

FOREST RESTORATION BY DESIGN:

Utilizing Low-Value Species Harvested
from Forest Restoration Projects in Local
CLT Manufacture and Design



Payton Narancic
M.S. Mass Timber Design Focus
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Forest Restoration Projects in Local CLT
Manufacture and Design**

By
Payton Narancic

Graduate Committee Members: Mark Fretz,
Mariapaola Riggio, and Judith Sheine (Chair)



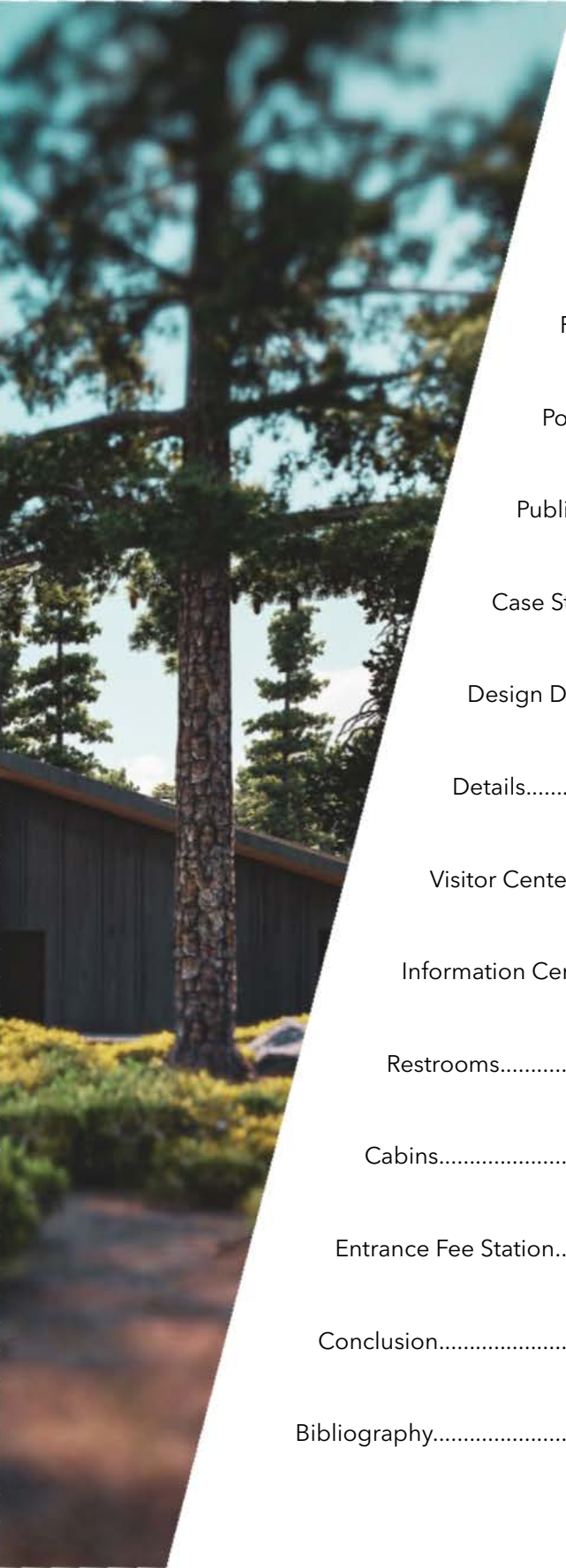


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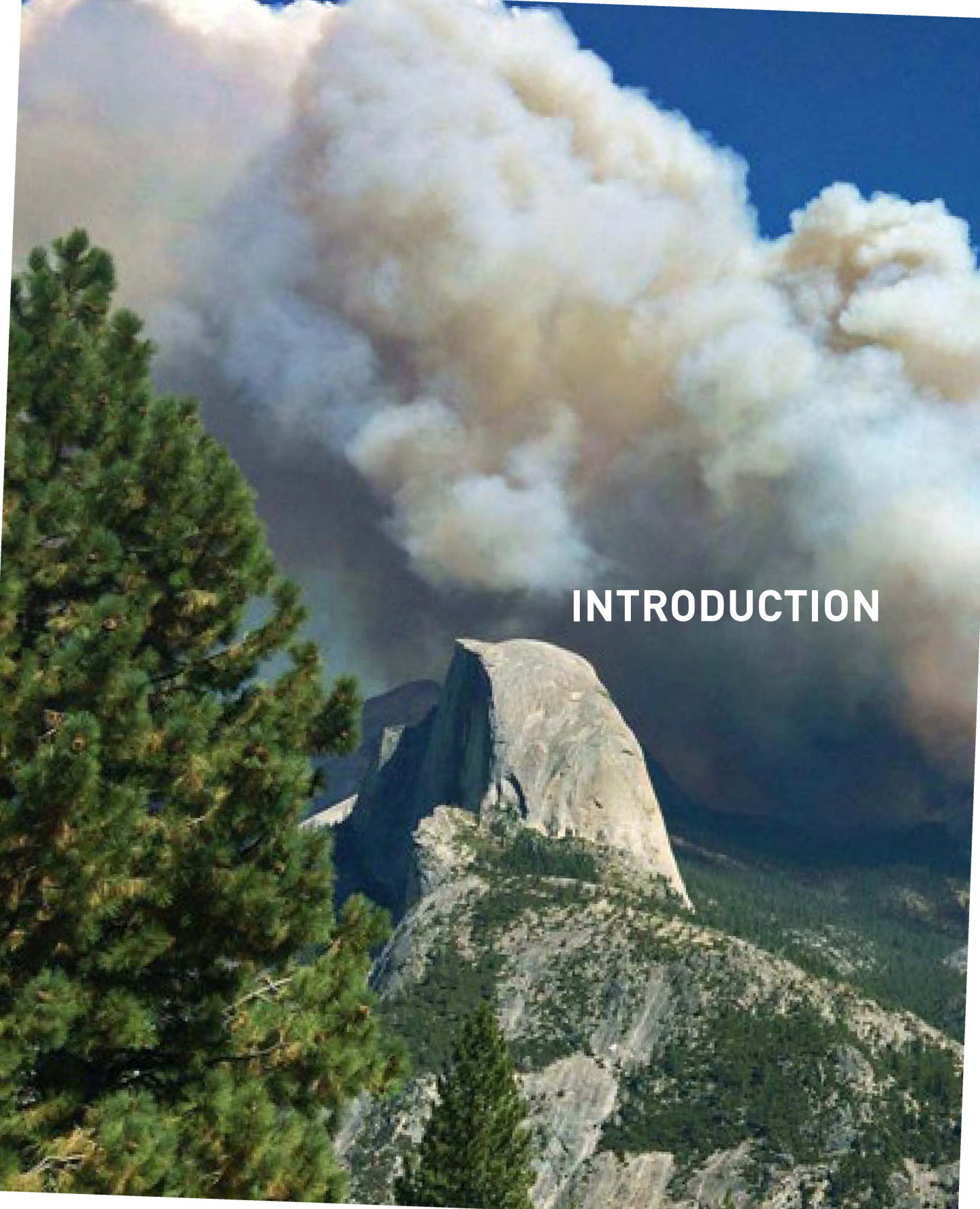
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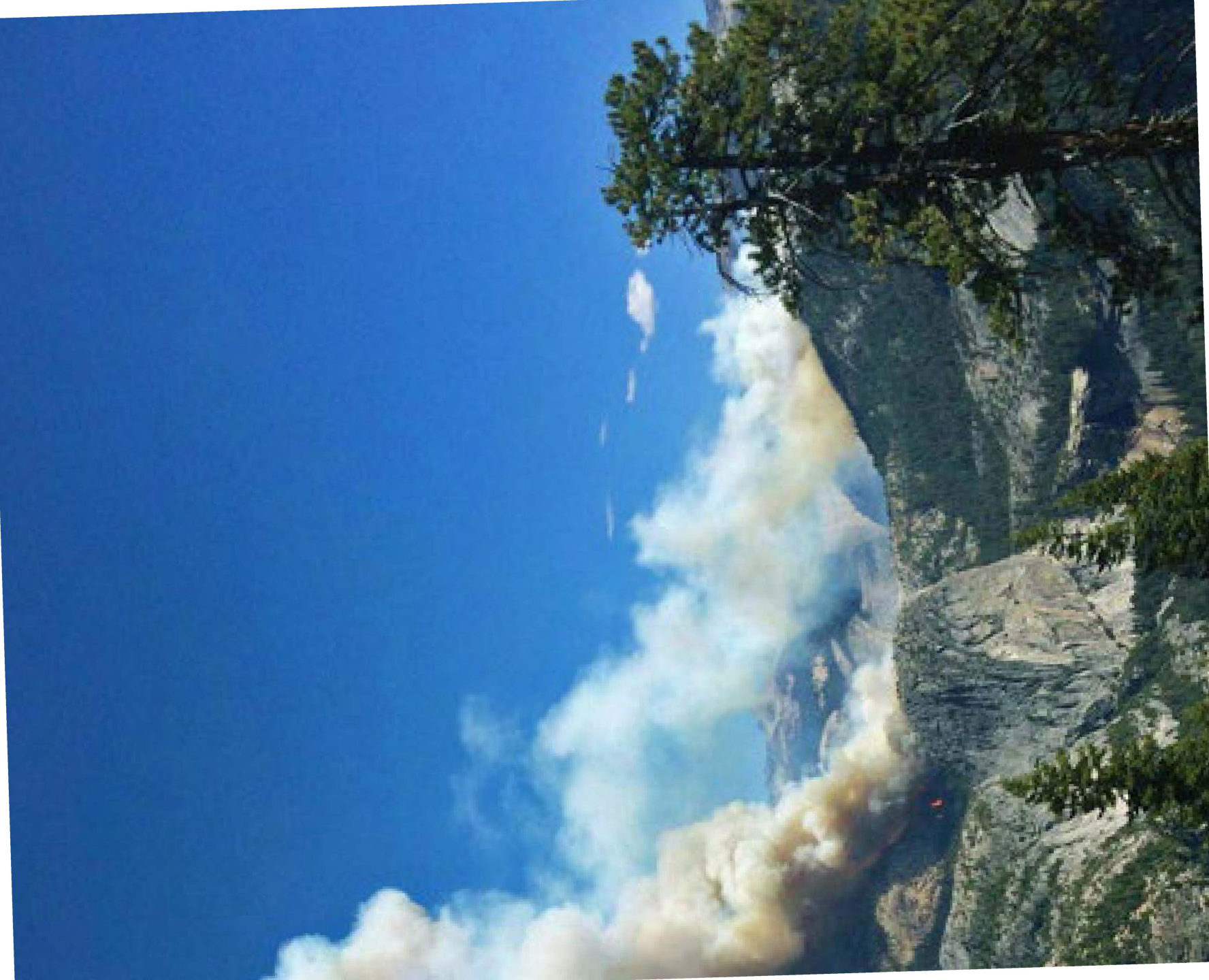
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A photograph of a volcanic eruption. A massive, billowing plume of white ash and steam rises from a mountain peak, filling much of the sky. The plume has a yellowish-tan tint, suggesting ash content. In the foreground, a large, dark green evergreen tree stands on the left, partially obscuring the view of the mountain. The mountain's rocky, light-colored peak is visible in the center. The sky is a clear, deep blue. The word "INTRODUCTION" is overlaid in white, bold, sans-serif capital letters on the right side of the image.

INTRODUCTION





ABSTRACT

Climate change is causing immense stress on our forests. Years of wildfire suppression and ever-extending periods of drought are fanning the flames of catastrophic wildfires at an unnatural scale (Williams et al. 2019) (Ager et al. 2017). The west coast has suffered the brunt of these negative impacts as wildfire seasons are becoming increasingly worse every year, with California being severely impacted. The abundance of small-diameter trees and dry fuel accumulating in forests is reinforcing the need for better forest management practices as human activity in the last century has proven to be detrimental to the global climate (Williams et al. 2019). The goal of this research is to examine the relationship between collaborative forest restoration and local mass timber production in order to showcase the use of mass timber as a means to improve wildfire resilience and push the United States toward developing its mass timber industry at a local scale. The use of low-value

species, harvested from forest restoration projects, in mass timber panels can create a symbiotic relationship between forestry, architecture, and the respective local economy. This project addresses the utilization of low-value tree species, Ponderosa pine specifically, from forest restoration projects in the Sierra Nevada forests of California to manufacture mass timber locally that, in return, can provide the material for public lands facilities as demonstration projects in parks affected by wildfires.

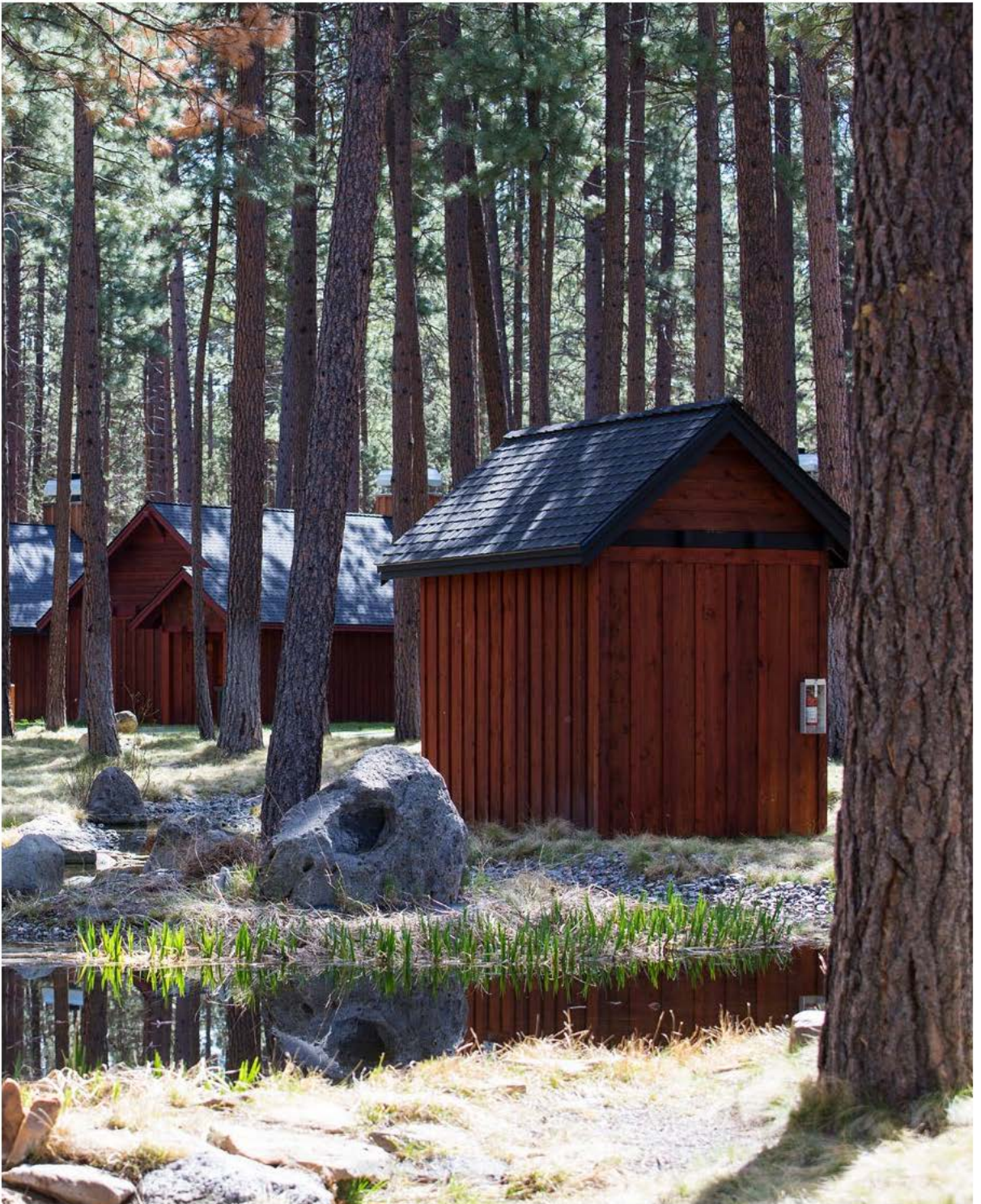


INTRODUCTION



Forest mismanagement is worsening the effects of climate change and, thus, causing forests to suffer. Years of wildfire suppression due to human intervention has caused forests to become increasingly vulnerable to unnatural fire behavior (Liang, Hurteau, and Westerling 2018) (Williams et al. 2019). Although forest restoration projects, including thinning efforts, are effective at creating forest resiliency, these efforts are often expensive ventures and harvest low-value wood species that are used for low-yield profit products such as biofuel and paper pulp; this results in immense expenditure losses that government agencies are typically burdened with (Ager et al. 2017) (Bukauskas et al. 2019). Mass timber products offer an alternative for lower-grade species as they can be engineered to enhance the wood's structural capabilities (Cherry et al. 2019). Unfortunately, the production of mass timber, such as CLT (cross laminated timber) panels,

can require significant investment into expensive equipment that is still developing in the United States (Albee et al. 2018). For this reason, mass timber production has been largely unattainable for small-scale production. All of these intersecting issues lead to the primary research question: how can forest restoration and thinning, used to reinforce wildfire resilience in forests, create local benefits by using mass timber production generated from associated local forest restoration endeavors? Addressing this question can expand the narrative of the possibilities of mass timber production in the United States while also tackling the issue of wildfire vulnerability in forests.



WILDFIRES AND ARCHITECTURE

Public lands, such as national and state parks, in the west are facing increased wildfire activity driven by severe drought and an abundance of small diameter trees and dry fuel. The KNP complex fire in Sequoia National Park decimated an estimated 3-5% of California's giant sequoias and, in the past two years, we have lost 20% of all sequoias due to fire activity (Sediman 2021). In addition to ecosystem devastation, the built environment is also severely affected. In August of 2020, Big Basin Redwoods State Park, the oldest state park in California, suffered catastrophic losses as a

result of the CZU complex fire; nearly all of the park's facilities were destroyed leaving only charred remains of the park's historic structures. As climate change continues to worsen wildfire seasons, we can expect to witness more and more environmental destruction, both natural and built. For these reasons, this project specifically explores the designs of typical public lands facilities in order to address the replacement of these structures that are in the most vulnerable wildfire regions.

Left page image: A structure affected by California's Dixie Fire
Source: PBS

Top right image: General Sherman, the world's largest tree by volume during the KNP fire
Source: The Mercury News

Bottom right image: The remnants of the Big Basin Redwoods State Park visitor center
Source: SF Gate



PROJECT OBJECTIVE SUMMARY

This project is a demonstration of the use of small-scale, Ponderosa pine CLT that can be harvested from forest restoration projects in the Sierra Nevada mountains of California and be used to replace public lands structures that were destroyed in wildfires. The intent of this design demonstration is to show a variety of typical park buildings that showcase different spans, sizes, and levels of complexity as well as to exhibit the unique relationship between forestry and architecture. The designs of these buildings reflect

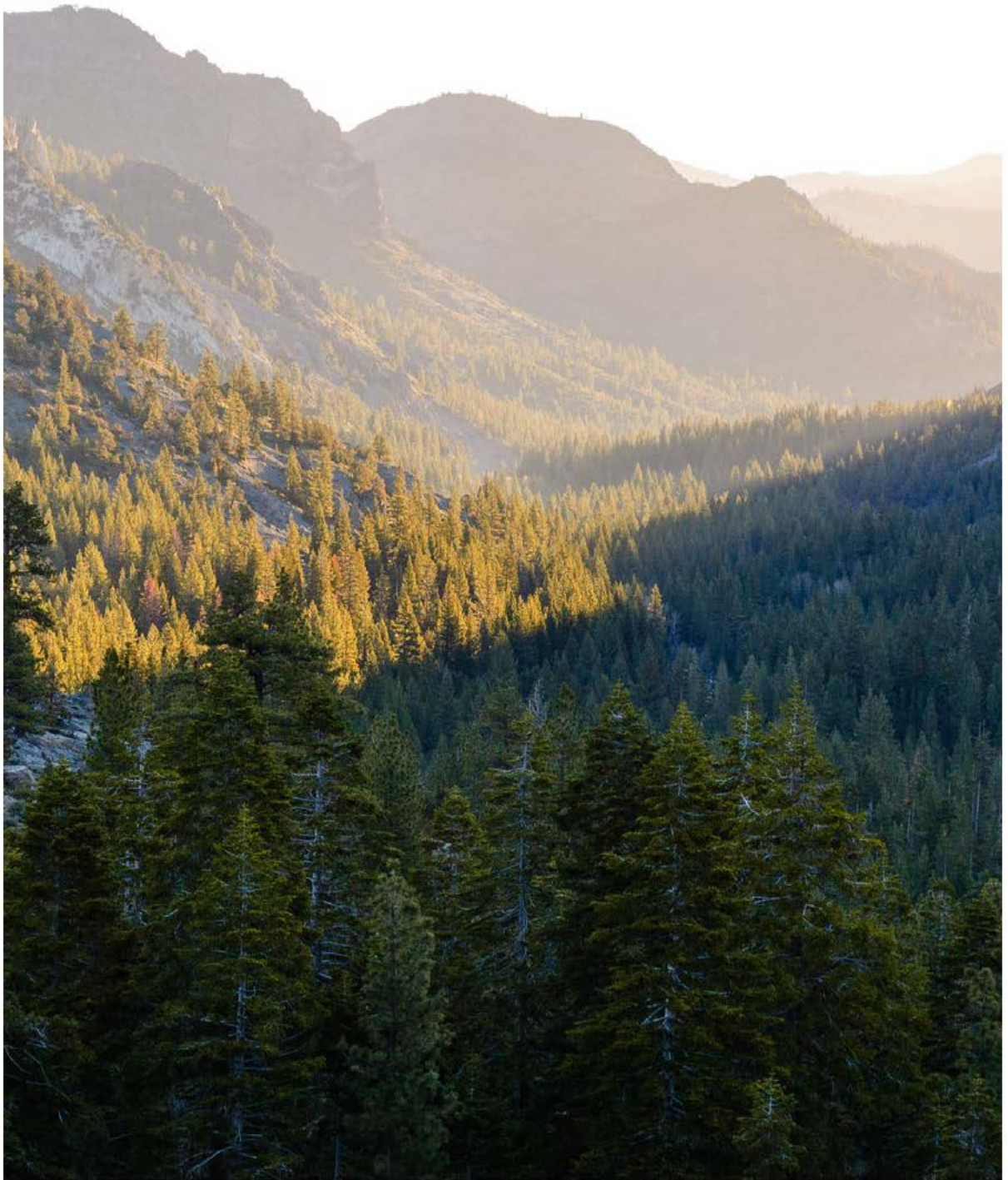
the redefining of park architecture to make for a more contemporary approach that celebrates the use of modern technologies and natural materials. The use of timber from forest restoration-harvested endeavors also provides the opportunity for local mass timber development. The basis of this design project is defined using Timber Age Systems' production processes, structural data, and 5ftx10ft Ponderosa pine CLT as described later in the report.





FOREST RESTORATION





FOREST RESTORATION AND MASS TIMBER

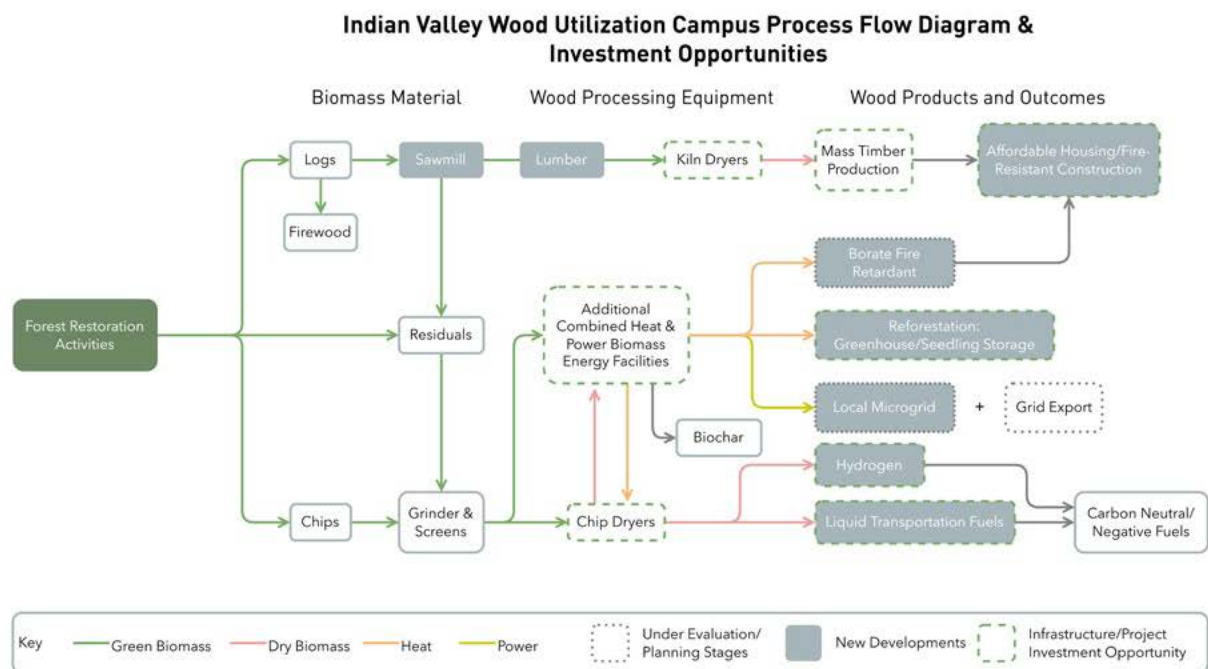
Wildfire and forest management are complex issues that are becoming increasingly prevalent due to catastrophic fire behavior. With each fire season becoming increasingly worse on the west coast, creative solutions involving collaborative measures are beginning to unfold (Ager et al. 2017). Forest restoration collaboration projects are currently underway such as the A to Z Forest Restoration Project in Colville, Washington. This project is a collaboration between Vaagen Timbers and the US Forest Service that focuses on allocating harvesting from restorative operations to Vaagen Timbers in order to offset the costs that the US Forest Service would typically be responsible for (Vaagen, n.d.). In return, Vaagen is able to utilize the harvested timber in order to create mass timber products and sell them for a profit. However, not many projects like this exist. Additionally, a small number

of companies are beginning to venture into small-scale mass timber production such as Stoltze Timber in Montana and Timber Age Systems in Colorado. Timber Age Systems, more specifically, is producing CLT made of Ponderosa pine, a species that has generally been deemed as low-value for construction uses. The company is the first CLT producer in the southwest and is capitalizing on the need for healthier forests and more sustainable construction types ("Timber Age Systems, Inc.," n.d.). The Sierra Institute in Taylorsville, California is also developing small-scale, local mass timber production in tandem with their forest restoration projects (Redmore et al. 2021). Other manufacturers in North America are exploring other forms of mass timber such as dowel laminated timber (DLT), nail laminated timber (NLT), and interlocking CLT. Thoma Holz100 in Canada is manufacturing glueless



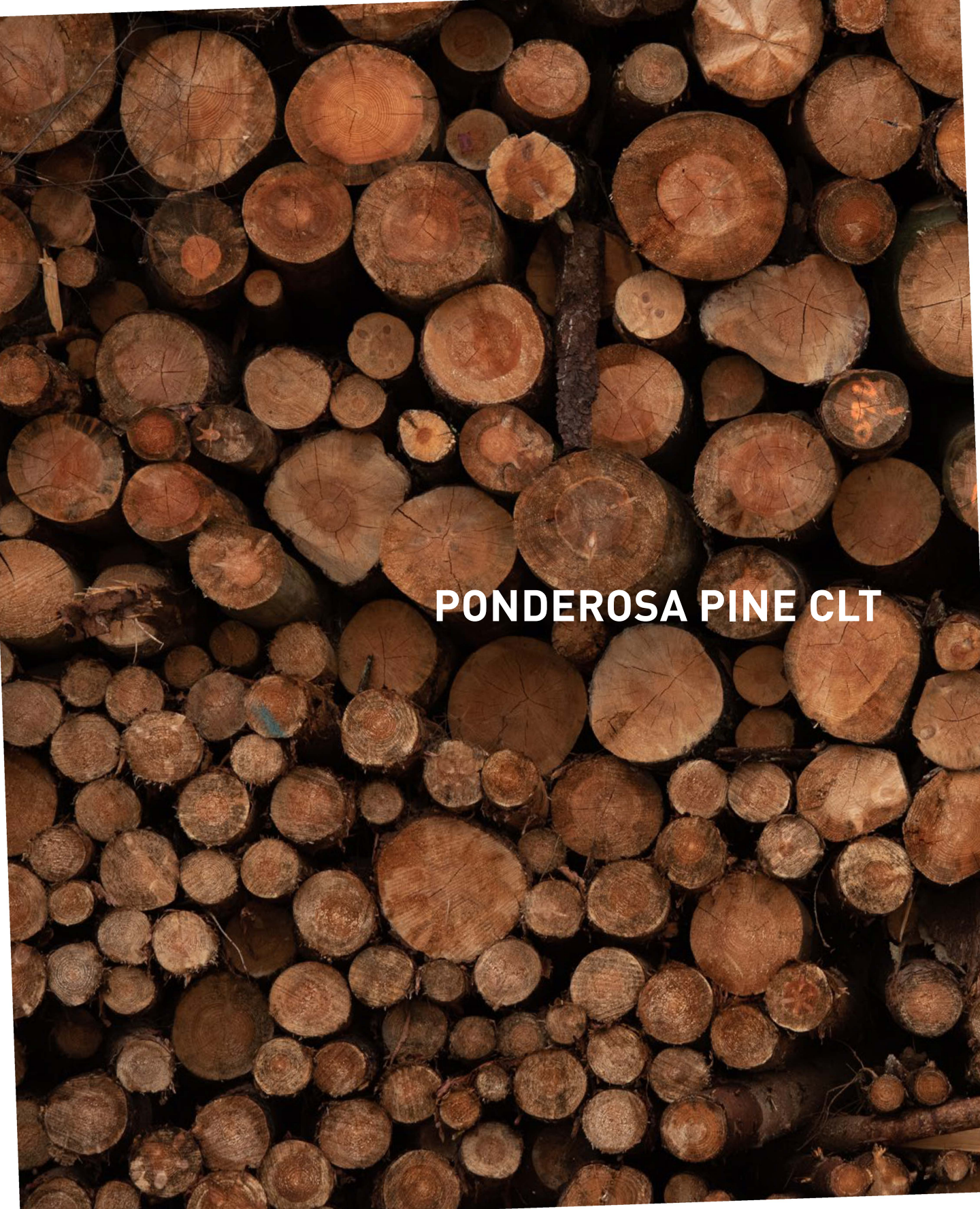
CLT adhered with dowels and Structurcraft, also located in Canada, is creating NLT and DLT options; Euclid Frames, located in Utah, is developing glueless interlocking CLT systems. The intersection between forest management and mass timber production has

the potential to create a synergetic relationship that addresses multiple issues at once: the need for forest thinning and a sustainable mass timber market in the United States.



A diagram outlining the pathway to mass timber production utilizing forest restoration harvested timber
Source: The Sierra Institute



A close-up, top-down view of a large pile of cut logs. The logs are of various diameters, from small branches to thick trunks. The wood grain is clearly visible on the circular cross-sections, showing concentric growth rings and radial lines. The colors range from light tan to dark brown, with some areas appearing more weathered or charred. The logs are stacked closely together, creating a textured, organic pattern. The lighting is somewhat uneven, with brighter areas on the top surfaces and darker shadows in the crevices between the logs.

