporated processors. Still, a portion of the state's logging firms operate at a scale that does not support such significant investments and thus continues to rely on conventional techniques.

Missouri's logging industry has been relatively measured in adopting mechanized logging practices. This cautious approach reflects the state's commitment to preserving traditional methods that align with local values and the unique characteristics of its forests. This preservation of conventional techniques underscores the resilience and deep-rooted traditions held by Missourians in managing their natural resources. While mechanized logging offers clear benefits, Missouri's forestry sector exemplifies the balance between modernization and tradition, ensuring that local values and environmental considerations remain integral to timber harvesting practices.

Mechanized Timber Harvest Operation | Mark Twain National Forest Timber Sale
Photo Credit: Ross, H. (2024). Renewable Resource Solutions, LLC. [Unpublished photographs].

Whole Tree Timber Harvest Operation | Private Timber Sale
Photo Credit: Ross, H. (2024). Renewable Resource Solutions, LLC. [Unpublished photographs].

Manufacturing Industry

The forest products manufacturing industry plays a crucial role in processing timber resources into finished products, supplying both domestic and export markets. This sector encompasses primary and secondary wood processing facilities, including sawmills, veneer plants, post and pole mills, cooperage mills, paper product manufacturers, and engineered wood product facilities. These businesses contribute substantially to the state's economy by generating employment, tax revenue, and industrial output, while also influencing timber demand, regional wood flow, and supply chain dynamics.

Assessing historical and current market saturation, geographic concentrations, species and product demand, and sourcing trends is essential to understanding the manufacturing sector's economic stability and growth potential. To achieve this, two primary data sources were analyzed: the Timber Products Output (TPO) database and Forisk market data.

Timber Products Output

The USDA Forest Service's Forest Inventory and Analysis (FIA) program, in collaboration with state natural resource agencies such as the Missouri Department of Conservation (MDC), and university partners, assesses past trends, current status, and future potential of forests and forest products. Within FIA, the Timber Products Output (TPO) program conducts annual surveys of primary wood processing facilities to track timber removals and industrial uses of roundwood, reporting on volumes received and residues generated by the primary forest industry at both the tree species and county levels. These datasets provide critical insights for stakeholders, enabling informed decision-making regarding forest resource availability and harvest intensity (Markowski-Lindsay, Brandeis, & Butler, 2023).

In 2023, Missouri Department of Conservation foresters conducted interviews with 137 mill owners and operators, representing a random sample of primary wood processors across the state, collecting operational data for the 2022 calendar year. Following USDA survey guidelines, the sample was drawn from approximately 320 mills listed in MDC's online database of primary mills. The study achieved a 69% response rate, with 95 completed surveys (Treiman & Morris, 2023). The survey is voluntary, and it is challenging to get some of the facilities to report data due to the time and effort required to compile and submit data, but also due to privacy concerns and a somewhat prevalent perceived lack of trust in the government.

> ACCURATE DATA IS ESSENTIAL FOR RESOURCE PLANNING AND INDUSTRY GROWTH
>
> Low TPO survey participation forces reliance on outdated figures and limits informed decision-making in wood procurement, forest management, and market development.

Forisk

Forisk is an independent forest economics research firm that provides forward-looking analysis to professionals and investors in wood markets, bioenergy, timberlands, and timber real estate investment trusts. The firm evaluates forest supplies, wood demand, and timber pricing to develop forecasts and strategic guidance for its clients. Forisk's approach emphasizes rigorous research, clear communication, localized market analysis, and direct forestry expertise. Given the capital-intensive nature of the forest industry, investment and allocation decisions rely on localized analysis and accurate market forecasts to guide strategic planning (Forisk Consulting, LLC, n.d.).

Historical Analysis of Missouri's Forest Product Manufacturing Sector

The USDA Forest Service's Timber Products Output (TPO) program has been instrumental in tracking changes in Missouri's forest products sector over time. To analyze long-term industry trends, **Table M2** provides TPO data from 2012 to 2019 reviewed through the USFS TPO Interactive Reporting Tool TPO (U.S. Department of Agriculture [USDA], Forest Service, n.d.), and 2022 data sourced directly from the Missouri Department of Conservation's (MDC) 2022 TPO report (Treiman & Morris, 2023).

Trends in the Number of Mills in Operation (2012-2022)

As shown in **Table M2**, active forest product manufacturing facilities have been declining industry wide. From 2019 to 2022, the industry experienced a 13% reduction in overall capacity, with a net loss of 47 milling operations. Sawmills accounted for a 10% contraction during this period, reflecting a net loss of 30 operations (Treiman & Morris, 2023).

- From 2015-2019, there appears to have been a ~20% contraction in both the hardwood and softwood sawmill industries (net loss of 56 sawmills); however, sawmills with mixed procurement experienced a 6% increase during the same period, adding five mills (Treiman & Morris, 2023). It is important to note that this loss/increase may reflect existing mills adapting their procurement strategies to remain competitive vs. establishment of new companies.

- As reported in the Missouri 2022 TPO Report (Treiman & Morris, 2023), of the 275 sawmills, there were:
  - **26 large mills** (over 5 million board feet annually)
  - **107 medium mills** (1- 5 million board feet annually)
  - **142 small mills** (under 1 million board feet annually)

- Overall, sawmills account for 91% of the forest product manufacturing sector in the state.

Concentration of Mill Operations (2022)

Based on **Table M3**, approximately 46% of all sawmills in Missouri are located in the Ozark and Southeast regions, reflecting the state's strategic distribution of timber supply and historical investments in forest product infrastructure. The Ozark region alone accounts for 76 sawmills, while the Southeast region contains 50 sawmills, thereby reinforcing these areas as Missouri's primary timber-processing hubs.

Table M2: 2012-2022 | Number of Mills in Operation

TPO Interactive Reporting Tool (USDA, Forest Service, n.d.); *MDC 2022 TPO Report* (Treiman & Morris, 2023)

	2012	2015	2018	2019	2022
Bark/mulch mill	1		2	2	
Biomass/energy plant		7	4	10	
Concentration/export yard		7	4	3	
Fuelwood		1	1	2	
Log home mill (inc. Viga and Latilla mills)	13	18	11	12	
Miscellaneous mill	2	1	2	1	
Post mill	6	5	5	9	
Pulp/Paper mill	1	1	1	1	
Sawmill (incl. cooperage/stave, handle mills)	377	358	327	307	277
Veneer/plywood mill	2				
Total	**402**	**398**	**358**	**350**	**303**

Below is a breakdown of companies by product type. Since some firms produce more than one product, a single company may be counted once for each product category it manufactures. The totals for each category represent the number of companies that specified using Hardwood, a combination of Hardwood/Softwood, or Softwood.

	2012	2015	2018	2019	2022
Hardwood	**270**	**269**	**218**	**220**	**^**
Bark/mulch mill			1	1	
Biomass/energy plant	1		1	1	
Concentration/export yard		6	4	10	
Fuelwood		7	4	3	
Log home mill (incl. Viga and Latilla mills)		1	1	2	
Miscellaneous mill	7	5	4	4	
Post mill				1	
Pulp/Paper mill	1	1	1	1	
Sawmill (incl. cooperage/stave, handle mills)	259	249	202	197	
Veneer/plywood mill	2				
Hardwood/Softwood	**99**	**96**	**111**	**99**	**^**
Biomass/energy plant			1	1	
Concentration/export yard		1			
Miscellaneous mill	2	5	3	3	
Pole mill	1	1			
Post mill	1		1	1	
Sawmill (incl. cooperage/stave, handle mills)	95	89	106	94	
Softwood	**33**	**33**	**29**	**31**	**^**
Bark/mulch mill				2	
Miscellaneous mill	4	8	4	5	
Pole mill	1		2	1	
Post mill	5	5	4	7	
Sawmill (incl. cooperage/stave, handle mills)	23	20	19	16	

^No species level data available for 2022; mill types have been left blank unless a direct alignment was possible.

Table M3: 2022 | Number of Mills by Type and Region

MDC 2022 TPO Report (Treiman & Morris, 2023)

	Charcoal	Cooperage	Broker	Other	Posts	Sawmill	Total
Central		1		5		19	**25**
Kansas City						13	**13**
Northeast			1	3		34	**38**
Northwest			1			23	**24**
Ozark	5	1		2	2	76	**86**
Southeast			3	2		50	**55**
Southwest				1		35	**36**
St. Louis				1		25	**26**
Total	**5**	**2**	**5**	**14**	**2**	**275**	**303**

Number of Mills and Maximum Capacity Wood Demand

Missouri's forest products manufacturing sector is a critical driver of the state's timber economy, with processing facilities operating at varying capacities to meet market demands. The Forisk Q2 2024 dataset reviewed in **Table M4** provides insights into the estimated wood demand at full operational capacity, offering an assessment of potential infrastructure needs if all mills operated at 100% utilization (Forisk Consulting, LLC, 2024).

Forisk's dataset does not represent a full market inventory; only large capacity sawmills and plywood/veneer mills meeting minimum annual production thresholds (5 and 10 million board feet in annual production respectively) are included. At full operational capacity, these select manufacturing facilities would require approximately 3.17 million tons of wood annually across 42 mills. Collectively, the Ozark and Southeast regions account for 58% of total potential capacity (1.83 million tons) (Forisk Consulting, LLC, 2024).

- **Southeast Region:** The largest single wood-consuming region with 949,950 tons of potential annual capacity across 10 mills. This region also has the majority of the potential softwood demand (204,150 tons) across 1 lumber mill (72,900 tons) and 1 chip mill (131,250 tons).

- **Ozark Region:** The second largest wood-consuming region, with 876,110 tons of potential annual capacity across 15 high-production mills. The industry is heavily concentrated in hardwood production, with only 36,685 tons of potential softwood consumption across two lumber mills.

- Notably, the Kansas City region does not currently have any high-production facilities. The 5 remaining regions – central, northeast, northwest, St. Louis and Southwest – have the remaining capacity with 41% of the state's high-production mills spread across these regions. In this 5-region area, there were two lumber mills – both in the St. Louis region – that noted potential softwood capacity, accounting for a potential demand of 46,523 tons.

High-Production Mill Softwood Capacity

Softwood production capacity in Missouri is a smaller but still significant portion of the state's overall wood demand, with an estimated total of 287,358 tons of annual softwood production capacity. This accounts for approximately 9% of the total annual potential mill capacity reported in **Table M4**.

Table M4: Q2 2024 Estimated Wood Demand at Full Capacity by Region

Source: Forisk Consulting, LLC. (2024). Missouri Forest Products Industry: Q2 2024 Mill Capacity and Wood Demand Analysis. May 2024

	Wood Demand at Capacity (tons)	Number of Mills
CENTRAL	**306,930**	**3**
HARDWOOD	**306,930**	**3**
Lumber	***110,180***	***2***
Stave (Barrel)	***196,750***	***1***
NORTHEAST	**94,440**	**2**
HARDWOOD	**94,440**	**2**
Lumber	***55,090***	***1***
Lumber, Pallet	***39,350***	***1***
NORTHWEST	**110,180**	**2**
HARDWOOD	**110,180**	**2**
Lumber	***110,180***	***2***
OZARK	**876,110**	**15**
HARDWOOD	**774,730**	**13**
Lumber	***582,550***	***9***
Lumber, Other	***104,090***	***2***
Flooring	*49,000*	*1*
Pole	*55,090*	*1*
Pellet, Domestic	***33,000***	***1***
Stave (Barrel)	***55,090***	***1***
SOFT/HARD	**22,680**	**1**
Lumber	***22,680***	***1***
HARD/SOFT	**78,700**	**1**
Lumber, Other	***78,700***	***1***
Boards	*78,700*	*1*
SOUTHEAST	**949,950**	**10**
HARDWOOD	**590,250**	**8**
Lumber	***590,250***	***8***
SOFT/HARD	**97,200**	**1**
Lumber	***97,200***	***1***
MIXED	**262,500**	**1**
Chips	***262,500***	***1***
SOUTHWEST	**506,270**	**5**
HARDWOOD	**506,270**	**5**
Lumber	***165,270***	***3***
Pellet, Domestic	***341,000***	***2***
ST. LOUIS	**329,610**	**5**
HARDWOOD	**188,880**	**3**
Lumber	***188,880***	***3***
SOFT/HARD	**22,680**	**1**
Lumber	***22,680***	***1***
HARD/SOFT	**118,050**	**1**
Lumber, Pallet	***118,050***	***1***
GRAND TOTAL	**3,173,490**	**42**

SPECIES	DESCRIPTION
HARDWOOD	100% Hardwood
HARD/SOFT	Hardwood (75%) and Softwood (25%)
MIXED	Hardwood (50%) and Softwood (50%)
SOFT/HARD	Softwood (75%) and Hardwood (25%)

Category	Mill Types Included
Sawmills	5+ MM BF annual production: hard and softwood sawmills
Structural Panel & Veneer	10+ MM BF annual production: plywood and veneer mills
OSB and Mass Timber	OSB and Mass Timber mills (those producing glulam, cross-laminated timber, mass plywood panels)
Engineered Wood	mills producing I-joists, strand lumber, laminated veneer lumber (LVL), fingerjoint millwork, rimboard, matting, heavy timbers
Fiber & Biomass Processing	pulp mills, wood pellet plants, wood chip mills, panel mills

EXISTING FOREST PRODUCT PRODUCTION

The following tables are derived from the 2018 TPO dataset reviewed through the USFS TPO Interactive Reporting Tool TPO (U.S. Department of Agriculture [USDA], Forest Service, n.d.).

Raw Material Production Volumes

Statewide Raw Material Production

As demonstrated in **Table M5**, Missouri's total roundwood production in 2018 was 128,140 cubic feet (MCF), with hardwood species making up the majority of harvested timber (USDA, Forest Service, n.d.). The breakdown by species class and ownership source highlights the key contributors to Missouri's timber supply.

Hardwood vs. Softwood Production

Missouri's roundwood supply is overwhelmingly dominated by hardwood species (92% of total roundwood volume) and roundwood harvested from private landowners, underscoring the importance of engaging private landowners in active forest management.

- **75% Private Landowners:** 98,822 MCF
- **14% National Forests:** 17,955 MCF
- **9% Other Public Lands:** 11.363 MCF

Softwood Production and Utilization

As demonstrated in **Table M5** and **M6**, softwood roundwood production is a small but significant segment of the total harvest.

Missouri's Softwood Roundwood Sources

- **70% Private Landowners** 5,031 MCF
- **21% National Forests:** 1,468 MCF
- **9% Other Public Lands:** 639 MCF

Softwood Products Manufactured

- **73% Saw Logs:** 5,259 MCF
- **17% Poles, Posts, Pilings:** 1,204 MCF
- **7% Miscellaneous Wood Products:** 492 MCF
- **3% Bioenergy/Fuelwood:** 175 MCF

Table M5: 2018 Volume of Roundwood Production by Species Type

Volume (MCF) of roundwood by ownership class // Volume (MCF) of industrial timber received by primary timber-processing facilities timber product, Missouri,2019 (USDA, Forest Service, n.d.)

	SOURCE OWNERSHIP (MCF)			TOTAL ROUNDWOOD	
	National Forest	Other Public	Private	Harvested	Exported
Hardwood	**16,485**	**10,724**	**93,791**	**121,002**	**3,946**
Bioenergy/Fuelwood	262	473	923	1,658	**12**
Miscellaneous	132	136	2,816	3,084	**2,737**
Poles, Posts, Pilings	20	6	103	129	**0**
Saw logs	16,071	10,109	89,949	116,129	**1,197**
Softwood	**1,470**	**639**	**5,031**	**7,140**	**9**
Bioenergy/Fuelwood	29	51	95	175	**0**
Miscellaneous	9	16	476	500	**9**
Poles, Posts, Pilings	230	145	829	1,204	**0**
Saw logs	1,202	427	3,631	5,259	0
TOTAL	**17,955**	**11,363**	**98,822**	**128,140**	**3,955**

The following are the definitions from TPO Reporting

Exported is the amount of roundwood harvested in a State and processed in another State

Table M6: 2018 Volume (MCF) of Roundwood Processed by Primary Timber-Processing Facilities by Species Type

Volume (MCF) of industrial timber received by primary timber-processing facilities by species group and timber product, Missouri, 2019 (USDA, Forest Service, n.d.)

	SOURCES OF ROUNDWOOD PROCESSED (MCF)		TOTAL ROUNDWOOD PROCESSED IN MISSOURI (MCF)
	Missouri	Imported	
Hardwood	**117,056**	**7,554**	**124,610**
Bioenergy/Fuelwood	1,647	0	1,647
Miscellaneous	347	203	551
Poles/Posts/Pilings	130	0	130
Saw logs	114,931	7,351	122,282
Softwood	**7,130**	**794**	**7,924**
Bioenergy/Fuelwood	175	0	175
Miscellaneous	492	267	758
Poles/Posts/Pilings	1,204	0	1,204
Saw logs	5,259	527	5,787
TOTAL	**124,186**	**8,348**	**132,534**

The following are the definitions from TPO Reporting

Retained: ("Missouri") amount of roundwood harvested in the State and processed in the State

Imported: amount of roundwood harvested in another State and processed in the State

Receipts is the total amount processed in a State **Retained + Imported = Receipts**

Volume of Roundwood Imports & Exports

Missouri's timber trade is shaped by long-term trends in wood product movement, with import and export volumes varying by species, product type, and regional market demand.

NET IMPORT-EXPORT DEFICIT: 4,393 MCF

MORE ROUNDWOOD IS IMPORTED THAN IS EXPORTED

SUGGESTS INDUSTRY DEMAND IS HIGHER THAN PRODUCTION

Table M6 (USDA, Forest Service, n.d.) demonstrates that imports supplement 6% (8,348 MCF) of roundwood consumption, and that Missouri has a net deficit of 4,393 MCF, importing more wood than is exported. This deficit suggests that Missouri's processing sector requires more raw material than the state currently produces or harvests. Though 93.7% of

processed roundwood is already sourced from in-state forests, there is room to further reduce reliance on imports by optimizing local forest management and expanding in-state harvesting. While the Missouri TPO Reports available at the time of publication provide additional insights into timber imports with regard to source and average, detailed information on exports was unavailable at the time of publication.

Roundwood Imports

While year specific data was not available from TPO at the time of writing, **Table M7** illustrates the average annual roundwood imports (from 2012-2018) by state. Missouri imports an average of 54,920.1 green tons of timber annually, with saw logs making up over 99% (54,134.4 green tons) of total imports. Missouri's saw log imports are concentrated in a few key states, with Arkansas, Illinois, and Kansas accounting for nearly 78% of total roundwood imports. Notably, 785.7 green tons of miscellaneous wood imports are sourced solely from Illinois.

Table M7: 2012-2018 | Average Annual Imports by State and Product Type

Industrial timber imports by timber product and major species group (green tons) (USDA, Forest Service, n.d.)

	Roundwood
Miscellaneous	**785.7**
Illinois	785.7
Sawlogs	**54,134.4**
Arkansas	*16,512.9*
Illinois	*13,859.0*
Iowa	*1,355.7*
Kansas	*11,894.6*
Kentucky	*3,392.1*
Mississippi	*1,278.6*
Nebraska	*544.1*
Oklahoma	*4,018.9*
Tennessee	*1,278.6*

Primary Mill Residue Production

Missouri's forest products industry generates a significant volume of mill residues as a byproduct of primary wood processing. As demonstrated in **Table M8,** the total mill residue output was 1,886,502 tons in 2018 (USDA, Forest Service, n.d.).

The primary residue categories include bark (22%), coarse residues such as chips, slabs, and edgings (52%), and fine residues like sawdust (26%). Hardwood saw logs produced the majority of these residues, accounting for ~95% of coarse residue and fine sawdust, reflecting the dominance of hardwood in Missouri's sawmilling sector. Softwood residues, while significantly lower, still totaled 98,215 tons, primarily from saw log processing.

Table M9: 2018 | Mill Residue Volume by Species Type

Primary mill residue volume (green tons) by roundwood type, species group, and residue type, Missouri, 2019 (USDA, Forest Service, n.d.)

	MILL RESIDUE (Green Tons)			
	Bark	Coarse Residue*	Sawdust	Total
Hardwood	**394,094**	**923,602**	**470,591**	**1,788,287**
Bioenergy/Fuelwood	171	402	340	913
Miscellaneous	1,435	2,685	1,979	6,099
Poles/Posts/Pilings	643		8	651
Saw logs	391,845	920,514	468,265	1,780,624
Softwood	**22,261**	**46,701**	**29,252**	**98,215**
Miscellaneous	1,948	5,676	3,307	10,932
Poles/Posts/Pilings	4,448	686	3,043	8,177
Saw logs	15,865	40,338	22,903	79,106
Total	**416,356**	**970,302**	**499,844**	**1,886,502**

*Chips, slabs, edgings, trims, cores, etc.

Residue Markets

Hardwood residues dominate Missouri's mill byproducts, comprising 95% of total residues, with miscellaneous byproducts accounting for 64%, followed by fiber byproducts (13%) and fuel byproducts (13%). Though softwood residues only account for 5% of all mill residues (98,215 tons) - and 87% going to miscellaneous byproducts - 70,870 tons (3%) remain unutilized, highlighting an opportunity to enhanced processing, market development, and bioenergy initiatives. (USDA, Forest Service, n.d.)

Table M9: 2018 | Mill Residue Markets by Species and Type

Disposition of mill residue at primary wood-using facilities by residue use, major species group, and type of residue (green tons), Missouri, 2019 (USDA, Forest Service, n.d.)

	MILL RESIDUE BYPRODUCTS (Green Tons)				
Residue Type	Fiber	Fuel	Misc.	Not Used	Total
Hardwood	247,617	252,958	1,220,042	67,671	**1,788,287**
Bark	30,560	38,761	307,370	17,404	**394,094**
Coarse Wood	193,021	114,258	583,150	33,172	**923,602**
Fine Wood	24,036	99,938	329,523	17,095	**470,591**
Softwood	3,622	5,867	85,526	3,199	**98,215**
Bark		526	21,452	283	**22,261**
Coarse Wood	1,992	1,322	42,763	624	**46,701**
Fine Wood	1,630	4,019	21,311	2,292	**29,252**
Total	**251,239**	**258,825**	**1,305,568**	**70,870**	

Efficient residue management is essential for the sustainability of Missouri's forest sector and for minimizing waste. Expanding softwood processing could significantly increase the availability of residues for engineered wood products and biomass markets. Establishing stable markets for these softwood byproducts is crucial to the success of this expansion.

SHORTLEAF PINE | UTILIZATION

In recent years, markets for shortleaf pine have been minimal or nonexistent, making it difficult for forest managers to sell timber containing a significant pine component. Due to the lack of viable markets, many landowners and managers have adopted a "let them grow big" approach, opting to leave shortleaf pine standing rather than harvesting it. In cases where pine removal was necessary for silvicultural objectives, some managers reported felling trees and leaving them on the ground due to the absence of buyers.

To assess current shortleaf pine utilization and market potential, two datasets were reviewed:

- 2022 Timber Products Output (TPO) Survey – Provided by the Missouri Department of Conservation (Morris, 2024), this dataset offers insights into pine utilization across Missouri's forest products industry.
- 2018 Forest Inventory and Analysis (FIA) Data – Provided the raw data to calculate growth-to-drain ratios, which compare merchantable bole wood growth to removals to assess sustainable harvest levels.

Shortleaf Pine Harvest | Mark Twain National Forest Timber Sale

Photo Credit: Ross, H. (2024). Renewable Resource Solutions, LLC. [Unpublished photographs].

While shortleaf pine remains underutilized, FIA and TPO data confirm its sustainable growth potential, particularly at moderate harvest levels. Expanding market opportunities for shortleaf pine could enhance harvest feasibility, support forest management objectives, and provide economic benefits to landowners and mills willing to process this resource. Strengthening demand would improve resource utilization and ensure the long-term viability of Missouri's shortleaf pine forests.

CURRENT PINE UTILIZATION IN MANUFACTURING

The 2022 Timber Products Output (TPO) survey dataset (Morris, 2024) provides insights into pine utilization across Missouri's forest products industry. Of the 264 mills surveyed, 59 mills (22%) reported using shortleaf pine in their manufacturing processes, though specific volume data was not provided. Those mills processed 27,468 million board feet in 2022.

Regional Distribution of Current Shortleaf Pine Utilization

Table M10 provides insight into the regional distribution of mills using shortleaf pine. The Ozark region had the highest concentration of pine-utilizing mills (34 of 72 mills, 47%), followed by the Southeast region (16 of 50 mills, 32%). Other regions, such as Central (1 mill), Southwest (1 mill), and St. Louis (7 mills), report limited pine use.

Despite these figures, 78% of mills (205 of 264) did not report using shortleaf pine, reflecting their limited commercial demand. Several regions, including Kansas City, Northeast, and Northwest, did not report pine utilization among surveyed mills.

Table M10: 2022| Total Mills

Unpublished MDC 2022 TPO Data (Morris, 2024)

Region	Not Utilizing Pine	Utilizing Pine	Total Mills
Central	24	1	25
Kansas City	10		10
Northeast	35		35
Northwest	15		15
Ozark	38	34	72
Southeast	34	16	50
Southwest	32	1	33
St. Louis	17	7	24
Total	205	59	264

*75 companies without active reporting

Types of Mills Utilizing Shortleaf Pine

Table M11 outlines the various types of products produced by mills that reported using shortleaf pine. Notably, the most commonly produced product is ties (54 mills) followed by lumber (40 mills), and pallet lumber (31 mills). Since this product data reflects the number of mills producing each item (rather than mill count), these figures highlight product diversity rather than mill specialization.

Key Findings

- Sawn products dominate production, with 143 instances of mills reporting output.
- Ties and pallet lumber production are also significant, with 54 and 31 mills, respectively.
- Sawn products dominate production, with 143 mills reporting output.
- Ties and pallet lumber production are significant, with 54 and 31 mills engaged in their manufacturing, respectively.
- The Ozark and Southeast regions lead in shortleaf pine utilization, accounting for over 87% of mills using pine. Industrial lumber products are the primary output in both regions with most mills manufacturing ties and pallet lumber.

Table M11: 2022| Number of Shortleaf Pine Manufacturers by Product Type

Unpublished MDC 2022 TPO Data (Morris, 2024)

Below is a breakdown of companies by product type. Since some firms produce more than one product, a single company may be counted once for each product category it manufactures. The totals represent the number of companies that reported manufacturing each product type.

Product Types	Central	Ozark	Southeast	Southwest	St. Louis	Total
SAWN PRODUCTS	**1**	**81**	**46**	**1**	**14**	**143**
Lumber		**22**	**14**	**1**	**3**	**40**
Cants		*6*	*4*		*1*	***11***
Dimensional		*1*				***1***
Flooring		*1*				***1***
Grade		*3*	*1*		*1*	***5***
Live edge					*1*	***1***
Unspecified Lumber		*11*	*9*	*1*		***21***
Industrial Products	**1**	**55**	**32**		**9**	**97**
Blocking		*6*	*4*		*1*	***11***
Pallet Lumber		*18*	*12*		*1*	***31***
Slabs					*1*	***1***
Ties	*1*	*31*	*16*		*6*	***54***
Post & Pole		**4**			**2**	**6**
Poles		*1*				***1***
Posts		*3*			*2*	***5***
MANUFACTURED PRODUCTS		**2**				**2**
Pallets, Finished		*2*				***2***
BYPRODUCTS, FUEL, & SPECIALTY PRODUCTS	**3**	**7**	**5**		**1**	**16**
Bedding	**1**	**1**	**1**			**3**
Bedding, Excelsior	*1*		*1*			***2***
Bedding, Pellet		*1*				***1***
Wood Chips & Particles	**1**	**3**	**2**			**6**
Mulch	*1*	*1*	*2*			***4***
Sawdust		*1*				***1***
Shavings		*1*				***1***
Wood Fuels	**1**	**1**				**2**
Biochar	*1*					***1***
Charcoal		*1*				***1***
Other		2	2		**1**	**5**
Craft					*1*	***1***

GROWTH-TO-DRAIN

Growth to drain estimates can be used in conjunction with growth and removal data to help determine how sustainable potential management schemas are. The growth to drain ratio provides a snapshot and can be used to make initial feasibility assessments. When a mill or plant is looking to be established, these can be further investigated in conjunction with net growth projections to determine the amount of timber available in a specific geography within the context of current markets.

To estimate growth-to-drain ratios, FIA average annual gross growth of merchantable bole wood volume of growing-stock trees and average annual removals of merchantable bole wood volume of growing-stock trees on timberland were summarized; sawlog growth and sawlog removals are a subset of growing stock data. Removals include timber harvest removals and other removals, which includes land clearing.

Growth-to drain ratios were calculated by dividing growth by removals. **Table M10** identifies growth to drain ratios at the county and state level for various harvest scenarios. Total harvest volumes are shown for Year 30 at current annual harvest

volumes, at harvest of 2% of standing volumes annually, and at harvest of 3% of standing volumes annually. The percentage of current volumes remaining at year 30 is also shown for each of these harvest schemas, and growth to drain ratios are shown for the same. A growth to drain ratio of more than 1 indicates that there is more volume growth than there is volume harvested in the year. A growth to drain ratio less than 1 indicates that more wood was harvested than was put on by growth. Note that when there aren't any removals in a county, a growth to drain rate is not reported due to the mathematical nature of the ratio; however, it should be noted that these areas have substantial growth and no removals.

County level growth to drain ratios after 30 years of harvesting at current annual harvest levels are erratic. Harvesting 2% of standing volume over 30 years resulted in growth exceeding removals in most counties, yielding growth-to-drain ratios between 0.55 - 3.15 and annual harvest volumes ranging from ~259,000 – 1.4 million cubic feet at the county level. Total harvest volume at this level would be 9.3 million cubic feet. A projected harvest of 3% of the standing volume over 30 years indicated that removals would slightly outpace growth. Under this scenario, annual harvest volumes would range from ~340,000 - 1.8 million cubic feet, totaling 1.25 billion cubic feet harvested over 30 years.

Table M12: 30 Year Growth to Drain Estimates at 2% and 3% Harvest of Standing Timber Volume (Cubic Feet)

Average Annual Growth to Drain of Shortleaf Pine Removals of Growing Stock and Saw Timber Trees (CF) on Timberland by Region and County. Average annual gross growth of merchantable bole wood volume of growing-stock trees (at least 5 inches d.b.h.), in CF // Average annual harvest removals of merchantable bole wood volume of growing-stock trees (at least 5 inches d.b.h.), in CF // Average annual other removals of merchantable bole wood volume of growing-stock trees (at least 5 inches d.b.h.), in CF, on timberland of Missouri, by Species, by County. (USDA, Forest Service, n.d.)

