Contents under Pressure: Using Architecture and Forestry with Fire-Retardant-Treated Wood to Construct Better Connections between the Built and the Natural Environments

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Keywords: Accreditation, Collaboration, Housing, Wildfire, Wood Products.

The United States is undergoing a national wood revival. This wood revival's nascent emergence suggests that architects are (again) becoming more familiar and comfortable with the advantages associated with wood-based construction, albeit slowly and in a piecemeal fashion. What appears to be missing from the wood revival, however, is not the sense of aesthetics or utility but rather the sense of urgency. After years spent teaching seminars to practicing architects, engineers, building/fire inspectors and officials (including in the wildland-urban interface or WUI) and teaching forest policy and wood products classes to university students, including about fire-retardant-treated wood (FRTW), class participants seemingly lack awareness of the connections between wood utilization and forest health based on questions they ask of the instructor during class.

This paper will strengthen the case for building (stronger) connections between architecture university programs and forestry/wood products academic programs in the United States. First, this paper will review recent data concerning both the current housing crisis as well as the current forest health/wildfire crisis in the United States, suggesting that addressing the forest health/wildfire crisis sustainably could help address the housing crisis simultaneously. Next, this paper will briefly qualitatively review professional architectural and forestry/wood product-focused organization accreditation schemes. Finally, the paper will suggest ways to adopt simple and inexpensive changes in pedagogy to help build those stronger connections in the absence of support from accreditation guidelines, with an emphasis on building with wood in the WUI.

> "An urban fire doesn't really exist, as such, until it burns a building: until it uses architecture as fuel."
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> —Christopher Hawthorne, *L.A. Times*[1]

INTRODUCTION

The United States is undergoing a national wood revival. Demand for building materials that are biophilia-engendering, carbon-sequestering, and are produced renewably and sustainably is helping increase domestic wood utilization through construction. Wood-using projects range in size from smaller-scale, stick frame, single-family residential homes to large warehouses of Type I or II construction and even massive cross-laminated timber tower projects ("plyscrapers"). As a result, it is difficult to venture into a major urban area without seeing at least some exposed wood in buildings under construction.

While the increased wood utilization is beneficial for a myriad of reasons, the revival also does not convey the whole story. For every single project that shows exposed wood, there are several other projects in the same area that show exposed steel beams that could have used wood instead (e.g. non-load bearing partitions in a Type II office building). The wood revival's nascent emergence suggests that architects are (again) becoming more familiar and comfortable with the advantages associated with wood-based construction albeit slowly and in a piecemeal fashion.

What appears to be missing from the wood revival, however, is not the sense of aesthetics or utility but rather the sense of urgency. After years spent teaching seminars to practicing architects, engineers, building/fire inspectors and officials (including in the wildland-urban interface or WUI) and teaching forest policy and wood products classes to university students, including about fire-retardant-treated wood (FRTW), it seems class participants are not aware of the connection between wood utilization and forest health based on questions they ask of the instructor during class. These questions largely center on basic aspects of wood and FRTW construction: Can wood be used in all five types of construction? Can wood outperform steel in a fire? Are the chemicals used to make FRTW toxic? Can FRTW be painted or coated in the field? These questions are typical of what class participants usually ask FRTW-manufacturing instructors year-round and throughout the U.S.[2]

Not only are these questions covering topics that one might consider squarely in the domain of architecture university programs, but also notice that the more frequently asked questions do not ask about sustainability or connections to forest health. When the participants are polled at the end of class, always after a concluding course module that covers the WUI and International WUI Code, most of the attendees responded that they never consider that their building material

selection could have a net-positive impact on forested environments located away from their project's site i.e., that building material selection could benefit remote economies and ecosystems. The questions, revisited time and again through courses like AIA-approved Lunch and Learns, suggest that the links between built and forested environments are not covered (well) in our architecture university programs as well as our forestry university programs.