PONDEROSA PINE CLT



TIMBER AGE SYSTEMS

This project is based on the small-scale, Ponderosa pine CLT manufacturing process employed by Timber Age Systems (TAS). TAS is the first producer of CLT in the American southwest and currently utilizes Ponderosa pine obtained from forest restoration on private properties in Durango, Colorado. The company's forest thinning efforts meet the needs for two prominent issues: the lack of small-scale mass timber production in the U.S. and wildfire vulnerability in western forests. According to TAS co-founder, Andy Hawk, the company has invested approximately \$1.2 million total into their operations and functions under a vertically integrated system from log hauling to milling to sawing to vacuum pressing. The panels they are currently producing have been accepted for building department permitted use and have undergone evaluation from a faculty member in an engineering department at a local university, with validation by an external engineering peer review, to demonstrate that they meet the requirements of IBC 2018 (see Appendix for structural data). The company is also currently seeking PRG 320 certification.

TAS has developed a set of guidelines for their Ponderosa pine CLT; they offer both 3-ply (3in thick) and 5-ply (5in thick) CLT with maximum dimensions of 5ft x 10ft and a maximum horizontal span of 10ft. The table on the right page outlines the various pre-assembled CLT panel assemblies that TAS offers and their corresponding dimensions. Panels can also be stacked on top of one another vertically to achieve a total height of 20ft. Based on structural guidance from engineering professor Mikhail Gershfeld at Cal Poly Pomona, it was determined



*Top image: Colorado Ponderosa pine
Source: Timber Age Systems*

*Middle image: 5-ply Ponderosa pine CLT
Source: Timber Age Systems*

*Bottom image: A small parcel delivery room
near Durango, CO
Source: Timber Age Systems*



Standard Panel Dimensions

Product	Max Width	Max Length	Thickness	Notes
3-ply CLT Panel Uninsulated	62" (1575mm)	120" (3048mm)	3" (76mm)	TAS CLT Panels are designed to spec. Individual panel width and length will vary
5-ply CLT Panel Uninsulated	62" (1575mm)	120" (3048mm)	5" (127mm)	TAS CLT Panels are designed to spec. Individual panel width and length will vary
R50 Tightpack Cellulose Wall or Roof on 3" CLT	Design Specific	Design Specific	14 7/8" (378mm)	Thickness dimension is approximate and will vary slightly depending on membrane & cladding specifications (roofing or wall cladding material not included)
R21 EPS Wall on 3" CLT	Design Specific	Design Specific	8 1/2" (216mm)	Thickness dimension is approximate and will vary slightly depending on membrane & cladding specifications (roofing or wall cladding material not included)
Notes: Timber Age CLT are engineered and designed to order. Timber Age Systems CLT maximum dimension is 5'x10'. Dimensions provided here are representative of current manufacturing processes. Final dimensions of project specific panels or panel components may vary slightly depending on component specifications.				

Source: Timber Age Systems

that no more than two panels should be stacked vertically without additional structural support.

*Left and right images: A Ponderosa pine CLT shed
Source: Timber Age Systems*

This project evaluates the design opportunities of forest-restoration-harvested Ponderosa pine CLT panels manufactured using this vacuum press process over the more typical light wood frame and heavy timber construction found in public parks' buildings by demonstrating their design application in a series of typical public lands' facilities. The focus of this research is primarily applicable to the Sierra Nevada mountains of California where Ponderosa pine is widely available and forest restoration efforts are underway.





A photograph of a forest road. In the foreground, a paved road has the word 'STOP' painted in large white letters, oriented upside down. The road is bordered by a dense forest of tall, thin evergreen trees. The ground is covered with dry pine needles and some low-lying green shrubs. The text 'PUBLIC LANDS BUILDING TYPES' is overlaid in white, bold, sans-serif font on the right side of the image.

PUBLIC LANDS BUILDING TYPES



6126

Full

Chlorine Used
Disinfectant
For Improper
Food Storage

BE PREPARED
TO SHOW
DISCOUNT CARD
AT
CHECK-IN

Photo
Identification
Required at
Check-In

KEEP
➔
RIGHT

STOP

Campground
Host
Site 91

STOP

INTRODUCTION

Public lands are home to various types of buildings that serve a multitude of purposes. This section of the project catalogs typical structures one might find in parks and describes their purposes. Most of the buildings noted are typical of parks in the western United States, primarily in forested and/or mountainous regions; types differ across the country depending on park needs and their respective contexts. This list is not exhaustive and some building types may not be included.





ENTRANCE FEE STATION



The humble entrance fee station is the gateway to a new experience and a reminder of the memories we made as we leave. Although it is one of the smallest building types in most public lands, it makes a critical first impression about the facilities in the park and the visitor's forthcoming experience. Entrance fee stations typically accommodate 1-3 employees who greet visitors, provide information about the park, and process entrance fee payments. The program consists of a small office space with typically nothing more. This

building type is fashioned to match the vernacular of the other buildings in the park and the local context.

*Top left image: Yosemite National Park entrance
Source: National Park Service*

*Top right image: Butano State Park entrance
Source: California Department of Parks and Recreation*

*Bottom image: Crater Lake National Park entrance
Source: National Park Service*



VISITOR CENTER



The visitor center is the anchor of the park. After a guest enters the park, the visitor center is typically their first stop where they can purchase souvenirs, receive directions from park staff, use the restroom facilities, and eat. Visitor centers vary in size depending on, but are not limited to the type of park (i.e. county, state, national), the number of visitors it receives, and topographical restraints. The building's program also varies depending on the needs of the park, but most often consists of a souvenir shop, an information exhibit and desk, restroom facilities (either within the building or detached), and a place to purchase food and/or camping supplies. The visitor center, like the entrance fee station, is one of our first and last points of contact within the park and leaves a lasting impression.

*Top image: Hoh Rain Forest Visitor Center at Olympic National Park
Source: FFA Architecture + Interiors*

*Bottom left image: Henry Cowell Redwoods State Park Visitor Center
Source: Redwood Hikes*

*Bottom right image: Big Basin State Park Visitor Center/ Headquarters before the CZU fire in 2020
Source: Redwood Hikes*

RESTROOMS



Restrooms are essential facilities that are often overlooked due to their lackluster nature. They are one of the most frequented and abundant building types with locations scattered throughout the park; these locations include near trailheads, visitor centers, parking lots, campgrounds, and the backcountry.



*Top left image: Restrooms in Stanislaus National Forest
Source: US Forest Service*

*Top right image: Skinner Butte Park restrooms, Eugene, OR
Source: City of Eugene*

*Middle image: Restrooms in Medicine Bow National Forest, WY
Source: Recreation.gov*

*Bottom image: Restrooms at Olympic National Park
Source: FFA Architecture*



INFORMATION KIOSKS



Information kiosks serve as crucial wayfinding points for trailheads and as educational opportunities. These kiosks typically display maps of the park and its associated trails along with other information regarding the natural context. Additionally, informational kiosks can be found along park trails to signify an important landmark and provide scientific and historical information.

*Top image: Information kiosk in the Hoh Rain Forest, Olympic National Park
Source: National Park Service*

*Bottom image: Information kiosk at Frank Kinney Park, Eugene, OR
Source: Payton Narancic*

SHELTERS/PAVILIONS



Pavilions serve as transition spaces between the open-air and shelter while still allowing visitors to experience the nature of the park. Pavilions are notable gathering spaces that offer picnic benches and, at times, barbecues for cooking. Occasionally, information kiosks and pavilions are combined to create an opportunity for both shelter and learning.

*Top image: Pavilion at Hendricks Park, Eugene, OR
Source: Eugene, Cascades, and Coast*

*Middle image: Pavilion at Silver Falls State Park
Source: Reserve America*

*Bottom image: Information pavilion at Lassen
Volcanic National Park
Source: Active Rain*

RANGER HOUSING



Ranger housing serves as full-time or part-time lodging for rangers working within the park. The building's program is largely reliant on the employment status of those living there (full-time vs. part-time) and its location within the park (near park headquarters vs. backcountry). Living quarters that are in close proximity to the park headquarters are typically equipped for full-time living and function most similarly to a house. On the other hand, backcountry ranger housing is meant for temporary stays; rangers embark on extended trips to a park's backcountry to check snow levels, trails, and other conditions and will stay in smaller, temporary living quarters that are often meant exclusively for shelter.

*Top left image: Ranger housing in Grant Grove, Sequoia National Park
Source: National Park Service*

*Bottom left image: Ranger cabin at Point Reyes National Seashore
Source: Cabin Porn*

*Right image: Ranger cabins in Yosemite National Park
Source: Cabin Porn*

GUEST CABINS



*Top left image: Guest cabin at Silver Falls State Park
Source: Oregon State Parks*

*Top right image: Manzanita camping cabins in Lassen
Volcanic National Park
Source: Sunset*

*Bottom left image: Calaveras Big Trees cabins in Calaveras
Big Trees State Park
Source: Calaveras Visitors Bureau*

*Bottom right image: Tilly Jane A-frame in Mt. Hood
National Forest
Source: Recreation.gov*

Cabins offer guests an alternative experience to camping in parks. Park cabins vary in their level of accommodations; for example, some cabins provide guests with full services such as running water and electricity while others may solely provide beds and a heating source similar to backcountry ranger housing. Generally, most cabins will not provide the same accommodations as a typical home.

CAMPING FACILITIES

Campgrounds are generally comprised of a complex of buildings that serve guests during their stay. Depending on the campground, visitors will typically check-in at an entrance building or ranger station which may also offer items for purchase such as food and firewood. Additionally, guests have access to restroom and bathhouse facilities scattered throughout the campground. In some cases, an amphitheater is located within or close to the campground for park related activities.

*Top left image: Burlington Campground entrance building, Humboldt Redwoods State Park
Source: Redwood Hikes*

*Top right image: Cougar Rock Campground Ranger Station, Mt. Rainier National Park
Source: Park Ranger John*

*Bottom left image: Cougar Rock Campground restrooms, Mt. Rainier National Park
Source: Park Ranger John*

*Bottom right image: Burlington Campground restroom/showers, Humboldt Redwoods State Park
Source: Redwood Hikes*



MAINTENANCE & OPERATIONS



Typically hidden out of view of the public, maintenance and operations buildings are key to the functions of the park. These buildings are used for equipment storage, vehicle and machinery servicing, and shop work. Because these buildings are not publicly accessible, they are often simple in design and can even be built using prefabricated systems. The size of these buildings are dependent on the needs of the park.

Top left image: Maintenance building in San Juan National Historical Park

Source: Valdez Construction

Top right image: Maintenance building in Richmond National Battlefield Park

Source: National Park Service

Bottom image: Maintenance and operation facilities in Muir Woods National Monument

Source: Google Maps



LOOKOUT TOWERS



Once crucial to park management operations, lookout towers have become obsolete in the age of more advanced technology such as helicopters, drones, and cameras. Lookout towers are now outdoors destinations that can be rented for overnight stays. These structures typically take advantage of views of dramatic landscapes which makes them highly desirable for tourists. Original towers were constructed on wood stilts with a small wooden structure on top. These wooden structures eventually were overtaken by steel construction.

*Top left image: Mt. Fremont fire lookout at Mt. Rainier National Park
Source: Cabin Porn*

*Top right image: Hirz Mountain lookout in Shasta-Trinity National Forest
Source: US Forest Service*

*Bottom image: Lookout on Cone Peak, Big Sur
Source: Mapio*

RANGER STATIONS



Ranger stations serve as information centers for park visitors where guests can receive backcountry permit passes, camping reservations, general information about the park, and other services. These buildings are typically landmarks and will be scattered throughout a park or along highways. Sometimes ranger stations will replace a visitor center altogether or will be combined with a visitor center. These structures vary in size depending on their location and the needs of the park.

Top image: McKenzie Ranger Station, Willamette National Forest
Source: Pivot Architecture

Bottom left image: High Sierra Ranger Station in Sierra National Forest
Source: The Living New Deal

Bottom right image: Tuolumne Meadows Ranger Station in Yosemite National Park
Source: NoeHills Travels in California

Right page image: A backcountry cabin at night
Source: Cabin Porn





CASE STUDIES



INTRODUCTION

The following case studies are examples of modern landscape-inspired structures that redefine public lands architecture. Typical buildings found in western American parks, as seen in the "Public Lands Building Types" section, often use visually dense materials such as heavy timber, masonry, and dark cladding. These case studies redefine the architectural experience of the outdoors and highlight the simplicity of form and materials to create beautiful designs. The following buildings were specifically chosen for their use of timber construction, materiality, response to the surrounding landscape, and architectural expression.







JUVET LANDSCAPE HOTEL

Building Type: Hotel

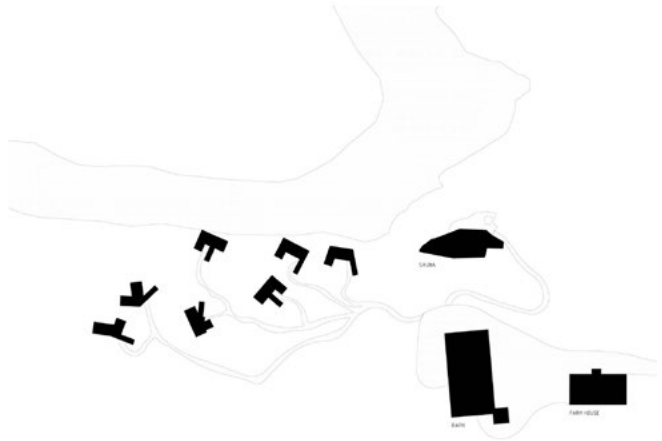
Location: Valldal, Norway

Architect: Jensen & Skodvin

Year(s) Completed: 2008; 2010; 2013

Construction Type: CLT

Located in southwestern Norway, the Juvet Landscape Hotel is a classic example of the Scandinavian celebration of nature and its elements. The hotel consists of seven rooms, all of which are independent CLT structures, with unique floor plans that respond to the surrounding views; the differing floor plans prevented invasive site excavation due to their response to the existing landscape. The architects employed a steel stilt system which



Left page image: A room overlooking the river below
Source: Jensen & Skodvin

Top right image: Diagrammed site plan of the hotel and its facilities
Source: Jensen & Skodvin

Bottom image: Each guest room has a unique floor plan that responds to views
Source: Jensen & Skodvin

allowed the structures to carefully sit over existing rock. The hotel is also comprised of a sauna/bathhouse, two “birdhouse” rooms, and an existing farmhouse and barn. The recently added birdhouse rooms utilize a modernized log cabin technology as opposed to CLT.

The hotel is located along a national tourist road and is complemented by a viewing platform and restaurant across the road (also designed by Jensen and Skodvin) as part of efforts to develop tourism in the area. The site and surrounding context offer picturesque views



Image: A “birdhouse” room
Source: Jensen & Skodvin

of the surrounding mountains and the Valldøla river. The architects meticulously designed each room to reflect the local landscape in its materiality and form; the simple structures disappear into their environment so as not to overwhelm the existing natural conditions. The use of highly reflective glass reinforces the architect’s intent to blend the structures in with their background while also offering guests the luxury of breathtaking views with optimal privacy.

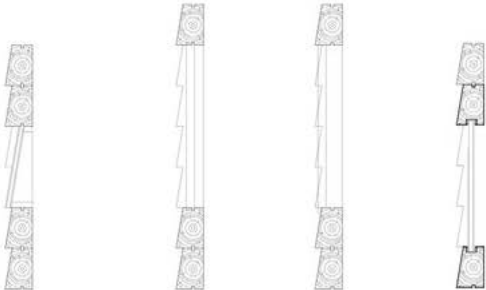
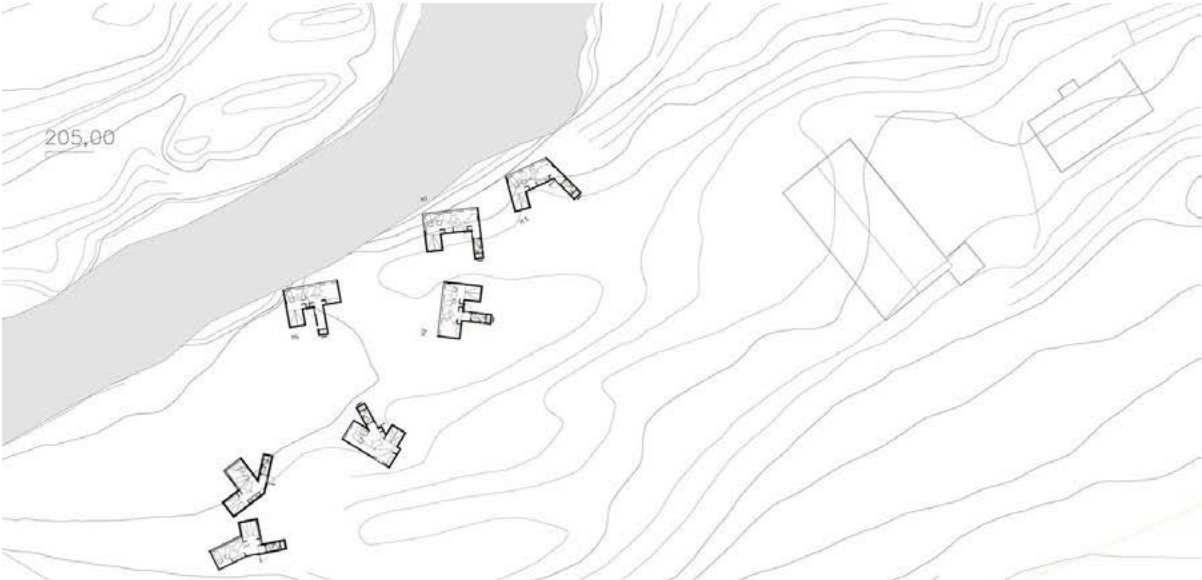


Image: The log-house technique used in the birdhouse rooms
Source: Jensen & Skodvin

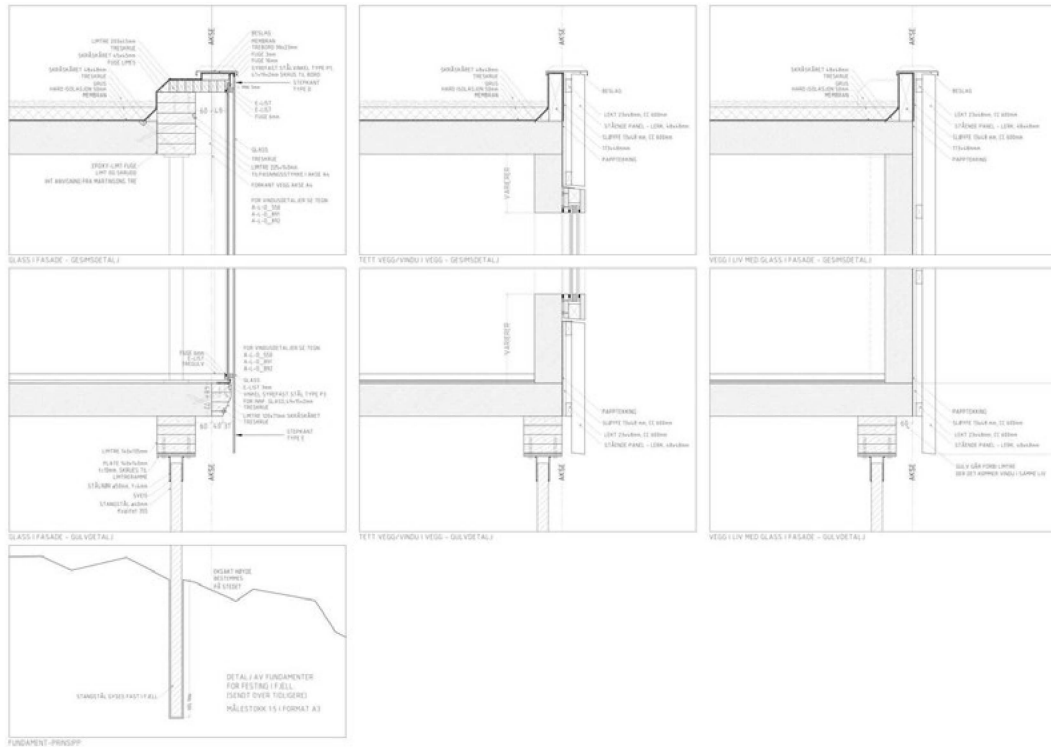


Left page bottom image: A site plan of the hotel
Source: Jensen & Skodvin

Right page top image: A birdhouse room amongst the trees
Source: Jensen & Skodvin

Right page bottom image: A landscape room in the evening
Source: Jensen & Skodvin

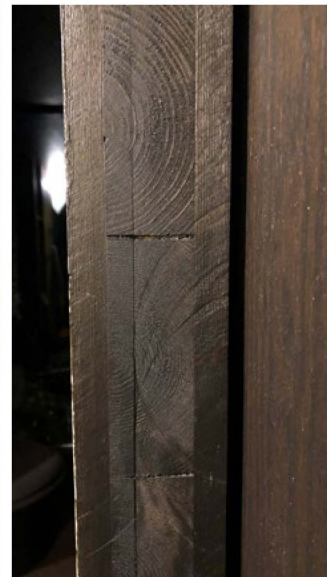


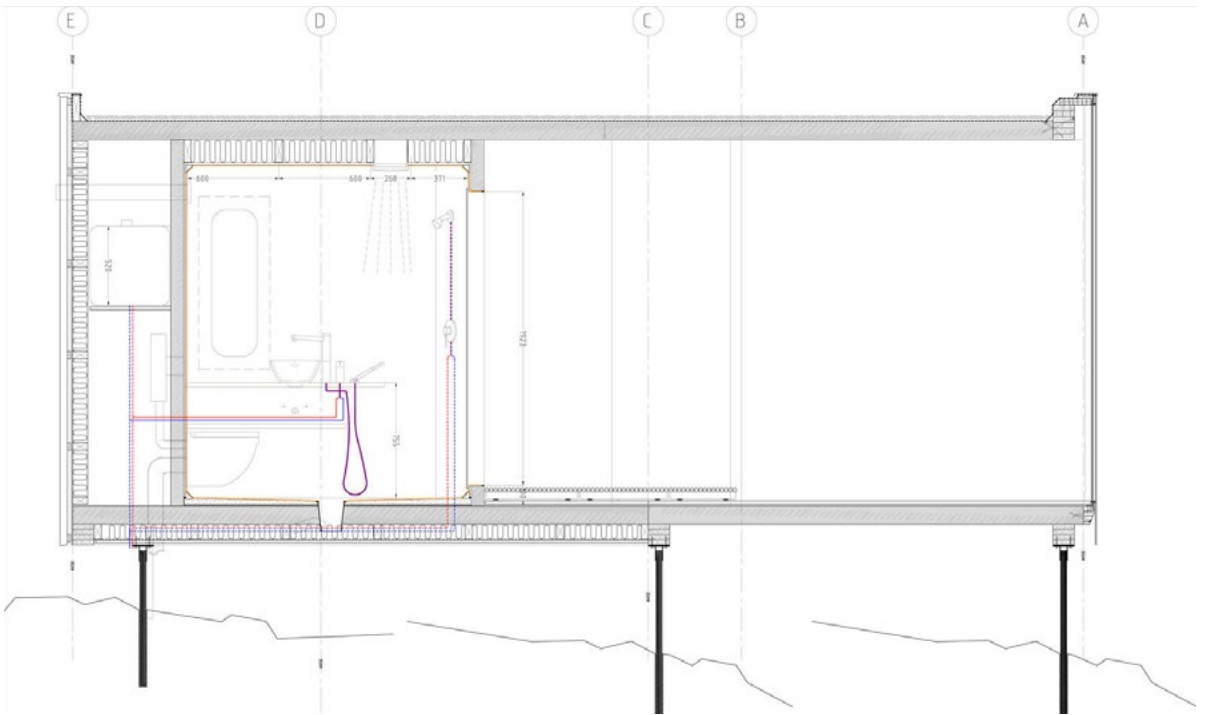


Top image: Section details for the landscape rooms
Source: Jensen & Skodvin

Bottom left image: The landscape rooms are integrated with the natural context
Source: Jensen & Skodvin

Bottom right image: A CLT wall in a landscape room
Source: Payton Narancic

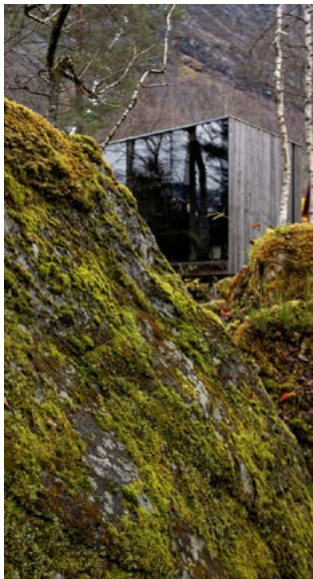




Top image: A section detail showing the rooms' stilt system
Source: Jensen & Skodvin

Bottom left image: The rooms are strategically hidden behind geographic features
Source: Jensen & Skodvin

Bottom right image: Highly reflective glass mirrors the surroundings and offers privacy
Source: Jensen & Skodvin





LANGISJÓR RANGER CABINS AND REST STOP

Building Type(s): Ranger cabins; restrooms

Location: Langisjór, Iceland

Architect: Arkís Arkitektar

Year(s) Completed: 2015

Construction Type: Unspecified timber

The Langisjór ranger cabins are small timber structures located in the remote wilderness of Iceland. These cabins serve as temporary living quarters for rangers on-duty in the backcountry and also provide restroom facilities, information posts, and a campsite. These minimalist buildings use larch siding intended to weather with the extreme elements of the Icelandic climate and were designed to echo the colors, mood, and forms of their context. The care and attention to



Left page image: The upturned edge of the roof creates a more modern take on park architecture
Source: Arkís Arkitektar

Top right image: The ranger cabins occupy a remote landscape
Source: Arkís Arkitektar

Bottom image: The natural wood siding has weathered with the extreme elements
Source: Arkís Arkitektar





design in these small structures shows the value that can be added to buildings that are typically used for utilitarian purposes.



Left page top image: Windows frame views of the dramatic landscape
Source: Arkis Arkitektur

Left page bottom image: The weathered wood blends the buildings in with the natural environment
Source: Arkis Arkitektur

Right page top image: The buildings feature a modern take on the classic shed roof
Source: Arkis Arkitektur

Right page bottom image: The view from the wood platform
Source: Arkis Arkitektur



TIMBER AGE OUTDOOR KITCHEN

Building Type(s): Outdoor kitchen

Location: Durango, Colorado

Builder: Timber Age Systems, Inc.

Year(s) Completed: 2018

Construction Type: CLT (Ponderosa pine)

Timber Age Systems' outdoor kitchen project showcases their use of self-milled, self-produced Ponderosa pine CLT with a heavy timber frame. This open air structure occupies a client's backyard to create an outdoor social space. The pavilion is semi-enclosed with CLT panels and features vertical joinery of panels in order to increase the structure's height. Heavy timber columns and trusses are employed in order to maintain an open-air experience. As seen in the panels, the blue



*Left page image: Vertical connections were used in order to increase the panels' heights
Source: Timber Age Systems*

*Right page top image: The home owners wanted a social outdoor space
Source: Timber Age Systems*

*Right page bottom image: The pavilion in-progress
Source: Timber Age Systems*



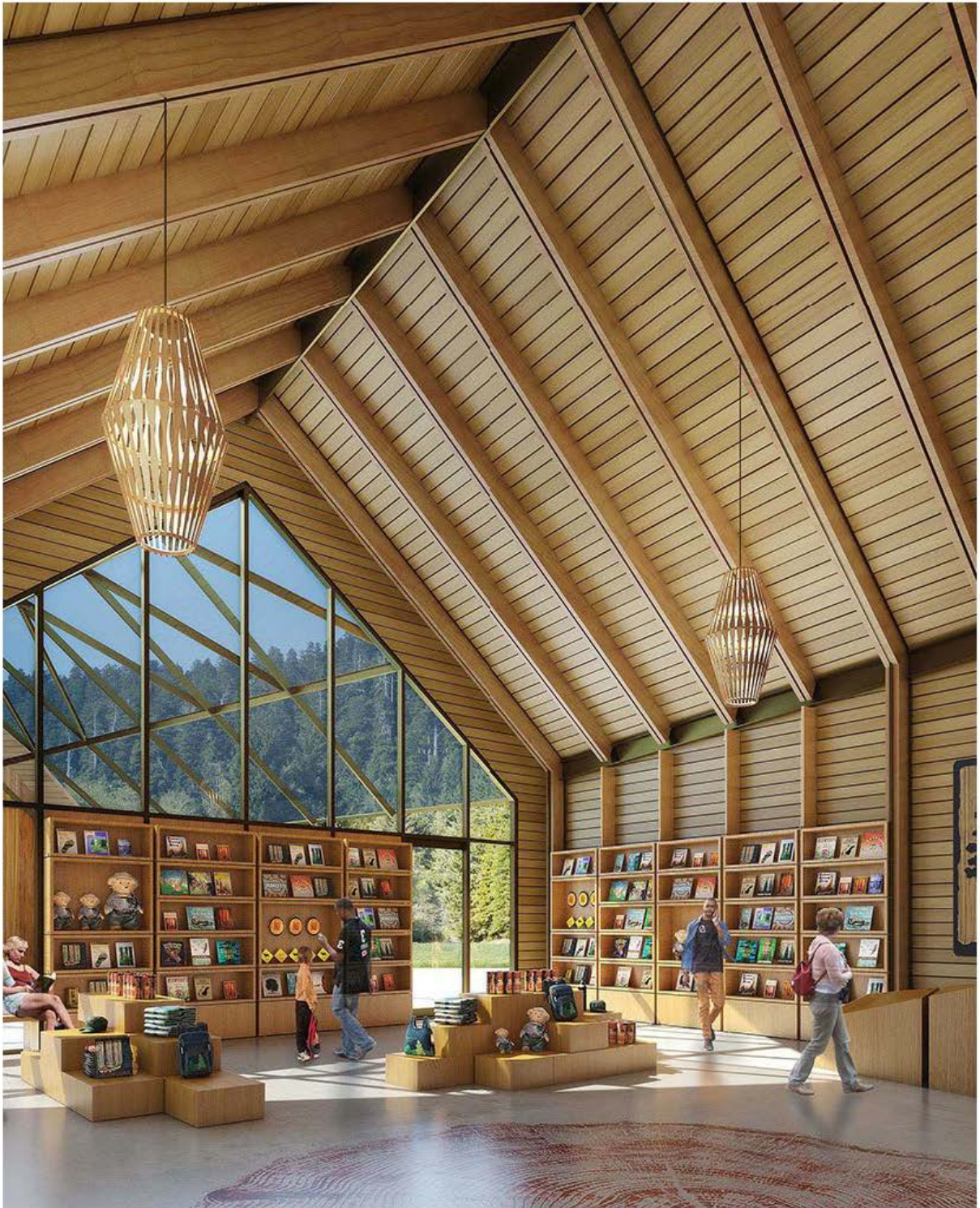
stain from the harvested Ponderosa pine is evidence of transforming low-value timber into an effective product; Timber Age Systems uses Ponderosa pine harvested from forest restoration efforts intended to mitigate wildfire severity. This project was also a part of the company's Wood Innovation Grant that they received in 2018.

Left page top image: The building was the first of its kind using 100% Ponderosa pine
Source: Timber Age Systems

Left page bottom image: The pavilion during construction
Source: Timber Age Systems

Right page bottom image: Even the cabinetry was built out of Ponderosa pine
Source: Timber Age Systems





REDWOOD VISITOR CENTER

Building Type(s): Visitor Center

Location: Orick, California

Architect: Siegel & Strain

Year(s) Completed: In progress

Construction Type: Glulam and steel

Located in Redwood National and State Parks, the new Redwood Visitor Center uses modern timber technology as a nod to historical heavy timber public lands buildings. This visitor center will become the new gateway to the parks and will feature an information exhibit that teaches guests about redwoods, wildlife, indigenous culture, the nearby watershed, and restoration efforts. The program also consists of a souvenir shop, office spaces for park staff, a cafe, and restroom facilities.



