

fire//box: mass timber and disaster-relief architecture
2025 PIVOT Architecture Fellowship
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PIVOT
ARCHITECTURE



//frontmatter

"In order to change an existing paradigm you do not struggle to try and change the problematic model. You create a new model and make the old one obsolete."

-Buckminster R. Fuller

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A photograph of a forest fire. In the foreground, a large, dark log is being consumed by bright orange and yellow flames. Thick white smoke rises from the fire, filling the upper half of the frame. In the background, several pine trees are visible, some with their needles turned brown from the heat. The overall scene is dramatic and captures the intensity of the wildfire.

section 01 - defining the problem

Overview

Oregon currently faces increasingly demanding resiliency challenges in both wildland fire management and in preparing and mitigating the effects of existing fires, particularly fire's effect on low-income rural communities. As the Pacific Northwest begins to feel an uptick in the urgency of action, the architecture that shelters those who live in the Wildland-Urban Interface (WUI) and in rural areas will become increasingly important for the safety of at-risk Oregonians.



The 2020 Two Four Two Fire in Chiloquin, Oregon. Source: Evan Wright, OPB

The number of ODF-protected acres burned increased over 25 times the number of acres burned from 2019 (20,000 acres) to 2020, skyrocketing to 540,000 in just one year. Over 10 times that 2019 amount burned in the following year of 2021 (231,000 acres) (Oregon Department of Forestry, 2023). On average, the years between 2019 and 2022 saw an average of 118,000 protected acres burned yearly, while the previous decade (between 2002-2011) had averaged only 13,000 acres per year (Oregon Department of Forestry, 2023). This 800% increase in protected acres burned suggests that wildland fires are becoming increasingly larger, hotter, and more common, despite modern advances between cities of the past and current Oregonian urban planning and fire protection services.

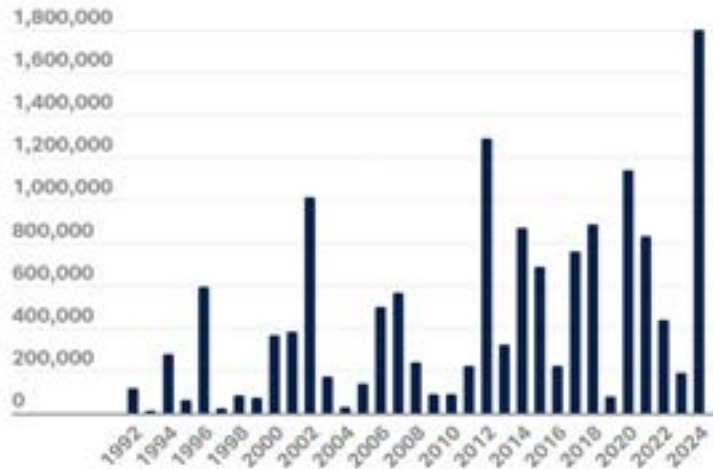


A home near the Columbia River after the Rowena Fire. Source: April Ehrlich, OPB

The past century has seen major fires near such as in the Tillamook or Yacolt Burns. These burns, particularly the four burns that destroyed the Tillamook State Forest, were though to be once-in-a-century freak accidents. However, fire has returned to modern Oregon's landscapes. 2002's Biscuit Fire began inside the 180,000-acre Kalmiopsis Wilderness and burned over 500,000 acres by its end (Robbins, 2021). The Kalmopsis wilderness, while adapted for fire, had become overgrown due to fire suppression efforts that allowed the overgrowth of underbrush. Oregon was given another warning sign in 2007, where the Egley conflagration amongst other fires consumed a near 50,000 acres, unprecedented in the years between 2003-2006.

Oregon's fire history, when observed from 1993 to 2012, maintained a relative pattern of four to five years of lull time between increasingly larger and larger conflagrations up until 2013. Fires have lost all pattern between lulls and stops since, increasingly exponentially in the number of acres burned and newly characterized by vicious and unpredictable intensity. At present time, official counts for 2024's fire season broke the records set by both 2020 and 2021. 1.9 million acres were burned in a nearly five-month long fire season that cost the state a preliminary 650 million (Baires, 2024). 2025's fire season burned a smaller 338,000 acres but consumed 200 structures, part of a worrying trend that sees fire creep closer and closer to communities.

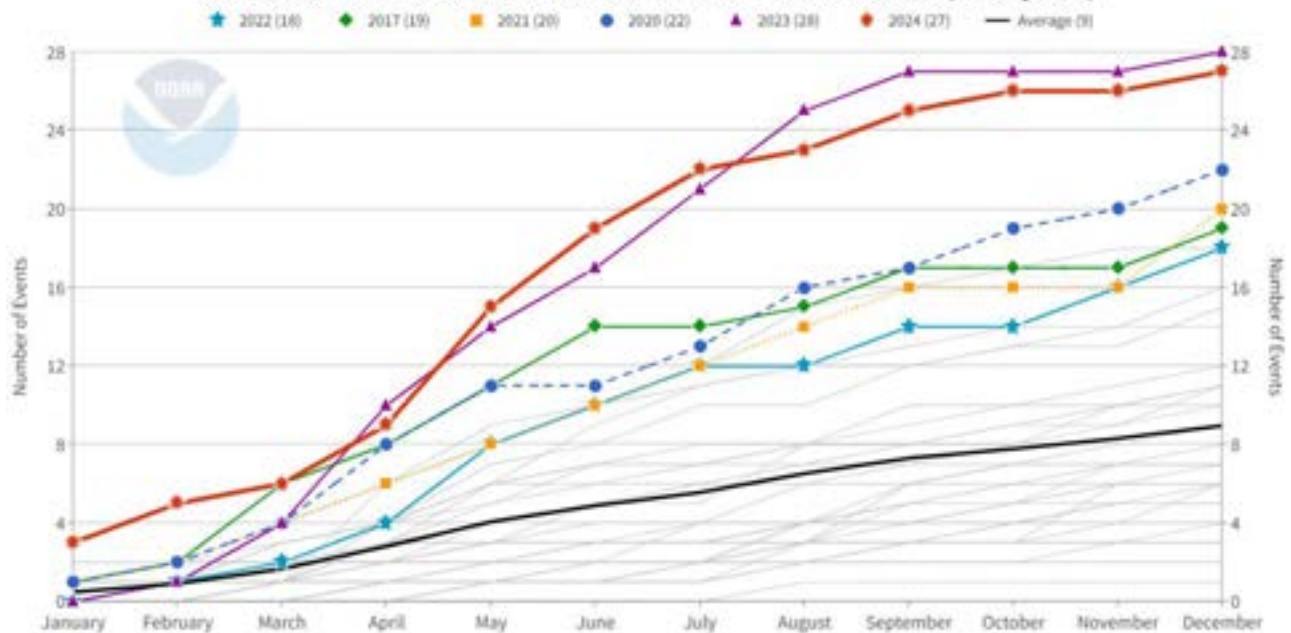
Total acres burned by wildfires in Oregon per year



*2024 numbers through Aug 5. Majority of acres burned in grassland
2002: **Biscuit fire** - 500,000 acres in southwest Oregon.
2012: **Holloway, Long Draw, Miller Homestead fires** - 964,051 acres in SE Oregon
2020: **Labor Day Fires** - almost 1 million acres burned around Sept. 7-8 in W. Oregon
2021: **Bootleg Fire** - 413,762 acres near Klamath Falls

Source: Forest Service Research Data Archive, National Wildfire Coordinating Group

1980-2024 United States Billion-Dollar Disaster Year-to-Date Event Count (CPI-Adjusted)



Patrick Skrip, the manager of rural Douglas Forest Protective Association, says new fires they fight today are part of longer fire seasons which are worsened by increasingly high temperatures linked to climate change. Higher temperatures all over Oregon suddenly push inhabited areas once reliably safe from fire's historic shed patterns into danger. All signs point to once abnormal weather, fire seasons, and high costs as a new and reliable standard.

Constant setbacks due to loss of infrastructure occurring with the all too new and all too consistently growing fire season do not bounce off Oregon easily. Oregon Constitutional Measures 5 and 50, as well as Oregon's tax code, land use laws, and a housing affordability crisis make rebuilding after natural disaster difficult. These factors have also stifled inflow of funds towards preventative measures that can help communities prepare for wildfires before they happen. Oregon's current building stock, particularly its housing, is marked by its age and its inflated price due to bottlenecks in material and labor costs and availability. With these roadblocks, architects need to be involved at the forefront of disaster relief design to lend their skills to those who need them most. A series of leading questions asks architects to research the following:

What are the best technologies and materials available to build resilient architecture?

How could our current methods of disaster preparation and response be improved upon?

How could architects cut costs and balance performance demands with design goals?

What would truly meaningful resilience in Oregon look like?

Challenges

Oregon is faced with a unique geography and habitat. The frequency of major wildfires is increasing, all while Oregon faces a major crisis in forest management.

The Wildlife-Urban Interface is hugely interlaced into Oregon's urban and residential fabric; out of Oregon's 2 million structures, 75% sit in the WUI, with 1/4th of Oregon's 36 counties composed entirely of communities identified to be at high risk to wildfire.

Current disaster-responsive housing options don't easily transition to permanent, high-quality housing. Many after disaster most spend years waiting for new homes and experience further setbacks caused by the lack of or lackluster options available to them as temporary or transitional housing.

Insurance services provided after disaster as related to home and business insurance may not be able to fully cover rebuilds or fully restore homes. Builders may be overwhelmed with volume after a disaster. Rising construction and material costs will make the job harder, and Oregon's confusing system of property tax and building law may restrict rebuilds and new developments.

After disaster, the most affected members of Oregon will be its poorest, oldest, and least formally educated. Legacy community members, like seniors on fixed incomes, are often forced to leave their home states to purchase cheaper property elsewhere after a disaster. This demographic flight can rob Oregon of the people who know and love it best.

Scope

The explicit focus of this project will be mass timber, and its application in disaster relief. Ultimately, it was very difficult to narrow down a topic that inherently involves failures from multiple systems at almost every scale of society, and which has an infinite number of possible solutions. I have chosen only to define what disaster relief architecture should feature, and why mass timber is unique to other solutions as is specifically possible in Oregon.

Mass timber and modular construction has been a hot topic in the Pacific Northwest since the early 2010s, picking up steam with a string of progressively extreme wildfires that have robbed many communities of their homes. Mass timber structures massively save on construction time, provide higher fire and seismic resistance, and can be flat-packed or volume-built and shipped to areas in need. Challenges remain in creating a model that is affordable, fire-proofed, and ready to be deployed. Designers must also work to make disaster relief look and feel community-appropriate.

This project is composed of six main chapters, which explore relevant literature on and innovative examples of disaster relief architecture, mass timber construction, modular building, and resilient communities. With limited resources, the design and funding for disaster relief architecture needs to maximize the value for cost, while managing to create works that are true to community needs. In order to create a scope of study relevant to architecture, laws and history discussed as in relation to fire and seismic risk management will be limited to those that directly affect the dollar values of and the performance requirements for residential architecture.

This project is a direct followup to a previous project, *fire//place*, which contains further background information about the basic material science and formal composition of fire-resistant structures. That project also advocates for the use of mass timber, biogenic materials, and hyper-local materials sourcing, while placing an emphasis on architecture's impact on the environment. As many already know, buildings and the construction industry are top contributors of carbon emissions into the atmosphere both in the extractive manufacturing of materials and in operational costs of building maintenance. The biggest new contributor of carbon emissions to the atmosphere is wildfire, now dwarfing the contributions of industry. Increased wildfire has in part been directly caused by way of climate change due to the emissions of our architectural industry. The self-defeating process of build, emit, burn, and repeat creates a vicious new feedback loop.



Thesis Statement

Disaster relief architecture is a distinct field that draws on features of modular, affordable housing, and trauma-informed design; mass timber is uniquely poised to meet the design demands of current relief models because of both mass timber's material properties and because of Oregon's current need for a viable incentive to solve its forestry management and wildfire crises.



**Aug. 14,
1933**
Tillamook Burn begins



1980
Oregon's timber industry begins to collapse
under economic depression



2018
The California Camp Fire claims 88 lives
and destroys a whopping 27,000
structures, making it the deadliest fire in
California's history.



2020
A huge fire season decimates both Oregon
and California. In Oregon, the Alameda Drive,
Santiam, Indian Creek, Beachy Creek, Slater,
Riverside, and Archie Creek fires were all
characterized by either huge acreage or high
loss of life and structure.

1973

Oregon establishes
Senate Bill 73, which
creates State Building
Code

1859

Oregon is settled and
admitted into the Union.
Trading and logging
bolster its development
as a new state.

1973

Oregon establishes Senate Bill 100, the
first of many land use bill efforts meant
to conserve land for farming and timber
harvesting. SB 100 and related bills in
Oregon have dictated the formation of
the Urban Growth boundary and have
created "anti-sprawl" policies.



2013

Oregon publishes its full Oregon
Resilience Plan, a comprehensive
assessment of Oregon's disaster
preparedness and infrastructure.
The plan indicates Oregon is in major
need of seismic retrofit.



2020

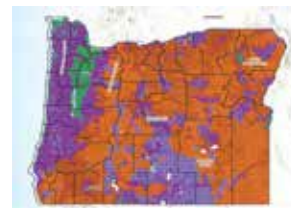
California passes AB3074, requiring
"ember-resistant zones" around homes.
Fire Hardening Disclosures by homes in
zones. AB38 essentially





May 1, 2022

Oregon's first USRC platinum building, the Oregon State Treasury Resiliency Building, opens its doors. This building was funded by the BRIC program.



March 21, 2025

The Oregon House files House Bill 3944 to repeal SB 678 and SB 83.

Many counties had appealed their ratings, citing exploitative use of the map by fire insurance companies and map inaccuracies. Additionally, many homeowners rejected mandatory home hardening requirements, citing expense and an overstep of authority.

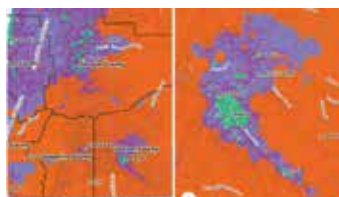


July 11, 2022

The Oregon Building Codes Division announces a new grant program that incentivizes fire hardening for those who have a claim to a structure damaged in the 2020 wildfires. This program continues to run in eight counties, including Lane.

June 30, 2022

ODF and OSU make the official Wildlife-Urban-Interface map available to the public as part of Senate Bills 762 and 83. This map both officially defines the WUI and marks high and extreme risk tax lots in each of Oregon's counties.



April 4th, 2025

Secretary Noem's direction of FEMA leads to the end of the Building Resilient Infrastructure and Communities program, describing grant funds as "wasted and ineffective."

Feb. 10th, 2025

The Eugene City Council approves a Fire Service Fee as part of a strategy to address citywide budget gaps worth 11.5 million and to newly staff a fire department that has remained the same size since 1981.



2021

ing intense fuel reduction to create homes, and later AB38, requiring homeowners in severe fire hazard mandates fire retrofitting.



The Amenity Trap

The “Amenity trap” refers to areas that are primarily economically driven by tourist access to natural features, like oceans, forests, mountains, and lakes. Recreational appeal creates an influx of short-term visitors who do not own homes in the area, which places unusual seasonal or event-based strain on the amenity-rich destination. These tourist floods may not produce the funds to pay for infrastructure costs and damage to natural amenities because of a reliance on local property tax for monies.



Features of amenity-rich places.
Source: Headwaters Economics

Beautiful natural areas also attract big spenders, such as retirees, developers, and remote workers who have incomes supported by ventures not tied to the amenity areas. Without the proper preparation for an influx of new residents, amenity areas can struggle to come up with the money to protect their own resources and keep prices down for original residents. Oregon is a classic example of an amenity trap community, facing similar challenges to much of Colorado, Montana, and California.

Wildfire, Land Use, and Housing



Houses along a Portland Urban Growth Boundary.
Source: AP Photo/Jenny Kane

Why is wildfire now such a acute issue as opposed to years past? The answer lies in how Oregon has mishandled its status as an amenity-rich place. Wildfires in Oregon are worsening due to three primary factors: long term economic depression combined with unique land use and tax law, forestry mismanagement, and climate change.

Climate change has produced an age of mega-fires that has shaken not only Oregon but nearby California and Washington, as well as a growing number of Southwestern and West South Central states. Wildfires as related to climate change are more frequent due to rising temperatures which dry out vegetation, aggressive and out of season winds which increase the wind-borne carriage of embers, and changes in pest populations that can kill off plants en masse. Climate change would have inevitably increased the likelihood of fires in Oregon and will continue to do so. However, there are major legal roadblocks in place that discourage preventative forest management, increase barriers in rebuilding those who have lost their homes after wildfire, and prevent the development of new fire-wise housing. These specific roadblocks disproportionately affect and confuse Oregon's marginalized communities.

First and foremost, Oregon is uniquely dependent on property tax for revenue to fund civic necessities, because many Oregonian city general funds do not receive revenue from income or sales tax. City general funds typically cover fire, police, library, parks and recreation, and community development. However, property tax rates are subject to regulation as defined by fixed limits on the yearly rise of property tax as was outlined in Measures 5 and 50, which were passed in 1990 as amendments to Oregon's constitution.

Measures 5 and 50

Prior to their passage:

- Full market value of property was taxable.
- There were no separate definitions of assessed value, as there are now.
- Most levies were limited to an annual growth rate of 6%, unless approved by voters to exceed.

Measure 5, passed in 1990

- Set tax rate limits based on the real market value (RMV) of property.
- Set caps for education and general government taxes: For every \$1,000 of a property's real market value, taxes can't be higher than \$5 for education and \$10 for general government.
- Shifted K-12 education funding to the state. Before Measure 5, local property taxes generated two-thirds of school funding — local property taxes now fund one-third.

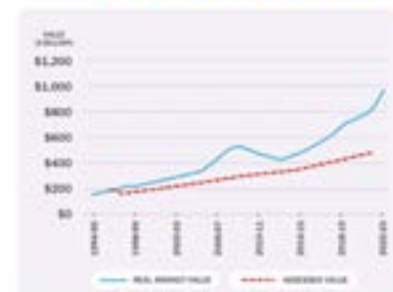
Measure 50, passed in 1997

- Replaced existing levies with permanent tax rates, an effective cut of 11%.
- Required property taxes to be levied on assessed value instead of real market value.
- Created the Changed Property Ratio to establish assessed value for new construction.
- Set a limit on increases in assessed value of 3% per year.
- Created local option levies with voter approval to fund operations or capital projects, which can be reduced if Measure 5 limitations are exceeded.

Summary of Measures 5 and 50. Source: City of Eugene



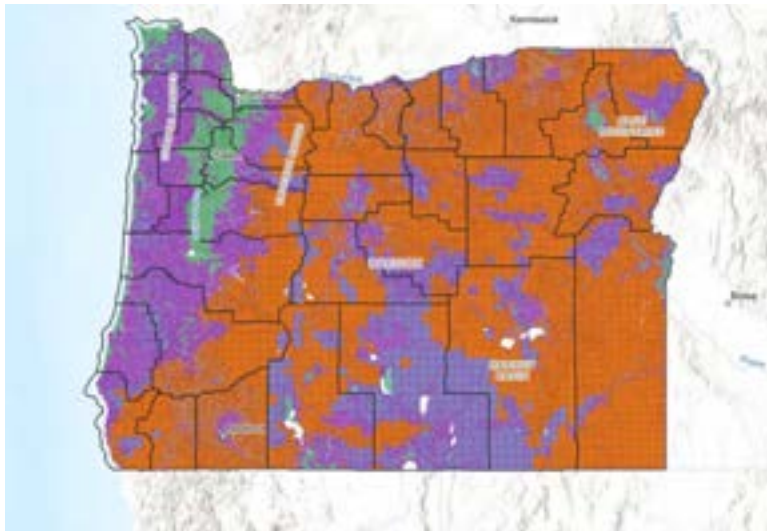
Assessed vs. Real Market Value of Properties in Oregon



AMV vs RMV growth in Oregon. Source: City of Eugene

Measures 5 and 50 redefined early calculation of property tax via the division of a tax levy by the Real Market Value of the home to a system based on Assessed Value. AV is determined by the government based on RMV and Maximum Assessed value as was set in the 1997-1998 tax year, whichever is lesser. Whereas previous taxes could include tax on the RMV and increases were limited to 6%, post-1990 property tax increases are capped at 3%.

Using AV to assess taxes effectively means that property tax on new construction takes longer to generate the same tax value for cities as older homes; for example, new student housing built in Lane County in 2023 had an RMV of 90 million but was only subject to property tax on the AMV value of 36 million (City of Eugene, 2024). This problem compounds when measures which try to incentivize new housing developments, like temporary property tax exemptions, introduce population growth stressors on civic services that project property tax will not cover. Oregon is also the only state in which assessed property values are not reset to market value after sale, which means that the homes with the same sales price can be subject to different amounts of property tax based on the year assessed. This practice largely favors older homeowners who own homes initially assessed at low values.



The now repealed draft wildfire risk map outlined in SB 762; areas of greater risk are in orange. Source: OSU

This loss of property tax income is creating increasingly strained fire and police budgets in Oregon's city governments, which makes managing natural wildfire, arson, public safety, and evacuation much more difficult. The tight budgets also mean that preventative measures against wildfire, such as home hardening programs, fall to the wayside. Oregon's unique "kicker" law has historically prohibited the state from saving money for future emergencies as a way to offset slim budgets at the city level. The law, established in 1979, returns higher-than-expected tax revenue to tax payers. Newly proposed 2025 reforms in Senate Bill 1177 have argued for allocating the kicker bill towards a wildfire relief fund, but the bill is not yet passed.

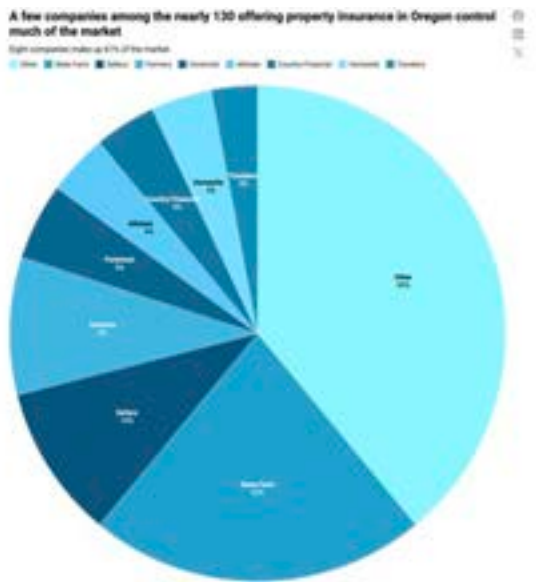
Measure 5 and 50's application to new construction can also surprise homeowners who may be rebuilding after wildfire, where the same laws that capped Eugene's aforementioned student housing property tax revenues can still produce new property tax rates devastating to individual homeowners building anew. As one victim of the Santiam Canyon fires described, she "...didn't have the option to replace my home built in 1968 with a 1968-valued home" (Sherwood, 2024).