Merchantable bole wood volume of growing-stock trees by County and Region		Current Harvest Volume (CF)			2% Annual Harvest of Standing Volume (CF)			3% Annual Harvest of Standing Volume (CF)		
		Annual Harvest Volume	YR30 Total Harvest Volume	YR30 Growth to Drain	30 YEAR TOTAL Harvest Volume	% Volume Remaining After Harvest	YR30 Growth to Drain	30 YEAR TOTAL Harvest Volume	% Volume Remaining After Harvest	YR30 Growth to Drain
Ozark	**836,382,531**	**6,665,393**	**199,961,794**	**-**	**577,914,537**	**-**	**-**	**755,451,132**	**-**	**-**
Carter	117,314,329	579,536	17,386,077	17.93	90,016,181	1.61	1.77	117,209,167	1.21	1.18
Dent	59,797,284	283,561	8,506,816	13.40	42,130,680	1.36	1.49	55,039,280	1.02	0.99
Douglas	38,815,375	892,510	26,775,289	0.83	23,544,983	1.02	1.05	30,927,617	0.77	0.70
Howell	66,830,404	389,486	11,684,583	10.26	46,621,638	1.34	1.46	60,927,896	1.00	0.97
Oregon	59,724,180	370,132	11,103,965	6.79	38,613,463	1.15	1.21	50,616,690	0.86	0.81
Ozark	39,200,378	-	-	-	25,030,061	1.11	1.15	32,834,725	0.83	0.76
Phelps	12,051,829	-	-	-	7,369,969	1.02	1.00	9,685,487	0.76	0.66
Pulaski	2,398,929	-	-	-	2,143,244	2.13	2.24	2,775,706	1.60	1.49
Ripley	86,363,901	-	-	-	53,951,340	1.06	1.07	70,838,447	0.80	0.71
Shannon	154,510,536	167,480	5,024,390	57.14	106,657,711	1.30	1.41	139,467,046	0.98	0.94
Texas	198,957,966	3,982,689	119,480,674	2.40	141,576,334	1.41	1.57	184,788,990	1.05	1.05
Wright	417,421	-	-	-	258,933	1.05	1.05	340,081	0.78	0.70
Southeast	**405,472,105**	**2,847,664**	**85,429,911**	**-**	**266,957,304**	**-**	**-**	**349,964,452**	**-**	**-**
Bollinger	33,883,157	-	-		20,577,550	1.04	1.01	27,356,017	0.77	0.68
Butler	44,559,298	86,404	2,592,124	29.44	30,282,257	1.26	1.36	39,621,112	0.95	0.91
Madison	44,458,985	1,170,197	35,105,918	1.04	29,311,334	1.22	1.34	38,365,714	0.91	0.89
Reynolds	130,952,323	657,913	19,737,402	10.99	89,384,199	1.28	1.39	116,917,085	0.96	0.92
St. Francois	3,530,522	-	-	-	1,656,699	0.57	0.05	2,203,139	0.43	0.03
Ste. Genevieve	4,099,574	913,551	27,406,535	(1.84)	2,892,574	1.67	2.23	3,750,223	1.25	1.49
Stoddard	528,867	-	-	-	637,255	3.61	3.15	817,382	2.73	2.10
Wayne	102,903,060	19,598	587,932	229.96	65,632,227	1.11	1.14	86,100,513	0.83	0.76
Iron	39,151,040	-	-	-	25,932,026	1.20	1.27	33,966,786	0.90	0.85
Perry	1,405,279	-	-	-	651,183	0.56	-	866,482	0.41	-
Southwest	**56,922,007**	**-**	**-**	**-**	**34,537,982**	**-**	**-**	**45,403,107**	**-**	**-**
Barry	19,904,859	-	-		11,836,162	0.96	0.90	15,573,399	0.72	0.60
Christian	5,372,903	-	-		3,169,133	0.94	0.87	4,171,226	0.71	0.58
Laclede	20,242,887	-	-		12,501,843	1.04	1.03	16,422,873	0.78	0.69
McDonald	4,148,469	-	-		2,232,710	0.78	0.55	2,950,513	0.58	0.37
Taney	7,252,889	-	-		4,798,133	1.20	1.27	6,285,097	0.89	0.84
St. Louis	**106,566,125**	**376,089**	**11,282,666**	**-**	**72,780,196**	**-**	**-**	**95,196,608**	**-**	**-**
Crawford	1,178,572	-	-		1,351,272	3.32	3.01	1,735,810	2.51	2.00
Franklin	4,009,306	-	-		3,273,217	1.80	1.96	4,252,845	1.35	1.30
Washington	101,378,248	376,089	11,282,666	14.24	68,155,708	1.24	1.33	89,207,953	0.93	0.89
Total	**1,405,342,769**	**9,889,146**	**296,674,371**	**-**	**952,190,019**	**-**	**-**	**1,246,015,299**	**-**	**-**

SHORTLEAF PINE | PRICING

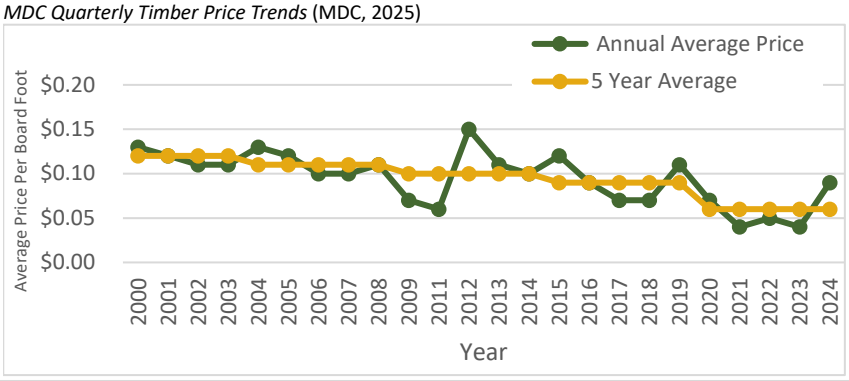
Shortleaf Pine Price Trends | Sawlogs

The Missouri Department of Conservation (MDC) plays a crucial role not only in ecological management but also in assessing the economic impact of the state's forest products. As such, MDC compiles timber price data based on a rolling average of reports from state and private foresters collected over the past twelve months, offering a robust overview of market dynamics and pricing trends.

As shown in **Figure M6,** the price/board foot (USD) of shortleaf pine sawlogs has fluctuated considerably since 2000. The highest average price was $0.15/board foot in 2012, and the lowest average price was $0.04/board foot in 2021 and 2023. The market rebounded to $0.09/board foot in 2024 (MDC, 2025).

Figure M6: 2000-2024 | Shortleaf Pine Sawlog Price Trends

MDC Quarterly Timber Price Trends (MDC, 2025)



Southern Yellow Pine Lumber Price Trends

Southern yellow pine (SYP) lumber manufacturing presents significant opportunities in states adjacent to Missouri. However, the commodity nature of SYP lumber, encompassing a variety of regions and species, typically prioritizes price and availability over source attributes. This focus makes it challenging for Missouri-grown shortleaf pine to compete economically, as its slower growth and higher production costs do not align well with market demands for cost-efficiency and uniformity. Despite these challenges in traditional lumber markets, Missouri's shortleaf pine can potentially carve out a niche for itself by highlighting its unique qualities. Its enhanced durability and distinct aesthetic characteristics, for instance, make it appealing in specialty markets where consumers are willing to pay a premium for specific wood attributes, distinguishing it from generic bulk products.

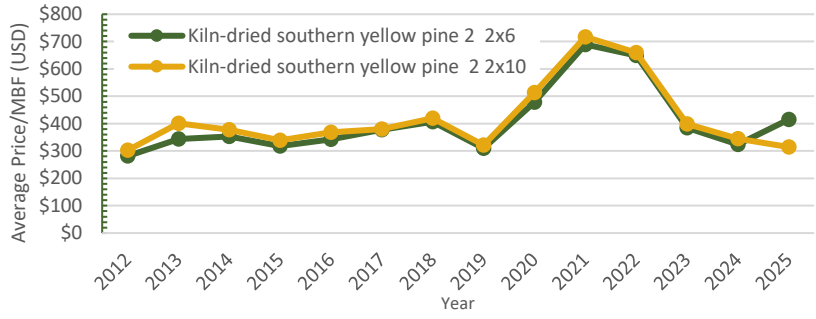
2012-2025 | Historical Pricing of Southern Yellow Pine #2 Lumber

Figure M7 illustrates the average price of SYP per thousand board feet in the Eastern Region, covering mills in Georgia, Florida, South Carolina, North Carolina, and Virginia. Prices are reported in dollars per thousand board feet for random length boards, reflecting only the product cost and do not include shipping expenses.

- Both dimensions of kiln-dried SYP #2 Lumber (2x6 and 2x10) exhibit similar pricing trends over the years, suggesting that market forces affecting SYP prices impact various dimensions similarly.
- After the sharp decline in 2022, the prices for both dimensions show signs of recovery in 2023 and stabilization in 2024 and into 2025. This may indicate that the market has adjusted to previous fluctuations and reached a new equilibrium.

Figure M7: 2012-2025Q1 | Average Southern Yellow Pine #2 Lumber Price/MBF

2021-2025Q1 Average price of SYP #2 per thousand board feet (Eastern Region: Georgia, Florida, South Carolina, North Carolina, and Virginia) (Fastmarkets, n.d.)



Random Lengths, a division of Fastmarkets, supplies lumber pricing data derived from professional assessments of lumber prices paid during the periods prior to reporting, typically analyzed on a weekly basis. These prices are determined through comprehensive industry interviews.

2012-2025 | Southern Yellow Pine Framing Lumber Average Pricing

The Fastmarkets 2025 Lumber Lengths and Studs Pricing Dashboard reveals that the average annual price of SYP underwent significant fluctuations during the pandemic, reflecting the volatile market conditions of the period (Fastmarkets, n.d.). This highlights the impact of global events on commodity prices, underscoring the importance of adaptive strategies in the lumber industry.

Figure M8 presents a detailed annual average price for various dimensions and grades of framing lumber from 2012 through the first quarter of 2025. These broad averages serve to mitigate the impact of the more pronounced weekly price swings typical of commodity lumber markets. This smoothing effect is crucial for industry stakeholders who rely on trend analysis for long-term planning. However, though this single price point simplifies the longer-term price trends into a more digestible format, it does not display the year-on-year fluctuations that might be critical for understanding market dynamics more deeply.

For stakeholders requiring detailed analysis of pricing trends over time, additional data breaking down prices by year or quarter would be necessary to observe the market's evolution and respond to changes effectively. Detailed pricing insights for various grades of southern pine are available in Fastmarkets' Random Lengths Lumber Price Guide, dated January 23, 2025. This guide is an essential tool for buyers and sellers to gauge market conditions accurately.

Figure M8: 2012-Q1 2025 | Southern Yellow Pine Framing Lumber Price Trends

(Fastmarkets, n.d.)

Industrials, Specialties, & Other Items	
Economy/#4	
Kiln Dried Dimension	**Price/MBF**
2x4	$310
2x6	$290
2x8	$285
2x10	$205
2x12	$260
Framing Lumber	
Kiln Dried Dimension	**Price/MBF**
2x4 #2&Btr.	$435
2x6	$412
2x8	$375
2x10	$315
2x12	$425
2x4 #3/Util	$360
2x6 #3	$335
2x8	$310
2x10	$265
2x12	$270
Structural Light Framing	
2x4 #1	$450

Selects & Commons - Price/MBF				
	C & Better	**D**	**#2**	**#3**
1x4	$1015	$810	$615	$520
1x6	$1585	$1100	$595	$425
1x8	$1445	$1115	$585	$365
1x10	$1540	$1330	$530	$360
1x12	$1930	$1415	$595	$375

Southern Pine Pressure - Treated Lumber - Price/MBF					
Framing Lumber	**8'**	**10'**	**12'**	**14'**	**16'**
2x4 #2	$620	$580	$580	$635	$600
2x6	$560	$575	$575	$620	$615
2x8	$515	$540	$530	$525	$565
2x10	$465	$500	$510	$515	$495
2x12	$445	$490	$535	$460	$615
Squares & Timbers					
4x4 #2	$690	$690	$620	$640	$690
4x6	$675	$670	$705	$670	$675
6x6	$765	$800	$740	$690	$750
Boards/R.E.D.					
1x4 #2	$820	$785	$715	$715	$815
1x6	$715	$750	$820	$650	$850
5/4x6 Std.	$685	$650	$655	$630	$630
Premium	$950	$925	$935	$845	$905

SHORTLEAF PINE | STRENGTH ROOTED IN TRADITION

Shortleaf pine is renowned for its robust physical and mechanical properties, which render it highly adaptable for both structural and aesthetic applications. Characterized by an excellent strength-to-weight ratio and notable measures of Modulus of Elasticity (MOE) and Modulus of Rupture (MOR), shortleaf pine is ideally suited for critical structural components such as roof trusses, floor joists, and wall studs. Its inherent durability and minimal volumetric shrinkage afford it dimensional stability, making it indispensable in decking and other infrastructural applications that regularly encounter environmental changes.

The wood's moderate density not only facilitates easier transportation and handling but also sustains its structural integrity, thereby enhancing its economic feasibility for large-scale construction projects. Aesthetically, the straight grain and medium texture of shortleaf pine enhance its visual appeal and workability, making it a favored choice for precision millwork, cabinetry, and interior trim. Additionally, its reliable nail-holding capacity is essential for ensuring the durability and integrity of woodwork and cabinetry installations. Although shortleaf pine dries effectively under standard kiln schedules, careful handling is necessary to prevent defects such as checks and splits during the drying process (USFS, 1997; Clark & Phares, 1961).

ATTRIBUTES

Physical Properties

Shortleaf pine provides a high-quality lumber yield and exhibits distinct physical characteristics that make it valuable for various applications.

- The sapwood, typically a yellowish-white, contrasts with the reddish-brown heartwood, which develops as the tree matures (U.S. Forest Service [USFS], 1997).
- The grain is straight, contributing to its ease of processing and uniformity in finished products, while the medium texture provides a balanced surface for finishing (USFS, 1997).

Shortleaf Pine on Landing| Mark Twain National Forest Timber Sale

Photo Credit: Ross, H. (2024). Renewable Resource Solutions, LLC. [Unpublished photographs].

Mechanical Properties

The mechanical properties of shortleaf pine, as documented by the USDA Forest Service (USFS, 1997), demonstrate its robustness and adaptability. These properties include high density, optimal moisture content with minimal shrinkage, substantial modulus of elasticity and rupture, strong compression strength, significant hardness, and reliable shear strength, making it well-suited for specific applications that require structural integrity and durability.

Density	833 kg/m^3 when green and 577 kg/m^3 at 12% moisture content, indicating suitability for structural applications due to its strength and durability
Moisture Content & Shrinkage	Tangential shrinkage is 7.7%, radial shrinkage is 4.6%, and volumetric shrinkage is 12.3%, ensuring stability when dried properly
Modulus of Elasticity (MOE)	1.75 x 10^6 in/lb^2 (12.0 GPa), offering stiffness for structural integrity
Modulus of Rupture (MOR)	13.1 x 10^3 in/lb^2 (90.3 MPa), highlighting its high strength under bending stress
Compression Strength	7.27 x 10^3 in/lb^2 (50.1 MPa) parallel to grain, essential for load-bearing applications
Hardness	690 lbf (3070 N), suitable for flooring and decking
Shear Strength	1.39 x 10^3 in/lb^2 (9.58 MPa), ideal for structural connections

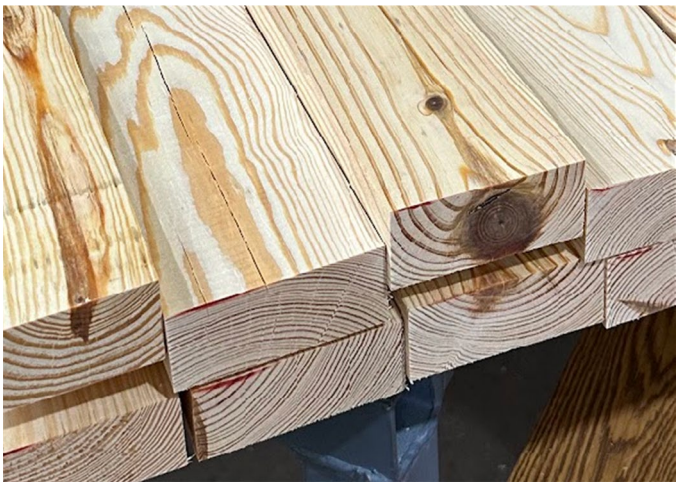
Comparative Yield and Strength Analysis

Shortleaf pine's slower growth rate contributes to higher wood density, offering superior strength and durability compared to faster-growing pine species (Murphy, 1985). This characteristic enhances its market appeal for sustainable construction and premium wood products, aligning with modern demands for eco-friendly materials.

Phillips and Schroeder (1975) carried out comprehensive yield studies on shortleaf pine, focusing on the green lumber and residue yields from merchantable stems. The findings demonstrated that shortleaf pine, particularly the higher-grade logs, tend to yield a greater proportion of high-grade lumber compared to loblolly pine. However, the overall volume yield is marginally lower due to the slower growth rate of shortleaf pine. Additionally, their research indicated that gang sawmills enhance lumber yield efficiency by minimizing kerf loss, in contrast to circular sawmills.

Shortleaf pine, compared to loblolly pine (*Pinus taeda*) and longleaf pine (*Pinus palustris*), offers a unique balance of strength, durability, and yield potential. Studies indicate that while loblolly pine grows faster, shortleaf pine's slower growth results in higher wood density (Murphy, 1985). The modulus of elasticity (MOE) for shortleaf pine is higher than loblolly's, making it stiffer and more suitable for structural applications (USFS, 1997). Longleaf pine, while also dense, is less abundant and more expensive to manage, making shortleaf pine a competitive alternative.

While limited research on shortleaf pine has been conducted, no research on Missouri-grown shortleaf pine was found. Most shortleaf pine produced outside of Missouri is plantation-grown and it is expected that naturally grown Missouri-grown shortleaf pine will be stronger due to its slower growth. A study of Missouri grown shortleaf pine lumber was conducted, and results are presented in the following section.



Missouri-Grown Shortleaf Lumber

Photo Credit: Renewable Resource Solutions, LLC. (2025). [Unpublished photographs].

Comparison of growth rings in
Missouri-grown shortleaf pine lumber
v. plantation-grown shortleaf pine lumber

Plantation-Sourced Shortleaf Pallet Stock

Photo Credit: Ross, H. (2024). Renewable Resource Solutions, LLC. [Unpublished photographs].

MISSOURI SHORTLEAF PINE LUMBER STRENGTH STUDY

While plantation-grown pine varieties dominate the modern timber market, there is an opportunity to separate Missouri-grown shortleaf pine from plantation-grown shortleaf pine as a sustainable and high-performance lumber resource. The mechanical properties of southern yellow pine (SYP) wood from plantation pines are known to be inferior to those from old growth forests, where trees grow slower, though there is no data specifically on Missouri-grown shortleaf pine.

A study was conducted to assess the mechanical properties of shortleaf pine lumber sourced from non-plantation forests in Missouri. This study conducted a combination of non-destructive and destructive tests on 150 boards of Missouri-grown shortleaf pine lumber to compare it to typical plantation grown lumber.

Initial assessment of the ring count per inch indicated that the wood had tighter rings than commercially available plantation SYP lumber. However, the mechanical properties are also affected by other factors, such as juvenile wood, knots, slope of grain, and reaction wood.

The lumber pieces were visually graded using the Standard Grading Rules for Southern Pine Lumber published by Southern Pine Inspection Bureau (SPIB). This provides a preliminary assessment of the yield of the lumber for each structural grade, critical for determining the suitability of the lumber for various structural applications.

All lumber pieces were then nondestructively evaluated for stiffness using the transverse vibration method specified in ASTM D6874. To assess the strength properties of the lumber, 30% of the lumber pieces were tested for static bending following ASTM D198 standards. The static MOE and MOR were calculated from the test results. The wood moisture content (MC) and wood specific gravity (SG) of the static bending specimen were measured. The wood MC was monitored through the entire project. The relationship between dynamic MOE and static MOE and that between static MOE and MOR was determined.

The results from both testing methods were then analyzed and correlated to derive an accurate estimation of the overall mechanical properties of the lumber. Study results are not available at the time of publication; results are expected March 2025.

This study serves as a foundation for understanding how non-plantation shortleaf pine can be marketed to meet demands for strength, sustainability, and local products. With increasing demand for sustainable building materials, consumers are exploring alternative sources of eco-friendly, high-quality lumber, especially in visible products. Missouri shortleaf pine has the potential to be marketed as a premium product that could provide ecological benefits over SYP plantation pine products.

Key benefits:

- Improved Construction Characteristics: Non-plantation grown shortleaf pine has the potential to be used in applications where increased strength is preferred.
- Biodiversity Support: Maintaining naturally regenerated Shortleaf Pine stands enhances biodiversity by preserving habitats for native species.
- Forest Health and Resilience: Non-plantation management practices promote diverse age structures and reduced vulnerability to pests and diseases.
- Carbon Sequestration: By utilizing slow-grown, dense wood, we can contribute to long-term carbon storage in durable wood products.

Shortleaf Pine Lumber Study Testing
Photo Credit: (2025). Renewable Resource Solutions, LLC. [Unpublished photographs].

Shortleaf Pine Lumber
Photo Credit: (2025). Renewable Resource Solutions, LLC. [Unpublished photographs].

SHORTLEAF PINE | THE LUMBERING GIANT

Shortleaf pine has stood as a lumbering giant in Missouri's landscape, both for its ecological benefits and for its contributions to the timber industry. It has seen cycles of prosperity and adversity, driving the growth of entire communities and nationwide infrastructure in the past to struggling to maintain its place in today's forests.

HISTORY OF SAWMILLS IN MISSOURI

Missouri's timber industry experienced a significant transformation during the late 19th and early 20th centuries, driven largely by the rapid growth of the railroad system and industrial expansion.

This era, spanning the 1880s to the 1910s, was marked by a timber boom that saw major companies such as the Missouri Lumber and Mining Company (MLMC) moving into the region to exploit its abundant shortleaf pine and oak forests. The MLMC's sawmilling operation began in 1887 and lasted until 1909 at their Grandin, MO location, moving on to West Eminence in the fall of 1909 until 1919. At its height of production, the Grandin-based sawmill consumed the timber resources from 70 acres per day. At the end of its fourteenth year of operation, MLMC had cut more than 213,017 acres of forest land (Cunningham, 2007).

At its peak in 1899, Missouri lumber production was 724 million board feet of lumber, exhausting the pine resources and leading to a decline in the industry (Cunningham, 2007). As the major companies withdrew, the local communities that had grown dependent on them were left to revert to subsistence farming and small-scale timber operations. Hardwoods quickly replaced the pine, and regrowth was cut over to maintain pastureland. This period marked a significant socio-economic shift for the region, with long-lasting impacts on the local populations.

Three crews loading cars with logs | Grandin, MO
Photo Credit: C3875-f001-016 (ca. 1907). The State Historical Society of Missouri-Columbia

Logging Crew | Missouri Lumber Camp
Photo Credit: Griffith, H. M. (ca. 1907). The State Historical Society of Missouri-Columbia.

From 1910 to the mid-1930s, initiatives towards industrial conservation commenced, accompanied by the establishment of governmental forestry programs. However, these early efforts encountered resistance from local populations wary of external interventions and their potential impacts on livelihoods. Despite initial resistance, the 1930s represented a pivotal turning point. The federal government began acquiring and designating vast areas for national forest creation, setting the stage for more effective forest management strategies at both state and national levels by the mid-20th century.

Today, Missouri's shortleaf pine resource faces a management-driven decline once again – this time due to under-utilization. While this issue is the opposite of historical over-exploitation, the outcome remains the same: economic downturn from mill closures and the loss of critical shortleaf pine forests.

SHORTLEAF PINE MARKETS | PRIMARY FOREST PRODUCTS

OPPORTUNITIES FOR INCREASED EFFICIENCY AND ECONOMIES OF SCALE

Collaborative Approach to Market Access

Like Missouri, patterns of exploitation followed by conservation efforts occurred throughout the neighboring states south of Missouri. In the 1950s, less than two million acres were dedicated to southern pine plantations. However, by the end of the 20th century, this number had escalated to 32 million acres across the Southern United States, turning the region into what is now known as the wood basket of the world. Mills in this region produce approximately 63% of the total timber volume in the United States (Fox, Jokela, & Allen, 2004; Oswalt, Smith, Miles, & Pugh, 2014).

Despite Missouri's proximity to these successful restoration and utilization efforts, the economic feasibility of transporting to the large mills in the southern U.S. has historically been challenging due to low volume and high transportation costs. Based on discussions with industry staff during site visits for this study, collaborative practices like utilizing shared log yards for storing and cooperatively shipping logs to larger mills had existed in the past to mitigate the challenges of small volume production. Reviving these types of collaborative solutions in strategic locations could significantly boost economies of scale when attempting to compete in traditional Southern Yellow Pine markets. Moreover, cooperatively run log yards provide the ideal opportunity to establish local cooperative-run mills that process logs directly into lumber, further reducing transportation costs and maximizing local job opportunities. The development of such collaborative efforts often faces the same challenges that conservation and restoration efforts faced at the turn of the 20th century: the fiercely independent spirit characteristic of Missouri's forest industry and a lingering distrust of state and federal initiatives that remains entrenched among industry professionals and stakeholders alike. Efforts to foster industry's participation in collaborative solutions and initiatives will be one of the most critical components to the overall success of the restoration of shortleaf pine in Missouri.

A New Spin on Sawing

Most Missouri sawmills currently operate on a small scale, primarily processing hardwood using circular saws which saw logs into lumber one piece at a time and require multiple passes on the log. Changing the sawing strategy by transitioning to gang sawmills, which utilize multiple blades to cut a log into multiple pieces of lumber simultaneously, could offer numerous benefits.

Circular Saw in Use | Missouri Sawmill
Photo Credit: (2024). Renewable Resource Solutions, LLC. [Unpublished photographs].

Gang sawmills can cut both hardwood and softwood, including shortleaf pine, more efficiently (Phillips and Schroeder, 1975). Gang saws also have the advantage of a thinner kerf than circular saws, resulting in less wood waste and increased lumber yield. This increased recovery rate can be especially valuable in today's market, where maximizing raw material use is essential for profitability and sustainability. Moreover, gang sawmills provide greater accuracy and consistency in cutting, producing boards that are more uniform in size and shape. This precision reduces the need for further processing and trimming, which in turn lowers labor costs and energy consumption.

The higher throughput of gang saws means sawmills could increase their productivity, reducing downtime and operational bottlenecks. Over time, this could lead to lower operational costs and increased production. As a result, Missouri sawmills that switch to gang saw technology could enhance their competitiveness in the industry while also improving the capacity to saw shortleaf pine. Consideration should be made to separate residuals if a mill runs hardwood and softwood. Training will be needed for sawyers who are making the switch from sawing random length hardwoods to pine boards.

The infrastructure of U.S. and Canada presents a significant opportunity for the forest products industry. This market encompasses highways, railroads, marine and inland waterways, and electric systems – all sectors where wood products have historically played a major role. While wood was once a primary material in U.S. infrastructure, its market share has declined due to competition from steel and concrete. However, renewed interest in sustainability, cost efficiency, and ease of construction has positioned wood as a viable alternative in many applications (Smith et al., 2000).

Infrastructure Markets and Industrial Purchasing

All four infrastructure sectors are categorized as industrial markets, where buying and selling are conducted by organizations rather than individuals. Industrial purchasing decisions are based on organizational goals rather than individual preferences (Muth & Hendee, 1980). This means that government agencies, municipalities, and private-sector stakeholders make procurement choices based on factors such as cost, durability, regulatory compliance, and sustainability (Smith et al., 2000).

Wood Preservation for Infrastructure Applications

Wood infrastructure products require preservative treatments to protect against decay from insects, fungi, and environmental exposure. The type and amount of preservative depend on the product's application, and standards are governed by:

- **American Wood Protection Association (AWPA)** (www.awpa.com) – U.S. regulatory body
- **Canadian Standards Association (CSA)** (www.ipac-canada.org/canadian-standards-association-csa) – Canadian regulatory body

Regulatory oversight is provided by agencies such as the U.S. Environmental Protection Agency (EPA) and the Canadian Pest Management Regulatory Authority (PMRA), ensuring that all treatments meet environmental and safety standards (EPA, 2022).

Standards and Compliance for Treated Wood

Preservation typically involves placing the entire product in a pressure cylinder, ensuring deep penetration of preservatives into the wood structure. However, some species such as western red cedar may only have the lower portion (butt) treated.

The American Wood Protection Association's (AWPA) treatment penetration and retention standards ensure that products meet long-term durability benchmarks. Many government agencies require third-party certification to verify compliance with AWPA and CSA standards. Companies like Timber Products Inspection (TPI) (https://www.tpinspection.com) provide inspection services to wood treaters, ensuring adherence to industry regulations (TPI, 2023).

Industrial Wood Preservatives in North America

The primary industrial wood preservatives used for infrastructure applications in North America include the following waterborne and oil-based preservatives:

- **Chromated Copper Arsenate (CCA):** Long-standing treatment for southern pine, offering proven durability and minimal environmental migration.
- **Ammoniacal Copper Zinc Arsenate (ACZA):** Waterborne treatment for structural applications, offering deep penetration into wood fibers.
- **Copper Naphthenate (CuN):** Petroleum-carried treatment used for utility poles and bridge timbers.
- **4,5-Dichloro-2-N-Octyl-4-Isothiazolin-3-One (DCOI):** Emerging alternative to creosote for industrial applications.
- **Creosote:** A coal tar distillate used in treating railroad ties, utility poles, and bridge timbers. Known for its durability, creosote-treated wood requires high-temperature application (200°F) during treatment (Freeman & McIntyre, 2008).

Pricing in the Infrastructure Market

Unlike the commodity lumber market, where prices are largely determined by weekly market reports, pricing in the infrastructure sector is more complex. For standard lumber products such as posts, dimension lumber, docks, and marinas, prices tend to follow industry pricing sources, including Random Lengths' weekly market reports on treated lumber as mentioned in the shortleaf pine pricing section of this report.

However, most infrastructure-related wood products are manufactured to specific government or engineering

specifications, requiring additional manufacturing, treatment, and quality control processes that affect pricing. These products include:

- **Guardrails**: Often sold as complete projects, including wood posts/blocks, steel guardrails, and galvanized hardware.
- **Bridges & Salt Storage Buildings:** Frequently priced as lump-sum projects, where total costs are determined upfront.
- **Government Procurement & Open Bidding:** Many infrastructure projects, including highway structures, are sold through an open-bid process, where multiple suppliers submit sealed bids.