Left page image: Information exhibit and souvenir shop
Source: Siegel & Strain

Top right image: The indoor picnic area overlooks the Prairie Creek watershed
Source: Siegel & Strain

Bottom image: The buildings are connected by a breezeway that leads to hiking trails
Source: Siegel & Strain

Additionally, the building was designed to achieve net-zero energy and is all-electric; as shown in the diagram below, the building uses natural ventilation and shading

devices to reduce thermal loads while the roof employs photovoltaic panels to achieve energy self-sufficiency.

Left page top image: Building sections
Source: Siegel & Strain

Left page bottom image: Diagram of sustainability strategies
Source: Siegel & Strain

Right page top image: Overall site plan
Source: Siegel & Strain

Right page bottom: The building serves as a gateway to nearby trails
Source: Siegel & Strain







VATNSHELLIR INFORMATION CENTER

Building Type(s): Information Center

Location: Vatnshellir, Iceland

Architect: Arkís Arkitektar

Year(s) Completed: 2018

Construction Type: Unspecified timber

The Vatnshellir Information Center is located at a tourist destination within Snæfellsjökull National Park. The program includes a reception area where guests meet for tours of the nearby Vatnshellir cave. Although there is little information about this building, there are presumably restrooms and an office area for tour staff. This building has a commanding presence in its context, yet respects the surrounding landscape with its natural wood materiality.



Left page image: The entrance to the visitor center

Source: Arkís Arkitektar

Top right image: The backside of the building serves the tour staff

Source: Arkís Arkitektar

Bottom image: The building frames views of the surrounding landscape

Source: Arkís Arkitektar

A photograph of a wooden interior corner, likely a sauna or a modern lounge. The walls and ceiling are clad in light-colored wooden planks, showing natural wood grain and knots. A built-in wooden bench is visible in the lower-left corner. A sharp, bright beam of light enters from the right, casting a strong shadow across the bench and the wall. The text "DESIGN DEMONSTRATION" is overlaid in white, bold, sans-serif capital letters. A thin black L-shaped line is positioned in the upper right corner of the image.

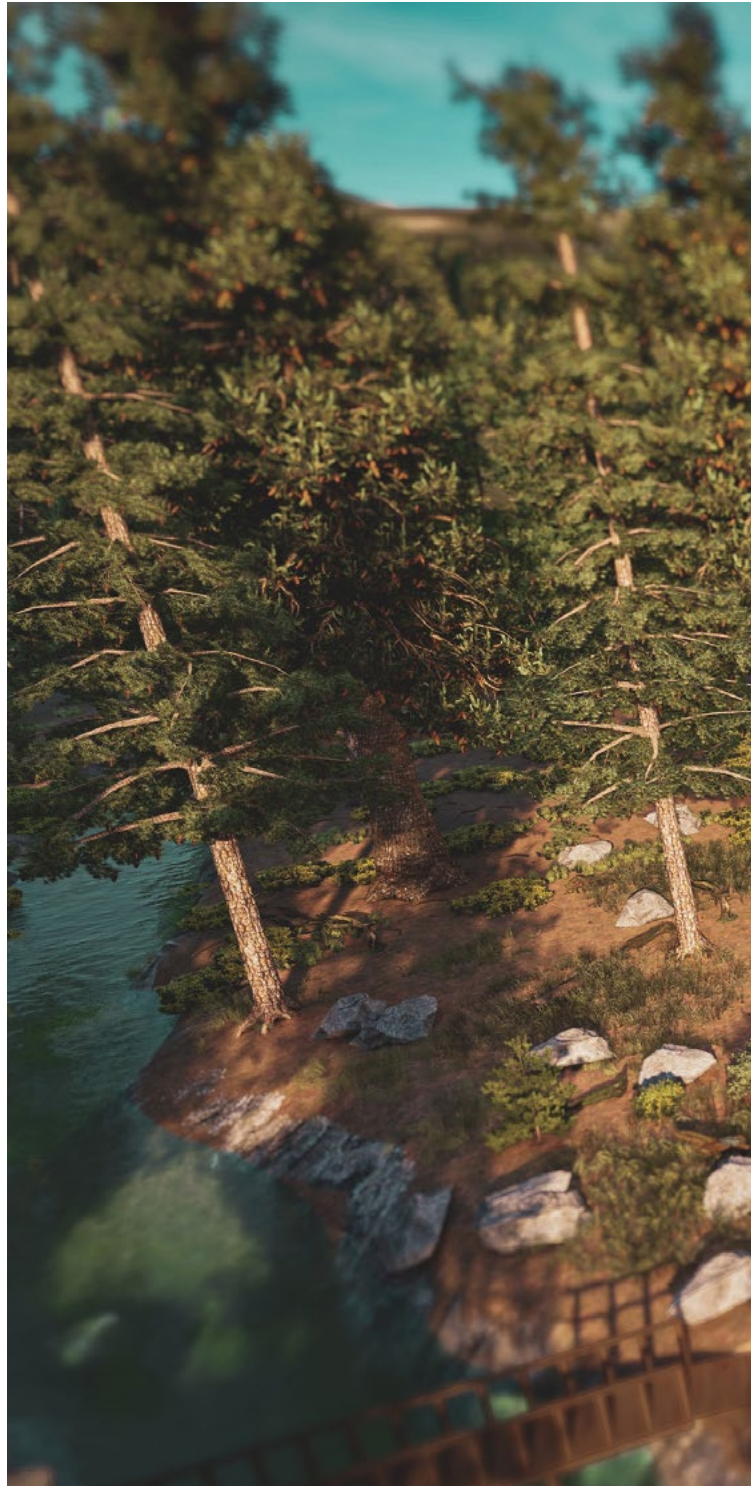
DESIGN DEMONSTRATION



INTRODUCTION

Based on the building type catalog and case studies, typical park structures were evaluated for the feasibility of Ponderosa pine CLT application. The 5ftx10ft panel size poses structural and detailing challenges which means not all park building types are appropriate candidates for this type of mass timber application. For example, the panels should not be stacked more than 20ft in wall applications which deems them unfit for larger-scale buildings. Furthermore, there are challenges to roof applications; the panels have a maximum span of 10ft meaning other structural members are required to carry roof loads. Therefore, the following building types were chosen as a representative sample of typical scales, spans, and details that could be applied to not only the building types they represent, but also other park facilities.

In the proposed designs, both dimensional lumber and heavy timber sourced from Ponderosa pine are used in tandem with the Ponderosa pine CLT to achieve larger roof spans; the intention is to maximize the use of forest restoration-harvested Ponderosa pine in order to increase the material's value and maintain its locality to the respective communities that will manufacture these products. However, the dimensional lumber and heavy timber are not limited to strictly Ponderosa pine; other species harvested from forest restoration projects that are structurally appropriate can also be used. Glulams were intentionally not chosen for additional structural members in order to avoid sourcing that is not local and technology that is capital-intensive. Systems for windows, doors, and other various details were also developed.



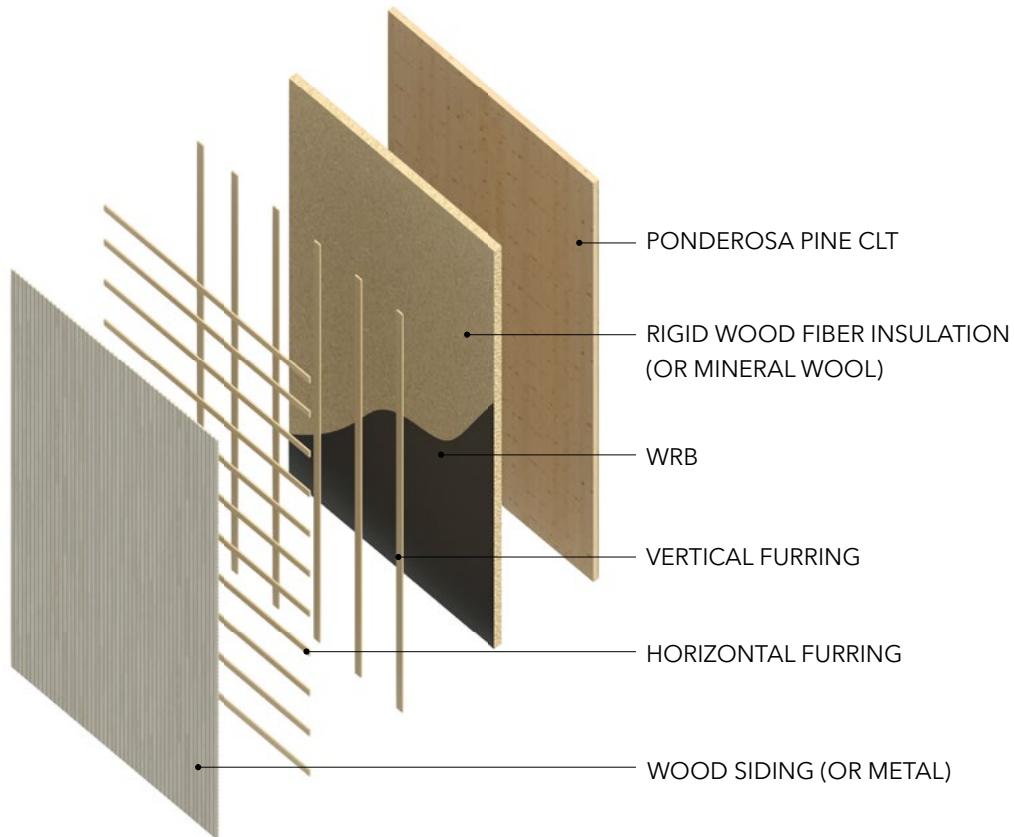


A photograph of a modern wooden building. The roof is made of horizontal wooden planks and slopes downwards from left to right. A vertical wooden beam supports the roof. The walls are made of vertical wooden slats. The word "DETAILS" is written in white capital letters on the right side of the image. A small evergreen tree is visible in the bottom right corner. The lighting is warm, suggesting late afternoon or early morning.

DETAILS



TYPICAL WALL ASSEMBLY AND FIRE RESILIENCE

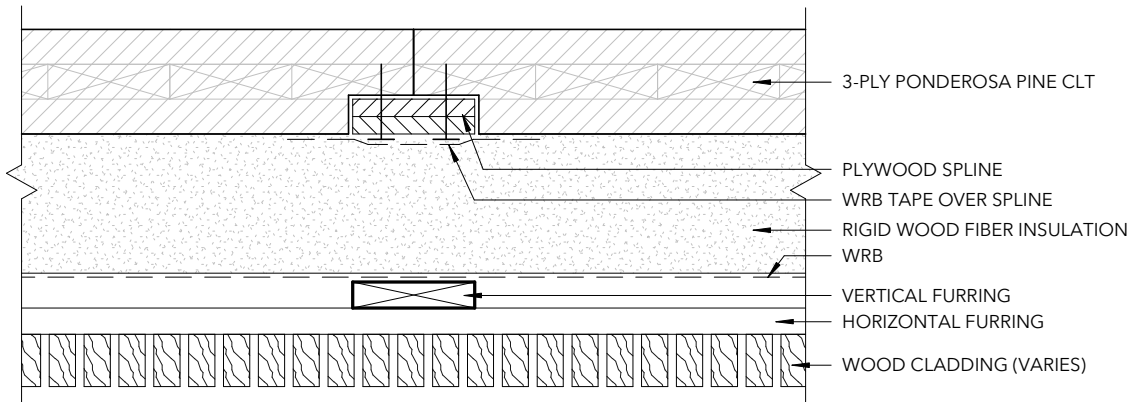


This wall assembly maximizes the use of bio-based materials such as CLT, wood fiber insulation, wood furring, and wood siding. Ideally, all of the wood based products can be sourced from forest restoration-harvested timber including species that are not Ponderosa pine. This idea reinforces local sourcing and manufacturing. Fire resilience is also a critical aspect of these structures. Although the intent is to maximize the use of low-value wood from forest restoration projects, metal siding can also be used in place of wood siding to increase fire resilience. Other fire resilience strategies

include minimal roof overhangs, metal roofing, mass panel wall construction, and fire resistant insulation. Wood fiber insulation treated with borate provides fire protection; mineral wool insulation can also be used.

Note: Some details show 3-ply CLT and others show 5-ply CLT. Both types of CLT are interchangeable in the following details.

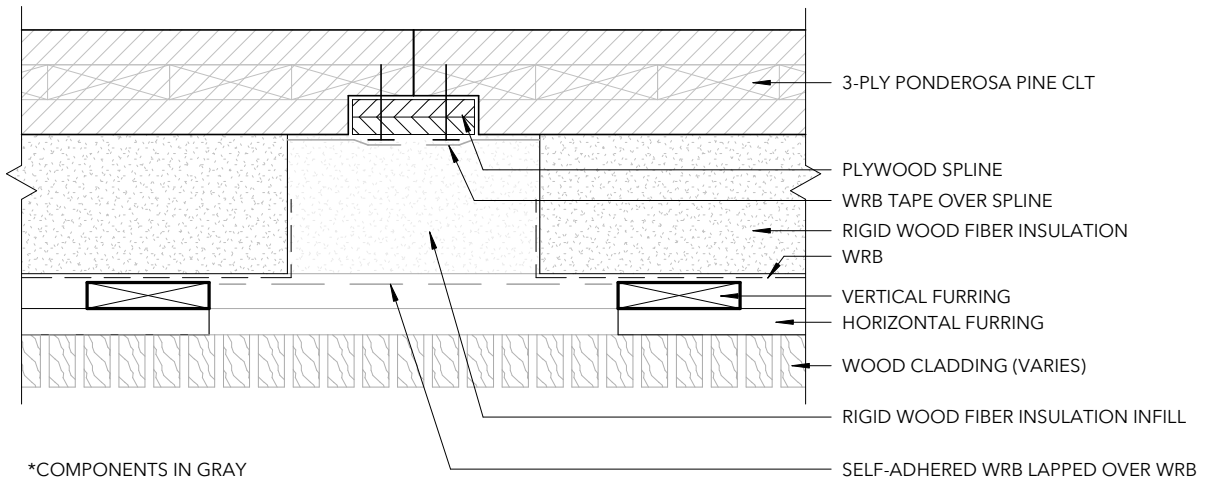
PANEL-TO-PANEL CONNECTION



In-Field Assembled Panel

CLT panels provide the opportunity for both in-field and off-site wall assembly. The detail above is an example of a wall assembly constructed in-field; this type of construction offers better waterproofing protection to the CLT and wood fiber insulation because there are fewer joints. A downside of this detail is that the CLT and wood fiber insulation are at a higher risk for moisture intrusion during construction since there are periods of time where they are left exposed to the

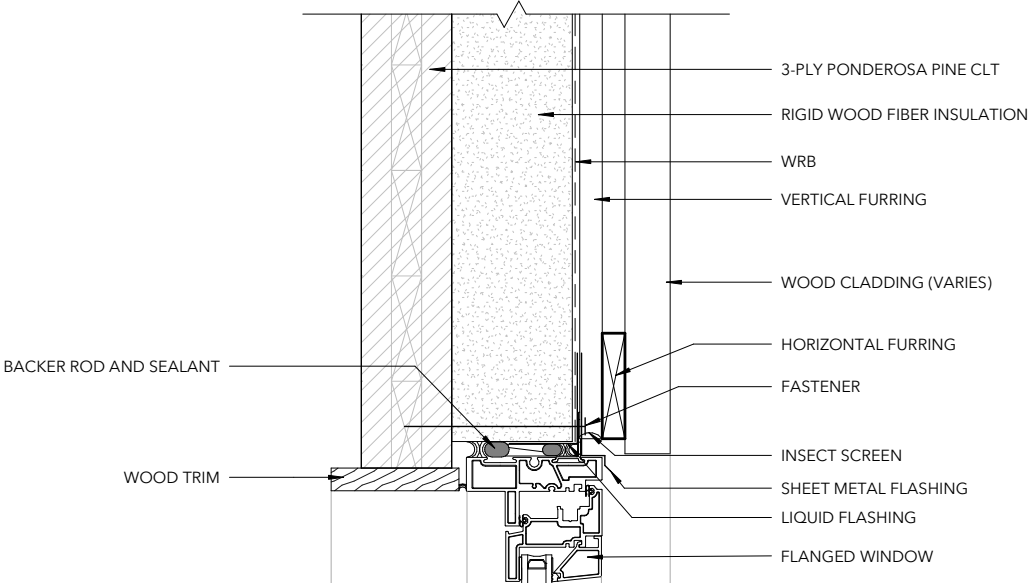
elements. The detail below is an example of off-site wall assembly with on-site infill. This method offers better protection to the wood-based materials during construction and simplifies in-field work; however, there is a greater risk for moisture intrusion since there are joints in the weather-resistive barrier (WRB) every 5ft.



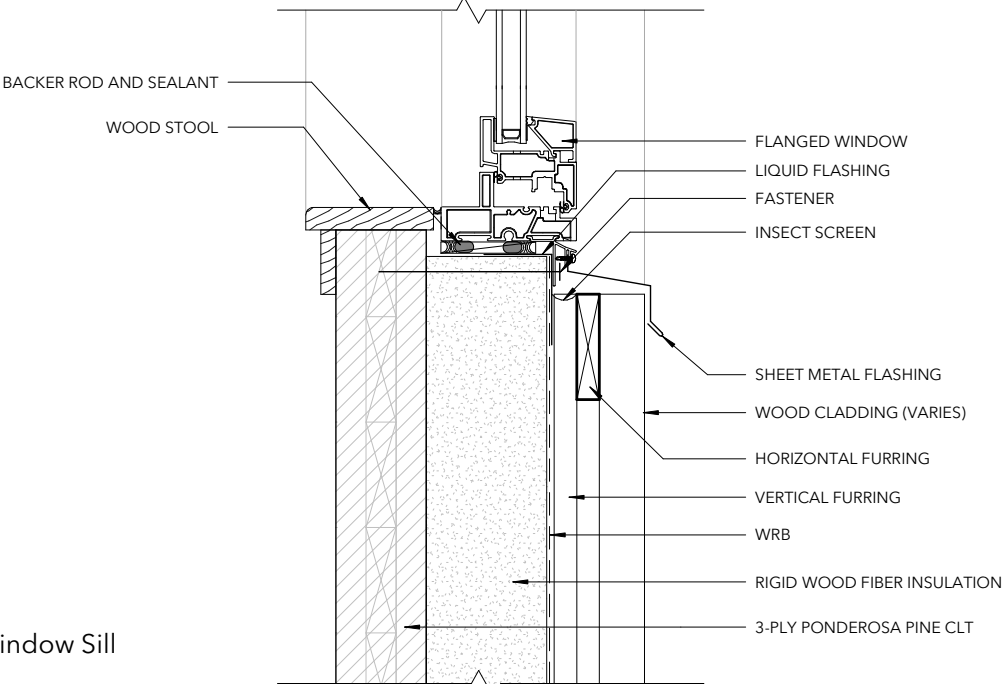
*COMPONENTS IN GRAY
ASSEMBLED ON-SITE

Off-Site Assembled Panel

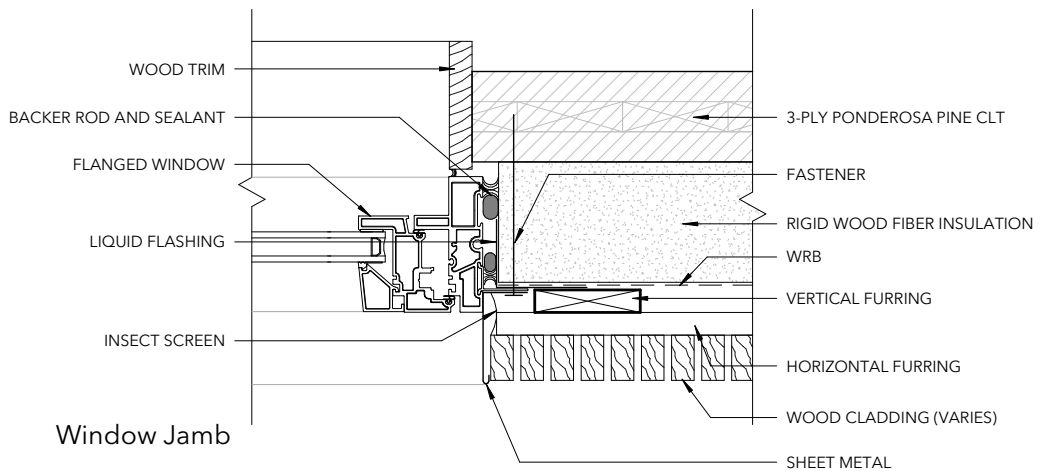
WINDOW DETAILS



Window Head

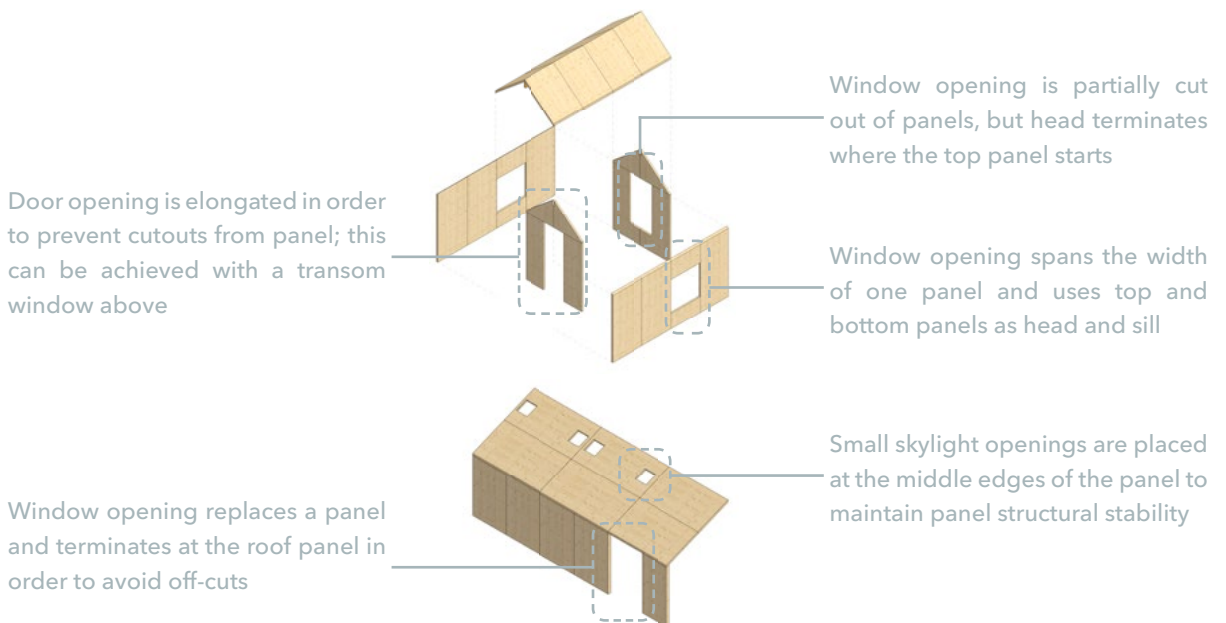


Window Sill

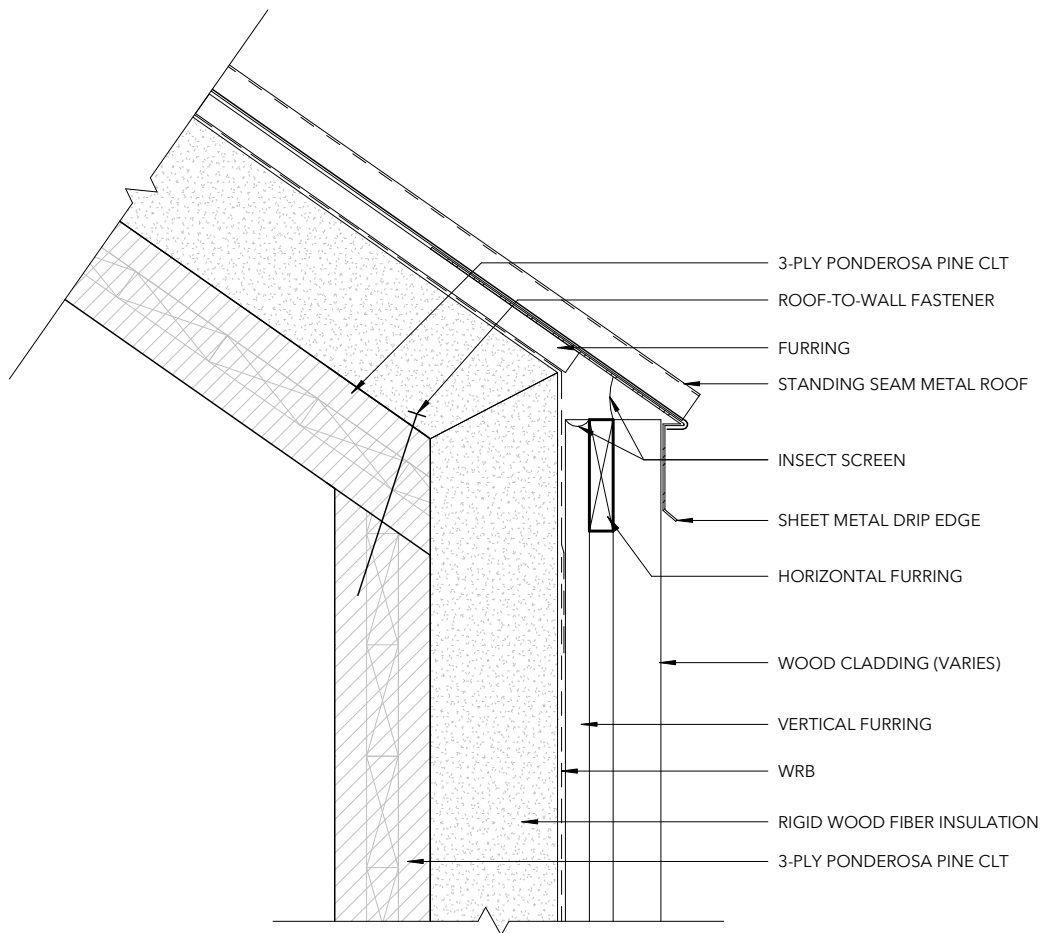


CLT window details are unique in that they do not require additional framing for the head, jamb, and sill. These details demonstrate how to approach window openings using Ponderosa pine CLT panels; doors can be detailed in a similar fashion. Although openings can be cut directly out of a panel, best practice is to avoid punched openings due to the panels' small size and to mitigate waste. Where appropriate, windows should fit between panels as illustrated in the diagrams below. Additionally, windows, such as storefronts, that are

carried to the underside of a CLT roof can use the roof panels itself as a header. This approach also prevents waste from panel off-cuts. Small skylight openings should not be cut from the center of the panel, but rather at the middle ends of a panel to maintain structural properties. It is important to note, however, that these guidelines may not be appropriate for every building. Openings are dependent on a building's program and may require other configurations.



ROOF DETAIL

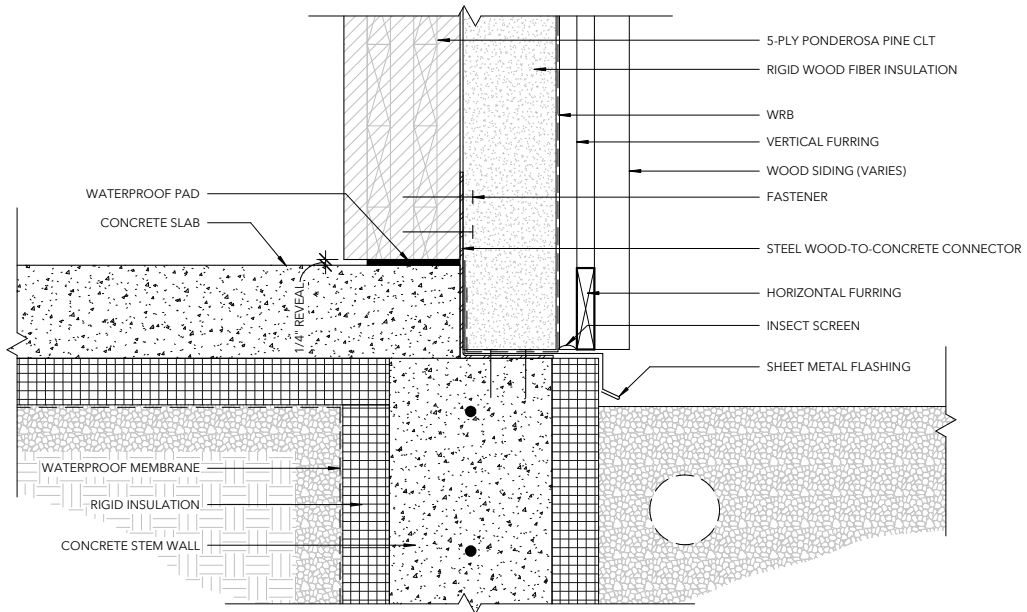


The detail above demonstrates a general approach to an eaveless roof design to increase fire resilience. Eaveless roofs prevent flames from catching underneath overhangs, thereby preventing the entire building from combusting. The CLT wall and roof panels also create a continuous envelope seal that are intended to improve thermal performance and mitigate fire spread. Similar to CLT panels, wood fiber insulation carbonizes when exposed to fire which helps to insulate the rest of the assembly from fire spread.

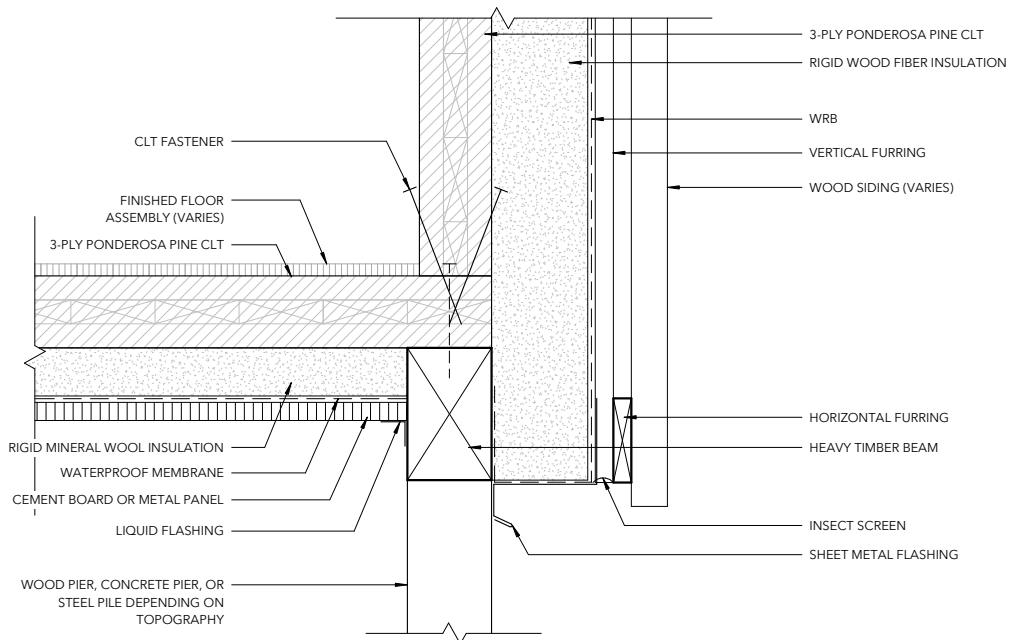
The details to the right illustrate two different foundation conditions that can be employed depending on the

context of the building. The detail on the top of the right page is an example of a concrete foundation with a concrete floor which would be an appropriate application in larger scale buildings, restrooms, and any building requiring a permanent foundation with few site challenges. The detail on the bottom of the right page depicts a pier foundation appropriate for buildings in difficult terrain; the pier system enables the building to be lifted above grade and placed where necessary on its respective topography.