Senate Bill 1545 tried to prevent this effect from occurring by resetting the tax rate for wildfire victims as long as the homes are built on the same footprint. This approach incentivizes wildfire victims to rebuild within the same place and without improvements to the homes they formerly had, which may or may not be the best decision for those in wildfire-burdened areas. Oregon also attempted to pass legislation (SB 762 and SB80) which required home-hardening upgrades to existing homes and included a wildfire hazard map. However, rural communities complained that the map caused a decrease in the property values of their homes and contributed to insurance rate hikes, while many could not afford to conform to new home-hardening laws. The bills were repealed, with only new builds required to meet hardening standards.

Measure 5 and 50's terms do not aid in the ongoing Oregon housing crisis, which is characterized by a severe lack of affordable housing for populations with low incomes. The average home price in Oregon in May 2025 was 550,00 dollars, which means that the average home is affordable to the less than 20% of the Oregon population who earn \$120,000/yr and up (OHCS, 2023). Oregon's affordable housing stock is old, disproportionately placed in WUI areas, and extremely limited, while the building market does not produce new homes for those with middle-incomes. The choices for the average household therefore become divided between permanent rentership or buying an less-than-ideal home for more than they can comfortably afford. Oregon's State of the State's Housing Report found that Oregon's wages are rapidly outpaced by the rising cost of rents, with every additional dollar in wages earned matched with a seven dollar increase in the price of the median home (OHCS, 2023). To boot, Oregon's population is aging and staying in place, limiting housing turnover (CSI Oregon, 2025). Despite pushes from Governor Tina Kotek to build new homes, housing production is declining from pandemic rates, with Oregon permitting only 14,000 new units in 2024.

Oregon's land use laws, specifically Oregon's Urban Growth Boundary (UGB), set strict boundaries for city growth to prevent suburban sprawl and protect forests and farmland. Governor Tim McCall introduced the UGB among other land use laws in 1973 with Senate Bill 100. Cities can appeal to add land if they can demonstrate a need for expansion via a set of predetermined criteria, one such criteria being a forecast of 20 years of expected population growth. The limited land available for new permits drives up the price of new construction and may shunt new developments into awkward and ill-connected areas. For many homeowners, the cost of land artificially inflates the price of the home on top of it; this not only drives up the price of homeownership, but again forces Oregon home buyers to overpay for lower quality homes. Oregon lawmakers are aware of the strain that land use laws put on housing prices; SB 1051, HB 2001, and HB 4031 have provided leeway for infill within UGBs for Accessory Dwelling Units (ADUs).

Oregon's tax and land use laws are not the full picture of Oregon's housing crisis. Other issues include investor home-buying, NIMBY or not-in-my-backyard movements which provide resistance to building upwards and inwards, rising labor and material costs left-over from COVID supply chain issues, and high rates of second home ownership in specific amenity-rich towns. There are also a number of social stigmas related to increased wildfire risk and Oregon's related crises in drug use and chronic homelessness that drive developers away. However, the state's vacancy rate still sits at 6%, where recent precedents in Montana and Colorado see housing and rental prices begin to majorly come down at rates of 15% or more (Harris, 2025). Ultimately, no single factor can be seen as the real reason for Oregon's correlated affordable housing and wildfire crises. The most obvious issues with property tax, land use law, and supply/demand are one place to start.

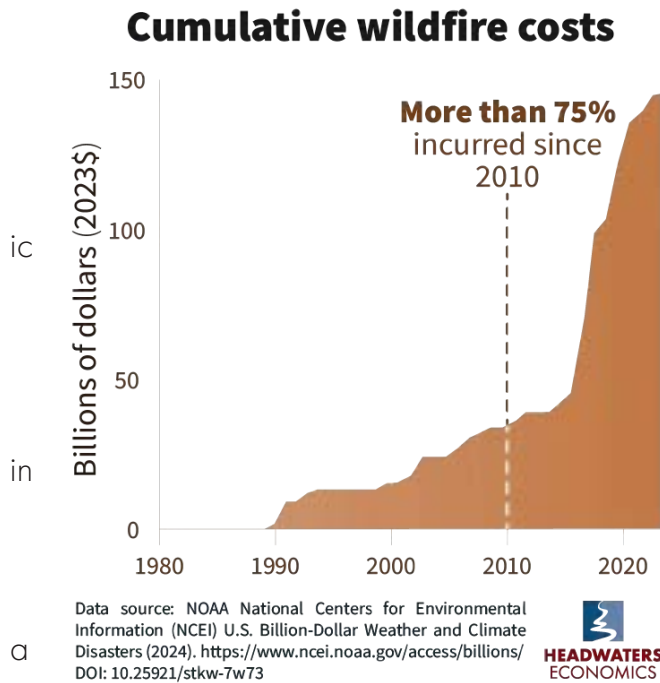


Oregon's current major insurers. A monopolistic insurance market means changes to policies can be sweeping and uncontested.
Source: Oregon Department of Consumer and Business Services

One other major thread exacerbating the effects of poverty on wildfire-stricken communities is the nascent insurance crisis rippling through Oregon and California. Increasing yearly wildfire counts have begun to drive up the cost of insurance premiums in areas with high risk, some insurers even fleeing areas entirely. In Oregon, fire insurance premiums are up an average of 30%, with major insurance companies Safeco, Kemper, Progressive, and Oregon Mutual no longer accepting new customers (Baumhardt, 2024). Certain areas in Oregon, like Sisters or La Pine, have been quietly declared uninsurable by providers who may still be offering other new policies elsewhere in the state. Moreover, major insurers in Oregon refuse to accept proof of home hardening as reason for a discount, citing that hardening only effectively reduces risk at a neighborhood scale unachieved by Oregonian communities.

General homeowner's insurance has risen by 13% in the US between 2020 and 2023 (Keys and Mulder, 2024). This trend is set to continue, with key experts agreeing that climate change is now severe enough to begin to affect real changes to disaster loss trends, while construction costs in the US have reached an all time high (NAHB, 2025). More than ever, homeowners left without options are turning to programs like The Fair Access to Insurance Requirements (FAIR) Plans, or state-sponsored "insurers of last resort."

Fire insurance in particular, given that it is included within a standard home or business owner's insurance policy, drives increasing wealth disparity along with other rising cost-of-living expenses. The majority of Americans do not own their homes, with 2/3 of all houses under a mortgage (Headwaters Economics, 2025). Because fire insurance is required by most lenders, rising premiums can force many out of their homes, or lead to a homeowner pursuing deliberate under insurance by purchasing a low-coverage plan. Those with federally backed mortgages, which can be parts of home ownership assistance efforts such as the Federal Housing Administration's first-time buyer loans, must maintain fire insurance as a prerequisite to their mortgage agreement.



Flight purely from insurance stress is one way in which wildfire recovery can create dramatic demographic change, which will be discussed in more detail in the following parts of this section. Flight due to either perceived or actual financial risk from wildfire has economic impacts beyond the obvious, reducing a city's tax income but also driving down the value of homes, municipal bonds, and local businesses (DeGood, 2020). Residents of Oregon's Blue River, for example, have described difficulties acquiring loans in the area as banks see the formerly fire-stricken town as a bust. Flight from wildfire is also not always effective or rational; 2021 Texas transplant home buyers exhibited pattern of avoiding the most high risk areas which had already burned down in California's wildfire zones by moving out of California entirely.

The same transplants then chose to move to similarly high risk areas in Texas to buy new homes, where conditions for catastrophic wildfire breakout are now a ticking time bomb..

The same high insurance rates which exacerbate wealth inequality and lead to government subsidy can also inversely produce a strange flood into dangerous areas. Falling property values and government insurance subsidy in high level fire risk areas have in some cases attracted an influx of low income residents, illustrating the risks some Americans may take to offset rising costs (Headwaters Economics, 2025). This effect has occurred in both Oregon and Montana, another fire-burdened state, which sees floods of new single family homes in high risk areas like Ravalli County (Kimball, 2025). The WUI was the fastest growing land-use type in the country from 1992 to 2015, suggesting that few people who moved to these areas were seriously unaware of the growing risk to their homes. Floods into WUI areas have slowed from 2022-2024, but the initial boom has left millions in high risk zones.

These trends suggest that understanding of actual risk is lacking in many who move away from or into wildfire, pointing towards gaps in education among home and business owners about how to articulate the both the reasons for their vulnerability to wildfire and possible solutions. These gaps in consumer understanding of fees, taxes, and changes to insurance policy seek to further lead homeowners to be under insured and poorly positioned to protect themselves from fire.

The Wildfire Insurance Crisis

Home insurance in areas with high wildfire risk is becoming more expensive and harder to obtain, with potential consequences for state and local budgets.



Wildfires contribute to more costly insurance

The rising costs of wildfire recovery and rebuilding are among the reasons home insurers are raising rates, issuing non-renewals, and exiting risky locations.



High insurance costs lead to underinsured homes

In some western states, insurance has increased more than 50% in the last five years. A growing number of homeowners are underinsured or uninsured.



The underinsured struggle to recover from disasters

After wildfires, uninsured and underinsured households lack the resources to rebuild, extending the period of displacement.



Without insurance, home financing is unavailable

Inadequate insurance leads lenders to deny mortgage applications, reducing home ownership and impacting property values.



Inaction raises costs for local and state budgets

Delays in rebuilding increase the demand for temporary housing and social services, adding billions to recovery costs.

Declines in home values reduce local services such as police, schools, and street maintenance that rely on property tax revenue.

The need for revenues increases the frequency of emergency allocations, unplanned tax increase and may threaten bond ratings.

What needs to happen: Reduce community risk

Investing in community-scale wildfire-resistant construction, vegetation management, and neighborhood planning can minimize damages from wildfire and improve the accessibility and affordability of insurance.

Beyond misunderstanding or being unable to get proper insurance, actually having insurance is not a panacea, even without counting costs. The failure of government-sponsored last resort insurance plans like California and Oregon's FAIR sees massive government losses and often inadequate services at best. As of June 2025, there is currently a lawsuit against California's FAIR plan insurers California Fair Plan Association, *Barak v. California FAIR Plan Association*, which accuses the CFPA of acting in bad faith so as to not pay out policies for recent wildfire victims (Lathrop GPM, 2025). Larger attempts at market manipulation by law so as to stop insurance premiums from skyrocketing means private insurance companies are further incentivized to pull out of areas altogether. In turn, manipulation also reduces the ability of insurance companies to actually price premiums that create an adequate disaster pool and pay reinsurance fees in full, as reinsurance is oxymoronically not subject to federal regulation.

Fire insurance itself is built on a system that is highly flawed. Fire insurance may or may not cover the total cost of reconstructing a home, and efforts to rebuild historical homes to code or as last left may prove surprisingly expensive. Fire insurance also often does not fully cover all the living expenses incurred by those affected by fires, as claims will require detailed and often exhaustive lists of hotel fees, transport costs, and lost work time, among many other small expenses. Insurers will often use misleading or vague language to try to dodge filling claims, and legally inexperienced insurees may find the process of filing claims difficult to the point of impossibility. For a recent example, as was outlined in *Barak v. California FAIR Plan Association*, the CFPA attempted to dodge the aforementioned claims by improperly restricting coverage to losses visible to "the average person" (Lathrop GPM, 2025). Similar practices of obfuscation are often echoed by private insurance companies like State Farm, which is of June 2025 currently embroiled in a lawsuit over the denial of smoke damage claims in Altadena, California (Austin, 2025).

The destruction of structures by wildfire and earthquakes inevitably releases a variety of Volatile Organic Compounds (VOCs) into the air as a byproduct of combustion. Studies by Science Journal in the wake of the Los Angeles fires showed elevated levels of benzene in the atmosphere months after the fire's end, a chemical which correlates to loss of reproductive capability in humans (Cornwall, 2025). There is currently no guaranteed recourse for the millions of people in Los Angeles who may experience long term health issues as a result of exposure to VOCs.

Relying on insurance after a natural disaster is reductive and wasteful in its presuppositions. Either one assumes an insurance policy so comprehensive and detailed that it would never be feasibly priced, or throws away the impact of destroyed structures on the environment as a necessary evil. The value of a stable structure, which can weather disaster, is not only in its preserved equity but also in the community and wellbeing of those who occupy it. In the big picture, a constant cycle of destruction and rebuilding maximizes carbon consumption, and proves extremely costly.

Carbon-intensive materials with high transport needs create a building culture of huge carbon expenditure and extractive and exploitative supply chains



Climate Crisis



Huge natural disasters begin occurring with alarming frequency, destroying building stock

Construction worker flight and rising costs of available labor sap contractors of the workers they need to complete projects



Housing Crisis



Inflation, stagnant wages, and receding economies create a mass poverty crisis felt all over the world

Buildings are constructed completely in opposition to their environments and without any connection to local economy, for very high prices and on very long timelines



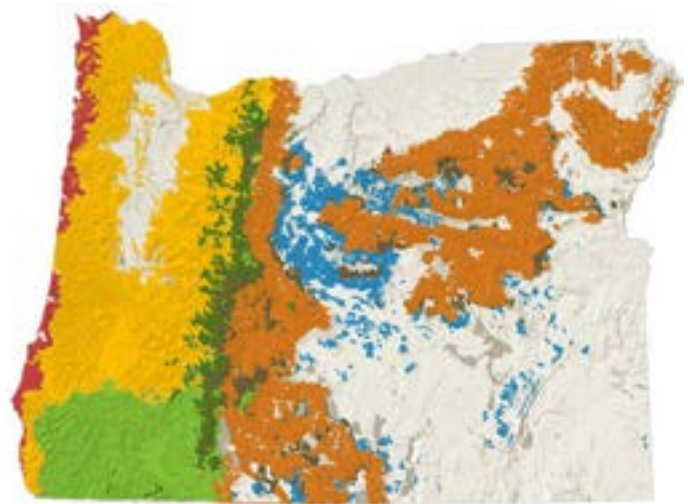
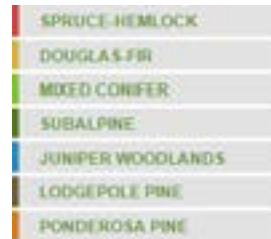
Results



Disadvantaged community members are at a high risk of losing homes and businesses to natural disaster, while available rents and rates rise higher and higher



Forestry in Oregon



Current distribution of tree species
used for timber harvest in Oregon.
Source: Oregon Department of
Forestry

As was introduced in the previous section, many cite wildfire in Oregon to be caused by overgrown forests. But why does forest management affect fire safety in Oregon, and how has forestry and the timber industry failed Oregonians?

In large part, the fall of the post-war era timber industry combined with ill-timed recessions in Oregon's economy in the late 19th century completely de incentivized the financial feasibility of regulating Oregon's forests. The Oregon economy was once based around its abundant forests, prized for the Douglas firs and Ponderosa pines found in the Western Cascades. The Gold Rush created settlements in rural Oregon as the timber industry was propelled by the advent of new transcontinental railroads (Wells, 2006). A massive building boom following World War II stripped private timber landowners down to the limits of their forests, resulting in timber harvests on federal lands. The 1950s and 1960s saw Oregon begin a long fall down the path of forestry mismanagement, turning to controversial practices such as clear-cuts, slash burning, artificial plantations, and the use of insecticides and herbicides.

Thomas McCall, Oregon's governor from 1967 to 1975, ran on a robust platform of "livability," believing Oregon's natural resources had to be aggressively maintained as conserved public property (Wells, 2006). Increasingly, Oregon's economy had grown to accommodate a staple influx of affluent retirees and eco-minded tourists, who were naturally opposed to logging's presence in their new home-towns. The 1980s recession then hit the US housing market hard with high interest hikes, decimating Oregon's lumber industry, which primarily produced wood for housing. The recession happened just as Southern US and Canadian markets had begun to produce timber, the South's timber supply now replenished after clear cuts in the early 1900s (Wells, 2006).

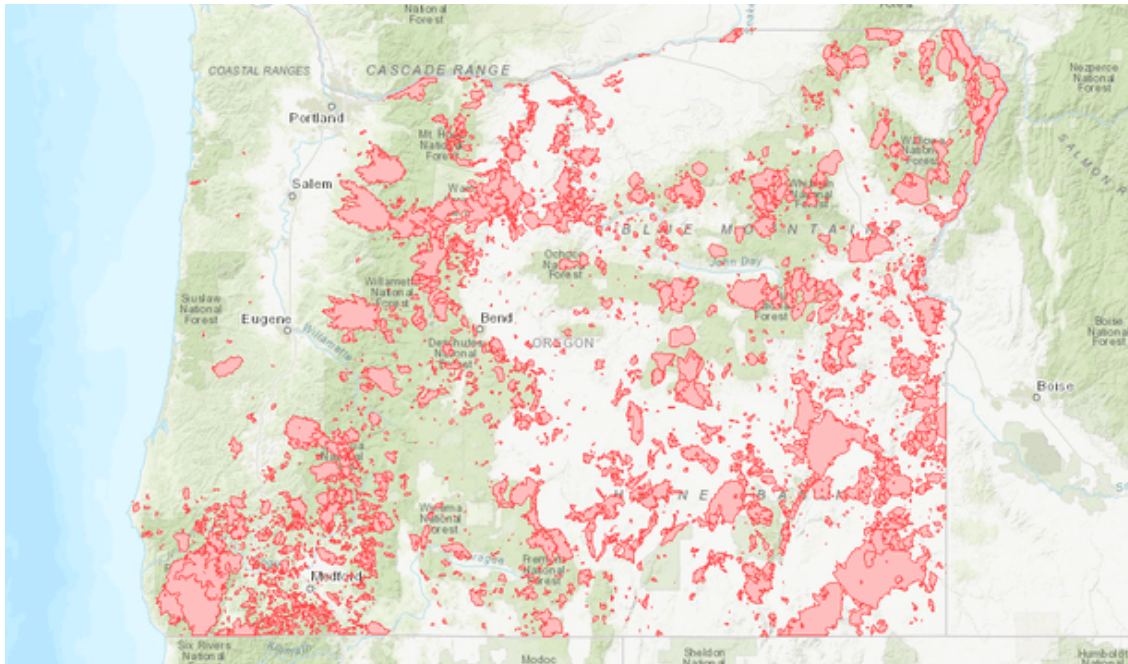
Federal forests, which were producing the majority of Oregon's timber in the 1980s, became subject to new environmental regulation. Appeals and lawsuits concerning endangered species such as the northern spotted owl as well as the 1994 Northwest Forest Plan put huge swathes of federal forests under protection. The 1994 plan restricted Oregon's timber harvests to 1.2 billion board feet per year on the protected tract of land designated as an owl habitat, a number which the state began to fall drastically short of (Wells, 2006).

Today, 60 percent of Oregon's forests are federally owned and facing wildfires of greater frequency and intensity. The reasons for the uptick in fires as related to forest management are varied and controversial; many cite the Oregon Department of Forestry's policy of wildfire suppression, a lack of prescribed burning, and a lack of pruning and clearing forests of under-story growth. However, the ODF has historically been strained by environmental lawsuits and tight budgets. Between 1989 and 2008, environmentalists won or settled 520 of 1,125 litigations as related to the limitation of logging and forest management activity, while general funds did not provide adequate preventative management monies (Beda, 2020). Even with new cash flow from the federal government in the wake of 2020's fire season and continuing escalation of the issue, forestry management now spends the bulk of any new money on fighting active fire, not on management (Beda, 2020).

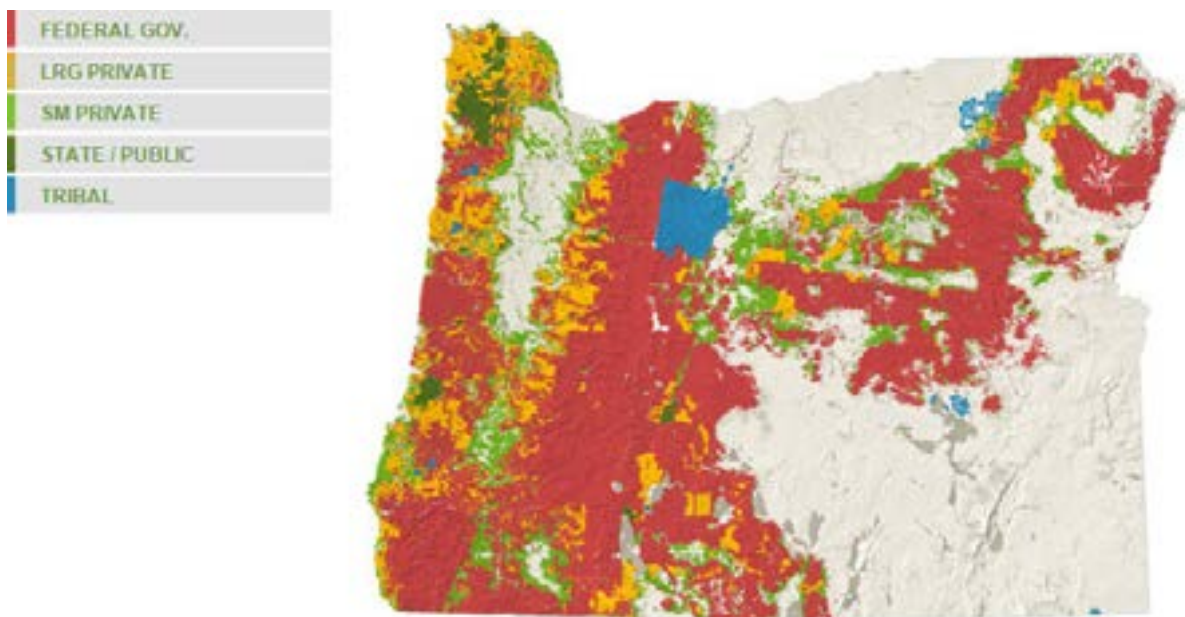


Area included in Northwest Forest Plan, 1997. Source: US Forest Service

Oregon is still bound by the 1994 restriction on its board feet harvested, and has never harvested anywhere close to the limit from the protected tract since that year due to concerns about water contamination amid habitat loss. For endangered species like the spotted owl, numbers have not improved because of deaths to wildfire, which has led to growing talks of reform for the Northwest Forest Plan (Koberstein, 2015). Meanwhile numbers for the cost of 2024's wildfire season have been newly reported at a gross of 318 million, a number which eclipses the 10-year average cost by 76 million and is almost triple the cost of both the 2020 and 2021 fire seasons, which cost around 130-140 million each (OFRI 2025). The previously discussed "kicker bill" and Oregon's well-intentioned wildlife conservation movements have in effect put forest management on a 40 year back burner, producing an acute new crisis.