This paper will strengthen the case for building (stronger) connections between architecture university programs and forestry/wood products academic programs in the United States. First, this paper will review recent data concerning both the current housing crisis as well as the current forest health/wildfire crisis in the United States, suggesting that addressing the forest health/wildfire crisis sustainably could help address the housing crisis simultaneously. Next, this paper will briefly qualitatively review professional architectural and forestry/wood product-focused organization accreditation schemes. Finally, the paper will suggest ways to adopt simple and inexpensive changes in pedagogy to help build those stronger connections in the absence of support from accreditation guidelines, with an emphasis on building with wood in the WUI.

CREATING THE SENSE OF URGENCY

As the population of the United States continues to increase, simultaneously so does the demand for dwelling units, with the most often-sought locations being those in proximity to workplaces and desired amenities. Unfortunately, many of these locations are already developed and occupied. As a result, with the supply of available, desired units being low, prices subsequently are skyrocketing, particularly in dense, urban corridors. Communities adversely impacted by rising real estate prices are responding by both building out and building up, resulting in an increased urban densification nationwide. By the year 2040, two-thirds of the country's population will be concentrated in just 10 large, regional "megapolitan" clusters.[3]

As these clusters continue to build up, they also build out, encroaching on the WUI. Defined, the WUI is "any developed area where conditions affecting the combustibility of natural and cultivated vegetation (wildland fuels) and structures or infrastructure (built fuels) allow for the ignition and spread of fire through these combined fuels."[4] Growth in the WUI has increased dramatically during the past generation; from 1990 to 2010, the WUI in the U.S. experienced a 31% increase in population and a 41% increase in the number of housing units constructed.[5] The trend continues unabated. For example, at the end of 2011, one out of every five Coloradans lived in the WUI.[6] Between 2012 and 2017, the number of people living in Colorado's WUI grew from 2 million to 2.9 million people, an increase of roughly 50-percent. By the end of 2018, half of Colorado's population was living in the WUI.[7]

Simultaneously, as populations increase outside forested areas, tree density or the number of trees per acre inside these forested areas also continue to increase. Historically, human efforts to manage forests including fire exclusion/suppression combined with livestock grazing practices and harvesting techniques altered fire regimes for forests, particularly low-to-mid elevation, western coniferous forests. With these forests now more structurally homogenous (e.g., same species sharing a similar age class), decreased tree diameters, and possessing higher fuel loads, these ubiquitous forests are now more susceptible to catastrophic wildfire events due to the "overly dense and unhealthy forest conditions."[8]

This susceptibility has led to three pronounced trends over the last 20 years. First, wildfires continue to burn in the U.S. with increasing intensity and efficiency. According to data from the National Interagency Fire Center's (NIFC) National Interagency Coordinating Center (NICC), since 2000, the average number of acres burned in wildfires in the U.S. each year is increasing, while the average number of wildfires each year is decreasing.[9] In other words, the U.S. is experiencing fewer fires but these fewer fires are burning more forestland per fire (see Fig. 1).

Second, the costs to suppress these more efficient and devastating wildfires are increasing, too. Expenditures from the U.S. Forest Service for fire suppression consumed 16% of the agency's budget in 1995. That percentage increased to 56% by the end of 2017. The U.S. Forest Service had projected that two-thirds of its budget would go to fire suppression by 2025; more recently, the agency announced that it would more likely spend two-thirds of its budget on fire suppression by 2021 instead, four years earlier than expected.[10]