FOUNDATION DETAILS



Concrete Foundation with Concrete Floor



Pier Foundation with CLT Floor

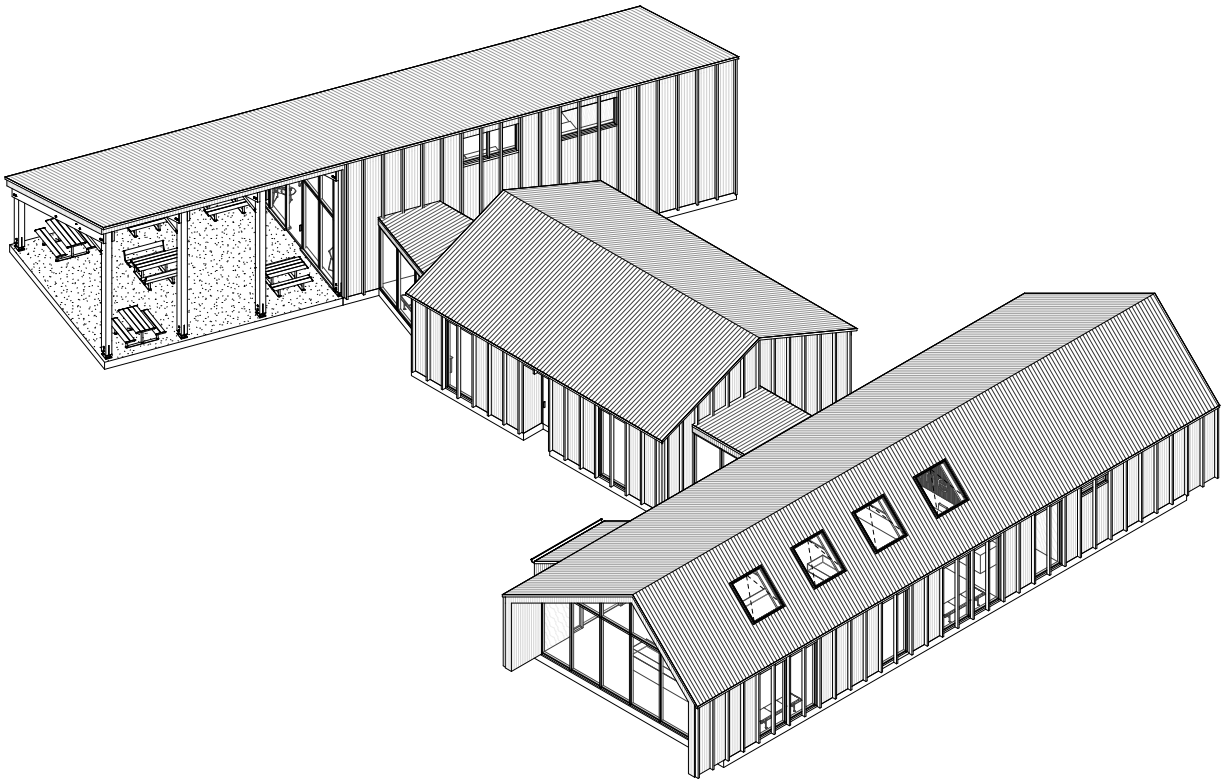
VISITOR CENTER







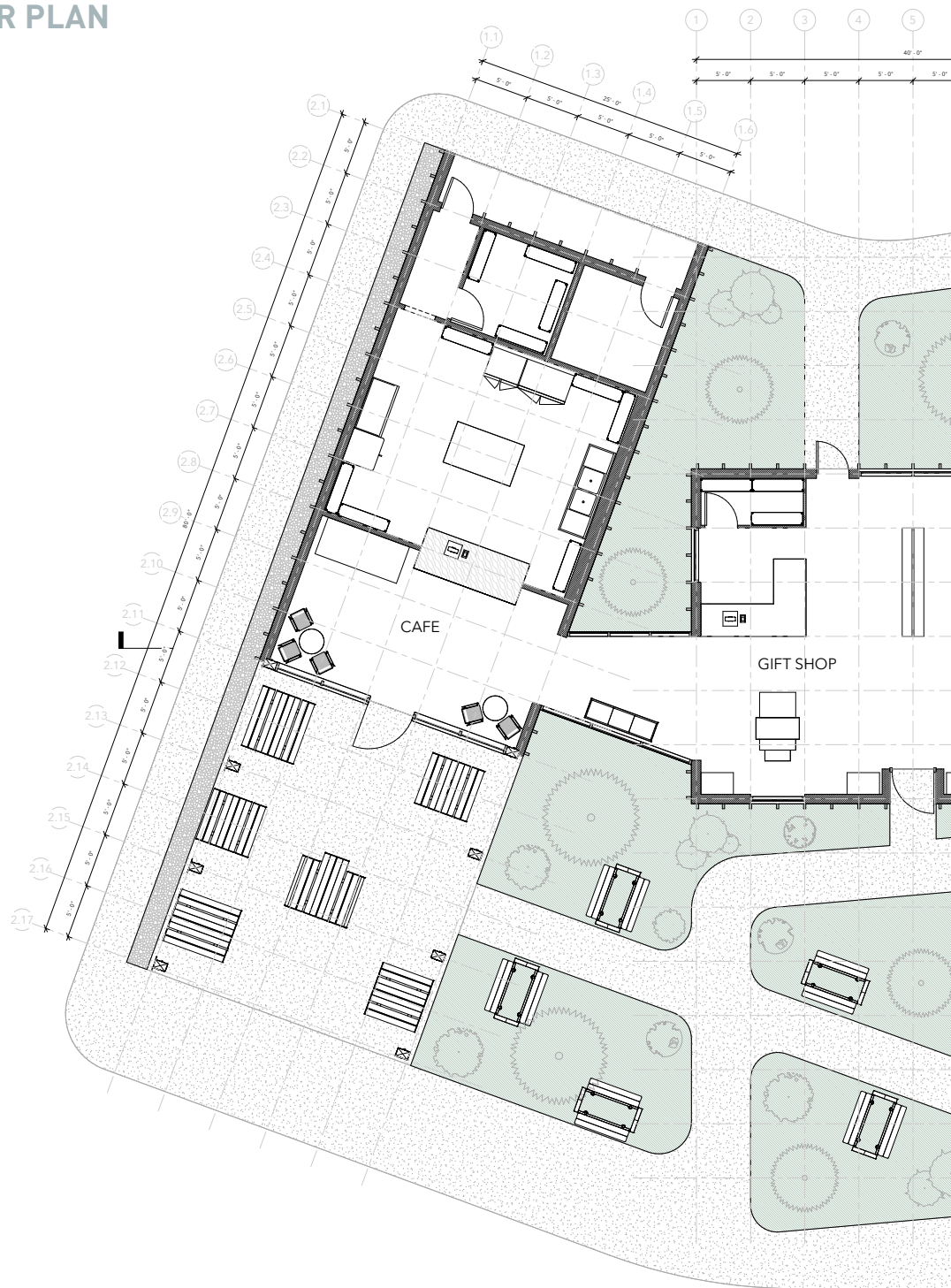
VISITOR CENTER

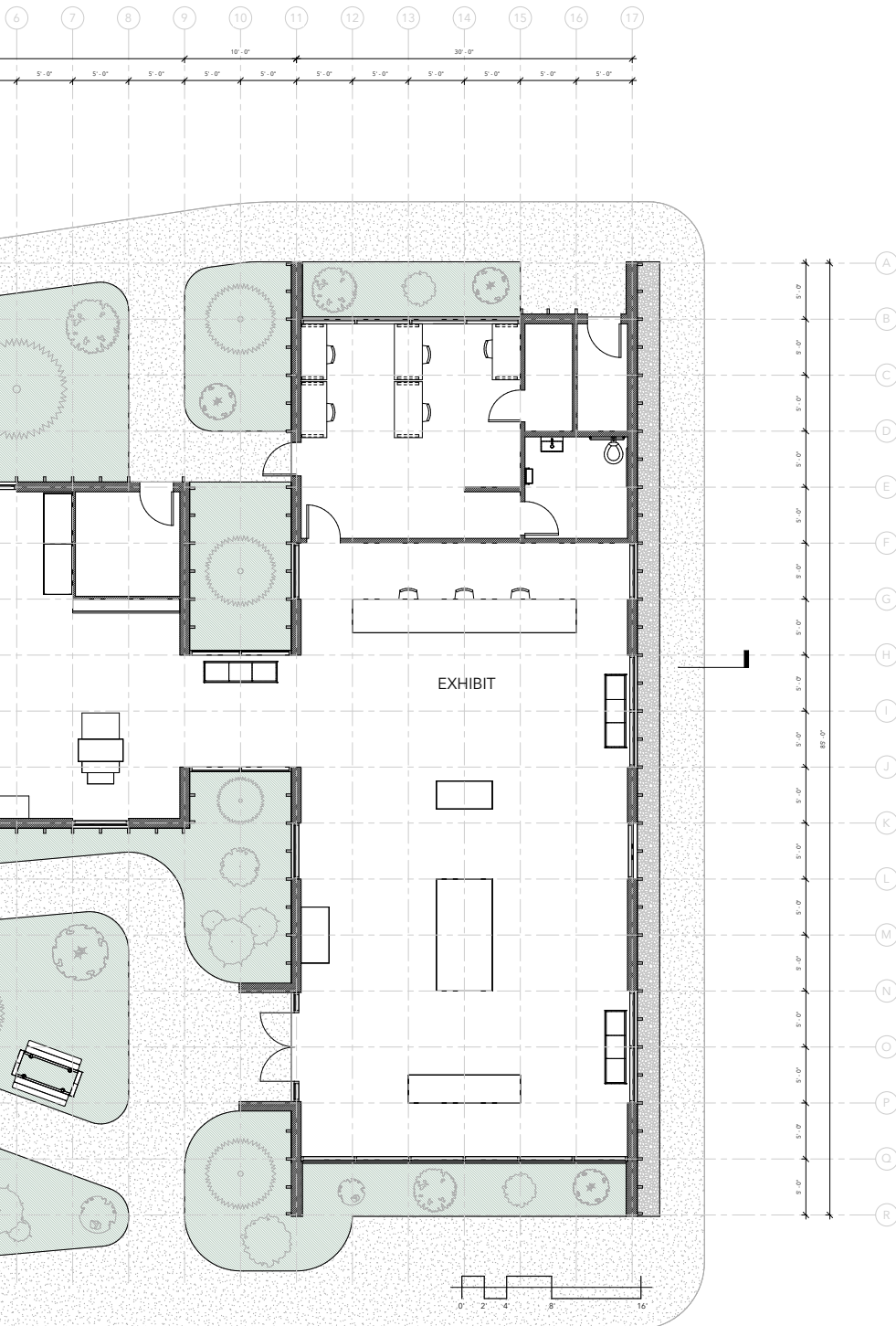


The visitor center is intended to accommodate different floor plan variations by separating the program into three separate buildings: an exhibit, gift shop, and cafe. Restroom facilities for guests are a separate building type that can be placed near the visitor center. Each building is connected to one another through a breezeway that can either be open or enclosed depending on the climate. Due to roof structural demands, the buildings are outfitted with Ponderosa pine beams. The gable roofs of the exhibit and gift shop require beams and steel collar ties, while the shed roof of the cafe requires beams with knee braces to form a rigid connection. These building types can

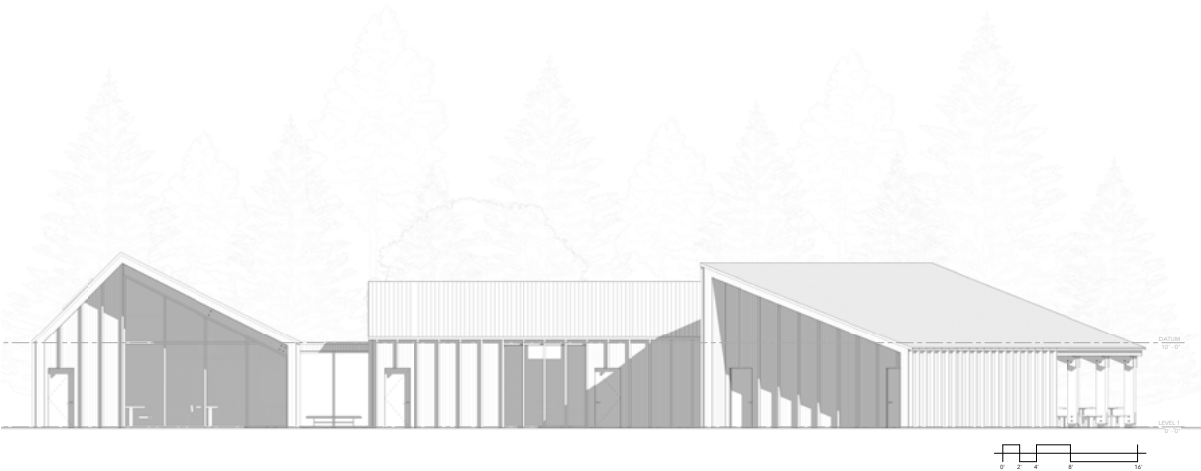
also host different programmatic functions depending on the needs of the park; for example, the cafe can be used as park ranger headquarters instead. In brief, the intent of this programmatic composition is to allow for the most amount of flexibility with straightforward construction solutions. Five-ply CLT is used for these structures and light-wood frame furring walls are used for walls that require plumbing for toilets and sinks.

