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Precision Forestry & Advanced Wood Science



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Precision Silviculture Updates

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University of Georgia Warnell School of Forestry & Natural Resources

2026 Georgia Forestry Association Conference

24 July 2026



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& Natural Resources**

Outline

- Market changes and the need for altered management
- Updated pine species-site relationships and productivity ratings for the Coastal Plain
- Lower density plantings
- Species selection, pine straw, stumpage prices and economics
- Summary and future directions



Market Changes

Familiar Headlines...

Billions in economic losses expected due to Georgia paper mill closures

By Kim Jarrett | The Center Square | Sep 10, 2025



International Paper to Close 2 Georgia Mills, Cut 1,100 Jobs

International Paper Co. has announced the closure of two Georgia paper mills, including a Savannah mill that's been a key part of the local economy for 90 years

By Associated Press | Aug. 21, 2025, at 1:45 p.m.

Georgia Pacific keeping Perry mill closed as it studies 'another business opportunity'

Gannett | JAMES CALL, TALLAHASSEE DEMOCRAT
February 16, 2024



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How paper mill closures are affecting Georgia's logging industry

THE CURRENT

NEWS: BUSINESS

Georgia timber industry faces struggle as large mills close

Closings affect 4.5 million tons of state's timber harvest, 70 logging crews

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ARTICLES

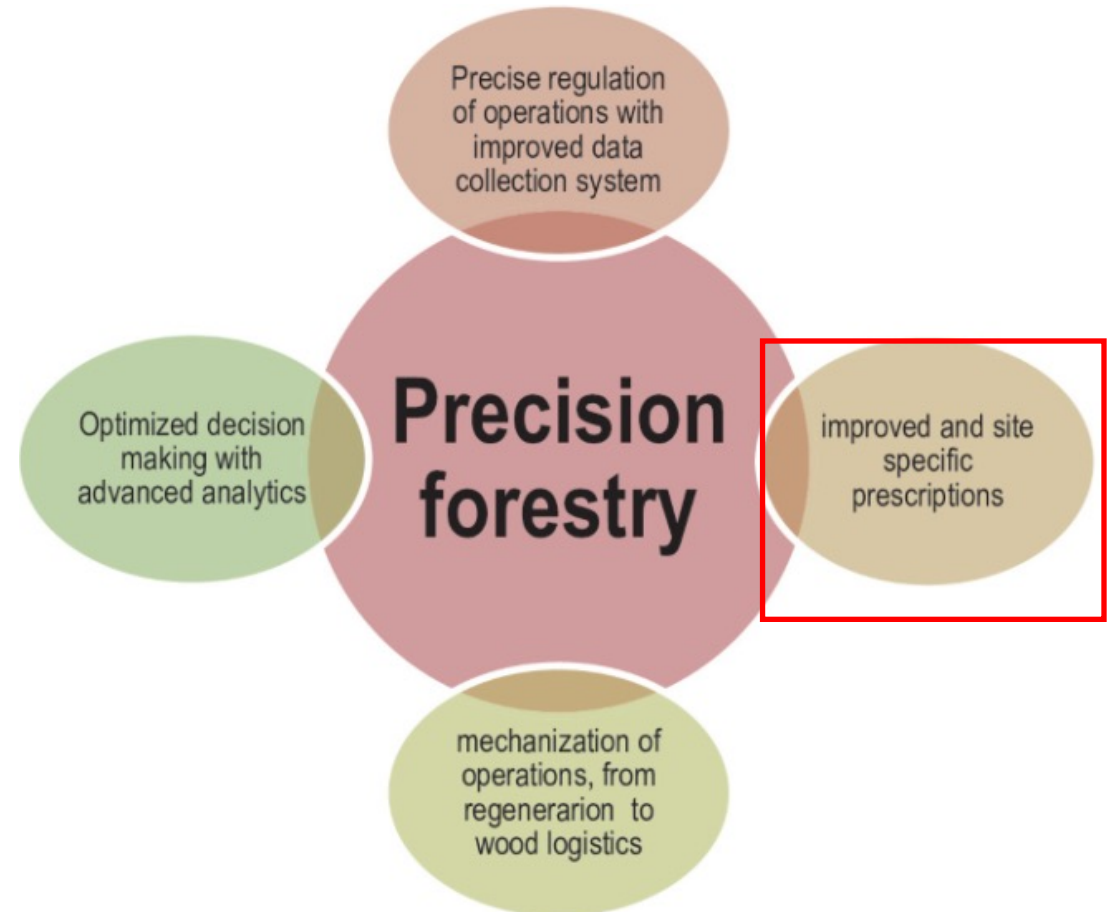
Timber's Tipping Point

As hurricane impacts and mill closures collide, Florida's \$25B timber industry is in the midst of a reckoning — and searching for a renaissance.

Brittney J. Miller | 10/9/2025

Altered Management

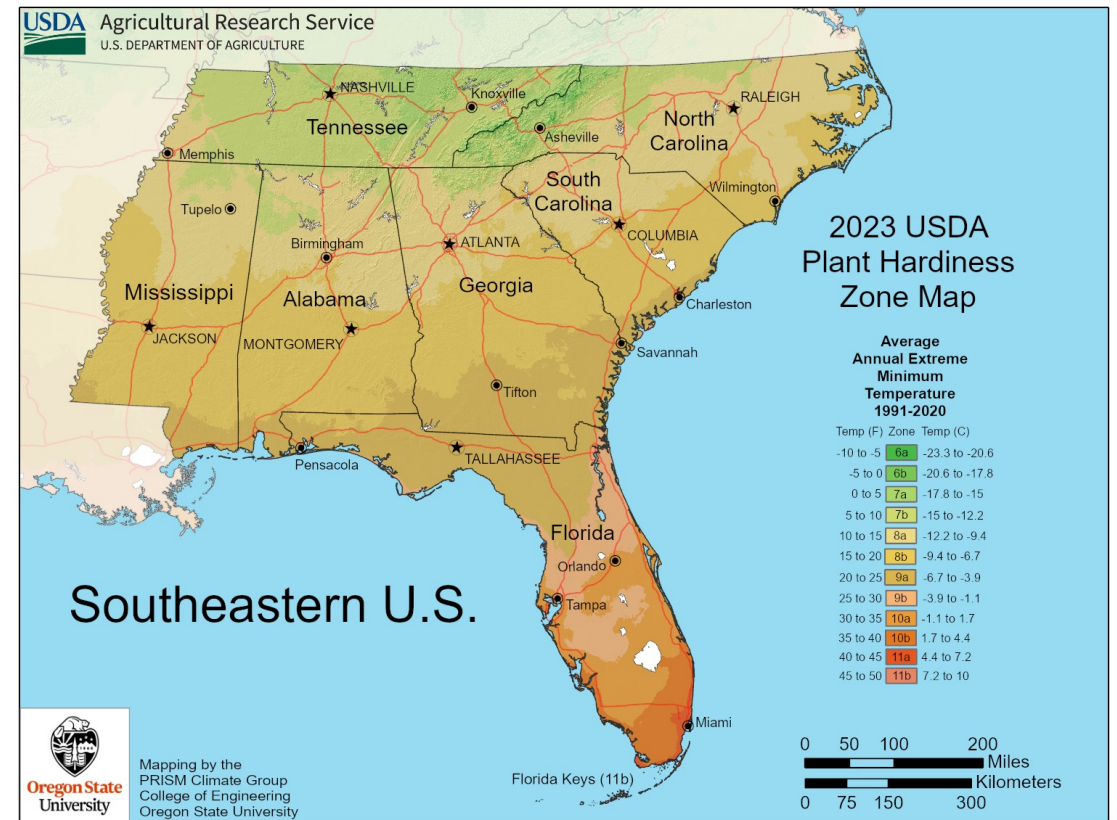
- ‘Precision forestry’ more important than ever
- Altered or market losses, decreasing land base, natural disasters
- Presentation focus on silvicultural practices for site specific prescriptions
- Improve decision-making to better meet landowner objectives



From Kumar et al. (2025)

Updated species productivity ratings

- Species-site relationships
- Dependent on pine species, soils (drainage, nutrients, texture, etc.), climate
- Landowner objectives
- Ultimate goal of project: Update NRCS Web Soil Survey website forest productivity estimates (SI and MAI)



USDA Southeast Region Plant Hardiness Zone Map

[Area of Interest \(AOI\)](#) |
 [Soil Map](#) |
 [Soil Data Explorer](#) |
 [Download Soils Data](#) |
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- Building Site Development
- Construction Materials
- Disaster Recovery Planning
- Land Classifications
- Land Management
- Military Operations
- Recreational Development
- Sanitary Facilities
- Soil Health

Vegetative Productivity

- Crop Productivity Index
- Forest Productivity (Cubic Feet per Acre per Year)

Forest Productivity (Tree Site Index)

[View Description](#) |
 [View Rating](#)

View Options

- Map ☒
- Table ☒
- Description of Rating ☒
- Rating Options ☒
 - ☐ Detailed Description

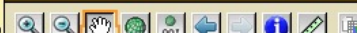
Basic Options

Tree slash pine |
 USDA 1929 (550)

Advanced Options

[View Description](#) |
 [View Rating](#)

Soil Map


 Scale (not to scale)