Finally, the indirect costs borne by communities in the WUI are increasing and possibly in ways that might be unexpected or unanticipated. As a result of its liability from the wildfires in 2017 and 2018, including the 2018 Camp Fire in California, that started from its failed power lines, Pacific Gas and Electric (PG&E) has recently and intentionally established blackouts through northern California as the chances for high-speed winds to again cause a power line to fail, spark, and initiate a catastrophic wildfire are very high. Subsequently, more than two million PG&E customers have spent days and could spend as long as a week without electricity. Consider, too, that in addition to modern conveniences like coffee makers, refrigerators, and gas pumps, fire-detection and fire-fighting equipment (e.g., smoke detectors, water pumps) run on electricity, too. This most recent PG&E outage represents the largest planned power outage in human history. The related public outrage is reaching a boiling point; a passing motorist reportedly fired a shot at a PG&E truck in Colusa County, California just as the planned outages began, and PG&E has erected protective barriers around its headquarters in San Francisco as a precaution.[11]

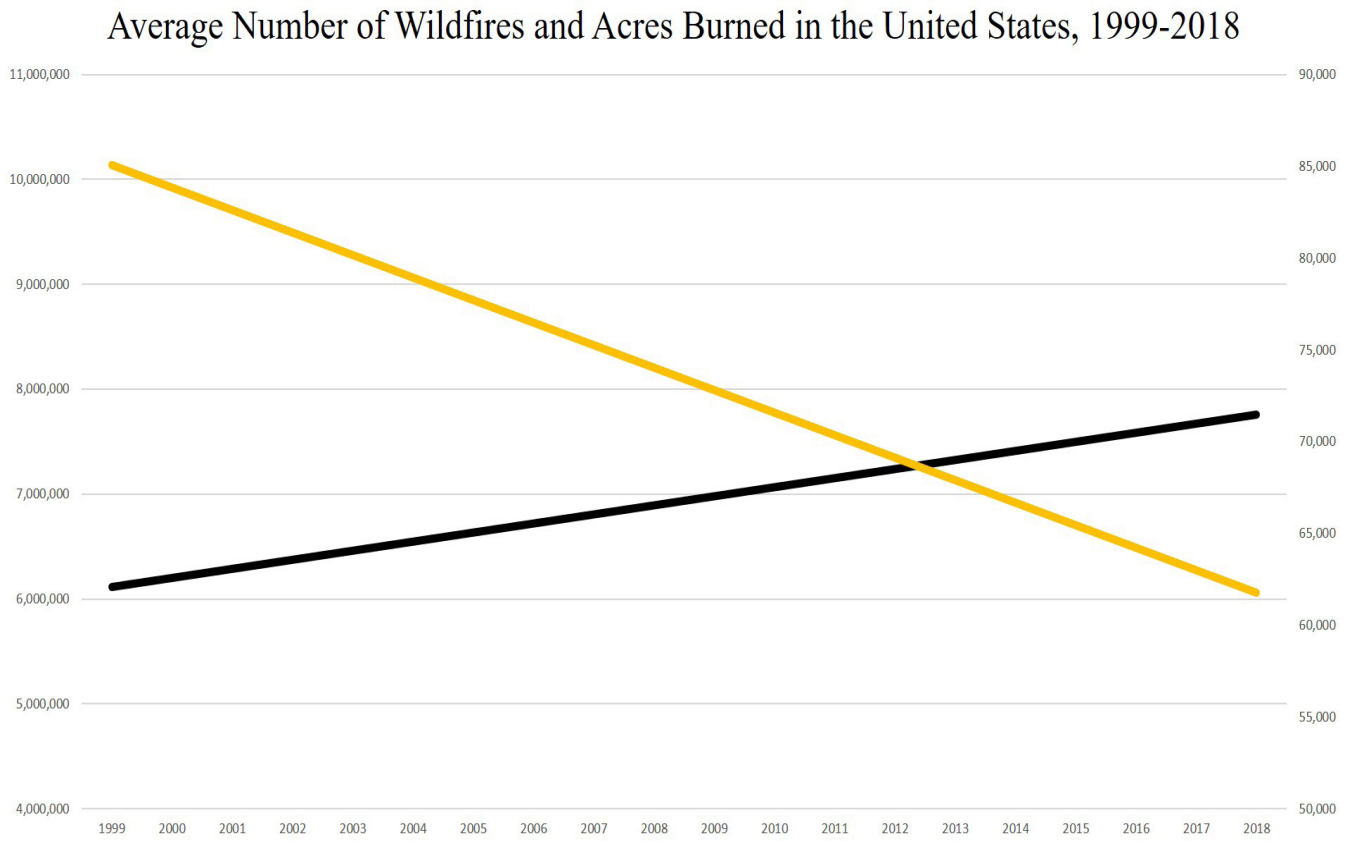

Figure 1. The orange line shows the average number of wildfires in the U.S. from 1999 – 2018 (right Y-axis). The black line shows the average number of forested acres burned for the same time period (left Y-axis).

THE MISSING LINK

With two diametrically opposed forces seemingly at the breaking point, between humans encroaching on the WUI and with tree density from inside the WUI accruing, one may be inclined to ask what opportunities exist to help relieve some of the pressures. One of the most apparent solutions sets involve sustainably and renewably harvesting wood material from forests in the WUI and use that material to build units to address the housing crisis. Architects and foresters could help build the connection between the forest management and housing supply issues by utilizing more wood from the WUI and even use some of that material to build fire-resistant structures in the WUI. The question then becomes: are architects and foresters trained to view these issues as being linked?

Accreditation: Architectural Programs

National Architectural Accreditation Board (NAAB)

Founded in 1940, the NAAB accredits professional degree programs within schools of architecture in addition to other programs when they are identified as being relevant to a school's professional program. Also, the NAAB accreditation standards "include general studies in combination with professional and elective studies, outcome-based performance criteria for evaluating student work, and procedures for guiding the accreditation process."[12] As of June 2019, over 130 programs (9 of which are candidates for accreditation) are accredited by the NAAB in the U.S., including Washington, D.C., and Puerto Rico. Most programs offer a Bachelor and/or Master of Architecture degree; few offer a Doctor of Architecture.