Oregon's history of fire as expressed as perimeter data. Source: National Interagency Fire Center



Current distribution of types of forest ownership in Oregon. Source: Oregon Department of Forestry

Oregon Forestry Facts

(sourced from the Oregon Forest Resources Institute Forest Facts Reports of 2020 and 2025)

- *Despite the federal government's ownership of only 60% of all forests in Oregon, 86% of all fires occur on federal land.*
- *Only 34 percent of Oregon's forests are privately owned, yet private forests produce 80% of the timber harvest in Oregon.*
- *From 2011 to 2021, Oregon's forests grew an annual average of 2.6 billion cubic feet of new wood; after accounting for 1.1 billion cubic feet harvested and 800 million cubic feet lost to tree death from natural causes, Oregon left 725 million cubic feet of new wood in its forests.*
- *On federal land, the amount of timber that dies offsets annual growth by 36%, but leaves behind a net 56% increase in standing volume of federal forests. Only 8% of federal annual timber growth is harvested each year.*

Disaster and Demographics

What is the human cost of wildfire, and who is at risk from fires in Oregon? The loss of homes and businesses to wildfire has a number of equally important short and long term consequences. In particular, wildfire has the power to radically change majority demographics in affected areas. Overwhelming evidence shows that in wildfire events, disproportionate damages are dealt to minority groups, particularly those who are poor and disabled.

Wild Fire Risks to Communities, a U.S. Forest service data conglomerate, is a primary source of data concerning wildfire's risk to different groups across America. Information from a 2024 update to the database revealed that Oregon and Washington counties have a much higher threat of wildfire than previously estimated, with 60 percent of counties in both states now classed as high wildfire risk zones (Wildfire Risk to Communities, 2025). For example, Lane County (where this study is written from) has a 60 percent higher threat of wildfire than the national average. Data from the Risk Explorer classes a third of Lane County homes as indirectly exposed, with another third directly exposed to wildfire.



A fire damaged mobile home in Santa Rosa, California. Source: Justin Sullivan, Getty Images

Statistics from the Forest service show that nearly three out of four people living on tribal reservations live in high wildfire risk areas, while 20 percent of all places with high wildfire risk were also populated with a high percentage of manufactured homes. A 2019 Portland State University study, "Social vulnerability to large wildfires in the western USA," found that increased wildfire risk was exacerbated by other common conditions of poverty. These conditions include homes with an increased percentage of elderly (65+) or youth (17 and under) occupants, lacking a car or consistent access to affordable transportation, and living in areas reliant on singular routes of egress (Palaologou et al., 2019).

Many in poverty will live in closely connected apartment complexes or compact mobile home parks, which increases the ratio of evacuating cars to available highway exits. In turn, the orientation and distance between these types of housing developments may increase the likelihood of fire transfer between structures. Because many in poverty may be impoverished due to disability or a fixed income, such as an elderly person's reliance on Social Security, injury from wildfire (including effects from smoke exposure) in poor communities is typically more severe than in wealthier communities. Poverty is also associated with immigration status, foreign language barriers, and under-education, all of which may hinder a person's ability to find or seek evacuation and disaster preparation information, or which may even discourage the willingness to do so (Palaiologou et al., 2019).



Fires encroaching on a crowded suburb. In a densely populated suburban environment, residents are simultaneously disadvantaged by fire spread between closely spaced homes and the likely crowding of egress routes in an evacuation. Source: Scientific American

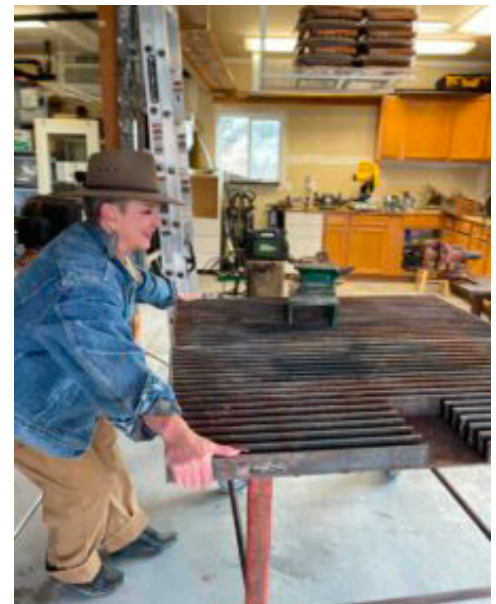
Loss of structures to natural disaster not only affects the most disadvantaged communities disproportionately, but can produce post-disaster gentrification. A 2024 retrospective of the community rebuild in Northern California after the 2018 Camp Fire found that the fire drove reconstruction trends to favor faster rebuilds for homes that had a higher pre-fire value, with many lower income residents unable to rebuild at all (McConnell and Braneon, 2024). At the same time, human migration at large continues to place more and more people in metropolitan areas with hotter summers and in regions with a high fire risk. This creates a scenario where lower income residents who have moved to a high fire risk area may be inadvertently stepping into a scenario which will further reinforce cycles of poverty and instability. Trends also illustrate that real estate in the WUI proves most attractive to retiring seniors, who are more likely to be disadvantaged after a natural disaster due to health risks and a lack of financial mobility (Clark et al., 2022).

The demographic changes that occur after major disaster can be seen through interviews in Oregon's wildfire-burdened communities, such as those in Blue River and Talent. Both communities have lost legacy residents to the fires, after rebuilding costs, fears of future fires, and a loss of economic opportunity and income pushed many residents to leave the area permanently.

A key interview with Blue River locals by Brian Bull of the Click in 2021 found that a former resident of 26 years, Micki Shampang-Voorhies, chose to use her insurance money to buy a finished home in Nevada. She saw that construction costs and a long permitting process would have eaten more of her insurance payout than an entirely new home somewhere else, a sentiment echoed by 50 year Blue River resident Jim Baker, who described the rebuilding process as "torturous."



The burned remains of a Blue River homestead. Source: Brian Bull



Micki Shampang-Voorhies in her new metal-working shop in Kingston, Nevada. Source: Micki Shampang-Voorhies.

"You know, we've lost a third of our community...and so, what's our demographic? Who are we rebuilding for?" she [Melanie Stanley, Blue River's unofficial mayor] asked." -Brian Bull, 2021, "As Blue River Recovers, Locals Ask: Who's Coming Back?"



Defective homes marked for removal in Phoenix, Oregon. Source: Jane Vaughan, JPR

Elsewhere in Talent, Oregon, Carsyn Currier of KLTN 10's 2021 interview "Permanent housing could be years away for some Almeda Fire victims" spoke to State Representative Pam Marsh, Talent resident Edy Westcott, and FEMA representative Paul Corah. The proposed solutions for rebuild after the Almeda fire painted a grim picture. Westcott was one of more than 700 residents who did not qualify for a FEMA trailer, instead shuffling between different hotels as she waited for solutions.

In 2024, an update by name of "Almeda Fire recovery housing is selling in online auction, four years after the wildfire" by Jerry Howard of KDRV found that more than 100 modular FEMA mobile homes that had been deployed for disaster relief were being auctioned off at low prices. The homes had failed to live up to code standards and were discovered to be "intensely flawed." Pam Marsh was once again interviewed, acknowledging that

"...an awful lot of wildfire survivors probably had to make other choices or even leave the community while they've been waiting for us to rebuild."

Issues stemming from the co-occurring affordable housing shortage, rising US inflation, increasing climate stress, and lack of resources available to communities all put unique stress on each community. Often, setbacks are so frequent and funding is so inconsistent that many community members give up entirely.

Wildfire and Rural Communities

Part of how Oregon has attempted to manage the cost of wildfires, as well as unique factors relating to rural demographic trends, means that rural communities like Blue River are more acutely disadvantaged by wildfires. Rural communities in Oregon are on average poorer, of less access to healthcare, and older than communities in urban areas (United For Alice, 2023). Because many who live in rural areas are farmers, ranchers, or timberland owners, rural homes tend to be surrounded on all sides by hazardous vegetation with few firebreaks. Those who own large tracts of lands are subject to increasing fees for firefighter protections, as Oregon prices wildfire protection as a per acre fee paid along with property tax. Senate Bill 762, which tried to carve out a bigger budget for wildfire protection in 2021, has stuck landowners with higher protection bills as part of its effort to raise money.

Rural farmers and ranchers are also the most vulnerable to costs for land maintenance such as preventative thinning fees, which are priced per acre and will reoccur each year. Rural communities will often employ seasonal workers for timber and farm harvests among other kinds of help, which increases the demand for workforce housing. This demand has been historically met with clusters of manufactured homes, a housing type more common in rural Oregon as both seasonal and full-time rural workers are often low-income.

Fires in central Oregon burning over farmland in August, 2025.

Source: Mankato Free Press



Manufactured home clusters in rural communities are typically the only affordable housing in towns like Talent and Phoenix, and are usually older and built to zoned densities no longer legal for new mobile home parks. These traits mean that manufactured homes in Oregon's rural communities are more likely to be more flammable and more likely to transmit embers between homes, but also that rebuilding after a disaster may mean that updated zoning laws from Oregon's Chapter 446 class rebuilding in the same place as newly illegal or newly constrained.

Holiday Farm Fire

Primary Communities Affected: Blue River

Acres Burned: 173,000

Total Structures Destroyed: 1218

Homes Destroyed: 470



Leveled structures in Blue River after the Holiday Farm fire.

Source: Register Guard

Almeda Drive Fire

Primary Communities Affected: Phoenix, Talent, Medford

Acres Burned: 3000

Total Structures Destroyed: 2600

Homes Destroyed: 2400



Before and after photos of the Almeda Drive Fire's path through Talent, Oregon.
Source: CNN and Maxar Technologies

Beachie Creek Fire

Primary Communities Affected: Gates, Mill City, Lyons, Detroit

Acres Burned: 192,000

Total Structures Destroyed: 522

Homes Destroyed: 486



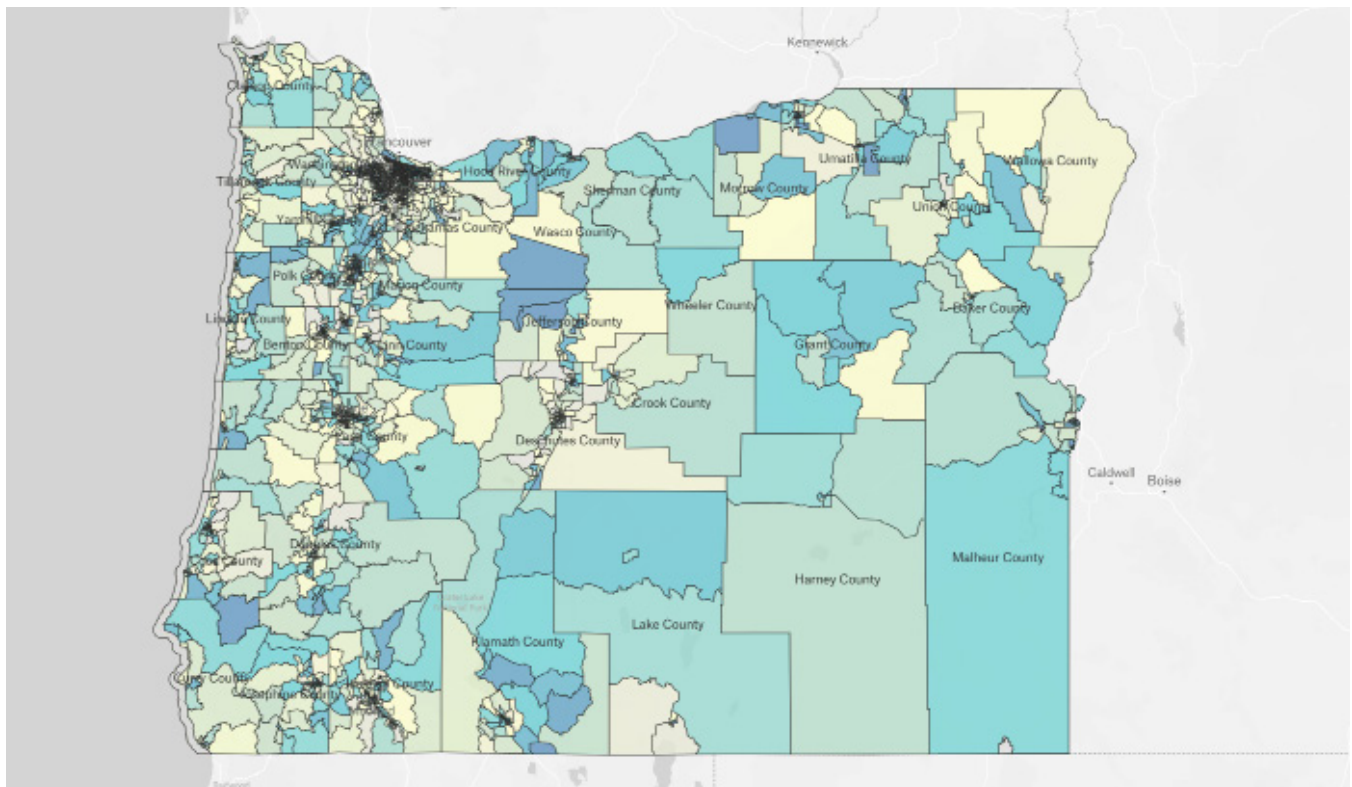
Before and after photos of the Beachie Creek Fire's path through Detroit, Oregon.
Source: KGW and Maxar Technologies

Mapping

Maps specifically created and analyzed for this project include the base layers of and information obtained from:

- The total distribution of the state's most recent building footprint count, from Oregon GEOHub Data.
- The most recent official map of the Wildlife-Urban interface, from Oregon GEOHub Data.
- Oregon's county lines, from Oregon GEOHub Data.
- Oregon's urban growth boundary, from Oregon GEOHub Data.
- Oregon's social vulnerability map, from Oregon State University's Oregon Explorer
- A new map created with data from Oregon Housing and Community Service's 2025 comprehensive list of available affordable housing locations and characteristics
- U.S. Census Bureau data on the number and distribution of Oregon's housing units
- Data about wildfire's risk to Oregonian communities from the open-source publication "Exposure of human communities to wildfire in the Pacific Northwest" by Joe H. Scott Julie-Gilbertson-Day of Pyrologix and Richard D. Stratton of the USDA Forest Service
- The Oregon Department of Forestry's 2020 Communities-At-Risk Report
- OHCS' summary of housing losses to wildfire as published in "Progress on 2020 Labor Day Disaster rehousing and recovery"

State-wide data that specifically displays Oregon's available building footprints along with its designated Wildlife-Urban interface, or the areas where human development has sprawled into contact with vegetative fuels for fire, was not readily available. To count for the number of structures, data from the state was downloaded and layered as a compiled map in QGIS via association of publically available Shape (SHP.) files with their corresponding CSV data. Structures were counted with the Vector Analysis and Join Attributes by Location tools. Building data initially came in counting 2,170,837 buildings. OHCS's list of affordable housing units, which came as an Excel spreadsheet of addresses, was converted to CSV and geoassociated with coordinates via Geocodio. Housing specific counts came from the U.S. Census Bureau and Pyrologix.

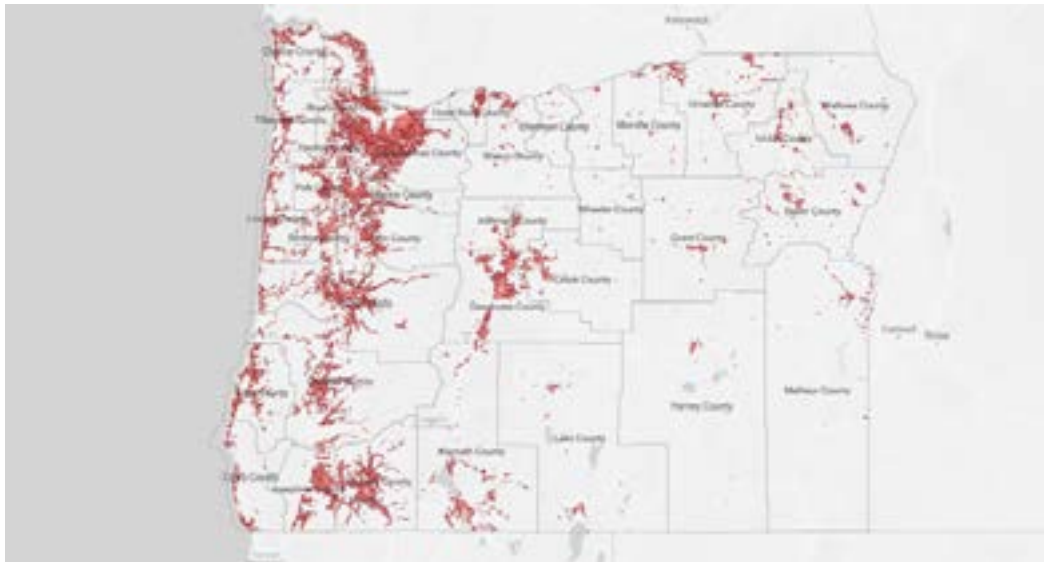


Oregon's Social Vulnerability Index to Wildfire Map. Source: Oregon State University GISci

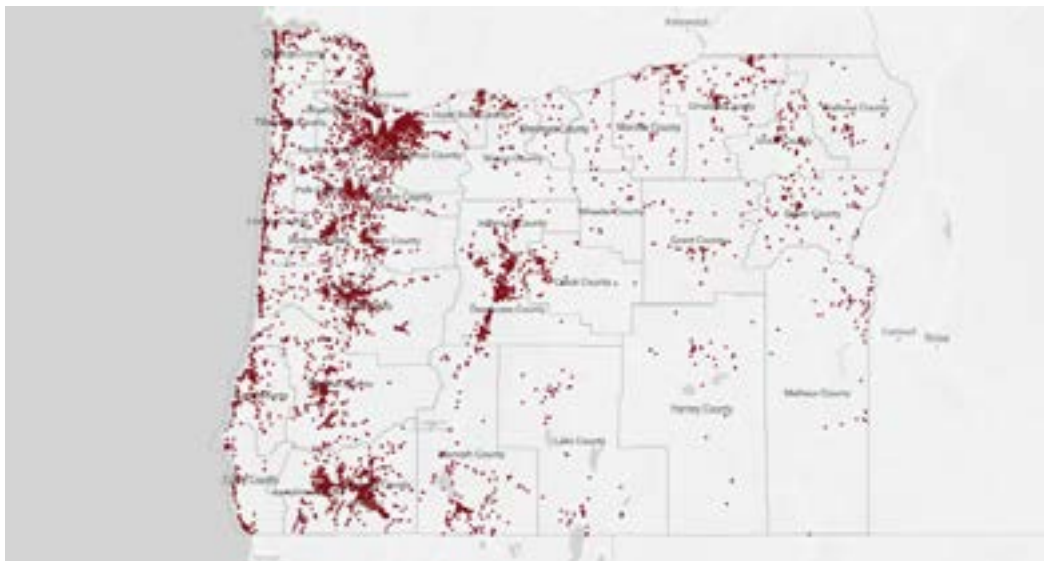
Indicators	Block Group	Tract/County Subdivision	Themes	Overall Social Vulnerability	Overall SVI Score	
Poverty	X*	X	Socioeconomic Status			 Data Unavailable
Unemployment Rate	X*	X				 Lowest Vulnerability (0-25th percentile)
Per Capita Income	X*	X				 Low to Moderate Vulnerability (25-50)
Less than High School	X*	X				 Moderate to High Vulnerability (50-75)
Over Age 65	X*	X	Household Composition & Disability		 Highest Vulnerability (75 - 100)	
Under Age 18	X*	X*				
Disability	NA	X*				
Single Parent Households	X*	X*				
Minority Population	X*	X*	Minority Status & Language			
Limited English Language	X*	X*				
Multi Unit Structures	X*	X*	Housing Type & Transportation			
Mobile Homes	X*	X				
Household Crowding	X*	X*				
No Vehicle Access	NA	X				
Group Quarters	NA	X*				

Oregon's Social Vulnerability Index and its components.

Oregon's Social Vulnerability Index and its components.



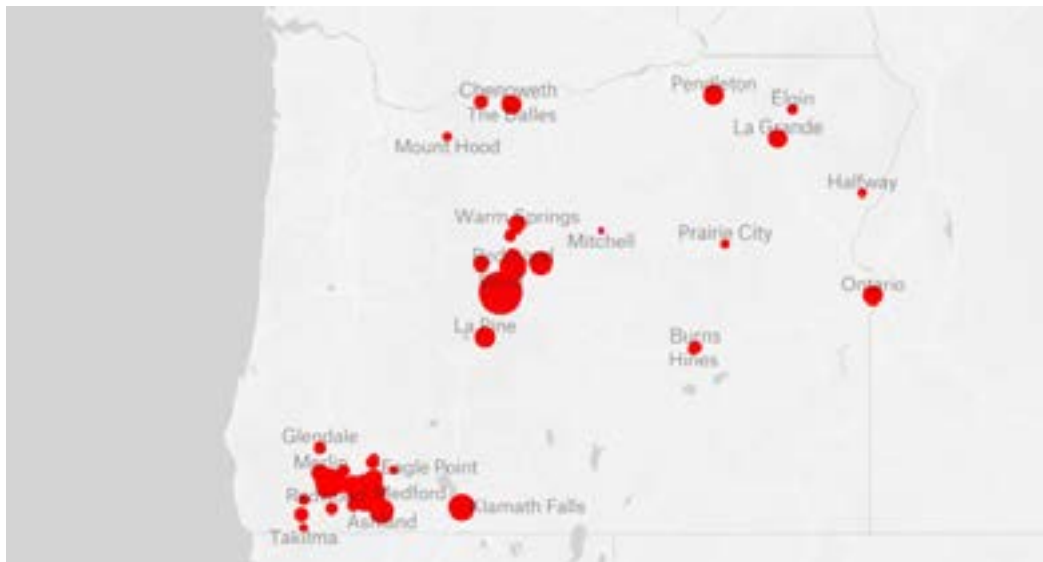
Oregon's Wildlife Urban Interface.



