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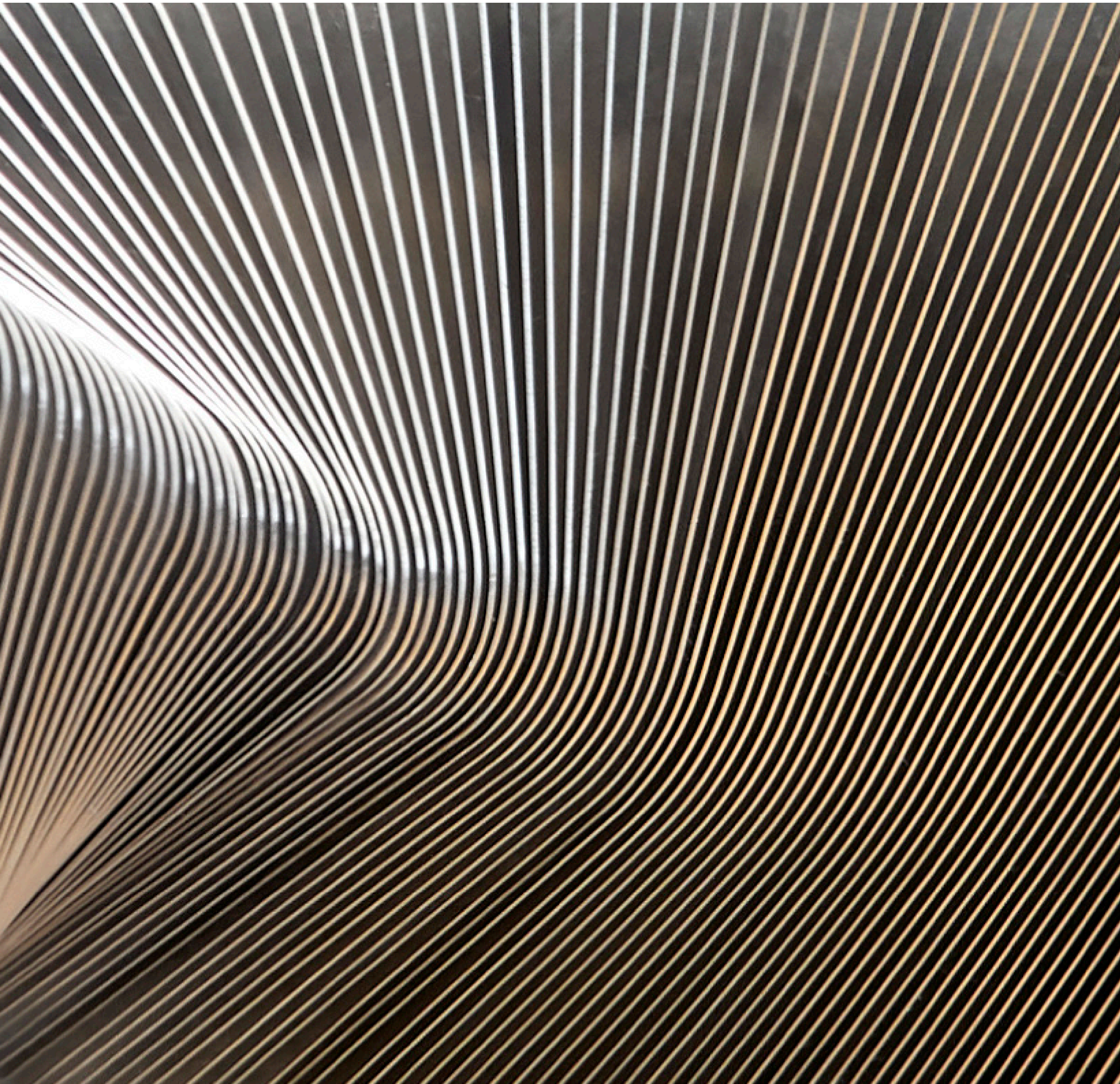

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Wood Cladding for Minnesota's Bell Museum

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Abstract

Tasked by our client to identify a local wood cladding product that met their institutional and budget goals, we researched several products for a new natural history museum in Minnesota. Ultimately, the Minneapolis Perkins&Will team designed and specified an environmentally responsible building façade assembly that aligns with the client's budget, values, and aspirations - while meeting institutional durability and maintenance requirements.

Four options were evaluated for cost, durability, source, warranty, and appearance. A single product met the client's criteria. Situated within a broader learning landscape and urban wildlife habitat, sustainably sourced thermally modified wood siding wraps the new museum building. This solution enabled the project team to meet the project budget, while embodying the values and cultural goals of the institution through the building façade design.

This initial project-related research evolved into a much larger research topic that continues to bring together a variety of local academic and industry experts, as well as architecture firms interested in employing sustainable wood in their projects.