The Missouri Department of Transportation (MoDOT) provides specific guidelines on bidding for highway projects (MoDOT, https://www.modot.org/bidding). Additionally, city and county governments may require sealed bids for purchasing wood products for stock replenishment or specific projects throughout the year. MoDOT maintains a list of qualified highway contractors, which wood product suppliers can contact to provide pricing and bid for projects.

Conclusion

With the increasing demand for sustainable, cost-effective, and durable materials in U.S. infrastructure, wood products have the potential to regain market share in highway, railroad, marine, and utility applications. By improving treatment methods, enhancing regulatory compliance, and promoting wood's environmental benefits, the industry can strengthen its role in modern infrastructure development.

Wood Preservation Plant

Photo Credit: American Wood Technology americanwoodtechnology.com/pressure-treating-plants

Highway System

The U.S. Highway System, consisting of 3.9 million miles of roads and streets, is a major consumer of wood products (Federal Highway Administration, 2023). Wood is used in sound walls, guardrail posts, signposts, salt sheds, formwork and falsework, and pedestrian bridges. The primary consumers of wood-based infrastructure materials include local, state, and federal governments, which procure materials based on compliance with established engineering and environmental standards (American Wood Council, 2021).

Missouri Department of Transportation (MoDOT)

The Missouri Department of Transportation (MoDOT) is responsible for maintaining 33,800 miles of highways and 10,385 bridges across the state (MoDOT, 2023). Missouri has the seventh-largest state highway system in the United States, which includes:

Interstate highways	U.S. routes	State routes	Lettered routes	Other routes
1,385 miles	3,412 miles	8,261 miles	18,998 miles	1,755 miles

In addition to road infrastructure, MoDOT also works to improve airports, river ports, freight development, railroads, public transit systems, and pedestrian and bicycle paths. Additional details on Missouri's transportation infrastructure system are provided in the Transportation section of this assessment.

Promotional Opportunities

In highway infrastructure projects, wood must be specified in engineering plans to be utilized. This means that design engineers must recognize the advantages of wood over competing materials like steel, aluminum, or concrete in applicable scenarios. Effective promotion of wood in highway construction starts with reaching specifiers, including private consulting engineers and state highway engineers.

Organizations such as the Missouri Society of Professional Engineers (MSPE) support professional engineers who influence material selection for infrastructure projects (mspe.org).

Once wood is specified in project plans, it is crucial to engage highway contractors, ensuring they are aware that the product meets all government specifications. Many states have highway contractor associations that facilitate industry promotion. This ensures wood products are included in highway construction projects, increasing industry adoption and long-term market viability. In Missouri, the Associated General Contractors of Missouri (AGCMO) represents contractors, specialty contractors, suppliers, and service providers involved in infrastructure development (agcmo.org).

Highway Guardrail Systems

Guardrail systems are protective barriers installed parallel to roads and highways to prevent vehicles from veering off their intended path. These systems are constructed primarily from steel or wood posts, spaced between 10 to 15 feet apart, with attached railings typically made of steel beams with W cross-sections or triple V cross-sections, wood timbers, or steel cable.

Treated Wood Guard Rail Post

Photo Credit: Soderberg, E. (2024). Renewable Resource Solutions, LLC. [Unpublished photographs].

Missouri has nearly 30,000 guardrails on its highways, making it a significant market for wood-based guardrail components. Highway engineers determine the material type based on state regulations, past experiences, and project specifications (American Association of State Highway and Transportation Officials, 2022). Wood remains a cost-effective alternative to steel, particularly in rural and secondary road applications.

Specifications and Materials

A standard highway guardrail consists of a top rail, midrail, and posts with a required height between 42 to 45 inches above the roadway surface. The standard size for wood guardrail posts is 6 inches by 8 inches, with lengths ranging between 5 and 6 feet. Guardrail blocks, which separate the rail from the post, typically measure 6 inches by 8 inches by 14 inches. These components are often chamfered to facilitate water drainage and pre-drilled before being treated with preservatives to enhance durability.

The most common wood preservative for guardrail applications is Chromated Copper Arsenate (CCA), known for its ability to protect against decay, insects, and environmental exposure (Freeman & McIntyre, 2008). All hardware used in conjunction with treated wood should be hot-dipped galvanized to minimize corrosion from preservative chemicals.

Market and Competitive Landscape

The primary competition for wood guardrails comes from galvanized steel I-beam posts, which are favored by some highway departments due to their ease of installation and low maintenance requirements. While steel posts typically have a longer lifespan, they are more expensive than wood alternatives (Forest Products Laboratory, 2020).

Guardrail purchasing occurs at multiple levels:

- **Local procurement:** Individual towns or counties purchase guardrail materials for road maintenance.
- **Highway bid projects:** Large-scale infrastructure projects specify guardrail materials as part of broader contracts.
- **Specialized contractors:** Guardrail installation is typically performed by highway contractors, who act as subcontractors within larger infrastructure projects.

Market Opportunity for Missouri

As states continue to prioritize cost-effective, sustainable infrastructure solutions, wood-based guardrail systems remain a viable alternative to steel. By focusing on treatment advancements, regulatory compliance, and cost competitiveness, the forest products industry can maintain and expand its presence in highway infrastructure markets.

Signposts

Roadway signs play a critical role in transportation infrastructure, providing directions, information, and warnings to motorists. These signs typically consist of sign blanks, sign faces, and signposts. According to Cunard (1990), the most widely used materials for sign blanks include wood (primarily plywood) and aluminum.

The Federal Highway Administration (FHWA) estimates that there are over 58 million traffic signs in use across the U.S., with a total valuation exceeding $6 billion. This equates to an average of 15 signs per highway mile. Annually, an estimated $250 million is spent on street and highway signage, making this an essential market for durable and cost-effective materials.

Treated Wood Guard Rail Post

Photo Credit: Soderberg, E. (2024). Renewable Resource Solutions, LLC. [Unpublished photographs].

Standards and Material Requirements for Signposts

Signpost materials must meet several stringent requirements to ensure durability, safety, and cost-effectiveness. The American Association of State Highway and Transportation Officials (AASHTO) (https://transportation.org) establishes these standards, which include the following criteria:

- **Structural Rigidity:** Signposts must be able to withstand environmental stressors such as wind loads, ice accumulation, and snow weight without twisting or collapsing.
- **Safety Compliance:** Posts should be designed as breakaway or bend-over structures to minimize vehicle damage and occupant injury upon impact.
- **Availability and Cost Efficiency:** Materials should be readily available, affordable, and easy to install and maintain. (Cunard, 1990)

Wood Signpost Specifications and Treatment

The most common wood signpost sizes are: 4” x 4”, 4” x 6”, and 6” x 6”. These posts typically vary in length from 12 to 20 feet, depending on highway or local roadway requirements. To enhance durability and longevity, most wood signposts are treated with Chromated Copper Arsenate (CCA) in accordance with American Wood Protection Association (AWPA) standards. Additionally, hardware used in conjunction with treated wood must be hot-dipped galvanized to prevent corrosion caused by preservative chemicals.

Competitive Materials in the Signpost Market

While wood remains a viable and sustainable choice for roadway signage, it competes with aluminum and steel alternatives. The main advantages and challenges of these materials are:

- **Wood:** Cost-effective, locally sourced, and sustainable, but may require periodic treatment and replacement.
- **Aluminum:** Lightweight, corrosion-resistant, but higher initial cost.
- **Steel:** Used for larger sign installations that require I-beam posts, offering durability but with a significantly higher cost and installation complexity.

Market Opportunity for Missouri

The integration of wood signposts into roadway infrastructure presents a significant opportunity for Missouri to leverage its shortleaf pine resources. By utilizing sustainable forestry practices and following established guidelines-such as those developed by the state of Wisconsin for material selection, installation, and preservation, Missouri can expand its market potential. This strategy not only supports local industry but also positions Missouri as a regional supplier for neighboring states seeking sustainable and cost-effective signpost solutions.

The use of treated wood signposts in highway and roadway signage offers a cost-effective, durable, and environmentally responsible alternative to metal counterparts. With adherence to AASHTO and AWPA standards, and strategic utilization of Missouri's shortleaf pine, the state can strengthen its role in transportation infrastructure markets while supporting sustainable forestry initiatives.

Other Highway and Road Maintenance Infrastructure Applications

Wood continues to play a crucial role in highway infrastructure, particularly in applications where corrosion resistance, durability, and cost-effectiveness are critical. While materials such as steel and concrete dominate modern highway infrastructure, certain structures, such as salt storage buildings and small bridges, benefit from treated wood solutions due to their resistance to corrosion, ease of construction, and environmental advantages. (Kostick, 1992; Wheeler Consolidated, 1988)

Market Opportunity

Wood continues to be a valuable material in highway infrastructure, particularly for salt storage buildings and small bridges where corrosion resistance, environmental sustainability, and cost-effectiveness are essential. As regulations surrounding industrial material runoff and construction sustainability increase, treated wood solutions provide a durable, long-lasting alternative to steel and concrete structures, ensuring their viability in future infrastructure projects. (EPA, 2022; Kostick, 1992; Wheeler Consolidated, 1988)

Treated Wood Salt Storage Buildings

The second-largest end-use for salt in the U.S. is highway deicing, with over 11.3 million short tons used for this purpose in 1990 (Kostick, 1992). One of the primary challenges associated with deicing salt storage is corrosion control, particularly in compliance with EPA regulations on industrial water runoff and water quality (Advanced Storage Technology [AST], 1988). Concrete and steel structures used for salt storage are susceptible to corrosion, similar to the damage seen in motor vehicles, bridge decks, and unprotected steel highway infrastructure. (Kostick, 1992)

Wood Salt Storage Building

Wheeler Lumber, LLC

A viable solution is the construction of salt storage buildings using treated wood materials. Promotional literature from Advanced Storage Technology, Inc. (1988) highlights the following benefits of wood-based salt storage buildings:

- **Resistance to corrosion**, preventing structural degradation (Wheeler Consolidated, 1988).
- **Environmental protection**, reducing industrial runoff concerns (EPA, 2022).
- **Improved workplace safety**, minimizing maintenance hazards (AST, 1988).
- **Aesthetic flexibility**, as wooden structures can be painted to blend with the surrounding environment (Wheeler Consolidated, 1988).
- **Minimal maintenance requirements**, ensuring long-term cost-effectiveness (AST, 1988). Wheeler Consolidated, Inc. (1988) asserts that wooden salt storage buildings do not rust, pit, or corrode and are unaffected by temperature fluctuations, alkaline soils, or acidic environments).

Treated Timber Bridges

Small bridges, particularly those used in off-road transportation, such as pedestrian footbridges and small vehicle bridges, represent another opportunity for treated wood applications in infrastructure.

Promotional literature from Wheeler Consolidated, Inc. (1988) highlights the advantages of small timber bridges, including:

- **Faster construction**, enabling year-round project completion (Wheeler Consolidated, 1988).
- **Lower maintenance requirements** compared to concrete and steel alternatives (AST, 1988).
- **Aesthetic appeal**, as timber bridges blend naturally with parklands and recreation areas (Wheeler Consolidated, 1988).
- **Enhanced durability**, particularly when constructed from pressure-treated wood (AST, 1988).

Potential markets for small treated timber bridges include:

- Public parks and recreation areas with hiking trails and access roads (Wheeler Consolidated, 1988).
- Golf courses requiring aesthetically integrated footbridges (AST, 1988).
- Private developments, including farms, large estates, and residential communities (Wheeler Consolidated, 1988).

Dowel Laminated Highway Bridge

Photo Credit: Wheeler Lumber, LLC

Piling Supporting Timber Bridge

Photo Credit: Smith, B. [Unpublished photographs].

Types of Wood-Based Highway Infrastructure Bridges

Several wood bridge types support modern infrastructure applications, including:

- Dowel-laminated highway bridges - Featuring engineered wood technology for enhanced load-bearing capacity (Wheeler Consolidated, 1988).
- Wood piling-supported timber bridges - Utilizing treated wood pilings for stability and longevity (AST, 1988).
- Treated wood pedestrian bridges - Designed for walkways and recreational trails in parks and urban areas (EPA, 2022).

Treated Wood Pedestrian Bridge

Wheeler Lumber, LLC
www.wheelerconsolidated.com

Railroad Infrastructure

The railroad industry represents a significant market for wood products, particularly in the construction of wooden crossties, bridges, and trestles. The U.S. rail network consists of freight and passenger services, with private freight companies operating most of the 140,000 miles of track, while Amtrak provides passenger service across 24,000 miles (National Transportation Strategic Planning Study, 1991). Railroads transport 25% of the nation's freight tonnage, making them a vital part of the transportation infrastructure.

Railroads in Missouri

Missouri ranks 10th in the nation in railroad mileage, with approximately 4,800 miles of track and an additional 2,500 miles of yard track. The state also has 7,300 highway-rail crossings and is home to 20 freight railroads, carrying the fourth-largest amount of freight tonnage in the U.S. (MoDOT, 2023).

Market Opportunity

The U.S. railroad industry continues to be a major consumer of wood products, with crossties and bridge timbers forming the backbone of railroad infrastructure. While hardwoods remain the preferred material, when treated appropriately softwood application present viable market opportunities. The increasing demand for railroad infrastructure maintenance and bridge preservation ensures that wood products will remain integral to railroad construction and maintenance for decades to come.

The North American Railroad Tie Market In 2023, the North American railroad tie market was valued at approximately $1.0 billion, with a projected 4.0% compound annual growth rate (CAGR), expected to reach $1.5 billion by 2034 (Transparency Market Research, 2023). This equates to the production of around 18 million wood crossties annually.

The Railroad Tie Association (RTA) advocates for the use of wood in crossties and railroad timbers, providing resources and support to its members. The organization focuses on education, research, and industry collaboration to highlight the advantages of wood ties in railway infrastructure (RTA, n.d.).

Crosstie (Railroad Tie)

Though the tie market is currently saturated, wood remains the dominant material for railroad crossties due to its strength, resilience, and cost-effectiveness. According to the Railway Tie Association (RTA, 1986), key benefits of wood ties include:

- High strength-to-weight ratio, with less than 0.5% of removed wood ties classified as broken.
- Fibrous and resilient properties, allowing ties to absorb impact loads effectively.
- High resistance to fatigue, with ties capable of handling millions of load cycles without measurable degradation.
- Predictable failure characteristics, reducing the risk of sudden structural failure.
- Extended lifespan with creosote treatment, lasting 30 to 40 years.
- Renewability, as wood ties are sourced from managed forests.
- Economic feasibility, making wood the most cost-effective material for crossties.

Railroad Ties in Service

Photo Credit: Kat Lawrence, Mississippi State University

Softwood vs. Hardwood Railroad Ties

Hardwoods, particularly oak, are traditionally preferred for railroad ties due to their superior density and durability. However, though less dense, softwood ties can be viable with proper preservative treatments.

Softwood ties are primarily used in light rail applications, such as subway systems and local passenger lines, where loads are lower. The most common preservatives for railroad ties include Creosote and Chromated Copper Arsenate (CCA), both of which enhance durability and resistance to decay (Forest Products Laboratory, 2020).

Standard Railroad Tie Specifications in North America

- **Standard railroad tie sizes include:** 7”x9”, 7” x 8” and 6” x 8”.
- **Crossties are purchased in three common lengths:** 8’ (light-duty track), 8’ 6” (most common), 9’ (heavy-duty track)

Railroads often purchase ties directly from manufacturers and have them treated at wood preservation plants. The primary competitor to wood ties is concrete ties, which offer longevity but are more expensive.

Large Timber for Railroad Bridges and Trestles

Another opportunity for Shortleaf Pine in Missouri is the supply of large timbers for railroad bridges and trestles. These timbers typically range in size from 6”x8” to 12”x12”, with varying lengths, and are crucial for bridge maintenance and construction. Railroads either purchase these timbers directly from wood treaters or procure untreated timber for preservation. The most commonly used preservatives for bridge timbers include Creosote and Copper Naphthenate, both of which perform well under high-moisture and high-impact conditions (RTA, 1986).

Marine and Inland Waterway Infrastructure

The waterborne infrastructure system includes channels, piers, wharves, cargo handling equipment, storage facilities, and intermodal transportation connections. These structures require substantial amounts of wood products, including lumber, timbers, and pilings for construction and maintenance. Marine applications of wood, especially pilings, represent a significant market segment for the wood products industry. The construction and maintenance of locks, dams, ports, and cargo terminals create ongoing demand for treated wood materials.

Wood Marine Infrastructure

Photo Credit: Smith, B. [Unpublished photographs].

The U.S. waterway system is maintained by both public and private sector entities. The U.S. Army Corps of Engineers is responsible for keeping inland waterways navigable, making them a major market for marine construction projects. Private sector involvement includes 29 primary ports and sub-ports across the U.S., owned or leased by individuals and companies, all of which require wood-based infrastructure solutions.

Missouri’s Waterway Infrastructure

Missouri has access to over 1,000 miles of navigable waterways via the Missouri and Mississippi Rivers. These waterways serve as critical transportation arteries, moving over 500 million tons of cargo annually, equivalent to removing 19 million trucks from highways (Missouri Department of Transportation, 2023). Missouri also features 568 lakes and 9 hydroelectric dams that continue to generate electricity (Missouri Legends, 2023). Additionally, outdoor recreation - including boating, fishing, and water-based tourism - generated nearly $8 billion for Missouri’s economy in the previous year, contributing 2.2% to the state’s GDP (Missouri Business Alert, 2023).

Wood Materials and Treatments for Marine Applications

Marine infrastructure relies heavily on treated wood products, including:

- Treated lumber, posts, poles, pilings, timbers, and decking.
- Common preservatives used:
    - Waterborne treatments such as Chromated Copper Arsenate (CCA) and Ammoniacal Copper Arsenate (ACA).
    - Creosote-treated pilings, particularly for high-durability marine applications, following American Wood Protection Association (AWPA) standards.
- All hardware used in marine construction must be hot-dipped galvanized to minimize corrosion from wood preservatives and environmental exposure.

Market Opportunities for Wood Products in Marine Infrastructure

Missouri's marine and inland waterway infrastructure provides a substantial market for treated wood products, particularly for cargo terminals, locks and dams, and recreational marine construction. The continued expansion of transportation networks and outdoor recreation facilities reinforces the demand for high-durability wood products, ensuring that treated wood remains a preferred material in waterborne infrastructure development.

The water-related transportation and recreation sectors require extensive infrastructure investment, creating several key markets for treated wood materials:

Expansion of Marine and Inland Terminal Facilities

- The growing demand for cargo handling, storage, and transportation interfaces (ship-to-truck and ship-to-rail) is driving the construction of new marine facilities.
- Wood products, including pilings, lumber, and wood structural panels, are essential for these structures.
- Concrete-based structures also require significant formwork and falsework, both of which depend on wood materials.

Locks and Dams Infrastructure Development

- Inland waterway traffic growth requires expanded lock and dam systems.
- Construction of new locks and expansion of existing ones will continue to drive demand for formwork and falsework wood applications (National Transportation Strategic Planning Study, 1991).

Construction and Maintenance of Recreational Docks, Piers, and Wharves

- Recreational docks, piers, and marinas require continuous construction and repairs to accommodate increasing tourism and outdoor activities.
- Annual economic losses caused by wood-destroying organisms in marine structures exceed $500 million in the U.S. alone (Helsing et al., 1984), reinforcing the need for treated wood materials.

The marine construction industry in Missouri includes numerous contractors specializing in waterfront infrastructure, docks, piers, and other marine-related projects. The Better Business Bureau of Missouri lists nearly 20 marine contractors operating within the state, providing services for both public and private sector projects. Visit: www.bbb.org/search to find current contractors.

Utility Pole Markets

Wood utility poles are critical components in electrical distribution networks, supporting power lines and ensuring reliable service across vast distances. The Missouri Electric Cooperatives serve nearly 80% of Missouri's landmass, providing electricity to over 2 million Missourians through 121,846 miles of power lines and 787,412 connected meters (Missouri Electric Cooperatives, 2023). The Missouri Public Service Commission (PSC) regulates electric companies across the state (Missouri PSC, 2023).

Wood Utility Poles in the U.S. Market

There are approximately 2,022 publicly owned electric utilities, 254 investor-owned utilities, 10 federally owned utilities, and 941 electric cooperative utilities in the U.S. As of 1991, these utilities managed over 11 million miles of overhead distribution lines and 1.5 million miles of overhead transmission lines. An estimated 95% of these lines are supported by wood utility poles, with an average spacing of 350 to 400 feet. This equates to between 138 and 158 million wood poles currently in service (Ng, 1994).

Southern Yellow Pine as the Preferred Utility Pole Species

Over 70% of annual U.S. wood pole production comes from southern pine forests, traditionally harvested from mature pine stands (Wright, 1979). Southern yellow pine is preferred due to its:

- Abundant supply, with a growth rate exceeding harvest levels.
- Dense, pure stands, enabling economical harvesting.
- Year-round harvest capability in various climates.
- Superior strength, making it one of the strongest coniferous species.
- Straight growth form, ideal for utility pole applications.
- Thick sapwood ring, allowing for effective preservative treatment (Williston & Screpetis, 1975).

Standards and Treatment for Wood Utility Poles

Wood utility poles must meet stringent national standards, including:

- ANSI O5.1 Specifications for Wood Poles: Dimensions and Quality (Wood Poles, 2023).
- National Electrical Safety Code (NESC): Governs overhead electrical line design and installation.
- Rural Electrification Administration (REA) / USDA Rural Development: Establishes guidelines for pole strength, dimensions, and acceptable wood species under Bulletin 1728F-700 (USDA Rural Development, 2023).

Poles undergo framing, drilling, and branding before being pressure-treated with preservatives to enhance durability. The most common treatments include:

- Creosote
- Chromated Copper Arsenate (CCA)
- Copper Naphthenate

Market Competition and Alternative Utility Pole Materials

While wood remains dominant, alternative materials such as concrete and steel are gaining limited market share (<5%). These alternatives are primarily used where engineering constraints require increased height or load-bearing capacity. However, wood utility poles continue to have a cost advantage in most cases (Taylor, 1988).

Wood Crossarms as an Additional Market

Wood crossarms support power lines at the top of utility poles. Shortleaf pine, douglas fir, and southern yellow pine are commonly used. Crossarms must withstand wind, snow, ice, and dynamic loads. Standard

sizes include:

- Lengths: 8’ and 10’ (custom sizes up to 28’ available).
- Thickness: 3 ½” x 4 ½”, 3” x 4 ¾”, and 4 ¼” x 5 ¼”.
- Treatment Methods: CCA, Creosote, or Copper Naphthenate (Koppers Utility & Industrial Products, 2023).

Standards for crossarms include:

- ANSI O5.3 – Specifications for Solid-Sawn Wood Crossarms.
- Rural Utilities Service (RUS) Bulletin 1728H-701 – Guidelines for cooperative utility crossarms (Wood Poles, 2023).

Timber Piling as a Related Market

Timber piling is used for structural support, similar to utility poles but driven into the ground for foundation stability under buildings, bridges and other load-bearing structures.

The ASTM D25 Standard Specifications for Round Timber Piles is the industry standard for piling materials (Timber Piling Council, 2023). Timber piling is commonly treated with: Creosote, CCA, Copper Naphthenate.

Standard lengths range from 20 to over 100 feet, with 35 to 60 feet being the most common. Competing materials include steel I-beams and Cast-In-Place (CIP) concrete tubes, but wood remains a competitively priced option.

Market Opportunity

Wood continues to be the dominant material for utility poles, crossarms, and timber piling, offering a cost-efficient, durable, and sustainable solution for electrical infrastructure. With extensive use in rural electrification, transmission networks, and structural piling, wood remains the preferred choice for engineered applications in the utility sector due to its strength, ease of treatment, and long-term performance.

Pricing

Utility poles are priced based on their class size and length, with costs ranging from $300 to over $2,000 per pole, depending on classification and specifications. Current retail prices for southern yellow pine utility poles can be found at Lighting Supply’s website: ledlightingsupply.com/utility-poles/southern-yellow-pine-utility-poles

The Missouri Electric Cooperatives (moelectriccoops.com) and the Missouri Public Service Commission (PSC) (psc.mo.gov/Electric/) oversee the state’s electric companies. These organizations have purchasing agents responsible for sourcing utility poles, meaning suppliers must engage directly with them to meet procurement needs. Price and availability are the primary decision-making factors in this market.

Pallets

The pallet market represents a significant opportunity for utilizing shortleaf pine lumber across Missouri. Traditionally, pallets have been constructed primarily from oak and mixed hardwood species due to their durability and weight-bearing capacity. However, there has been a noticeable increase in the use of southern pine species in the pallet industry in recent years. Pine pallets offer advantages such as reduced weight, which facilitates more efficient trucking loads. Additionally, pine is easier to shape and generally less expensive to produce, making it an attractive alternative for manufacturers. With a variety of established pallet companies operating throughout Missouri, there is significant potential to connect and enhance these markets.

Comparison of Pallet Characteristics by Lumber Species

The following table outlines the key differences between southern pine species and oak in pallet production (assuming a standard 40 x 48 in ⅝ in pallet):

Characteristics	Southern Pine Species	Oak
Pallet Weight	35-45 lbs.	40-70 lbs.
Weight-Bearing Capacity	2,500-3,000 lbs.	4,000-5,500 lbs.
Pros	▪ Reduced weight for transportation efficiency ▪ Enhanced ease of shaping ▪ Cost-effective production	▪ Enhanced durability ▪ Extended lifespan
Cons	▪ Limited durability compared to alternative materials ▪ Lower weight-bearing capacity	▪ Higher cost of production ▪ Increased weight for transportation loads

Trends in the U.S. Pallet Industry

The U.S. pallet industry is a complex and diverse market encompassing various sectors, including pallet manufacturers, recyclers, component producers, and treatment services. A study conducted by Virginia Tech and the USDA Forest Service Southern Region tracked trends in the pallet industry over several years. Notably, 57% of firms across the country reported that new pallet production is their primary source of revenue. In the Midwest region, pallet part markets have emerged as the leading revenue stream (Bush & Araman, 2006).

While hardwood species, particularly oak, have historically dominated the Midwest pallet market, there was a notable decline in their prevalence from 1915 to 2006. During this period, the demand for softwood species, particularly pine, increased. By 2006, 63.6% of wood pallets were produced from hardwood species, while softwood species accounted for 36.4% of production, with southern pine representing a substantial portion of the softwood segment (Bush & Araman, 2006). Although these trends are modest, their persistence suggests a potential shift in the market. The outlook for the increasing pine use in pallet manufacturing could be promising.

Pallet Treatment Methods and Regulations

Pallet production involves various treatment methods to enhance performance and compliance with regulations. The most prevalent treatment is heat treatment, which effectively meets shipping and FDA requirements. Another kiln drying is also widely used to reduce moisture content to 10-15%. Kiln-dried pallets are particularly valued for their strength and durability (Hiziroglu, 2017). Chemical treatment, although less common, entails chemical pressure-treating the wood to eliminate pests and disease.

Pallet Lifespan and Recycling

A pallet's lifespan is influenced by multiple factors, ranging anywhere between **3 to 10** years (Alanya-Rosenbaum, 2020). Generally, hardwood species have greater durability, leading to a longer lifespan compared to softwood species. However, the pallet recycling and pallet part industries have also contributed to extending the useful life of pallets. Additionally, the type of pallet treatment plays a role, as more extensive treatments tend to correlate with a longer lifespan.

Future Opportunities in Missouri's Pallet Market

Missouri has a strong foundation in pallet manufacturing, and the increasing use of shortleaf pine presents new opportunities for expansion. As market preferences shift toward lighter weight and more cost-effective materials, investing in the development of pine pallet production could strengthen Missouri's role in the national and regional pallet supply chain. Additionally, increasing recycling initiatives and optimizing treatment methods could further improve the sustainability and efficiency of the pallet market in the state.

Mass Timber

Mass timber is a category of engineered wood products that are created by bonding together layers of smaller wood pieces, such as planks or boards, to form large, solid panels or beams. These products, including cross-laminated timber (CLT) and glue-laminated timber (glulam), are known for their strength, stability, and sustainability. Mass timber can be used as structural material in large-scale construction, such as in multi-story buildings, offering an environmentally friendly alternative to steel and concrete. Use of mass timber promotes carbon sequestration, reduces construction waste, and often results in faster construction timelines due to prefabrication.

Example of Cross-Laminated Timber & Glulam

Photo credits: Reidmiddleton.com, lbmjournal.com

Types of Mass Timber

Parallel Strand Lumber (PSL): part of a family of products, structural composite lumber, that are made of dried and graded wood veneers, strands or flakes that are layered upon one another and bonded together with a moisture-resistant adhesive into large blocks known as billets. Other products in this group include laminated strand lumber (LSL) and laminated veneer lumber (LVL). In the case of PSL, long strands (longer than those used in LSL) are laid lengthwise in parallel.

- **Laminated Veneer Lumber (LVL):** part of the structural composite lumber family of products. In the case of LVL, veneers are bonded together under heat and pressure.
- **Laminated Strand Lumber (LSL):** part of the structural composite lumber, a family of products.
- **Cross-Laminated Timber (CLT):** an engineered wood product consisting of layers of kiln-dried dimension lumber (usually three, five, seven or nine) oriented at right angles to one another and then glued to form structural panels. By gluing layers of wood at right angles, the panel delivers excellent structural rigidity in both directions. In special cases, double outer laminations may be parallel and not alternating crosswise.
- **Glue-Laminated Timber (GLT/Glulam):** composed of wood laminations (or lams) bonded together with durable, moisture-resistant adhesives. The grain of all laminations runs parallel with the length of the wood member.

- **Dowel-Laminated Timber (DLT):** a mass timber panel product created by stacking dimension lumber together on its edge or cross laminating them, fitted together with hardwood dowels.
- **Nail-Laminated Timber (NLT):** made of dimension lumber stacked together on its edge and fastened together with nails or sometimes screws to form a solid structural element.
- **Mass Plywood Panel (MPP):** similar to CLT, but it is constructed from large-scale plywood panels. It uses engineered veneer and custom plywood layups as a base material rather than lumber.

Missouri's shortleaf pine stands as an untapped resource with immense potential to meet the growing demand in the mass timber market, particularly in neighboring states where the manufacture of mass timber products is taking place. As mass timber continues to gain traction across the U.S., Missouri is uniquely positioned to supply high-quality, durable dimensional lumber and cants that can drive growth in this burgeoning sector.

Shortleaf Pine: A Strong Competitor in the Mass Timber Industry

Shortleaf Pine (SLP) is known for its strength, durability, and versatility - qualities that make it an excellent choice for mass timber products such as cross-laminated timber (CLT) and glue-laminated timber (Glulam). With its natural resilience and structural integrity, shortleaf pine can easily meet the stringent standards required for these advanced building materials.