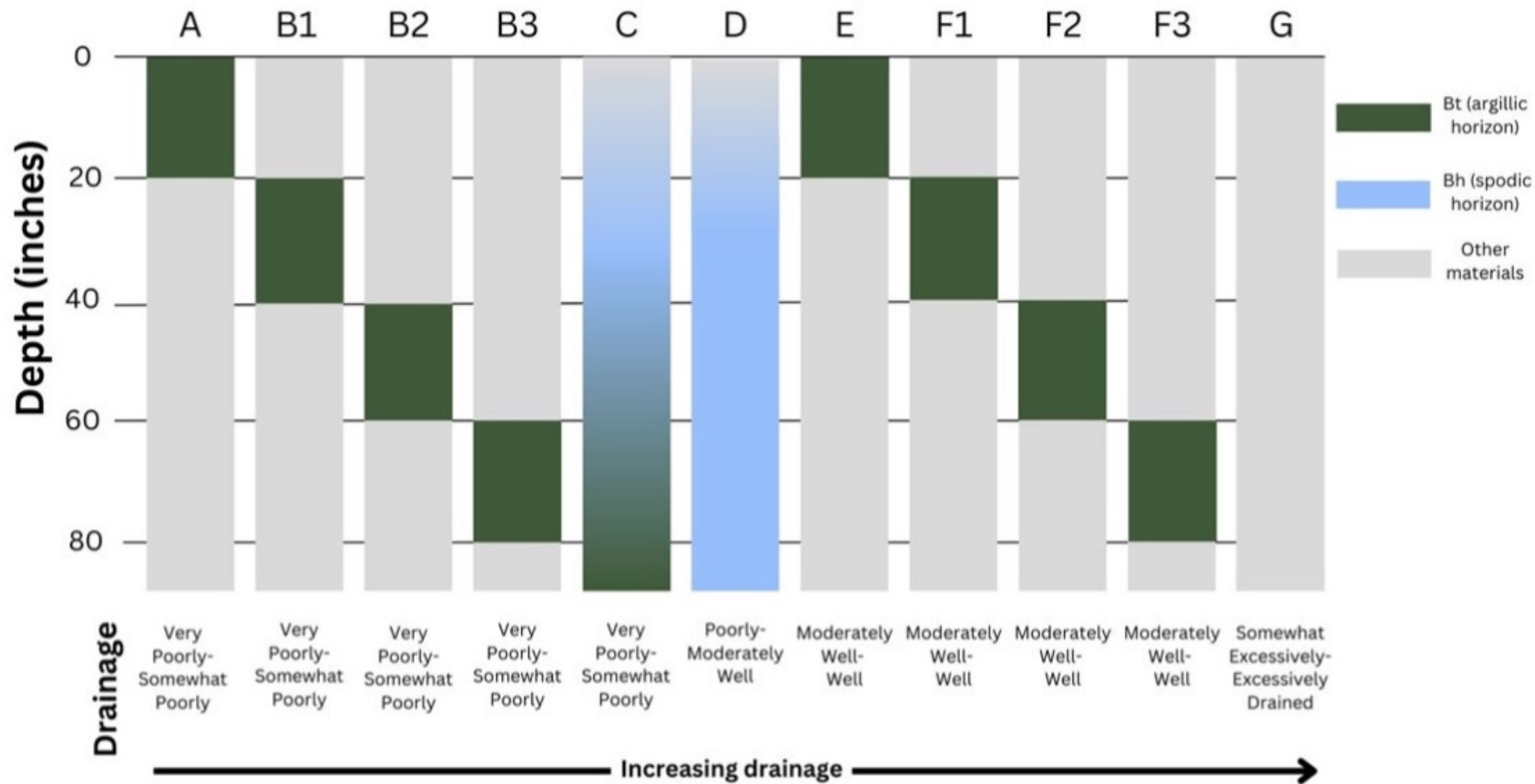
Updated species productivity ratings



Twiggs County, GA unthinned loblolly

- Longleaf stand inclusion criteria: previously forested, site prepared, containerized stock, no interplanting, at least 5-years old, and unthinned
- Similar criteria for loblolly and slash stands— included thinned stands @ 25 ± 2 years old for SI estimate
 - No recent fertilization history
- Soil profile and nutrients—NRCS/UGA
- Forest measurements—F&W Forestry or UGA
- Eventual goal-update NRCS Web Soil Survey species productivity ratings for Coastal Plain and Piedmont by CRIFF soil class

