SPECIAL 2020 FPS IC

# Seventy-five Years of Research in Wood Preservation and Deterioration

H. M. Barnes

**Abstract**

Seventy-five years of research in wood protection at the Forest Products Lab at Mississippi State University are described. A history of wood protection is presented along with an overview of the facilities supporting the research. Program objectives are presented along with the personnel responsible for building the program. A brief presentation of research areas is given followed by some program metrics.

It is a pleasure for me to be a part of the first virtual International Convention of the Forest Products Society (née Forest Products Research Society) and to share with you the growth and development of the research program in wood protection at Mississippi State University. Wood can last for centuries if we protect it from the agents of deterioration: decay, mold, and sapstain fungi; termites and wood destroying insects; chemical agents; and weathering effects. A casual glance at wooden churches in Scandinavia or wooden temples in Asia illustrate the point (Fig. 1).

## The Beginning

The Mississippi Forest Products Utilization Laboratory (the Lab) was established in 1964 by an act of the Mississippi Legislature. In 1992, it would become the Forest & Wildlife Research Center (FWRC) when it was merged with the research programs of the other two departments in the College of Forest Resources: the Department of Forestry and the Department of Wildlife & Fisheries (now Wildlife, Fisheries & Aquaculture). Administratively, the teaching program is administered through the Department of Sustainable Bioproducts (formerly Wood Science & Technology, later Forest Products). The first two buildings were completed in 1966–1967 and today the Lab has >90,000 $ft^2$ under roof (Fig. 2). In 1983, the Lab was dedicated to the first Dean of the School (now College) of Forest Resources, Robert T. Clapp (Fig. 3).

Within the buildings is extensive equipment for testing wood products and wood–lignocellulosics in finished and raw material forms. Germane to this presentation are the facilities and equipment supporting wood protection research. This includes multiple conditioning units, one of which is used for conditioning fire retardant–treated wood to high temperatures. Two labs are dedicated to bioremediation, microbiology, molecular biology, and genomics work. A pathology lab, an assay lab, a termite lab, and labs for fungal cellar exposure and evaluation and rapid evaluation of decay using modulus of elasticity or compression properties loss are utilized. A fully equipped mechanical testing lab, including several universal testing machines, is available along with a facility for testing full-sized poles (Fig. 4).

## Field test facilities

The original field test site was established at Dorman Lake on the College of Forest Resources' Starr Memorial Forest located 8 miles south of the campus. Starting in 1954, 10 years before the legislative birth of the Lab, field studies on fence posts treated by double diffusion were initiated. In addition to the Dorman Lake site (American Wood Protection Association [AWPA] Hazard Zone 4), we now maintain sites in four other locations:

1. Saucier, Mississippi, on the Harrison Experimental Forest, DeSoto National Forest adjacent to the field test plots of the USDA Forest Products Laboratory (AWPA Hazard Zone 5);
2. Keaau, Hawai'i, 9 miles south of Hilo on the big island of Hawai'i (AWPA Hazard Zone 5);
3. Waldo, Florida, on the University of Florida's Austin Carey Forest (AWPA Hazard Zone 5); and
4. McNeill, Mississippi (AWPA Hazard Zone 5) on Mississippi State University's Coastal Research & Extension Center. The McNeill site is used primarily

The author is the Thompson Distinguished Professor of Wood Science and Technology, Forest Products Lab., Forest and Wildlife Research Center, Dept. of Sustainable Bioproducts, College of Forest Resources, Mississippi State Univ., Starkville (hb1@msstate.edu). This paper was received for publication in September 2020. Article no. 20-00055.

Forest Prod. J. 70(4):476–481.
doi:10.13073/FPJ-D-20-00055


*Figure 1.—Ancient wooden structures standing today: (a) Heddal Stave Church, Heddal, Notodden municipality, Norway, circa 1200 AD; (b) Urnes, Luster municipality, Norway, 1130 AD; (c) Hōryū-ji (Temple of the Flourishing Dharma), Ikaruga, Nara Prefecture, Japan, 711 AD (oldest wooden building in the world); (d) Sakyamuni Pagoda of Fogong Temple, Yingxian County, Datong, Shanxi Province, China, 1056 AD.*

for the evaluation of the Formosan subterranean termite, *Coptotermes formosanus*.