Total buildings in Oregon's WUI.



Oregon's Urban Growth Boundaries.



Oregon's Top 50 at-risk Communities.



Labor Day Fire Path.



Total housing unit losses from Labor Day Fires.

section 01 - defining the problem



Oregon's available affordable housing.



Oregon's available affordable housing placed in the WUI.



Current OHCS rehousing projects across Oregon.

Of Oregon's total building stock of 2,170,837 total structures, 1,329,178 structures are in the WUI, which means that 61 percent of all structures in Oregon currently occupy space in direct contact with hazardous vegetation. Oregon's housing as identified by Pyrologix in a 2019 study had a total of 1,752,050 housing units, with 1,196,197 housing units total identified as in contact with hazardous vegetation. Housing since the study's publication has increased to 1,896,933 units in 2024. This means that 68 percent of Oregon's total housing as last measured is in increased danger from wildfire. Out of 2025's 1763 identified affordable housing structures, which provide a total of 77,653 housing units, 750 are in the WUI, which means that 26,053 units are at risk.

The National Register defines homes which are 50 or more years older as historic, a label which correlates to an increase in fire risk due to the wear and tear of insulation, structure, wiring, heating equipment, and features such as chimneys. This means homes built in 1975 and back are historic. We can see that in total, 131 housing structures accounting for 6004 units are defined as historic, while 745 housing structures accounting for 25,746 units have no known age. 37 of 131 historic structures have had known updates, which means that 3,024 units may or not have been retrofitted for seismic and fire safety. 13 of the known retrofits occurred before the year 2000, accounting for 903 units. This means that 40 percent of all housing units are either known to be historic or do not have a known age, with only 28% of those affordable historic units retrofitted between their construction and now. A third of those historic updates to affordable housing occurred 25 years ago or more. OHCS does not define mobile, manufactured, or RV communities as affordable housing, so those communities are excluded from their list of AH options.

The communities of Deschutes, Baker, Grant, Harney, Jackson, Jefferson, Josephine, and Wasco counties, which were all identified by the ODF's Communities at Risk Report of 2020 study at being between 80-100% saturation of high risk to all present inhabitants. 5. In Oregon, the 50 most exposed communities comprised only 19% of the housing units near WUI areas, but 80% of cumulative exposure of all housing to wildfire; these communities are majority located in Josephine, Jackson, and Deschutes counties, the three counties containing 32 unincorporated communities. Of all 50 communities, only 6 were urban.

Key Takeaways:

Oregon's minsimultaneously linked to increased wildfire exposure.

Many Oregon communities, particularly rural communities, are in harm's way; future fires will worsen the housing crisis, and untold health effects and businesses losses from fires are equal threats.

Oregon's ability to respond to fire is hindered by our current models of insurance, a rapidly changing climate, and a lack of investment in forest management.

Key laws related to Oregon's property and income tax serve as significant barriers to rebuilding for low-income households affected by wildfire.

The image shows a room with bright blue walls. Several horizontal wooden poles are arranged in a grid-like fashion, supported by vertical wooden posts. Large pieces of fabric in various colors, including orange, dark blue, and black, are draped over these poles. The fabrics are arranged in a way that creates a series of rectangular compartments or 'modules'. In the background, there is a white door and a wooden ladder-like structure on the wall. In the foreground, some folded fabrics and a blue bag are visible on the floor.

section 02 - modularity and disaster

The History of Modular Housing

Modular building consists of a frame or structure upon which smaller elements, ranging in scale from full units to singular rooms, are placed onto or fitted into. Prefabricated buildings are often similar in construction but are built in a factory or warehouse as a complete unit before being delivered to a site. Prefabricated buildings may or may not be designed as modules themselves.



The Prefab Stanyan house. Source: San Francisco History Center, San Francisco Public Library

Early commercialized modular building saw roots in the 1800s Gold Rush. Those without infrastructure in the new city of San Francisco sought out homes from New York, Boston, and Maine, cottages shipped in sets of packages. The prefab Stanyan house is one of the oldest existing homes in the San Francisco area, dated to 1854.

Between 1908 and 1940, the Sears Modern Homes program operated as part of the Sears catalog to provide 447 house varieties available for purchase. The Sears homes are known for their high build quality, arriving in kits that contained everything but the plaster and electrical equipment necessary to build the homes.

Over 75,000 Sears homes were shipped out. Lumber was shipped precut and homes were advertised as buildable without the knowledge of a carpenter. Homes were flat-packed and balloon-framed.



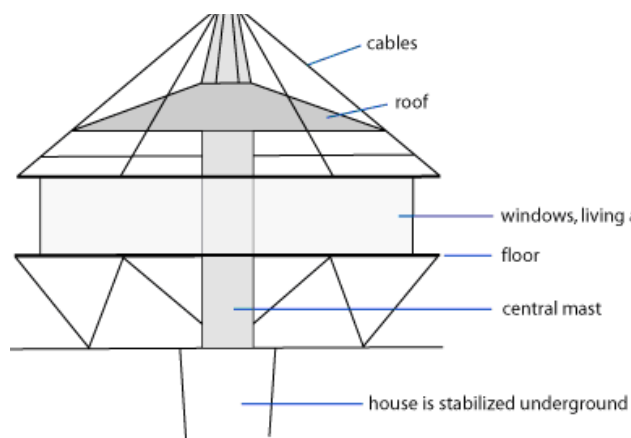
Advertisement for Sears home. Source: Sears Archives



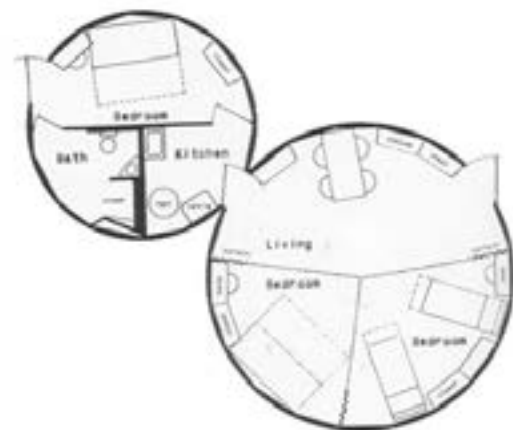
Prototypes of Dymaxion houses. Source: Archituul

The Dymaxion House was developed by architect Buckminster Fuller in 1930 as the first example of American modular construction. The Dymaxion house was born out of Fuller's desire to create a fully self sustainable unit. His original design, a hexagon, was constructed to be supported by a central pole connected to cables. Fuller grouped the utilities in the central core. The Dymaxion prototype was designed to be transportable in a tube, fully ready to be disassembled. The domed shape was chosen to take advantage of the passive ventilation effect created by the rounded roof in combination with carefully placed vents. Fuller's design sheltered families from earthquakes via the firm anchor to the ground through the central mast, and caught water through a catchment system.

Fuller's prototype of the Dymaxion was purchased in 1948 by investor and transformed into the Wichita house, a smooth circle. Because of Fuller's unwillingness to release the product as he felt the prototype was unfinished, the houses were never produced.



Structural system of a Dymaxion House. Source: Stanford University



Floor plan of Wichita House. Source: scene.org

In the 50s, Lustron and Gunnison prefabricated porch and addition modules that plugged into larger standard home frames, the base steel construction lending itself to modular features. The use of steel was possible due a post-war excess of the material. Lustron homes were enameled, intended to be highly durable and long-lasting.



A typical Lustron House. Source: Quentin Melson



A model of the Experimental House. Source: Architectural Record, December 1957

George Nelson, famous mid-century modern designer, ran with modular construction as part of a larger futuristic aesthetic. His 1957 Experimental House openly celebrated the forms created by modular units, and tackled affordability concerns by building with plastic and aluminum.

The Experimental House was based on cube-shaped modules that fit into 12 by 12 frames, with smaller modules using 12 by 4 frames serving as the connectors between modules.



Habitat 67's distinctive cubed form. Source: Daniel Lawrence Lu

Some of the most well-known modular buildings include Habitat 67, architect Moshe Safdi's concrete plug-in housing project, built in 1967 to great success. Paul Rudolph's Oriental Masonic Gardens was a similar 1970s proposal meant to solve a housing crisis in Connecticut. Rudolph's modules consisted of stacked rectangles with a singular barrel vault over each unit. The Metabolic architecture movement, while short-lived, produced the highly influential Nakagin Capsule building. This structure consisted of micro-apartment capsules which could be clipped onto central steel cores. While the capsules were ultimately never changed or replaced, the Nakagin building was a master work of the movement, which centered around finding ways for architecture to live as an "evolving" organism.



Initial drawing of Rudolph's master plan. Source: Paul Rudolph Collection, Library of Congress, Prints & Photographs Division



The Nakagin Capsule Tower. Source: The Museum of Modern Art

Rudolph's project held similarities to the design elements popularized in the later contemporary Urban Containers movement, which rose out of the crisis of housing affordability in 1990s New York City and continued into the early 2010s. The Urban Container craze was similar to modular movements of the past; architects strove to reuse or make use of a excess of material, in this case shipping containers, to meet a high demand for shelter. Container City by Cmglee bears striking resemblance both to Rudolph's Oriental Gardens and the Nakagin tower, employing a stack of interpolated shipping containers fitted with round windows. The sheet metal cladding born out of the shipping container base shelters a set of small interior homes.



Container City 2 at Trinity Buoy Wharf, London in September 2012. Source: Urban Space Management (Container City) LTD

The interest in disaster responsive and resilient architecture has trended upwards in combination with the increasing frequency of climate change's intense consequences. As floods, hurricanes, and fires become more common, a number of larger architects have already responded with prototypes that seek to take advantage of unique materials and cut down on construction time.

Disaster Relief

One of the architects most concerned with disaster relief is Japanese architect Shigeru Ban, known for his artful but simple wood constructions. Outside of his self-described “monumental” works, Ban emphasizes the use of local materials to create new structures for those displaced by disaster. Many of his temporary works use paper as the primary construction material, but Ban has also employed foam blocks and prefabricated panels as well as shipping containers. Most famously, his Paper Cathedral was so beloved by its community in Christchurch, New Zealand, that it was eventually made permanent.

Ban's GRFP Styrofoam block house for refugees in Ukraine. Source: Shigeru Ban Architects



Three-story shipping container apartment buildings designed as temporary housing for Onagawa earthquake victims. Ban cited complaints about government issued temporary houses as an inspiration for the build. The homes include built in storage and finished interiors. Source: Shigeru Ban Architects



Paper Cathedral, Shigeru Ban, Christchurch, New Zealand
Source: Shigeru Ban Architects

"Architects mostly work for privileged people, people who have money and power. Power and money are invisible, so people hire us to visualize their power and money by making monumental architecture. I love to make monuments, too, but I thought perhaps we can use our experience and knowledge more for the general public, even for those who have lost their houses in natural disasters." - Shigeru Ban



Deliberately half finished homes in the Villa Verde Project by Alejandro Aravena. Source: Suyin Chia

Another approach to building after disaster seeks to cut costs via an incremental approach. In this scenario, affected community members are given essentials such as a bathroom, kitchen, and bedroom, but structures are left uncompleted to be later filled in by modules or further customized as the occupant can afford it. This incremental process ensures that the occupants have the resources they urgently need and reconciles questions about expansion and site work. The incremental approach can also cut down on construction time and upfront cost, and may save money in the event that a community member chooses not to expand, while opening up a potential spot for another occupant.

Incremental building often uses modules in its development, usually involving a process where new modules are designed to connect to older modules in set stages correlated to cost and to the occupant's life span. The arrival of a new family member or aging kids is often a common scenario where a new module will be added. Building using modules and an incremental approach can create single family homes all the way up to multi-mixed-use commercial structures.

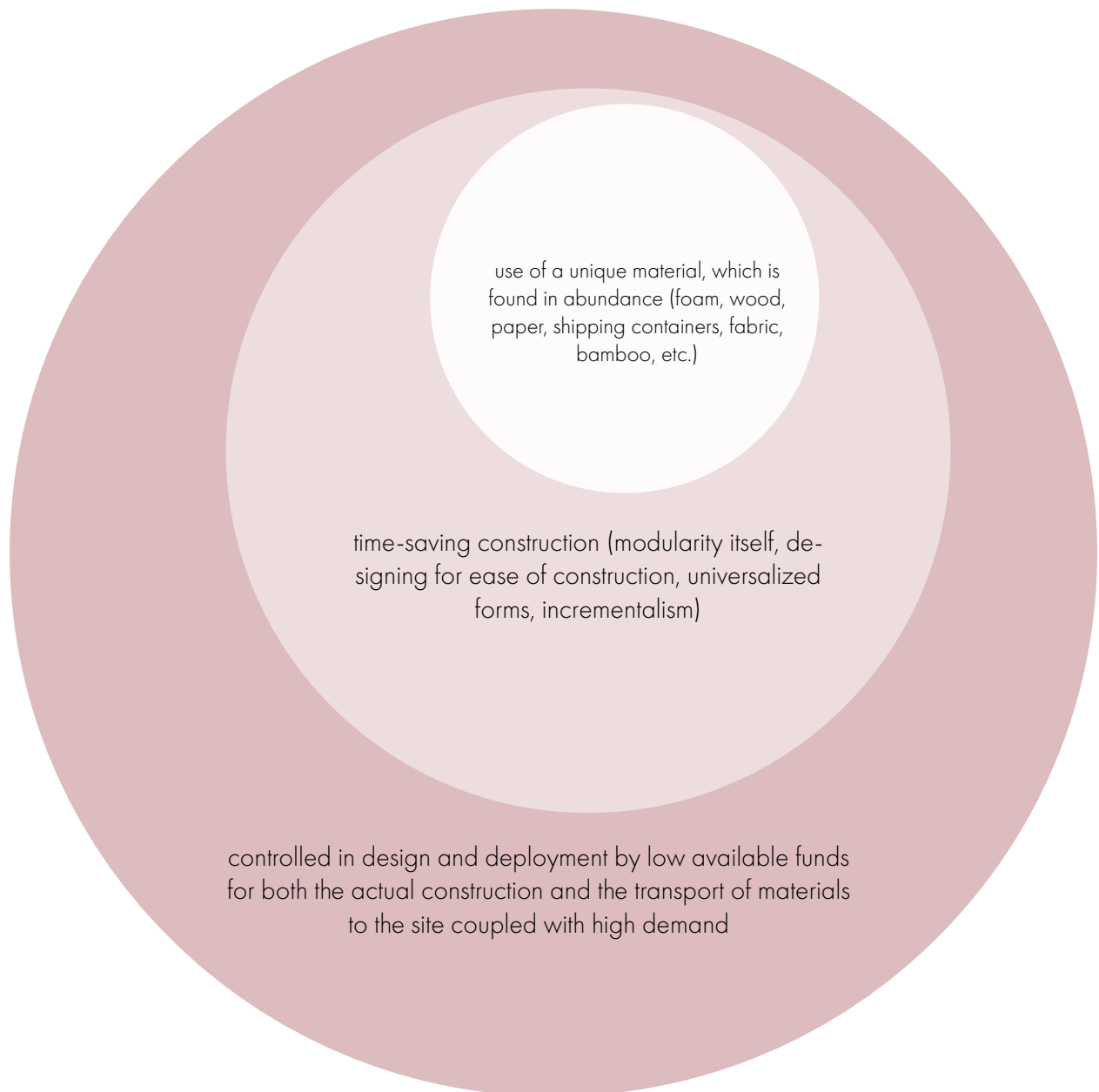


Expandable House by Stephen Cairns evolving over time. Source: Stephen Cairns, Urban-Rural Systems



"Build to Grow" social housing proposal, by Peruvian architects Rafael Arana Parodi, Carlos Suasnabar Martínez, Amed Aguilar Chunga, and Santiago Nieto Valladares. Source: Rafael Arana

Commonly Shared Features Between Modular Buildings and Disaster Relief Strategies:



Designing Good Disaster Relief



"1. Architects have practical mind- and skill-sets which are of significant value in disaster mitigation and recovery..."

To understand what actually creates good disaster relief, architects must form a critical understanding of the relevant law and its governing bodies, the context of previous relief successes and failures, and the distinctions between evolving solutions to the disaster relief challenge.

In an effort to effectively address all of these elements in a digestible manner, the introductory portion of this section covered the basic ideas behind disaster relief architecture and its shared with features with modular building to explain why the two are so often associated. To gain further understanding of disaster relief models in North America, it's important to discuss the Federal Emergency Management Agency (FEMA) and the long history of its use of trailers in disaster events, including the most current methods of relief FEMA is supplying after the Oregon Labor Day wildfires. Using the FEMA trailer to guide the scope of disaster relief precedents, the trailer's history will examine the Katrina Cottages, the Make It Right Foundation, and FEMA SEED. To aid in understanding the issues with current American disaster response, clarifying distinctions between modular and manufactured disaster relief will be made, and a critique of the current distinctions between temporary and permanent disaster relief will be provided including examples previously mentioned in the Demographics section. New principles of disaster relief architecture as related to common features of historical models will be defined.



Decommissioned modular homes at Royal Oaks in Phoenix, Oregon. . Source: Jane Vaughan/JPR

There are some design themes that reoccur with new major disasters and prove majorly informative as bad examples. As will be discussed, commonly used options like trailers or recreational vehicles are egregiously bad mostly due to a total lack of design. In certain cases, a designed response can do far more harm than good by being totally out of touch with the vernacular architecture of the community. Viewing a disaster-burdened community as a designer's dream "blank slate" is not a mindset likely to create an informed response.

The actual formal study of disaster relief and disaster resilient architecture, respectively, yields underwhelming results. While there is a fair amount of advisory on disaster planning as a whole, such as fitting key community centers (schools, hospitals, stadiums) with resilient features like generators or seismic bracing, the features highlighted are often focused on tweaks to existing architecture that is expected to survive a disaster. NBC article "3 years later: Rebuilding after the Alameda fire" asked a member of the Jackson County Community Long-Term Recovery Group what would most help their community, and received a common response: "It is housing," Wheeler Clay said. "It is housing. It is housing. And I hear from survivors, more often than you would think, I don't have time to deal with my feelings, I just need to get rehoused and so we have to be attentive to both of those."

Housing will remain the most common and immediately urgent form of architecture to lose, and is also a typology that is suited to previously discussed systems of modularity and incrementalism. This sentiment has been echoed throughout history in strategies for affordable, durable, and adaptable housing like in the Lustron or Dymaxion homes. By expanding on known approaches, architects have the unique ability to provide designs which are physically resilient, designed for healing, and constructed in appropriate replacement for a loss.

FEMA Trailers



A typical FEMA trailer. Source: Mariel Carr, "Where Have All the Trailers Gone?"

One seminal example of a model for disaster relief, and one which has been recently used in Oregon, is the FEMA trailer. FEMA trailers were mostly famously used in the aftermath of Hurricane Katrina and Hurricane Andrew. The modern day FEMA organization is reticent to use the trailers in disaster relief due to a laundry list of complaints and lawsuits about the housing.

FEMA trailers are mass-produced and designed to accommodate two adults and one child. The housing is explicitly built to be temporary, and trailers are often disposed of after a family has found more permanent housing, or sold at government auction. The primary materials used in the trailers are plastic, aluminum, and particle board, with trailers known to be poorly sound insulated and visibly flimsy. Residents cannot paint or customize the trailers or move the attached furniture inside, as mandated by FEMA terms.

Federal law prohibits the conditions under which FEMA trailers can be deployed; they may only be used for temporary housing for a term of no longer than 18 months. The trailers cannot be installed in flood plains, which was a hurdle for their use as relief in the aftermath of Hurricane Katrina, and trailers must be 20 feet apart from each other.

Angry graffiti on the side of a FEMA trailer, photographed on Rampart Street, New Orleans, Louisiana, after Hurricane Katrina. Source: Flickr/Trees and Water



The Sierra Club, an environmentalist organization, was instrumental in whistle-blowing high levels of formaldehyde in FEMA trailers supplied to victims of Hurricane Katrina and Rita in 2006 (The Sierra Club, 2016).

Formaldehyde exposure occurs inside FEMA trailers due to the glue used to apply interior finish boards, with mold, wind and water damage, and poor airflow cited as other FEMA trailer failures. FEMA trailers have been deployed in disasters and then subsequently found to be hazardous as recently as 2024, as previously discussed regarding Talent, Oregon.



Numbers for the cost of FEMA trailers range from around \$70,000 in base construction to \$180,000 for a full year of use, including site install and transport. In effect, these trailers are a type of single-use housing.

Headline announcing the sale of FEMA trailers. Source: KPRC Houston

Government auction for FEMA trailers sees many trailers stamped as unusable for further residential use due to their toxicity or failure, which drives down their value, but many may buy a used FEMA trailer for use as a residence regardless of risk. Prices at auction range from \$23,000 to \$30,000 dollars, suggesting that FEMA trailers lose value for their owners starting from first use.

Make It Right Homes



Designs for Make It Right Homes. Source: Graft Architecture

Katrina spawned a number of disaster relief housing projects, one of which was sponsored by Hollywood megastar Brad Pitt. His Make It Right Foundation built 109 homes in New Orleans' Lower Ninth Ward, a historically black and low-income neighborhood. Each of the homes was designed by a number of high profile architects, including contributions by Frank Gehry and Shigeru Ban. His foundation's rebuild serves as an intriguing reminder of the significance of understanding a site's character and community.

The homes, of which there were technically 106 when including 3 duplexes, cost 26.8 million to build. These 250,000 dollar homes were sold at an average of \$150,000 to occupants. A notable firm, Graft Architects, spoke of designs informed by historic New Orleans architecture, such as the camel-back or shotgun home. The homes were all supposed to be designed to meet LEED platinum status, and were rebuilt within the Lower Ninth Ward.

Only six years after construction completed in 2015, 2021 reports from urban planners stated that 99 of the 106 homes were vacant and in a state of disrepair. Residents cited severe mold problems and structural damage as a result of a complete lack of climate-appropriate design both in primary structural material and in basic form, with homes lacking adequate roof pitch and gutter systems.

Make It Right has refused to fix issues with the homes, the organization dissipating into the wind as lawsuits against Make It Right have overwhelmed the agency. Homeowners have seen Brad Pitt scurry to remove his name from use in the individual lawsuits.