OVERALL FLOOR PLAN





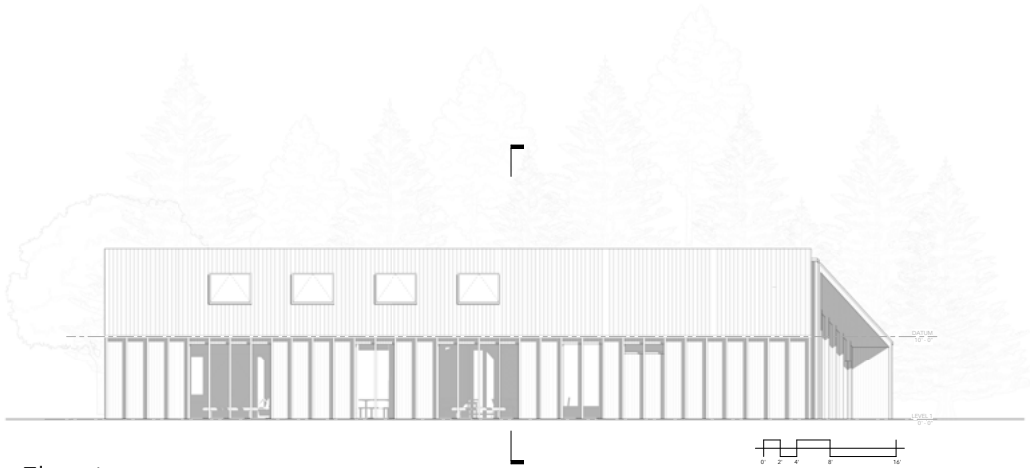
ELEVATIONS



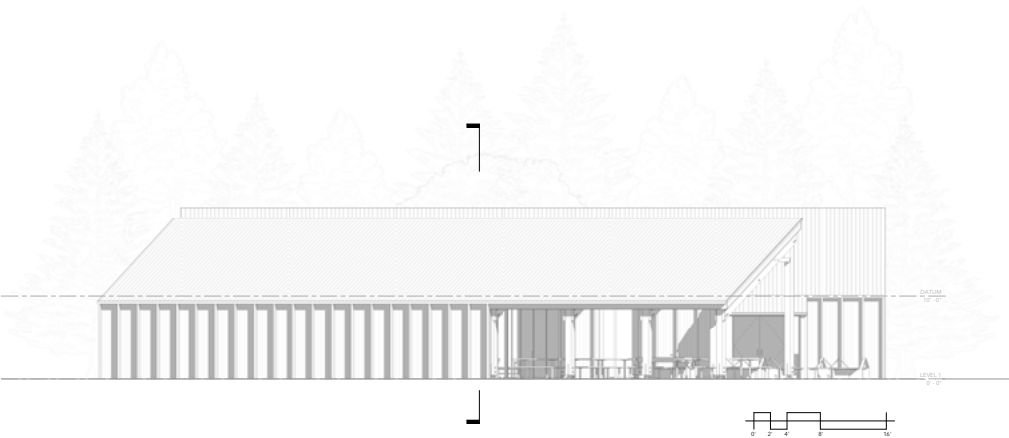
North Elevation



South Elevation

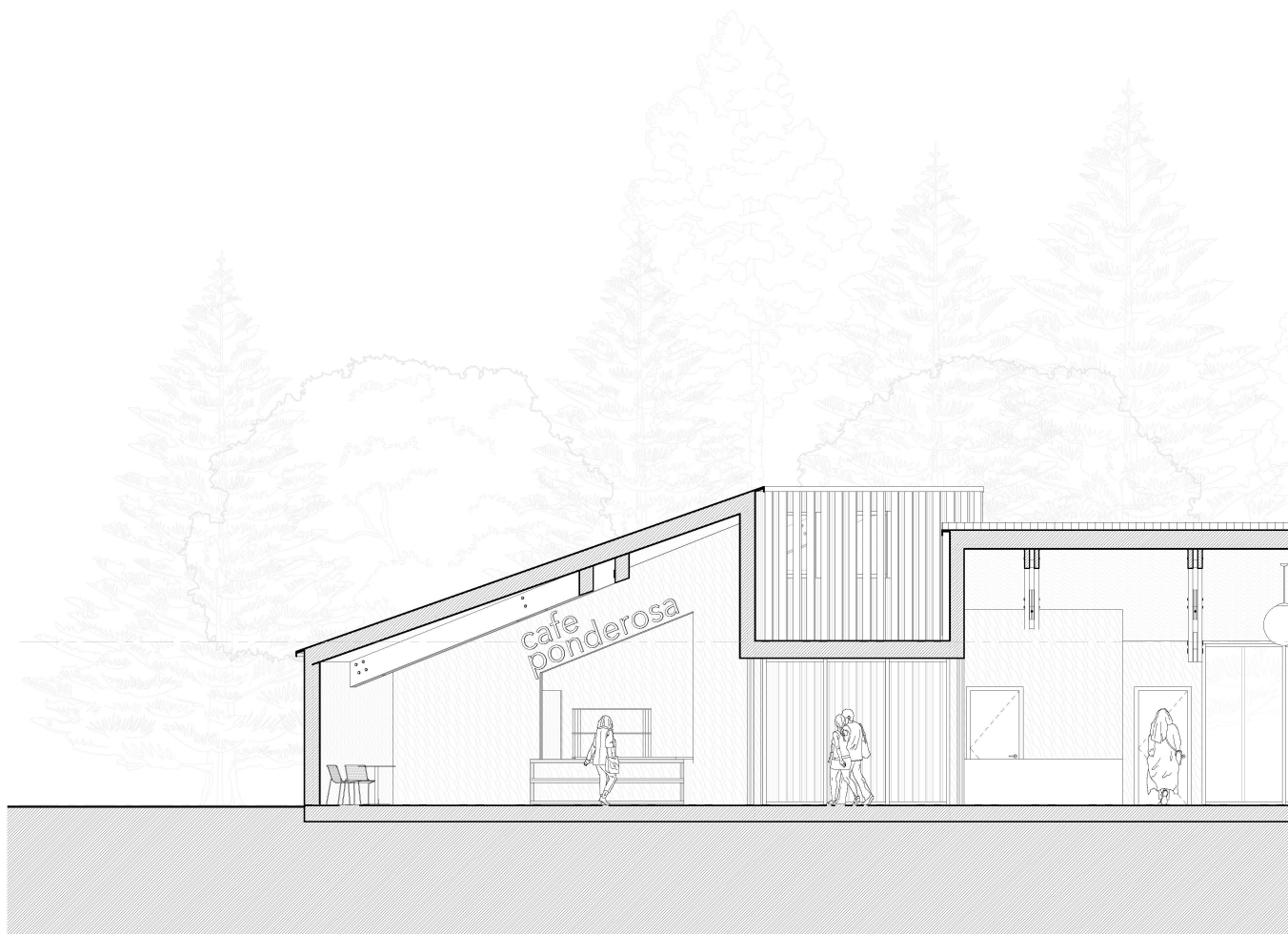


East Elevation



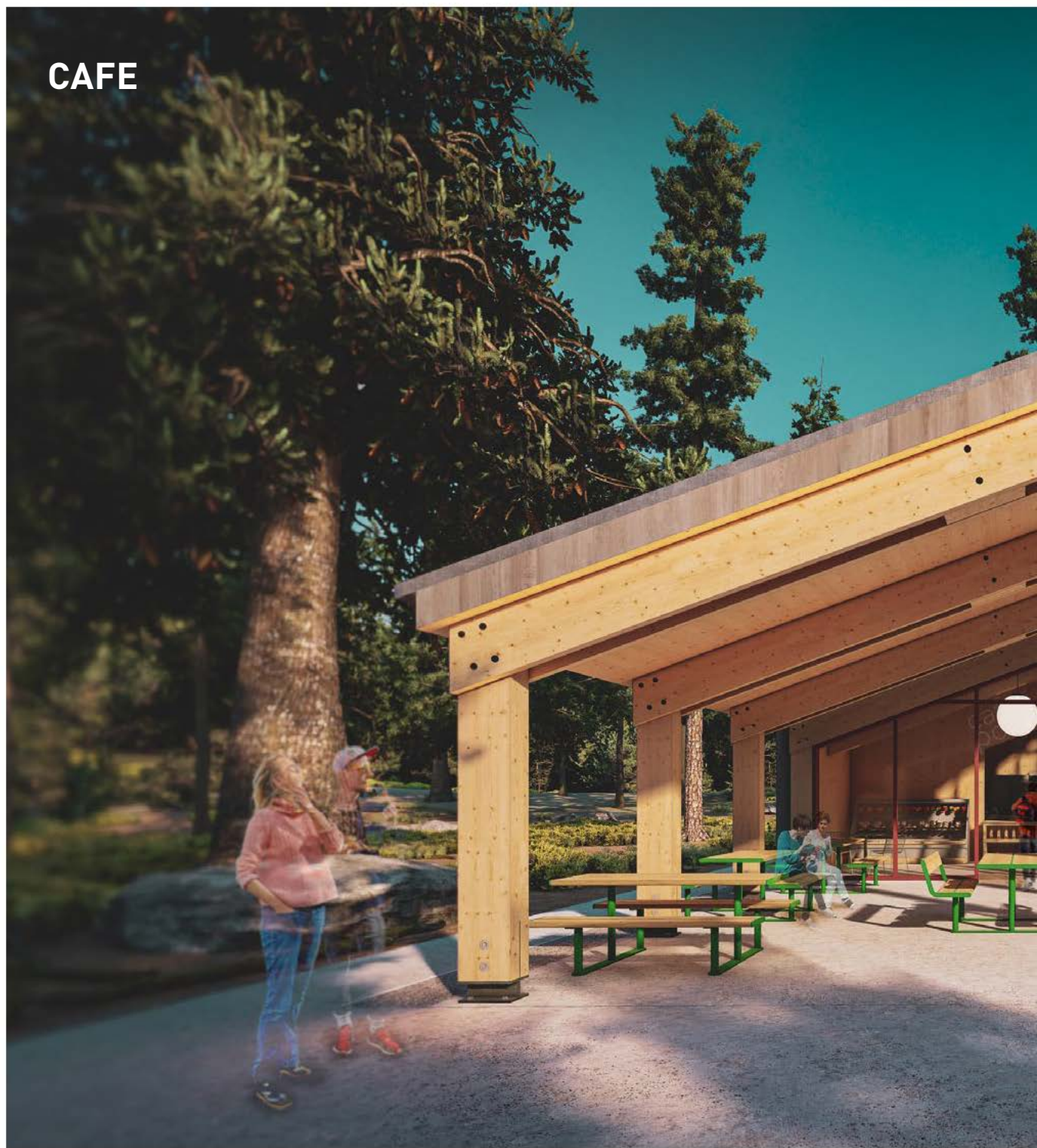
West Elevation

OVERALL SECTION



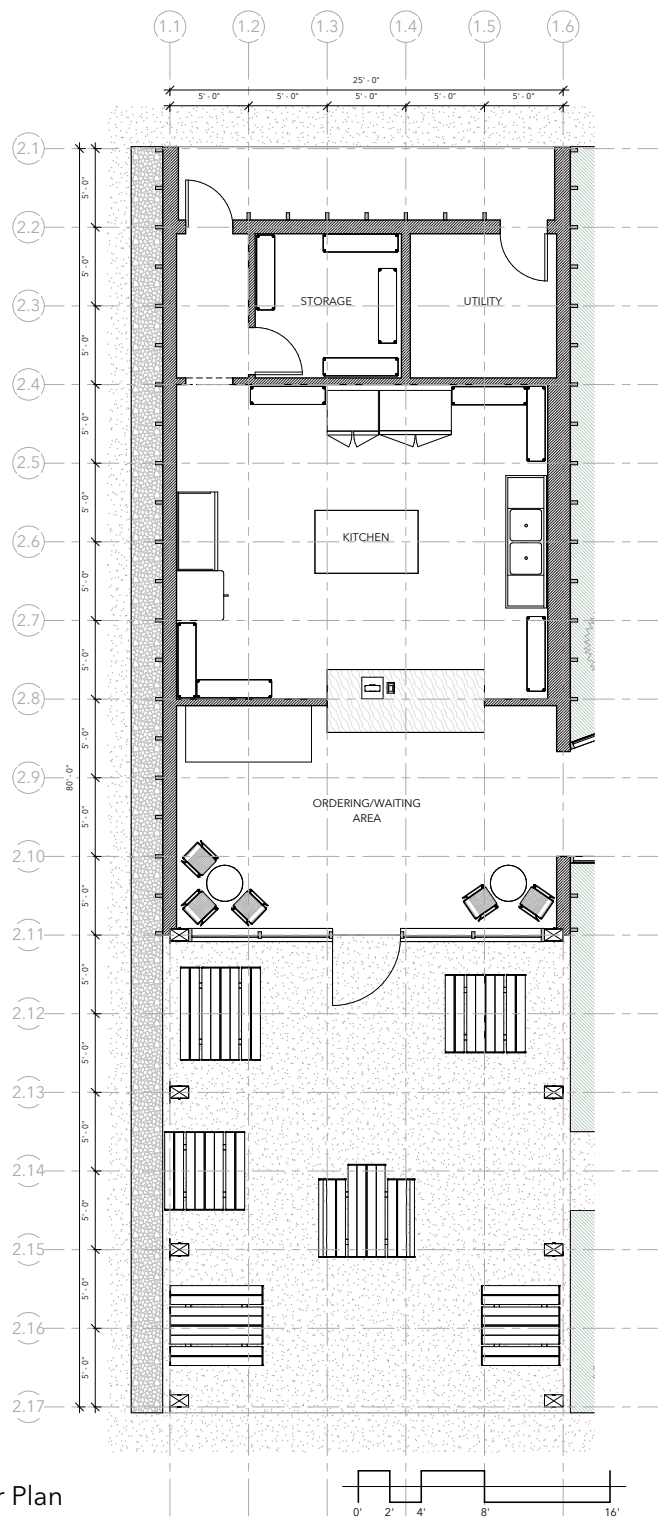


CAFE

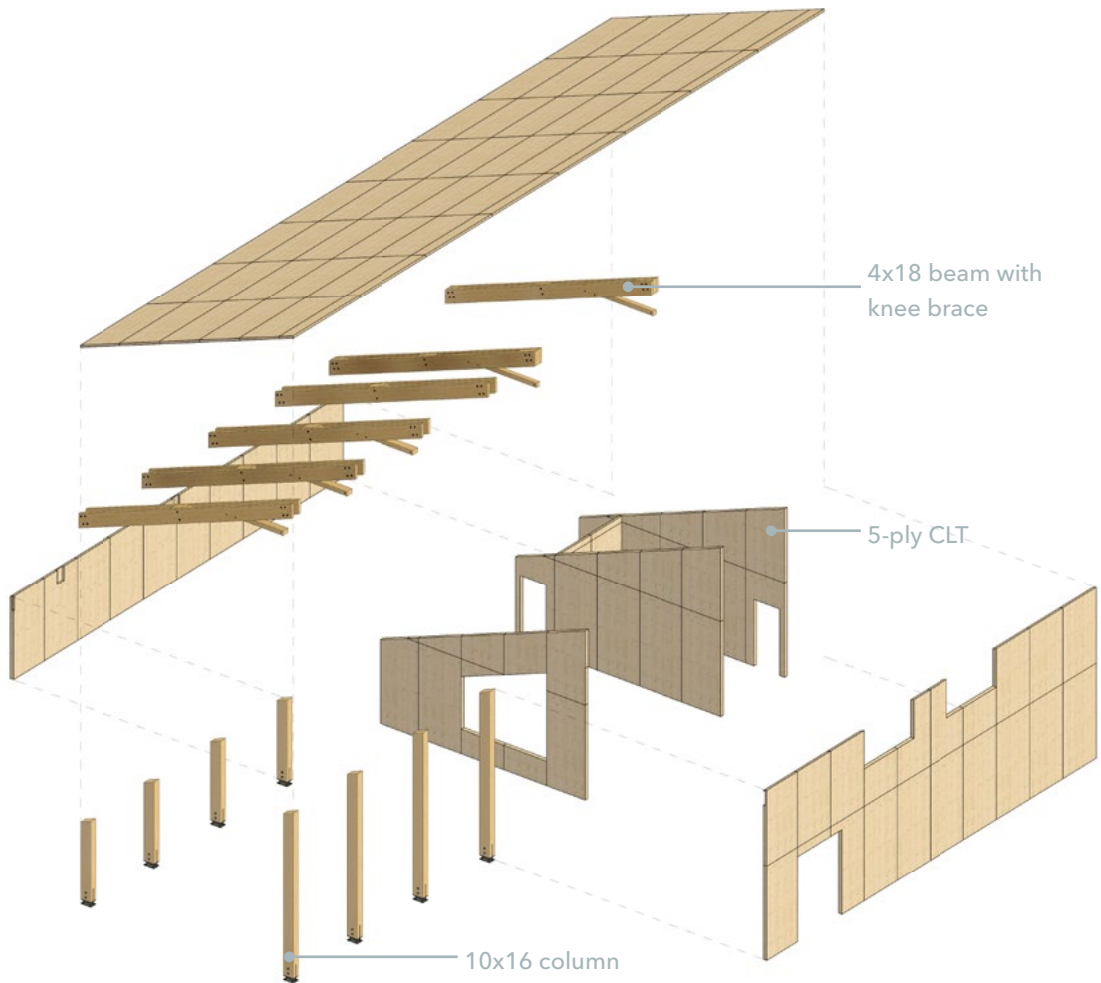




CAFE

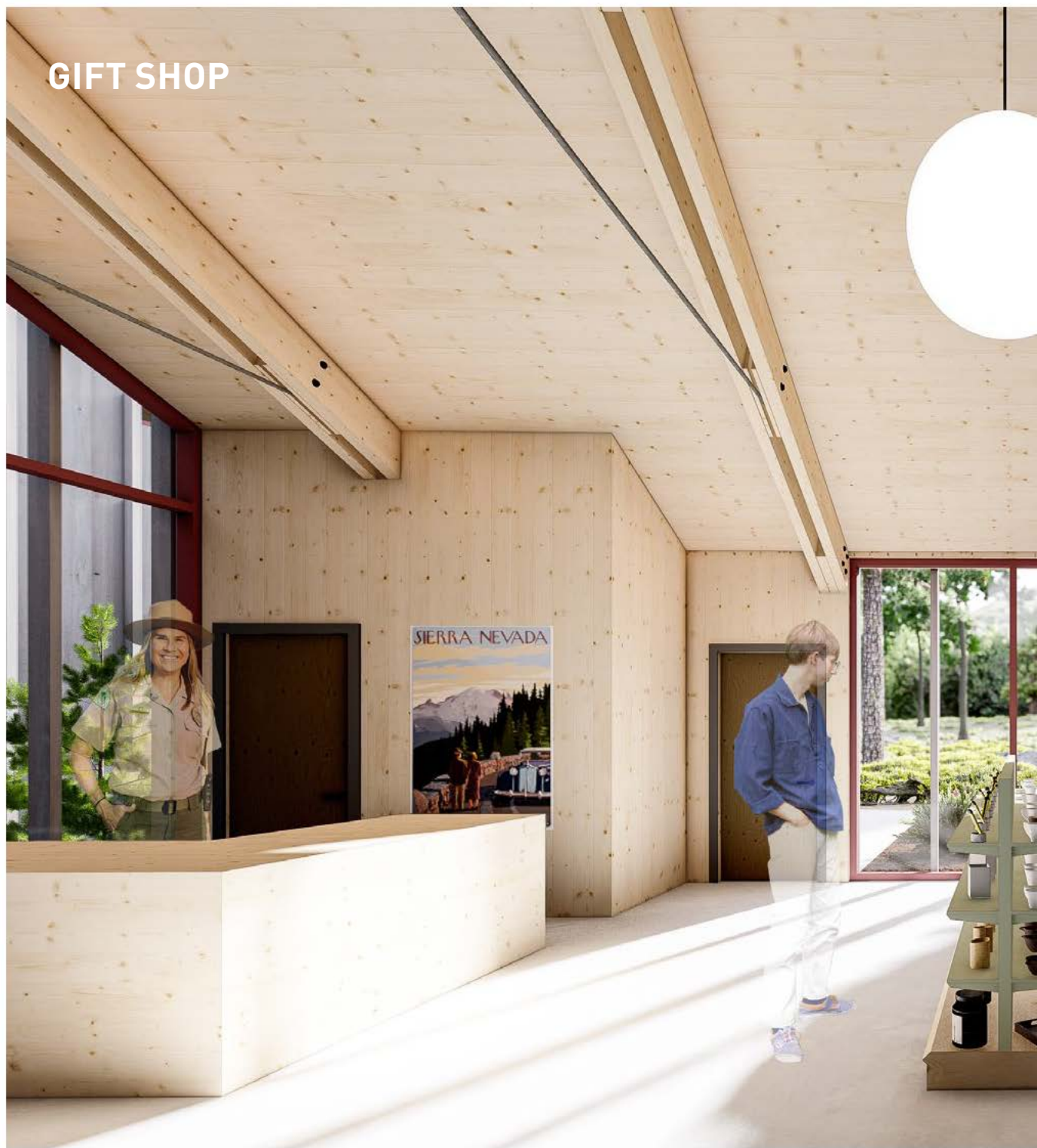


Floor Plan



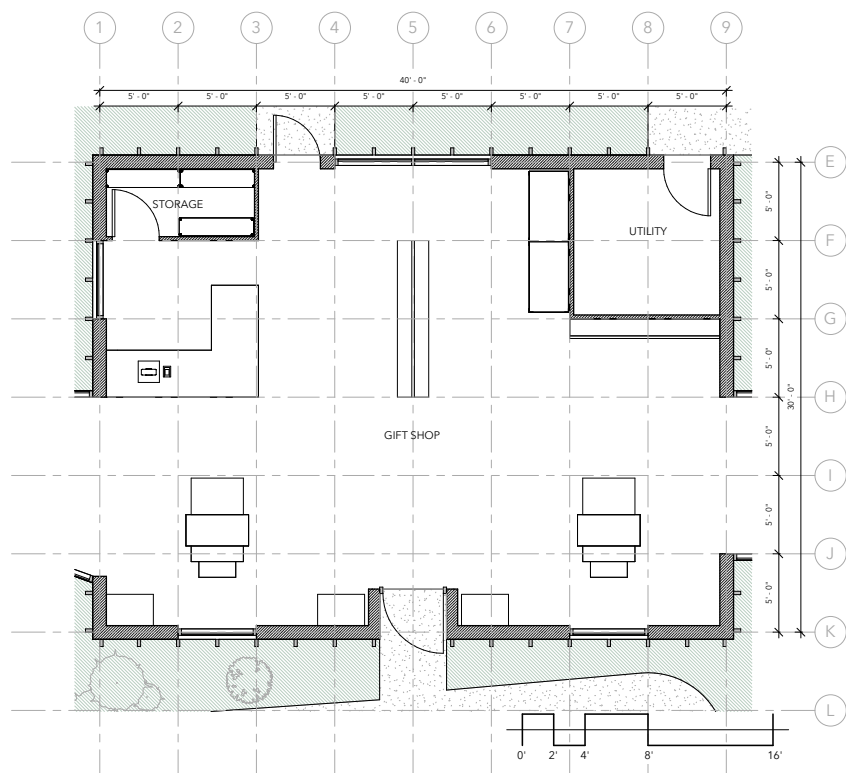
CLT and Structural Layout

GIFT SHOP

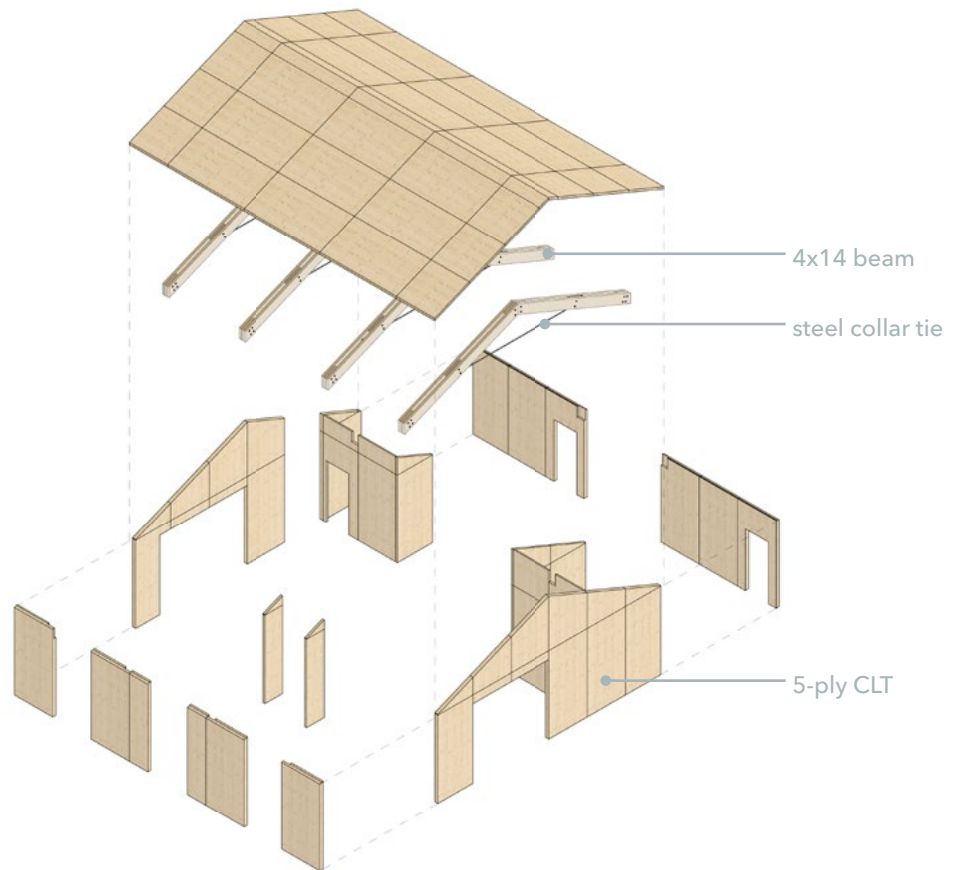




GIFT SHOP

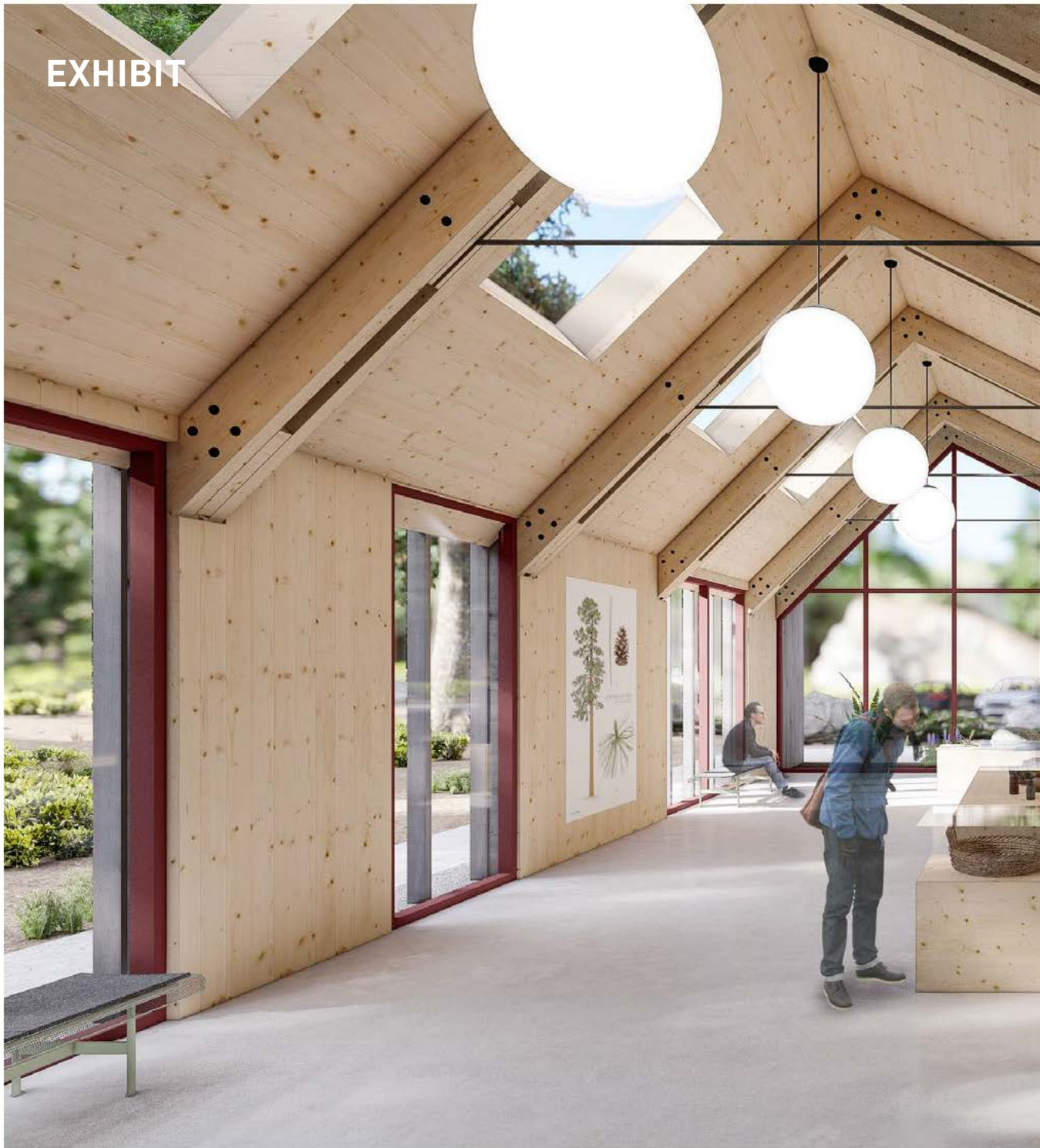


Floor Plan



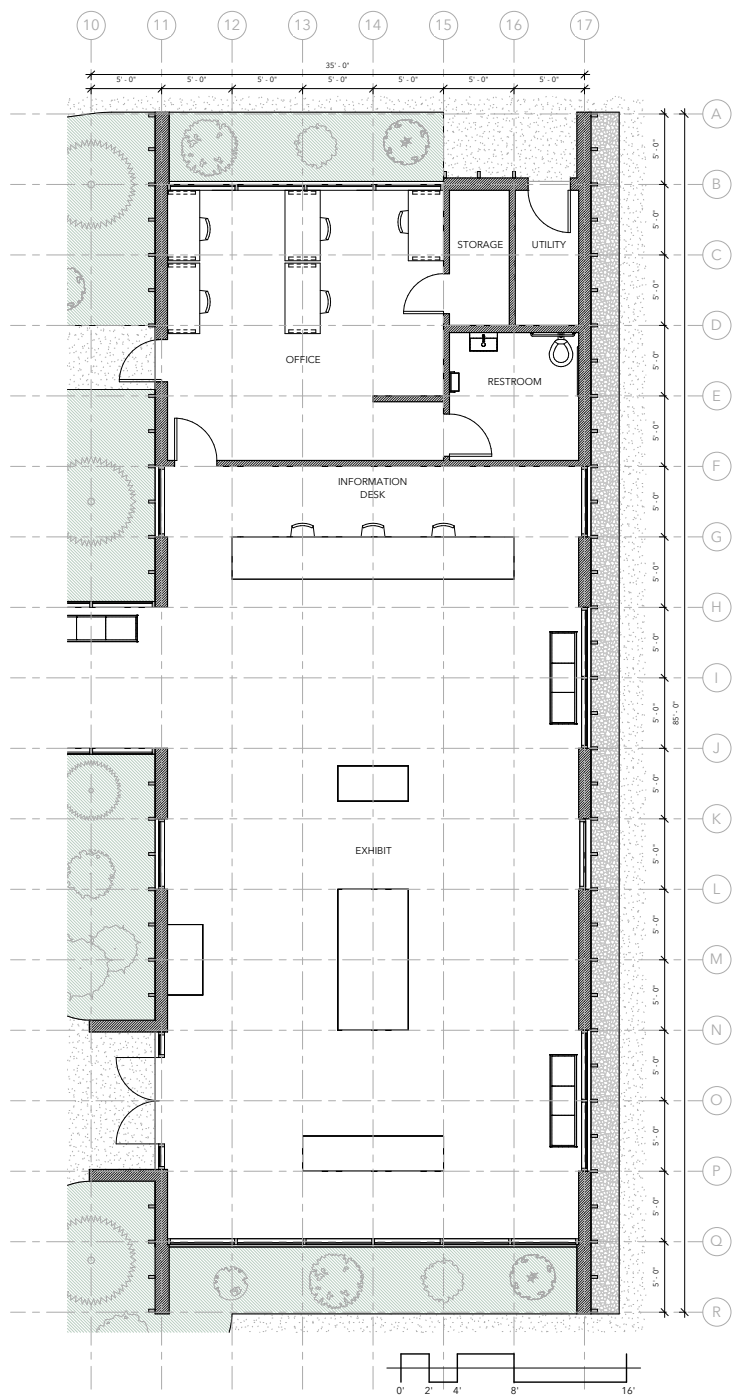
CLT and Structural Layout

EXHIBIT

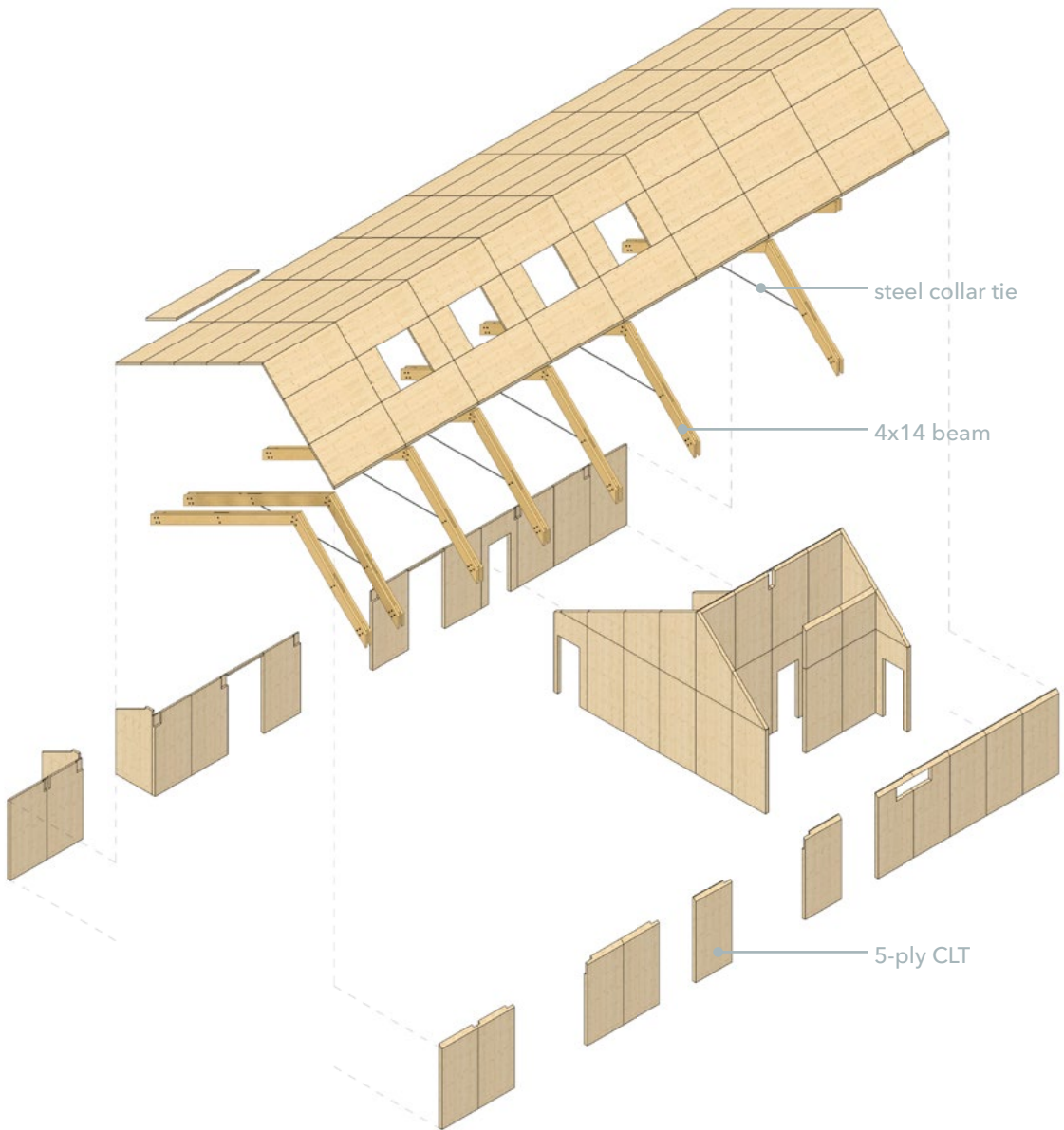




EXHIBIT



Floor Plan



CLT and Structural Layout





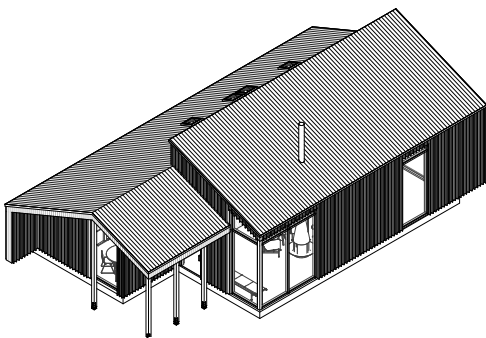
An aerial photograph of a lush forest landscape. A calm lake is visible on the left side, bordered by a rocky shoreline. A paved path winds through the forest, leading towards a modern wooden building with a slanted roof. The building is surrounded by landscaped grounds with rocks and small plants. Several people are walking along the path. The text "INFORMATION CENTER" is overlaid in white capital letters in the center of the image.

INFORMATION CENTER



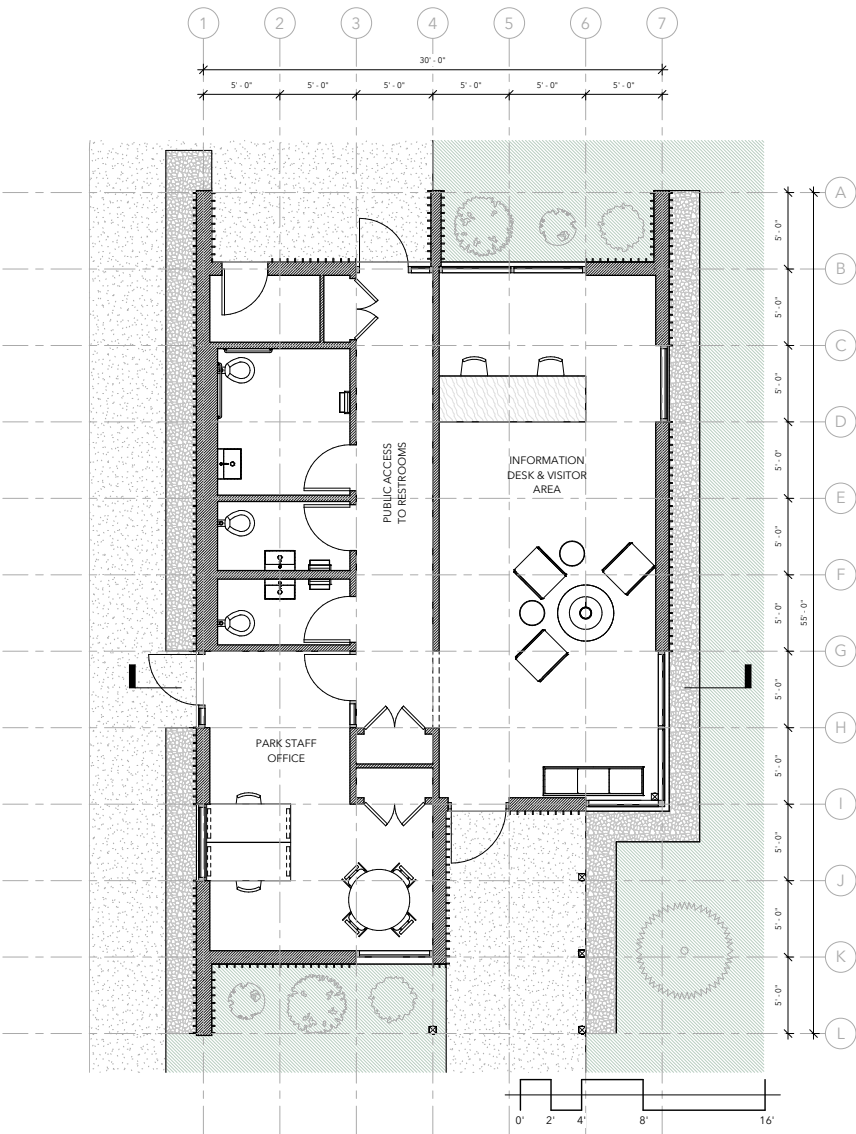
INFORMATION CENTER

The information center is intended to be used near minor park entrances and/or operate as a ranger station. The program features an information desk for guests, restrooms, and an office for park staff. Due to the building's small footprint, simple beam systems are used to span the roof with knee braces where necessary. Five-ply CLT is used for this building and light-wood frame furring walls are employed for walls that require plumbing for toilets and sinks.

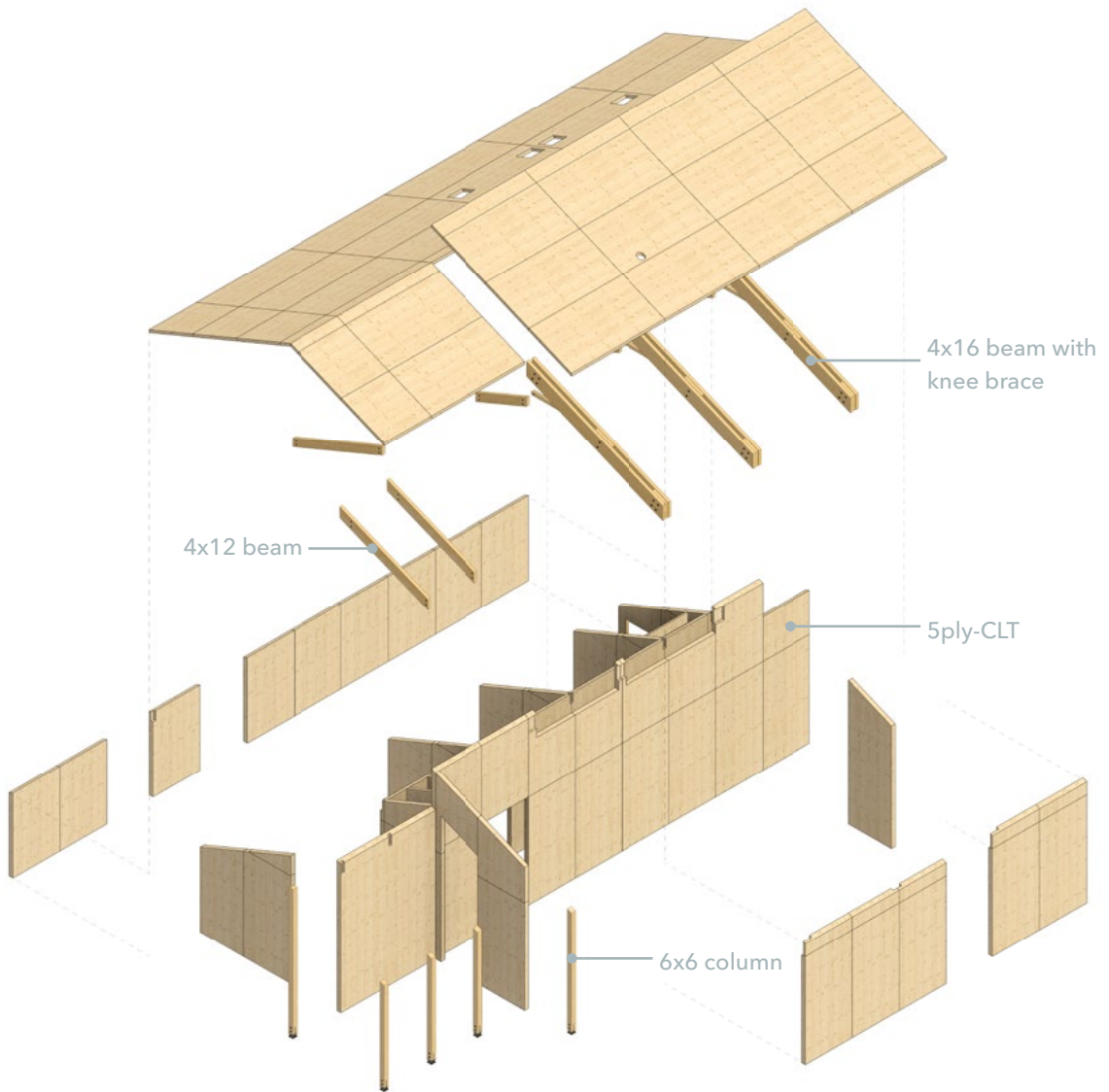




FLOOR PLAN



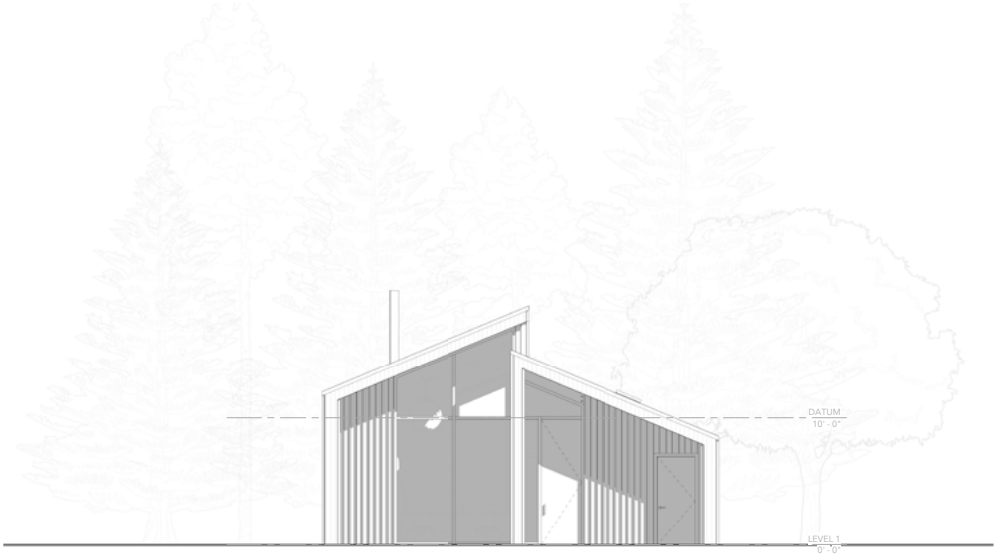
CLT AND STRUCTURAL LAYOUT



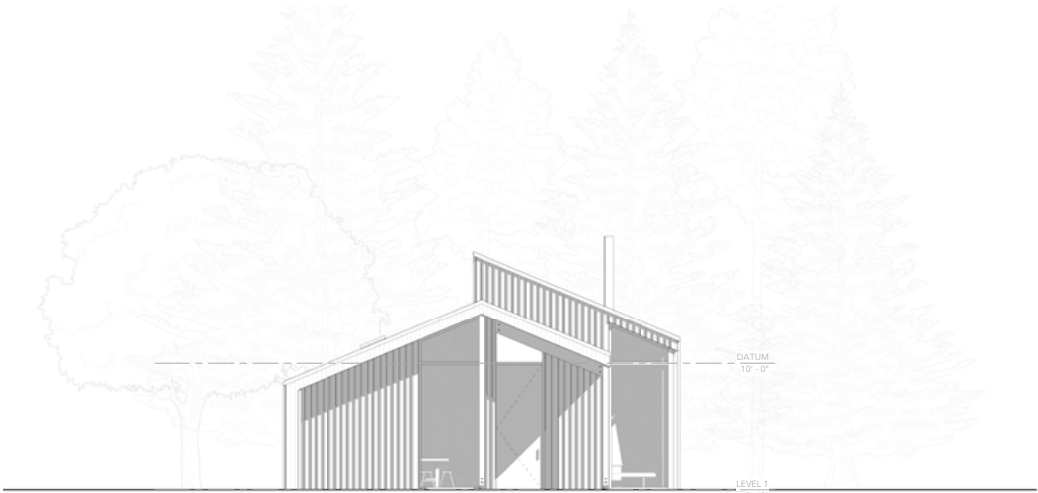
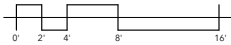