Marine exposure testing of wood products is contracted to certified exposure sites.

## Program Objectives

Our wood protection program objectives include the following:

1. Evaluate the effects of treatments on wood properties;


*Figure 2.—Current complex housing the R. T. Clapp Forest Products Laboratory showing original two (marked 1 and 2) buildings.*


*Figure 3.—Dedication of the Forest Products Utilization Laboratory to Dean emeritus R. T. Clapp.*

2. Seek new and improved systems and methods for treating wood and wood composites;
3. Evaluate preservative systems in laboratory and field exposures and develop new test methods;
4. Develop methods for preventing stain and molds in wood;
5. Develop a better understanding of the organisms responsible for deterioration;
6. Remediate waste streams;
7. Improve the durability of wood structures including mass timber construction;
8. Preservation of historical artifacts; and
9. Provide technical assistance to the industry and citizens of Mississippi, the nation, and the world.

## The People

Over the years, a dedicated faculty and staff have built the program in wood protection. The emphasis started with the Lab's first Director, the late Warren S. Thompson. Thompson's research area was wood preservation and deterioration. Later he would become College of Forest Resources Dean and first Director of the combined FWRC. He was responsible for the early work in characterization and remediation of effluent waste streams from treating plants.

Former faculty in wood protection along with their years of service and research interests are shown in Table 1, and they set the groundwork for the program in wood protection research. Current faculty are shown in Figure 5.

In addition to these, we currently have four adjunct faculty members: Dr. Nate Irby, Union Pacific Railroad; Dr. Grant Kirker, USDA Forest Products Laboratory (Madison, Wisconsin); Dr. Dragica Jeremic, CSA Group, Toronto; and Dr. Juliet Tang, USDA Forest Products Laboratory (Starkville, Mississippi).

The real worker bees have been our support research associates, technicians, graduate students, postdoctoral associates, and undergraduate hourly workers. Current staffing includes Michael G. Sanders, Sr., Research Associate in charge of our field tests and test plots and supervisor of our Formosan termite work, and Amy Rowlen, Research Associate III overseeing laboratory wood preservation and degradation testing. In addition to the research and technical staff, the department is supported by a roster

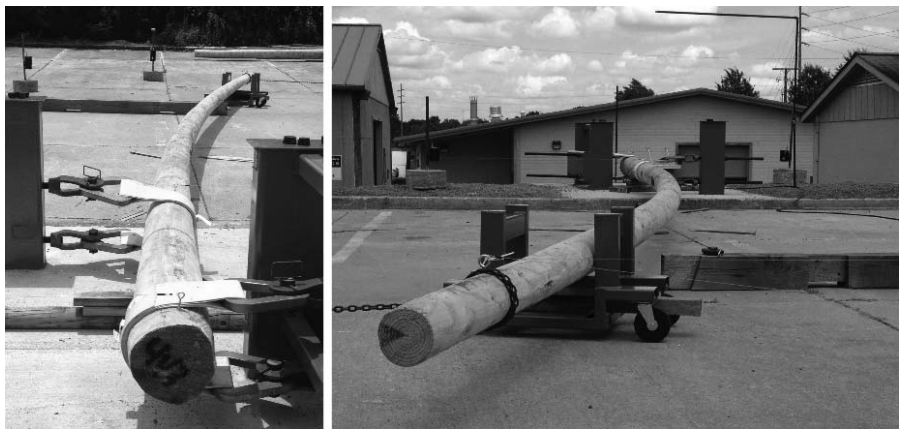

*Figure 4.—A full-sized pole test in progress.*

*Table 1.—Former faculty members with dates of service and research areas.*

| Name | Dates of service | Research areas |
|---|---|---|
| W. S. Thompson[a] | 1965–1982 | Wood preservation, pollution control |
| H. Rodgers | 1965–1967 | Coatings |
| E. R. Toole | 1968–1978 | Wood pathology |
| W. C. Kelso, Jr. | 1971–1982 | Treatment mechanics |
| G. D. McGinnis | 1971–1991 | Bioremediation, chemistry |
| L. L. Ingram | 1977–2008 | Bioremediation, preservative characterization |
| E. Schmidt | 1978–1979 | Wood pathology |
| T. L. Amburgey | 1979–2009 | Deterioration, durability, housing, pathology |
| T. P. Schultz | 1981–2013 | Preservative development, chemistry |
| A. Borazjani | 1984–2018 | Bioremediation, biotechnology |
| L. Prewitt | 1991–2013 | Microbiology, biotechnology |
| S. V. Diehl | 1993–2016 | Microbiology, biotechnology, fungal communities |
| S. Kitchens | 2009–2014 | Housing, durability, stains |
| D. Jeremic | 2012–2017 | Microbiology, fungal interactions |
| M. Nejad | 2014–2016 | Coatings, lignin derivatives |