Modified CRIFF Forest Soil Classification



Loblolly and slash pine estimates

Updated species productivity ratings



CRIFF C soil

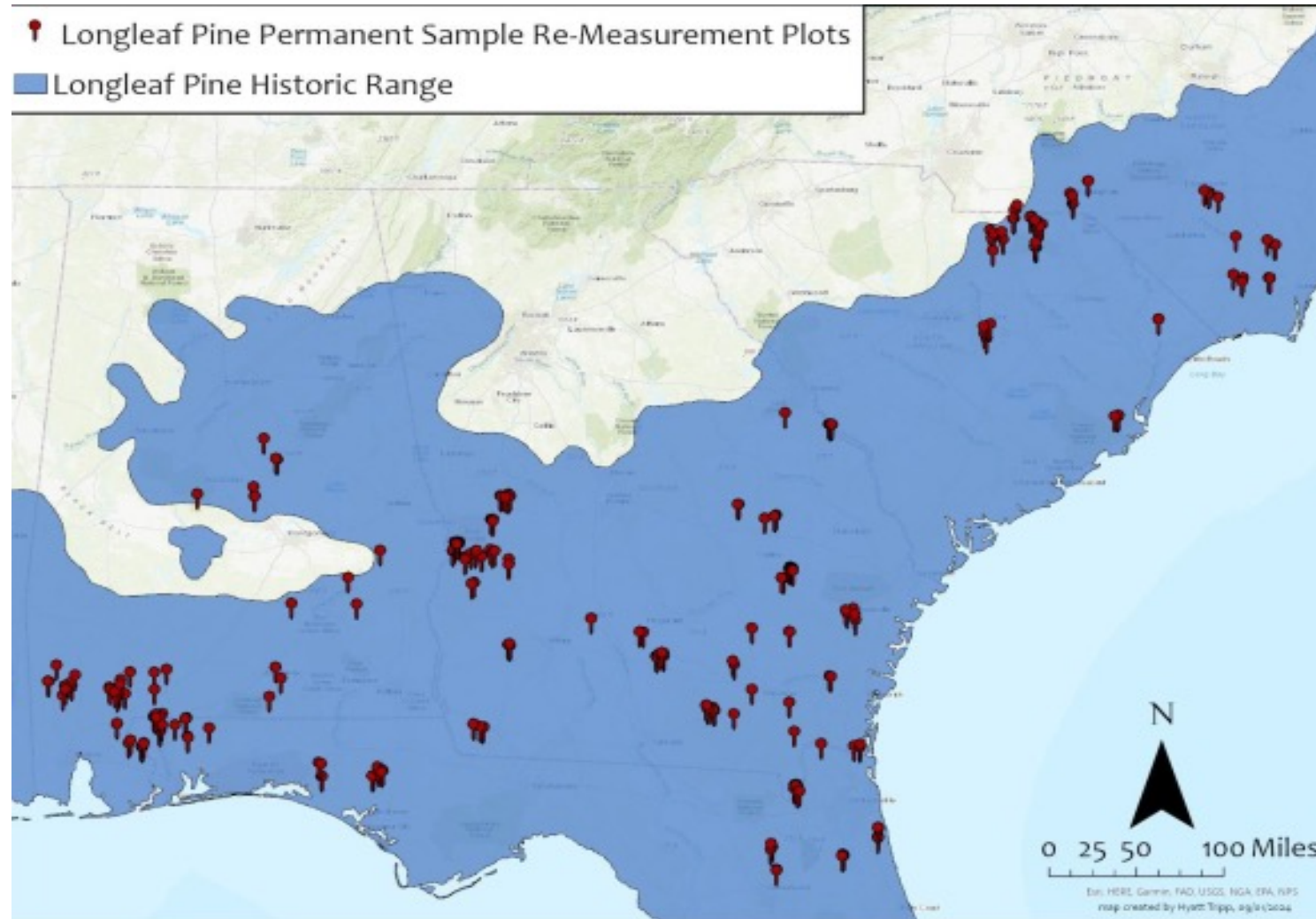


CRIFF E soil



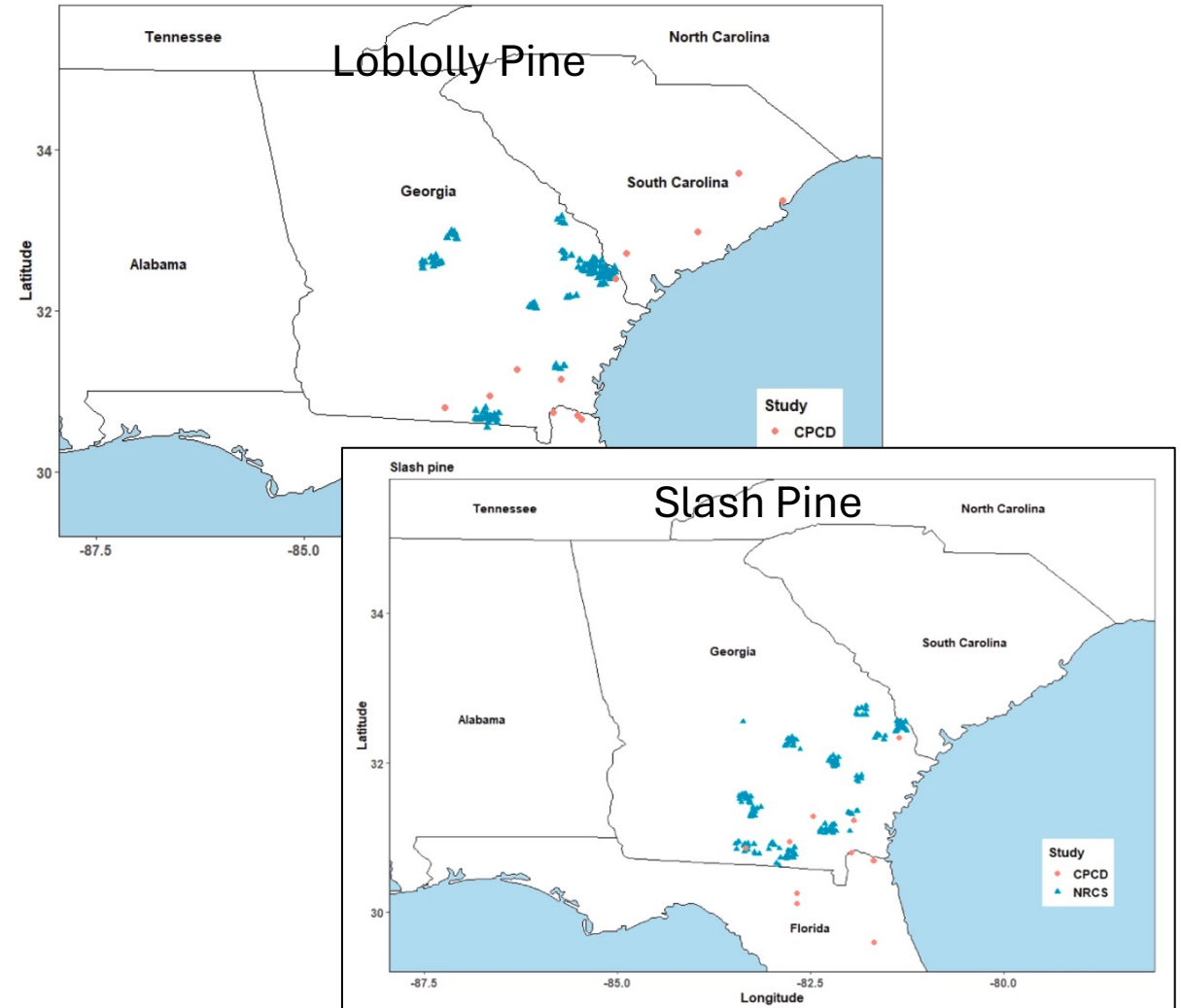
CRIFF F soil

Updated species productivity ratings

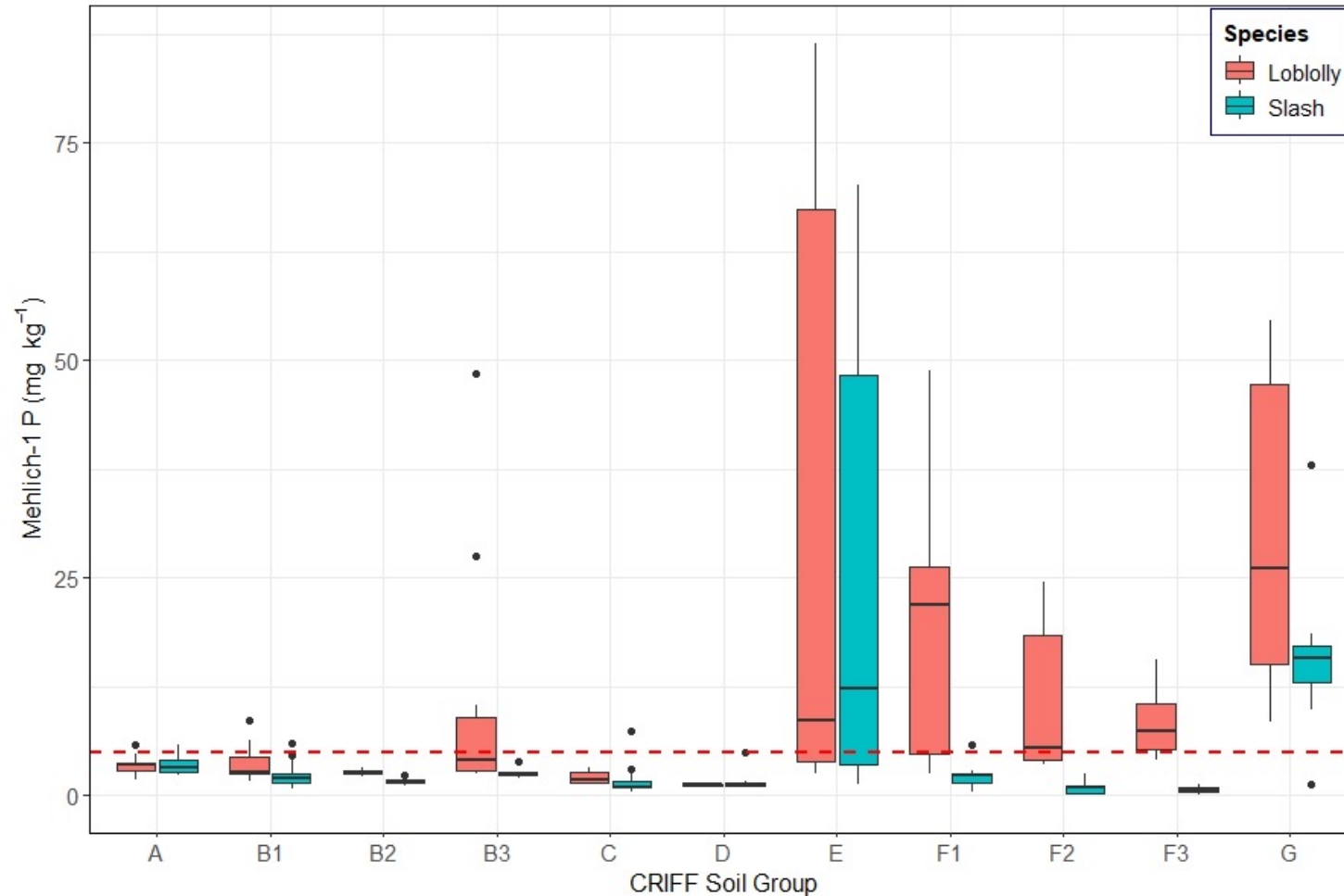


Updated species productivity ratings

- Similar studies conducted by UGA and NRCS from 2020 to 2024 with loblolly and slash pine
- 157 slash pine and 118 loblolly plots all in GA Coastal Plain
- Operational management (OP loblolly seedlings, no advanced genetics)
- Characterize SI and MAI by modified CRIFF soil group and surface soil extractable P (Mehlich I)



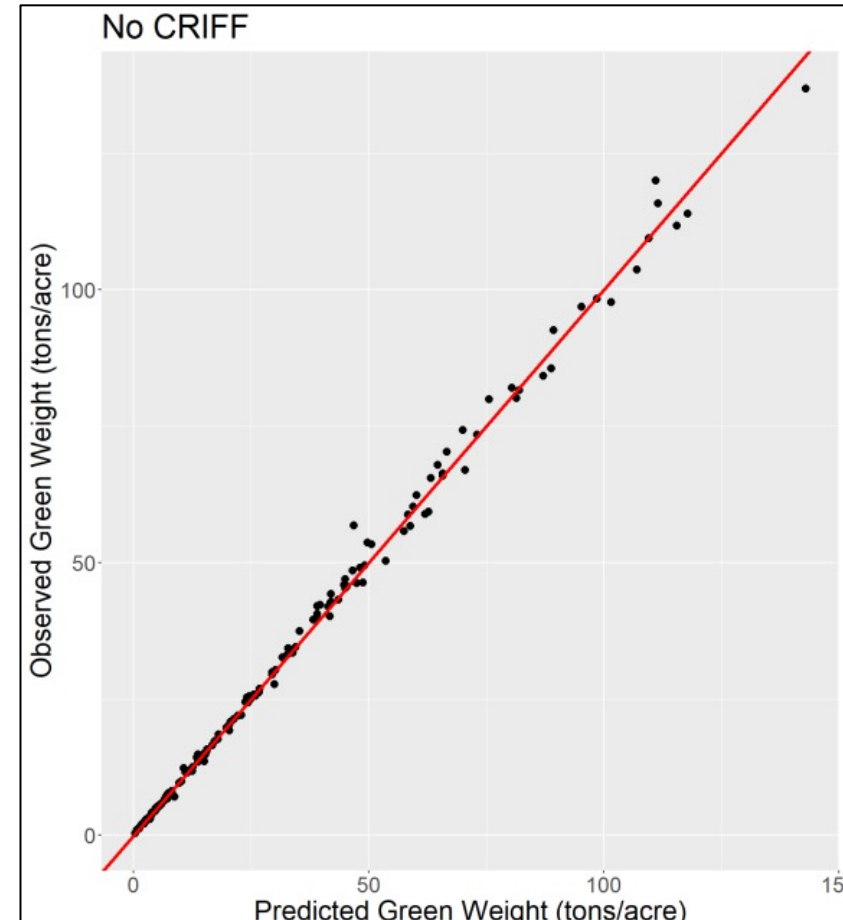
Updated species productivity ratings



Concentrations of surface soil extractable P measured in loblolly and slash pine plots in the NRCS study. The dotted line represents minimum sufficiency level of 5 mg kg⁻¹

Updated species productivity ratings

- For loblolly pine, modified CRIFF soil group and soil extractable P were significant productivity predictor variables ($R^2 = 0.899$)
- Slash pine soil groups and surface soil P weaker predictors of productivity ($R^2 = 0.490$)
- CRIFF system not a strong predictor of longleaf productivity



Longleaf Green Weight Prediction 1:1 Plot

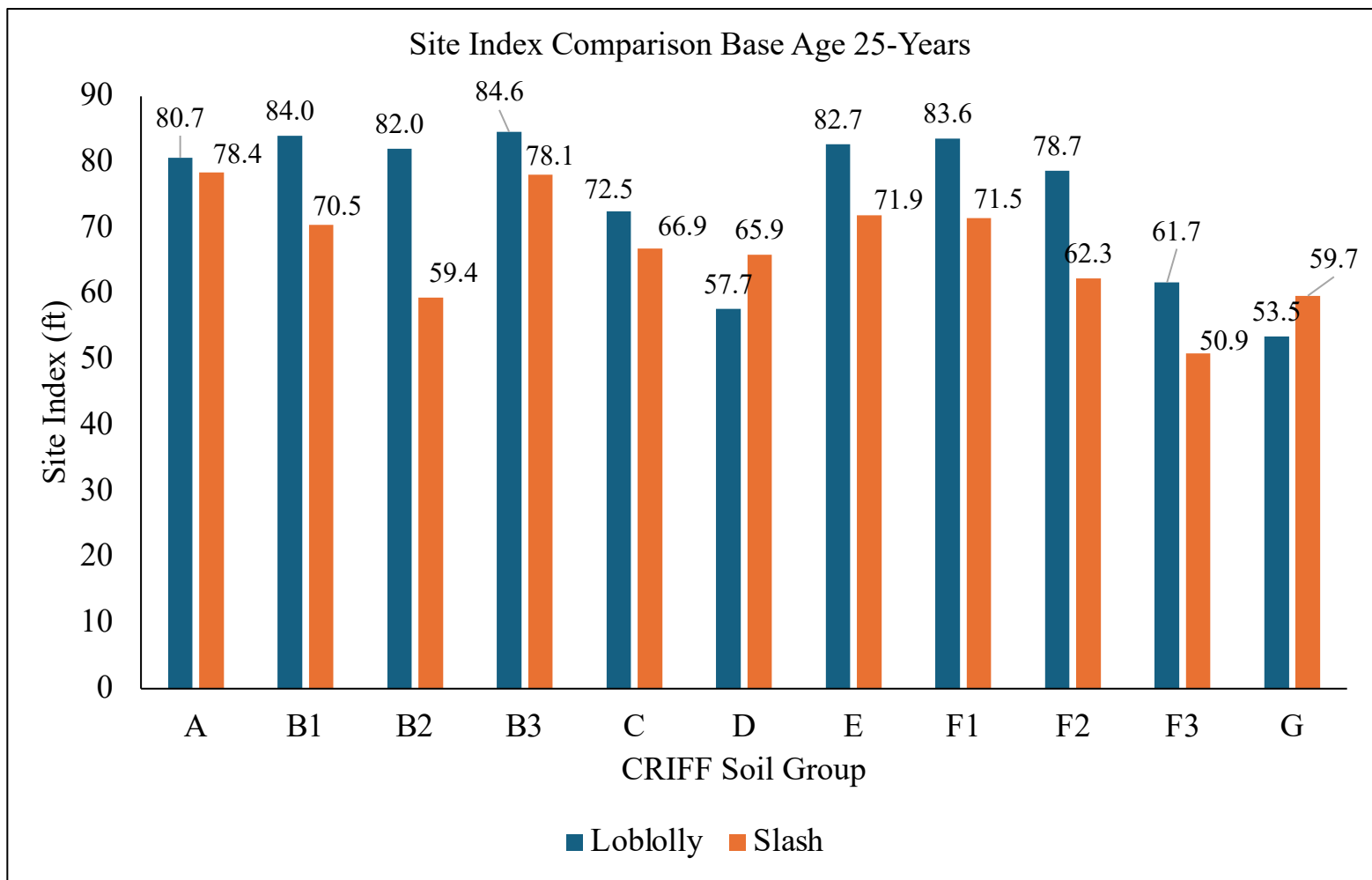
Updated species productivity ratings

Longleaf Pine

CRIFF Soil Group	n	Age (years)			Mean Annual Increment (tons/ac/year)			Site index (ft) (base age 25-years)		
		Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
A	2	9.5	9.0	10.0	1.0	0.2	1.8	57.2	41.2	73.2
B	11	9.8	6.0	21.0	1.5	0.6	3.3	63.5	41.1	74.6
C	2	13.5	11.0	16.0	2.3	1.0	3.5	56.7	54.2	59.2
D	7	10.3	7.0	12.0	1.3	0.2	2.7	52.7	35.3	72.0
E	31	13.7	5.0	28.0	2.8	0.1	6.0	65.1	36.6	85.7
F	50	13.3	5.0	28.0	2.2	0.2	5.6	61.3	40.6	90.8
G	47	15.5	6.0	32.0	1.7	0.3	4.3	53.3	32.6	71.2