Shortleaf Pine Tree & Lumber Grain

Photo Credit: Irving, P. (2024) Renewable Resource Solutions, LLC [Unpublished photographs, The Wood Database

According to ANSI-APA PRG-320-2018 Standard for Performance Rated Cross Laminated Timber, any softwood species recognized by the American Lumber Standards Committee (ALSC) under PS20 with minimum published specific gravity of 0.35, as published in the National Design Specification for Wood Construction (NDS) in the U.S. is permitted for use in CLT manufacturing. The minimum lumber grade to be used in parallel layers of CLT is 1200f-1.2E MSR or visual grade No. 2, whereas the minimum grade to be used in perpendicular layers shall be visual grade No. 3. Southern yellow pines, including shortleaf pine are currently being used in the manufacture of CLT and glulam products in states neighboring Missouri.

Pine Cants

Photo Credit: Forestry.com

According to WoodWorks Innovation Network, there are currently at least three mass timber buildings in progress or completed in Missouri. The GROW at Saint Louis Science Center (4790 sq. ft.) is a single-story facility built with beams which were factory built in Louisiana. The ceilings (hickory) and exterior siding oak) were both sourced and milled in Missouri. A second mass timber project in St. Louis is the WoodWard Lofts (234,987 sq. ft.) This project is a three-story historic printing company that has been converted into 164 lofts and retail space. The Kansas City Current Training Facility (17,599 sq. ft.) in Kansas City is a two-story mass timber facility. Due to the mass timber elements incorporated in all of these projects, on-site construction times were drastically reduced.

Meeting the Demand in Neighboring States

Neighboring states with active mass timber manufacturing present an opportunity for Missouri to export shortleaf pine dimensional lumber and cants. The demand for sustainable construction materials is on the rise, and Missouri's proximity to key markets like Arkansas and Illinois provides a logistical advantage. By supplying shortleaf pine to these facilities, Missouri can capitalize on the growing preference for eco-friendly building solutions, offering a reliable, locally sourced option that aligns with environmental goals.

The demand for Mass Timber has been significantly growing in recent years. According to data provided by WoodWorks, in 2018 there were a total of 439 mass timber projects nationally. In June of 2024 this number had increased by 5x to a total of 2,205 projects in development or completed. While much of the initial interest in mass timber was in the Western U.S., interest has also grown in the Midwest. WoodWorks reports mass timber manufacturing facilities located in Wayne, NE, Chicago, IL, and Conway, AR, and Missouri is centrally located to supply lumber to any of these manufacturers. All the manufacturers interviewed for this project reported purchasing lumber nationwide.

One mass timber manufacturing facility located in Chicago, IL, Sterling Structural, could potentially purchase shortleaf pine from Missouri for use in their product. Sterling procures southern pine species as part of its certified lumber program, including shortleaf pine which is used in both mass timber products and industrial matting. If pine is sourced from a southern pine lumber mill and bears an Southern Pine Inspection Bureau 2# stamp, it qualifies for inclusion in Sterling's product line.

The Sterling, Illinois facility exclusively purchases lumber, not roundwood, specifically in dimensions of 2"x6" and 2"x8", with lengths of 8', 14', 16', and 18'. All lumber must meet SPIB #2 standards and be kiln-dried to 15% or 19% moisture content. SPIB #2 refers to a grade of lumber established by the Southern Pine Inspection Bureau (SPIB), which sets standards for grading southern pine. These grading standards determine the quality and structural integrity of the lumber based on several factors like strength, appearance, and defects such as knots, splits, or wane. The #2 grade typically indicates structural lumber that has some defects but is still suitable for many construction applications.

Here are the key characteristics of SPIB #2 lumber:

- Knots: Permits larger and more frequent knots than higher grades, but must still be sound and tight.
- Splits and checks: Limited in size and length to ensure the lumber can still bear significant loads.
- Wane: Allowed but limited to a specific percentage of the lumber width or thickness.
- Grain: The slope of the grain is allowed to be steeper compared to higher grades, impacting strength.
- Warping: Some warping (bow, crook, twist, or cup) is permitted, but within limits to ensure usability.

SPIB #2 lumber is often used in structural applications such as framing, decking, and general construction, where high strength is necessary, but some imperfections are acceptable. Approximately 50-75% of the lumber is shipped by rail, facilitated by the facility's on-site rail spur. Sterling sources lumber from over 87 mills, both large and small, ensuring that price, quality, and volume meet their requirements.

Each of Sterling's operations, including industrial matting and mass timber production, processes around 75 million bf of lumber annually. While industrial matting incorporates a small volume of hardwood mats, the company primarily utilizes CLT for matting purposes. Sterling, Illinois sources wood from across the southern U.S., and indicated they would consider purchasing shortleaf pine lumber from Missouri.

Another mass timber manufacturing facility located in Conway, AR, Mercer Mass Timber produces CLT panels from shortleaf pine. Mercer purchases #2 grade 2”x6” and 2”x8” lumber. The highest priority for Mercer is working with sawmills which have a good working dry kiln, as moisture is a major issue. Mercer does not currently utilize rail transportation and receives lumber exclusively by truck. According to the Mercer website, the facility in Conway has an annual production capacity of roughly 31 million board feet of southern yellow pine CLT and GLT combined.

Neither of the above mass timber manufacturers purchase roundwood, only kiln dried lumber. Supplying either or them would require timber buyers to coordinate with sawing and drying services to produce 2”x4” or 2”x6” #2 grade dimensional lumber which could then be shipped by truck or rail to the mass timber manufacturing facilities.

Economic and Environmental Advantages

Expanding Missouri’s shortleaf pine into the mass timber market offers economic and ecological benefits. By tapping into this existing market, Missouri can create new jobs in forestry, manufacturing, and logistics, while also boosting the state’s economy. The strategic export of shortleaf pine to neighboring states will not only drive revenue but will also promote sustainable forestry practices, ensuring the health and longevity of Missouri’s forests. The environmental impact of mass timber cannot be overstated. Utilizing shortleaf pine for mass timber production contributes to carbon sequestration. Missouri’s forests, managed for sustainable timber production, can serve as vital carbon sinks, enhancing the state’s environmental stewardship while supporting the green building movement across the region.

Overcoming Challenges and Leveraging Opportunities

To successfully penetrate the mass timber market in neighboring states, Missouri must address certain challenges. Investment in processing infrastructure, such as state-of-the-art sawmills and manufacturing facilities, is crucial for producing high-quality lumber products that meet market demands. Furthermore, building relationships with mass timber manufacturers and major lumber suppliers in target markets will be key to establishing Missouri’s shortleaf pine as a preferred material.

Conclusion: Missouri’s Shortleaf Pine—The Future of Mass Timber

The time is ripe for Missouri to seize the opportunity in the mass timber market by promoting its shortleaf pine as a premier material for sustainable construction. With the right investments and strategic initiatives, Missouri can become a key supplier to the mass timber industry in neighboring states, driving economic growth and environmental benefits simultaneously. By unlocking the potential of shortleaf pine, Missouri can play a pivotal role in the future of construction, offering a product that meets the demands of the modern market while preserving the state’s rich natural resources.

Missouri has the potential to join an existing mass timber collaborative led by Bedrock and Mass Timber@MSU (Michigan State University) made up of seven other Great Lakes states. The aim of the collaborative is to develop a robust, holistic, Great Lakes region approach to take advantage of all the potential benefits of working with mass timber. The collaboration aims to use each states strengths to build and expand use of mass timber, which includes utilizing existing construction, manufacturing, forestry, and transportation workforces.

SHORTLEAF PINE MARKETS | BIOMASS, ENERGY, & BYPRODUCTS

Wood energy presents a locally grown, renewable alternative to coal, processed using a local labor force. Tree species that have limited markets can be used for wood energy in the form of wood chips (industrial scale) or wood pellets (commercial/residential scale). Energy markets can provide a great solution for areas in need of managing low-value species or species without adequate markets, such as shortleaf pine.

Forest products are considered "renewable" when sustainably managed. Missouri's woody biomass harvesting guidelines are outlined in the *Missouri Woody Biomass Harvesting Best Management Practices Manual* which provides sustainable harvesting parameters for biomass extraction. Prices for wood have been more stable than prices for fossil fuels in the long run, ensuring long-term energy security. In this context, the shortleaf pine market presents a viable, eco-friendly energy alternative. As coal plants transition towards cleaner energy solutions, the utilization of shortleaf pine and biofuels could become a promising source of sustainable energy.

Missouri's Energy Profile

Missouri's energy landscape remains heavily reliant on coal and natural gas for electricity generation. However, renewable energy sources, including biomass, are steadily gaining traction. With the state's abundant forest resources, biomass energy - particularly wood pellets - offers a growing opportunity for both local energy production and international exports.

Missouri's Shift Toward Renewable Energy

Missouri remains one of the most coal-dependent states in the U.S., relying on imported coal for over 99% of its energy needs. This dependence on fossil fuels poses significant economic and environmental challenges. In 2023, the state imported nearly 43.8 million tons of coal - primarily from Wyoming and Illinois - at an estimated cost of $1.13 billion (UCS). As environmental regulations tighten and coal import costs continue to rise, Missouri faces a critical juncture in its energy transition.

Currently, there are nine operational coal plants located throughout Missouri. As these facilities face increasing pressure to restructure, they have various options to consider for their future. The U.S. Department of Energy's Loan Program Office offers the Energy Infrastructure Reinvestment Program, which provides low-interest loans to support refinancing efforts and facilitate a transition toward cleaner energy solutions (Domeshek, M. 2023).

Missouri has started investing in renewable energy alternatives such as wind and biomass. Wind power currently dominates the state's renewable energy sector, but biomass energy-derived from Missouri's abundant forest resources-offers additional opportunities.

Regulatory and Market Pressures Driving Change

The Clean Air Act and Environmental Protection Agency (EPA) regulations are placing stricter emissions limits on coal-fired power plants, requiring either costly modifications or facility retirements (Domeshek, M. 2023). The U.S. Department of Energy's Loan Program Office is offering financial support through the Energy Infrastructure Reinvestment Program, which provides low-interest loans for power plants transitioning toward cleaner energy sources. These factors create an urgent need for Missouri to diversify its energy portfolio.

Opportunities and Challenges in Energy Transition

By integrating biomass heating with pellet production, industrial operations, and institutional energy systems, Missouri can reduce reliance on coal, support local forestry industries, and create a more sustainable energy economy. As technological advancements and policy incentives continue to evolve, biomass energy solutions will play an increasingly vital role in Missouri's renewable energy landscape.

While Missouri has substantial potential to expand its biomass energy sector, challenges remain. Infrastructure limitations, regulatory compliance, and market competition with other U.S. wood pellet producers must be addressed to ensure long-term success. However, with strategic investment and policy support, Missouri can leverage its rich forestry resources to become a significant player in the global renewable energy transition.

Combined Heat and Power (CHP) & Biomass Boiler Systems

Combined Heat and Power (CHP) systems and biomass boiler technology offer a promising pathway for Missouri's energy transition by improving efficiency and reducing dependence on fossil fuels. These systems utilize locally sourced biomass, such as wood pellets and wood chips, to generate both electricity and heat for industrial, commercial, and institutional applications. Missouri has already begun to expand biomass CHP and boiler adoption in schools, commercial operations, and wood processing facilities.

Economic and Environmental Benefits of CHP and Biomass Boilers

Combined Heat and Power (CHP), also known as cogeneration, is an efficient energy system that simultaneously generates electricity and thermal energy from a single fuel source. Use of CHP systems has increased due to its environmental benefits and contribution to renewable energy goals.

- **Improved Energy Efficiency** – CHP systems can achieve energy conversion efficiencies of up to 80%, significantly higher than conventional fossil fuel power plants.
- **Reduced Greenhouse Gas Emissions** – By displacing coal and natural gas with biomass, these systems help facilities meet stricter environmental regulations.
- **Cost Savings** – Biomass boilers reduce reliance on external electricity and fossil fuels, stabilizing energy costs over time.
- **Local Economic Development** – Expanding biomass energy infrastructure creates jobs in forestry, transportation, and equipment manufacturing while keeping energy dollars in Missouri's economy.

Biomass Boilers in Missouri Schools and Institutions

In 2009, Missouri took a significant step toward biomass energy adoption through the Fuels for Schools Program, funded by a $6 million American Recovery and Reinvestment Act grant. To date this initiative has enabled 8 schools across the Ozarks to install biomass heating systems, significantly reducing their reliance on conventional heating fuels. The participating schools included (Jensen, J. 2012, Morris, personal communication):

- Eminence R-I Elementary School
- Gainesville R-V School District
- Houston R-1
- Mountain View – Birch Tree Liberty High School
- Perry County School District 32
- Southern Reynolds County R-II School District
- Steelville R-III School District
- Summersville R-1

Most of these schools use wood chips as fuel, delivered by walking-floor semi-trailers and stored in large bins equipped with auger-fed systems that transport fuel into the boiler. These biomass heating systems have resulted in significant annual cost savings of approximately 67%, making them an attractive renewable energy option for other institutions.

Biomass Boiler Feasibility and Funding Opportunities

Other Funding Sources

In addition to past programs like Fuels for Schools, other funding sources are available, including:

- **USDA's Wood Innovation Program** – Supports the development of advanced wood energy systems and promotes sustainable forest management practices.
- **USDA's Community Wood Grant Program** – Funds community-scale biomass heating projects and technology adoption.
- **State and Federal Renewable Energy Incentives** – Renewable Energy Credits and grants aimed at reducing upfront investment costs for biomass heating infrastructure.

Fuels For Schools

For municipalities, schools, and industrial facilities considering the adoption of biomass boilers, feasibility studies and financial planning tools are essential. The Wisconsin Department of Natural Resources has developed "Wood Fuel Boiler Financial Feasibility" - a downloadable spreadsheet program for preliminary financial feasibility analysis of wood fueled steam boiler systems. The spreadsheet allows users to project:

- Fuel cost comparisons between wood, propane, natural gas, and heating oil,
- Operational cost projections, including payroll, electricity, maintenance, and waste disposal, and
- Return on Investment (ROI) analysis, factoring in potential savings and available incentives.

The Role of CHP in Missouri's Forest Industry Expansion

CHP systems are particularly well-suited for integration with wood pellet production facilities due to their ability to provide both the electricity needed for plant operations and the thermal energy required for drying wood chips before pelletization. This co-dependent relationship depends on several key factors:

- Electricity Production Costs vs. Purchasing Electricity – Facilities must evaluate whether generating electricity on-site is more cost-effective than purchasing it from an external source.
- Utilization of Thermal Energy Byproducts – Biomass boilers and CHP plants produce heat as a byproduct, which can be used in drying processes, reducing the need for additional fuel sources.
- Residual Biomass Utilization – Waste material from wood pellet production, such as sawdust and bark, can serve as feedstock for the biomass boiler, further improving operational efficiency and sustainability.
- Incentives – Facilities using CHP or biomass boilers may qualify for Renewable Energy Credits and other financial incentives, making investment in these systems more economically viable.

MILL RESIDUES & PROCESSED BYPRODUCTS

Wood Chips

Wood chips derived from pine trees play a crucial role in multiple industries, including pulp and paper production, bioenergy, and composite materials. These chips originate from three primary sources: clean in-woods chipping operations, sawmill residues, and dedicated chip mills. Each category serves distinct markets and has unique processing requirements.

Industrial Chip Pile
Adobe Stock Image, Licensed 2024

Clean In-Woods Chipping Operations

Clean in-woods chipping involves processing pine trees directly at the harvest site using mobile chippers. This method efficiently utilizes treetops, limbs, and non-merchantable logs that would otherwise go to waste. The resulting chips are typically uniform, free from excess bark or dirt, and suitable for various applications. Primary uses include, but not limited to:

- **Pulp and Paper Production**: Clean in-woods chips serve as a primary raw material for paper mills, particularly for kraft and mechanical pulp production. Their high fiber content and minimal contaminants enhance pulping efficiency (USDA Forest Service, 2023).
- **Bioenergy and Biomass Fuel**: Many power plants and pellet mills use in-woods chips as a renewable fuel source. Their lower moisture content makes them an efficient feedstock for biomass boilers
- **Composite Wood Products**: Engineered wood manufacturers incorporate in-woods chips into particleboard and fiberboard production, helping optimize forest resource utilization

Mill Residue (Sawmill Chips)

Sawmill residue chips are generated as a byproduct when processing pine logs into lumber. These chips come from slab wood, edgings, and planer shavings, making them relatively uniform in size and fiber quality. Primary uses include, but are not limited to:

- **Pulp and Paper Industry**: Sawmill chips are widely used in the production of high-quality paper and cardboard products due to their consistent fiber characteristics.
- **Wood Pellet and Bioenergy Production**: Many sawmills sell their residue chips to pellet mills or biomass plants, where they are processed into fuel for residential and industrial heating.
- **Animal Bedding and Landscaping**: Lower-grade sawmill chips can be repurposed for horse bedding, poultry farms, and landscape mulch applications.

Chip Mills

Chip mills are standalone facilities dedicated to producing wood chips from whole logs, primarily for industrial markets. Unlike sawmills that generate chips as a byproduct, chip mills directly process roundwood into high-quality, uniform chips. Primary uses include, but are not limited to:

- **Pulp and Paper Industry**: Chip mills supply high-volume, consistent-quality wood chips to large paper manufacturers. These chips undergo chemical or mechanical pulping to produce printing paper, packaging materials, and hygiene products (International Paper, 2024).
- **Export Market**: A significant portion of chip mill production is exported to international markets, particularly in Asia, where demand for wood pulp continues to rise.
- **Bioenergy & Pellet Production**: Some chip mills cater to bioenergy markets by supplying wood chips for pelletization and biomass combustion.

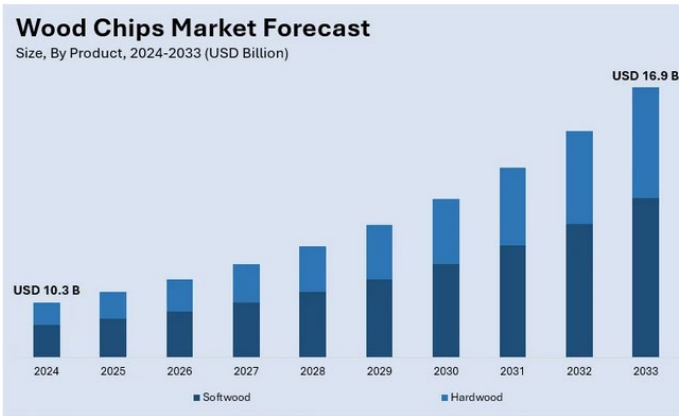
Market Outlook for Pine Wood Chips

Global Markets: In 2024, the global wood chips market was valued at approximately 10.3 billion USD. Projections indicate that this market will reach around 16.9 billion USD by 2033, growing at a compound annual growth rate (CAGR) of 5.4% from 2025 to 2033 (IMARC Group, 2024).

Domestic Markets: The North American Wood Chips Market has excellent prospects as a result of some key advancements including drying chips on site before shipping to save on fuel costs, using larger capacity portable chippers to chip onsite rather than at the mill, and the use of trailers with walking floors to allow easier unloading.

Global Wood Chips Market Forecast | 2025-2033

Photo Credit: IMARC Group, 2024



Wood chips are rapidly being used in a variety of sectors, including energy generation, home furnishings, and domestic heating, which has a substantial impact on market trends. Wood chips are versatile and can be used in a variety of applications that require efficient energy conversion. The North American wood chips market was valued at 7.2 billion USD in 2021 and is expected to reach 9.8 billion USD by 2031 with a CAGR of approximately 7.8% (6Wresearch, 2021).

Wood Shavings

Wood shaving plants play a significant role in Missouri's forestry and agricultural sectors. Missouri's pine shavings production is supported by a combination of mill residues and dedicated manufacturing facilities. These facilities produce wood shavings primarily for use as bedding in livestock facilities, landscaping applications, and various manufacturing processes. Pine shavings, derived from the planing and shaving of pine logs, serve as a versatile byproduct in various industries. Their applications range from animal bedding to horticultural uses, making them a valuable commodity in the wood products market.

Industrial Wood Shavings
Photo Credit: Adobe Stock Image, Licensed 2024

Overview of the Pine Shavings Market

Pine shavings, derived from the planing and shaving of pine logs, serve as a versatile byproduct in various industries. The global wood shavings market is experiencing significant growth, with projections estimating it to reach 18.2 billion USD by 2030, growing at a compound annual growth rate (CAGR) of 11.5% between 2023 and 2030 (Maximize Market Research, 2023). This expansion is driven by increasing demand in sectors such as animal husbandry, horticulture, and sustainable packaging.

Uses of Pine Shavings

- **Animal Bedding**: Pine shavings are extensively utilized as bedding material for livestock, including horses, poultry, and small animals. Their high absorbency helps maintain dry and hygienic conditions, while the natural aroma aids in odor control (AIGardenPlanner, n.d.).
- **Horticulture and Landscaping**: In gardening, pine shavings function as effective mulch, aiding in moisture retention, temperature regulation, and weed suppression. As they decompose, they enrich the soil with organic matter, enhancing fertility and structure. Their natural properties also help in controlling soil erosion and providing insulation to plant roots. Due to their antibacterial and antifungal properties, pine shavings are commonly used in horticulture to promote plant health and prevent diseases. (AIGardenPlanner, n.d.).
- **Packaging Material**: Due to their cushioning properties, pine shavings are employed in packaging fragile items. They provide protection during transportation and are considered an eco-friendly alternative to synthetic packaging materials. Their lightweight nature and biodegradability make them suitable for sustainable packaging solutions (MarkWide Research, 2025).
- **Industrial Applications**: Pine shavings are utilized in the production of particleboard and as a raw material in the manufacture of wood pulp and paper. They are suitable for creating composite wood products and contribute to efficient resource utilization in the wood processing industry (USDA Forest Service, n.d.).

Sources of Wood Shavings

- **Sawmills and Wood Processing Facilities**: These establishments produce pine shavings as a byproduct during the processing of pine logs into lumber. The shavings are collected during planing and milling operations.
- **Furniture Manufacturing Units**: Facilities involved in crafting pine furniture generate shavings during the shaping and finishing of wood components.
- **Specialized Wood Shaving Producers**: Some companies focus on producing standardized pine shavings tailored for specific applications, such as animal bedding or horticultural mulch.

Wood Shavings Production

For wood producers aiming to enter the pine shavings market, establishing dedicated production facilities is essential. These facilities should be equipped with:

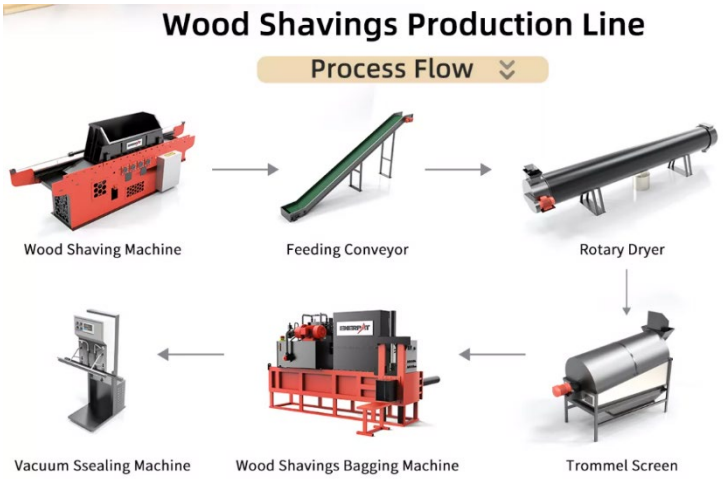
- **Wood Planing and Shaving Equipment**: Machinery capable of processing pine logs into shavings of desired sizes and textures.
- **Drying Systems**: To reduce moisture content, enhancing the quality and shelf-life of the shavings.
- **Screening and Packaging Units**: To ensure uniformity in product size and to package the shavings appropriately for distribution.
- **Storage Solutions**: Facilities to store raw materials and finished products, maintaining their quality before distribution.

Wood Shaving Production Process

In an efficient wood shaving processing plant, several machines work together to complete the production process. First, logs are fed into a wood shaving machine, which generates the shavings. A feeding conveyor belt then transports these shavings to a rotary dryer, where they are dried to a moisture content of less than 10%. After drying, the wood shavings are processed through a trommel screen that separates sawdust and smaller shavings. Finally, the shavings are conveyed to a bagging machine, followed by a vacuum sealing machine for packaging.

Wood Shavings Plant Production Line | Sample Process Flow

Photo Credit: Enerpat America.



A study conducted by the New Hampshire Department of Natural Resources and the University of New Hampshire focused on animal bedding and included a profit potential analysis, the results of which are presented in the table below (Smith, M. et. al.) This study could serve as a valuable resource in developing a new business plan for the wood shaving industry.

	Machine hours per week				
Financial variables	**8**	**16**	**24**	**32**	**40**
Loan period					
Production (yd³/yr)	3,796	7,592	11,388	15,184	18,980
Production (m³/yr)	2,902	5,805	8,707	11,609	14,511
Cost ($/yr)	83,996	116,882	149,768	182,653	215,410
Revenue ($/yr)	(27,056)	(3,002)	21,052	45,107	69,290
Implicit hourly wage ($)	(65)	(4)	17	27	33
Post loan period					
Cost ($/yr; operating)	41,131	74,017	106,903	139,788	172,545
Revenue ($/yr)	15,809	39,863	63,917	87,972	112,155
Implicit hourly wage ($)	38	48	51	53	54
Summary at year 15					
Payback period	>15 yr	12 yr 152 d	7 yr 3 d	4 yr 291 d	3 yr 6 d
Net present value ($)	19,281	282,430	545,580	808,740	1,074,397
Discounted BCR[1]	0.10	1.48	2.86	4.24	5.63

[1]BCR = benefit-cost ratio.

Production Capacity and Cost Considerations

The volume of wood shavings produced is largely determined by the type of machinery employed. A whole log shaver can process approximately 5.5 tons of logs or wood pieces per hour. The average startup cost for a wood shaving machine is around $50,000; however, this cost can vary depending on the size and configuration of the proposed shaving mill, as multiple machine systems may be utilized.

Economic Contribution of the Wood Shaving Industry

The wood shaving industry significantly contributes to Missouri's economy by creating jobs and supporting local timber producers. As the demand for sustainable and eco-friendly products increases, wood shaving plants position themselves as vital players in the green economy. The collaboration between these plants and local forestry operations creates a circular economy, where waste materials are repurposed, reducing environmental impact.

Challenges and Opportunities in the Missouri Wood Shavings Market

Missouri's wood shavings market often relies on locally sourced timber, including shortleaf pine, which is abundant in the region. However, challenges such as competition from larger markets in neighboring states like Arkansas and Iowa can impact growth and pricing.

A business plan was developed for the expansion of a shavings mill as a part of this assessment. More information about pine shavings production and the establishment of a shavings mill business model can be found in the Business Plan section of this publication.

Wood Pellets

Wood pellets are a renewable and energy-dense fuel source created from compacted wood residue, including sawdust, wood shavings, and low-value tree species. The USDA defines pelletization as the process in which raw wood is compacted into a homogeneous product with higher energy density and lower moisture content, facilitating transportation, handling, and usage.

According to the Pellet Fuels Institute (PFI), wood pellets are classified into three primary grades:

- **Premium Grade**: Less than 1% inorganic ash content, less than 8% moisture content, and bulk density of at least 40 lbs/cubic foot. Fines must be no more than 0.5% by weight.
- **Standard Grade**: Less than 3% inorganic ash content, less than 10% moisture content, and bulk density of no less than 38 lbs/cubic foot. Fines must be no more than 1% by weight.
- **Utility/Industrial Grade**: Inorganic ash content between 3% and 6%, with similar density and moisture standards to Standard Grade.

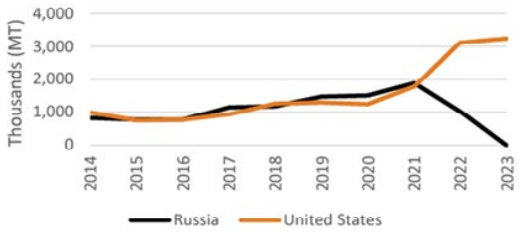
Biomass Co-Firing and Power Generation

Co-firing wood pellets with coal in existing power plants is an emerging strategy for reducing carbon emissions while maintaining grid stability. Industrial biomass boilers achieve 85%-95% energy conversion efficiency, making wood pellets a highly effective renewable energy source (USDA North American Pellet Sector Report). Given Missouri's reliance on coal, transitioning toward biomass co-firing could help the state meet emissions regulations while supporting local forestry and manufacturing sectors.

Global Demand and Export Trends

The European Union (EU) has established biomass as a key component of its Renewable Energy Directive (RED), increasing demand for imported wood pellets. In 2022, U.S. wood pellet exports to the EU grew by over 75%, as European nations sought alternatives to Russian biomass supplies following geopolitical tensions (USDA 2024). The figure at right shows the upward trend of U.S. wood pellet exports to the EU as Russian pellet exports declined to zero in 2023. Key export destinations include the U.K., Denmark, the Netherlands, and Belgium, where government incentives promote biomass energy adoption. In December 2024, the U.S. exported 879,323 metric tons of wood pellets, pushing the total exports for 2024 to a record 10 million metric tons (Voegele).

EU Imports of Wood Pellets from Russia and U.S. (Ireland, 2024)



With Missouri's abundant forest resources and proximity to the Mississippi River, strategic investment in wood pellet infrastructure could allow the state to capitalize on these international markets. Expanding production capacity and ensuring compliance with EU Deforestation-Free Supply Chain Regulations (EUDR) would be critical steps toward making Missouri a competitive supplier in the global wood pellet trade.

Economic and Environmental Benefits of Residential and Industrial Wood Pellets

The transition to wood pellet-based energy presents multiple advantages (BERC 2007):

Cost Efficiency

One ton of wood pellets provides the equivalent energy output of:

- 120 gallons of heating oil
- 170 gallons of propane
- 16,000 ft³ of natural gas
- 4,775 kWh of electricity

Cost Comparisons

Paying $200/ton for pellets is equivalent to paying:

- $1.67 per gallon for heating oil
- $1.18 per gallon of propane
- $12.50 per 1,000 ft³ for natural gas
- $0.04 per kWh for electricity

Additional Pellet Market Options

While wood pellets are widely recognized for their role in renewable energy, their applications extend beyond heating and power generation. Several emerging markets offer year-round demand and diversification opportunities for pellet manufacturers. These include animal bedding, pellet grills, and wood flour production. Expanding into these markets can help stabilize revenue streams, particularly during the offseason for heating pellets, while also leveraging existing production infrastructure to maximize resource utilization.

Animal Bedding

Wood pellets can also be used for animal bedding, offering high absorbency, reduced dust, and the ability to compost bedding waste into fertilizer. Pine and aspen are preferred species for animal bedding wood pellets. This secondary market could provide year-round demand, stabilizing revenue streams for pellet manufacturers during the typically low demand periods for heating pellets in the Missouri summer months.