Signs protesting the foundation's neglect. Source: Capital B



A dilapidated Make It Right Home. Source: Capital B



A historic Louisiana shotgun home. Source: Unique Nola



A shotgun-inspired Make It Right home.
Source: Graft Architecture

The Make It Right homes served as a fascinating example of disaster architecture that completely ignored its community. The architects involved seemingly failed to create contextually appropriate homes in the Lower Ninth Ward despite their architectural abilities in other areas. Each home was over-ambitious in scale and overly unique; homeowners complained not only of the poor quality of the housing, but the stigmatizing effect created by owning a home which served as a visual reminder of the Make It Right project and the hurricane itself.



Shigeru Ban's previously mentioned Onagawa community center (top) versus the home he designed for Make It Right (bottom).

The Louisiana home's porch coverage is far too high up to be functional, rendering the form void of functionality.

Source: Shigeru Ban Architects

Katrina Cottages



One of the first Katrina Cottages on display. Source: Bruce Tolar

The Katrina cottages arose from a committee of community members and a dozen architects who created the plans for the cottages at the Mississippi Renewal Forum in October of 2006 (Tolar, n.d.). While many Katrina cottages and most alternative housing provided after the hurricane were ultimately traded for larger, conventional suburban alternatives, one particular case study in the town of Ocean Springs, Mississippi, saw new life using the disaster housing.



Cottages at Second Street, Ocean Springs, Mississippi. Source: Bruce Tolar



Oak Park in Ocean Springs, Mississippi. Source: Bruce Tolar

Ocean Springs created a permanent infill project called Cottage Square, where modular cottages were delivered to the site and on permanent foundations within four days. This first development inspired a nearby cluster, the Cottages at Oak Park, which was financed by leftover funds from FEMA's Alternative Housing Pilot Program (Tolar, n.d.). Models were similar to the original trailer forms of the first rendition Katrina cottages, but new developments began to build upward as another cluster, the Cottages at Oak Park, transformed the initial Katrina cottage form into a healthy and dense neighborhood by stacking models.

Katrina Cottages



Examples of Katrina Cottage Modules
Source: Project Small Houses

Small, prefabricated homes delivered volumetrically to sites in Louisiana and Mississippi, and designed by a group of dedicated volunteer architects in collaboration with community members. Homes could "expand" to add porches or new rooms, and were able to accommodate modifications for placement onto fixed pier and beam foundations or as a unit on wheels.

New



Make It Right home in the Lower 9th Ward. Source: Dezeen

Historic



Single level home from Louisiana's French Quarter, c.1900. Source: Circa Old Houses

New

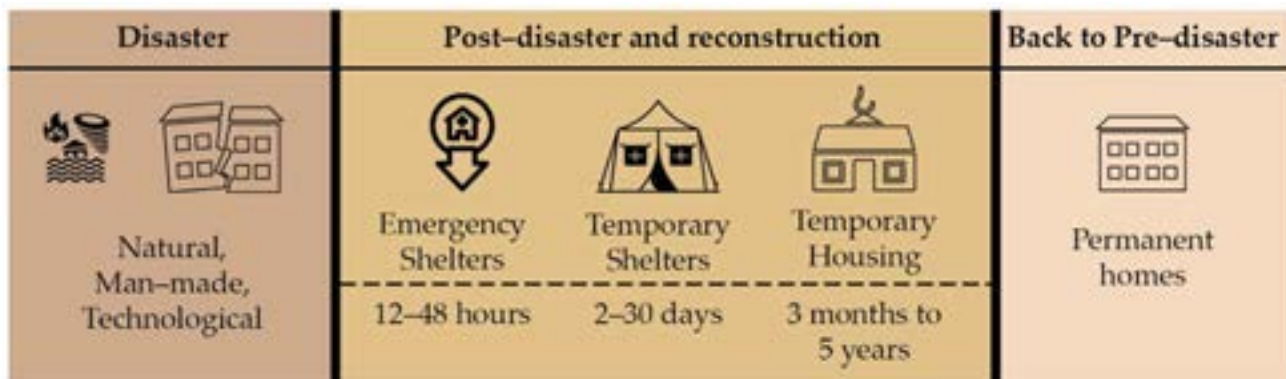


A duplex Katrina cottage. Source: Placemaker

Temporary Housing

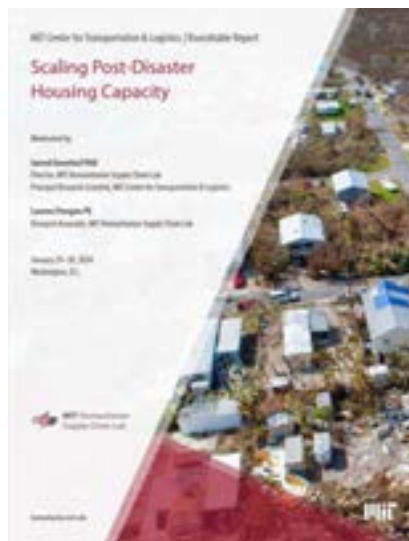
As has been shown in the case study of Katrina and the use of FEMA trailers, temporary housing as provided by the government did not fulfill the needs of disaster victims, leading to two differing outside approaches to provide routes to permanent housing. How can we learn from the failures of and solutions to the most recognizable form of American disaster relief?

Firstly, in defining temporary architecture, there needs to be a immediate distinction between what could be described as a phase of construction and what is disposable. Approaches like Expandable House, for example, have many temporary phases where the building is stripped down to the bare essentials on a single floor. In the most plain definitions of shelter, such as sheltering in tents, the tent requires a relatively small amount of effort to manufacture, transport, and set up when compared to other forms of disaster relief shelter. A distinction can be made between the actual timelines of different types of temporary architecture, where temporary shelter differs from temporary housing in its lifespan and form. Three key documents summarize lessons learned from temporary housing communities formed after major hurricanes and floods in the US, including hurricanes Katrina and Andrew, which are pictured on the next page. Quarantelli defines emergency shelter as a loosely organized solution characterized by sheltering in public or civic space or in the most immediate protection, such as a tent, for the days immediately after disaster or during disaster. Temporary shelter involves moving into quarters explicitly not one's own for weeks to a month, such as a friend's home, a mass shelter, or a hotel. Temporary housing is characterized by private units expected to be occupied on a short tenure of months to 5 years, while permanent housing is the highest quality and most desired option, designed to be occupied for life (Quarantelli, 1981).



Stages of Disaster Reconstruction

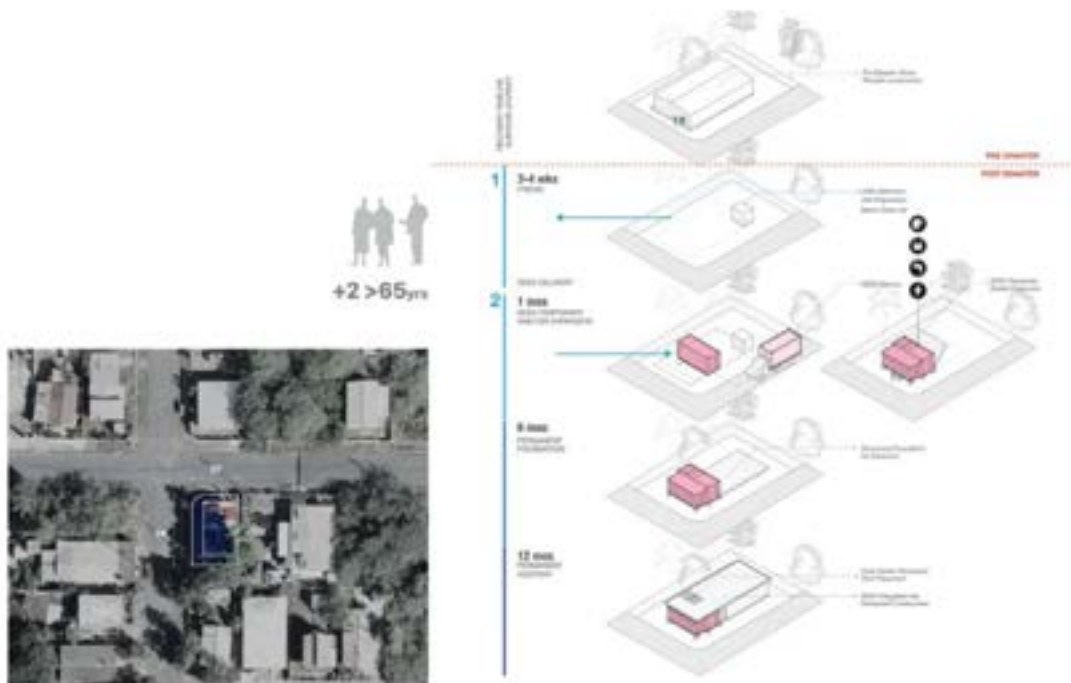
Source: Sustainability of Temporary Housing in Post-Disaster Scenarios: A Requirement-Based Design Strategy



To understand temporary housing in the US is largely to understand FEMA. FEMA limits the scope of its agency to an 18-month provision of temporary housing via a standardized HUD-code trailer, but will also provide cash benefits for households trying to cover repairs, supplies, and temporary housing outside of the agency, also limiting payout amounts and windows for application to 18 months. However, the agency understands the limits of these approaches, and has already piloted research into providing permanent housing in efforts like the Alternative Housing Pilot Program (which the Katrina cottages were a part of), the Joint Housing Solutions Group, and reforms of the 1988 Stafford Act. The newest ventures include FEMA Seed, a build-to-grow permanent housing solution for flood victims, and new modular homes for fire-stricken Lahaina. Both strategies seek to extend the life and quality of temporary housing, SEED hoping to transform a single module into a variety of permanent options, while Lahaina modular homes redefine definitions of FEMA's "temporary" assistance to provide shelters that are designed to last 30 years.



FEMA SEED (Shelter for Emergency and Expansion Design)
Source: Urban Risk Lab



Expansion of the SEED over time.
Source: Urban Risk Lab



A built module of the SEED.
Source: Urban Risk Lab



New modular housing made available by FEMA to victims of the 2023 Hawaii wildfires. These homes have been advertised as lasting 30 years or more, a significant step up in FEMA's housing quality.
Source: Maui Now

The issue with “temporary” housing as has been provided in the form of FEMA trailers or similarly strategies like the use of recreational vehicles (RVs) is a lack of architectural planning for an end-of-life or second transition phase from temporary to permanent housing. Quarantelli identifies three reoccurring issues with temporary housing. One issue is that without proper infrastructure, FEMA trailers, RVs, and hotels become accidental permanent housing after outside help exceeds its timeline. Literature overwhelmingly documents common scenarios where shelters overstay their welcome, much to the anger and dissatisfaction of their occupants. The predetermined end of life scenario for the FEMA trailer, in particular, is an architectural oxymoron; the home is not of quality to be permanent housing, but is expensive and non-recyclable. FEMA trailers and other low cost manufactured housing are effectively a waste of resources in the scenario where adequate permanent housing is able to be built on a reasonable timeline. More often than not, efforts to help can become traps where community members are forced to stagnate out of a lack of options.

Another issue is that victims of disaster simply do not like being in mass temporary housing developments and prefer to place temporary housing on their own properties when possible. This makes site remediation, transport of temporary housing to each site, and installation of temporary housing as individual to the site the preferred but energy intensive method of providing temporary housing. Because FEMA and other organizations try to consolidate resources and minimize transport and outreach costs, providers of temporary housing will typically try to avoid delivering temporary housing in this manner, which results in mass developments. Mass developments create the inevitable final issue wherein the new communities are poorly organized, lacking resources, and alienating for residents. Temporary communities which are planned well can also hurt victims because these communities are inherently meant to end, further destabilizing the new relationships between and life routines of those who have already been displaced.



Modularity



Incrementalism



Flexibility



Speed



Durability



Affordability



Humility



Circularity

Design Principles

We can use the aforementioned case studies of both good and bad approaches along with comprehensive literature review as references to create the principles shown here.

Modularity: Designing structure and program to subdivide into a set of smaller parts that can take advantage of prefabrication.

Flexibility: Design of final product to accommodate the user's desire for change and individuality despite the use of modular construction. For example, using open floor plans, designing for multiple points of entrance, and using removable or convertible furniture.

Speed: Choosing a system for constructing modules that is quick, designed to be transported easily, and which could be constructed accurately by the average laborer.

Durability: Physical resilience of the structure and improvement in quality over the former architecture. These measures will include the thoughtful consideration of the unique wind, seismic, and rain loads of the area, as well as the fire, tsunami, tornado, and flood risk. For example, Oregon homes in fire-burdened areas would need to incorporate non-flammable siding and Class-A roofs.

Affordability: Designing both for the affordability of the structure during first construction and in making sure that maintenance costs will be minimal.

Humility: Choosing a form that is true to the vernacular architecture of the area and does not attempt to reinvent an area's look or feel. Those affected by disaster want to be reminded of home, not their loss.

Circularity: Choosing local labor, materials, and designers so as to invest in the area receiving new disaster relief for the long term. The architecture provided should connect to restoring the natural environment and local business around the site to provide further economic protection to the community and the environment.

Key Takeaways:

Approaches to rebuilding after a disaster typically incorporate distinct material and programmatic features to deal with the constraints of time and money.

Limitations on budget and scale mean that most disaster housing will draw on the following strategies: incrementalism, modularity, or prefabrication.

If disaster response is too divorced from its pre-disaster vernacular, it may fail both socially and functionally. Architects who impose a vision for radically different or newly artistic urban planning and architecture will inevitably alienate communities.

Those who have been affected by disaster resoundingly prefer architecture that has some role in restoring a sense of normality and which is connected to the past.

section 03 - why mass timber?

What is Mass Timber?

Mass timber is an engineered wood product created out of various combinations of wooden boards, lamellae, or offcuts with different polyurethane glues. Elements are laminated with resins to create bonds stronger than the wood's own natural connection to its fibers.

Mass timber comes in a variety of orientations and methods of lamination, with some methods using physical connections such as nails or dowels. Mass timber differs from more traditional heavy timber or light frame lumber in its dimensional flexibility, the density and age of the wood fibers used, and in the structural shapes and strategies that create mass timber forms. In terms of structural capacity, mass timber should be thought of not as a replacement for light wood framing but as a replacement for structural concrete and steel, able to mimic the structural shapes of their construction as well as traditional "wood shapes."



Visual representation of the different major types of Mass Timber products.

Source: Gong, M. (2021). Wood and Engineered Wood Products: Stress and Deformation. In (Ed.), Engineered Wood Products for Construction.

Circularity

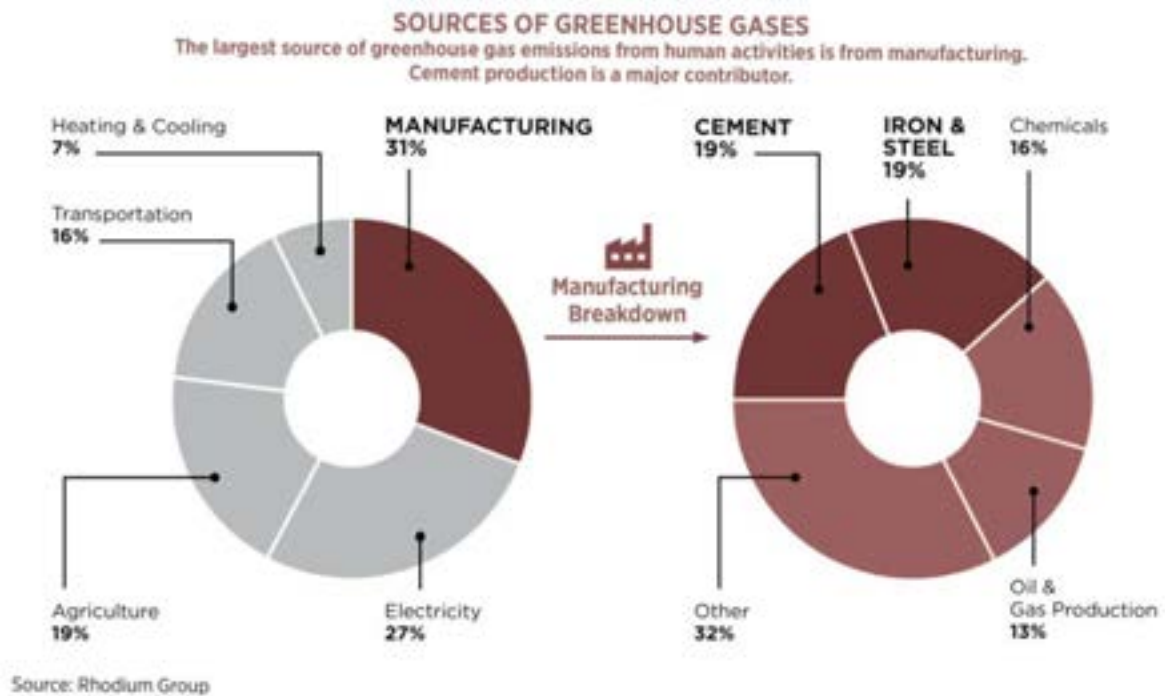


Diagram of a circular economy.
Source: Future Food Systems

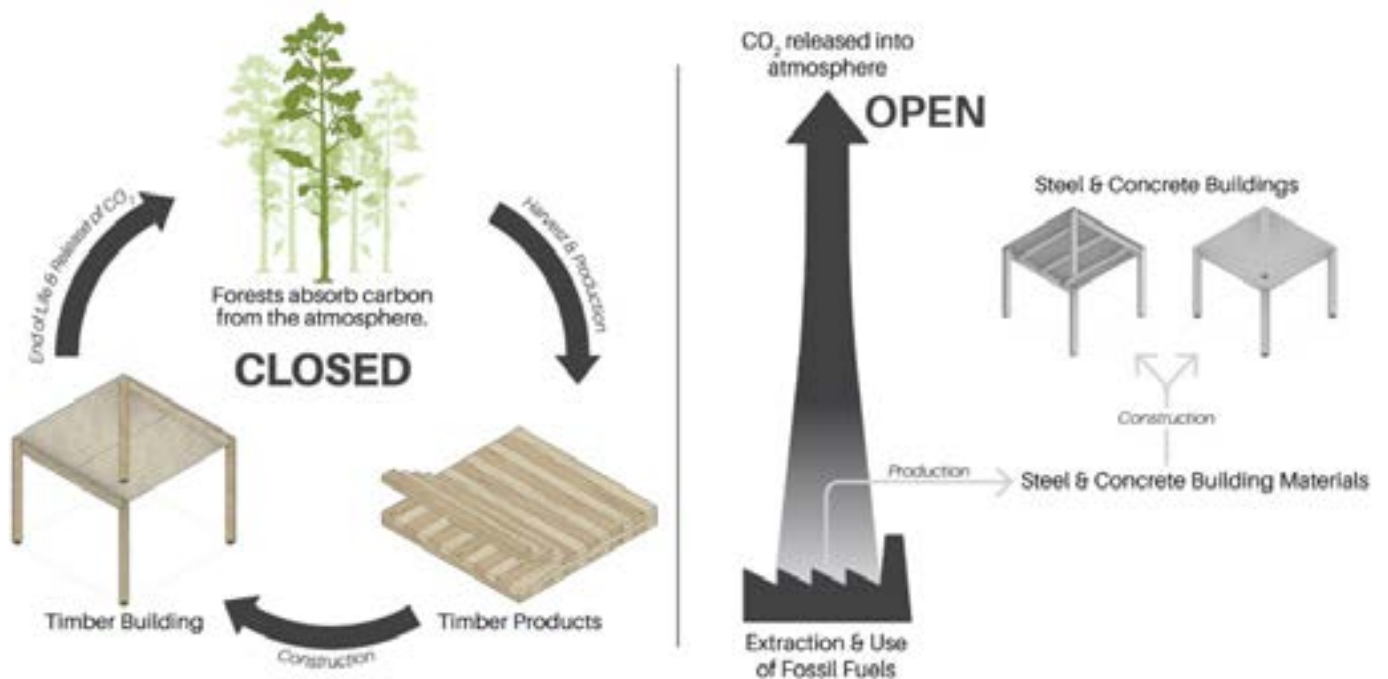
One key aspect of responding effectively to disaster is an effort to create a circular and interconnected economy through the initial aid, as opposed to building communities that have an inherent reliance on outside help in the event of another disaster. Features of such an economy aim to reuse waste products and extend the lifespan of building materials while simultaneously contributing to the wellbeing local businesses.

In Oregon, mass timber could be part of a revival in the timber industry and in manufacturing, providing jobs in forest management. Mass timber products are not structurally weaker when they are created from younger trees, which encourages regular thinning of the under-story of large forests while leaving old growth trees untouched. This reduces the need to clear cut large areas, which when performed can result in deforestation, loss of animal habitat, and soil erosion. Some mass timber products, like mass ply, can be made from the offcuts of other timber processes or trees which are otherwise too damaged to have purpose. Tree species which are typically unusable for lumber due to quality issues can be given new life in mass timber products through lamination and thermal treatment. New value found in previously unharvested forests could help to stop forests from being turned into farmland, which in turn would preserve complex forest ecosystems which support fish spawn and clean our air and ground water.

Mass timber reduces embodied carbon in building structures, both in the primary structure and in use as an interior finish by way of replacing concrete. The use of exposed wood as opposed to gypsum wallboard means that less gypsum is used in overall construction, a positive for the environment considering that gypsum boards cannot be recycled after use. Mass timber's ease of construction could also attract new workers and would guarantee a safer and cleaner job site for projects. For Oregon, which has struggled to bring back timber jobs after the 1980s recession, mass timber products represent an opportunity to modernize the image of wood while succeeding where other prefabricated and modular approaches to its housing crisis have failed.