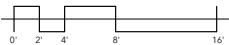
ELEVATIONS

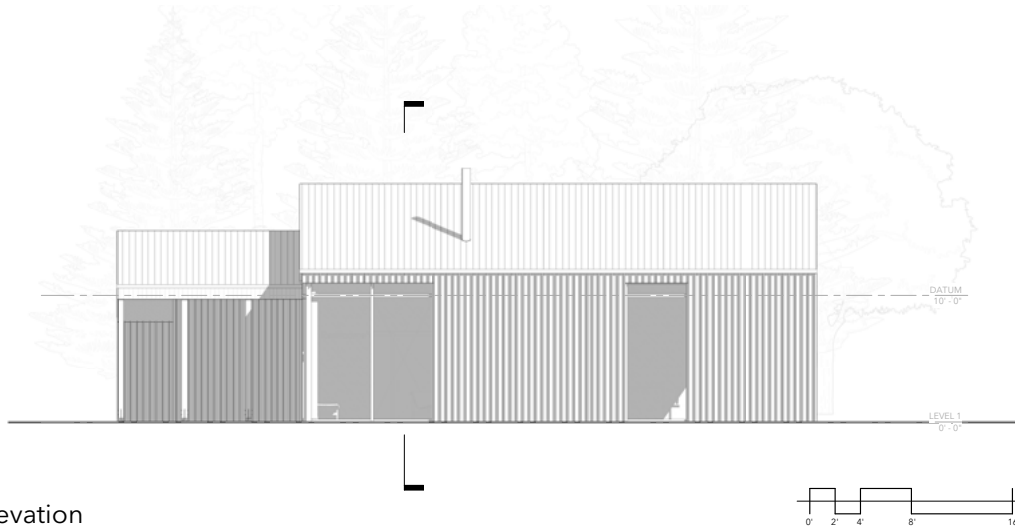


North Elevation

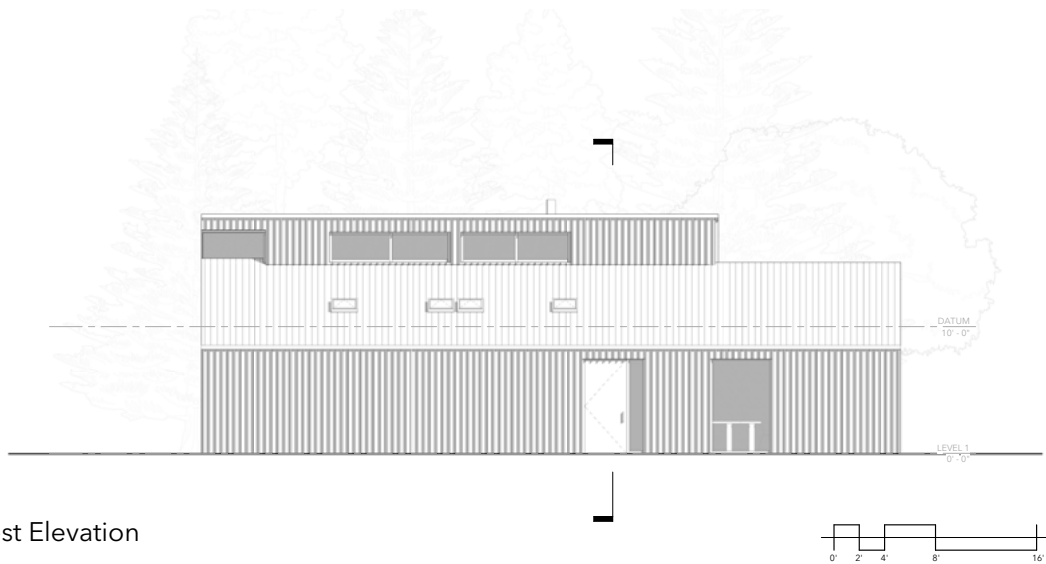


South Elevation





East Elevation



West Elevation





SECTION















RESTROOMS

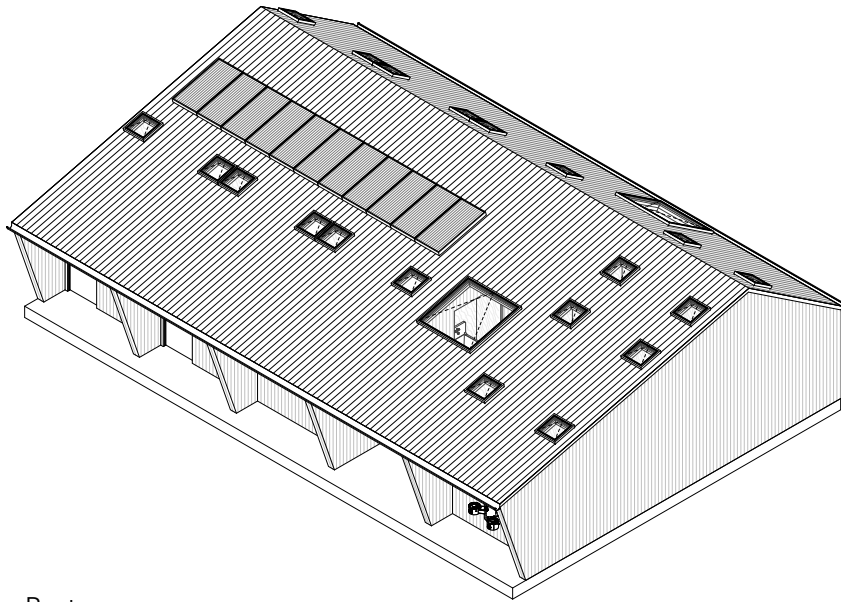




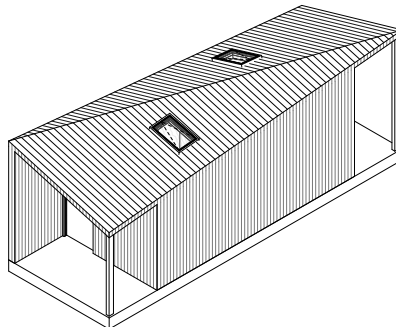
RESTROOMS

This building type consists of two different designs: small restroom structures intended to be scattered throughout a park and larger restroom facilities for busier parts of a park and its campgrounds. The small restroom facility is constructed with 3-ply CLT and utilizes a Ponderosa pine column where the roof cantilevers. The program consists of two private accessible stalls and a small utility closet. The larger restrooms are comprised of a flexible program that allow it to be adapted to different needs of a park. For example, showers can be added to the building

to accommodate a campground and stalls can be added to the floor plan as needed. This facility is also constructed of 3-ply CLT and does not require additional structural members to support its roof. Light-wood frame furring walls are used for walls that require plumbing for toilets and sinks. Lastly, due to the nature of this building type, the roof and wall assemblies do not need to be insulated and the building does not need to be conditioned which significantly simplifies construction.

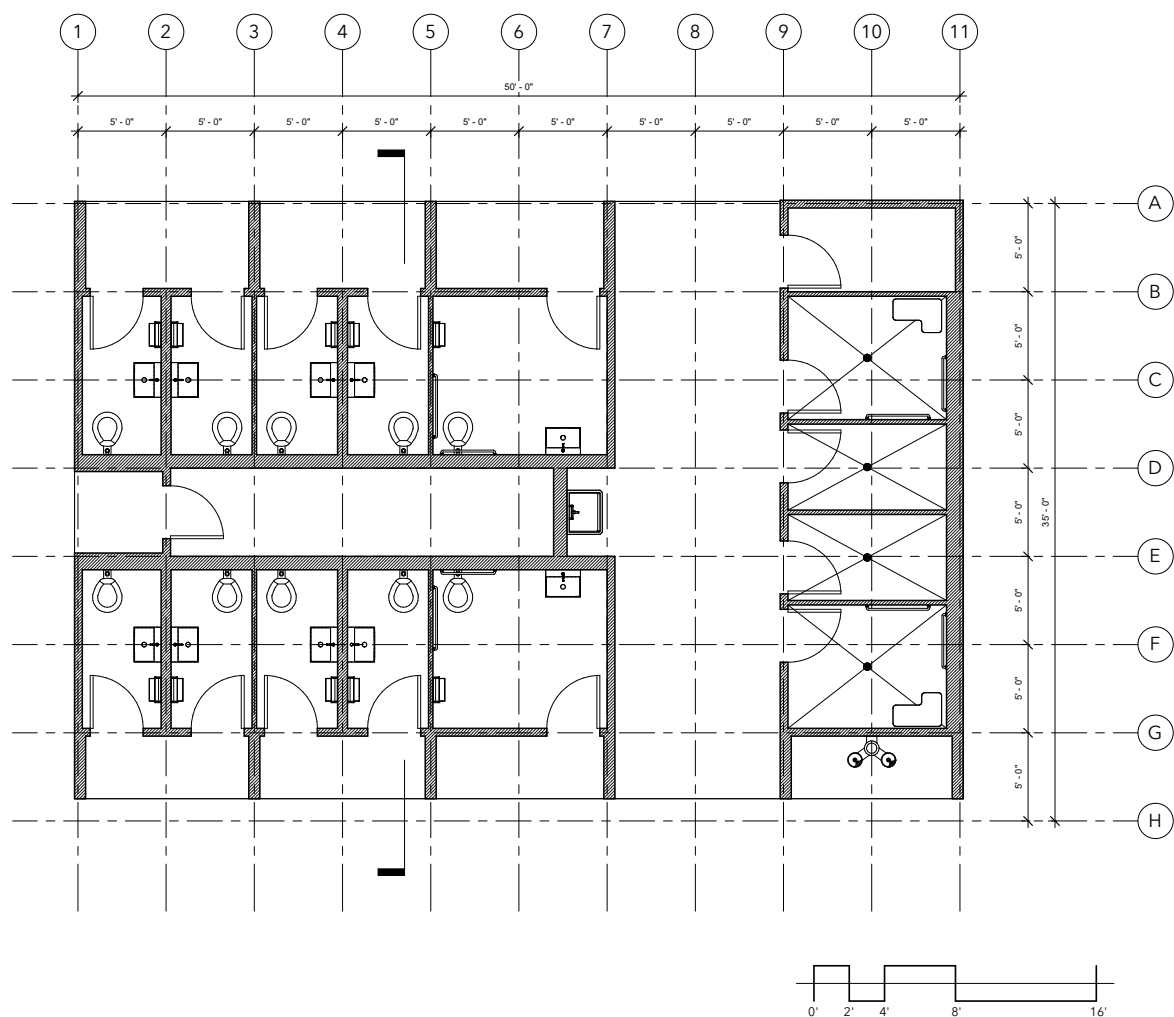


Large Restrooms



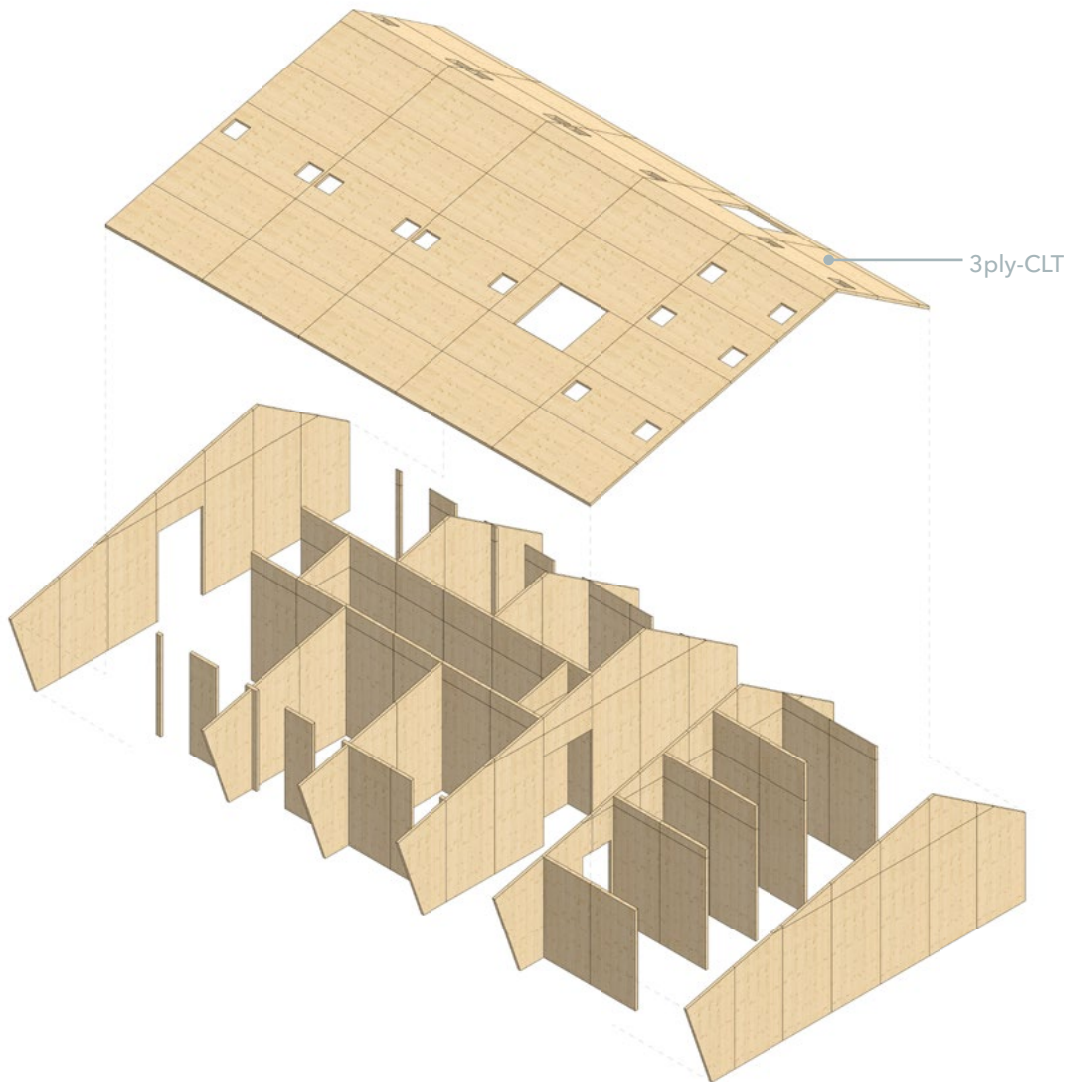
Small Restrooms

LARGE RESTROOMS



Floor Plan*

*The showers are intended for use at campgrounds; the showers can be removed from this floor plan in order to provide strictly restroom facilities.

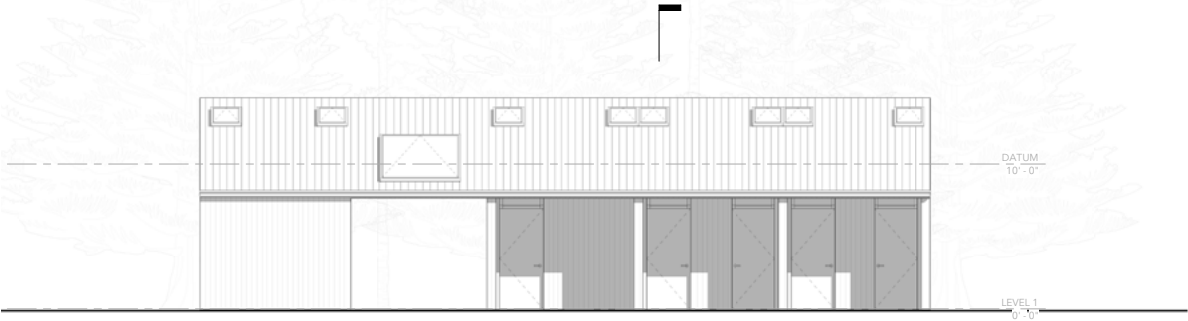


CLT and Structural Layout

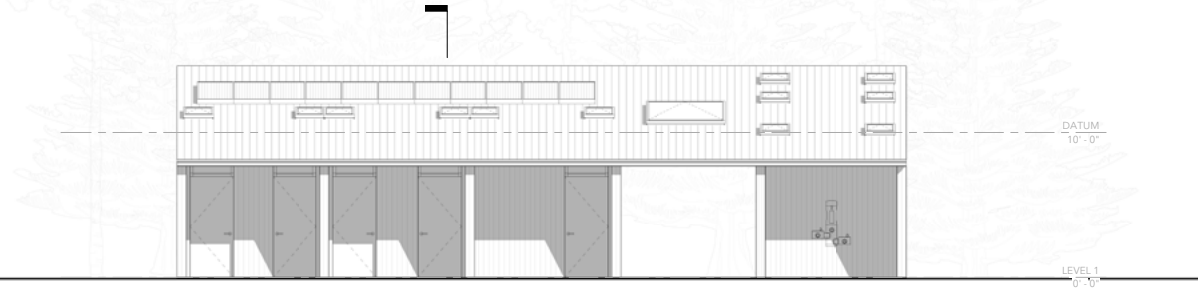
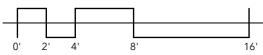




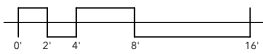
LARGE RESTROOMS

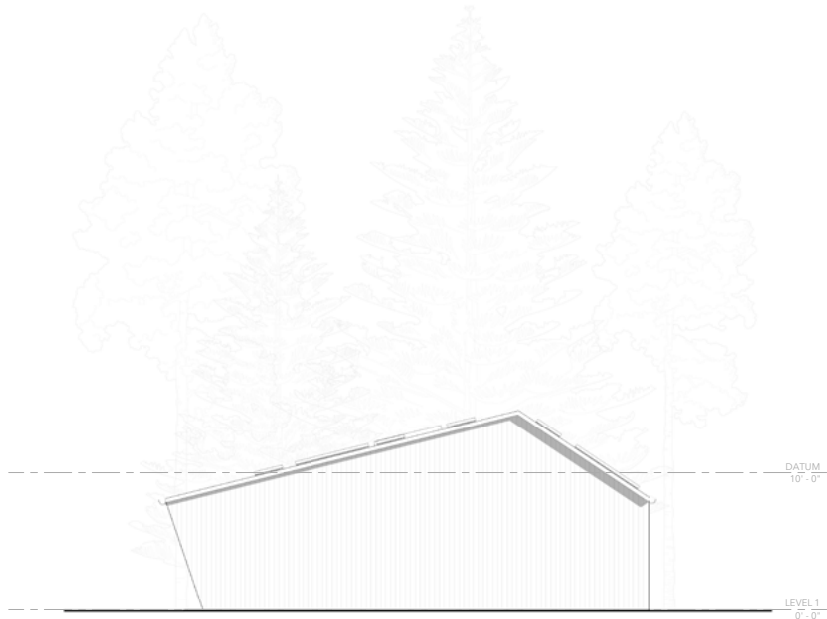


North Elevation

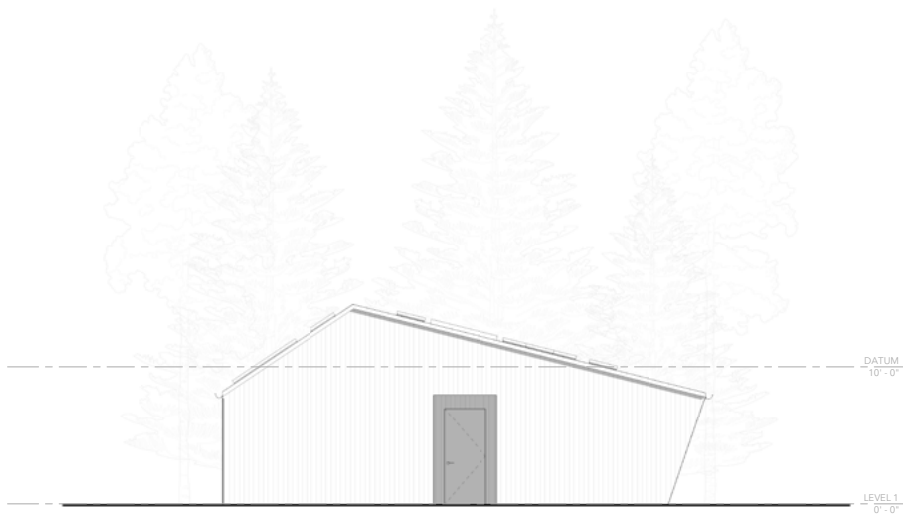
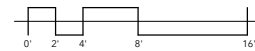


South Elevation





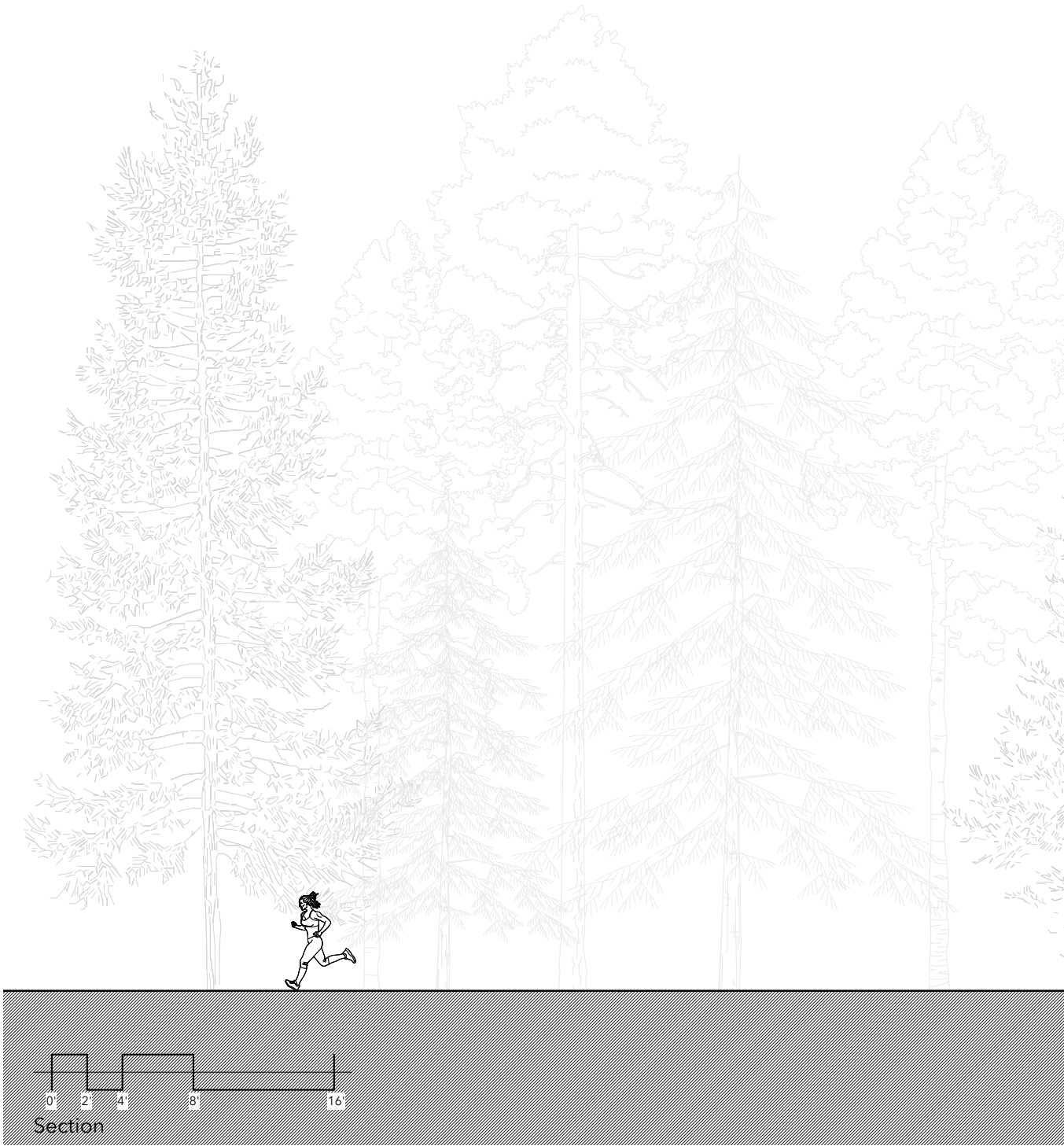
East Elevation

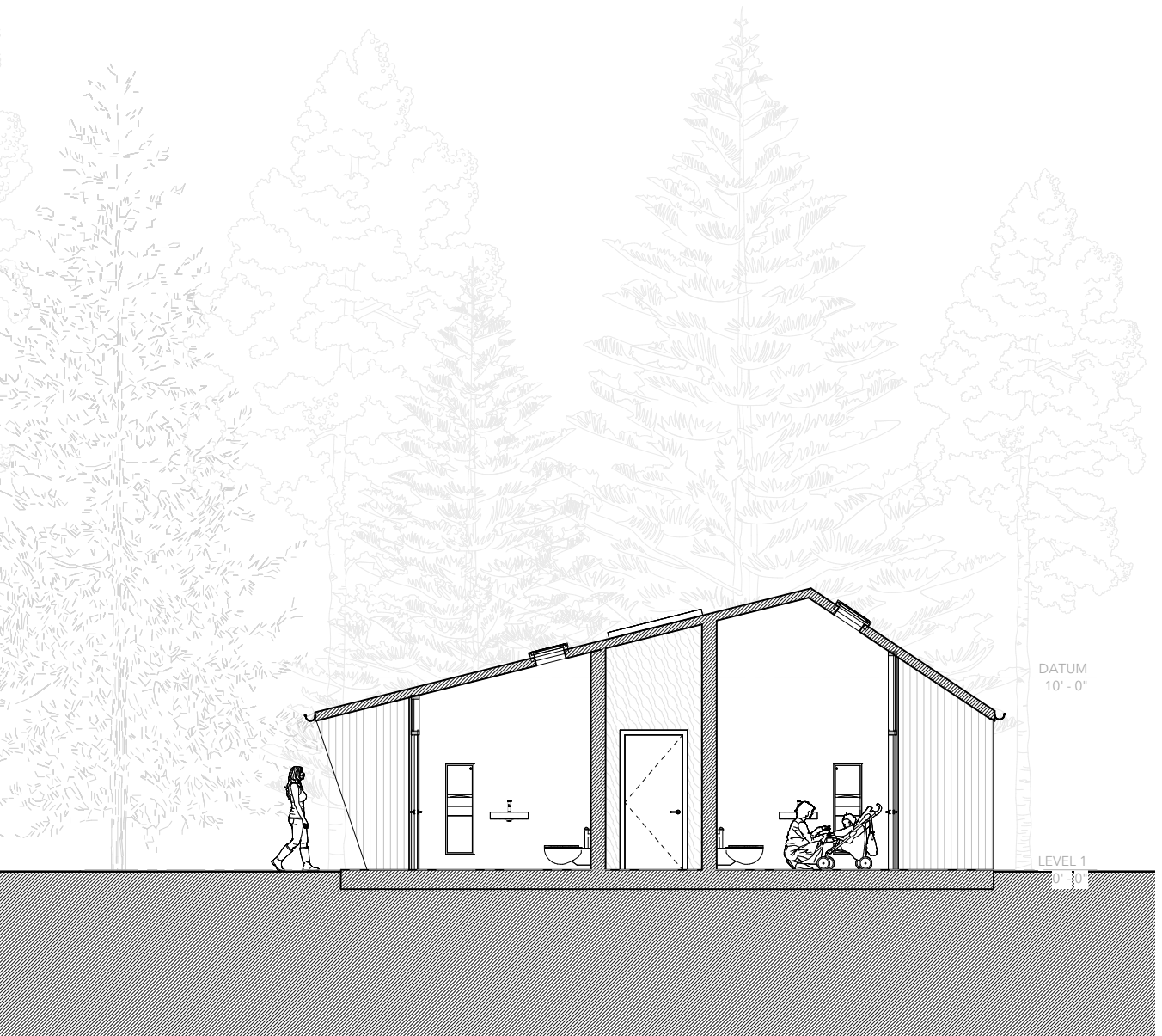


West Elevation



LARGE RESTROOMS

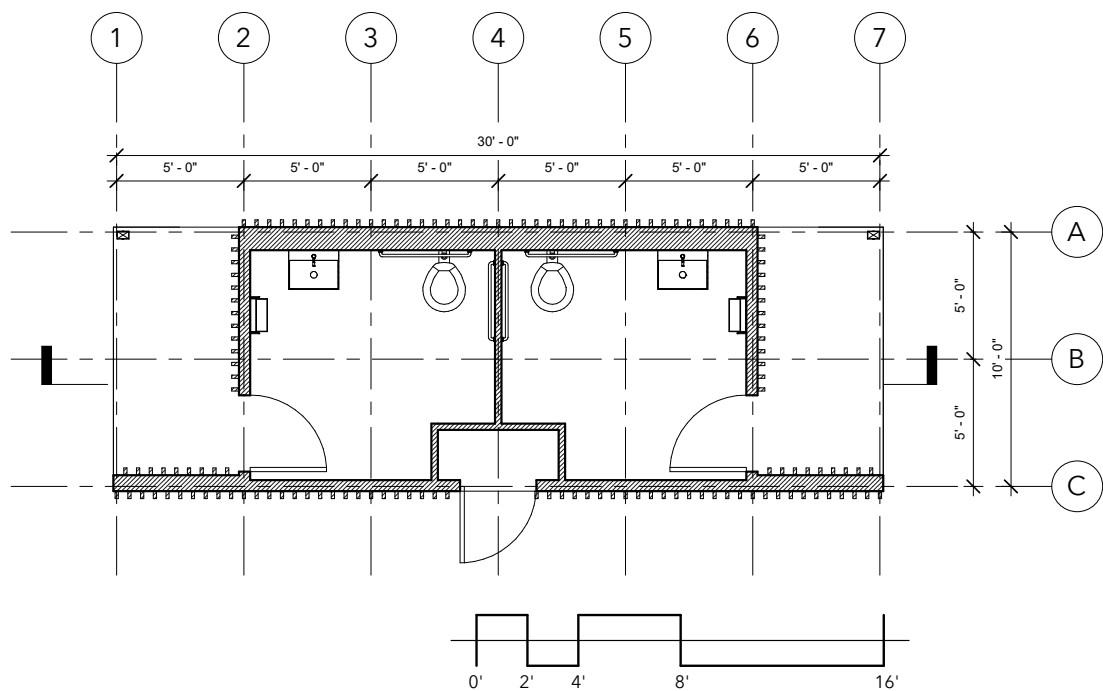




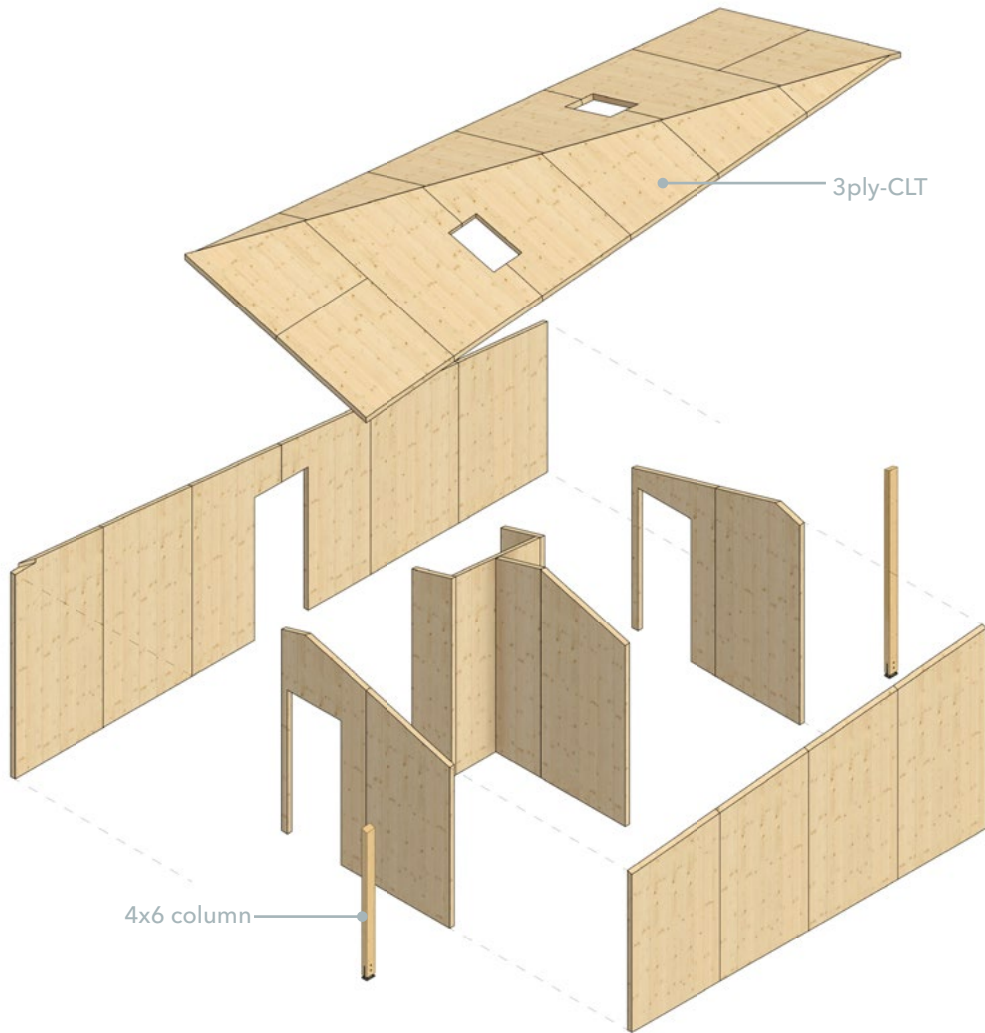




SMALL RESTROOMS



Floor Plan

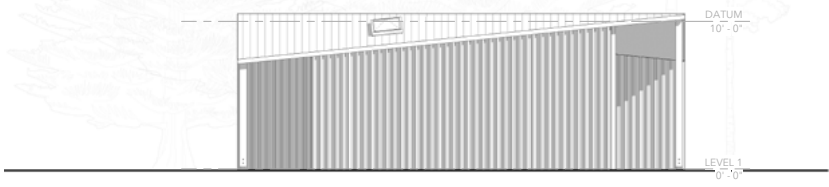


CLT and Structural Layout

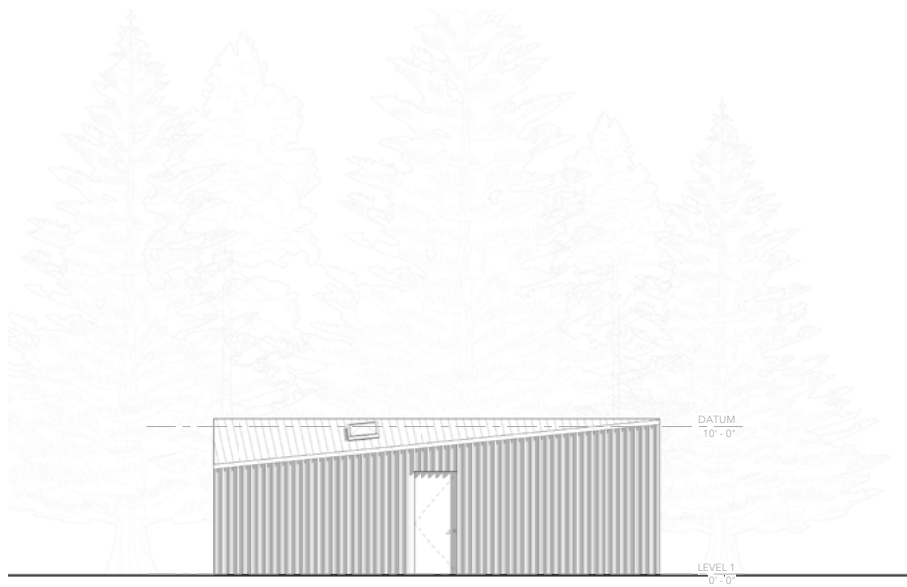
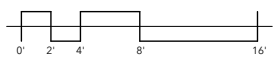