Barbeque Pellets

Pellet grills are experiencing a surge in popularity, much like the growing use of pellets in residential heating and industrial energy production. Although SLP pellets would most likely not be used in food grade barbeque pellets, this could also provide year-round demand and help to diversify potential pellet mills market opportunities.

Challenges and Growth Opportunities

Despite strong market potential, Missouri's wood pellet industry faces several challenges:

- **Production Capacity Constraints**: The February 2024 fire at Ozark Hardwood Pellets has reduced Missouri's total pellet output, necessitating investment in new facilities.
- **Regulatory Compliance**: EU biomass imports must adhere to strict sustainability and deforestation regulations, requiring Missouri producers to meet international standards.
- **Domestic Market Expansion**: While Missouri's heating demand for pellets fluctuates seasonally, growth in secondary markets such as animal bedding and industrial biofuels could stabilize production year-round.

Domestic Market Potential

The abundant shortleaf pine resources, proximity to key transportation networks, and increasing demand for renewable energy, position the state as a strong contender for wood pellet industry growth. Missouri currently has three operational wood pellet manufacturing facilities, with a pre-fire combined capacity of approximately 157,000 tons annually (EIA 2024).

International Market Potential

With the European Union (EU) and other international markets increasingly seeking sustainable biomass for electricity generation, Missouri has the potential to position itself as a key supplier of wood pellets and biofuels. The EU's Renewable Energy Directive (RED) prioritizes biomass as a key component in reducing carbon emissions, creating a strong demand for U.S. wood pellet exports.

Missouri's wood pellet industry, while currently in its early stages, has the opportunity to scale production to meet growing international demand. Expanding wood pellet production could help Missouri tap into global markets, reduce dependence on coal, and establish itself as a leader in renewable biomass energy.

By investing in infrastructure, ensuring regulatory compliance, and expanding domestic and export markets, Missouri can play a role in the global energy transition toward sustainable biomass solutions.

Wood Flour

Wood flour, a finely pulverized form of wood cellulose, is a versatile material used across various industries. Its applications range from serving as a filler in composite materials to functioning as an absorbent in chemical processes. The production and demand for wood flour are influenced by its diverse uses and the availability of raw materials. Traditionally, wood flour has been produced from wood residues generated during various wood manufacturing processes. However, as demand grows, sourcing wood flour directly from roundwood is becoming a viable alternative, offering greater consistency and quality control.

Wood flour is created by pulverizing dry wood to achieve a fine, flour-like consistency, typically with a moisture content between 4% and 8% (Clemons, 2010). The industry often prefers wood flour that is light in color, lightweight, highly absorptive, and free from resins. To meet these standards, the raw material must be free from bark, dirt, and other contaminants (Clemons, 2005). Light-colored wood species, such as white pine, are commonly favored for their desirable properties in producing high-quality wood flour (University of Florida, n.d.). The shift toward using roundwood allows manufacturers to maintain a stable and high-quality supply of wood flour, meeting industry specifications more consistently than wood residues.

Sources of Wood Flour

The primary sources of wood flour include:

- **Sawmill Residues**: Byproducts from sawmills, such as sawdust and wood shavings, are processed into wood flour. This approach promotes the efficient use of resources and minimizes waste in wood processing industries. Utilizing sawmill residues not only provides a cost-effective raw material source but also contributes to sustainable manufacturing practices (Prater Industries, 2023).
- **Furniture Manufacturing Waste**: Offcuts and sanding dust from furniture production are collected and refined into wood flour. This practice reduces waste and provides valuable raw material for various applications, including composite manufacturing and industrial absorbents (Prater Industries, 2023).

Uses of Wood Flour

- **Composite Materials:** Wood flour is extensively used as a filler in the manufacturing of wood-plastic composites. These composites are prevalent in products like decking, fencing, and automotive components, offering enhanced strength and durability while reducing production costs. The incorporation of wood flour into thermoplastics improves mechanical properties and provides a wood-like aesthetic to the final product (PJ Murphy, n.d.).
- **Construction Materials:** In the construction sector, wood flour is a key ingredient in producing materials such as linoleum flooring, adhesives, and sealants. Its natural properties contribute to the

durability and environmental sustainability of these products. Additionally, wood flour is utilized in the creation of lightweight building panels and insulation materials, enhancing energy efficiency in buildings (Clemons, 2010).

- **Industrial Applications:** Wood flour serves as an absorbent in various industrial processes, including the cleanup of spills and as a carrier for chemicals and pesticides. Its high absorbency and biodegradability make it an eco-friendly option for such applications. Moreover, it is used in the production of foundry molds, providing a cost-effective and efficient solution in metal casting industries (Prater Industries, 2023).
- **Consumer Goods:** The material is found in numerous consumer products, such as cosmetics, where it acts as a natural exfoliant, and in pet care items like cat litter, benefiting from its absorbent nature. Its fine particle size and non-toxic properties make it suitable for personal care applications, ensuring safety and effectiveness (Clemons, 2010).

Overview of the Pine Wood Flour Market

The global wood flour market is experiencing growth, driven by increasing demand in sectors such as construction, automotive, and consumer goods. This expansion is attributed to the material's versatility, cost-effectiveness, and environmental benefits. For wood producers aiming to enter the wood flour market, establishing dedicated production facilities is essential. These facilities should be equipped with:

- **Grinding Equipment**: Machinery capable of pulverizing wood residues into fine, consistent particles suitable for various applications.
- **Drying Systems**: To reduce moisture content, enhancing the quality and shelf-life.
- **Screening and Classification Units**: To ensure uniform particle size distribution, meeting specific industry standards.
- **Packaging Solutions**: Facilities to package the wood flour appropriately for distribution, maintaining product integrity.

Investing in such infrastructure enables producers to meet the diverse needs of the market, from supplying high-quality fillers for composites to providing materials for industrial and consumer applications.

VALUE ADDED OPPORTUNITIES

International Compliance and Certification

WOOD TREATMENT REQUIREMENTS & SERVICE PROVIDERS

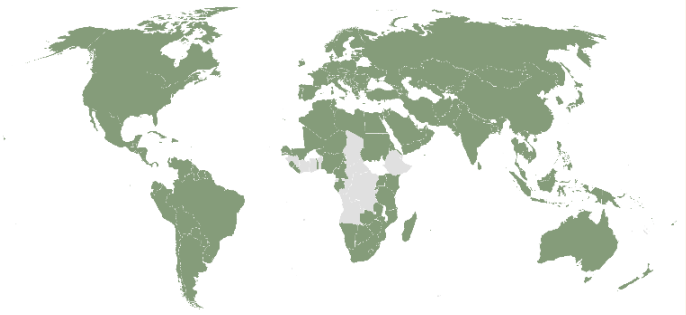
Wood Packaging Materials are defined as shipping units constructed completely or partially of solid wood materials such as pallets, skids, boxes, crates, reels, etc., in addition to individual pieces utilized for blocking, bracing, and dunnage for securing the shipment while in transport.

ISPM-15 Heat Treat History

In 2001, the American Lumber Standard Committee (ALSC) launched a program to oversee agencies responsible for ensuring compliance with heat treatment (HT) labeling of wood packaging materials. This program was established under the International Plant Protection Convention (IPPC) Guidelines for Regulating Wood Packaging Material in International Trade.

115 Countries Require ISPM-15 Certification

Photo Credit: Acadon, n.d.-a



The ALSC Board of Review, an elected body, carries out this function in accordance with a Memorandum of Understanding (MOU) with the United States Department of Agriculture's Animal and Plant Health Inspection Service (USDA-APHIS). The program operates under ALSC policies and procedures, ensuring that wood packaging facilities adhere to ISPM-15 standards (MFPA, n.d.-a).

ISPM-15: International Standard for Phytosanitary Measures for Wood Packaging Material in International Trade

The ISPM 15 standard, officially titled the "*International Standard for Phytosanitary Measures for Wood Packaging" Material in International Trade*, is a global phytosanitary regulation developed under the International Plant Protection Convention (IPPC) of the Food and Agriculture Organization (FAO). Its primary goal is to prevent the spread of wood-borne pests through packaging materials, protecting ecosystems worldwide (Acadon, n.d.-b).

Companies involved in manufacturing wood packaging for international trade must comply with ISPM 15, ensuring their materials undergo approved phytosanitary treatments such as heat treatment (HT) or fumigation (MB - methyl bromide). A standardized marking confirms compliance, eliminating the need for a separate phytosanitary certificate during international shipping (Acadon, n.d.-b).

This standard specifically regulates wood packaging materials in global trade by outlining approved phytosanitary treatments and mandatory markings. The IPPC mark, which must be applied to compliant packaging, includes:

- The ISO country code
- The certifying agency logo
- The facility identification number
- The IPPC symbol
- The letters HT (heat-treated) or MB (methyl bromide fumigation)
- A DUN or DUNNAGE designation (if applicable) for loose wood used as dunnage (Missouri Forest Products Association [MFPA], n.d.-b)

The American Lumber Standard Committee (ALSC), in coordination with USDA-APHIS and the wood packaging industry, has developed a heat treatment program to certify compliance with ISPM 15 through official labeling (MFPA, n.d.-b). With over 170 countries participating in the IPPC, ISPM 15 plays a critical role in ensuring safe, standardized, and pest-free wood packaging materials in international trade (MFPA, n.d.-b).

There are three types of Heat Treated (HT) stamps used in conjunction with ISPM-15:

HT Lumber Grade Stamp	This mark indicates that individual solid wood raw material has met the minimum core temperature of 56 C for 30 minutes. The mark serves in establishing a chain of custody between the site that treated the raw materials and the site that will certify finished wood packaging materials as being in compliance with ISPM-15 guidelines.
Finished Product HT Quality Mark	This mark identifies assembled wood packaging materials (pallets, boxes, crates, etc.) as being heat-treated and debarked in compliance with ISPM-15.
HT Quality Dunnage Mark	Dunnage is defined as wood packaging materials used to secure or support a commodity but which does not remain associated with the commodity. This mark identifies wood dunnage (blocking, bracing, chocking, etc.) as being heat-treated and debarked in compliance with ISPM-15.

Kiln Verification Service

The United States Department of Agriculture Animal & Plant Health Inspection Service (APHIS) has entered into a Memorandum of Understanding with the Southern Pine Inspection Bureau, with the overall direction and control of the cooperative program to be maintained by APHIS. This program provides the necessary documentation that kiln dried Southern Pine lumber exported to foreign countries has reached a critical temperature at the core to eradicate the "Pinewood Nematode" and its vectors.

The USDA-APHIS requires a “phytosanitary certificate” for companies to ship lumber abroad. The certificate involves kiln verification/calibration. The USDA has approved MFPA as a third-party verifier to complete these inspections (MFPA, n.d.-c).

Accredited Agencies for Supervision and Lot Inspection

Company	City	ST	Phone	Website
Wood Packaging Products Heat Treatment				
American Wood Inspection Services	Carrollton	MO	540.558.8380	heattreatinspections.com
Lee Global, Inc.	Joplin	MO	866.327.1899	leeinspect.com
Missouri Forest Products Association	Jefferson City	MO	573.634.3252	moforest.org
Kiln Verification/Calibration				
Missouri Forest Products Association	Jefferson City	MO	573.634.3252	moforest.org
Pressure Treated Wood				
Southern Pine Inspection Bureau	Pensacola	FL	850.434.5011	spib.org

CHAIN OF CUSTODY CERTIFICATION

Why is Forest Management (FM) Certification Important?

A forest achieving forest management certification provides confirmation that it is being responsibly managed. Once certified, products sourced from these forests can be sold with a certification claim. Once certified products pass through a certified "chain of custody" system, end-use products containing certified materials can be labeled as such to provide consumers with assurance that the products they are purchasing come from responsibly managed forests.

Forest Certification Schemes

There are three major forest certification schemes: Forest Stewardship Council (FSC), Sustainable Forestry Initiative (SFI), and Programme for the Endorsement of Forest Certification (PEFC). FSC and PEFC are considered international standards that are open to qualifying participants worldwide and SFI is only available to qualifying participants in North America. Though SFI Certification is only available to qualifying forestlands and companies within North America (United States and Canada), SFI and PEFC have established reciprocity and honor each other's fiber sourcing standards and claims. This reciprocity agreement provides SFI certificate holders the opportunity to participate in the certified forest product marketplace internationally.

Globally, FSC Forest Management Certification covers 400 million acres and PEFC Forest Management Certification (inclusive of SFI and the American Tree Farm System) covers 730 million acres (2023 Report). In the U.S. specifically, there are two primary certification schemes: FSC and SFI (which is inclusive of the American Tree Farm System). To achieve either SFI or FSC certification, an independent assessment is conducted by a recognized certification body to evaluate forest management practices against a set of rigorous forest management certification standards. Both the SFI and FSC certification standards ensure management practices consider biodiversity, protection of endangered species, indigenous peoples' rights, community relations and workers' rights, environmental impact, and sustainability.

Both Forest Management Certification systems have substantial coverage in the U.S. Approximately 4.5 million acres are FSC Certified as of data available in May 2024. The December 2023 PEFC Global Statistics Report shows the American Tree Farm System as covering 15.9 million acres and SFI Forest Management Certification covering 66.9 million acres.

SFI vs. FSC

Though the primary purpose of the FSC and SFI certifications is to ensure responsible forest management practices are utilized, their key difference is their scope and how they were created:

- The Forest Stewardship Council (FSC) is an international forest management certification scheme that was originally developed by a group of businesses, environmentalists and community leaders after the 1992 earth Summit in Rio failed to produce an agreement to stop deforestation. As FSC is a 'global' forest management certification scheme, the scope of the standards must be inclusive enough to thoroughly assess a wide variety of global forest markets and widely varying conditions of forest, labor, import/export, and other pertinent laws, rules, and regulations.

- The Sustainable Forestry Initiative (SFI) was established in 1995 as a voluntary code of conduct for the members of the American Forest & Paper Association to address sustainable forestry practices within North America. As this forest management certification scheme focuses solely on forestlands within the United States and Canada, they are more pointed in scope and do not have to cover the wide range of assessment criteria required of a global standard.

Certification in Missouri

Forest management (FM) Certification in Missouri

SFI Forest Management Certification is currently the only system that covers forestland acres in Missouri. There are currently two major forestland ownerships in Missouri that have SFI Forest Management Certificates: Missouri Department of Conservation (696,365 acres) and Pioneer Forest (144,000 acres). Additionally, the American Tree Farm System, a small landowner certification system that certifies parcels of 10 acres or more, has 330 tree farms (76,240 forested acres) within its system as of May, 2024.

While the most recent FSC International/FSC US reporting from 2022 shows 3,835 acres in Missouri, a search for FM standard certificates using the parameters of FM, FM/COC, and CW/FM Certificate holders with an FSC 100% output claim category showed there were no FSC Certified landholdings in Missouri as of 5/2/2024. The Pioneer Forest terminated their FM FSC Certification on 4/25/2013.

Industry Certification in Missouri

Once raw material is sourced from forests certified under a Forest Management Certification, they enter what is known as the "Chain of Custody" (COC) system. All three major certification schemes (FSC, SFI, and PEFC) have COC Certification standards and offer voluntary certification to all facets of the forest industry in order to carry a claim forward from the forest to the end-user. Essentially, a COC system is one that tracks the flow of certified wood and forest products from the forest to the consumer. The rigorous COC standards set forth by all three of the major certification schemes provide a means to ensure that products labeled with their respective claim(s) maintain their integrity and can be traced back to responsibly managed forests.

There are currently no major primary mill facilities that hold an FSC COC Certification in Missouri per a detailed search of the FSC Public Search tool. The research showed that there are currently a handful of small specialty companies that are FSC Certified (millwork, etc.). The only primary mill facility identified was International Veneer and Timber (IVT) that is headquartered in Frohna, Missouri, with a second location in Forest County, Wisconsin. Between their two locations, IVT harvests and delivers more than 4,000,000 board feet of veneer logs per year, and ships 1,200+ containers to customers worldwide per their website.

Currently, the only wood product manufacturing company in the state that is SFI Certified is the Independent Stave Company. As of February 2022, "all American oak barrels manufactured domestically will be certified to the Sustainable Forestry Initiative Fiber Sourcing Standard".

There are two large packaging companies with multiple facilities that carry COC Certification in the state: WestRock Company (FSC and SFI) and International Paper North American Container (FSC). However, the facilities located within the state for both companies are for conversion of materials, not production. International Paper announced its plant in St. Louis, MO would be closing in 2025.

FSC and Federal Lands

While there have been ongoing discussions of pilot projects within the Federal Forest system, there are currently no U.S. Forest Service lands that are FSC Certified. As noted on the FSC US website:

> […] "FSC certification of U.S. Forest Service lands (i.e., National Forests) was not possible due to an agreement amongst stakeholders that additional FSC forest management requirements were needed to capture the unique conditions associated with National Forests, including ownership, history, mandate and resource management

objectives. In January 2015, the FSC U.S. Board of Directors initiated a process to develop both the necessary supplementary certification requirements for the FSC Forest Stewardship Standard, and the Certification Body Auditing Procedures. The process to develop these requirements followed FSC procedures for developing or revising normative documents, including technical input and oversight from a chamber-balanced and consensus-based working group and technical experts. It also included opportunities for broad stakeholder engagement. The supplementary requirements and associated Certification Body Auditing Procedures were taken through three rounds of public consultation. The supplementary requirements for national forests were approved by FSC in March 2019".

Certification and Export Markets

The European Union's Regulation on deforestation-free products (EUDR) enforcement date started June 29, 2023, and introduced the need for companies to screen global suppliers through mandatory deforestation and forest degradation due diligence. The EUDR replaces the EUTR, which was primarily aimed at combating illegal logging and prohibited illegally harvested wood or timber products from being placed on the EU market. The EUDR covers a range of forest products, including but not limited to roundwood, sawn timber, wood-based materials, paper, and furniture. The EUDR will apply to all wood harvested from June 29, 2023, and placed on the EU market after December 30, 2025. Any wood harvested after June 29, 2023, but delivered to the EU before December 30, 2025, must adhere to the existing EUTR.

Numerous entities within the forest industry, including the Southern Forest Products Association, have been actively engaged in assessing and potentially mitigating the effects of the EUDR on forest-derived materials originating from the United States. Although these efforts may succeed in refining the language and implications of the EUDR and alleviating at least some of its impact on US-sourced forest products, it serves as yet another indication of global market trends creating an ever-increasing importance of certification for market participation. While voluntary forest and COC certification does not inherently ensure conformance with the EUDR, all three of the major forest certification schemes require their certificate holders to undergo a thorough due diligence process and therefore can serve as a conformance exhibit. Large companies now have until December 30, 2025, to comply, and small and medium-sized enterprises until June 30, 2026.

EUDR Impacts to the Forest and Lumber Manufacturing Industry

According to the 2019 Missouri Department of Agriculture Forestry Snapshot, China and Canada have been the top two export markets for the U.S.; however, Vietnam, Mexico, the United Kingdom, and Japan have steadily increased their imports of U.S. lumber, with Missouri exporting $6,518,000 in forest products to the European Union in 2019.

After December 30, 2025, exporters will need to provide the following information and documentation:

1. **Detailed Description of the Products**: type of product (e.g., roundwood, sawn timber, paper, etc.) and its specific use.
2. **Geolocation Data**: Precise geolocation coordinates of where the forest products were harvested
3. **Supplier and Supply Chain Information**: Full details of suppliers and any intermediaries involved in the supply chain from the point of harvest to delivery.
4. **Due Diligence System Documentation**: Evidence of a due diligence system in place that assesses the risk of deforestation and forest degradation associated with the products being exported.
5. **Risk Assessment Results**: Results of the risk assessment indicate that the risk of deforestation is negligible and supporting documentation to substantiate these findings.
6. **Mitigation Measures**: Description of measures taken to mitigate any identified risks.
7. **Compliance with Local Laws**: Proof that the harvest of the forest products complies with the legal requirements related to land use, labor rights, and environmental protection in the country of origin.
8. **Annual Reporting**: A public report submitted annually detailing the due diligence system implementation.

OPPORTUNITIES

SHORTLEAF PINE BRANDING INITIATIVE

While competitive and volatile low-value industrial-use markets and transportation issues remain the primary logistical challenges for Missouri's shortleaf pine market, stakeholder feedback gathered during this assessment indicates that internal challenges, such as fragmented efforts and resistance to cooperative and market-driven programs, further limit growth opportunities.

Missouri's forest industry, historically unified by the railroad and booming industrial-use product markets, now faces modern challenges as demand and pricing volatility and competition from lower-quality but cheaper alternatives often push Missouri-grown shortleaf pine out of the market entirely. This fiercely competitive environment has deepened the divide among Missouri's independently minded forest product companies, isolating them and hindering collaboration that could strengthen the industry as a whole. A lack of cooperation within the industry has led to missed opportunities, with valuable resources remaining underutilized, reducing the economic sustainability of forest management across the state.

The Ties that Bind

In the late 1870s, most of Missouri's timber was utilized locally due to limited transportation options. The advent of the railroad and the establishment of the Missouri Lumber and Mining Company mill in Grandin sparked a rapid expansion of Missouri's shortleaf pine industry, fueling economic growth throughout the late 1800s. Even after the closure of Grandin's "Big Mill" in 1909, Missouri shortleaf pine remained a vital resource, supplying countless railroad ties that supported the expansion of the U.S. transportation network well into the early 20th century.

Missouri's forest product industry finds itself at a familiarly pivotal moment, once again seeking a connection between its exceptional resource and new market opportunities. Just as it has in the past, Missouri-grown shortleaf pine stands ready to serve as the unifying "tie" that will carry Missouri's forest industry into the future.

Why Branding Matters: Establishing Value and Recognition

Effective branding is essential in today's competitive markets to differentiate a product and drive demand. For Missouri-grown shortleaf pine, a cohesive branding strategy not only enhances visibility and creates a recognizable identity but also builds trust and credibility across the forest industry and beyond. This broad-based trust fosters improved collaboration within the industry, enhancing the collective strength and market positioning of Missouri's shortleaf pine.

Positioned as the material of choice for architects, designers, and industries that value quality, heritage, and sustainability, Missouri-grown shortleaf pine celebrates its unique characteristics, fosters a renewed appreciation for its superior quality, and builds a lasting connection with modern markets through strategic storytelling, partnerships, and targeted outreach. By focusing on product markets such as custom millwork, architectural trim, molding, cabinetry, and premium decking, branding efforts will enhance demand for Missouri-grown shortleaf pine as a top-tier choice for both residential and commercial design projects. Key markets for these premium products include St. Louis, Kansas City, and Columbia.

Showcasing Missouri-grown shortleaf pine's unmatched qualities provides Missouri landowners and forest product companies with the marketing benefits of brand recognition while also offering an opportunity to highlight their own craftsmanship and contribution to Missouri's legacy and future. This strategic shift emphasizes its fine grain, workability, locality, and sustainability, fostering a longer-lasting, premium market demand and unlocking its potential in higher-value, appearance-driven markets.

Formation of the Missouri Shortleaf Pine Brand Coalition

A statewide branding campaign provides a unique solution to overcome past barriers caused by limited industry cooperation. By focusing on product recognition rather than company-specific promotion, the campaign creates a shared platform that benefits all stakeholders. Unified messaging amplifies their voices, allowing for more effective marketing, advocacy, and partnerships. Additionally, a collaborative branding effort leverages the diverse skills within the industry, driving innovation and efficiency. This approach encourages collaboration across the forestry sector, fostering a sense of collective ownership and shared success.

To be successful, a brand campaign would be designed to respect and celebrate the individualistic spirit of Missouri's forest industry. Development of a voluntary Missouri Shortleaf Pine Brand Coalition comprised of stakeholders from various sectors (e.g. landowners, loggers, truckers, sawmills, manufacturers, distributors, retailers, industry associations) would ensure crucial industry engagement and support a unified approach. In doing so, the campaign reinforces both individual pride and collective strength, allowing Missouri's forest industry to thrive without compromising its character.

An integral part of this effort involves partnering with Think Wood, an organization that advocates for wood in building applications. Through collaboration with Think Wood, the coalition can effectively reach architects, developers, engineers, and both commercial and residential contractors, the primary target markets for Missouri-grown shortleaf pine. Think Wood's resources and educational tools will equip these professionals with the necessary knowledge and advocacy skills to preferentially select Missouri-grown shortleaf pine for their projects, leveraging its unique qualities and sustainability attributes.

Missouri-Grown Shortleaf Pine is Well Positioned for a State-Specific Branding Campaign

Missouri's Shortleaf Pine is uniquely positioned to thrive under a state-specific branding campaign due to its exceptional characteristics and local significance. As Missouri's only native pine species, it offers an undeniable connection to the state's natural heritage, aligning perfectly with regional pride and sustainability initiatives. Its slower growth and tighter grain distinguish it from shortleaf pine products produced in other regions, giving it superior durability, workability, and aesthetic appeal—qualities highly sought after in premium, appearance-driven markets.

As such, Missouri-grown Shortleaf Pine is a natural fit for architects, designers, and manufacturers that are increasingly prioritizing sustainable forest products that offer both beauty and resilience for applications such as custom millwork, architectural trim, molding, and decking. Creating a branding campaign that highlights this coalescence of aesthetic appeal, durability, sustainability, and historic importance could create a clear connection between the products and target markets.

By elevating Missouri-grown Shortleaf Pine as a premium, local resource, a targeted branding strategy can create a competitive advantage, enhance market access, and inspire greater investment in the state's forestry sector.

Strength Rooted in Tradition

Missouri's shortleaf pine is a tree that embodies the resilience, strength, and rich heritage of the state and its inhabitants. For generations, this remarkable species has been much more than timber; it has been a cornerstone of Missouri's history, a source of economic vitality, and a critical part of the region's ecosystem. It holds within it a legacy that connects consumers to the craftsmanship and durability of the past in its bespoke and innovative uses today.

As today's industries and consumers increasingly seek materials that balance strength, beauty, and environmental responsibility, Missouri Shortleaf Pine stands tall and ready to meet these demands. Slow grown in Missouri's unique

climate, the shortleaf pine grown here develops tight growth rings that give it unparalleled durability and a distinct aesthetic when compared to those grown in plantations or forests in other states. It is a resource as rugged and enduring as the people and landscapes it has served for centuries. Creating a unified brand is more than a strategy; it's a commitment to preserving and promoting a natural resource that has stood the test of time.

A state-specific branding campaign for Missouri-grown Shortleaf Pine may be one of the critical keys to unlocking its untapped potential. By uniting industry stakeholders, addressing prevailing internal challenges, and showcasing the product's distinctive strengths, Missouri can secure a sustainable and prosperous future for its forestry sector. The insights and strategies outlined in this branding section are intended to serve as a foundation for the development of a comprehensive branding and marketing campaign.

To visually anchor this strategy, a potential logo and tagline have been conceptualized, as shown in **Figure M9**. This figure presents the logo in a clean branding format alongside an example of how the logo might appear when impressed or printed on wood products. This visual representation is designed to encapsulate the essence of Missouri's heritage and the robust qualities of Shortleaf Pine, ensuring that the branding resonates with both industry insiders and consumers.

Missouri's shortleaf pine is more than a product - it is a reflection of the state's natural heritage, resilience, and commitment to sustainable craftsmanship.

Figure M9: Sample Logos and Brand Identity Guide

Sample Brand Identity Guide

- **Tagline:** *Strength Rooted in Tradition*
- **Mission:** Celebrating the heritage, craftsmanship, and premium quality of Missouri-grown Shortleaf Pine while positioning it as a high-end, sustainable lumber choice for architects and designers.
- **Brand Personality:** Timeless, Natural, Premium, Innovative, Rooted in Tradition

Sample Typography

Primary Font (Logo & Headings)	Secondary Font (Subheadings)	Body Font: (General Text)
Montserrat Bold	Playfair Display	Avenir
Modern, Geometric, and Clean	Elegant, Classic, & Premium	Readable, Contemporary, & Warm

Sample Color Pallet

Color Name	Hex Code	Description
PRIMARY		
Deep Olive Green	#343929	Strength & Connection to Nature
Warm Taupe	#BCAAA4	Sophisticated Neutral
Soft Sage Gray	#5A665C	Earthy & Elegant
ACCENT		
Golden Amber	#C58C39	Luxury & Warmth
Rich Dark Brown	#3E3525	Craftsmanship & Durability
Charcoal Black	#212121	Modern & Timeless

Sample Brand Mood Board

SHORTLEAF PINE INDUSTRY EXPANSION AND DEVELOPMENT

SITE LOCATION

Potential Mill Sites, Building & Equipment

In recent years Missouri has seen multiple wood processing mills close or become inactive. According to the MDC, 154 mills closed from 2019 - 2024 and an additional 19 mills became inactive during that time period. This infrastructure could potentially be leveraged by new or expanding businesses with a great opportunity to more easily establish manufacturing businesses at these sites.

Figure M10 and Figure M11 show the numbers of closed and inactive mills, respectively, by county as retrieved from the MDC database.

There are a limited number of inactive mill sites across the state; several in the southern regions closest to the heart of the shortleaf pine resource as shown in **Figure M10.**

A larger number of mills closed during this time period with the highest numbers per county in the southern regions. Iron County had the most closures, shown in red on **Figure M11**. Macon, Ripley, Texas, and Wright counties follow with 7-8 closures each. Bollinger, Butler, Morgan, Reynolds, and Wayne counties had 4-6 closures during this time period, and several counties had 1-3 mills closed (shown in yellow).

These sites could have buildings and other infrastructure, utilities, equipment, machinery, and other materials still left on site that may be able to be purchased toward the start of a new mill.