Longleaf pine planted most frequently on E, F, and G upland soils

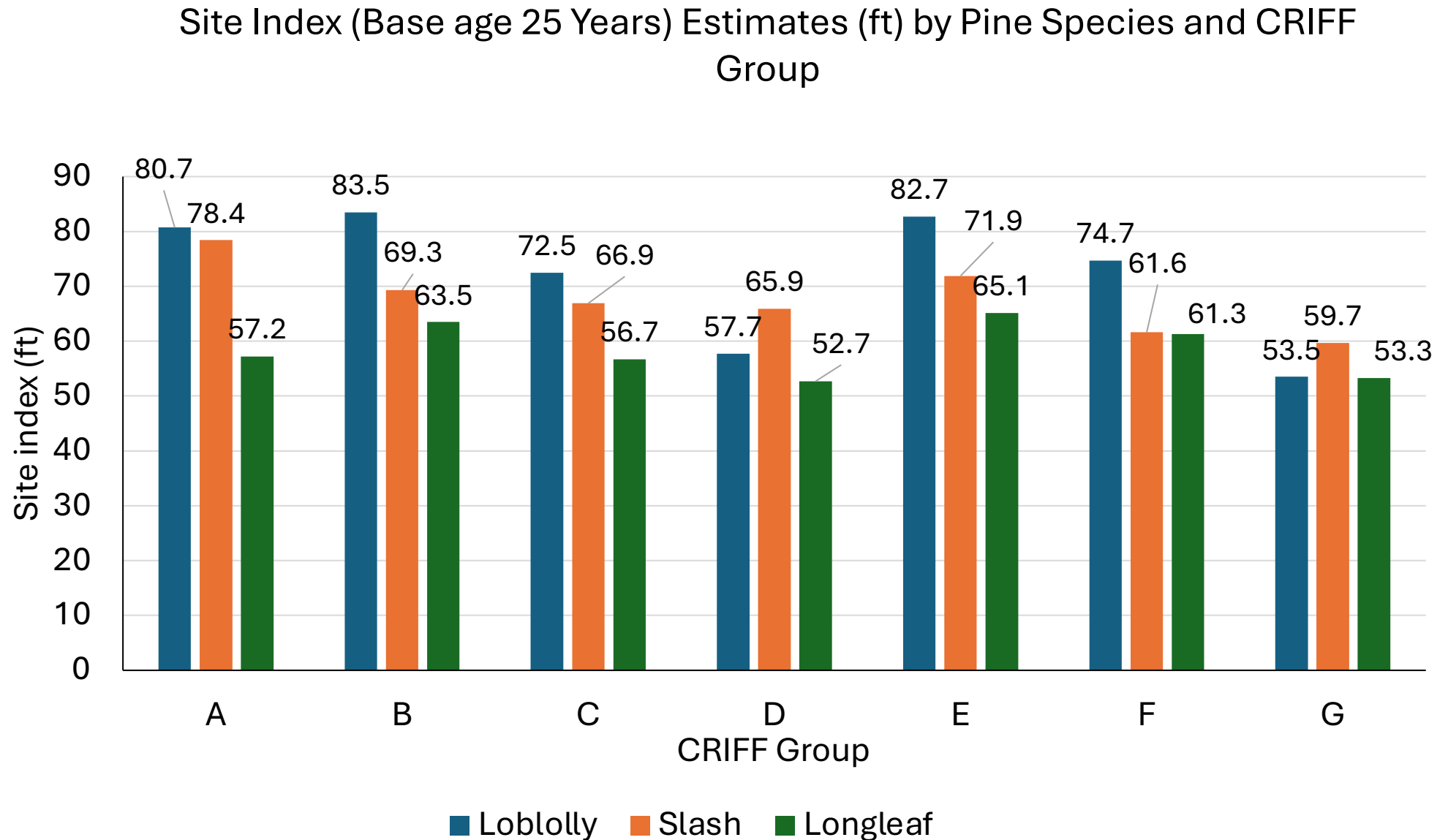
Loblolly versus Slash Pine Comparison



CRIFF Group	Delta Lob
A	-2.3
B1	-13.5
B2	-22.6
B3	-6.5
C	-5.6
D	+8.2
E	-10.8
F1	-12.1
F2	-16.4
F3	-10.8
G	+6.2

Slash better on CRIFF D and G soils,
toss-up on A soils

Loblolly vs Slash vs Longleaf Pine Site Index by CRIFF Soil Group



Updated species productivity ratings

Summary

- In summary, if growing the maximum amount of wood per acre is a management objective:
 - OP Loblolly pine is best on groups B, E, and most F soils
 - Either loblolly or slash pine is suitable for A, C, and maybe B3 with Bt 60 to 80”
 - Slash pine is recommended for groups D (without fertilization); longleaf pine is best suited for group G or likely F with Bt 60 to 80” (rare)—F3
 - Loblolly > slash pine impact of surface soil extractable P on productivity
- We are in the process of completing phase II (second measurements) of these projects to update and validate results

Lower Planting Densities



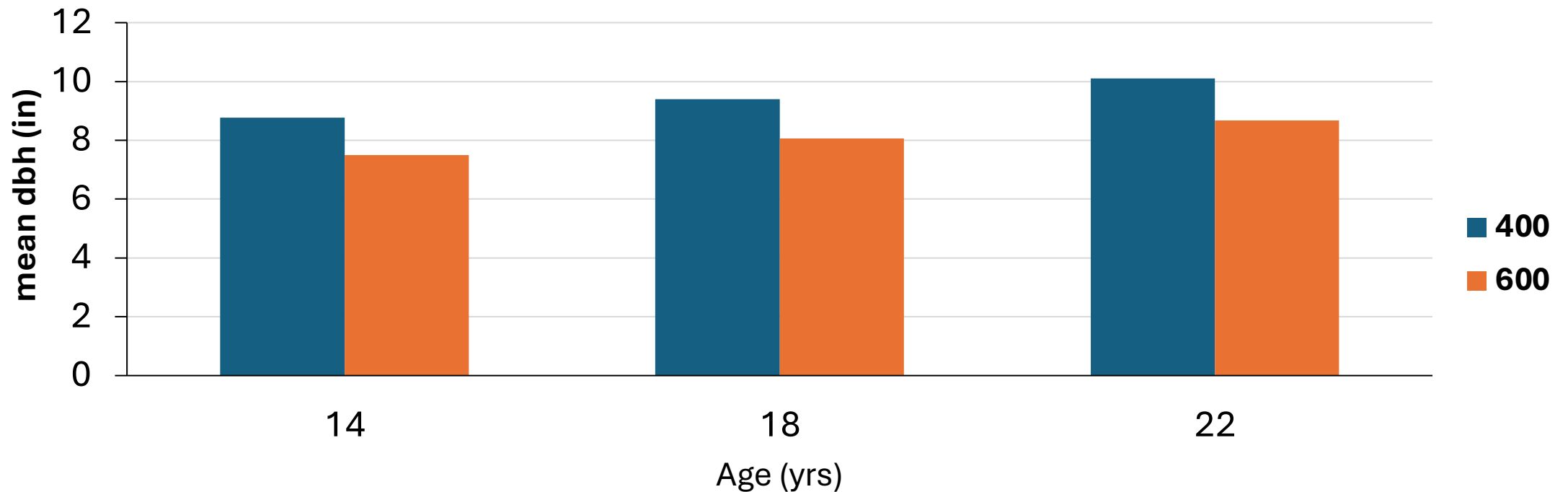
- Option to reduce upfront reforestation costs
- Move greater proportion of stems into chip-n-saw product class at first thin
- Longer duration prior to first thinning
- Site preparation carefully tailored to conditions
- Success will depend on use of species/genetics best adapted to site conditions

Lower Planting Densities: GA Piedmont Example

- 400 vs 600 trees per acre (TPA) loblolly planting study
- A UGA PMRC loblolly pine spacing study compared planting @ 400 TPA to 600 TPA (near Eatonton, GA)
- Old-field site (greater fertility, lower soil bulk density in top 8” and no hardwood competition vs cutover sites)
- Good soils (Cecil and Davidson); Loblolly $SI_{25} \approx 75$ to 80 ft
- Pre-plant herbicide to control herbaceous weeds and 1st year post-plant herbaceous weed control
- No thin

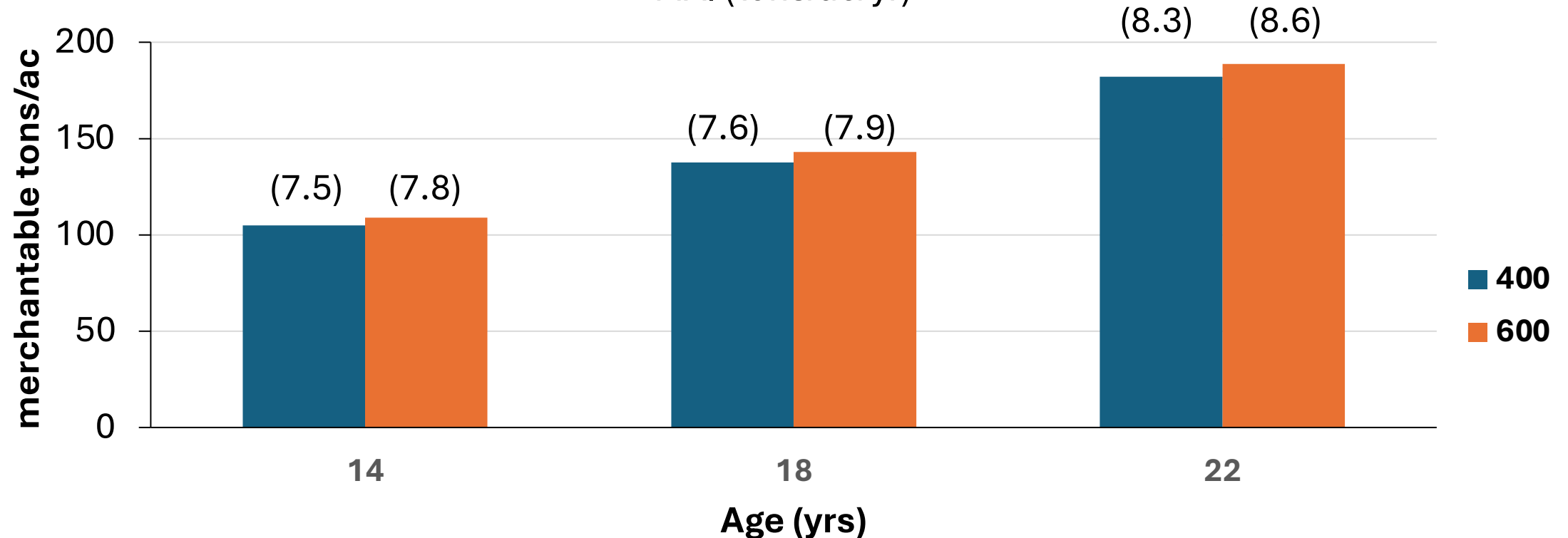
Lower Planting Densities: GA Piedmont Example

BF Grant old-field planted loblolly @ 400 vs 600 TPA mean dbh at ages 14-, 18, and 22-yrs



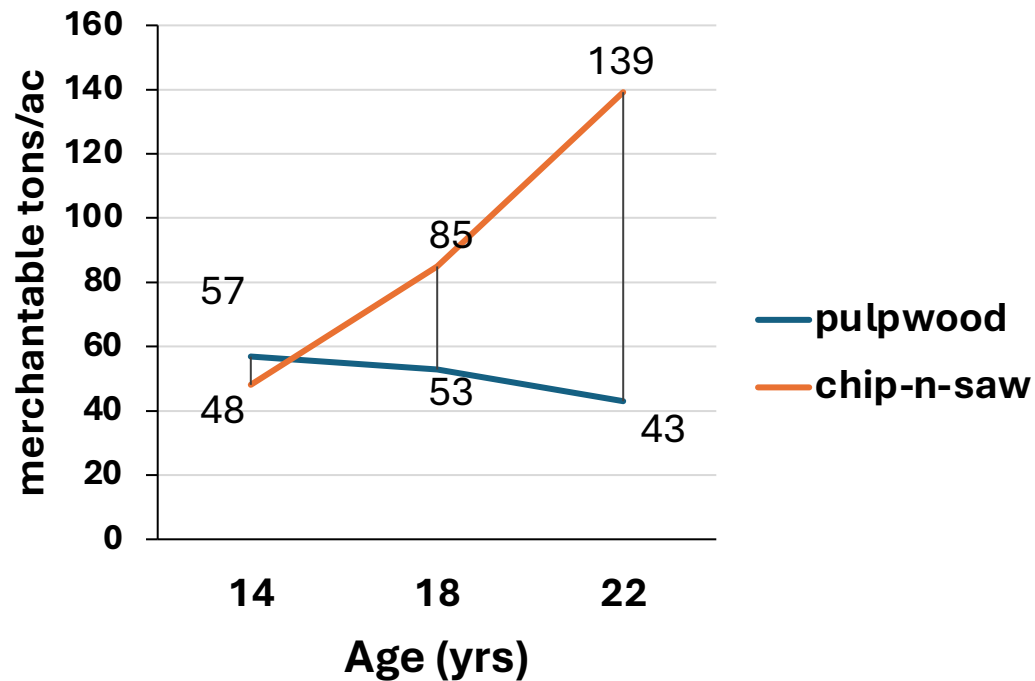
Lower Planting Densities: GA Piedmont Example

BF Grant old-field planted loblolly @ 400 vs 600 TPA - merchantable tons/ac
at ages 14, 18 & 22-yr &
MAI (tons/ac/yr)