[a] Service as department head; retired in 1992 as Dean of the College of Forest Resources and Director of the Forest & Wildlife Research Center.

of business and administrative staff coordinated by Ms. Jeanie McNeill.

## The Research Program

Our research program and studies can be grouped into four categories loosely based on funding source: Housing, Lucas Laboratory (seed monies donated by the Lucas family), Wood Utilization Research, and Wood Protection Testing Laboratory.

### Housing

Under the umbrella of Housing research, we have the

- Southern Climatic Housing Center, a consortium of seven Mississippi State University departments in association with the Coalition for Advanced Wood Structures, an outreach program of the Advanced Housing Research Center of the USDA Forest Products Laboratory. The funding for this program has been expended, but structures built and projects initiated are still ongoing. A portion of the ongoing mass timber research is considered under this umbrella.
- Work at the aforementioned Formosan Termite Research Facility, located at McNeill, Pearl River County, Mississippi, is also grouped under Housing. Laboratory and field-testing projects with the Formosan termite, *Coptotermes formosanus*, are conducted at this facility. The Formosan termite is a very destructive imported pest from Indochina and is a threat below the 35°N parallel.
- Studies dealing with the biodeterioration of mass timber construction are ongoing.

### Lucas Laboratory

The Lucas Laboratory includes research aimed at developing the following:

- A comprehensive understanding of the microbial decomposition of wood;
- Accelerated test methodology for evaluating systems that protect wood from biodegradation;

**HM Barnes**, ‘71–

Thompson Distinguished Professor

- Wood preservation, effects on properties, treatment mechanics

**DD Nicholas**, ’82–

Professor

- Preservative development, new testing methodology, dimensional stabilization

**CE Stokes**, ‘15–

Assistant Professor

- Deterioration, durability, microbiology, environmental remediation

**TSFA França**, ‘19–

Assistant Professor

- Biodegradation, mass timber durability, NDE

**DJV Lopes**, ‘19–

Assistant Research Professor

- Wood preservation, computer vision, thermal modification

*Figure 5.—Current faculty in wood protection (research interests shown).*

- Methods for improving long-term weathering characteristics of wood products; and
- Microbial methods for conversion of woody biomass to fuels, chemical products, and feedstock.

To increase our understanding of how microbial communities work to decay wood, we are conducting studies to (1) identify the community of microorganisms present and active during wood decay; (2) evaluate microbial community ecology; (3) identify and quantify wood-degrading enzymes; and, (4) explore new approaches such as enzyme inhibition (gene knockout), transcriptomics of copper tolerant fungi, mucilage inhibition, and metagenomic analysis of early colonizer bacteria that may be involved in 'softening' wood for decay fungi.

Two AWPA testing standards have been set based on Nicholas' work with accelerated test methodology:

- E22-16 Laboratory Method for Rapidly Evaluating the Decay Resistance of Wood-based Materials Against Pure Basidiomycete Cultures Using Compression Strength: Soil/Wafer Test (AWPA 2020);
- E23-16 Laboratory Method for Rapidly Evaluating the Decay Resistance of Wood-based Materials in Ground Contact Using Static Bending: Soil Jar Test (AWPA 2020).

Work based on accelerated aboveground tests and accelerated ground contact tests is continuing, in partnership with the USDA Forest Products Laboratory (Madison, Wisconsin). Coating systems for cross-laminated timber protection against common microorganisms are also being evaluated.

In terms of microbial conversion systems, we have investigated the use of ligninase and cellulase enzymes extracted from decay fungi to remove lignin from cellulosic biomass without degrading the cellulose fibers. In addition, work with bulk extraction of enzymes from wood decay fungi for use in pulping processes has been conducted.