Referenced in both the NAAB's Procedures and Conditions for Accreditation is the NAAB's values statement. Of note is the "Constant Conditions for Diverse Contexts" section:

> The NAAB Conditions for Accreditation are broadly defined and achievement-oriented so that programs may meet these standards within the framework of their mission and vision, allowing for initiative and innovation. … The NAAB assumes the responsibility for undertaking a fair, thorough, and holistic evaluation process, relying essentially on the program's ability to demonstrate how, within its institutional context, it meets all evaluative criteria. The process relies on evaluation and judgment that, being rendered on the basis of qualitative factors, may defy precise substantiation.[13]

In other words, deliberately within the NAAB's accreditation process, flexibility exists. Programs could conceivably focus more on wood-based construction and its connections to the natural world with regards to wildfire and to the housing/building crises, and room exists in the Procedures and the Conditions document to do so. In the 2016 Visiting Team Report template, under I.1.4#D "Stewardship of the Environment," program evaluators are to ensure the program describes its approach to developing architects/graduates who "are prepared to both understand and take responsibility for stewardship of the environmental and the natural resources that are significantly compromised by the act of building and constructed human settlements."[14] In addition, when evaluating a program's "Curricular Framework" in section B.8, the visiting team must also evaluate students' "[u]nderstanding of the basic principles utilized in the appropriate selection of interior and exterior construction materials, finishes, products, components and assemblies based on their inherent performance including environmental impact and reuse."

The potential exists for architectural programs to connect forest health with responsible, renewable, and sustainable building design. The potential, however, also exists for programs to be discouraged from doing so. Examine again the wording under the "Stewardship of the Environment" section. Graduates must take responsibility for stewardship of the natural resources that are "significantly compromised" through building activities for human needs. What about taking responsibility for the environments that could be improved or "restored," to borrow from the U.S. Forest Service's parlance[15] on forest restoration? Efforts to build that link between forest and built environments may not be considered given the perjorative "significantly compromised" term in the NAAB's value statement. Does room exist in the values statement to also consider environments that could be "significantly improved," too? Wood extraction and utilization should not be viewed as always negative, as the NAAB's values statement implies.