Keywords: *resilient, local, FSC, wood, siding, thermal modification*

1.0 Introduction

Nearly half of the Bell Museum's exterior is clad in eastern white pine siding (Figure 1). Typically, white pine is not considered an acceptable material for building envelope, but for this project its performance is exemplary. Clear-grained, stable, and strong—in the 19th century, white pine was in great demand for use in furniture, building structures, and, most famously, masts for sailing ships. One of the largest tree species found in North America, some measure over eight feet in diameter and two hundred feet tall.

Featuring the work of renowned diorama artist Francis Lee Jaques, the new Bell Museum is Minnesota's natural history museum and a gateway to University of Minnesota research (Figure 2). As a site for Minnesotans and visitors to learn about the world we inhabit, it was vital to our client that the new building feature local materials. And like the learning landscape it occupies, the building needed to offer opportunities to tell Minnesota's natural history stories (Figure 3).

In alignment with the university's commitment to sustainability and the museum's focus on wildlife, all the exterior glazing includes a bird-safe frit pattern. Recalling the Iron Range mining heritage of Minnesota, much of the building is clad in panelized steel. Finally, 40 percent of the building envelope utilizes thermally modified white pine board siding. A product of responsibly managed Minnesota forests, this material aligns perfectly with the sustainability and storytelling priorities of our client. But like many journeys, we took a circuitous path to the destination.