Figure M11: Number of Inactive Mills by County 2019-2024

(USDA Forest Service. 2024)

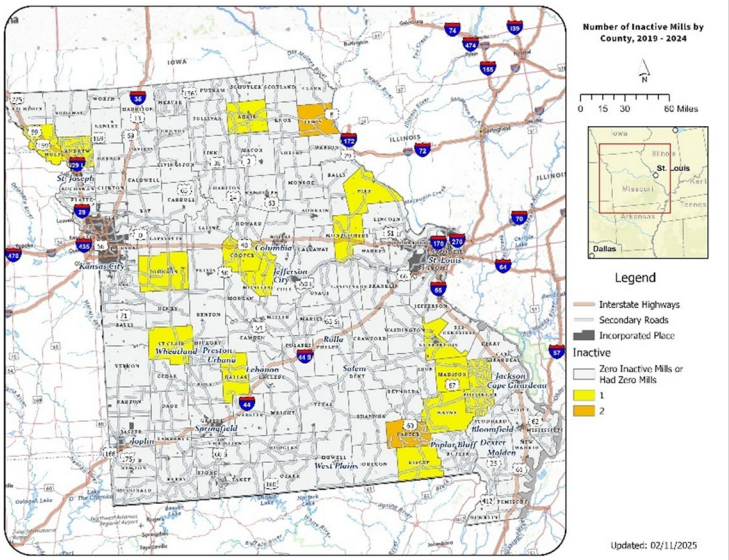
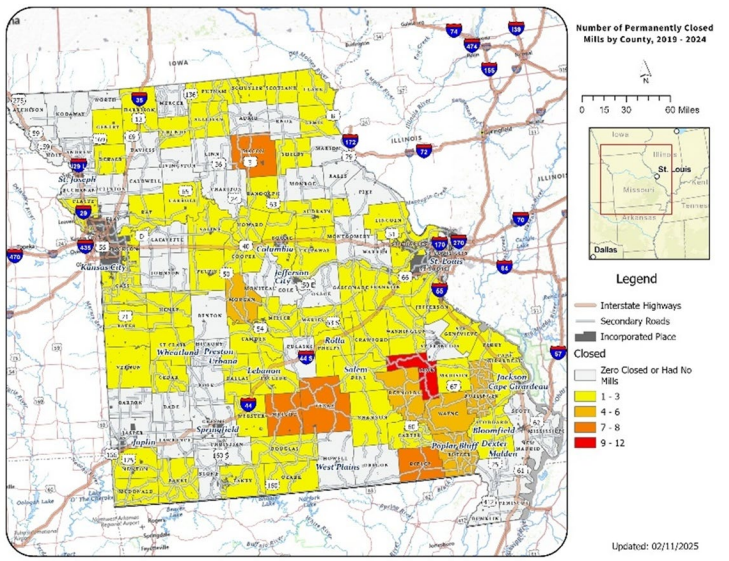


Figure M11: Number of Closed Mills by County 2019-2024

(USDA Forest Service. 2024)



Siting Near the Forest Resource

Transportation is a major cost in forest products manufacturing and cost benefits can be achieved through siting near the forest resource and/or near markets. As reported by loggers during site visits conducted as a part of this assessment, log haulers in Missouri prefer short hauls and max out at about 120 minutes one way so that they can complete up to two runs in a day.

A series of GIS analyses *(USDA Forest Service. 2024)* were conducted to determine the haul times from various shortleaf pine stands and from current manufacturing sites in Missouri . One way truck travel times from the resource are shown in 30-, 60-, 90-, and 120-minute intervals. **Figure M12** shows the truck travel time from the center of the shortleaf pine resource in Carter County. Truck travel time from the center of the shortleaf pine resource in Shannon County is shown in **Figure M13** . And finally, truck travel time from the shortleaf pine stand in Texas County is shown in **Figure M14.** Conversely **Figures M15 – M18** show truck travel time from Harvey Pallets in Centerville, MO, Harvey Pallets in Winona, MO, Brewer Boys in Eminence, MO, and Baker Forest Products in Eminence, MO. These analyses can be used to plan siting and transportation logistics for both supply and demand. The maps shown in these figures are provided in full size in Appendix A of this assessment.

Truck Travel Time 30-120 Minutes

Figure M13: Carter County

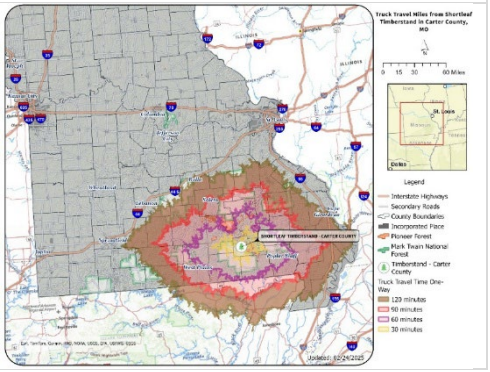


Figure M14: Shannon County

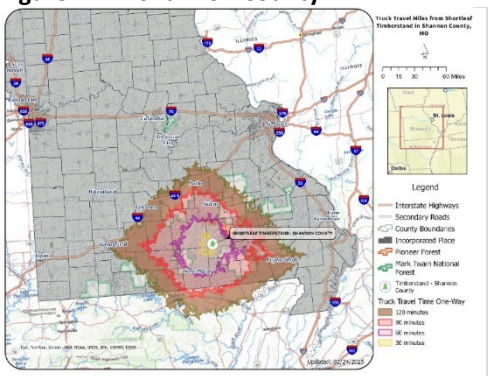
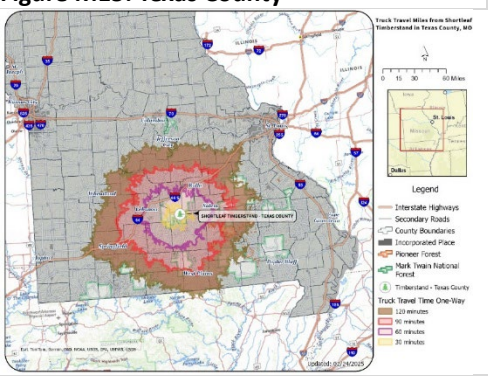


Figure M15: Texas County



Truck Travel Time 30-120 Minutes

Figure M15: Harvey Pallets (Winona)

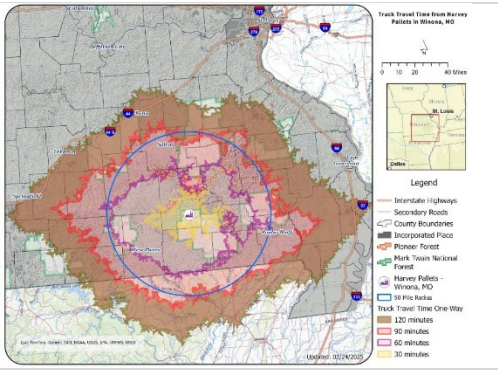


Figure M126: Harvey Pallets (Centerville)

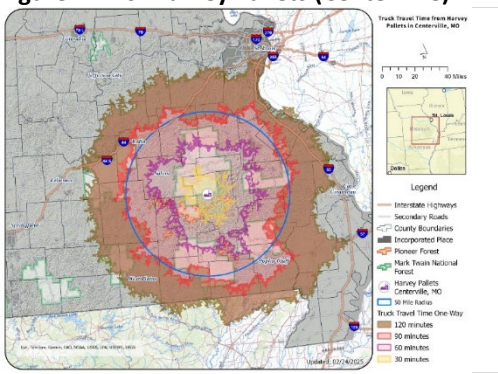


Figure M17: Baker Forest Products

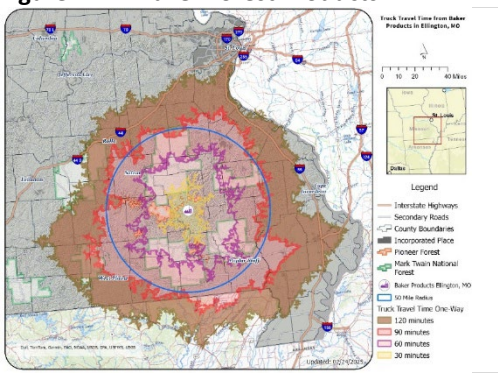
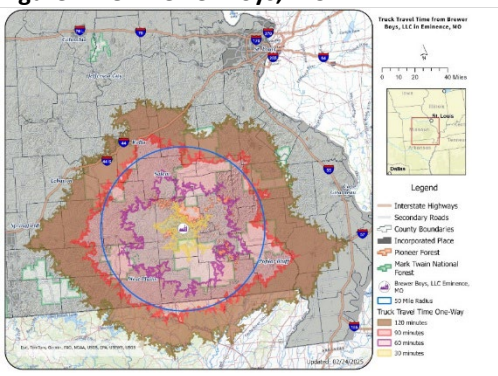


Figure M18: Brewer Boys, LLC



INFRASTRUCTURE

When evaluating the feasibility of establishing a new facility or expanding an existing mill, transportation is a critical factor that directly impacts operational efficiency, cost-effectiveness, and supply chain. The ability to efficiently move raw materials, finished products, and byproducts will determine the scalability and profitability of any expansion effort. Businesses must assess economies of scale for all available transportation modes, ensuring that selected methods align with product types, market demands, and distribution networks.

A key component of transportation planning is understanding title transfer norms and industry standards related to freight movement. Familiarity with contractual obligations, risk allocation, and liability considerations enables businesses to negotiate more favorable logistics agreements. Proper evaluation of these factors helps mitigate financial risk and ensures a streamlined transition when scaling operations.

Transportation logistics requirements vary significantly depending on the type of products, customers, and geographic reach of the business. It is essential to assess internal personnel capabilities to determine whether the existing team possesses the skills, experience, and capacity to manage a more complex or expanded transportation network. If gaps exist, targeted training, recruitment, or outsourcing solutions may be necessary.

One strategic option for managing logistics complexity is partnering with third-party freight logistics providers. These companies specialize in freight forwarding, transportation management, customs brokerage, warehousing, and distribution. By leveraging the expertise of third-party logistics firms, businesses can reduce overhead costs, minimize risk, and improve overall operational effectiveness. Leading third-party freight logistics providers in the United States include C.H. Robinson, XPO Logistics, Coyote Logistics, and Echo Global Logistics, each offering tailored solutions for industries with specialized freight needs.

Transportation Options for Forest Products

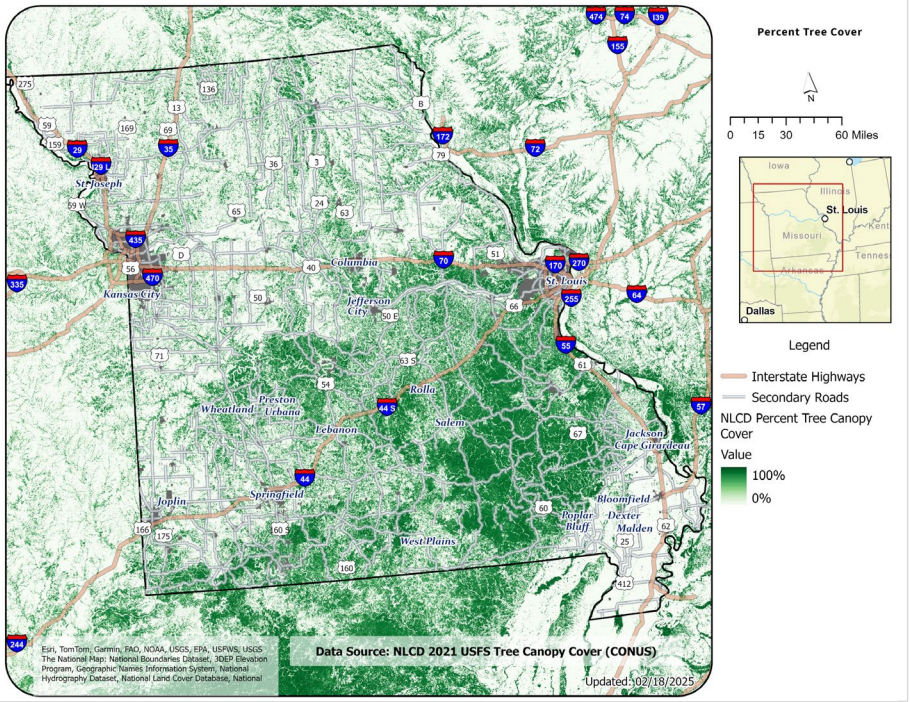
Missouri's logging industry is heavily dependent on efficient transportation networks to move raw materials from forestlands to sawmills, veneer plants, and wood-processing facilities. The state's highway, rail, and waterway infrastructure play a crucial role in ensuring timely and cost-effective movement of harvested timber. Each transportation option with its own set of pros and cons.

- **Trucking:** This is one of the most common ways to haul freight. It's flexible, fast, and can be cost-effective for shorter distances.
- **Rail:** Rail is often a good option for shipping large quantities of freight over long distances. It's generally more cost-effective than trucking and it can be more environmentally friendly.
- **Water:** Water transportation, such as shipping by barge or container ship, can be a cost-effective option for shipping large quantities of freight over long distances.
- **Intermodal:** Intermodal transportation combines multiple modes - such as rail, truck, and sometimes water - to move freight in standardized containers without the need for direct handling during mode transfers. It is especially effective for long-distance shipments where the integration of rail and trucking creates a more cost-effective solution (MoDOT, 2020).

Log Trucking

Figure M169: Major Highways and Percent Tree Cover

(USFS, 2024)



Freight trucking remains the backbone of Missouri's wood products industry, providing regional, national, and international market access. The state's strategic location and robust highway system, including major freight corridors such as I-70, I-44, and I-55, facilitate the efficient transport of forest products to processing and distribution hubs. St. Louis and Kansas City serve as primary freight hubs, housing warehouses, rail intermodal terminals, and logistics centers that streamline the movement of raw and finished wood products (Federal Highway Administration [FHWA], 2023). Although other transportation methods, such as rail and water, play significant roles in long-distance freight transportation, trucks provide unmatched flexibility for businesses, enabling first- and last-mile connections to suppliers, customers, and intermodal transport terminals (MoDOT, 2022). **Figure M19** shows major highway routes in relation to percent tree cover across the state.

Missouri Log Trucking Regulations: Weight Limits, Special Permits, and Reciprocity

Missouri imposes size and weight restrictions on log trucks based on roadway designations. The maximum legal gross vehicle weight for standard log trucks is 80,000 pounds. Trucks exceeding this limit must apply for overweight permits (Missouri Department of Transportation [MoDOT], 2021).

Missouri allows oversize and overweight permits for non-reducible loads only. If a load can be reduced to meet standard size and weight requirements, a permit is not granted. Special permits authorize transportation of overweight, oversized, or over-height loads, subject to designated route approvals (MoDOT, 2021).

Missouri participates in reciprocity agreements that allow out-of-state log trucks to operate within the state under specific conditions. These agreements are intended to streamline interstate log transport and minimize permitting conflicts. However, log trucks operating under reciprocity must adhere to Missouri's size and weight regulations or obtain additional state permits as required (MoDOT, 2021). However, despite significant efforts on behalf of the industry, reciprocal agreements with Arkansas, Iowa, and Illinois are not in place and lower truck weight limits in Arkansas continue to impact interstate trucking.

Challenges and Opportunities in Missouri's Log Trucking Industry

Transporting logs and raw wood materials presents unique logistical challenges due to size and weight restrictions, safety regulations, and infrastructure constraints. Required permits for oversized or overweight loads can increase transportation expenses and complexity (Missouri Department of Transportation [MoDOT], 2021). Additionally, log truck operators must

adhere to stringent cargo securement rules, driver hours-of-service limits, and vehicle safety requirements, all of which impact efficiency and scheduling. Missouri's rural road network, which is often essential for logging operations, can pose accessibility issues, particularly during inclement weather or seasonal load restrictions. These factors contribute to higher operational costs and logistical challenges for the industry. Several industry associations have worked with

Despite these hurdles, opportunities exist to optimize log trucking operations through regulatory adjustments, infrastructure investment, and technology adoption. Improving rural road maintenance and expanding permit allowances could enhance cost-effectiveness and efficiency for log haulers. Additionally, technological advancements in fleet management, GIS mapping, and fuel efficiency strategies can help reduce costs and increase safety compliance.

The state's strategic location with access to major highways and rail connections offers potential for multi-modal transportation solutions, allowing logs to be transported more efficiently while reducing reliance on over-the-road trucking. By addressing these challenges and leveraging emerging opportunities, Missouri's logging industry can remain competitive and sustain long-term growth (MoDOT, 2021).

Road System

Highway Network

Missouri's highways are the backbone of its freight transportation system, supporting industries, businesses, and communities across the state. With over 400 million tons of freight transported on Missouri's highways annually by more than 32.5 million trucks, highways serve as the dominant mode of freight movement.

Missouri has the seventh-largest state highway system in the United States, encompassing 33,856 miles of roadway. The system is a critical component of the national transportation grid, connecting major economic corridors and enabling efficient movement of goods across state and regional markets (MoDOT, 2022).

The state highway system is categorized into four primary classifications based on ownership and signage:

- Interstates: Federally designated highways facilitating high-speed travel across states.
- U.S. Highways: National highways serving long-distance and regional traffic.
- State-Numbered Routes: Missouri-specific highways connecting rural and urban areas.
- State-Lettered Routes: Primarily rural highways serving localized transportation needs.

These four classifications collectively span 32,073 miles, with an additional 1,759 miles consisting of outer roads, business routes, and other connector roads.

The system is anchored by major interstates, including:

- I-70: A critical east-west corridor linking St. Louis to Kansas City.
- I-44: A southwest-to-northeast route connecting Missouri to the national freight network.
- I-55 and I-64: Key north-south highways enhancing connectivity to neighboring states and major urban centers.

Ongoing investments in maintenance and modernization further enhance Missouri's position as a critical transportation hub in the Midwest (MoDOT, 2022). Over the past decade, the Missouri Department of Transportation (MoDOT) has prioritized maintaining high-quality roadway conditions across these classifications. Currently, approximately 90% of interstates and major routes are in good condition, while 80% of minor routes and 74% of low-volume routes meet

satisfactory maintenance standards. These improvements reflect the state's proactive approach to preserving infrastructure longevity and ensuring safe, efficient travel for residents, businesses, and freight carriers (MoDOT, 2022).

Local Roadways

Beyond the state highway system, Missouri's local road network plays a fundamental role in connecting industry and resources. Managed primarily by county and municipal governments, these roads link residential neighborhoods, commercial districts, and industrial zones to the broader state and federal highway system.

Missouri's local road network includes:

- 23,000 miles of city streets, facilitating intra-city travel and commercial access.
- 74,000 miles of county roads, supporting rural communities and industrial transport.
- Nearly 14,000 bridges, ensuring connectivity across waterways and challenging terrain (MoDOT, 2022).

Sustained investments in local road maintenance and upgrades are essential to keeping these routes safe, efficient, and capable of supporting Missouri's growing economy. Strategic funding initiatives and public-private partnerships continue to play a key role in addressing infrastructure challenges and modernizing transportation networks across the state.

Forest Roads

Forest roads are essential for timber harvesting operations, enabling the transportation of logs from remote forest areas to sawmills and processing facilities. Designed to accommodate heavy logging trucks and specialized forestry equipment, these roads must meet rigorous engineering standards to support frequent and high-load traffic (Missouri Department of Natural Resources, 2023).

The construction, maintenance, and modification of forest roads must comply with state and federal environmental regulations (Missouri Department of Natural Resources, 2023). To prevent excessive soil erosion, water pollution, and habitat disruption, these agencies enforce strict guidelines for road construction, drainage, and surfacing materials (Federal Highway Administration, 2021). Specific activities, such as large-scale logging operations or significant road modifications, often require permits from regulatory agencies, ensuring that the road network remains compatible with conservation goals. Best Management Practices (BMPs) are applied to minimize sedimentation in waterways. (Missouri Department of Conservation, 2023).

Forest roads also provide essential access to recreational sites, including hiking trails, camping areas, and conservation lands (U.S. Forest Service, 2022). These roads support Missouri's outdoor tourism industry, enabling entry to state parks, national forests, and privately owned recreation lands. Certain areas may require seasonal closures or access permits to prevent overuse and environmental degradation (Missouri Department of Conservation, 2023).

Bridges

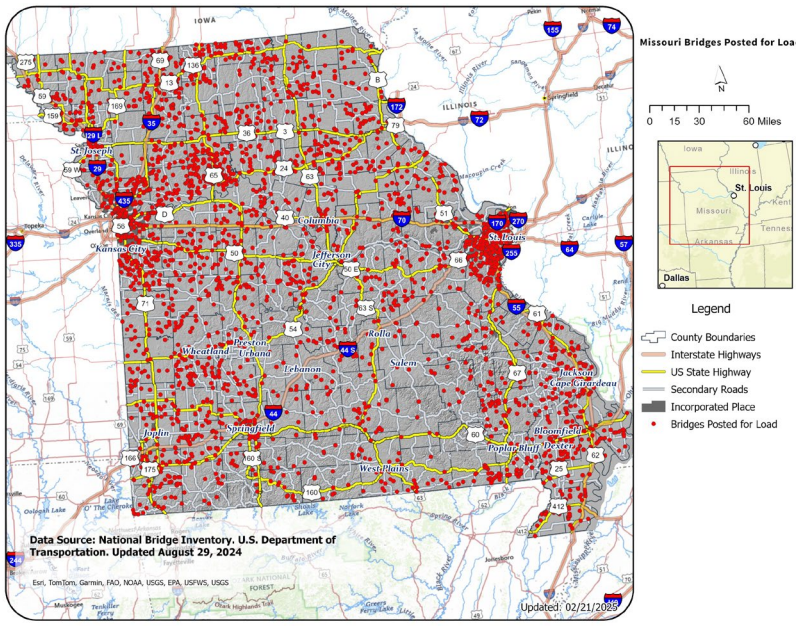
Missouri's transportation network includes 10,392 bridges, which are integral to both freight and passenger travel (Missouri Department of Transportation, 2024). Bridges posted for load are highlighted in **Figure M20**.

However, aging infrastructure poses a growing challenge, with 759 bridges currently classified as in poor condition and 869 designated as weight-restricted due to structural deficiencies (American Society of Civil Engineers, 2023).

With roughly 94 bridges deteriorating into poor condition annually, Missouri faces an ongoing challenge in maintaining a safe and efficient bridge network.

Figure M20: Missouri Bridges Posted for Load

(USFS, 2024)



Investment and Future Plans

Missouri has made substantial advancements in modernizing and expanding its transportation infrastructure over the past decade. The state has completed over 4,206 infrastructure projects, investing approximately $11.1 billion in maintaining and improving highways and roads. Looking ahead, Missouri is committed to further enhancing its transportation network, with an additional $10.6 billion allocated for highway projects over the next five years. These planned improvements, scheduled between 2025 and 2027, will encompass over 13,000 miles of roadway upgrades, ensuring the continued efficiency and reliability of Missouri's transportation system (Missouri Department of Transportation [MoDOT], 2022).

The Statewide Transportation Improvement Program for 2025–2027 also aims to rehabilitate or replace approximately 971 bridges, ensuring that the total number of poor-condition bridges remains below 900 (Missouri Department of Transportation, 2024; Federal Highway Administration, 2023). This initiative prioritizes bridges that:

- Pose safety risks due to structural weaknesses.
- Restrict freight and commercial traffic due to weight limitations.
- Serve as critical connectors for rural and industrial areas.

This investment underscores the state's dedication to economic development, safety, and connectivity, reinforcing Missouri's role as a vital transportation hub in the Midwest. As Missouri continues to invest in its transportation infrastructure, targeted improvements will reduce congestion, support freight movement, and facilitate economic growth by improving accessibility to key industrial and commercial centers. ensuring that both forest roads and highways remain functional and sustainable for decades to come (Federal Highway Administration, 2023).

Rail System

Missouri's freight rail system is a critical component of the state's transportation network, bolstering economic activity and enhancing the efficiency of goods movement. The system is reported to facilitate the equivalent of over 21 million truckloads annually, underscoring its role in reducing roadway congestion and promoting environmental and operational efficiencies (American Association of Railroads [AAR], 2020).

Figure M21: Ownership of Class 1 Freight Rail Lines

(USFS, 2024)

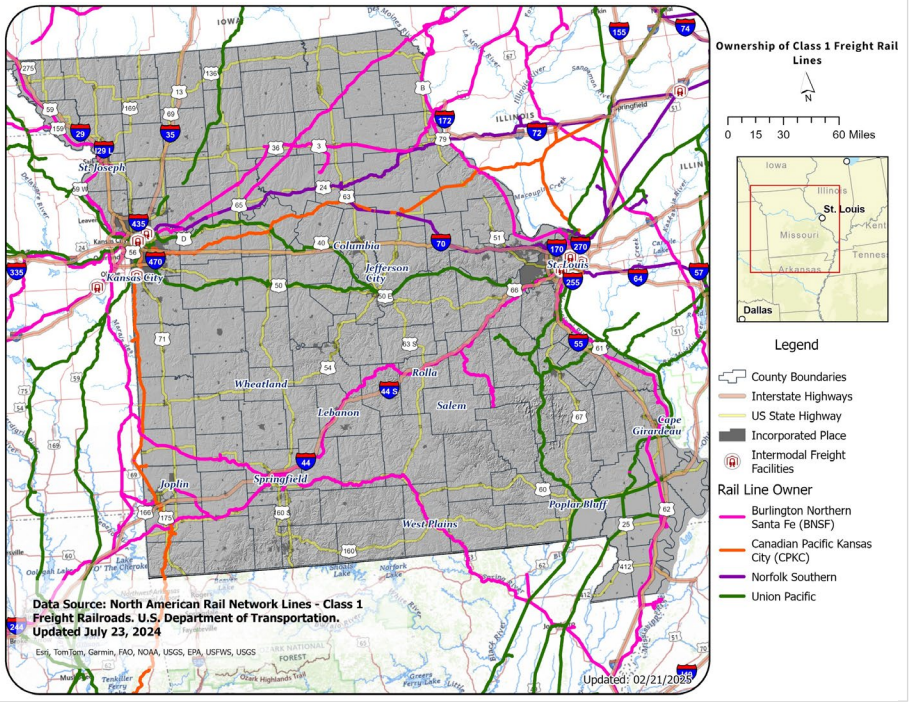


Figure M21 highlights strategic rail routes that connect Missouri's major economic hubs, ensuring the smooth flow of raw materials and finished products for key industries such as agriculture and manufacturing. Furthermore, around 40% of Missouri's freight is transported by rail, a share expected to grow as the network modernizes and expands its capacity (Missouri Department of Transportation [MoDOT], 2019).

The state hosts several major freight railroads, including:

- **Union Pacific Railroad:** As one of the largest freight rail networks in North America, Union Pacific operates extensive lines through Missouri, linking cities like St. Louis and Kansas City to regional and national markets. Its network supports a broad range of cargo—from agricultural products to industrial materials and consumer goods (Union Pacific, n.d.).
- **BNSF Railway:** BNSF Railway's key routes traverse Missouri, connecting major hubs and ensuring efficient transportation of commodities such as coal, grain, and intermodal containers (BNSF Railway, n.d.).
- **Kansas City Southern Railway:** With a network extending through the southeastern United States and into Mexico, Kansas City Southern enhances Missouri's access to international markets and regional distribution centers (Kansas City Southern, n.d.).
- **Norfolk Southern Railway:** Operating primarily in the eastern part of the state, Norfolk Southern provides additional connectivity essential for industrial and agricultural shipments (Norfolk Southern, n.d.).

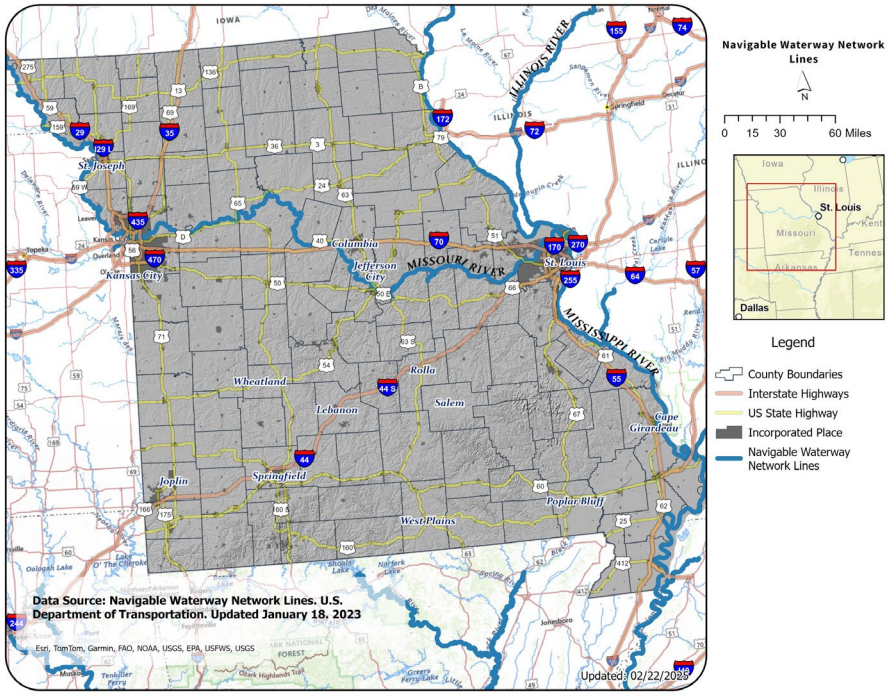
In addition to these core operations, Missouri's rail system benefits from ongoing investments in infrastructure and safety improvements. Recent trends include the development of intermodal facilities that integrate rail with highway and port operations, further streamlining logistics and enhancing the network's overall efficiency (AAR, 2020). These investments are complemented by regulatory and technological advancements aimed at increasing capacity and ensuring the safe, reliable movement of freight across the state.

Waterways

Missouri's navigable waterways, as shown in **Figure M24,** are integral to its freight transportation network, providing an efficient and cost-effective means for moving large quantities of goods. The navigable rivers support industries such as agriculture, manufacturing, and energy, allowing for the bulk transport of products and materials. The development and maintenance of port facilities and river infrastructure enhance the effectiveness of this transportation mode, ensuring that Missouri remains well-connected both nationally and internationally (U.S. Army Corps of Engineers, 2021).

Figure M17: Navigable Waterway Network Lines

(USFS, 2024)



Missouri's waterways are also essential to the timber industry, particularly in regions rich in forest resources like the Ozarks. Historically, major rivers such as the Missouri and Mississippi have played a vital role in transporting timber and other forest products. Although alternative transportation modes have become more prevalent, waterways continue to offer a cost-effective and environmentally friendly option for bulk exports. Their use reduces fuel consumption and emissions, thus supporting sustainable long-distance shipping (Missouri Department of Transportation, 2020).

An estimated $12.5 billion in cargo is transported annually via Missouri's waterways. The state features approximately 1,050 miles of navigable rivers, including 500 miles of the Mississippi River and 550 miles of the Missouri River, alongside 14 public port authorities and over 200 private ports. These extensive waterways facilitate the smooth flow of goods and bolster the state's economic strength.

Key Missouri's Waterways

1. **Mississippi River**: As one of the largest and most important rivers in the United States, the Mississippi River forms Missouri's eastern border and serves as a major artery for commercial shipping. The river supports the transportation of timber and agricultural products, coal, and other bulk commodities. Major ports along the river, such as those in St. Louis, facilitate substantial cargo traffic and contribute to the state's economy by linking Missouri to international markets via the Gulf of America (U.S. Department of Transportation, 2019).
2. **Missouri River**: Flowing through the heart of the state, the Missouri River is a fundamental inland waterway for freight and transport. It provides access for shipping agricultural products, industrial goods, and raw materials. Key ports along the Missouri River, including those in Kansas City and Jefferson City, support regional and national trade (Missouri Department of Transportation, 2020).
3. **Osage River**: A tributary of the Missouri River, the Osage River is utilized for both commercial and recreational purposes. It supports local shipping and transportation needs, particularly in central Missouri.
4. **Kaskaskia River**: Though smaller, the Kaskaskia River also contributes to Missouri's waterway network, facilitating regional transport and economic activities in the southwestern part of the state.