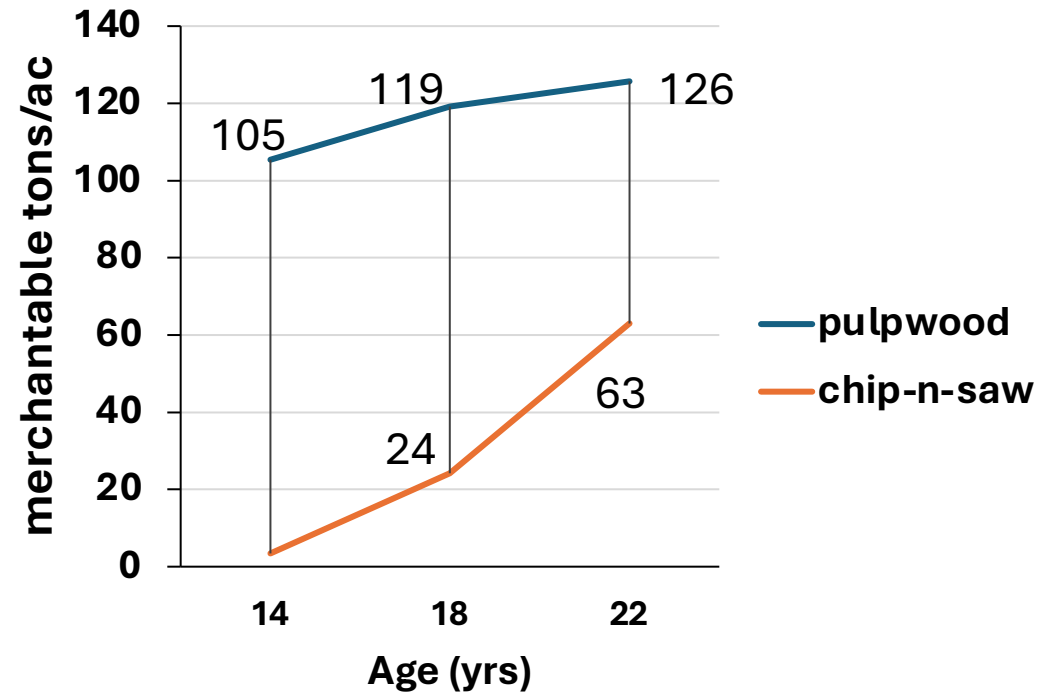
Lower Planting Densities: GA Piedmont Example

400 TPA pulpwood (PW) & chip-n-saw (CNS) merchantable tons/ac at ages 14-, 18- and 22-yrs



Pulpwood: PW = 4.6-9.5" dbh to 3" top ob
Chip-n-saw: CNS = > 9.5" dbh to 6" top ob

600 TPA pulpwood (PW) & chip-n-saw (CNS) merchantable tons/ac at ages 14-, 18- & 22-yrs



Lower Planting Densities: GA Piedmont Example

- Survival was very high through age 22-years for both the 400 and 600 TPA planting densities (>90% for both densities at age 22-years)
- Basal area/ac (ft²) differences between 400 & 600 TPA were small: 172.5 vs 181.0 at age 14-years, 195.5 vs 206.7 at age 18-years & 216.3 vs 233 at age 22-years, respectively
- To keep a loblolly pine stand healthy & vigorously growing, the 1st thinning should be when the stand BA gets to about 140 to 145 ft²/ac, but this study (as well as other studies) does show that loblolly pine can handle higher BA/ac
- Merchantable tons/ac differences were also small between the 400 and 600 TPA: 105 vs 109 at age 14-years, 137.6 vs 143 at age 18-years & 182 vs 189 at age 22-years, respectively → the same small differences as MAI

Lower Planting Densities: GA Piedmont Example

- Product class distributions between the 400 & 600 TPA planting densities:

400 tpa	Age (years)	Pulpwood (tons/ac)	Chip-N-Saw (tons/ac)
	14	57	48
	18	53	85
	22	43	139

600 tpa	Age (years)	Pulpwood (tons/ac)	Chip-N-Saw (tons/ac)
	14	105	3.5
	18	138	24
	24	126	63

- 600 TPA had 17% of it's total merchantable tons/acre in the CNS class @ age 18-years
- 400 TPA had over 60% of it's total merchantable tons/acre in the CNS class @ age 18-years

Lower Planting Densities: GA Piedmont Example

- With loblolly pine's:
 - Genetic improvement (advanced generations--open and closed pollinated),
 - Often higher initial survival rate than slash (5-15+%) and longleaf (25-33+%), and
 - Ability to carry a higher basal area per acre than either species
- Planting at a lower (400 in this case and in some trials down to 300-350 TPA with good genetics) planting density compared to the current 500-600 TPA planting density gives landowners
 - (1) A larger window of time before the 1st thinning is needed.
 - (2) Larger diameters at thinning which equates to more tons/ac in the CNS product class and the ST class if stands are carried to ST size.
 - (3) Lower stand establishment costs.

Pine Species selection, pine straw raking, stumpage prices, and economics



Species selection, pine straw, stumpage prices and economics

- Pine straw and cost-share (e.g., NRCS EQIP) associated with longleaf pine can make species planting decisions more difficult for private landowners
- Compare loblolly and longleaf pine
 - 400 tpa 28-year one-thin loblolly rotation
 - 605 tpa 45-year two thin longleaf rotation with and without pine straw and NRCS EQIP cost share
- Growth and yield generated by UGA SIMS (dbh driven) model (Shiver and Borders 2010)
- Bare land value (BLV) = \$/acre-Compare differing rotation lengths and solved with a discount rate (5%)

Species selection, pine straw, stumpage prices and economics

Practice	Cost per acre (\$)	Loblolly cost per acre (\$)	Longleaf cost per acre (\$)
Chemical site prep	110	\$309	\$375 (no cost share) - With EQIP (half of costs) \$187.5
Seedlings	54 (OP bareroot loblolly) 120 (longleaf container)		
Planting	100		
First year herbaceous weed control	45		

- Property taxes, fire break maintenance, etc. costs total \$10/ac/yr for each analysis

Species selection, pine straw, stumpage prices and economics

- Longleaf pine straw income \$210/ac (ages 12-20 prior to first thinning)
- Pine straw raking costs: mow-\$50/ac @ ages 3, 6, 9, 12; herbicide - \$60/ac @ age 12 years (\$260/ac total cost)

Pine stumpage
price set (\$/ton)

	Pulpwood (PW)	Chip-n-saw (CNS)	Sawtimber (ST)
Set 1	2	18	25
Set 2	5	21	29
Set 3 (GA CP 2022-24 TM-S)	14	24	31

Species selection, pine straw, stumpage prices and economics

Loblolly Pine 400 TPA

Thin/clearcut time	MAI (tons/ac/yr)	Pulpwood	Chip-n-saw	Sawtimber
		*****tons/acre*****		
Age 15-years	6.1	38	0	0
Age 21-years		4	22	6
Clearcut 28-years		0	19	82

- No pine straw or cost share assistance

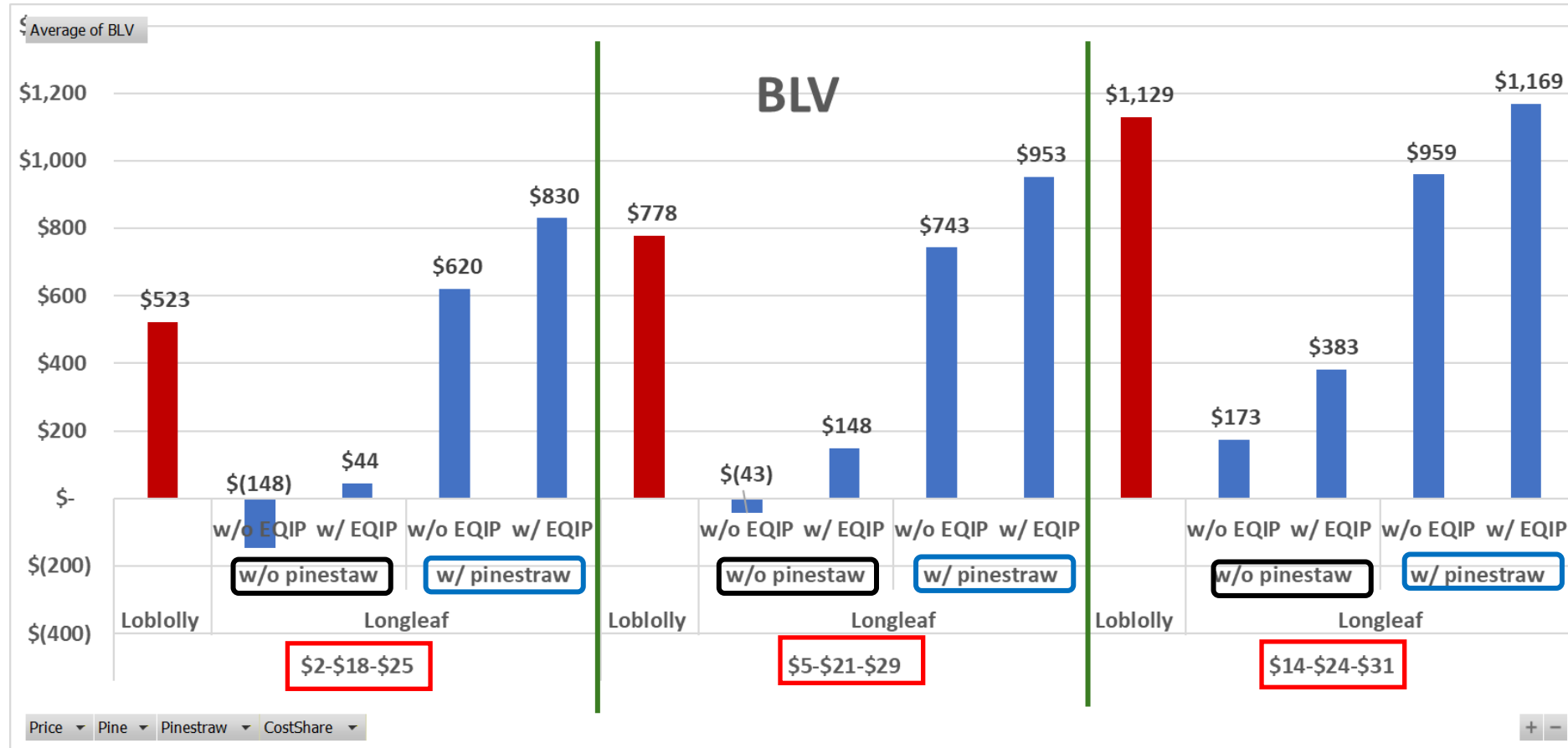
Species selection, pine straw, stumpage prices and economics

Longleaf Pine 605 TPA

Thin/clearcut time	MAI (tons/ac/yr)	Pulpwood	Chip-n-saw	Sawtimber
		*****tons/acre*****		
Age 20-years	4.0	39	0	0
Age 32-years		5	25	7
Clearcut 45-years		4	50	50

- No pine straw
- Pine straw—\$210/ac/yr from age 12- through 20-years
- 50% EQIP cost share for establishment
- Combination of pine straw and cost share

Species selection, pine straw, stumpage prices and economics



Loblolly = red bars (400 tpa, thin at 15 years, 28-year rotation; highest BLV)
Longleaf = blue bars (605 tpa, thin at 20- and 33-years, 45-year rotation)

Summary

- Updated pine species productivity ratings by soil group should be useful for precision silviculture decisions on Coastal Plain sites
- Lower planting densities will be needed to offset poor or non-existent pulpwood markets—minimal drop off in productivity with good management, genetics, and survival rate
- Longleaf pine better financial return than OP loblolly pine at lower stumpage prices with cost share and pine straw
- Precision forestry with regards to silvicultural prescriptions is becoming increasingly important as markets and margins become tighter

References

- Dickens, E.D., Zhao, D., Clabo, D., Markewitz, D., Bullock, B.P., and Pederson, D.C. 2024. Soil-based assessment of site productivity for southern pine plantations in the coastal plain of the southeastern US: (II) slash pine. *Forest Ecology and Management* 566: 122093.
- Kumar, H., Pareek, N., and Asieleavio, J. 2025. Forest preventatives, mitigation measures, strategies, and challenges. In Remote Sensing and GIS Applications in Forest Conservation Planning. Springer, Singapore. pp. 347-368.
- Shiver, B.D., Borders, B. 2010. SiMS 2009 Simulator for Managed Stands version 9.3.3. ForestTech International, LLC, Watkinsville, GA 30677.
- Zhao, D., Dickens, E.D., Clabo, D., Markewitz, D., Bullock, B.P., and Pederson, D.C. 2024. Soil-based assessment of site productivity for southern pine plantations in the coastal plain of the southeastern US: (I) loblolly pine. *Forest Ecology and Management* 565: 122054.