SMALL RESTROOMS

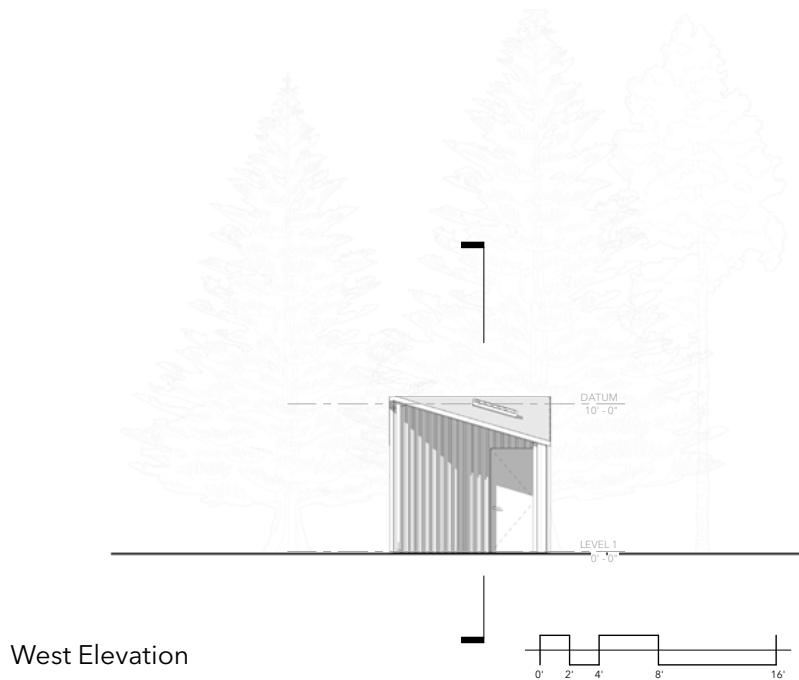
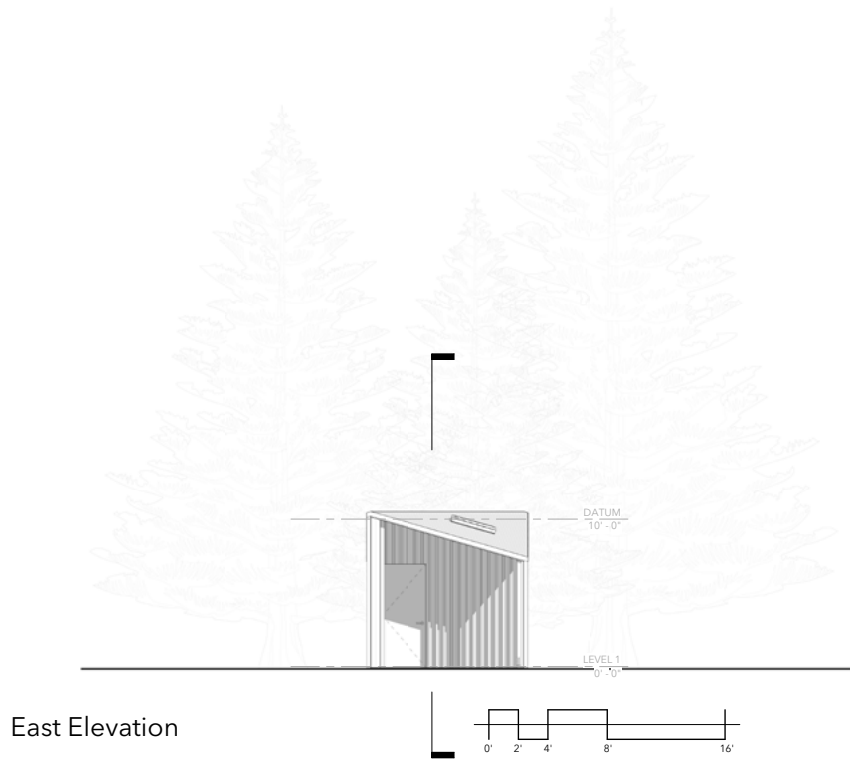


North Elevation



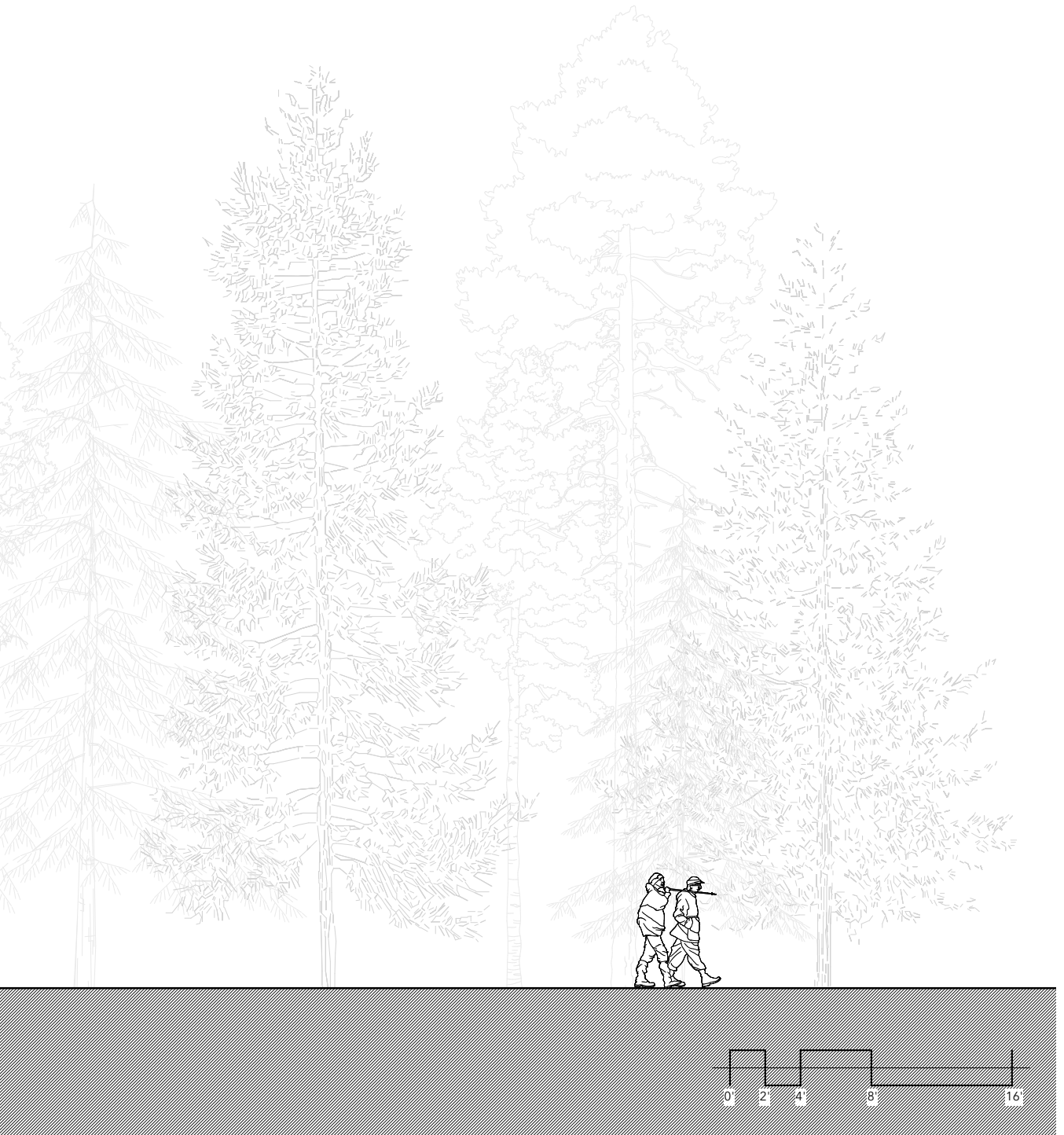
South Elevation





SMALL RESTROOMS









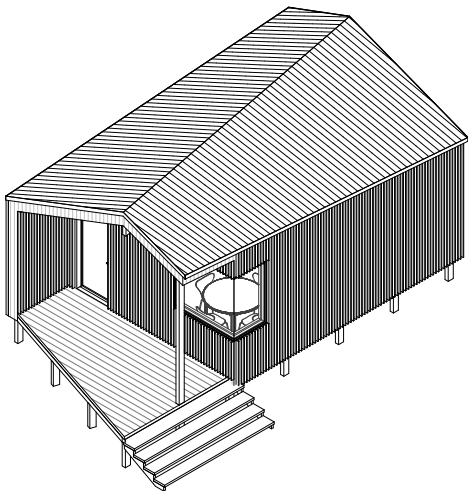
A scenic outdoor campsite with a fire, people, and a cabin in the background. The scene is set in a clearing with tall evergreen trees in the background and a body of water to the right. In the foreground, there are patches of green grass and small shrubs. A campfire with a bright orange flame is burning on the right. Two people are standing in the middle ground, and another person is sitting near the fire. A small, light-colored cabin is visible in the background on the right. The sky is blue with white clouds.

CABIN



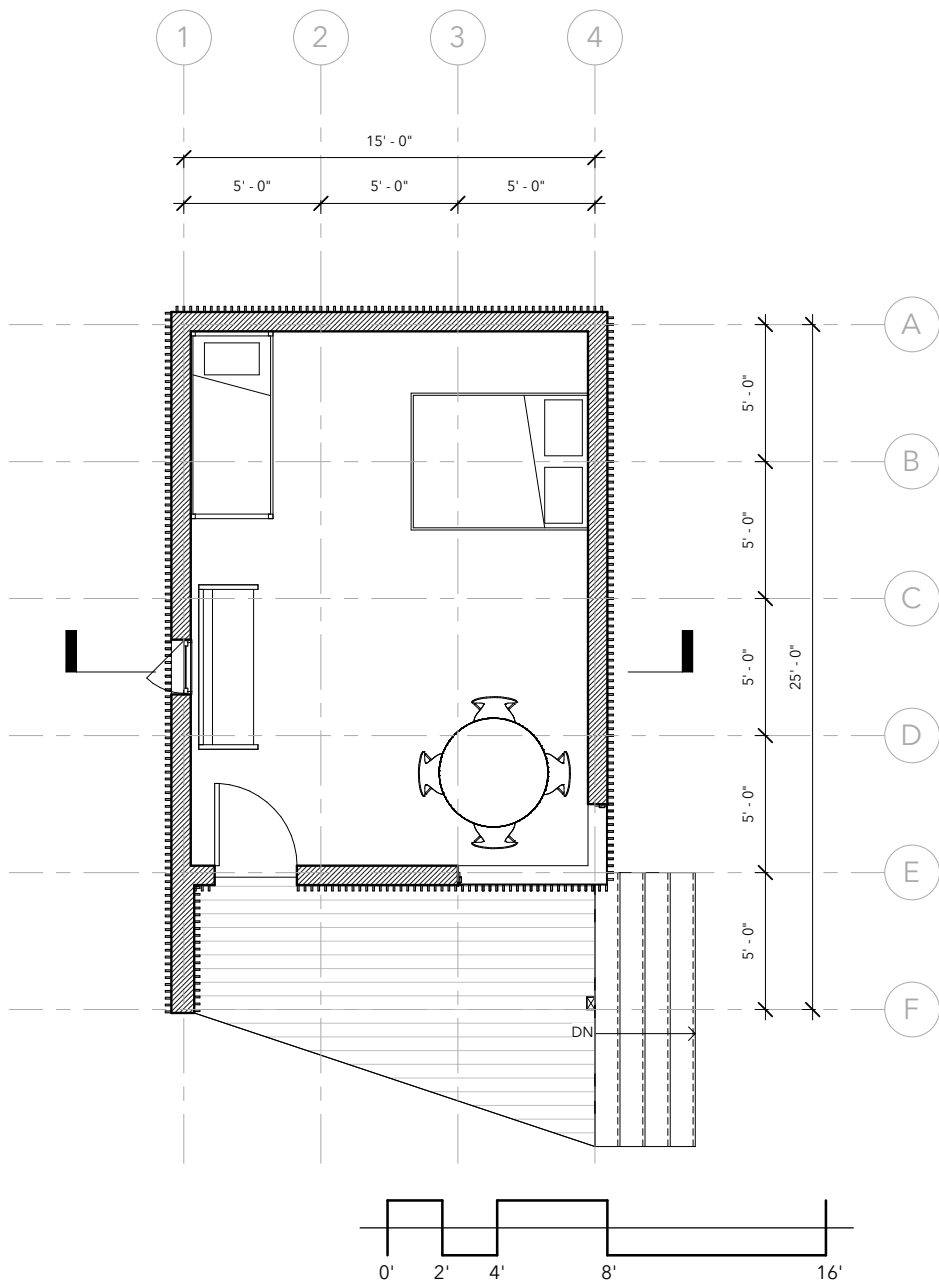
CABIN

The program for this building type is a one-bedroom space with designated sleeping, lounging, and eating areas. This structure requires 3-ply CLT, a ridge beam, steel collar ties, and a column to support the roof cantilever. The cabin is intended to be placed in nearly any condition and can be supported on a simple pier or pile system.

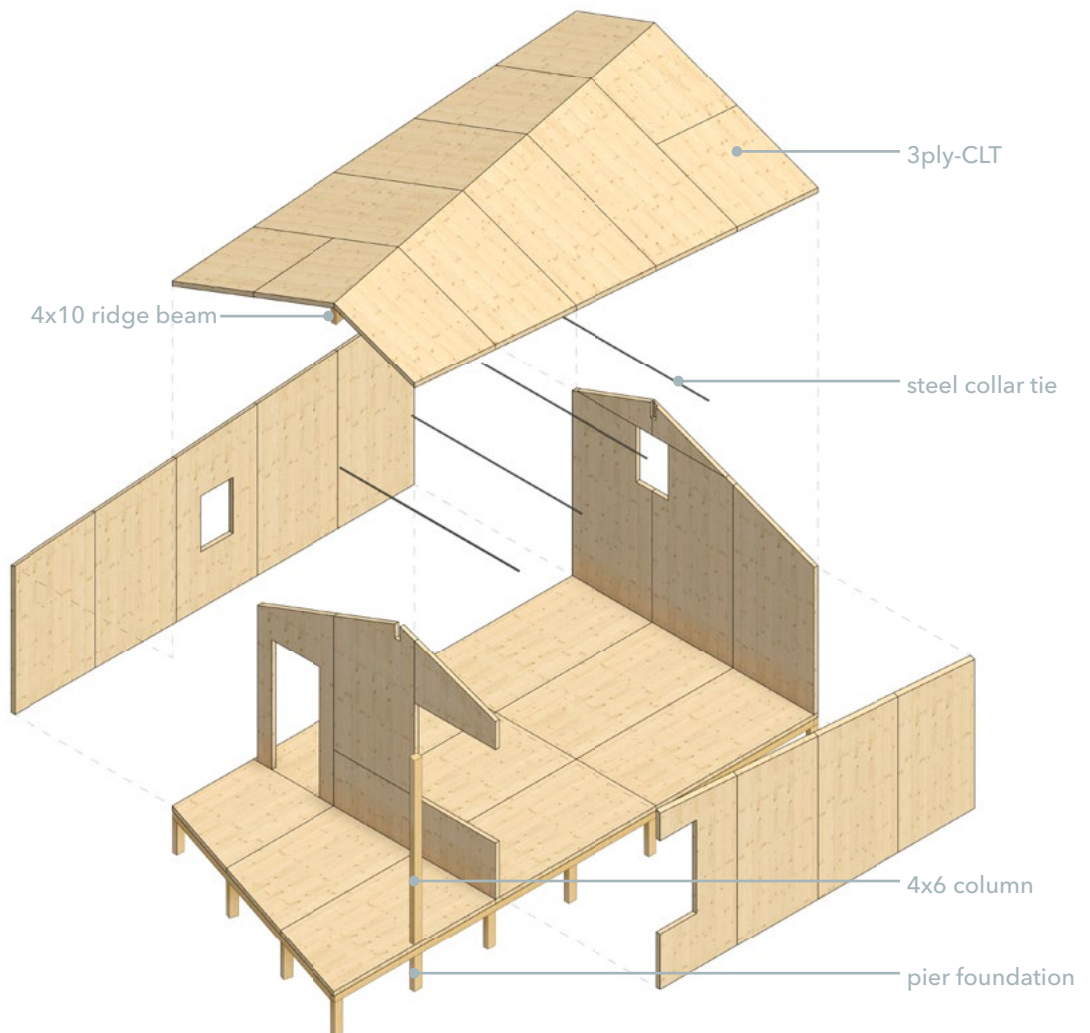




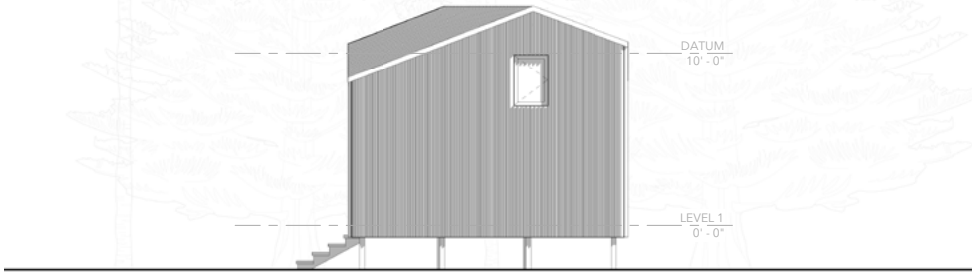
FLOOR PLAN



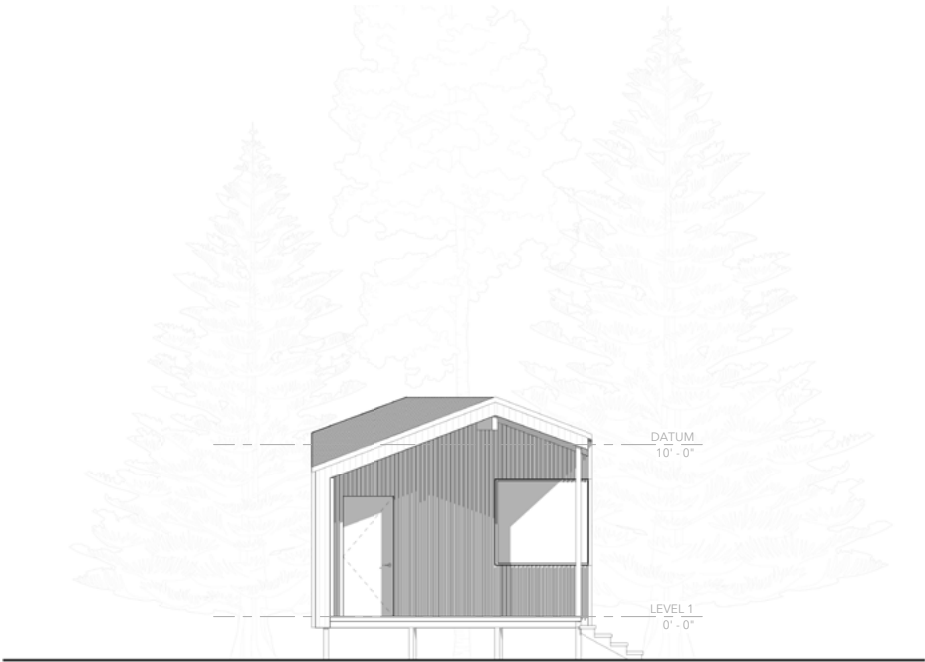
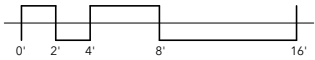
CLT AND STRUCTURAL LAYOUT



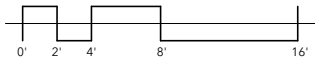
ELEVATIONS

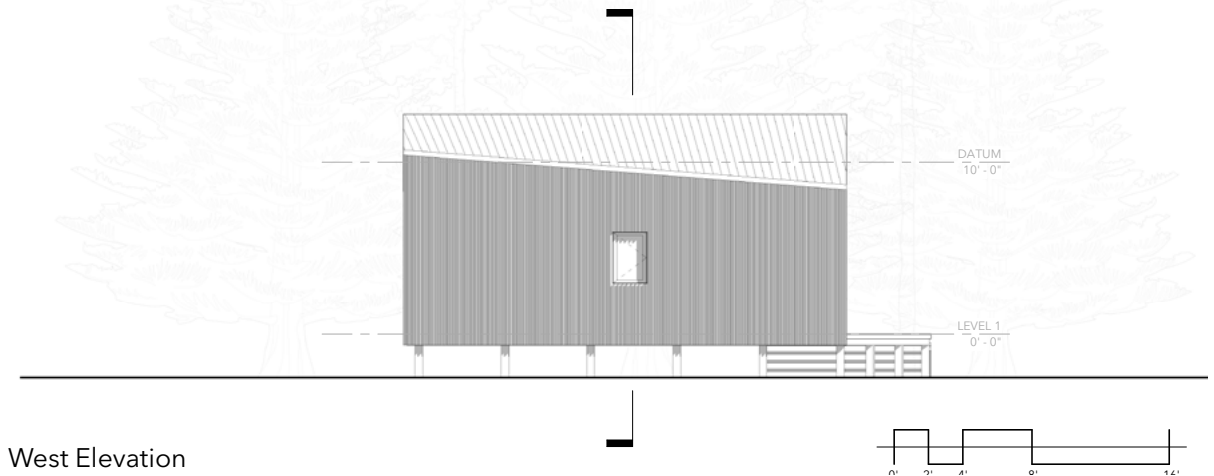
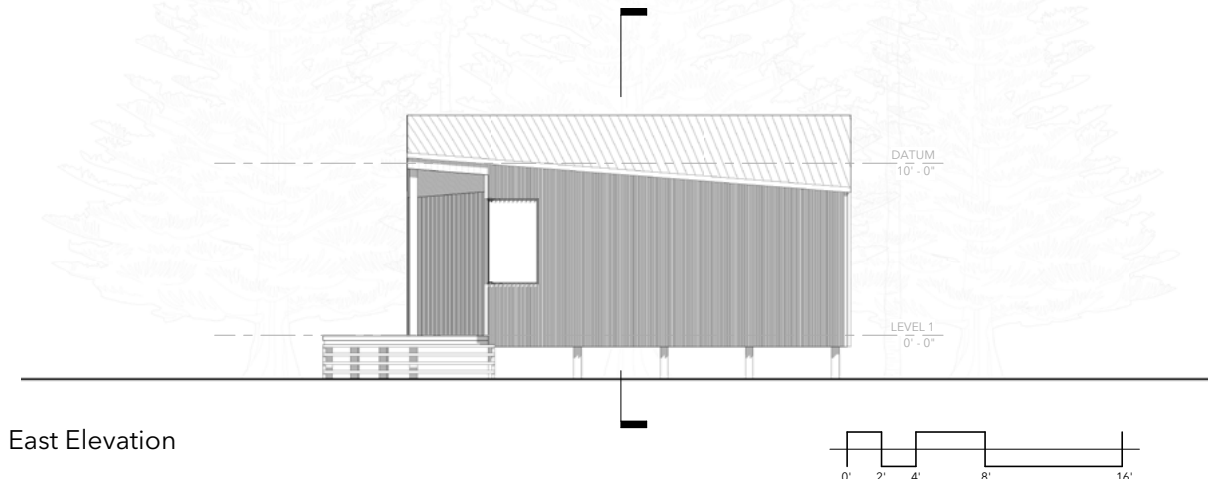


North Elevation



South Elevation

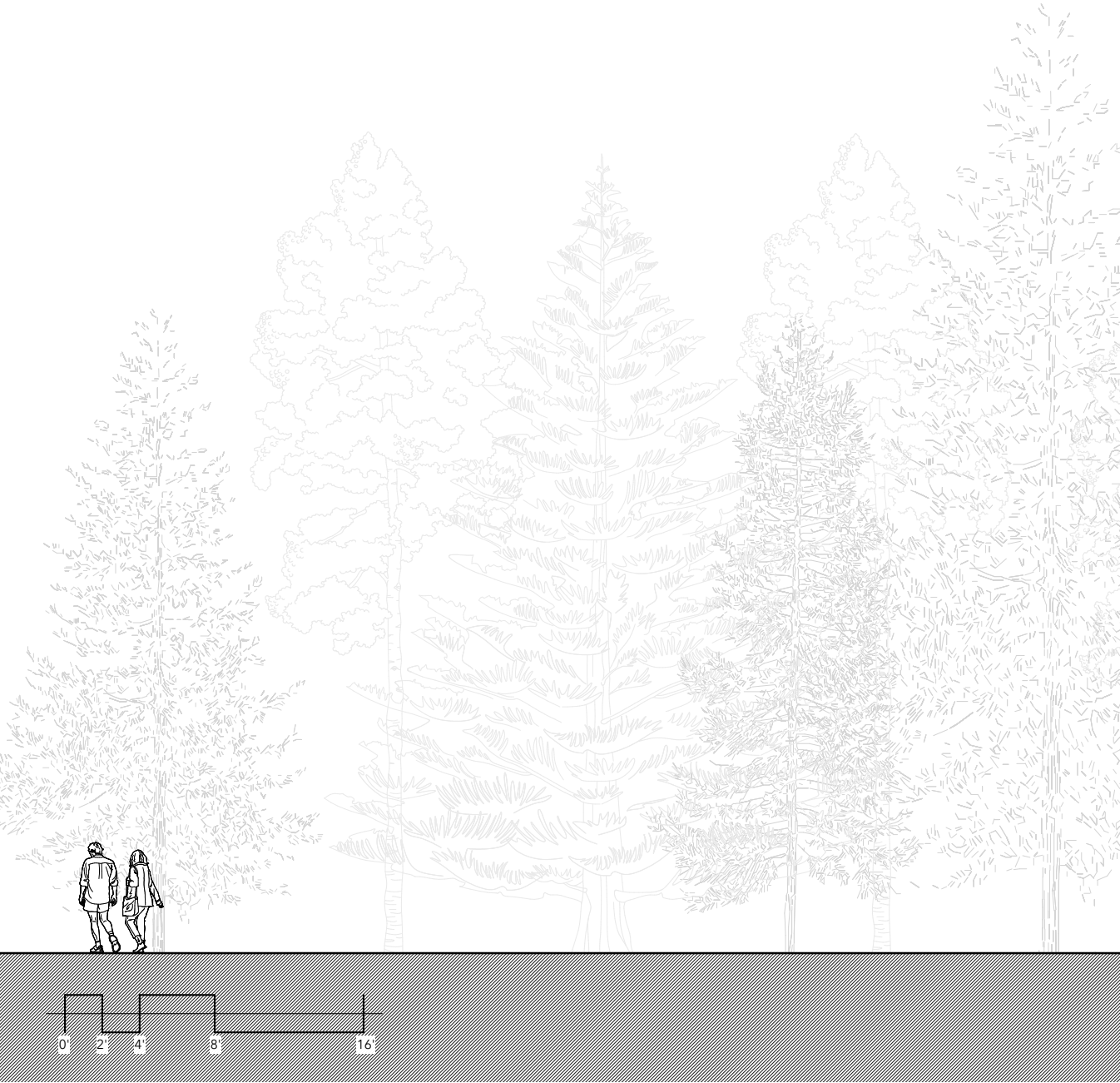


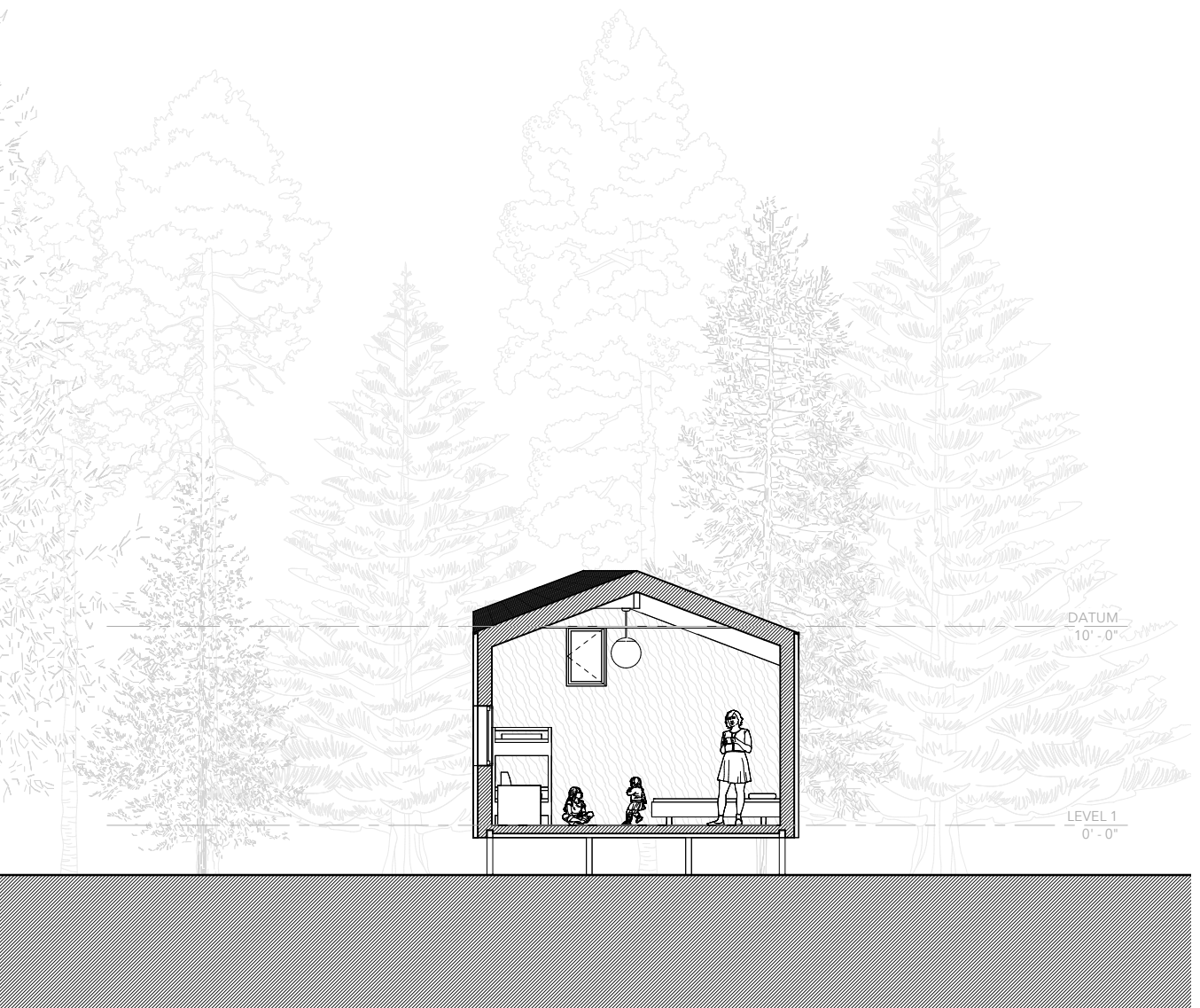






SECTION









A photograph of a paved road with a white arrow pointing forward, leading through a forest of tall trees. A red building is visible on the right side of the road. The text "ENTRANCE FEE STATION" is overlaid in the center.