Concrete and steel manufacturing as expressed as carbon expenditure. Source: LMN Architects

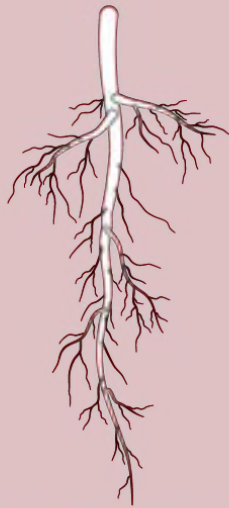


Comparative utility of biogenic carbon. Source: DrawArchitecture

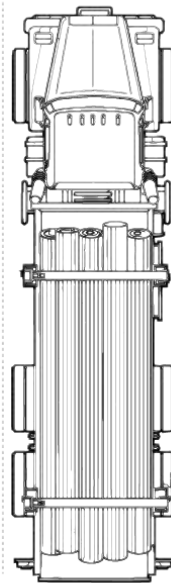
Mass Timber and Carbon

(sourced from Volume 251 2 of Building and Environment journal, in "Environmental impact assessment of mass timber, structural steel, and reinforced concrete buildings based on the 2021 international building code provisions"

- Biogenic carbon refers to the carbon sequestered into the building material itself, such as the carbon inside of wood or plant fibers
 - Biogenic carbon is released when the material decays; this means longevity of materials is the name of the game
- Embodied carbon refers to the "spend" of carbon as emissions related to construction and building material
 - This is the mandatory carbon expenditure involved in producing a product such as carbon burned to smelt steel
 - Emissions from construction activities like transports or repairs are also included within embodied carbon
- Operational carbon refers to carbon emissions during habitation and operation of a building, such as air exchange, heating, cooling, and activities such as cooking or showering
 - This category will not include the manufacturing, replacement, repair, or site transport of systems, only the actual carbon it takes to run systems when they are in place
- Mass timber sequesters 0.5 pounds of carbon per pound of wood in assembly, while concrete and steel do not sequester carbon, as they are not biogenic materials
- Timber industry uses far less embodied carbon than either the concrete or steel industry (0.017 tons of carbon for every ton of timber); steel embodies 1.8 tons of carbon for each ton of steel produced, while concrete embodies 0.6 tons of carbon per ton of concrete
- While concrete's embodied carbon is lower than steel, buildings tend to use far more weight in concrete than in steel for the same square footage



Effective disaster response includes the effort to create a resilient economy through the initial outside help



Mass timber could be part of a revival in the timber industry and in manufacturing, which would bolster housing production and provide new jobs.



Mass timber products derived from younger trees encourages reforestation of the unbroken large forests with old growth trees



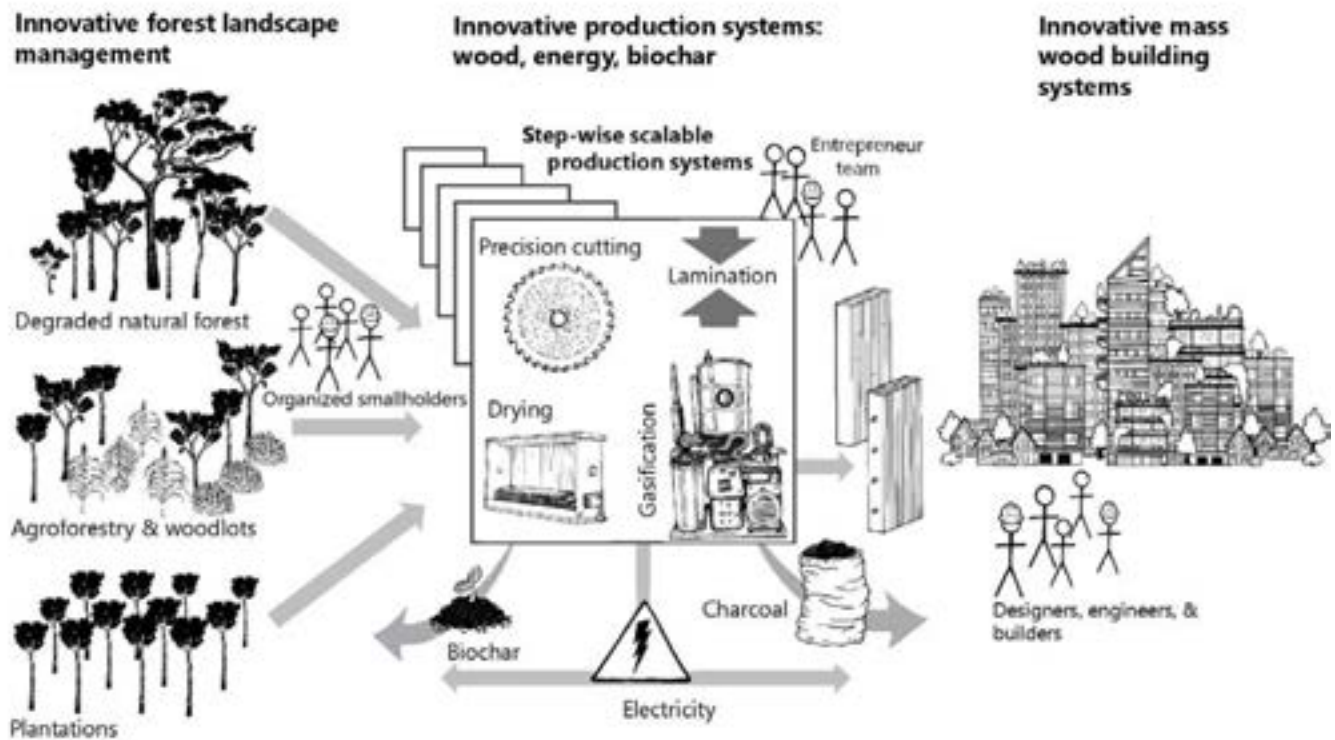
Products can
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Mass timber construction is dry, precut, and fast. Mass timber homes could be the solution to the high costs and shortage of labor.



Tree species which are typically unusable as lumber can be given new life in mass timber products through lamination and thermal treatment.



Proposed system of circularity in the timber industry.
Source: Gong, M. (2021). Wood and Engineered Wood Products: Stress and Deformation. In (Ed.), Engineered Wood Products for Construction.

Use in Disaster Relief

Beyond its unique properties as concerned to circularity, mass timber also possesses many other features that are beneficial in disaster relief architecture.

- Mass timber products are far more dimensionally stable than light framing members due to the perpendicular layers of the products, which stress panels in both directions. Tolerances for mass timber panels can easily be cut by CNC router to 1/16" or 1/8", eliminating air gaps in buildings. These tight tolerances mean mass timber buildings are much more energy efficient and will more easily meet passive ventilation goals when coupled with good design. This accuracy also ensures easy construction and enhances perceived quality within projects.
- Mass timber wall assemblies eliminate wall cavities, which can eliminate the chance for unseen mold. Traditional stick-built homes and standard modular homes create wall cavities often vulnerable to moisture, insects, and animals, and which act as thermal bridges. As opposed to stick frame walls, timber panels can be left unfinished in interiors, saving on the costs of drywall. Wood also has naturally antimicrobial properties and is easily cleaned. A mass timber product such as CLT or MPP can be used for floor, ceiling, and wall finishes. Beyond performance, wood is a naturally calming material that satisfies biophilic design goals within the default finish of the material.
- Mass timber panels can easily last for 100 years without upkeep or replacement to the panel itself. Cradle-to-grave analysis of standard modular homes, stick-built homes, and modular mass timber homes found that standard modular homes consumed 75 tonnes of carbon over a 100 year lifecycle, with traditional stick-built homes clocking in at 34 tonnes. In comparison, mass timber modular homes required only 19 tonnes of carbon in maintenance over 100 years (Barside, 2025). Replacements for siding were the only modifications required for the mass timber homes, whereas flooring, interior finishes, and floor underlays were frequently replaced in both of the alternatives.
- The number of pieces and the packaging and transport of each material and finish in regular homes can be greatly reduced by using mass timber. Panels can be removed and replaced if damaged. Mass timber structures also support being "cannibalized," or taken apart and reused. Because connections between panels can employ simple screws, panels can be re-screwed multiple times or trimmed down for reuse, and offcuts from the manufacturing process are often valuable and viable for other projects.



Charred CLT section. Source: Timber Frame Engineering Council

- Mass timber products have naturally high fire ratings, performing better than unprotected steel and equal to concrete in furnace testing.
- Mass timber's fire resistance comes from wood's natural ability to char, which forms a protective coating over the inner timber. Char is very difficult to ignite and allows wood the unique structural property of self extinguishing when removed from heat.
- After testing CLT panels to the standard fire resistance test (CAN/ULC S101 (Canada), ASTM E119 (USA), and ISO 834 in other countries), a five-layer (7.5") CLT floor panel has received a 1.5-hour rating, while a three-layer (4.5") wall panel can receive a 45-minute rating. This metric means that each inch of CLT adds 11 minutes of fire resistance; a 3" exterior wall would provide 33 extra minutes of fire resistance.

Seismic testing of 10-story structure by LEVER Architecture. Source: Building Design + Construction



- Wood performs well in lateral bracing due to wood's own inherent property of ductility. Wood cells are long, thin, and elastic, and strong both in tension and in compression when forces are applied parallel to or along the grain. Resistance to shear force is further improved by cross lamination. If using mass timber in construction, the stiffness of the many interior walls can easily serve as an adequate shear system without disruption to the design.
- The mass of a structure correlates to the seismic inertia generated in an earthquake. As wood is five times lighter than concrete, seismic forces are reduced within the structure.

Practices for Efficiency

Mass timber has a number of material-specific constraints that need to be considered from the first point of design. Without a knowledge of the chosen material, change in direction and design will come at the cost of time and money. Factors include:

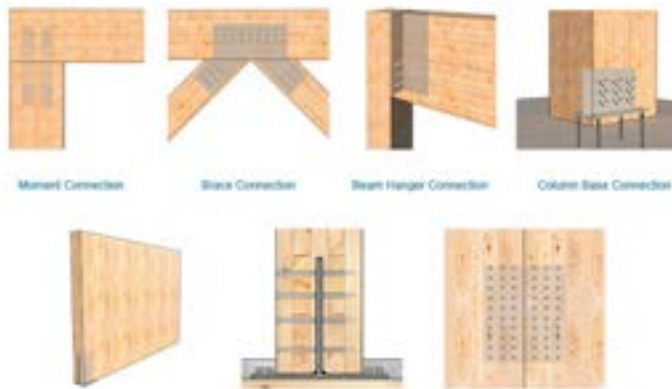


CLT spans. Source: Bending Properties of Cross Laminated Timber (CLT) with a 45° Alternating Layer Configuration, Luleå University of Technology

- The desired mass timber product or products and their specific strengths and weaknesses (MPP, for example, has a higher compressive strength when used for flooring than other mass timber products like CLT). Different mass timber products may be combined to maximize structural efficiency.
- The exact thickness of the product chosen; the availability of specific thicknesses can act as a bottleneck. Choosing a manufacturer that can only produce a standardized thickness, like 3 ply CLT, may result in high costs and over-engineering for a project due the redundant wood fiber.
- The species of tree used in the product, both due to questions about the supply chain, transport of the product, and the differing structural strengths and finishes between types of wood. The official list of species defined for use in CLT is outlined in AIAS PRG 320; some wood species may not be approved for usage.
- The panel size desired for the construction in relation to the manufacturer's available billet sizes and cost per cut. A billet is a large slab manufactured to standard size for later cutting.

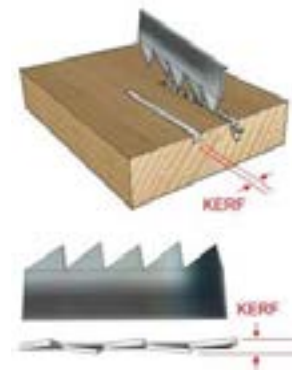
Differing CLT layups with mixed wood species. Source: "Properties of mixed species/density cross laminated timber made of rubberwood and coconut wood," Structures Magazine, June 2022



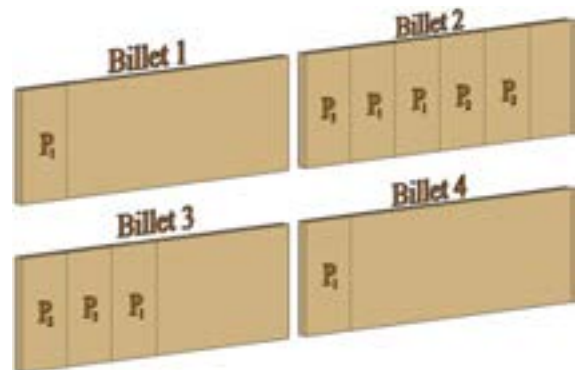


Left: Different CLT connectors. Source: MTC Solutions

Right: Saw kerf visualization. Source: DT Online



Billet layout. Source: "Mass-customisation of cross-laminated timber wall systems at early design stages,"
University of Technology Sydney



- Designing for CNC cutting; if a CNC will be doing all of the cutting, turn radius for the blade will differ with the bit, which means that designers must plan out billets with this radius included. Different cutout shapes will also have differing possible tolerances, such as circles, which are typically at a 1/8" tolerance versus a 1/16" tolerance for straight cuts.
- Designing for saw cutting; each saw blade's thickness will have a different kerf width, and will require a length of waste area at exits, which must once again be accounted for when laying out billet cuts.
- Span direction of the architecture and strength of the wood product; for example, MPP can span two ways, while CLT is stronger in the direction of its primary wood grain.
- Finished vs. unfinished delivery; most mass timber products will arrive without the need for further finishing, but this varies per product, and therefore could add time and expense if a finish coat is needed.
- Connections between panels; wood can be connected via splines, tongue-in-groove cuts, hidden ties, wooden joints, or any number of steel connectors, all of which have different applications and prices. Certain connectors may create tripping hazards or be visually unattractive.

Major Design Limits

In a number of interviews and in person visits part of this project, there are key limitations beyond manufacturing for efficiency in designing residential buildings using mass timber. These challenges are not new to architects, and are in some ways shared with structures built from concrete.

Because mass timber is a solid panel, there will not be available cavities in the wall for plumbing and electrical. Designers typically approach this issue by gapping walls, adding one strategically light framed wall, or variations in panel thickness and floor and roof assemblies. Modular assemblies also run the risk of inefficiency without a strategy for transportation and construction. If shipping volumetrically, designers will be limited to a maximum size of 14' wide by 40'-60' feet long, depending on the truck available; wider transport options are available but homes will begin to require road escorts after exceeding 14' in width.



MEP cut flush into CLT wall. Source: Woodworks

Designing with modules also requires designers to choose between designing for “open” or “closed” modular systems. Open modular systems are modular in the sense of plan; the modules can be constructed as complete units with full walls on all sides, but the designer plans for areas that are punched out of the module if combined. Closed systems anticipate connecting all modules as constructed with full walls back to back, which places restrictions on the openness of the final result. Double walls or double roofs created by stacking and pairing modules are inefficient and can waste fiber, but savings from the ease of the construction may make up the difference.



Double wall modular construction.
Source: Weber Thompson



Module constructed with “punched out” wall.
Source: Kalesnikoff

Key Takeaways:

Mass timber is particularly relevant to disaster relief in Oregon because of Oregon's historical and economic connections to its forests.

Mass timber naturally eliminates bottlenecks and imprecision in construction via the dimensional stability, transportability, and true-to-CAD accuracy of individual pieces in kits-of-parts.

Designing with mass timber must involve planning for efficiency in the actual manufacturing process so as to not waste material. Planning for manufacturing may result in restrictions on the final design.

Disaster relief can suffer from over and under design; mass timber's quick construction times mean the majority of the success of each project depends on the knowledge and planning of the architect during early design stages.

A large, light-colored wooden beam is suspended horizontally by two thick purple lifting straps. The beam is covered in numerous handwritten signatures and names in dark ink. Some legible names include "Angel", "Cristina", "Jesse", "The Washington", "Alex", and "Wesley". The beam is positioned in the upper half of the frame, with a cityscape visible in the background. The city features various buildings, including a prominent one with a "NEO" sign, and a street with cars. The sky is blue with scattered white clouds. The text "section 04 - case studies" is overlaid in white, lowercase letters on the beam.

section 04 - case studies

The Sierra Homes

Year Completed: 2023

Size: varies

Architect: atelierjones

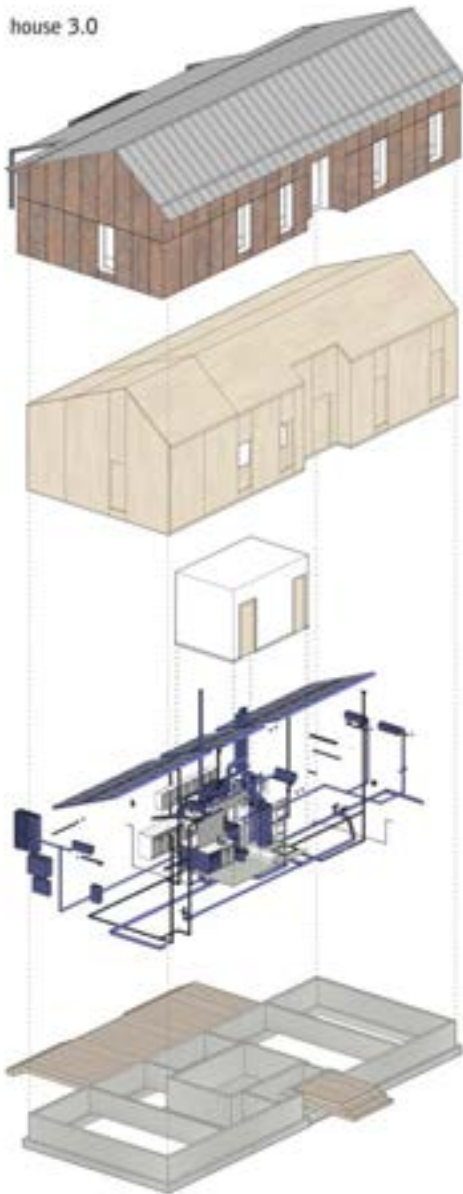
Building Type: Housing



The Sierra Homes were designed to “meet the challenge of affordable, rapid, and sustainable rebuilding” (atelierjones, 2024). The homes were designed specifically for rural communities affected by the 2024 Dixie Fire. Housing for rural communities often presents itself as one of the most challenging problems for architecture, as homes are in the highest risk zones for wildfires, while rural communities may also suffer additional disadvantages both economically and as a result of remote living.

atelierjones worked with the Sierra Institute for Community and Environment in funding the homes. Mass timber CLT walls, floors, and roofs are flat-packed and pre-cut to be assembled on site with small crews. Three modules, each centered around a core containing MEP, were designed for the Greenville community. A feature unique to this project, the Sierra homes are specifically designed to be fire hardy as a primary driver of design and material choice.

house 3.0



fire-hardened cortex and
aluminum shell

mass timber structure

modular wet core

mechanical + electrical +
plumbing + fire

foundation + decks

Minimal overhangs are seen over the main entrance of this design, which also includes enclosed decking. These features stop embers from catching on the home.

Left: Example of Module 3's construction and spatial layout.

Bottom: Sections of Module 3.



house 3.0





Community engagement helped the firm to build to the needs of those who had lost their homes. Constructions are turn-key and constructed to Passive House standard.

Interiors are warm, spacious, and filled with light.



Each home is clad with corten steel and uses high performance appliances and windows. The homes are specifically designed to incorporate defensible space into each module, using pea gravel, metal decking, and a clear zone of five to ten feet around the perimeter of the home.

CLT construction enabled the cores of the homes to arrive on site pre-assembled and ready to be placed on top of the foundations. Outer walls were then assembled around each core. Cores used a mix of CLT and light-frame walls to ensure adequate space for plumbing. Electrical boxes and wires were routed into channels cut directly into the CLT, a common strategy easily performed using standard 3-Ply CLT assembly.

All case study images courtesy of atelierjones.

Matt's Place 2.0

Year Completed: 2023

Size: 1000-3000 sq. ft

Architect: Miller Hull

Building Type: Housing

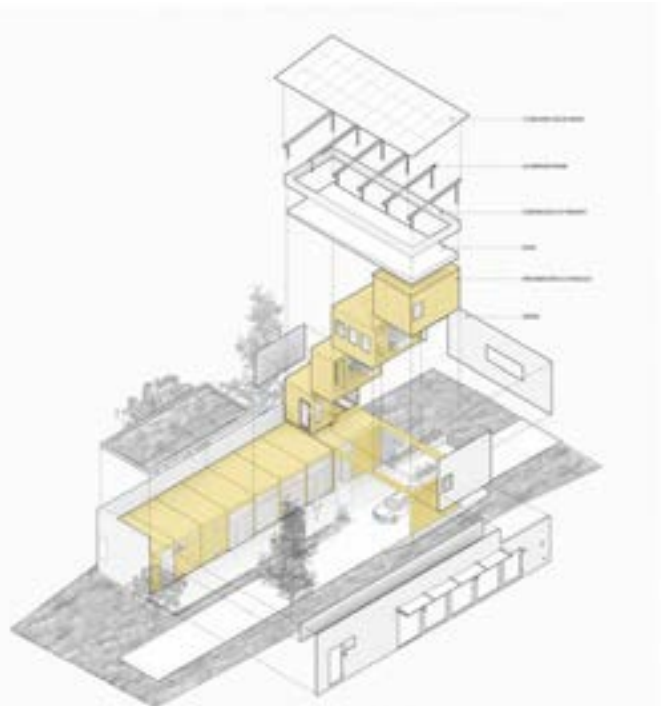
This unique project is one in a series of accessible homes to support those diagnosed with ALS. Miller Hull takes advantage of the soothing properties of wood and strength of CLT to create homes with open floor plans that can adapt to the needs of a resident patient.

This home is built in an L-shape to provide long and wide corridors and to maximize the entry of natural light. Construction was done as installments of thirteen modules prefabricated and delivered to the site.

Bottom: Construction of Matt's Place.

Right Middle: Axon highlighting the mass timber elements of the home.

Right Top: The finished home.



Matt's Place uses a interior spline between panels as a way to run conduit up from the floor and exterior walls and into the home itself. This version of Matt's Place conceptualized the homes as modules which were not volumetrically delivered but exploded and cut into regular panel sizes, assembled on site wall-by-wall.



Due to the accessibility challenges faced by those diagnosed with ALS, the home strives to utilize mass timber to cut down construction costs and maximize the therapeutic value of interiors while providing spacious interiors. CLT's durability lends itself to easy installation of medical devices that require wall mounts.

ALS patients will progress through the disease to a point where they are no longer able to go outside due to mobility restrictions and because of the disease's effect on temperature regulation of their bodies. Because patients will spend so much time inside, the mass timber serves to connect them to the outdoors and reduce interior associations to traditional medical facilities.

All case study images courtesy of Miller Hull.

Mass Casitas

Year Completed: 2023

Size: 1136 sq. ft

Architect: Hacienda CDC and Salazar Architect

Building Type: Housing

Location: Talent, Oregon, Madras, Oregon,

A part of the Port of Portland initiative, the Mass Casitas or mass (timber) homes were an affordable housing alternative designed for wildfire survivors in Oregon.