Figure 1: *Thermally modified white pine cladding at work in Minnesota.*

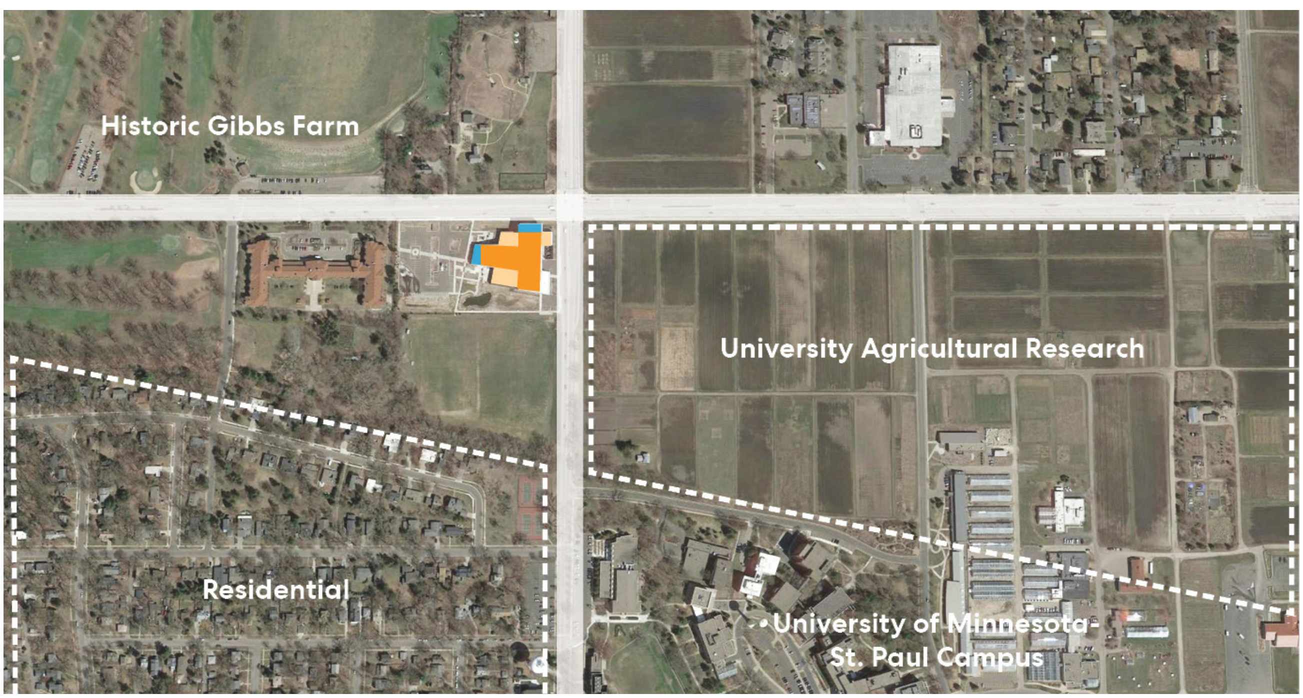


Figure 2: *Bell Museum site.*

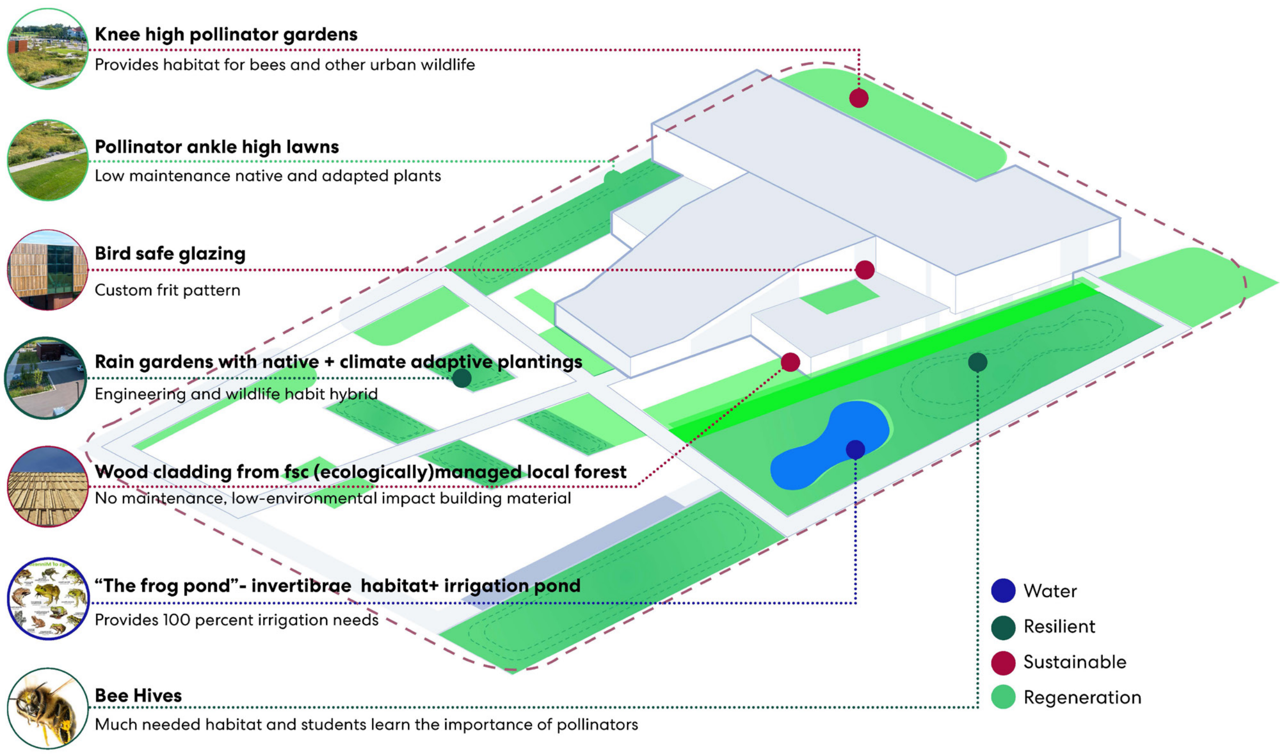


Figure 3: *Bell Museum learning landscape.*

2.0 Local Industry Partners

Our studio had never designed a wood-clad building. After receiving an enthusiastic response to the proposed wood cladding design, we looked to precedents and local industry partners for help. We were impressed by the robust materiality of the Living with Lakes Research Centre at Laurentian University, designed by Perkins&Will Vancouver, completed in 2011. Our design team appreciated the weathering-to-gray exterior siding and the material's connections to the local economy. We aspired to a similar alignment with our client's values.

Because of sustainable management, Minnesota forestry is shifting back to lumber harvesting, after decades of focus on pulpwood for paper manufacturing. The University of Minnesota supports this evolution with the work of the Department of Forest Resources, part of the College of Food, Agricultural and Natural Resource Sciences, whom we consulted in the early stages of our product research. Later, we learned about the Natural Resources Research Institute, a non-profit applied research group, located at the University of Minnesota-Duluth. A tremendous resource for information on forest product development, the NRRI Materials and Bioeconomy research group plays an important role in the development of wood modification technologies. Its focus on strengthening the bioeconomy of northern Minnesota aligned well with the resilience goals of the project team.

3.0 Cladding Literature Review and Research

Wood treatment technologies have been available for decades. However, due to the emergence of several environmental (deforestation), economic (increase in price of available wood), and regulatory pressures (governmental regulations on use of toxins), there is a renewed interest in the commercialization of these technologies.[1]

The first scientific study in thermal modification was conducted in 1920, proving that heat decreases moisture content and the ability to swell in wood species.[2] This research was conducted at the Forest Product Research Lab in Madison, Wisconsin in the 1920s.[3] In 1937, other research emerged establishing that heating wood under specific gaseous conditions leads to a substantial decrease in shrinkage, moisture, and swelling.[4] This study was subsequently followed by another study in 1949, highlighting that heating wood at specific temperatures and under controlled conditions increases dimensional stability and anti-fungal properties.[5]

Simultaneously, many efforts to develop and industrialize various wood processes were done in Japan, Canada, and Latvia in the 1970s and 1980s. Despite these efforts, wood modification technologies failed to move into the mainstream.[6] Europe emerged as a leader and established systematic R&D efforts leading to the implementation of industrial processes in various European nations in the 2000s. Eventually Finland, the Netherlands, and Germany achieved market leadership in the development of key modification processes available today.