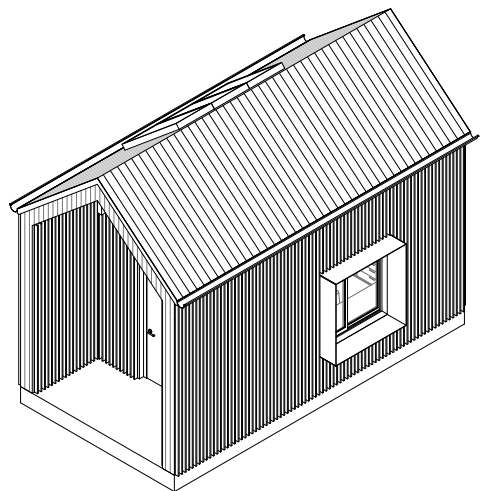
ENTRANCE FEE STATION



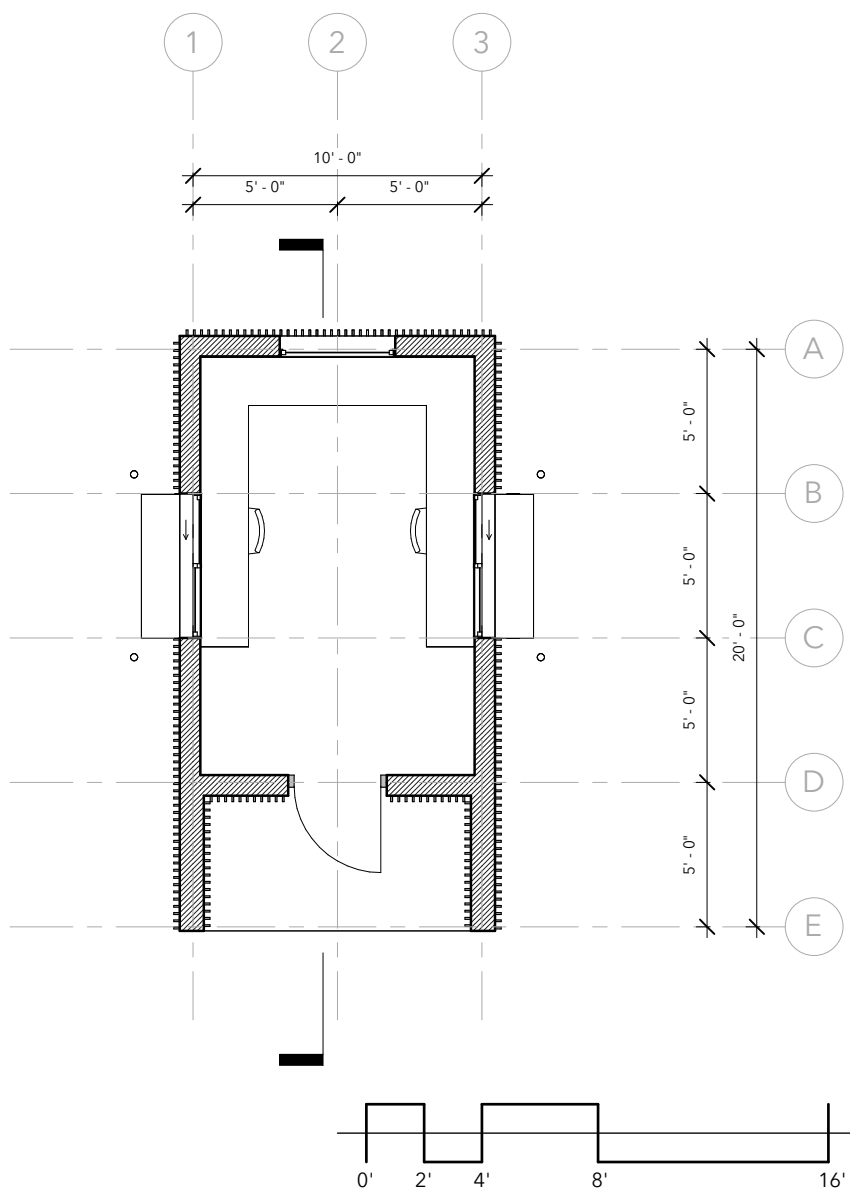


ENTRANCE FEE STATION

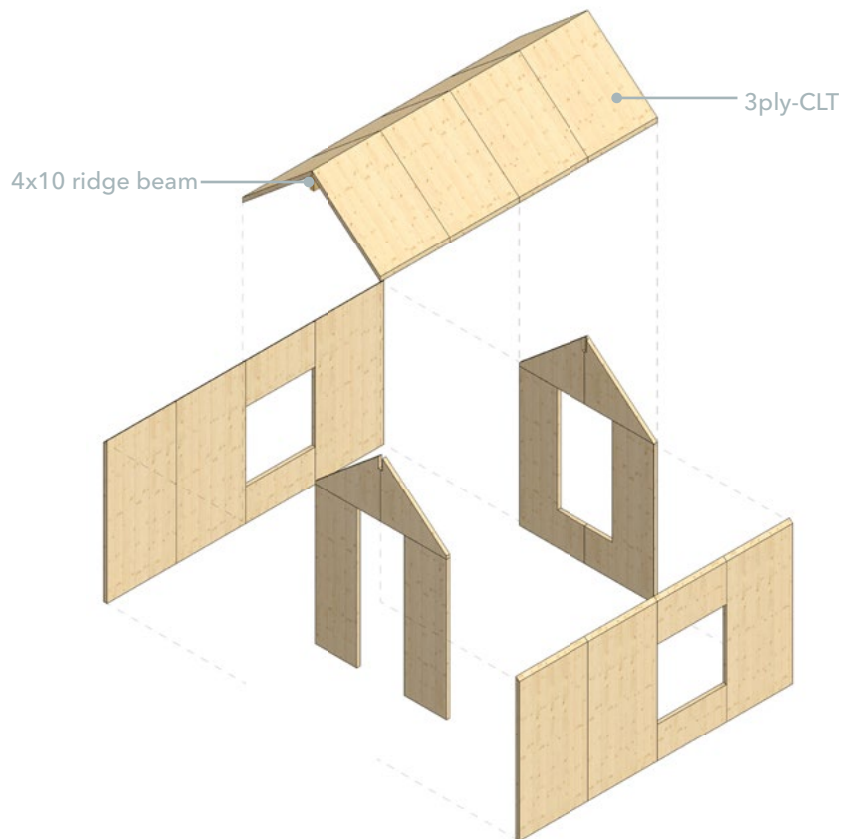
This small scale structure poses the least amount of limitations. Due to its small structural loads, the structure can be supported using only 3-ply CLT and a ridge beam at the roof. This program features adequate space for 2-3 park employees and drive-up windows for incoming guests.



FLOOR PLAN



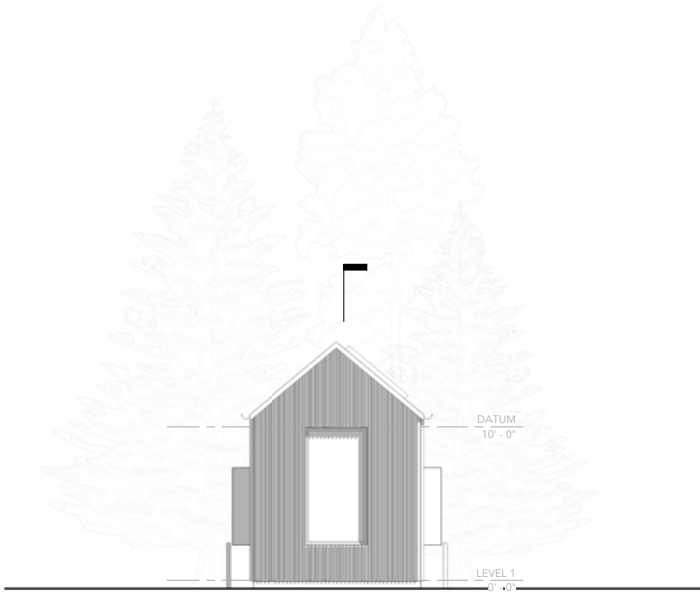
CLT AND STRUCTURAL LAYOUT



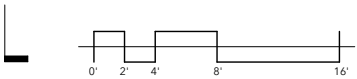




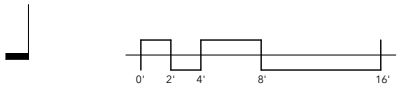
ELEVATIONS



North Elevation

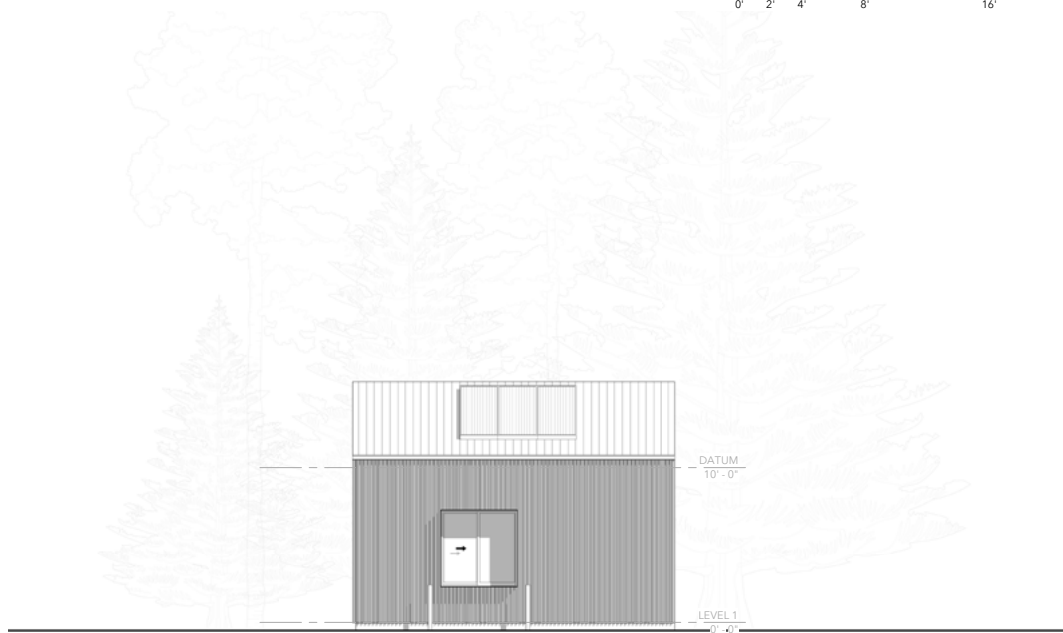
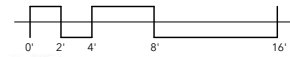


South Elevation

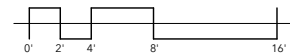




East Elevation



West Elevation

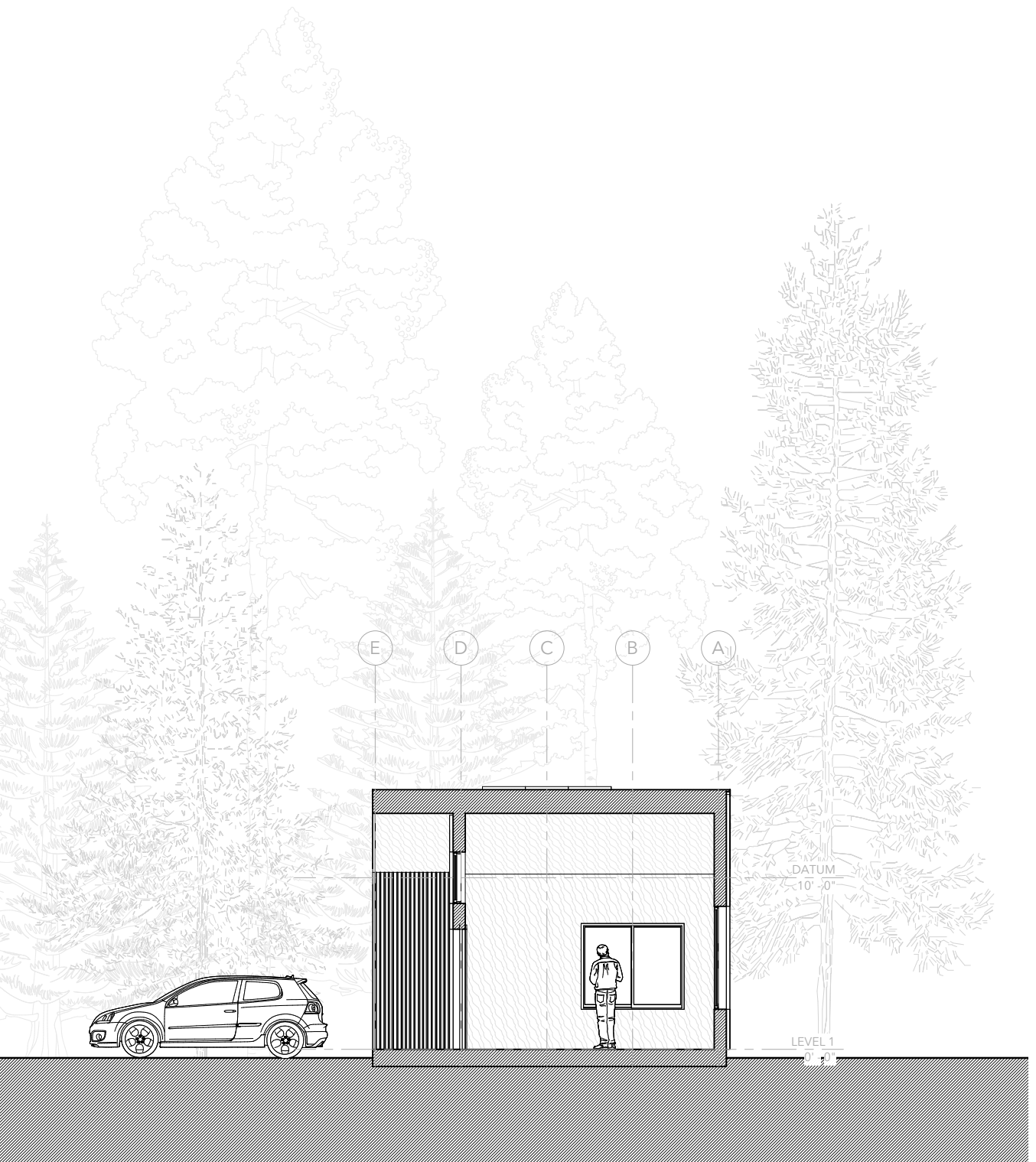






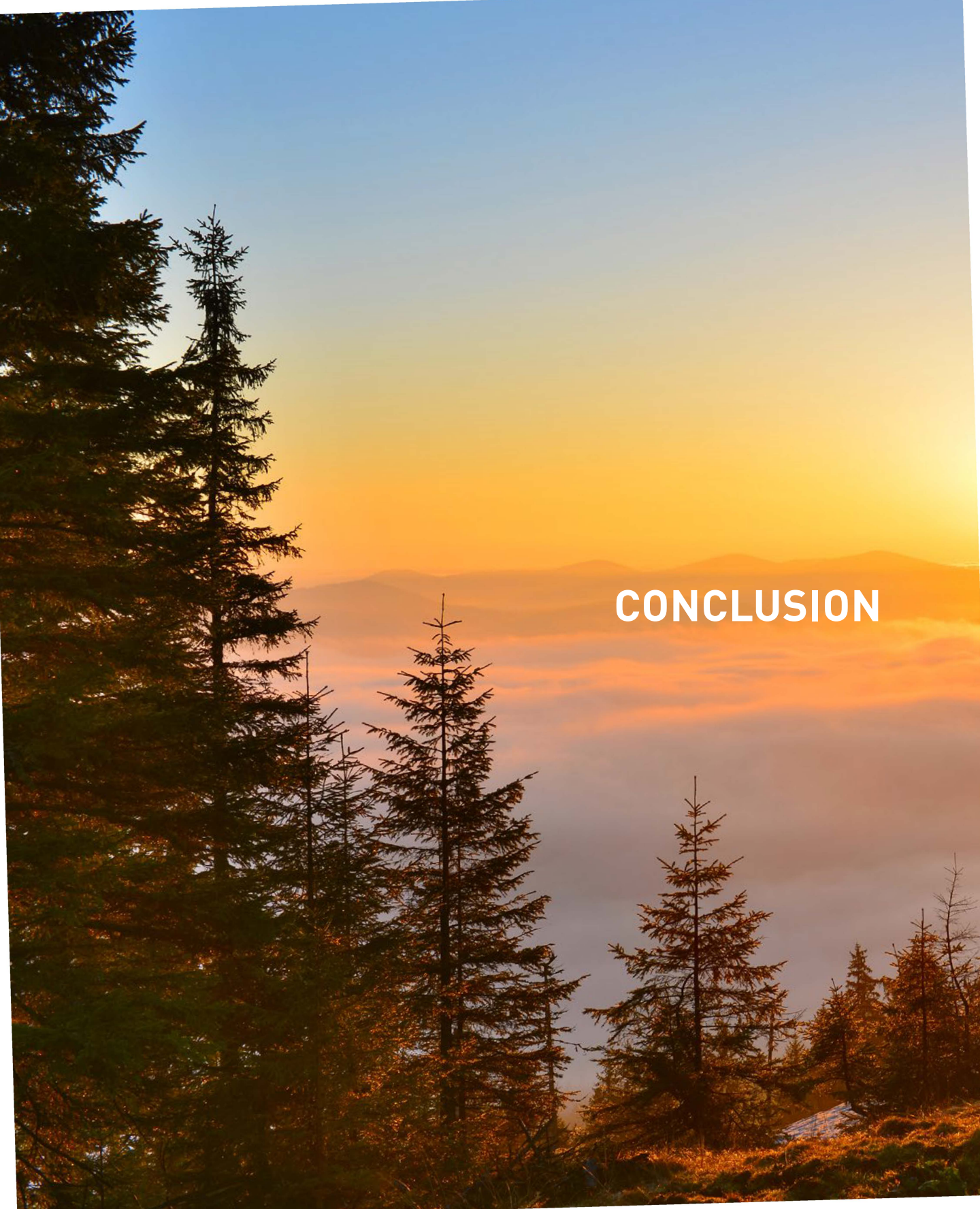
SECTION



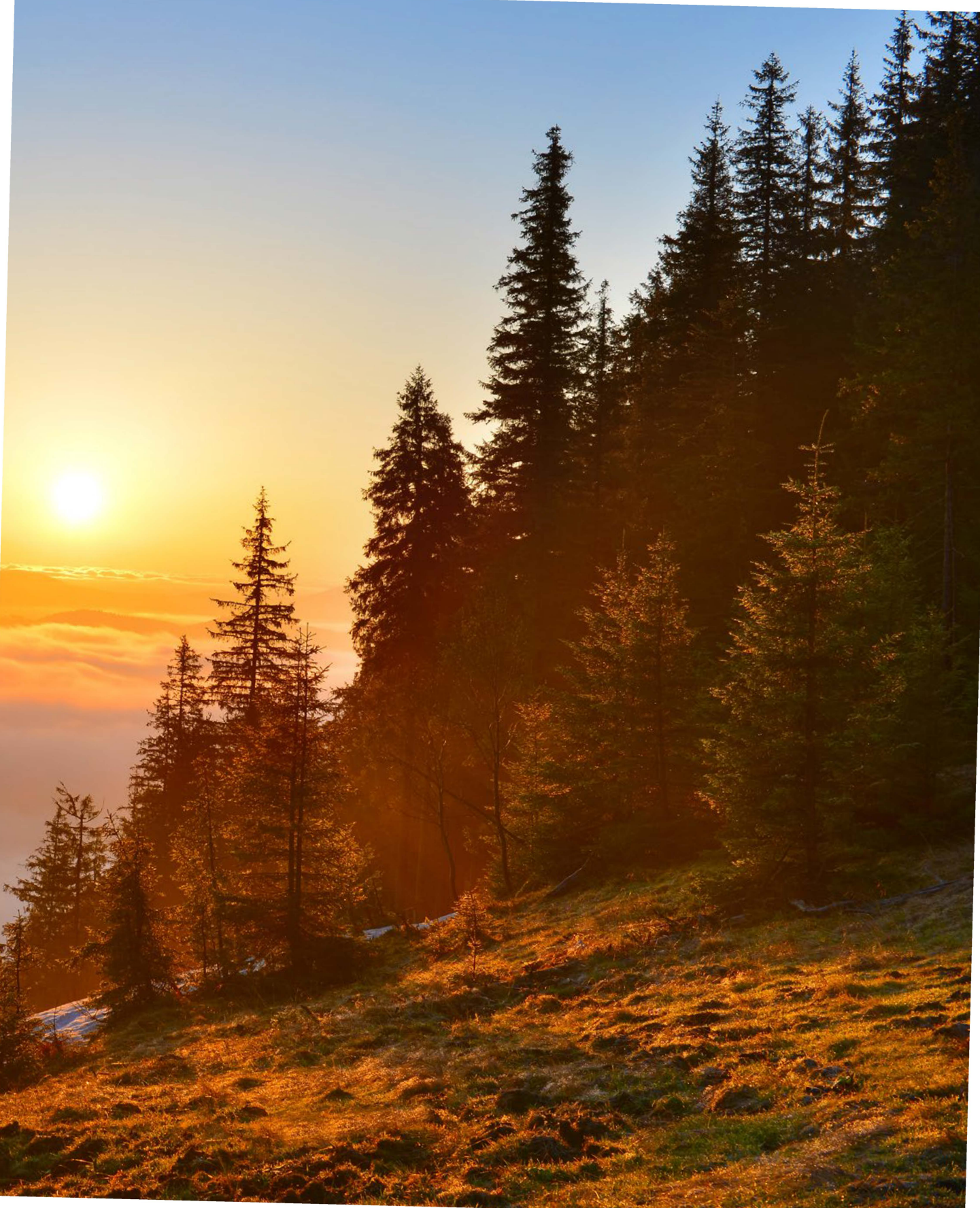








CONCLUSION



LESSONS LEARNED

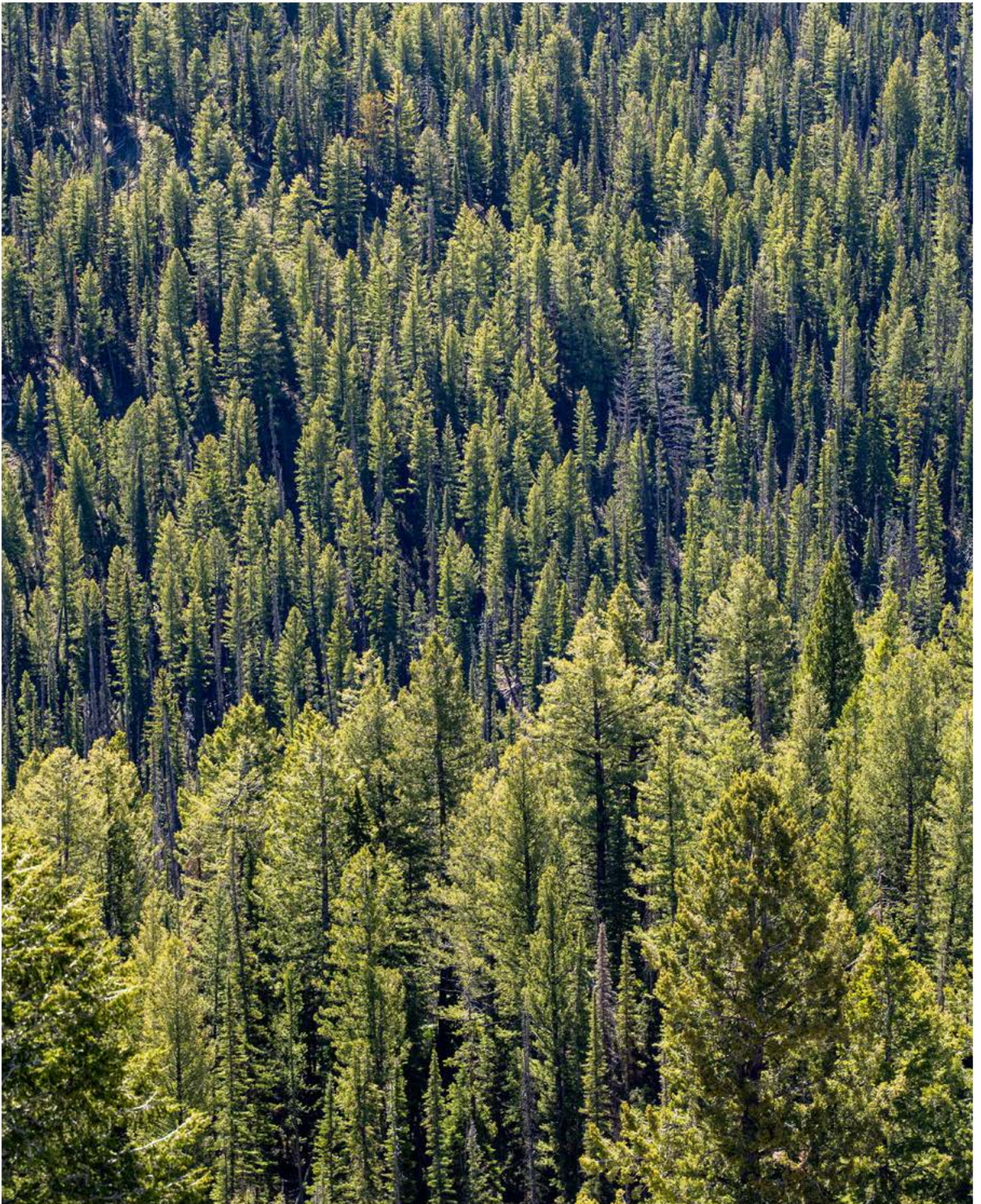
Although the structural properties of Ponderosa pine are less desirable than some other wood species, Ponderosa pine CLT panels can be an effective structural system with proper detailing and an understanding of small mass timber panels. Unlike most CLT panels on the market, 5ftx10ft Ponderosa pine panels have short spans which require integrating other structural systems to carry longer roof spans. These secondary structural systems can also be sourced from Ponderosa pine, but may not necessarily be Ponderosa pine or from forest restoration projects; heavy timber and dimensional lumber can either be sourced from a productive site, other low-value species, or can be recovered from past burn sites; it is important to note that Ponderosa pine can reach a diameter of 26in in 30 years and diameters of 30in to 50in are not uncommon for the species ("Ponderosa Pine (*Pinus Ponderosa*)," n.d.). These CLT panels also have significant height restrictions; because they are only 10ft tall, panels need to be stacked vertically in order to achieve taller wall heights. However, after consultation with Professor Mikhail Gershfeld, it is advised not to stack more than two panels in order to maintain structural wall stability.

Furthermore, compared to conventional light-wood frame and heavy timber buildings typically found in public lands, the Ponderosa pine CLT allowed for greater design flexibility in terms of architectural expression. Because the structures do not require conventional wood framing, the panels can be pre-cut to create more expressive forms that can be rapidly assembled. CLT also provides opportunities for faster construction time, less construction waste, off-site pre-assembly, and less on-site labor when compared to other construction types.

In conclusion, the exercise of designing public lands facilities from small-scale, low-value species mass timber panels sourced from forest restoration proved to be a viable construction type for replacing buildings in wildfire vulnerable areas.

FUTURE RESEARCH

This project addresses only one species and one CLT manufacturing process. There is much more research that can be done on alternative low-value species mass timber products from varying regions across the U.S. and Canada as well as on a variety of manufacturing processes (dowel-laminated timber, interlocking timber, etc.) that can make up an array of different mass timber products for local applications in the future. White fir, for example, is a low-value species that only has preliminary structural data, but could potentially be used in a similar application to Ponderosa pine in CLT. There are several recently completed and planned low-value species testing projects undertaken at the TallWood Design Institute and Oregon State University on Oregon-harvested Ponderosa pine in collaboration with Vaagen Timbers, and, additionally, white fir from California and Alaskan spruce using a more capital-intensive process with a large timber press; there is growing interest in the structural and commercial possibilities for these materials, along with the increasing local, less-capital intensive efforts as noted above (Bhandari et al. 2021) (Jahedi et al. 2021) (Macdonald et al. 2021). Furthermore, continued development of construction details and the application of these panels to other building types, such as housing and multi-story structures, is an important area of study. Much more work in this area will be coming in the near future and this project should become part of the growing efforts to create a sustainable mass timber industry in the U.S. supporting forest restoration efforts.



The background of the entire page is a close-up, vertical view of a wooden plank wall. The planks are light brown with visible grain patterns, including knots and wavy lines. They are arranged side-by-side, creating a rhythmic vertical texture.

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BIBLIOGRAPHY

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Note: Images with no source reference are courtesy of Adobe Stock or are personal photos.

For the Appendix, see separate document.

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