The homes more closely resemble a traditional modular home and were delivered fully built to each site. The homes are revolutionary in their use of MPP, and are designed to add on additional bedrooms and baths as part of a modular system. Pricing for the home saw that each home cost around \$400,000 per unit.

Bottom: Tina Kotek visits the Mass Casitas in Construction.





The Mass Casitas have been associated with mixed reviews from occupants who have not responded positively to the interior look of the mass plywood. Occupants feel that the end product suggests that the home is unfinished and overly unique, creating a visual stigma when observed by visitors to the homes. Conduit is also exposed across the home, which has contributed to an industrial feeling. Despite these visual challenges, the exterior form of the home and functionality as well as the expansion of the home through well defined modules are admirable elements of the Mass Casitas.

All case study images courtesy of Mass Casitas, Hacienda CDC, Salazar Architect, and Kristyna Wentz-Graff of OPB.

PathHouse

Year Completed: In progress

Size: varies

Architect: LSW Architects

Building Type: Housing

Location: Portland, Oregon



PathHouse is a modular mass timber housing system, developed by LSW Architects as part of a mission to mass produce mass timber housing. The project aims to produce 50,000 modules per year at 10-20% below market rate while maintaining a net zero carbon rating. Modules are designed to be stacked to be assembled into residential structures up to four stories high.

The project received funding from the US Forest Service and includes a co-patented floor cassette system as the driver for its design. The project is unique in its explicit use of stages so as to transform the module from disaster relief to ultimately permanent housing, and in its fire suppressive features. The project is currently operating under a site work contract with the USFS for a pilot project in Detroit Lake, Oregon, consisting of 27 modules arranged into 12 units. The project is also unique in its use of MPP flooring and CLT walls, a choice that strategically cuts costs while taking advantage of MPP's strength as a flooring system.



Left: Example of Module 3's construction and spatial layout.

Bottom: Sections of Module 3.

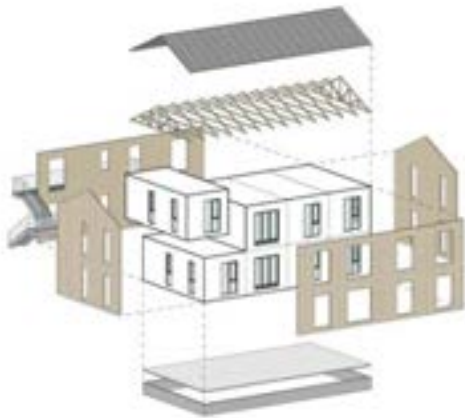
PATHHOUSE MODULE

Flexible. Durable. Smart. Pathhouse modules are designed with the future in mind. Timeless, sustainable, and beautiful materials provide the flexibility and longevity housing deserves. Units are delivered fully waterproofed for up to one year, and fire protected allowing you to move in immediately. Each module is tech ready, with integrated wifi, building monitoring, and infrastructure ready for a renewable energy

Example of an individual module's layout.

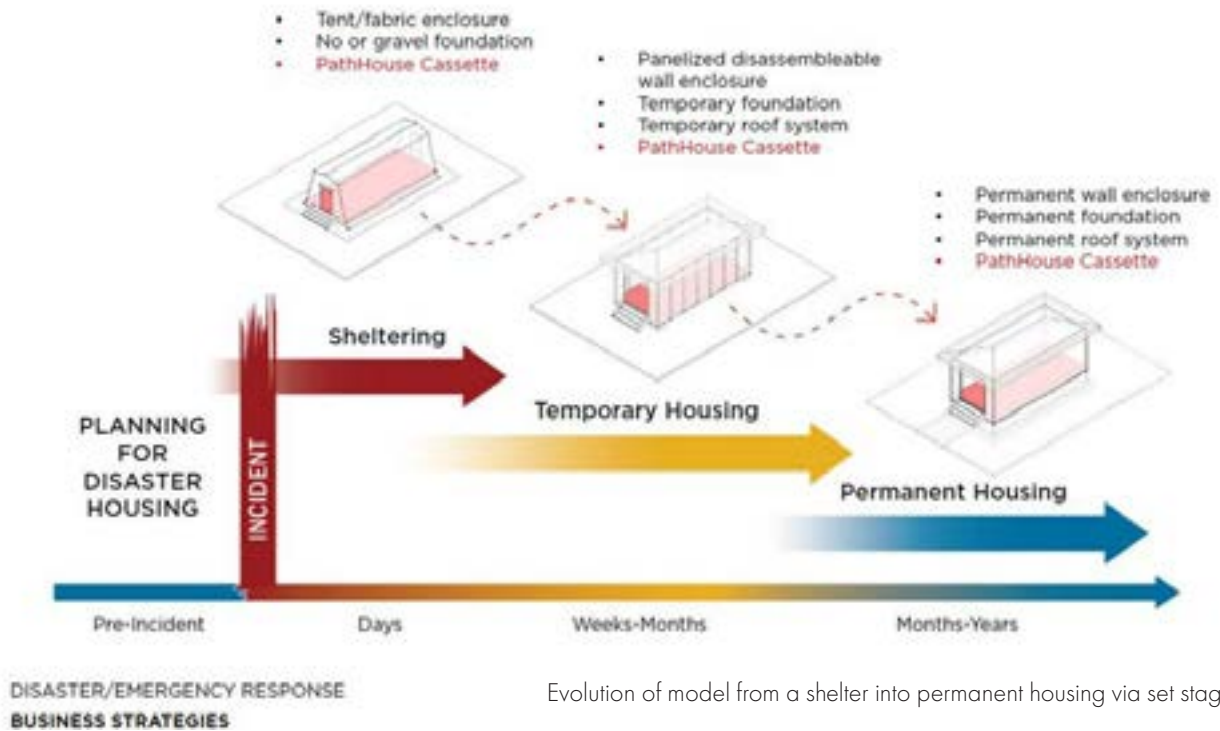


Modules transforming into multifamily dwellings.



The cassette floor system, which uses mass plywood to encapsulate equipment.





Evolution of model from a shelter into permanent housing via set stages.



All case study images courtesy of PathHouse in collaboration with LSW Architects and Zlatan

Estkwés

Year Completed: 2024

Size: 250 sq. ft

Architect: CedarStone

Building Type: Housing

Location: Eugene, Oregon



The Estkwés home is a newly developed tiny home already pre-approved as an ADU in Eugene, Oregon. The home was developed by local design/build firm CedarStone, lead by a duo of designer Adrienne Fainman and craftsman builder Cueyo Cataldo. The Estkwés home is 250 square feet, accommodating a full bath and including space for two beds, and designed to support disadvantaged mothers in transition from houselessness as part of a project collaborating with Hacienda CDC.

The home retails for \$139,000, excluding site-work, and is delivered fully built. Install happens on top of stem walls and takes less than a day, the only components placed at the site being the skylights. The home is built to be modular and can be mirrored around an additional core to expand the kitchen and include a dining room. The home is unique in its use of CLT and its cork cladding system, which has both water resistant and insulative properties while serving as siding.



Top: Interior of the home, showcasing the inclusion of a washer and dryer.





Top and bottom: Models of the module when mirrored and expanded.





Top: Interior of the home, with a view of the main bedroom and kitchen.

Bottom: The home as seen from outside with cork siding and skylight visible.



All case study images courtesy of CedarStone.

Məxilp

Year Completed: 2024

Size: 1000 sq. ft

Architect: CedarStone

Building Type: Housing

Location: Eugene, Oregon



The Məxilp home is a larger preapproved ADU in Eugene, Oregon. The home retails for \$367,000, excluding site-work, and is built on-site. The home is significant in that it is one of the first CLT homes in Eugene, Oregon, permitted under log cabin code.

The home features sho-sugi ban siding and a long, sloped roof with an extensive solar array. The home features one and a half baths, a full size washer and dryer, two bedrooms, and a full kitchen. While not a modular design, the home does feature a sizeable carport with surrounding insulated walls, designed to be filled in as another bedroom if desired. The home's structure was completed in three days, with the construction timeline consisting of two months split between 3-4 weeks of prefabricating the panels and 4-6 weeks of installation and finishing.



Top: Interior of the home, showcasing the inclusion of a washer and dryer.



Mass Ply Flat Pack House

Year Completed: 2025

Size: 760 sq. ft

Architect: Tallwood Design Institute in collaboration with Oregon State University and the University of Oregon

Building Type: Housing



The Mass Ply Flat Pack home is a two story prototype designed for use in affordable solar cottage clusters. Construction uses 3 ply MPP for exterior walls and 2 ply MPP for interior walls, with the plywood interior exposed throughout. The home is complete with one and a half bathrooms and two bedrooms.

The MPP Flat Pack home was lead by Tallwood director and UO professor Judith Sheine and UO professor Mark Fretz. The home is one of the first ever uses of the newly created mass plywood product for residential construction. MPP is particularly cost competitive as compared to CLT homes as the product can use a diverse number of log sizes to create shaved lamallae. In fact, MPP can be manufactured using logs as small as 5 inches in diameter, saving small lumber from becoming scrap.



Image: Marcus Kauffman



Image: Marcus Kauffman



Image: Marcus Kauffman



Image: Marcus Kauffman



Image: Marcus Kauffman

Interiors of the MPP Flat pack home show a surprisingly spacious and light-filled space. While project leads were initially concerned that the amount of exposed interior wood would be overwhelming, the final product's coloring provides an airy backdrop to the home.



The two-story home was built inside OSU's A.A Emmerson Advanced Wood Products Lab using a crane. The product itself can be flat-packed and shipped via semi-truck.



Marcus Kauffman



MEP strategy inside the home consisted of CNC-cut channels for electrical wiring, and enclosed cores hidden near the stairs. Door and window holes were cut into the thickness of the ply, eliminating headers.



All case study images courtesy of Marcus Kauffman, Mark Fretz, Jason Stenson and University

Hemlock Passive House

Year Completed: 2023

Size: 1541 sq. ft

Architect: Armand Graham

Building Type: Housing

Location: Hudson Valley, New York



The Hemlock Passive Home is an all-electric prefabricated cabin made from CLT panels. The home is 1,400 square feet, with 350 feet of porch space, housing three bedrooms and two baths.

The project is particularly relevant due to its creative use of Ponderosa pine. The home was built using the Timber Age Modular Building System, or TAMBS, a building method pioneered by Timber Age Systems. The CLT for the project was sourced from southwestern Colorado. Timber Age VP Chris Hamm discussed the decision to source Ponderosa pine for the project as a trial of a model for removing the hundreds of excess trees on acres once populated by only a few dozen Ponderosa pines. Forest systems across the West have faced similar patterns of overgrowth as a result of poor forestry management. This in turn has created an overgrowth of problem beetles, who enjoy the close proximity between trees and abundance of food. While Ponderosa pine is unusable in the lumber industry because of its natural proclivity for knotting and curving, it can be processed into CLT panels.



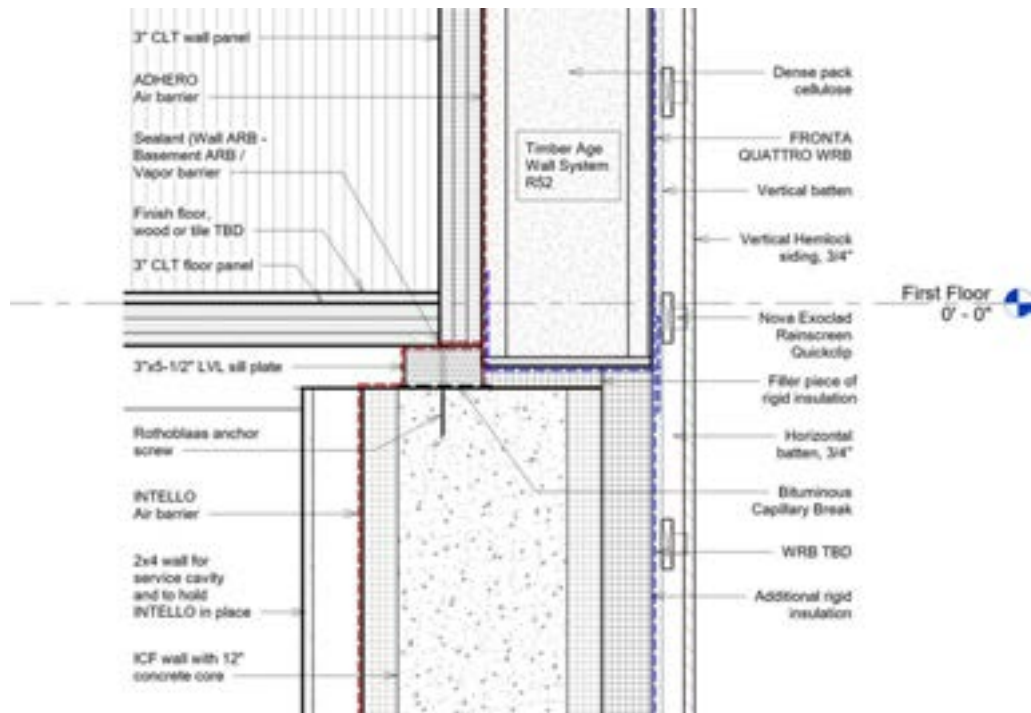
The structure of the home was based around CLT panels stacked on top of a concrete ICF basement. An exterior grid made from plywood provided space for dense pack cellulose insulation.



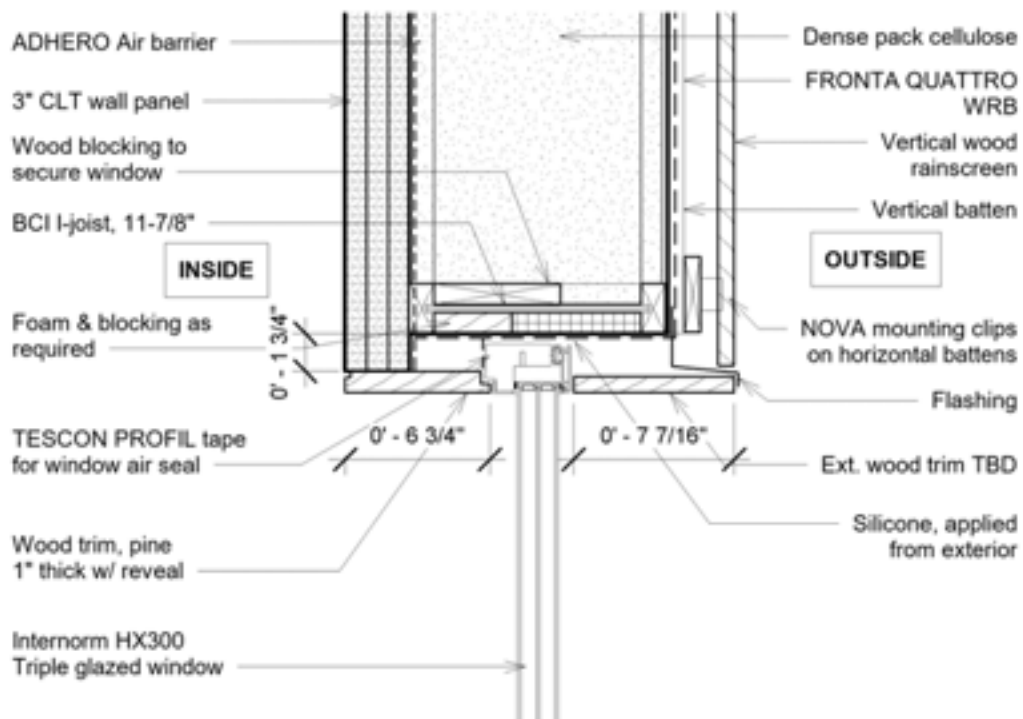
The base grid for the project works off of 4'x10' and 5'x10' panels. Coordinating shop drawings for the cutting of the panels was accomplished through weekly Zoom meetings over the course of a year.



While coordination of the initial design proved to be challenging, construction was completed on the insulated structure within three days of the panels arriving on site. The design was later fitted with solar panels.

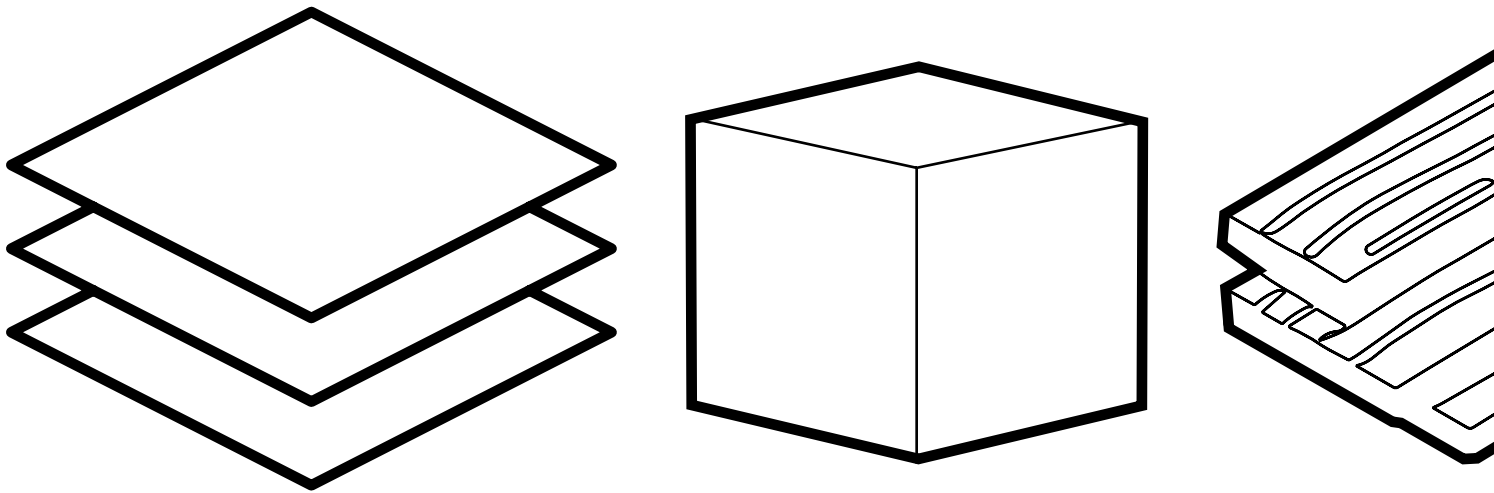


Construction details provided by the architect.



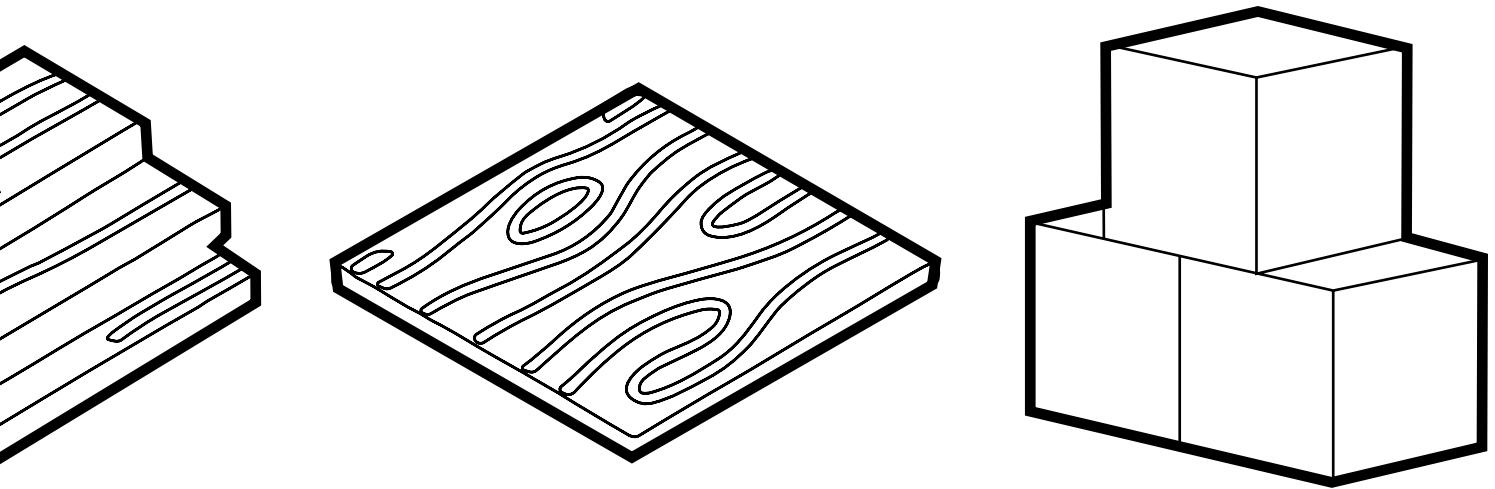
All case study images courtesy of Armand Graham and Chris Hamm

Case Study Synthesis and Reflection



- **16** total interviews with architects, mass timber, and wildfire experts
- **10** Case Studies
- **8** architect interviews
- **2** in-person case visits to case studies

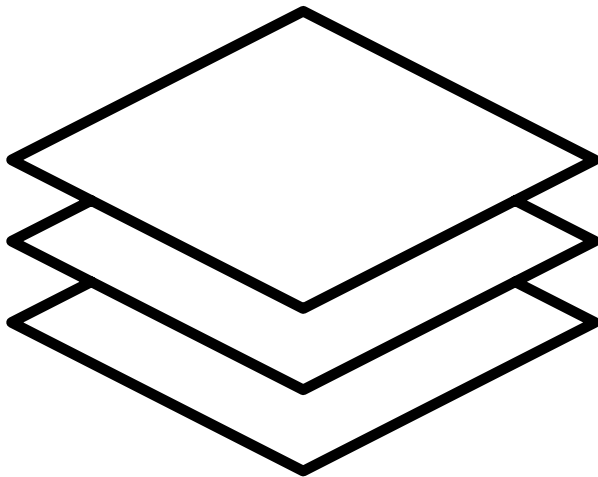
The seven case studies all demonstrate differing structural and programmatic approaches to mass timber in residential applications. Of the seven, five were directly related to wildfire relief; these models were the Mass Casitas, Sierra Homes, PathHouse, Estkwés, and the Mass Ply Flat Pack Home. Matt's Place served as an example of mass timber providing psychological relief for those living with ALS while accommodating program aimed at accessibility. Hemlock House served as an example of a residential use of new Ponderosa pine CLT, showcasing mass timber as the vehicle to provide new opportunities for recycling and repurposing a greater variety of wood species.