Current wood modification processes can be divided into three different categories: thermal, chemical, and furfurylation. These processes alter the cellular structure of wood, which is composed of cellulose, hemicellulose, and lignin polymers—all of which are hydroxyl groups that react with water molecules, leading to decay.[6] The main advantages of thermal treatment is increased durability, decay resistance, dimensional stability, and UV resistance. The drawback of the process is mainly reduction in the mechanical properties of wood: bending, compression, stiffness, and shear strength. Chemical processes use chemical substances to alter the wood structure. Thermal processes alter the wood by using a combination of different factors: treatment intensity (temperature & time), inert atmosphere and conditioning.[2]

Tasked by the University of Minnesota to identify a local wood cladding product that met their institutional and budget goals, we applied our understanding of modification processes to narrow down a list of four modified wood products. The results of this research were compiled and presented to our client. Durability and minimal maintenance were prioritized. Also, the client required a reasonable warranty on the material. The findings are summarized in Figure 4.

Wood cladding products reviewed

1. Eastern white cedar shakes
2. Wood acetylation
3. Charred wood
4. Thermally Modified Timber (TMT)

Eastern white cedar shakes

- Sourced from FSC certified forests in northern Minnesota
- Supports local economy. Made in Duluth, Minnesota
- Excellent durability, 25-year lifespan, without finishing, 50-year warranty, sealed
- Maintenance—most sealers require reapplication every 3-5 years
- Durability—excellent
- Decay resistance—very good
- Warranty is not available for FSC certified cedar in Minnesota
- Cost—low

Wood acetylation products

- Sourced from New Zealand Radiata Pine
- Acetylation process occurs in the Netherlands
- Maintenance—minimal
- Durability—excellent

- Decay resistance—excellent
- Warranty—50-year warranty
- Cost—medium

Charred wood

- Potentially sourced from FSC certified forests in northern Minnesota
- No local char treatment facilities. Likely shipped to Texas for char
- Durability—good
- Decay resistance—excellent
- Maintenance—Can be left unsealed, but usually sealed, reapplied every 7-10 years
- Historically proven service life—installations lasting 60-100 years
- Warranty—5-years
- Cost—high

Thermally Modified Timber (TMT)

- Sourced from FSC certified forests in northern Minnesota
- Supports local economy; harvested, milled, and treated in northern Minnesota
- Maintenance—minimal
- Durability—excellent
- Decay resistance—excellent
- Warranty—typically a 25-year warranty, but a 40-year warranty is available
- Cost—low.

As illustrated through the findings and Figure 4, eastern white cedar shakes were not available with a satisfactory warranty. The warranty for acetylated wood is very good, but it was disqualified by its overseas source and the toxicity of its chemical treatment. Short warranty and high price eliminated charred wood from consideration. The “cooked’” option, thermally modified timber, was the last product added to the evaluation set. But, as shown in Figure 4, it meets the criteria best.