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Growing Georgia's Forest Biomaterials-Based Economy

Innovations, Partnerships, and Opportunities

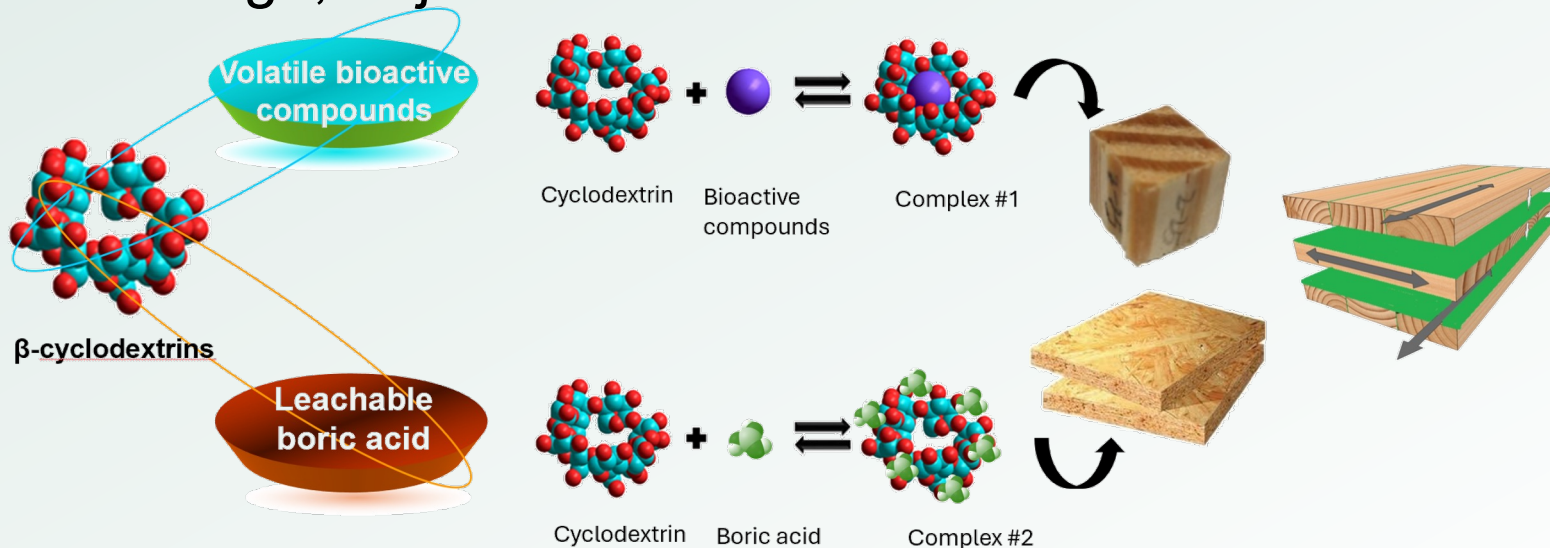
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- B.E. in Wood Sci. & Eng. /Furniture & Interior Design, Fujian A&F Univ.

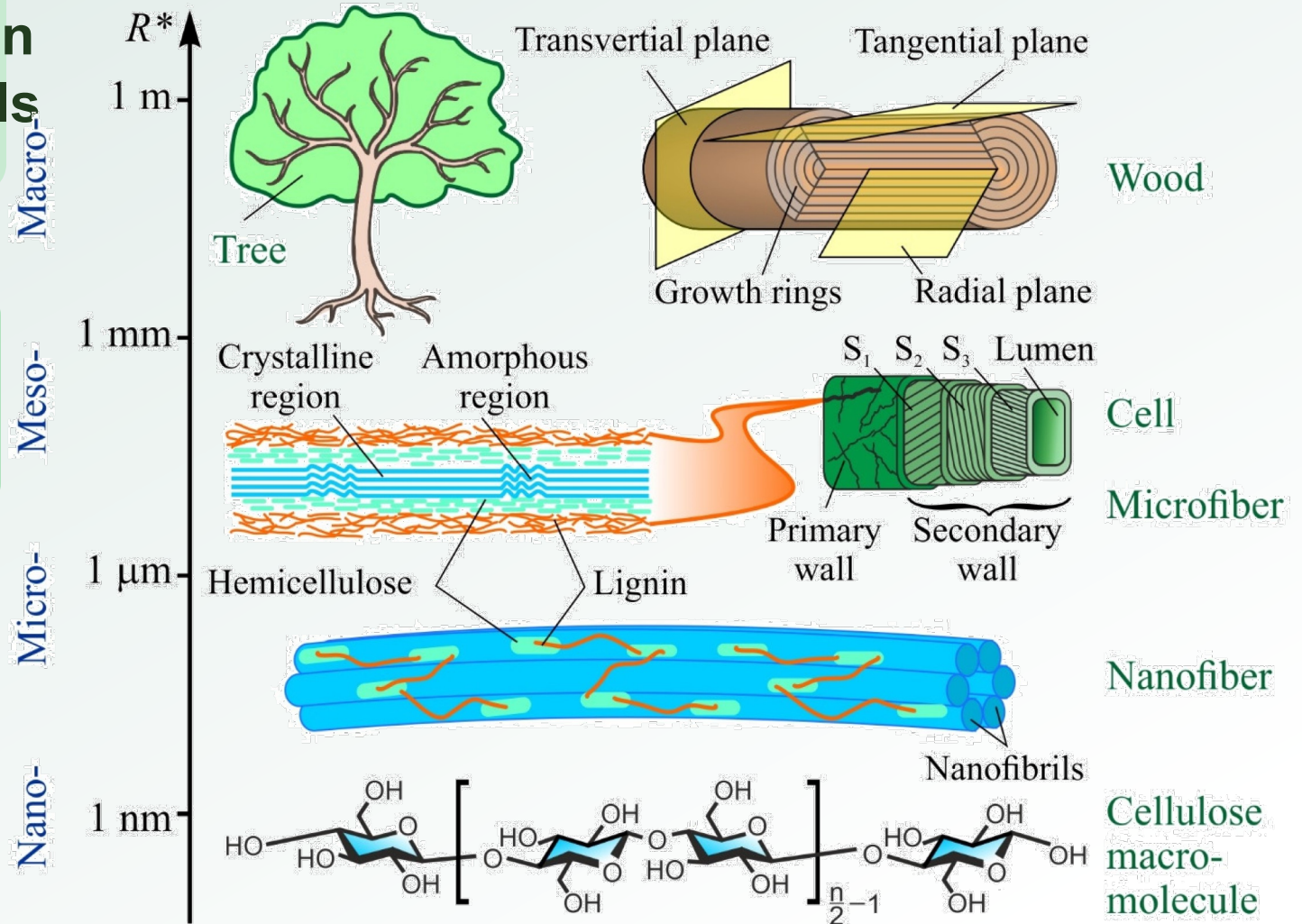


Creating More Values from Every Tree across Multiple Scales

- Service life extension & prediction of wooden infrastructure materials

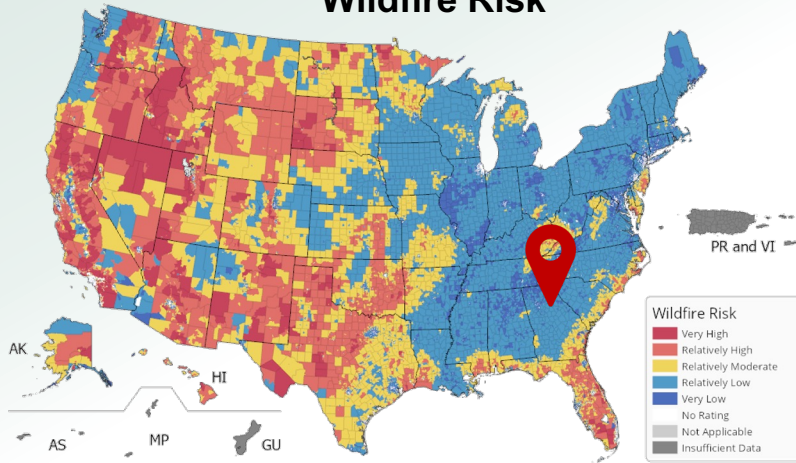
- Natural fiber-based composites

- Biomass to biproducts

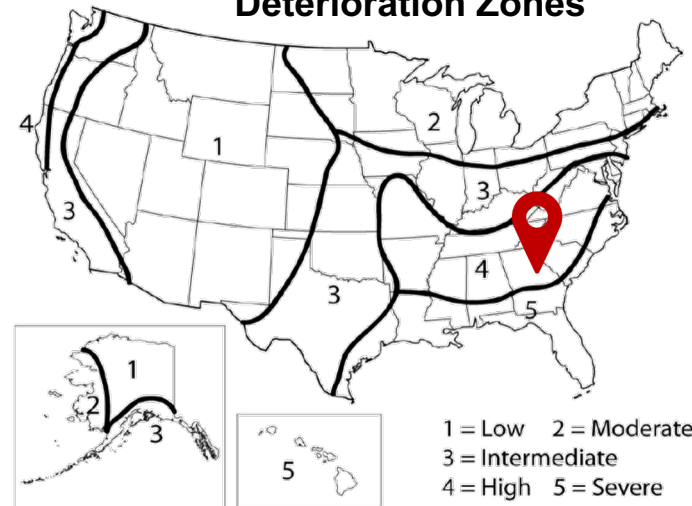


Mapping Risks of Wooden Infrastructural Materials against Abiotic & Biotic Agents