Marine Highways

Missouri is served by four nationally designated marine highways, receiving federal support for expanding waterway use:

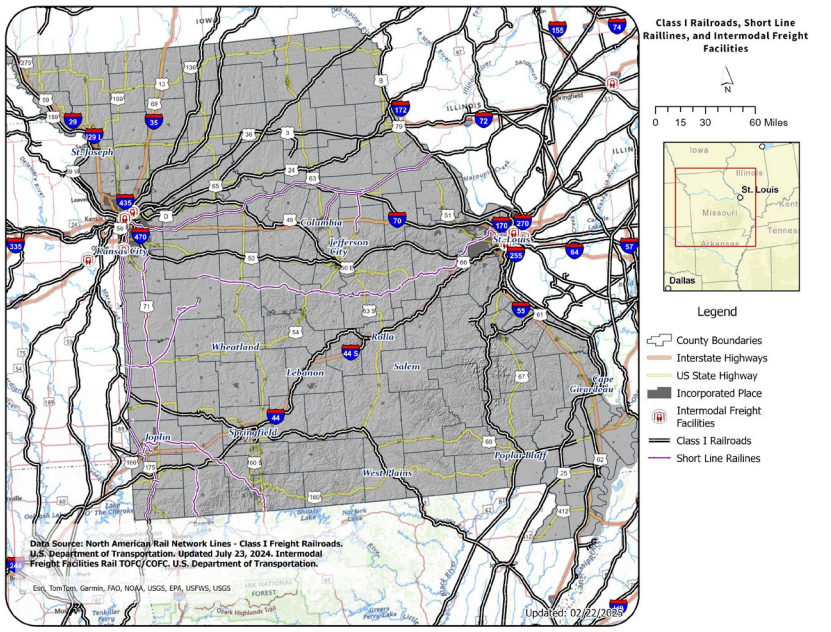
- **M-29:** Upper Missouri River from Kansas City to Sioux City, Iowa
- **M-70:** Missouri River from Kansas City to St. Louis
- **M-35:** Upper Mississippi River from the Twin Cities to St. Louis
- **M-55:** Illinois River from Chicago to St. Louis and the Mississippi River to the Gulf of Mexico

Intermodal Transportation

Intermodal freight transportation involves moving products and raw materials in containers that adhere to International Organization for Standardization (ISO) guidelines, allowing them to be transferred seamlessly between container ships, semi-trailer trucks, and trains (U.S. Department of Transportation, 2019). This method reduces the need to transfer cargo between different containers, thereby minimizing handling costs, reducing potential damage and loss, and enhancing overall security.

Figure M18: Railroads, Shortline Rail Lines, and Intermodal Freight Facilities

(USFS, 2024)



Missouri's Intermodal Hubs and Infrastructure

Missouri's central location in the United States has established it as a key player in intermodal transportation. Missouri has 141 intermodal facilities integrating rail with other modes of transportation, as identified in **Figure M25** (Missouri Department of Transportation, 2022). Several strategically located hubs facilitate efficient freight movement:

- **Kansas City Intermodal Center (KCI):** Located in the heart of the Midwest, the KCI is one of the largest intermodal facilities in the region. It integrates rail, truck, and air freight, providing seamless connections to national and international markets (Missouri Department of Transportation, 2020).

  Construction is under way for a new Union Pacific intermodal terminal in Kansas City, scheduled to open in mid-2025. This new location will provide customers in the growing markets of Missouri, Kansas, Iowa, and Nebraska access to Union Pacific's 23-state network, including ocean ports on the West Coast and the Gulf of America and significantly enhance the region's freight capacity and efficiency. The facility, designed to integrate seamlessly with existing rail and trucking networks, will streamline cargo handling and reduce transit times for both domestic and international shipments. This new terminal is positioned to serve as a critical node in the Midwest intermodal network, potentially benefiting a range of sectors - including forest products - by offering improved connectivity and specialized handling capabilities (RT&S, 2023).

- **St. Louis Intermodal Terminals:** Situated along the Mississippi River, these terminals serve as critical nodes that link waterborne freight with rail and truck services. They help ensure that goods can be efficiently distributed from the port to inland markets (Missouri Department of Transportation, 2020).

- **Other Regional Facilities:** In addition to Kansas City and St. Louis, Missouri has developed additional intermodal facilities near major highway corridors and rail lines. These hubs further enhance the state's capacity to serve geographically diverse customers by facilitating smooth transfers between transportation modes (U.S. Department of Transportation, 2019).

Potential Benefits of Utilizing Intermodal Transportation

Intermodal freight offers several advantages:

- **Cost Efficiency:** Maintaining cargo in the same container across modes minimizes handling and labor costs.
- **Cargo Integrity:** Reduced handling helps lower the risk of damage or loss.
- **Volume Efficiency:** Standardized containers streamline loading, unloading, and storage processes.
- **Security:** Fewer transfers enhance cargo security and decrease the likelihood of theft.

Forest Product Use of Intermodal Transportation

For forest products - such as timber, pulp, and paper - intermodal transportation presents unique advantages. Specialized containers and handling equipment designed to safeguard moisture-sensitive and bulky forest products are increasingly used at intermodal hubs such as those in Missouri. These facilities not only enable the seamless transfer of forest products between rail and truck modes but also help minimize handling damage and maintain product quality throughout long-distance shipments. In regions like the Ozarks, where forest resources are abundant, the integration of intermodal logistics has improved efficiency by reducing the time and cost associated with multiple transfers, thus enhancing overall supply chain reliability (USDA Forest Service, 2020).

Overall, Missouri's expanding network of intermodal hubs supports efficient and secure freight transportation, positioning the state as a vital link in regional and international supply chains.

UTILITIES

Missouri's utility infrastructure is a critical component of its economic landscape, supporting businesses, industries, and residential communities with essential services, including electricity, natural gas, water, telecommunications, and waste management. A reliable and efficient utility network ensures operational stability, facilitates industrial growth, and promotes sustainability. Key providers across each sector deliver essential services to both urban and rural areas, ensuring widespread access to vital resources. The Missouri Public Service Commission regulates most utility services, overseeing rates, service quality, and compliance with state and federal regulations.

The Missouri Public Service Commission oversees electric, natural gas, water, and sewer services across the state. It regulates rates, service quality, and compliance with federal and state regulations (Missouri Public Service Commission, 2023). Their role is to ensure fair pricing, promotes utility modernization, and enforces environmental and safety standards.

The Missouri Department of Natural Resources works with businesses; local, state and federal governments and the public to protect human health and the environment through implementation and enforcement of regulations developed by the U.S. Environmental Protection Agency (EPA) and by the state of Missouri. They confer air and water permitting on industrial sites, including sawmills.

Electric Utilities

Electricity is fundamental to business operations, industrial processes, and daily living. Missouri's electric utilities provide extensive coverage and reliable service to meet the state's growing energy demands. Key Electric Providers include:

- **Ameren Missouri:** Serves over 1.2 million customers primarily eastern and central Missouri, including St. Louis (Ameren Missouri, 2023).
- **Evergy (formerly Kansas City Power & Light):** Serves 1.6 million customers in Western Missouri, including the Kansas City metropolitan area, and Kansas.
- **Empire District Electric Company:** Serves localized communities including Joplin and surrounding areas.
- **Association of Missouri Electric Cooperatives:** 40 distribution cooperatives that provide electricity across the state

Natural Gas Utilities

Natural gas plays a vital role in industrial heating, power generation, and residential energy needs. Missouri's natural gas providers maintain infrastructure that supplies energy efficiently across the state. Key Natural Gas Providers include:

- **Ameren Missouri:** Provides natural gas services to a significant portion of its electricity customer base in Eastern and central Missouri. (Ameren Missouri, 2023)
- **Spire Inc.:** serving approximately 1.7 million customers in St. Louis and various other Missouri regions. (Spire Inc., 2023)

Water Utilities

Access to clean water is essential for both businesses and households. Missouri's water providers ensure a reliable water supply for industrial use, environmental management, and residential consumption. Key Water Providers include:

- **Missouri American Water:** Serves multiple cities, including St. Louis, Jefferson City, and Columbia. (Missouri American Water, 2023).
- **Local Water Districts & Municipal Water Departments:** Serve various geographies across the state. .

Telecommunications

A well-developed telecommunications network is crucial for business operations, industrial communication, and residential connectivity. Missouri has multiple providers offering broadband internet, telephone, and television services. Key Telecommunications Providers include:

- **AT&T:** Statewide coverage in both urban and rural areas for internet, phone, and TV services. (AT&T, 2023)
- **Spectrum (Charter Communications):** Provides internet, phone, and TV services in major cities and towns across Missouri.
- **Brightspeed (Previously CenturyLink): Provides** broadband internet and telecommunications services in rural and suburban areas statewide. (Lumen Technologies, 2023)

Waste Management

Waste disposal and recycling services are essential for industrial operations, commercial businesses, and residential communities. Major waste management providers ensure proper waste handling, landfill management, and recycling programs. Key Waste Management Providers include:

- **Waste Management, Inc:** Provides residential, commercial, and industrial waste collection and recycling services across multiple regions. (Waste Management, Inc., 2023).
- **Republic Services:** Specializes in waste disposal, recycling, and sustainability initiatives in multiple locations across the state. (Republic Services, 2023).

CONCLUSION

Although the largest market for the southern yellow pine species remains the traditional commodity markets such as dimension lumber, decking, floor joists and rafter materials, Missouri may not be able to economically compete with the large volumes of plantation grown pine located near the high production sawmills in America's wood basket; however, there are other opportunities to grow markets for short leaf pine.

Opportunities for market development in biomass and bioenergy, chips and shavings, and pellets show promise within Missouri's residential and school buildings as well as in national or global markets as shown by record high industrial pellet sales to the EU. Certification may become necessary to access global markets as consumers continue to demand more sustainable resources. Infrastructure applications are a ready market for shortleaf pine. Other states are currently using pine for infrastructure products and could be used as a resource to jumpstart a statewide MoDOT program. This is an opportunity for the state to demonstrate its commitment to restoring shortleaf pine while also using local resources and supporting local economies.

Engineered and industrial wood products such as the pallet market have shown a growing acceptance for pine. Mass timber is on the rise and buildings are already being constructed with mass timber in Missouri. Access to mass timber manufacturing facilities in Illinois and Arkansas can be explored.

Suppliers need to know how wood is perceived in any of these market segments so they can adjust their marketing strategies to the different customers. Challenges can be expected with premium lumber markets and the highway infrastructure markets because engineers aren't educated on the properties and values of wood, and in particular of Missouri's shortleaf pine. Industry associations can be leveraged to assist with educating design and construction professionals.

A unified approach would best serve Missour's forest products industry as they try to capitalize on any of these markets. Landowners, suppliers, and manufacturers need to work together to foster development of each market sector so that the industry can work as an integrated system providing markets for each product in the tree. A unique approach will have to be adopted to each segment of the industry. The lumber market could be tapped for Missouri-grown shortleaf pine to be sold as a premium product for visible products such as lumber, architectural pieces, molding, and decking. A statewide branding initiative for Missouri-grown shortleaf pine could leverage the cultural significance of the tree.

State agencies can foster market development by being a consumer for the industry themselves. State agencies can lead by example demonstrating for Missourians the value of incorporating shortleaf pine. An important message for decision makers is that increasing the use of a local resource helps create jobs, is environmentally sustainable, reduces carbon emissions, helps forest management practices and is good for rural economies.

State agencies and industry associations can be engaged to assist with the education of potential consumers, demonstration projects, promotion, and to showcase the purchases of shortleaf pine products for internal use as a commercial building product, infrastructure products, and in renewable energy systems. This could be speaking on the benefits of wood at their annual meetings or holding training classes in wood design.

RESOURCES

MILL DEVELOPMENT, MANAGEMENT, AND EFFICIENCY RESOURCES

The Wisconsin DNR provides a very detailed list of resources for forest industry businesses on their website at www.dnr.wisconsin.gov/topic/forestbusinesses/resources.

Category	Resource Name
Business Management	A Planning Guide for Small and Medium Sized Wood Products Companies
	Business Management Practices for Small to Medium Sized Forest Products Firms
Marketing	A Marketing Guide for Small and Medium Sized Primary Forest Products Processors
	Value-Added Wood Products Marketing Guide for Manufacturers and Entrepreneurs
Lumber Yield	Sawmill Badger - Hardwood Sawmill Analysis Tool
Business Plan Tool	Business Plan Compiler Tool [BOLT Tool]
	BOLT Mobile App Webinar
Sawmill Production	Rough Mill Improvement Guide for Managers and Supervisors
	So You Want to Build a Sawmill
	Manufacturing and Marketing Eastern Hardwood Lumber Produced from Thin Kerf Band Mills
	Quality Control Troubleshooting Tools for the Mill Floor
	Results-Driven Approach to Improving Quality and Productivity
	Circular Sawmills and Their Efficient Operation
	Improving Sawing Accuracy Does Help
	Balanced Saw Performance
	Bandsaw Cracking: Troubleshooting Causes
	How to Calculate Required Horsepower for Circular Saws
Grading and scaling	A Simplified Procedure for Developing Grade Lumber from Hardwood Logs
	Procedure for Quartersawing Logs 16-19 Inches in Diameter
	The Illustrated Guide to American Hardwood Lumber Grades
	A Guide to Hardwood Log Grades
	Local-Use Lumber Grading Handbook
Kiln drying	Dry Kiln Operator's Manual
	Dry Kiln Schedules for Commercial Woods
	Drying Hardwood Lumber
	Air Drying of Lumber
	Effects of End Coatings on Defects
	Quality Drying of Hardwood Lumber Guidebook
	Quality Drying of Softwood Lumber Guidebook
	Building Your Own Lumber Dry Kiln
	Operation and Cost of a Small Dehumidification Dry Kiln
	Understanding Vacuum Drying Technologies
	Comparing Vacuum and Conventional Drying
	Preventing Blue Stain
	Heat Treatment of Firewood
Utilization	Wood Utilization Options for Urban Trees
	Logging Residue Report
	Real Cost of Extracting Residue
	2009 Wisconsin Wood Residue Study
	Pine Straw Feasibility Study
	Moisture Content of Woody Biomass
	Hardwoods of North America
	Softwoods of North America
Financial Feasibility Spreadsheets	GRADEYIELD - Basic Sawmill Lumber Grade/Yield Analysis
	PROYIELD – Projection of Sawmill Yields
	SAWFEAS - Sawmill Financial Analysis
	DRYFEAS - Lumber Kiln Drying Operation Finance Analysis
	Wood Fueled Boiler Financial Feasibility Analysis

FOREST INDUSTRY AGENCIES AND ASSOCIATIONS

The following organizations provide support services to the forest products industry in Missouri and beyond.

Missouri Department of Conservation

The Missouri Department of Conservation (MDC) is the state agency responsible for managing Missouri's state lands and is a resource for forest industry producers and manufacturers. The state conducts and maintains key forest product industry information and provides technical assistance to forest products companies. MDC foresters work with the forest product industry to connect them with resources, supply, and markets. MDC also maintains a Mill Information Database on their website.

Missouri Department of Natural Resources

Missouri Department of Natural Resources offers wood energy assistance through educational resources and financial and technical assistance on wood energy projects.

Missouri Forest Products Association

The Missouri Forest Products Association (MFPA) promotes the business of all forest-related industries and encourages closer working relationships among forest products firms, forest owners, producers, and harvesters. This networking helps improve procurement, processing, research, and marketing of forest products. MFPA provides education and advocates for the logging and forest product manufacturing industries in Missouri.

The American Lumber Standard Committee Incorporated

The American Lumber Standard Committee Incorporated (ALSC) is a non-profit organization of manufacturers, distributors, users, and consumers of lumber, that serves as the standing committee for the American Softwood Lumber Standard (Voluntary Product Standard 20) and administers an accreditation program for lumber grading under the American Lumber Standard (ALS) system. The ALS is the basis for the sale and purchase of virtually all softwood lumber traded in North America. The ALS system also provides the basis for acceptance of lumber and design values for lumber by the building codes throughout the United States.

Southern Pine Inspection Bureau

The Southern Pine Inspection Bureau (SPIB) is a leading authority for grading and quality assurance in the Southern Pine lumber industry, helping to ensure consistency and compliance with recognized standards. SPIB offers essential expertise in establishing product reliability and access to diverse markets. By providing grading standards, SPIB ensures that lumber meets rigorous structural and aesthetic criteria, enabling companies to compete both domestically and internationally. SPIB's core services include lumber grading certification, technical publications, and research. In addition to offering a comprehensive standardization program of grading and manufacturing practices, SPIB also offers a variety of training courses designed to enhance industry knowledge and skills in lumber grading, quality control, and related processes.

Southern Forest Products Association

The Southern Forest Products Association (SFPA) is a trade organization dedicated to promoting southern pine products and supporting the industry that produces and markets them. SFPA provides a variety of resources, including market research, promotional materials, industry training programs, and advocacy for wood products.

Softwood Export Council

The Softwood Export Council (SEC) is a nonprofit organization that helps U.S. companies expand their global reach by promoting the export of softwood lumber products. For Missouri businesses interested in exporting shortleaf pine products, SEC can offer critical support in navigating international markets, understanding trade regulations, and building connections with overseas buyers. SEC's services include export readiness training, market research, trade leads, and participation in international trade events.

Softwood Lumber Board

The Softwood Lumber Board (SLB) is an industry-funded initiative that was established to promote the benefits and uses of softwood lumber products in outdoor, residential and non-residential construction. The SLB supports and offeres softwood lumber related research, education, and marketing campaigns focused on creating demand. SLB offers access to resources like promotional toolkits, technical guides, and funding for market innovation projects.

Think Wood is a communications and education program supporting the softwood lumber industry. Targeting architects, developers, engineers, and commercial and residential contractors, the program builds interest and intent to specify wood in the residential, midrise, and non-residential sectors.

WoodWorks is SLB's premier program for increasing the consumption and market share of softwood lumber in commercial and multifamily buildings. WoodWorks provides one-on-one project assistance, as well as education and resources related to the code-compliant design, engineering, and construction of non-residential and multi-family wood buildings.

The Wood Institute is SLB's online learning portal. It offers 190+ contemporary course offerings in wood design and construction. Course topics include light-frame, mass timber, carbon, sustainable forestry, codes, building science, prefabrication and construction process, interiors, decks, and more. Courses have been approved for credit by leading organizations including the AIA, GBCI, ICC, NCSEA, and others.

American Wood Council

The American Wood Council (AWC) is a leading organization dedicated to promoting the use of wood products as sustainable, efficient, and innovative building materials. For Missouri-based forest industry companies, particularly those interested in marketing shortleaf pine as structural or design material, AWC provides guidance on building codes, structural standards, and sustainability practices. AWC offers a range of resources, including access to technical publications, building code updates, software tools for wood design, and educational webinars for architects, engineers, and builders.

Credit Insurance

Credit insurance is a financial risk management tool designed to protect businesses against losses stemming from unpaid customer invoices. For Missouri forest industry companies expanding into international export, credit insurance can be vital in securing transactions with confidence. This tool not only safeguards revenue but also enables companies to extend competitive credit terms to customers without increasing risk. Credit insurance providers typically offer services like credit risk assessment, invoice coverage, and assistance in debt recovery. Credit insurance is offered through private insurers and brokers.

Hardwood Lumber Association

The Hardwood Lumber Association is committed to providing its members with the resources needed to drive business, market share, and industry visibility. Members are interested in manufacturing softwood products because without it, they don't have markets for the pine component of their mixed stand sales.

National Wood Pallet and Container Association

The National Wooden Pallet & Container Association is the largest organization of wood packaging professionals in the world, with more than 800 company members in 40 countries who manufacture, repair and distribute pallets and wood packaging in unit-load solutions, or who supply products and services to the industry. They provide an environment for our members to succeed while promoting the wood pallet and wood packaging industry.

U.S. Industrial Pellet Association

The U.S. Industrial Pellet Association serves as the wood energy sector trade association, promoting sustainability and safety practices within the industry. They advocate for wood energy and support renewable energy policy development around the globe.

FUNDING OPPORTUNITIES

Missouri Value-Added Grant Program

The Missouri Value-Added Agriculture Grant Program provides grants for projects that add value to Missouri agricultural products and aid the economy of a rural community. Grants provide assistance for industry and others for expanding technologies for agricultural product production. Funds can be used for business planning and development as well as other activities.

U.S. Forest Service Wood Innovations Program

The following funding opportunities are available through the U.S. Forest Service Wood Innovations Program.

Wood Innovation Grant Program: The Wood Innovation Grants Program stimulates, expands, and supports U.S. wood products markets and wood energy markets to support the long-term management of National Forest System and other forest lands. National focus areas include mass timber, renewable wood energy, and technological development that supports hazardous fuel reduction and sustainable forest management.

Community Wood Grant Program: The Community Wood Grant Program provides funding for grants to install thermally led community wood energy systems or to build innovative wood product manufacturing facilities. The Forest Service expects renewable wood energy systems installed under this program to use the most stringent control technologies. The program places extra emphasis on assisting sawmills in economically challenged areas to retool or add advanced technology.

Wood Products Infrastructure Assistance Grant Program: The Wood Products Infrastructure Assistance Program provides support for facilities that purchase and process byproducts of ecosystem restoration projects. This includes projects that establish, reopen, retrofit, expand, or improve a sawmill or other wood-processing facility in close proximity to federal or Indian lands that need ecosystem restoration and will generate byproducts. The emphasis is on areas of unnaturally severe high fire or insect or disease infestation with high priority for ecological restoration.

USDA Rural Development

The following pertinent funding opportunities are available through USDA Rural Development:

Federal USDA Rural Development: Timber Production Expansion Guaranteed Loan Program: The Timber Production Expansion Guaranteed Loan Program provides financial support to qualified lenders whose loan applicants want to establish, reopen, expand, or improve a sawmill or other wood processing facility that process ecosystem restoration byproducts from U.S. Forest Service National Forest System lands.

Rural Economic Development Loan & Grant Program in Missouri: The Rural Economic Development Loan and Grant programs provide funding for rural projects through local utility organizations. USDA provides zero-interest loans to local utilities which they, in turn, pass through to local businesses, the ultimate recipients, for projects that will create and retain employment in rural areas including business establishment and expansion and technical assistance.

Rural Energy for America Technical Assistance Grant Program in Missouri: The Rural Energy for America Technical Assistance Grant Program (REAP) provides technical assistance to agricultural producers and rural small businesses.

Rural Business Development Grants in Missouri: Rural Business Development Grants support targeted technical assistance, training, and other activities that promote the development and expansion of small and emerging private businesses in rural areas.

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MISSOURI SHORTLEAF PINE UTILIZATION

BREWER BOYS, LLC SHAVINGS MILL EXPANSION

BUSINESS PLAN | FEBRUARY 2025

Brewer Boys, LLC
16221 Bay Road
Eminence, MO 65466

INTRODUCTION

Mechanized Logging Operation in Shortleaf Pine Stand

Photo Credit: Ross, H. (2024). Renewable Resource Solutions, LLC. [Unpublished photographs].

This **Business Plan** is part of the broader *Missouri Shortleaf Pine Utilization Assessment*, a resource initiated by the Forest and Woodland Association of Missouri (FWAM) in partnership with the Missouri Department of Conservation, the L-A-D Foundation, and the Mark Twain National Forest to address the market barriers limiting shortleaf pine utilization. Recognizing the need to strengthen existing markets and uncover new opportunities for this underutilized species, FWAM and its partners developed the Assessment as a comprehensive resource for government agencies, loggers, sawmills, and secondary producers.

By providing key data on Missouri-grown shortleaf pine, the report highlights targeted areas for product manufacturing growth and underscores how expanding these markets can foster sustainable forestry practices, boost economic development, and enhance ecological resilience throughout the state.

The *Missouri Shortleaf Pine Utilization Assessment* brings together extensive data and analysis to guide sustainable shortleaf pine management. Its **Resource Assessment** details the species' historical significance, current distribution, ownership patterns, and growth projections, while the **Market Assessment** explores current industry capacity, supply-and-demand dynamics, potential product lines, and forest product manufacturing trends. It also examines opportunities for a collaborative branding initiative. This **Business Plan** proposes a targeted example of industrial expansion.

Brewer Boys, LLC specializes in producing pine shavings and pellets with a strong commitment to local sourcing and sustainability. To double its production capacity, the company plans to transition from purchasing out-of-state pine shavings to sourcing raw materials directly from the Mark Twain National Forest and surrounding areas. This expansion will process an additional 20,800 to 83,200 tons of raw materials annually, including shortleaf pine logs and woody biomass, annually, supporting ecosystem restoration efforts.

This expansion will also drive local economic development by creating jobs, supporting the logging industry, and alleviating financial burdens on Shannon County, Missouri. Additionally, it will enhance forest health and reduce wildfire risks by providing a sustainable market for underutilized byproducts from federal land restoration initiatives.

Currently, the facility does not process logs but instead purchases dried wood shavings from outside Missouri for bagging and shipment. The proposed expansion includes constructing a new building and acquiring equipment to process roundwood and other biomass from within the state, diversifying feedstocks while promoting sustainable harvesting of Missouri shortleaf pine.

To support the expansion's costs, Renewable Resource Solutions submitted a 2024 U.S. Forest Service Wood Products Infrastructure Assistance grant application on behalf of Brewer Boys LLC.

Brewer Boys LLC's expansion project represents a unique opportunity to address multiple community, environmental, and economic needs in southern Missouri. By increasing production capacity, sourcing raw materials locally, and supporting forest restoration efforts, the project will create a sustainable market for shortleaf pine byproducts while providing significant economic benefits to the region. With the requested financial assistance, Brewer Boys is poised to make a lasting impact on both the local economy and the health of the Mark Twain National Forest.

BUSINESS OVERVIEW

Brewer Boys, LLC is a family-owned business founded in 2012 by Chris Brewer and his three sons as a construction company. Over time, the sons bought out their father and continued to grow the business. In 2022, they made a strategic shift, selling the construction company to acquire Tim Banks Wood Products. The acquisition was completed on September 20, 2022, marking Brewer Boys, LLC's transition into pine shavings and pellet production.

Since then, the company has experienced rapid growth, more than doubling its production capacity. Currently, Brewer Boys, LLC produces 25,000 bags of pine shavings and pellets per week - about 1.3 million bags annually - using approximately 400 tons of raw materials sourced from Mississippi. To further expand, the company plans to invest in its own drying and shaving system, allowing for local log procurement and in-house processing. Additionally, Brewer Boys, LLC is exploring feedstock sourcing from the National Forest Service (NFS) to enhance supply chain control and cost efficiency.

The company currently employs 12 individuals, with plans to expand to 16 to support continued growth. The upcoming expansion project will double production capacity to at least 50,000 bags per week by utilizing local resources from the Mark Twain National Forest. Installing a wood shavings mill and drum dryer system will enable the facility to process raw pine logs and biomass on-site, significantly reducing transportation costs, increasing sustainability, and ensuring a reliable supply of materials for future growth.

MARKET OPPORTUNITY

The Mark Twain National Forest in southern Missouri holds substantial volumes of shortleaf pine and other timber types, including Loblolly/Shortleaf Pine, Oak/Hickory, Oak/Pine, and Eastern Softwoods. Ecosystem restoration efforts, such as the Missouri Pine-Oak Woodland Collaborative Forest Landscape Restoration (CFLR) project, provide a sustainable yet largely untapped supply of raw materials. With an estimated 856,982 green tons of biomass available in the CFLR area and only 7% of the volume goal met as of 2022, there is a strong need for markets that can utilize shortleaf pine byproducts. Brewer Boys' expansion will help address this gap by establishing a reliable, local demand for these materials.

Beyond economic benefits, this expansion will contribute to regional forest health by reducing wildfire risk, mitigating insect and disease infestations, and promoting ecological restoration. Currently, Missouri lacks a well-developed market for small-diameter shortleaf pine, limiting the pace of restoration. Brewer Boys' investment in local sourcing and processing will provide an immediate and practical solution to this ongoing challenge.

The availability of shortleaf pine in the region far exceeds the processing capacity of existing facilities. As a result, no restoration sales on the Mark Twain National Forest are currently under contract, despite the need to remove excess biomass. The expansion of Brewer Boys will create new opportunities for local loggers to purchase restoration sales and supply raw materials to the facility, supporting both economic development and forest management goals.

OBJECTIVES

1. **Expand Production Capacity:** Increase output from 25,000 to 50,000 bags of pine shavings per week to meet growing market demand.

2. **Source Local Materials:** Procure an additional 20,800 to 83,200 tons of shortleaf pine byproducts annually from the Mark Twain National Forest and other local timber sales, reducing reliance on out-of-state suppliers.

3. **Support Forest Restoration:** Establish a sustainable market for shortleaf pine byproducts, contributing to wildfire risk reduction, forest health, and ongoing federal land restoration efforts.

4. **Strengthen the Local Economy:** Create four new jobs in an economically distressed area while supporting regional logging and transportation industries.

5. **Enhance Infrastructure:** Install and commission a wood shavings mill, drying system, conveyor system, log deck, drum dryer, screen, fuel bin, and other necessary equipment to enable in-house processing of raw materials.

6. **Workforce Development:** Train employees on the new shavings mill and dryer system to optimize efficiency and maximize production capacity.

RISK FACTORS

1. **Market Price Volatility:** The pine shavings and pellets industry is highly competitive, with pricing influenced by macroeconomic and microeconomic factors outside of the company's control. Fluctuations in supply and demand could impact profitability.

2. **Raw Materials Cost:** The cost of wood fiber and roundwood is largely dictated by broader market conditions, including stumpage pricing, transportation costs, and landowner agreements. As the business relies primarily on National Forest Service (NFS) lands and surrounding areas for supply, any market shifts could affect operating expenses.

3. **Fuel Price Fluctuations:** Beyond feedstock and labor, fuel costs are one of the largest operational expenses. Significant increases in fuel prices could reduce profit margins and affect product delivery logistics.

4. **Workforce Availability**: The company plans to expand its workforce to 16 employees, but finding and retaining skilled labor may be challenging due to the facility's location in a sparsely populated area. Labor shortages could slow production growth and impact financial goals.

5. **Manufacturing Efficiency Risks:** The business strategy assumes that planned facility upgrades will increase mill throughput and improve overall efficiency. Delays in implementing these improvements or inefficiencies in operations could result in lower-than-expected financial performance.

6. **Reliance on a Major Wood Supplier:** Approximately 53% of the facility's logs and woody biomass are expected to come from ecosystem restoration projects on the Mark Twain National Forest. While this supply relationship is anticipated to continue, any disruption could make it difficult to secure alternative sources due to the proximity advantage of the current supply.