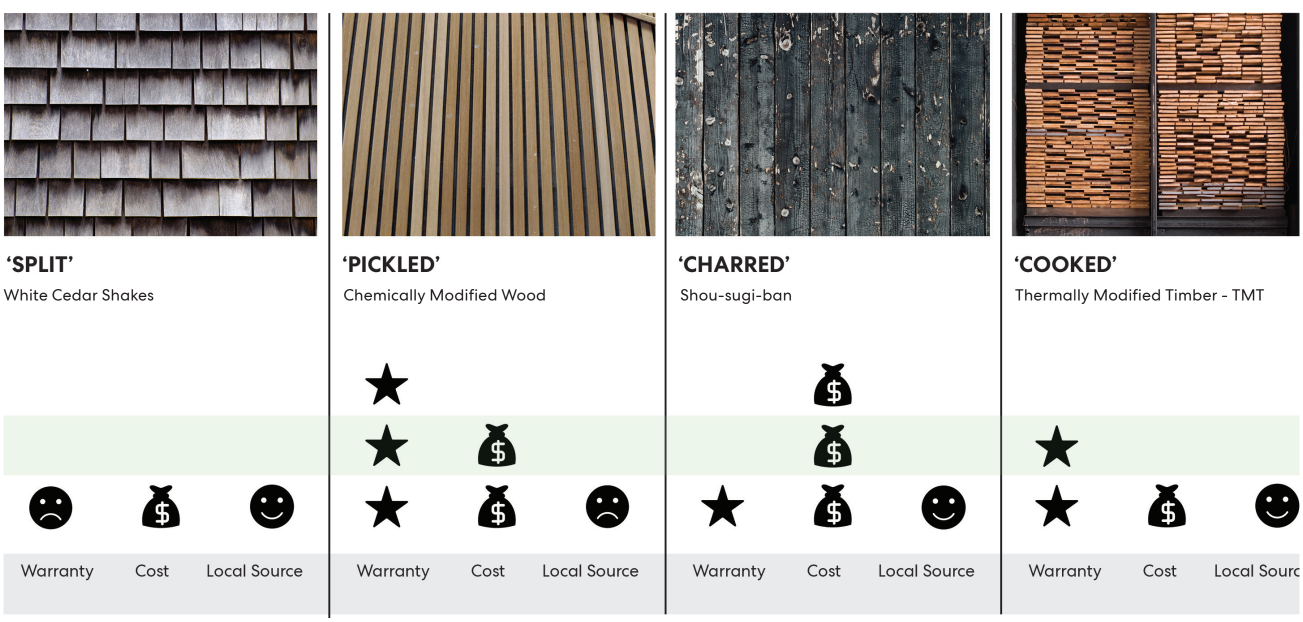


Figure 4: *Bell Museum wood products evaluation matrix.*

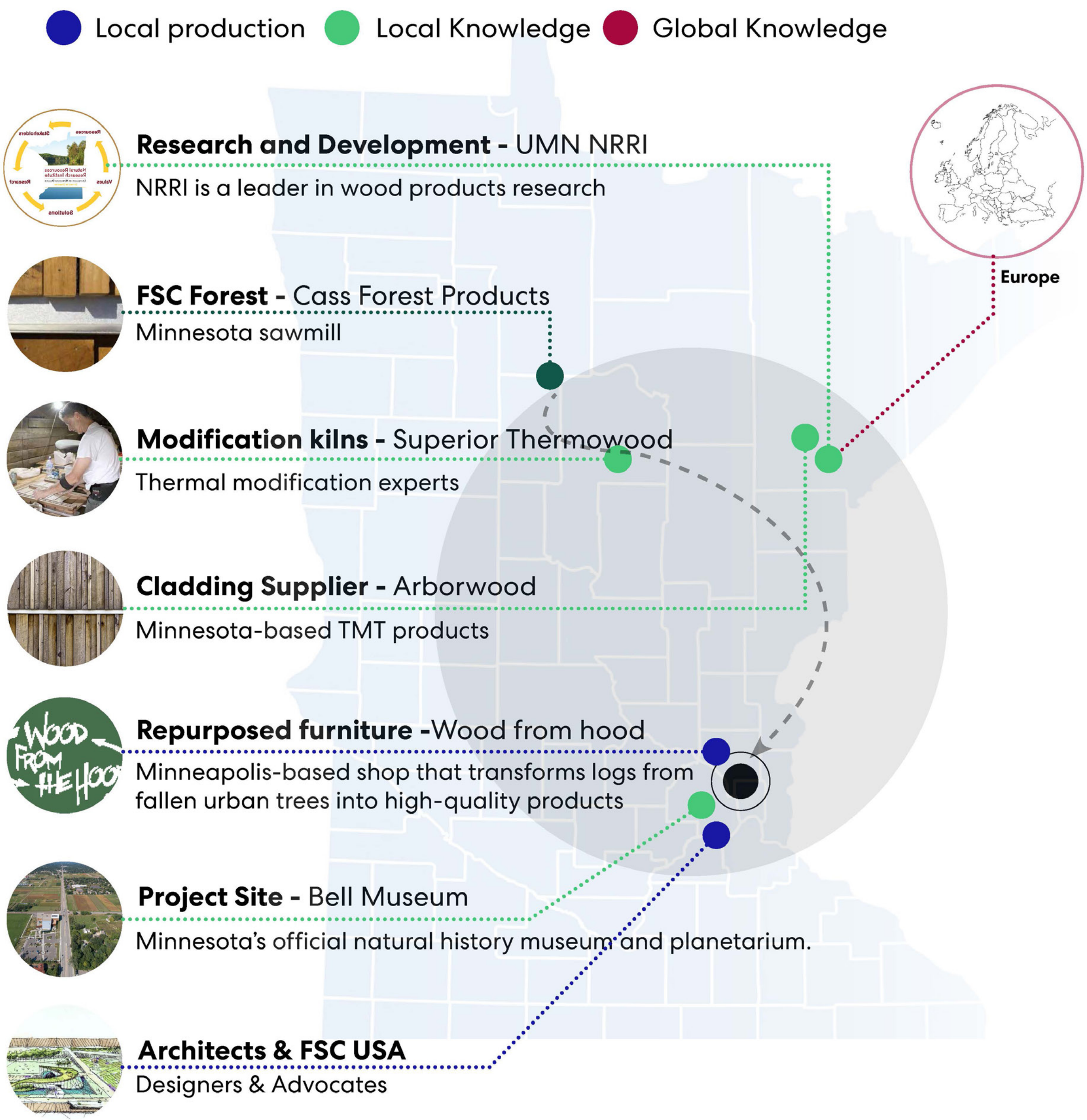
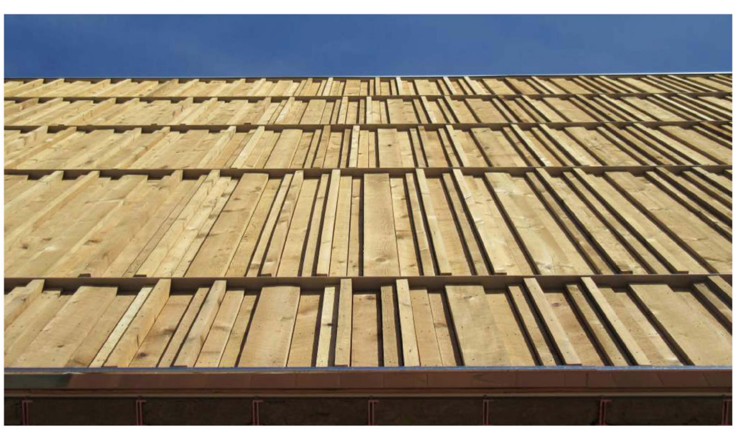
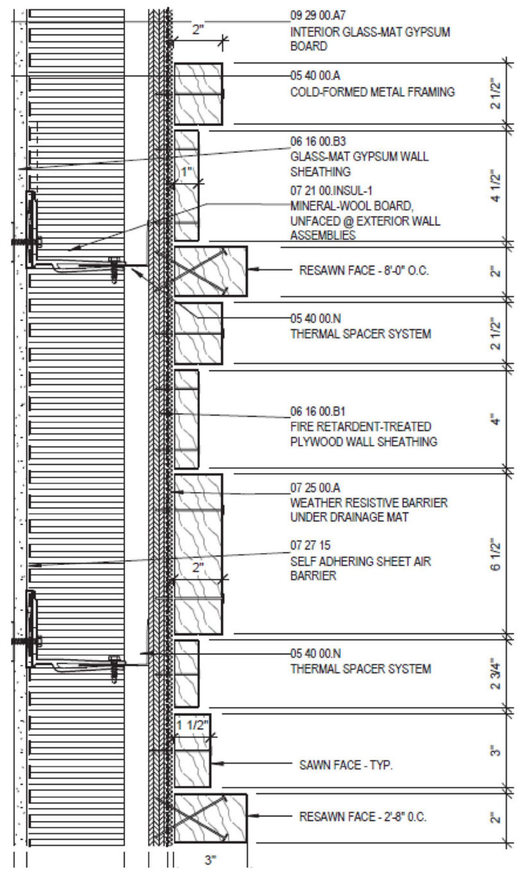