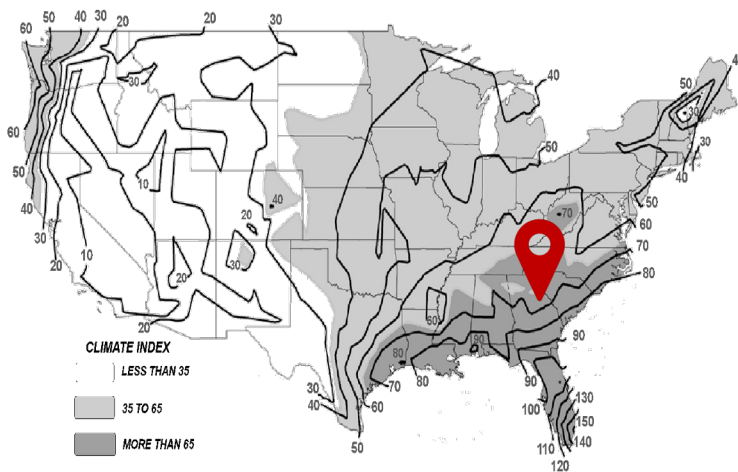
Wildfire Risk



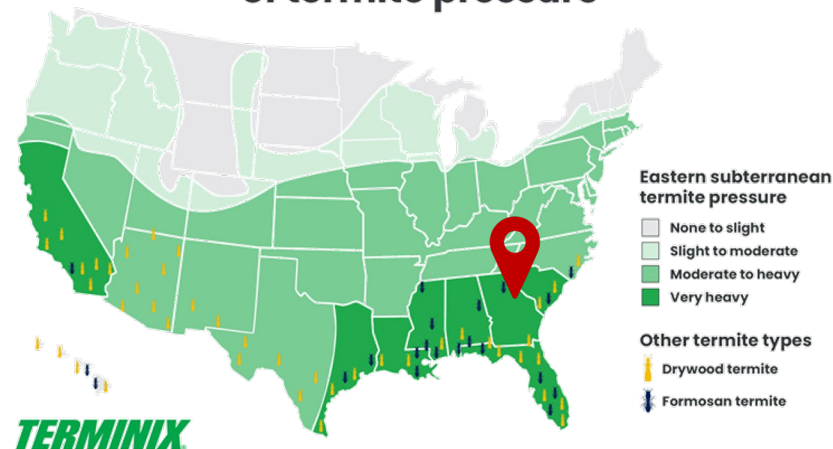
Deterioration Zones



Scheffer Climate Index-
Weathering of Wood



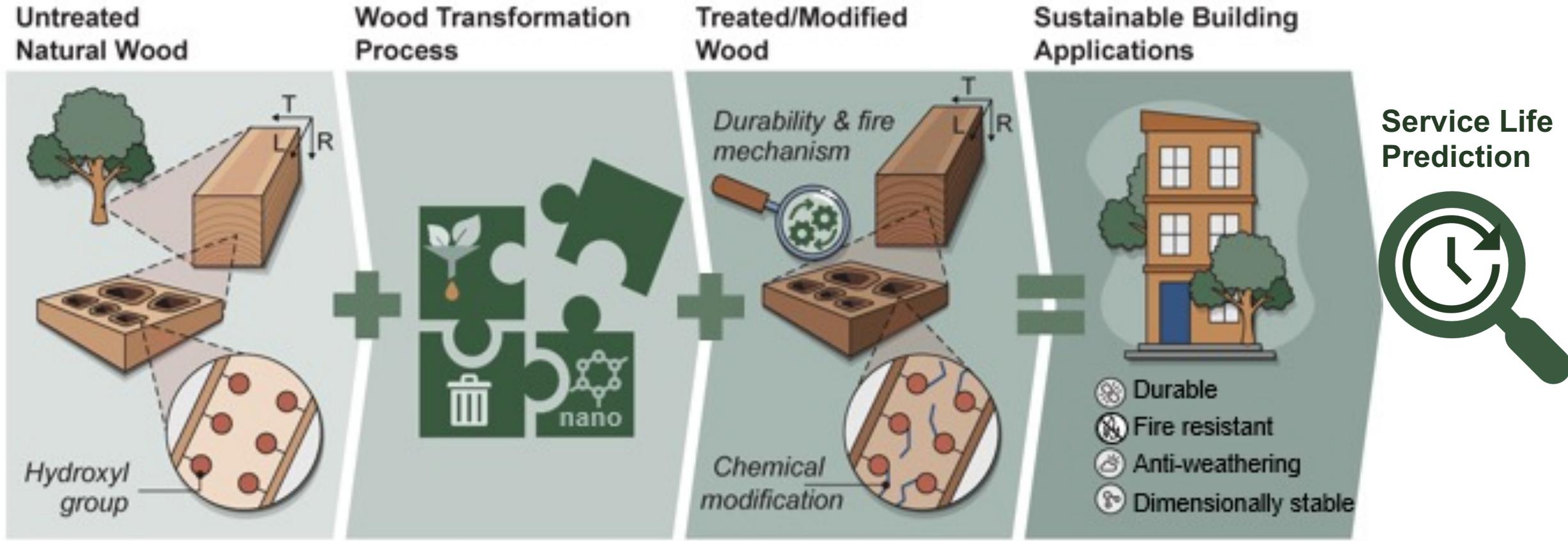
Geographic distribution
of termite pressure



> 90%

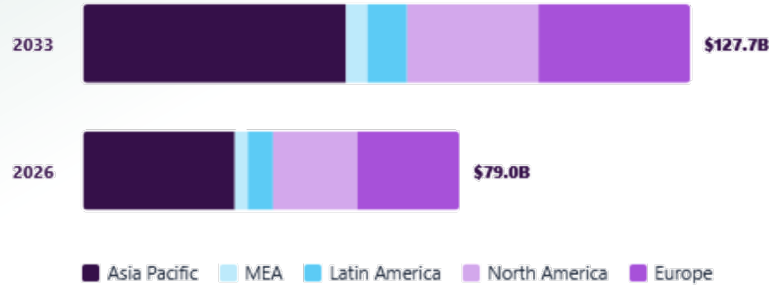


Service Life Extension & Prediction of Wooden Infrastructure Materials

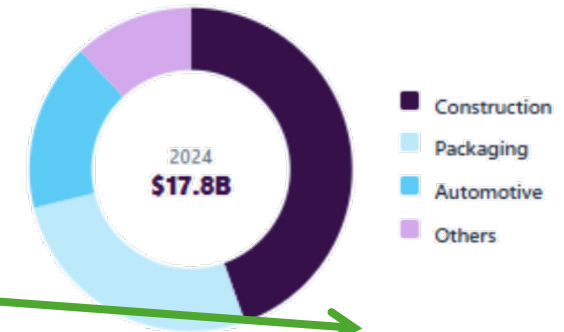


Small Diameter Wood, Manufacturing Residues & Residual Wood Fiber for Novel Composites

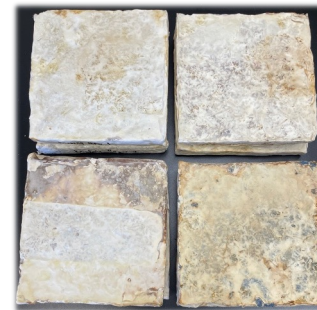
Global Insulation Market Size, By Region



Expanded Polystyrene Market, By Application, Grand View Research



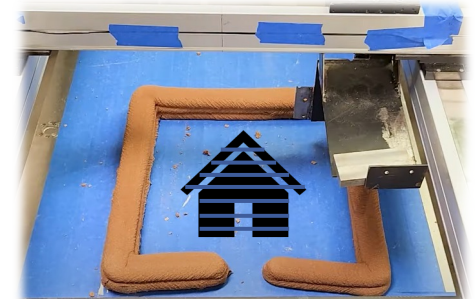
Insulation / Packaging



Fungi for Furniture



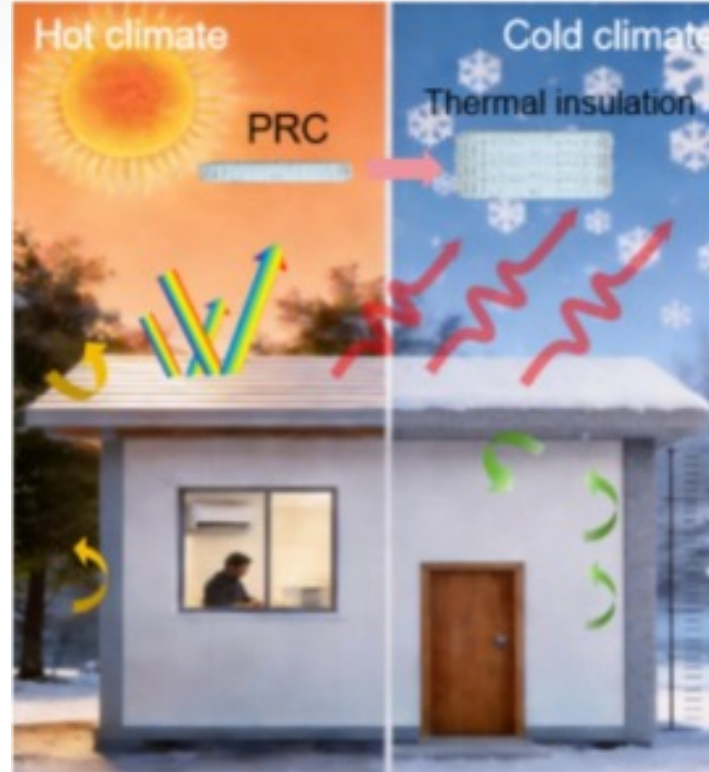
MyCeilings by Mycelium



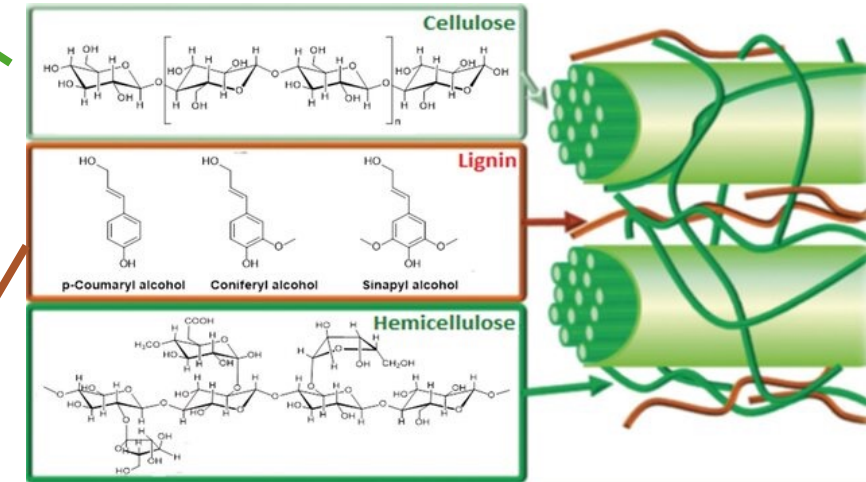
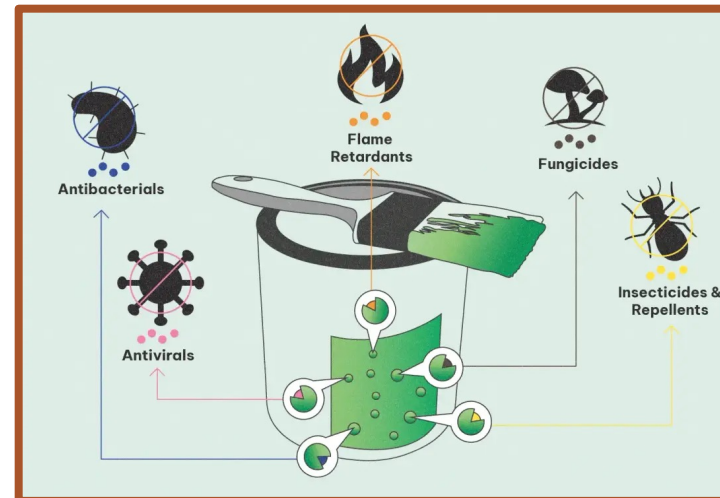
Additive Manufacturing

Biomass for Bioproducts

Cellulose based Passive Radiative Cooling



Multifunctional coatings



Wood Quality Consortium

Linking Silviculture with wood/fibers properties



Dr. Joe Dahlen
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Sources of variation:
genetic & environment



Industry –
fiber, lumber,
composites,
energy, chemical



Wood Quality Consortium
*Warnell School of Forestry
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Transition from fossil-dependent linear economy to a sustainable and profitable circular bioeconomy