Accreditation: Forestry Programs

Similarly, the organizations that could or do provide accreditation for university forestry programs also have a mixed approach regarding support for wood products and wood utilization training.

Forest Products Society (FPS)

Since its inception in 1947, the FPS has positioned itself as a network for disseminating information about all segments of the forest products industry, including distributing publications for the American Wood Council. Curiously, with its position as an information disseminator and with strong connections to academia (most members of the FPS leadership work in universities), the FPS does not accredit academic programs nor has university program accreditation appeared in the organization's peer-reviewed publication, the "Forest Products Journal." Curriculum design was discussed in roughly a dozen peer-reviewed publications in the journal during its first 18 years. After 1965, no articles appear in the journal that discuss curriculum design for wood products or wood technology.

Society of Wood Science and Technology (SWST)

The SWST started as the "American Institute of Wood Engineering" in 1958 and adopted its current name in 1960.[16] The organization positions itself as one "to advocate the socially responsible production and use of wood and lignocellulosic materials." To this end, the SWST developed an accreditation standard for wood science technology programs and first applied it in 1984 after some initial discussions and concerns in the late 1970s.[17] The standard has been updated at least half a dozen times over the last 30 years but the process takes one of two forms: 1) Co-accreditation with the Society of American Foresters (see below), or 2) standalone with SWST.[18] In either case, the SWST uses its own standards. Basic SWST curriculum requirements focus on the biological, physical, mechanical, and chemical properties of "renewable materials." In addition, students must "develop a foundation of understanding in one or more topic areas," which could include areas like "Harvesting, Processing, and Manufacturing of Renewable Materials," "Bioenergy and Bioconversion," or, what may be of most interest for this paper, "Sustainable Building Materials and Construction Methods and Management." This area includes:

> A variety of materials made from renewable materials exist or are being developed for use in construction. This application area serves to develop an appreciation for the potential impact of materials choices, and their applications on the everyday lives of people, the economic structure of business and industry, and the potential health and environmental effect of the choices that are made.[19]

Caveats exist. While certainly the SWST guidelines are robust concerning wood science, the associated, required topic areas are designed to be "flexible," so not all institutions may cover links between wood, forestry, and architecture, including WUI-related issues. Furthermore, the reach of the SWST accreditation appears to be limited to less than a dozen schools in North America with an additional four programs scattered across Asia.[20]

Society of American Foresters (SAF)

With over 11,000 members, SAF traces their origins back to 1900, and SAF initiated its accreditation program in 1935.[21] Currently, SAF accredits two categories of programs: forestry, urban forestry, and natural resources and ecosystem management programs leading to a Baccalaureate or Master's degree and forest technology programs leading to an Associate's degree.[22] With such a broad base for membership

and longevity outreaching the other forest product-related professional societies, it is surprising that SAF, while arguably having the most to offer in terms of resources and historical depth, has the least to say through accreditation regarding wood products manufacturing and wood utilization. Reviewing its accreditation guidelines, the only area where "forest products manufacturing" is listed specifically is as a technical education area charge under the Forest Technology or Associate's degree-level programs.[23] While other areas in the Handbook refer to timber or harvesting, only in the Forest Technology program is any elaboration on forest products, including primary and secondary fore products, actually present, although the actual "depth of instruction" is subject to "regional priorities and practices," permitting flexibility as seen in other accreditation standards.

DISCUSSION: BUILDING BETTER CONNECTIONS

What the review shows is that while forestry and architectural accreditation standards contribute substantially to ensuring graduates are capable of competently contributing to society writ large, they do so seemingly independently of each other. Furthermore, while flexibility allows the standards to adapt to local practices and needs, they also imply that not all students will possess the same skill sets upon matriculation. In other words, these accreditation standards may produce competent architects and foresters who may not have been exposed to and/or understand the link between forest health and wood building materials.