Figure 5: *Material journey.*

At the start of our research, we were aware of local building projects that used the other three options successfully, but most of the identified TMT precedents were in Europe. However, a local source for TMT was identified, located in Duluth, Minnesota. Using wood treatment technology developed in Finland and enhanced by NRRI research, the local source offers several thermally modified wood products, including flooring, decking, and siding. These products are "cooked" about eighty miles from Duluth at the Superior Thermowood kiln, in Palisade, Minnesota. Supporting environmentally responsible forestry strengthens the economy of Minnesota, site of over 6 million FSC certified forest acres.[7] The treatment facility, kiln, sawmill, and forests all lie within a 75-mile radius in northern Minnesota, bolstering that economy (Figure 5).

From the elevation view, the cladding displays a coarse surface. The design team developed this distinctive siding pattern of varying board widths and depths to provide generous surface area for enhanced drying capacity after exposure to moisture (Figure 6). The white pine boards are left rough, sawn and unfinished. Reduced cost is one benefit of this crude surface, but for the design team the rough-sawn texture provided a window into the origin story of the building envelope. With minimal finishing, the thermally modified boards are simply cooked, cut, and installed—the rough surface recalling the uneven bark of a white pine tree.





Wood is baked to 800 Deg F crystallizing the structure to creating a 50 year cladding. The process does not produce any notable toxic air emissions.

Figure 6: *Thermally modified wood cladding detail.*

4.0 Further Study

This project-based research evolved into a collaborative research effort between the University of Minnesota's Architectural Research Consortium and project team, which allows academics, students, and practitioners to jointly explore a research topic benefiting both academia and the building industry.