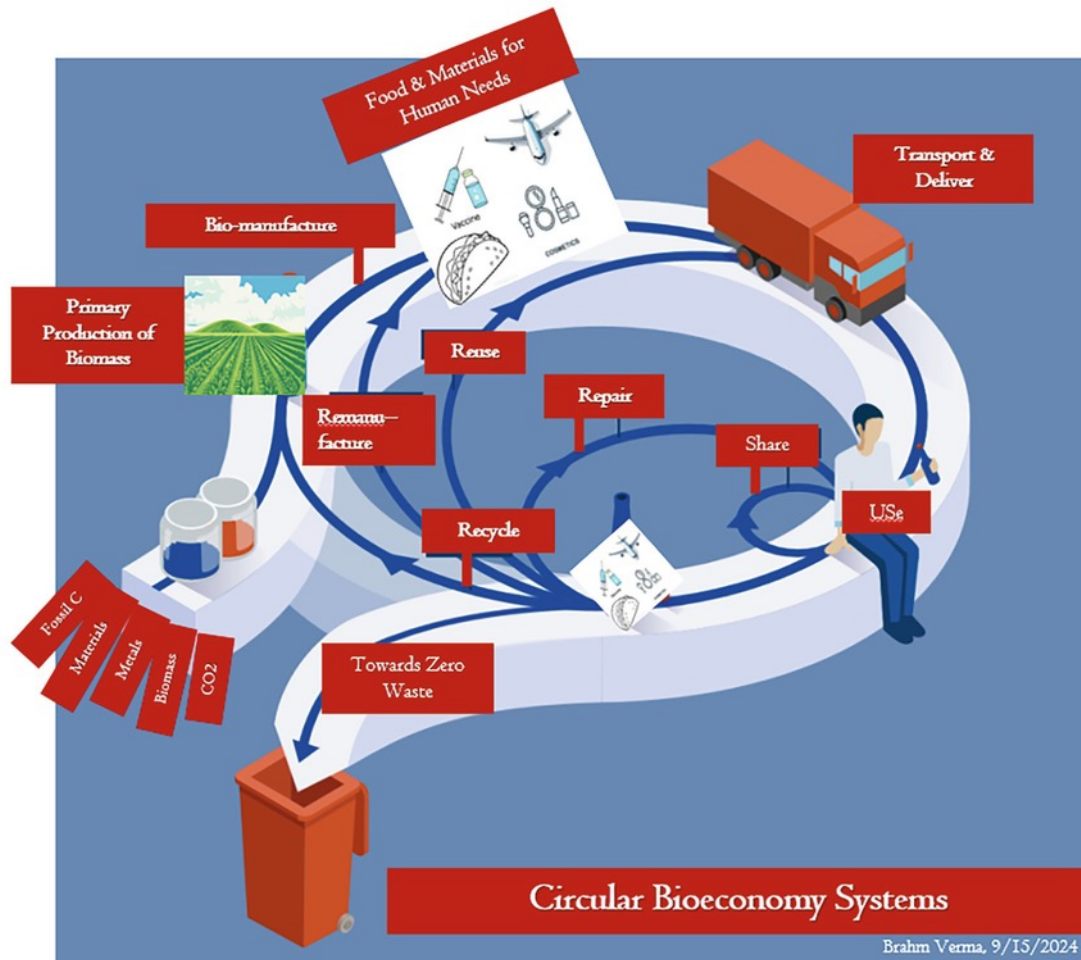
College of Agricultural &
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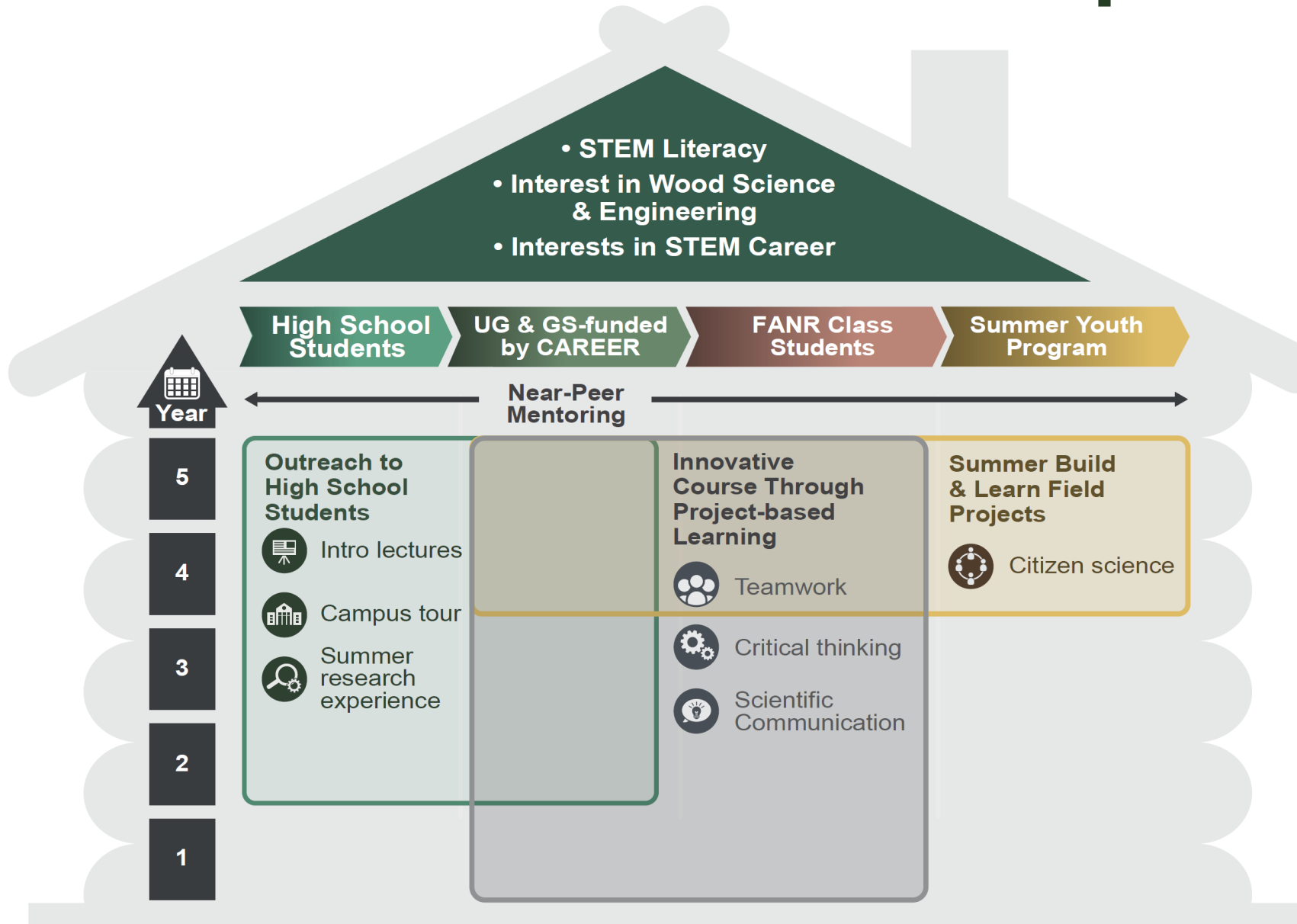


College of Engineering
UNIVERSITY OF GEORGIA



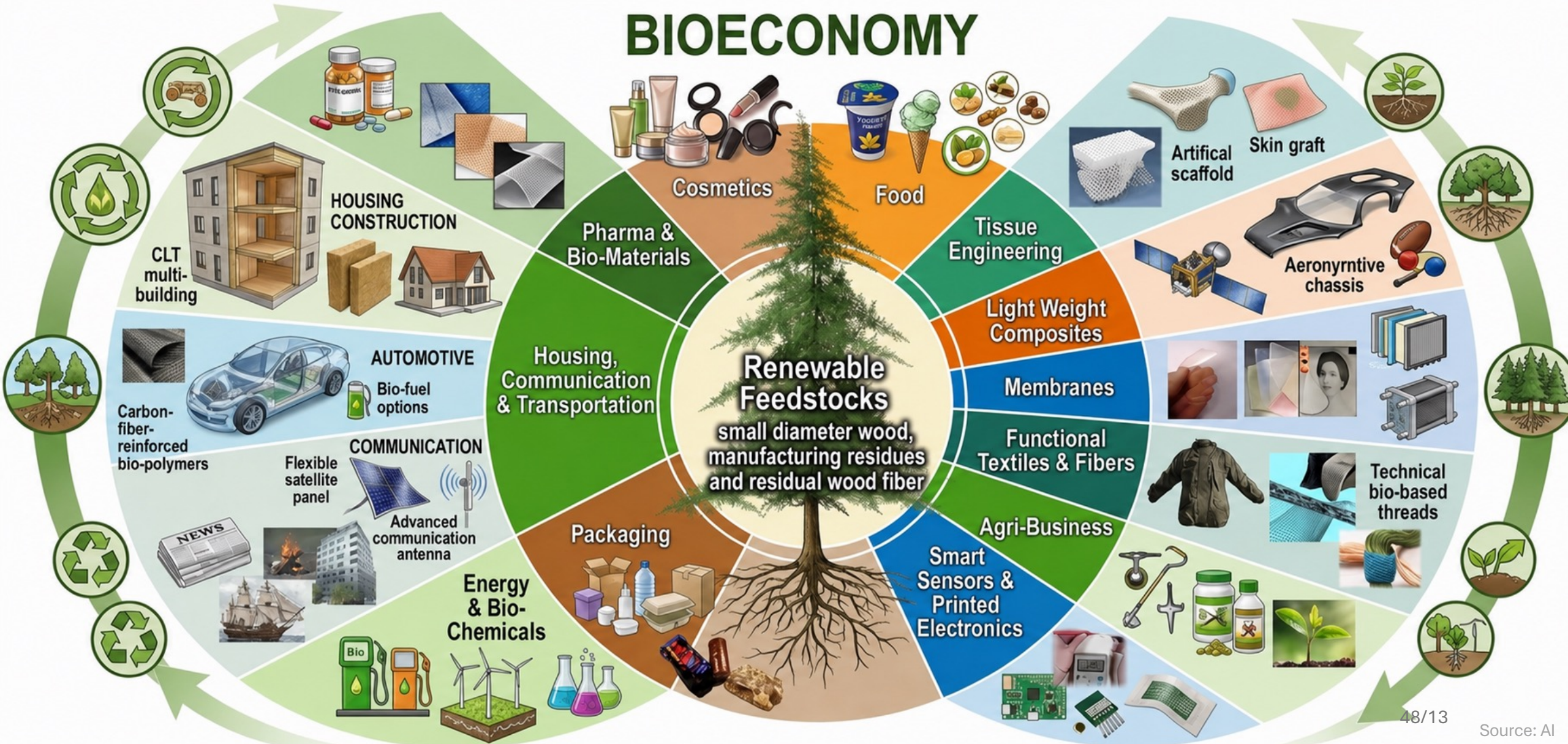
- Circular bioeconomy system in forestry
- Design for circularity to create new markets for biomass
- Increase forest derived products in everyday life

Future Workforce Development



FOREST BIOMATERIALS BASED

BIOECONOMY





YOU'RE INVITED!



Growing Georgia's Forest Biomaterials-Based Economy

Innovations, Partnerships, and Opportunities



TENTATIVE ROUNDTABLE DISCUSSION TOPICS



• Current Landscape

- Status, challenges, and opportunities



• Sustainability & Innovation

- Circular economy, policy, climate, and societal impact



• Industry Priorities

- Technology, markets, workforce, and partnerships



• Future Vision (10–50 Years)

- Moonshot ideas and transformative innovations



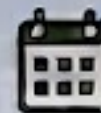
Interested?

- Dr. Kamal Gandhi
kjgandhi@uga.edu
- Tim Lowrimore
tim@gfagrow.org

Please
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Growing Georgia's Forest Biomaterials-Based Economy

Innovations, Partnerships, and Opportunities



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Thank you!

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Please
reach out!



Warnell School of Forestry
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