Opportunities to improve exist. Top-level, broad-reaching, systemic changes are possible. The NAAB's values statement could be broadened to acknowledge that material extraction and manufacture could also have positive results instead of only negative. The forest-related accreditation standards could do more to promote wood building material manufacturing and its related societal (architectural/construction) and ecological benefits (in the case of FPS, this area could provide the organization a much-needed niche).

However, given the flexibility in the way these standards are administered, perhaps the most beneficial steps that could be taken, quickly, in the near-term is to adjust how wood and wood building materials are taught in architecture (and forestry) classes. One easy adjustment is for architectural and forestry programs to coordinate events like hosting seminars, conferences, field trips, or social events so that they are mutually beneficial by encouraging student professionals to not only intermingle but also learn from one another.

More substantially and likely more rewarding is to include more discussion and examples of how wood can act as a link to relieving pressures in the WUI from both human encroachment and natural forest regeneration, subject to the needs and practices of programs and taking advantage of their individual creative strengths. For instance, wood products could be modified so that they are acceptable for use in the WUI and permitted by the IWUIC. Defined in the 2018 International Building Code (IBC), pressure-impregnated fire-retardant-treated wood (FRTW) consists of "wood products that, when impregnated with chemicals by a pressure process or other means during manufacture, exhibit reduced surface-burning characteristics and resist the propagation of fire."[24] FRTW can be used in all five types of construction, can outperform steel in a fire, and because they are pressure-impregnated, they will outperform a paint or a coating, which is why paints and coatings are not permitted as a substitute for FRTW.[25]

FRTW-related concepts are easy to reinforce. Videos of the ASTM E160 crib test comparing painted, coated, and FRTW samples are freely available online. Wood porosity, showing wood anatomical features that manufacturers typically seek, can be demonstrated easily by blowing bubbles into water through a small piece of red oak wood. Connections between harvesting wood in the WUI and then using said material to make structures, like homes, in the WUI more fire-resistant using products like FRTW can be brought to life through case studies from architecture firms, manufacturers, or even local building/fire officials (see Fig. 2).

CONCLUSION

Revisiting the opening Hawthorne quote, fires in the WUI could be illustrative of how architecture (and forestry) could continue to contribute fuel to the wildfire crisis, especially without any efforts to collaborate and adapt. Knowledgeable professionals, such as architects and foresters, not only have an opportunity but also a responsibility to help influence efforts to make structures more resistant to embers. For example, the latest efforts to reform the California Building Code in the WUI (Chapter 7A) currently leaves the fire resistance requirements for decking and fencing to only a Class B (ex. untreated western red cedar, untreated redwood) rating, the same requirements that were in place prior to the 2018 Camp Fire that decimated Paradise, California. Without changes, California is committing itself to repeating the Paradise experience as a Class B fence, connecting multiple residential structures (homes) in the WUI, is less like a fence and more like a fuse. Without input from professionals that have a basic understanding of the links between forest health and forest products, history is slated to repeat itself in one of the nation's largest forested states.

Given the intense pressures facing occupants in the WUI, greater attention is and will continue being paid to what materials are being used to build their structures. Similarly, schools of architecture (and forestry) are under pressure to identify and employ solutions that could address both the housing and forest health/wildfire crises simultaneously as built urban environments encroach on forested environments. Ultimately, with two diametrically opposed forces under pressure, one side will necessarily give way. The images of the breaking point appear in the media and appear stronger each fire season. Those people

Figure 2. Structures like this 5-over-3 podium building near Salt Lake City, Utah, can use wood harvested from the WUI to provide dwelling units in increasingly densified urban corridors while helping to reduce standing tree densities in nearby forests. This FRTW could also be used in structures built in the WUI, too.

who are empowered to act through education may help reduce the severity of any subsequent impacts from those WUI-related pressures releasing.

ENDNOTES

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