The first phase of the expanded research project consisted of a literature review of available research materials to understand known modification processes, including pre-harvest and post-harvest methods. The pre-harvest modification category surveyed different ways of using wood before harvesting as a means of increasing durability. This entails strategically employing inherent strengths of as-found wood or employing processes, such as girdling, before the tree is harvested. Post-harvest categories studied for this research included cellular and design-based methods that individually or in combination with other strategies make wood more resilient as a building material. The primary purpose of this phase was to develop a broader understanding of different factors that affect wood modification, from its cellular composition to building assembly level (Figure 7).

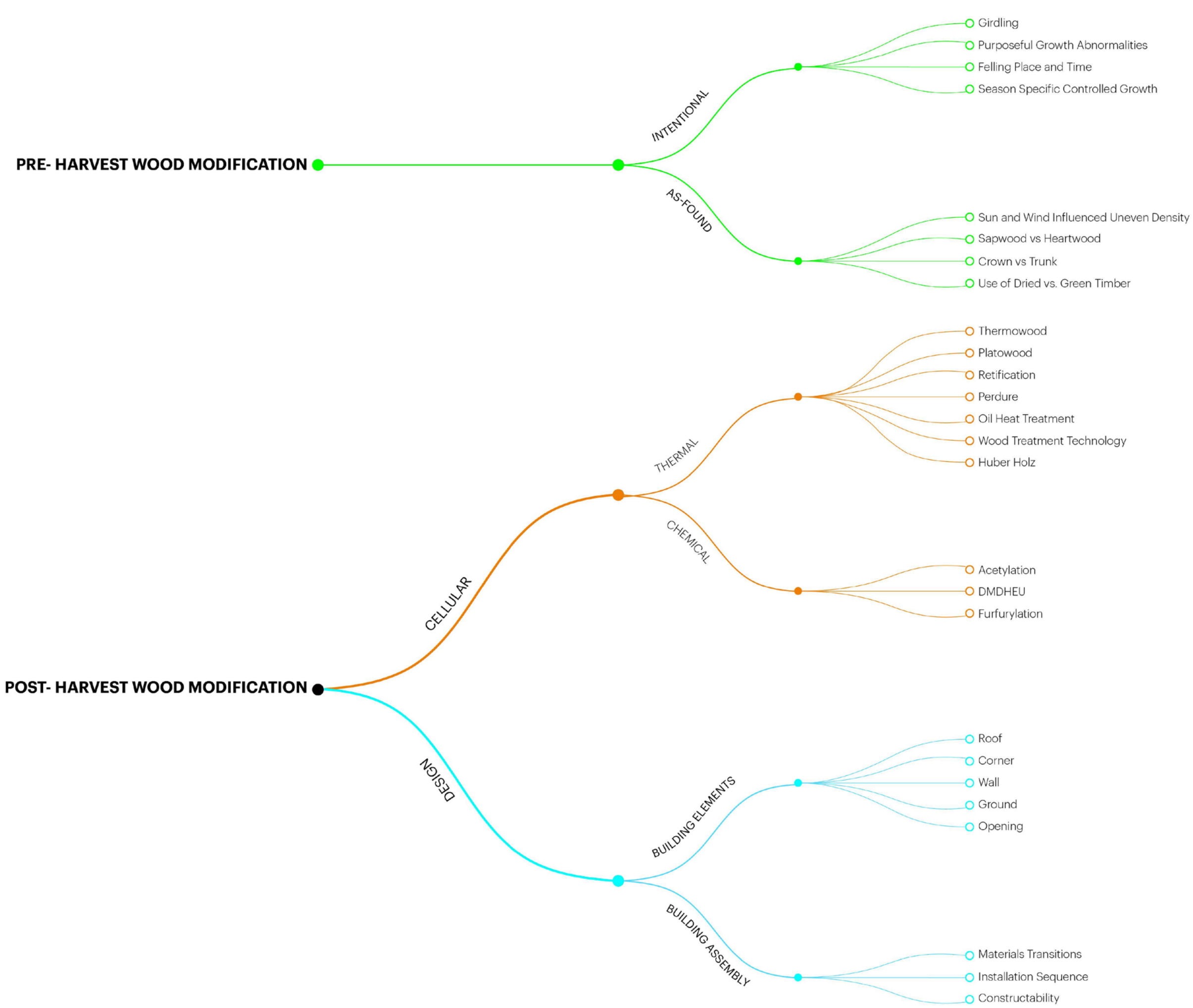


Figure 7: *Classification of wood modification processes into pre- and post-harvest categories.*