## Wood utilization research

Under the Wood Utilization blanket, we group studies aimed at

- effect of treatments on properties,
- preservation of historic artifacts and structures,
- protection of engineered wood composites,
- exposure test of various configurations,
- stain and decay prevention,
- development and refinement of new technology such as vapor boron treatment, and
- development and evaluation of new preservative.

We have completed extensive restoration projects on historic wooden covered bridges, the civil war city gunboat *USS Cairo* (Vicksburg National Military Park), and Locust Stand (Natchez Trace Parkway). The *USS Cairo* project saved the US Park Service an estimated US$5 million to US$6 million over other systems that were bid. New treatment technology has led to effective treatment of engineered wood products without the usual swelling effects of current waterborne treatments. Continuing studies evaluate properties of new treatments and preservative system. We have evaluated every new preservative standardized by AWPA over the past 4 decades. We utilize various standard and nonstandard test exposure configurations including simulated attics, in-track treatment evaluation, barrier wrap evaluation, tie exposure on ballast and ground contact, and others.

Our continuing program in systems evaluation has focused on the evaluation of wood durability in relation to the deteriorating organism, the effect of exposure on durability (including aboveground, terrestrial, and marine exposures), and the effect of fire retardant treatment and exposure on strength properties of lumber and plywood.

Our studies with molds and stains deal with phytosanitation issues, microbial and nonmicrobial stains in hardwoods (such as grey stain and sticker stain), and sapstain and mold prevention in lumber. We have evaluated the effect of a wide range of preservatives and fire retardants on the physical and mechanical properties of wood and biocomposites.

New treatment technologies research has been aimed at modeling moisture properties, preservative or fire retardant treatment of composites, and treatment and durability of new generation composites such as steam-pressed scrim lumber and mass timber. Formulating more environmentally benign preservative systems is continuing. Combination systems relying on synergism and antioxidants are showing promise.

## Wood protection testing laboratory

ISO 17025–accredited work is performed under the oversight and supervision of Timber Products Inspection, Conyers, Georgia. Laboratory and field testing of preservative and protection systems using AWPA, ASTM International, and Window & Door Manufacturers Association standards are included in this work.

# Outreach and Metrics

In terms of outreach, we

- sponsor and/or attend meetings, conferences, and participate in professional societies;
- develop training programs for the wood treating industry;
- publish in various organs (visit our website @ http://www.cfr.msstate.edu/bioproducts/ to download papers of interest);
- develop patents and disclosures;
- provide technical assistance to public and industry (call 662-325-2116 or contact individual faculty and staff members); and
- provide reports to stakeholders and sponsors.

## Professional society involvement

Here are some of the societies in which wood protection staff participate. Those with an asterisk indicate a presidency by a protection faculty member.

- Association of Southeastern Biologists
- American Chemical Society
- American Standards Committee O5 (ANSI)
- American Phytopathological Society
- American Society for Testing & Materials (D7)
- American Society for Microbiology
- American Wood Protection Association*
- Entomological Society of America
- Forest Products Society*
- International Academy of Wood Science
- Society of American Foresters
- International Research Group on Wood Protection
- International Society for Environmental Biotechnology

- IOM$^3$-Wood Technology Society
- Mississippi Forestry Association
- National Trust for Historic Preservation
- Railway Tie Association
- Southern Pressure Treaters Association
- Society for Wood Science & Technology*

## Other metrics

Wood protection faculty, staff, and graduate students account for >50 percent of the Lab's publications and hold 54 percent of the patents. Since FY95, Wood Protection research has generated 60 percent of the overhead accrued by lab scientists through extramural grants and contracts.

## Summary and Conclusions

This has been an abridged glance at the long-standing program in wood protection research at the Forest Products Lab, Forest & Wildlife Research Center, Mississippi State University. Starting from the pre-Lab days to the present, personnel and program areas were detailed. We invite readers to contact the Lab for information related to wood protection.

Within the past 2½ years, the Lab and the field of wood preservation has lost two of its stalwarts. This article is dedicated to their memory (Fig. 6).

## Acknowledgments

This publication is a contribution of the Forest and Wildlife Research Center, Mississippi State University. Approved as Journal Article SB1006.

## Literature Cited

American Wood Protection Association (AWPA). 2020. *In*: AWPA Book of Standards. AWPA, Birmingham, Alabama.

*Figure 6.—In Memoriam: Warren S. Thompson (left); M. H. Freeman (right).*