7. **Regulatory & Environmental Compliance:** Operating within the forestry and wood processing industry means compliance with state and federal environmental regulations related to logging, emissions, and land use. Changes in regulations or new restrictions on harvesting from public lands (such as the Mark Twain National Forest) could impact raw material availability and operating costs.
8. **Supply Chain Disruptions:** While the company aims to source wood locally, factors such as severe weather events, wildfires, natural disasters, or transportation/logistics issues could disrupt supply chains. A lack of access to raw materials would impact production and revenue.
9. **Capital & Financing Risks:** The success of the expansion depends on securing sufficient funding for infrastructure improvements. Interest rate fluctuations, changes in lending conditions, or delays in grant disbursement could impact cash flow and project timelines.

RISK MITIGATION STRATEGIES

1. **Market Price Volatility**
    - Diversify Revenue Streams**:** Expand product offerings to serve multiple markets to reduce reliance on any single sector.
    - Long-Term Contracts: Secure purchase agreements with large customers to stabilize revenue and mitigate short-term price fluctuations.

2. **Raw Materials Cost**
    - Supplier Diversification: Develop relationships with multiple timber suppliers, including private landowners, to reduce reliance on a single source.
    - Inventory Management: Maintain buffer stock to absorb short-term fluctuations in raw material costs.

3. **Fuel Price Fluctuations:**
    - Fleet & Route Optimization: Use fuel-efficient logistics planning to minimize transportation costs.

4. **Workforce Availability**
    - Competitive Compensation & Benefits: Offer wages, incentives, and benefits that attract and retain skilled workers.

5. **Manufacturing Efficiency Risks**
    - Preventative Maintenance Program: Regularly service equipment to avoid unplanned downtime.
    - Scalable Implementation: Phase facility upgrades to allow for incremental improvements and minimize disruption.

6. **Reliance on a Major Wood Supplier**
    - Diversified Procurement Strategy: Identify and establish alternative supply chains with private timberland owners and logging contractors.
    - Supply Agreements: Work with the U.S. Forest Service to secure multi-year agreements for sustainable raw material procurement.

7. **Regulatory & Environmental Compliance**
    - Proactive Monitoring & Engagement: Maintain ongoing communication with regulatory agencies to stay ahead of potential policy changes.

8. **Supply Chain Disruptions**
    - Emergency Response & Contingency Planning: Develop a crisis response plan for extreme weather events, transportation issues, or unexpected supply shortages.

9. **Capital & Financial Risks**
    - Diversified Funding Sources: Seek a mix of grants, loans, and private investment to spread financial risk.
    - Phased Investment Approach: Implement expansion plans in stages to align with available capital and cash flow conditions.

BUSINESS MODEL

Brewer Boys LLC will source raw pine logs and biomass directly from the Mark Twain National Forest and local timber sales. These materials will be processed in-house using the newly installed wood shavings mill and drum dryer system, which will produce pine shavings and pellets for sale. This vertical integration will reduce the company's dependence on out-of-state suppliers, cut transportation costs, and ensure a consistent supply of high-quality raw materials.

The company will primarily target industries that require bedding materials for livestock and poultry, expanding their customer base in these sectors. Brewer Boys will also explore additional markets for its wood pellets, positioning them as a renewable energy source.

OPERATIONS PLAN

1. **Equipment Installation**: Brewer Boys will purchase and install essential equipment, including a wood shavings mill, drum dryer, conveyor system, and associated machinery. The total investment in equipment and installation is estimated at $1,250,000, with additional funding for construction, electrical upgrades, and staffing.
2. **Workforce Expansion**: Brewer Boys plans to hire four new employees, bringing the total workforce to 16. These employees will receive training on the new equipment and production processes to ensure optimal operational efficiency.
3. **Raw Material Sourcing**: Pine logs and biomass will be sourced from the Mark Twain National Forest, particularly from areas targeted for ecological restoration. Local loggers and contractors will be engaged to provide a reliable supply of these materials.
4. **Quality Control**: Strict quality control procedures will be implemented to ensure that all pine shavings and pellets meet high standards, ensuring customer satisfaction.

FINANCIAL PROJECTIONS

The expansion project is expected to significantly boost production capacity and revenue. By increasing weekly production from 25,000 to 50,000 bags, Brewer Boys anticipates reaching an annual production volume of 2.6 million bags of pine shavings and pellets. This will require sourcing between 41,600 to 83,200 tons of raw materials annually.

The total financial investment for the expansion will amount to $1,250,000 for equipment and infrastructure upgrades, with additional private funding for construction and staffing. Financial assistance is being sought to cover the costs of equipment and installation. This expansion is expected to generate substantial revenue growth, driven by increased production capacity and local sourcing of materials.

IMPACT ON FEDERAL LAND MANAGEMENT

This business expansion will support forest restoration efforts by:

1. **Providing a Market for Shortleaf Pine**: By creating demand for shortleaf pine, this will incentivize the removal of overstocked and unhealthy trees, reducing wildfire risks and mitigating insect and disease infestations.
2. **Supporting Ecological Restoration**: Creates economic incentives for timber sales and thinning efforts, which will improve the health and resilience of the Mark Twain National Forest.
3. **Reducing Restoration Costs**: The establishment of a local market for timber byproducts will reduce transportation costs for loggers and contractors, making restoration projects more financially viable.

COMMUNITY IMPACT

Shannon County, Missouri, faces significant socioeconomic challenges, including high poverty rates, population decline, and elevated energy costs. The proposed expansion by Brewer Boys LLC will directly address these issues by creating stable, well-paid jobs and supporting local industries such as logging and transportation. This will provide economic opportunities for low-income households, helping to retain residents, reduce financial stress, and alleviate the burden of high energy costs.

FINANCIAL REVIEW

A financial analysis was conducted to evaluate the economic feasibility of the operation over a five-year period. The analysis includes projected revenue, expenses, and profitability trends, considering both anticipated cost escalations and potential revenue growth.

In Year 1, total income is projected to increase by approximately 30% compared to the previous year, driven by higher sales and grant funding. Over the five-year period, income is expected to grow steadily, with a cumulative increase of more than 170%. Cost of goods sold (COGS) follows a similar upward trend but at a lower rate, maintaining a stable gross profit margin.

Operating expenses, including labor, equipment maintenance, and transportation, are projected to rise modestly each year, with the largest cost components being supplies and payroll. The company anticipates capital expenditures in Year 1, including investments in electrical labor, building construction, and new mill equipment, which will impact short-term profitability but contribute to long-term operational efficiency.

By Year 3, the business reaches a significant financial milestone, achieving a positive net income as production doubles to meet growing demand. In Years 4 and 5, production is projected to increase by 15% annually, contributing to steady revenue growth.

A 3% annual inflation rate has been applied to most costs, with payroll expenses increasing by 4% per year to account for raises. Additional costs were allocated in Year 1 to hire new employees, supporting expanded operations. Capital expenditures in Year 1, including new building construction, result in a tax increase and higher utility costs, reflecting the facility's increased operational footprint. Supply costs decrease starting in Year 2 as the new mill becomes fully operational, allowing for a shift from purchasing shavings to procuring logs and producing shavings in-house. This transition reduces reliance on external suppliers and lowers material supply costs over time. These assumptions, combined with stable market conditions and strategic cost management, position the operation for sustained profitability and long-term growth.

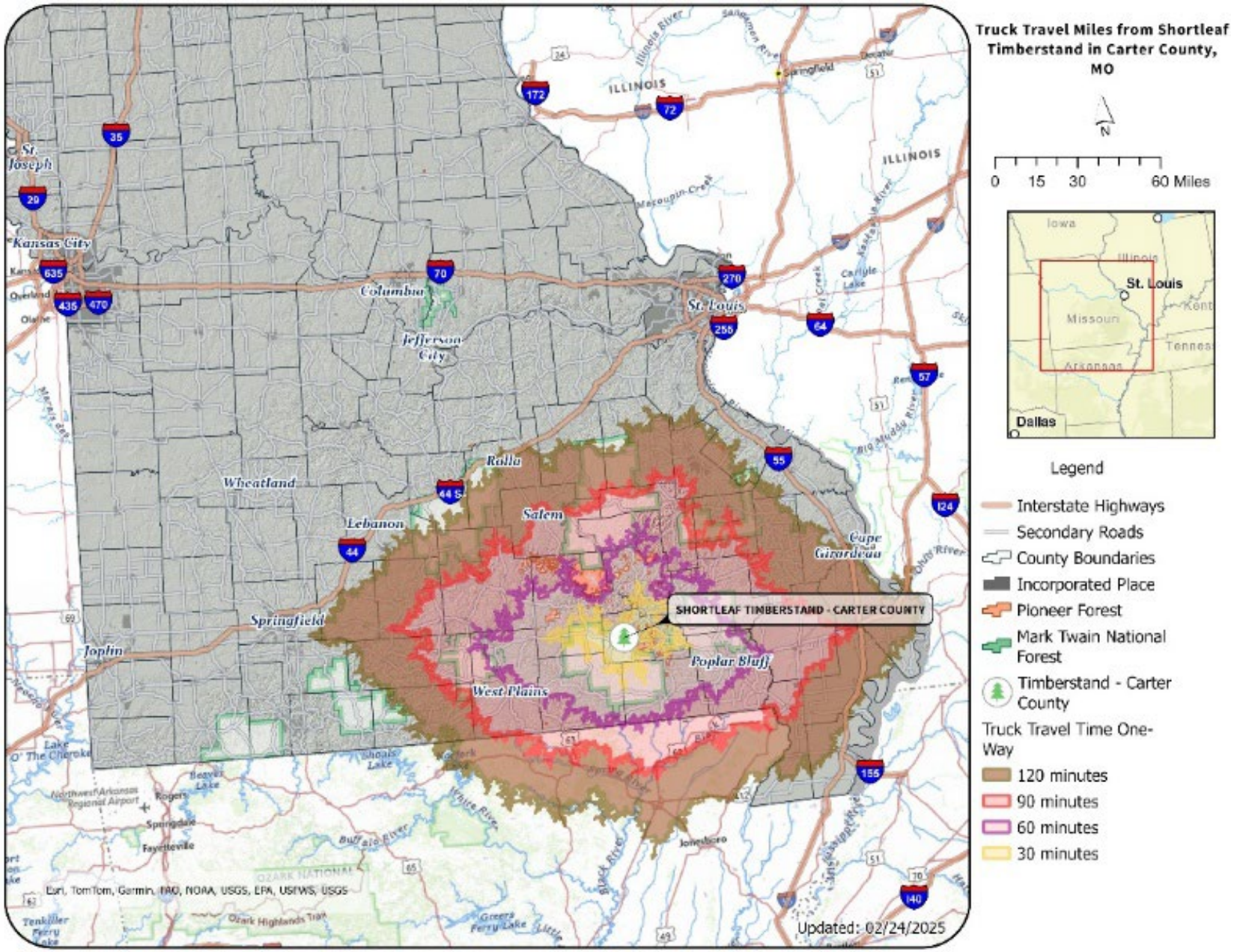
ASSUMPTIONS

The figures and percentages used throughout this business plan are subject to change depending on the conditions of future markets, supply and demand, dollar value, local, state, and national economic status, and other unforeseeable variables.

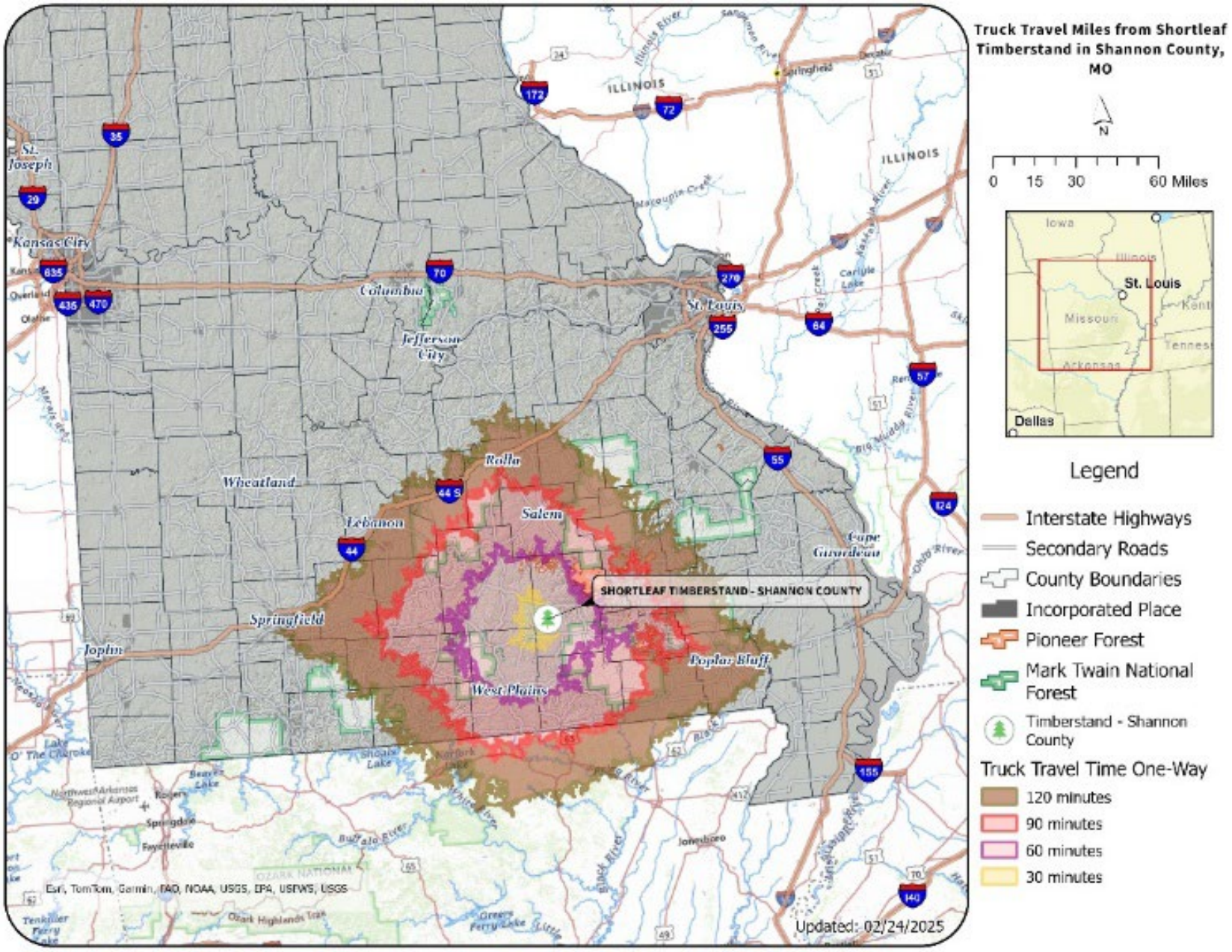
All the information provided is true to the best of Renewable Resource Solution's (RRS) knowledge and any oversight or misrepresentation is unintentional. New technology and innovative practices are continuously discovered, and the most efficient systems and methods today could be outdated in the near future. All information is presumed to be the most up-to-date information available as of the official publication date. Direct research should be done for the most current information when looking for specific price points related to business planning.

APPENDIX A: ONE WAY TRUCK TRAVEL TIMES FROM THE KEY LOCATIONS FOR FACILITY SITING

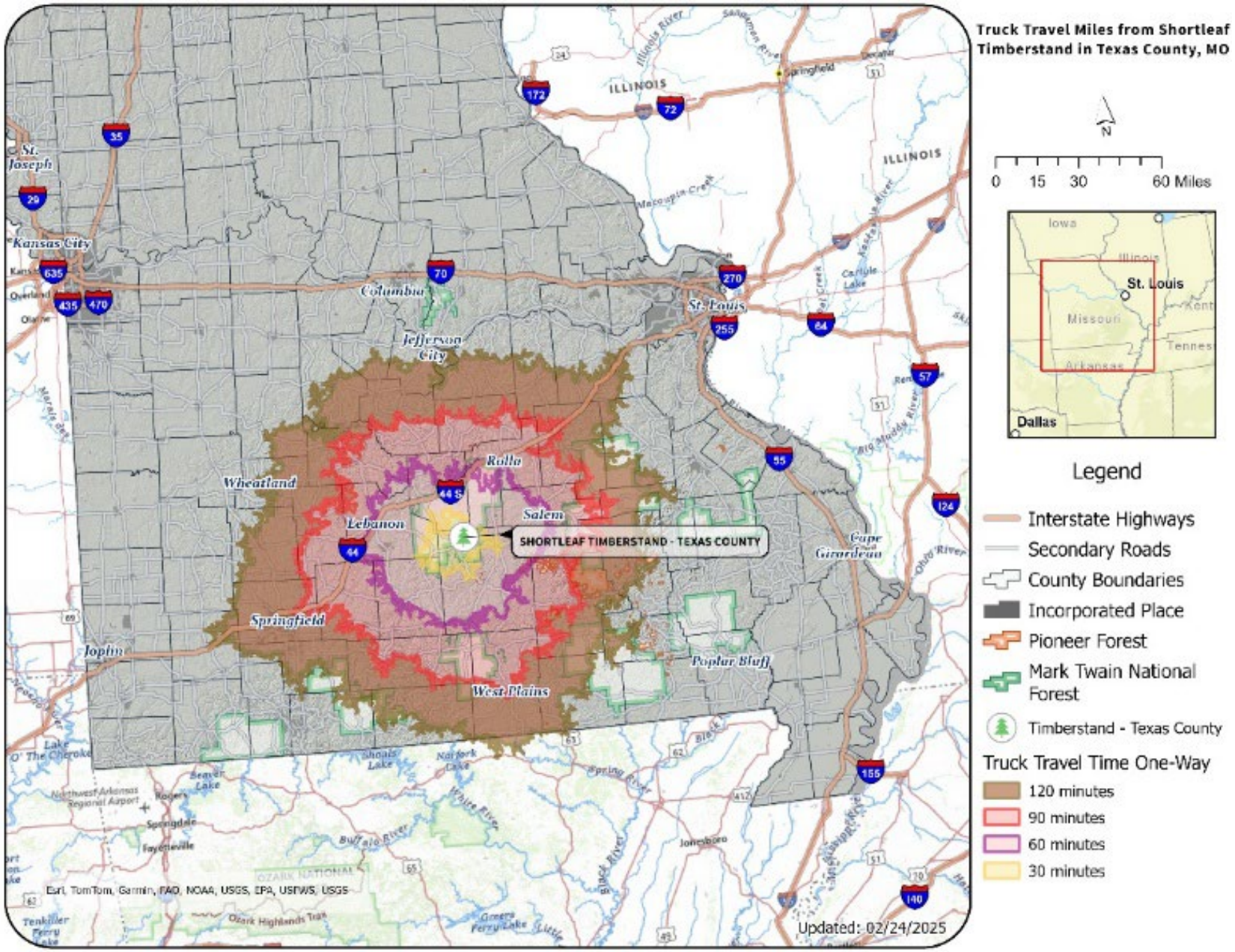
TRUCK TRAVEL TIME FROM THE CENTER OF THE SHORTLEAF PINE RESOURCE IN CARTER COUNTY



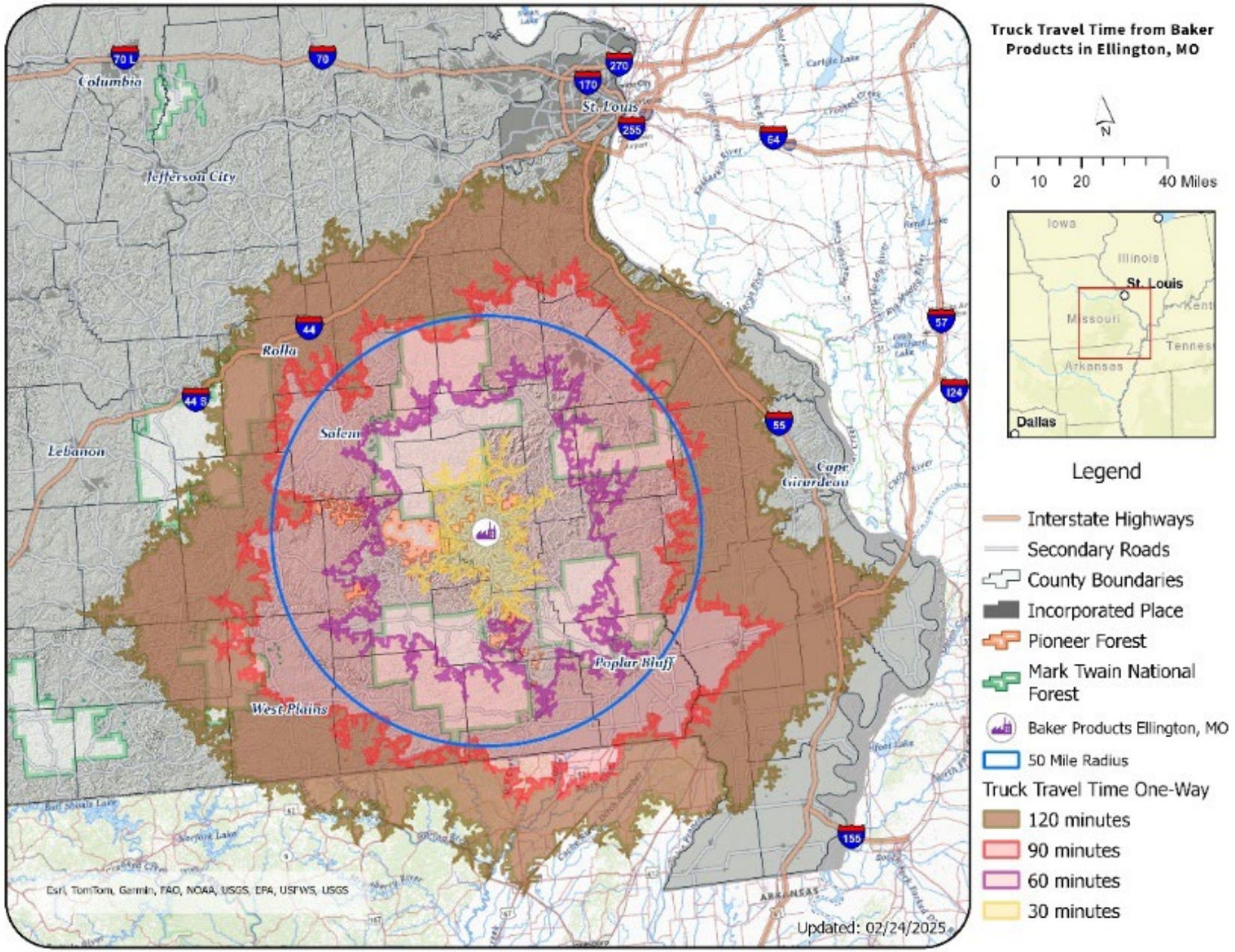
TRUCK TRAVEL TIME FROM THE CENTER OF THE SHORTLEAF PINE RESOURCE IN SHANNON COUNTY



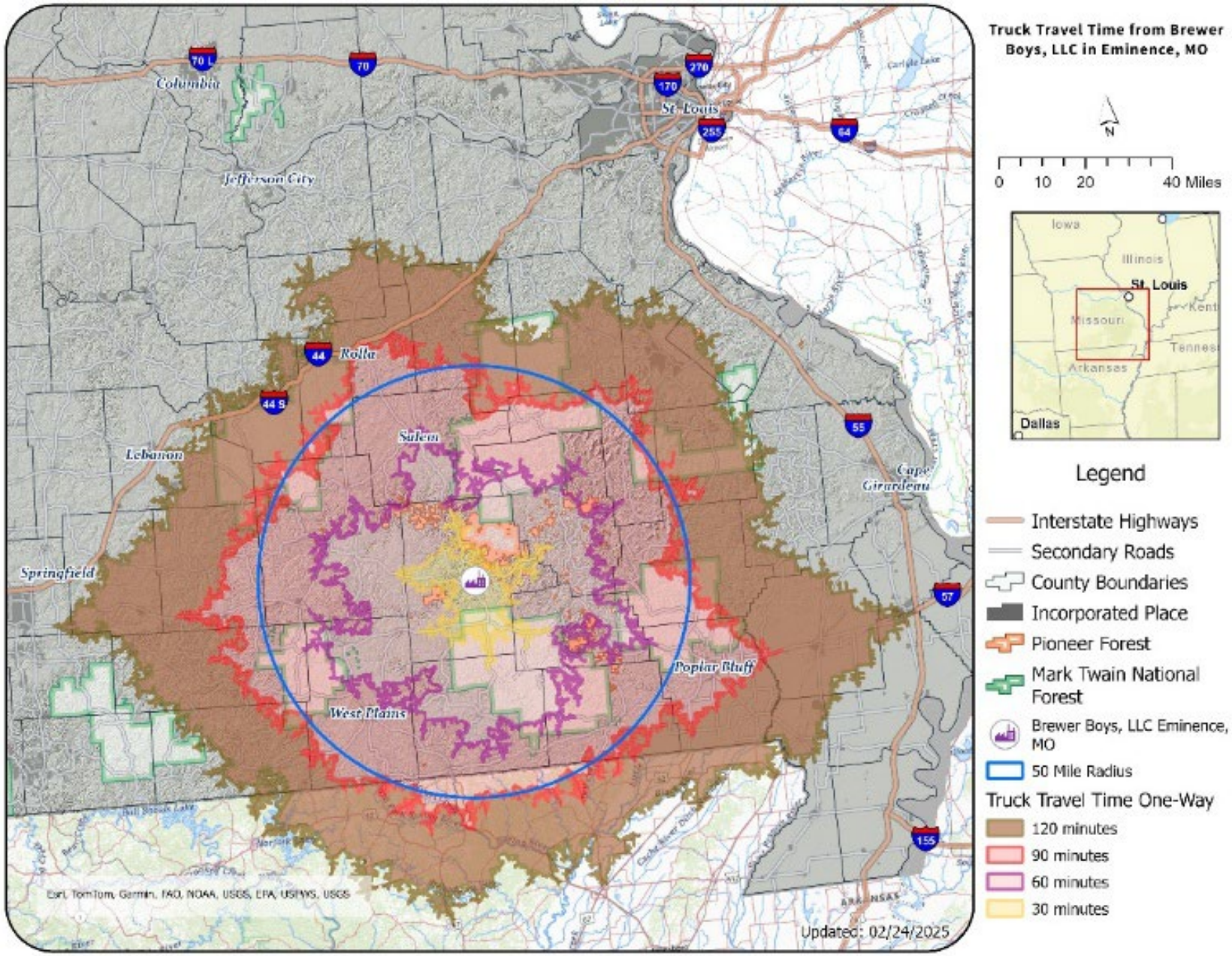
TRUCK TRAVEL TIME FROM THE CENTER OF THE SHORTLEAF PINE RESOURCE IN TEXAS COUNTY



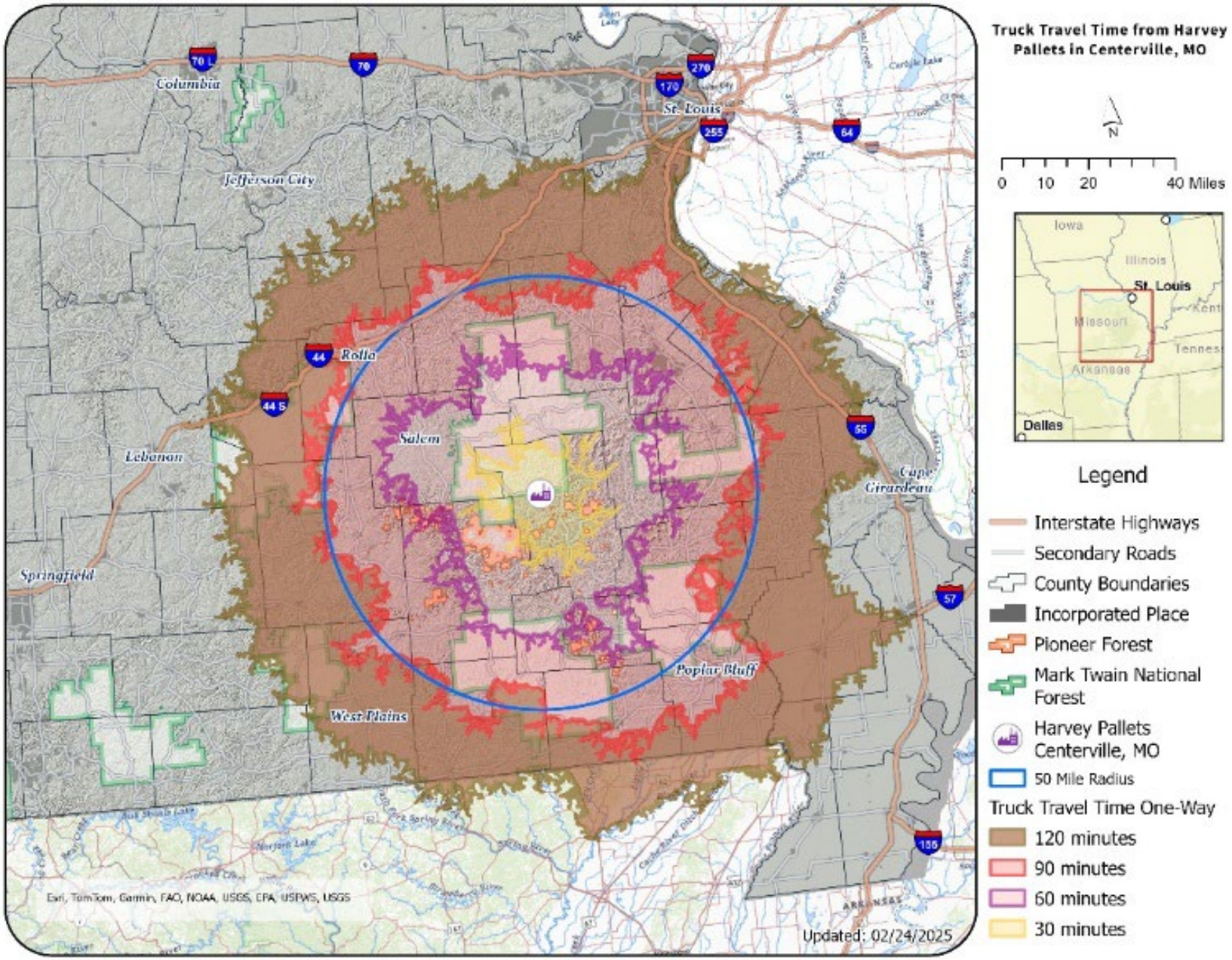
TRUCK TRAVEL TIME FROM BAKER FOREST PRODUCTS IN ELLINGTON, MO



TRUCK TRAVEL TIME FROM BREWER BOYS IN EMINENCE, MO



TRUCK TRAVEL TIME FROM HARVEY PALLETS, CENTERVILLE, MO



TRUCK TRAVEL TIME FROM HARVEY PALLETS, WINONA, MO