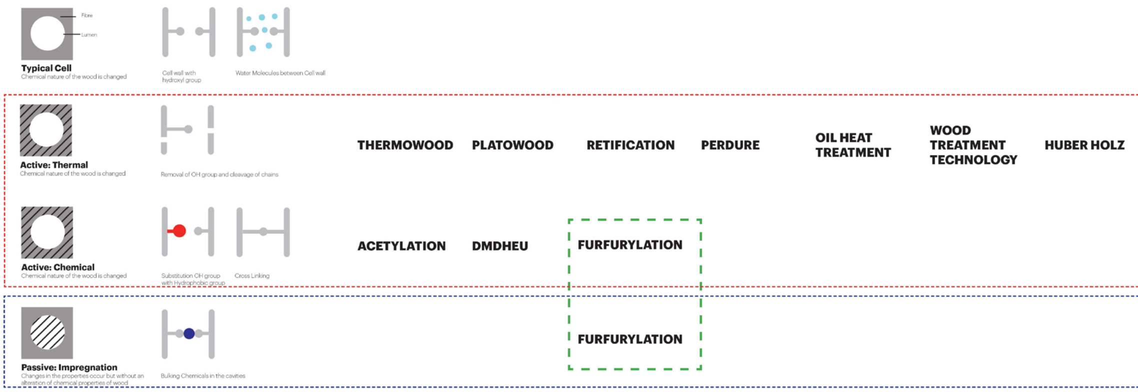


Figure 8: *Self-shading design strategies.*

The literature review allowed us to understand nuances of different modification processes and how these processes enhance wood's performance as a material by altering the molecular structure of the cell wall component (Figure 8).

We used the information gathered during the literature review phase to create a decision matrix that can be used as a reference guide for selecting different modification-based products. The matrix gives a synthesized summary of different strengths and weaknesses associated with a specific modification process, such as decay resistance, durability, color, suitable species, cost, etc., and allows users to make an informed choice based on their selection criteria (Table 1).

Table 1: *Matrix comparing different products based on key criteria. Higher number = higher importance rating, example: score 7= highest importance, score 1= lowest importance.*

Pugh Matrix					
			Solution Alternatives		
Key Criteria	*Importance Rating*	Benchmark Option	Thermally modified wood product	Acetylation based modified wood product	Furfurylation based modified wood product
Local Production	2		S	-	-
Cost	3		S	-	-
Durability	5		-	S	S
Decay Resistance	7		S	S	S
Warranty	6		-	S	-
Color	4		-	+	+
Environmental Impact	1		+	+	+
		Sum of Positives	1	2	2
		Sum of Negatives	3	2	3
		Sum of Sames	3	3	2
		Weighted Sum of Positives	1	5	5
		Weighted Sum of Negatives	15	5	11
		TOTALS	-14	0	-6

Legend

S = Same as industry benchmark
- = Worse than industry benchmark
+ = Better than industry benchmark

Figure 9: *Building and landscape enable journeys of discovery.*

5.0 Conclusion

Recent developments in forestry and wood treatment technologies offer great opportunities for healthy building projects. Promoting local economies and biodiversity, 100 percent of the wood cladding used on the Bell Museum is FSC certified. At the new Bell Museum, thermally modified white pine cladding amplifies the experience of the natural environment with a non-toxic, durable, low-maintenance cladding product (Figure 9). These qualities are available to any building owner that wants to embody their commitment to sustainability with a beautiful, robust material. Additionally, this project generated robust knowledge sharing around the topic of wood treatments amongst academia, industry partners, and Perkins&Will.

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Dave Dimond, of Perkins&Will, led the design effort for the Bell Museum.

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References

[1] Sandberg, D., Kutnar, A., and Mantanis, G., (2017). "Wood Modification Technologies - A Review", *iForest - Biogeosciences and Forestry*, Vol 10, pp. 895-908.

[2] Candelier, K., Thevenon, M-F., Petrissans, A., Dumarcay, St., Gerardin, P., and Petrissans, M., (2016). "Control of Wood Thermal Treatment and Its Effects on Decay Resistance: A Review", *Annals of Forest Science,* Vol. 73, No. 3, pp. 571–583.

[3] Hill, C., (2011). “Wood Modification: Update”, *Bioresources*, Vol. 6, No. 2, pp. 918-919.

[4] Stamm, A., and Hansen, L., (1937). “Minimizing Wood Shrinkage and Swelling Effect of Heating in Various Gases”, *Industrial & Engineering Chemistry,* Vol. 29, No. 7, pp. 831–833.

[5] Stamm, A., Burr, H., and Kline, A., (1946). “Staybwood-A Heat Stabilized Wood”, *Industrial & Engineering Chemistry,* Vol. 38, pp. 630–634.

[6] Homan, W. , and Jorissen, A., (2004). “Wood Modification Developments”, *Heron,* Vol. 49, No 4, pp. 361-385.

[7] Forestry Stewardship Council, (2018). “FSC US Management Certified Acres by State 2018”, Retrieved on 10/2020 from https://us.fsc.org/preview.fsc-certified-acres-by-state.a-204.pdf.

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