Of these case studies, PathHouse and the MPP House have not yet been made used for real-world relief, but provide valuable insight into the work being done to improve on past proposals as demonstrated in the other three cases. Problems identified as shared between the Sierra Homes and the Mass Casitas were the high price of the homes and the distinct look of the mass timber architecture. The Mass Casitas in particular were successful in their humble exteriors, but their bright colors and industrial interiors were somewhat alienating to new owners as anecdotally reported. The use of mass-ply, in this instance, made homeowners feel as if certain parts of their home were yet to be finished. The Sierra Homes are distinctly clad with metal corten steel siding, the installation of which requires a rain screen or stand-off clips. This training may not be commonly available to lower-income, rural communities and is more expensive and time-consuming to execute than other alternatives, knowledge of which may then make the metal siding distinctive.

6

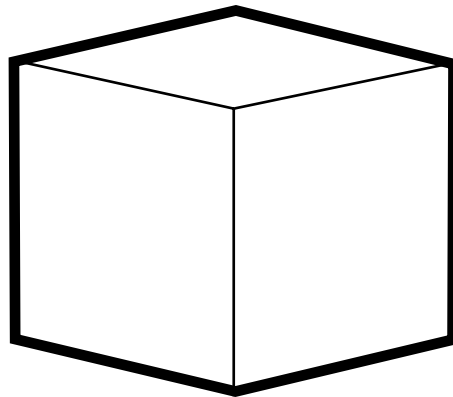
flat-packed



- Mass-ply House
- Sierra Homes
- Hemlock Passive House
 - Mæxilp
- CRTC BOLEH
- CRTC B-Hut

4

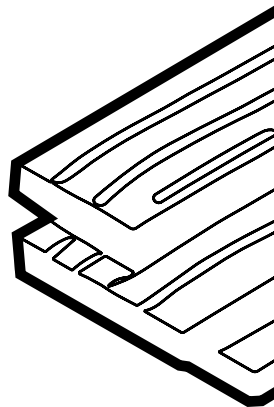
fully volumetric



- PathHouse
- Matt's Place 2.0
 - Estkwés
- Mass Casitas

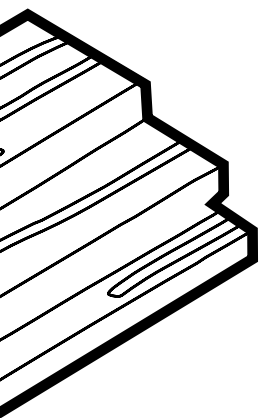
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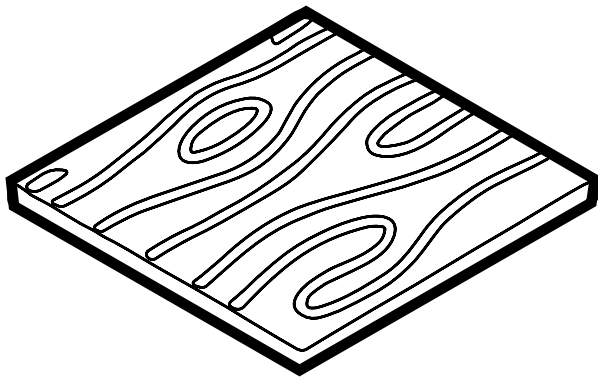
- Sierra House
- Hemlock House
 - Mæxilp
- CRTC BOLEH
- CRTC B-Hut
- PathHouse
- Matt's Place 2.0
 - Estkwés

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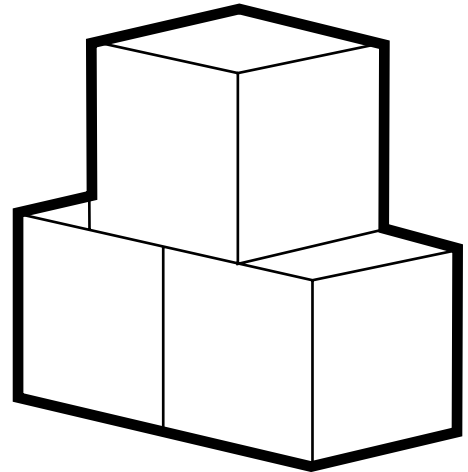
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- Mass-ply House
- Mass Casitas

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modular



- PathHouse
- Sierra Homes
- Matt's Place 2.0
 - Estkwés
- Mass Casitas

section 05 - The CRTC and Makah Tribe



The Composite Recycling Technology Center. Source: CRTC



The CRTC team, pictured in their manufacturing facility. Source: CRTC

Background

The Composite Recycling Technology Center is a 501 (c)(3) non-profit company based Port Angeles, Washington. They have pioneered a number of novel recycling technologies which, among other uses, aim to invent new ways to repurpose materials which have previously been considered unusable. Many of their products give carbon fiber new life in medical and sports equipment, where the aerospace industry previously had to dispose of some of the valuable fiber due to manufacturing errors. Another new product is Advanced Cross Laminated Timber (ACLT), a CLT panel made out of thermally treated wood.

The CRTC began producing mass timber in 2022 with the aim of providing high quality tribal housing to struggling nearby communities. Port Angeles is part of the Olympic Peninsula, which is home to the Lower Elwha Klallam, Jamestown S’Klallam, Port Gamble S’Klallam, Skokomish, Quinault, Hoh, Quileute, and Makah tribes. The CRTC’s CLT is manufactured through a partnership with the Makah tribe, which is now home to a sawmill gifted to the community through the CRTC. As part of a reciprocal relationship, the CRTC buys all of the timber used for ACLT from the Makah at full market price.

The CRTC’s mass timber is unique from other products currently available to American markets. Highly variable lumber costs for popular species of wood such as Douglas Fir can jump costs for residential projects; the use of only a set number of tree species in CLT also means that the mass timber market can exacerbate unnatural commercial forestry practices, such as planting artificial forests of only one tree species. These issues are circumvented through the CRTC’s business model, which uses Coastal Western Hemlock (CWH) to create ACLT.

CWH grows in abundance on the Makah tribe’s land, and is not subject to price volatility like other wood species as it has been historically perceived to be without value. CWH was thought for many years to be unusable as lumber due to high moisture content and a tendency towards knots. However, with a careful process of thermal treatment through kiln drying, the wood is able to be used for finishes, decking, and most importantly, CLT. The Makah tribe’s forestry practice excludes planting monocultural forests, instead using the CWH already abundant on their land, and includes harvesting trees on a 60-year rotation cycle, which is double to triple the length of typical short rotation cycles used in commercial timber harvest.

Projects at the CRTC

BOLEH (Built-On-Lot-Engineered Homes)

A 900 square foot model for tribal housing, engineered to meet calls for a mass timber model that can be built by local tribal labor after minimal training. The Makah tribe struggles to find laborers that will build homes on the reservation, as the cost of travel is prohibitive. The CRT's model for BOLEH housing uses custom two foot wide tongue-in-groove ACLT panels in combination with prefabricated wooden trusses. The current model features two beds and one bath, with plans for future four-bed and studio models.

Seattle Cottage Infill

Designed in collaboration with Atelier Jones, new DADU/modular cottages are aiming to create 4-6 unit cottage court developments in alignment with Seattle's reformed zoning laws. A May 2025 update to the city's zoning has legalized the construction of four homes on every residential lot, primarily as part of an effort to encourage the development of middle housing. The homes are an outgrowth of the experience gained in constructing the Sierra homes, now improving on the designs while using the new ACLT.

Army B-Huts

The US army has taken a larger interest in the use of CLT for easily constructed temporary housing. The B-Huts that the CRTC has developed have passed seismic testing and are currently being evaluated for performance in long-term storage and in construction in extreme climates. The B-Hut model takes advantage of the two-foot panel approach, but uses a steel frame, glulam ridge beam, metal post, and butterfly connectors between panels for added seismic and blast resistance.

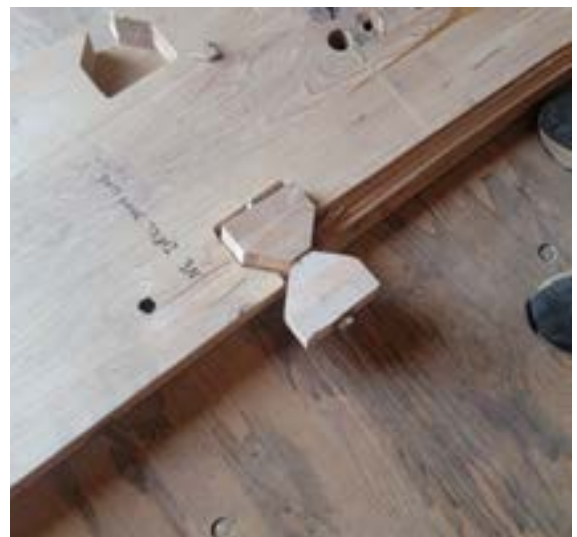
Construction models for a residential home and one of the B-Huts were available on display at the CRTC's factory and will be discussed in the following pages.



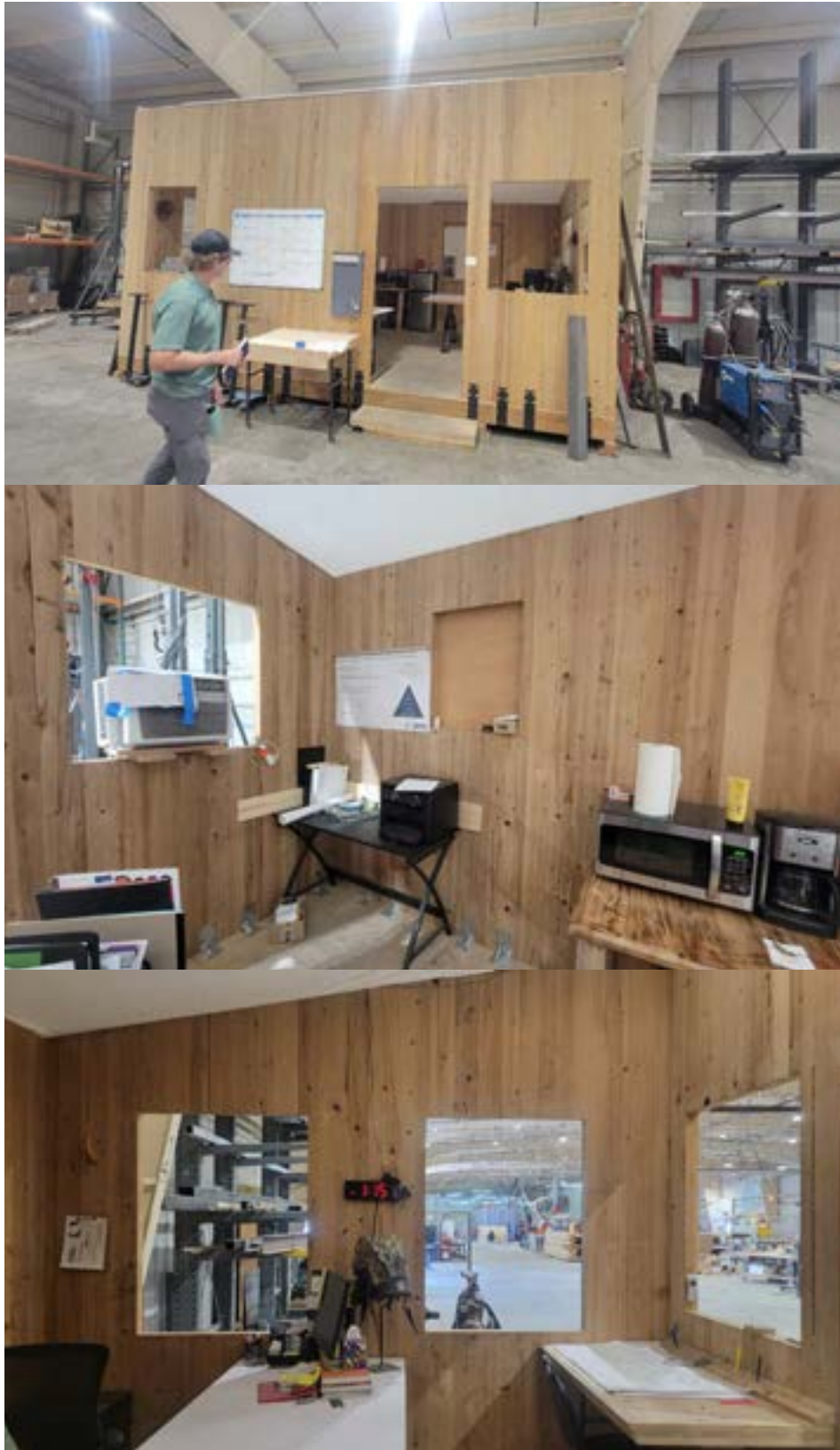
All images courtesy of Atelier Jones and the CRTC.



Exterior shots of the CLT B-Hut. Butterfly connectors provide shear resistance. The barrack model had recently been seismically tested.



Top: Labeled two-foot panels used to construct the roof. Bottom Left: Marker lines showing panel movement under earthquake testing. Bottom Center and Right: Connections between panels.



A residential model being used as an office space inside the CRTC's facility. CWH's signature black knots are visible on the CLT.



Interior and exterior wall-to-wall and wall-to-floor connectors, which use angle brackets, flat brackets, and tongue-in-groove cuts.



Top: CWH boards after planing and thermal treatment. Defective boards will be turned into decking.
Bottom: CWH after a round of thermal treatment. Small wood slats provide airflow between boards while iron plates help to keep the wood in the place.



Left: Coastal western hemlock (*Tsuga heterophylla*).

Source: The Gymnosperm Database

Right: Bacterial wetwood.

Source: Forest Pathology

The CRTC, similar to Hemlock Passive House, has been able to repurpose new wood species for CLT. Western Hemlock struggles with bacterial “wetwood,” a non-lethal disorder that causes deciduous trees to store water within the sap and heartwood portions of their tree trunks. This can cause excess moisture to build up and bleed out of the wood. Stagnant internal water contributes to rot in commercial lumber, but also decreases dimensional stability. The kiln drying process reduces moisture content of CWH wood from 70% to 8%, the wood slowly regaining moisture from the air after treatment to settle at 12%. The drying process hardens the wood and dissolves natural sugars in the fibers, which makes the product much harder for insects and fungi to eat.



Top: Custom connectors cut in-house by one of three CNC machines present at the facility.
Bottom: Wood waiting to be laminated.



Top: Freshly laminated panels. The evenness of the press can be evaluated by the distribution of the glue seepage.
Bottom: The CRTC's custom ACLT press, designed and fabricated in house. The press is designed to be significantly stronger, wider, and more even than other available commercial presses.

Looking Towards the Future

The CRTC and their collaboration with the Makah tribe is a powerful proof-of-concept for mass timber's ability to help communities become more resilient. The personal relationship between the CRTC and the tribe has given both parties mutual opportunities that help to utilize a resource already abundance in the local area. The CLT manufactured at the facility holds a deep connection to the people that will live inside the homes and incentivizes regular timber harvest, providing an abundant and well-priced supply of wood and preventing wildfire fuels from building up inside the Makah forests. The CRTC's in-house engineering and machining capability have allowed them to develop their panel assembly to completely meet the needs of their client while exceeding the quality of other available mass timber options.

The architectural and engineering knowledge that have gone into the homes has improved upon previous knowledge of key needs for tribal housing and for temporary housing in the army. The BOLEH design works with an understanding of the proper scale and scope of the client's desires and the challenges faced by chronic labor shortage and pricing demands. Homes are manufactured and constructed so as to be part of a deliberate, permanent change in quality of life for the Makah community. While tribal housing has been historically poor quality due to low availability of funds both for materials and in hiring designers and laborers, the housing provided for the tribe will be of the same residential quality those outside of the reservation have access to and will be bolstered by the resiliency of CLT to boot.

The CRTC is currently waiting on approval of the CWH species for use in CLT as defined by ANSI/APA PRG 320, the standard for performance rating of cross-laminated timber in the US. CWH, due to its previous lack of usable applications, was not included in previous editions of the standard. The CRTC's ACLT is expected to meet all standards defined in PRG 320, with construction beginning on 100 tribal homes in early 2026. Atelier Jones' cottage clusters, which will use the CRTC's ACLT, are part of Clallam County's initiative to develop affordable housing prototypes for Washington; Clallam County had identified finding rapid housing solutions for a stagnating economy as a key issue in their 2023 five-year plan.

The CRTC is a prime example of an effort to create a truly circular economy. The design and manufacturing process are open for replication, and the experience, expertise, and capital part of the existing CRTC aided in the setup of a new community business. The efforts by both the CRTC and the Makah tribe create jobs and products for both parties, which in turn provides benefits for a variety of businesses outside of the lumber industry.



Special thanks to Geoff Wood and the team at the CRTCI!



section 06 - fire // box housing

"A typical FEMA trailer can measure 14' by 22' (308 sq. ft.)[4]:56 or 8' by 32' (256 sq. ft.). It consists of a master bedroom with a standard size bed, a living area with kitchen and stove, bunk beds, and a bathroom with shower. "

"Each trailer is equipped with electricity, air conditioning, indoor heating, running cold and hot water, a propane-operated stove and oven, a small microwave oven, a large refrigerator, and a few pieces of furniture attached to the floor; usually a sofa bed, a small table, and two chairs."

"There are only a handful of FEMA trailer designs, so nearly all trailers have the same general layout. Furniture is attached to the trailer; it is not possible to move it, and it would be illegal to do so. It is also illegal to paint the inside or outside of the trailer."

"Trailers have little storage space, can be very cramped, and offer little or no privacy."

fire·box (noun)
an insulated compartment meant to protect valuables

fire//box housing

modular mass timber disaster relief





Methodology

fire//box housing is meant to be an exercise in designing using both the CRTC's ideas regarding their approach to tribal and infill housing and with the lessons learned from the larger pool of case studies. Homes are meant to resolve the common complaints that have come up in the literature on disaster relief and as specifically mentioned by occupants of case studies. The following complaints are as follows:

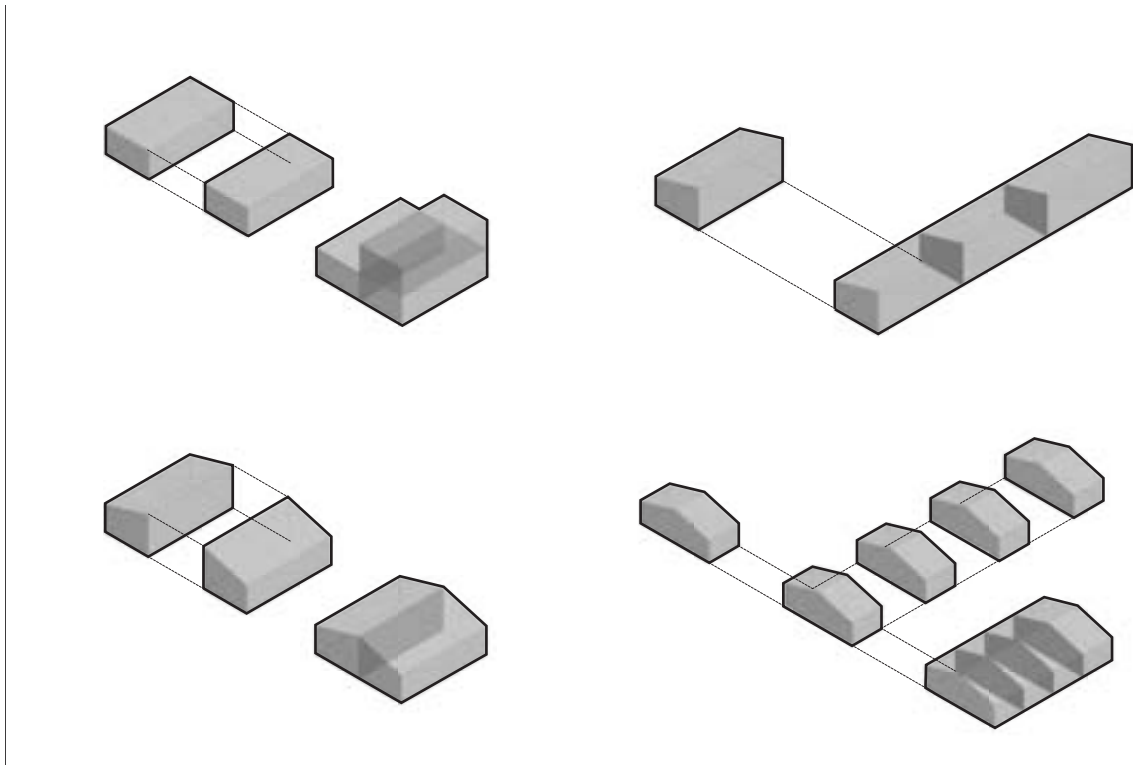
Common complaints about disaster relief housing:

- Lack of privacy
- Feeling of claustrophobia
- Lack of multiple entrances
- Long timelines for deployment

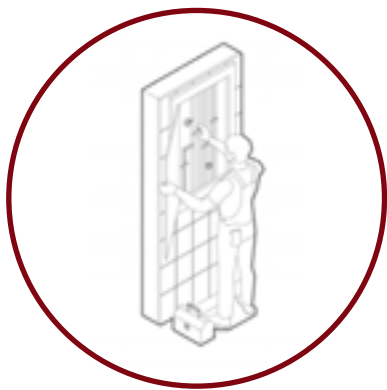
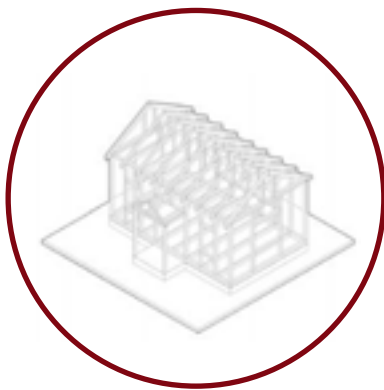
Specific complaints about case studies from occupants:

- Unexpectedly high costs
- Exposed conduit
- Dislike of mass-ply interiors
- Restrictive modular approaches

Homes employ a hybrid CLT-steel-light-framed structure, using helical piles to eschew concrete in the foundation of the home. The structure is created via the placement of decking and CLT panels onto a steel frame to create the floor. All panels in the construction are 2' wide and 8' tall, excluding the rake walls of the home, which are cut to slope. No walls is longer than 11' 11", which means that all panels can be cut from readily available 12' billets. The roof is light-framed to allow concealment of light fixtures. All services for the home are contained within a light-framed core wall, which services both the kitchen and bathroom. This project showcases the deployment of Phase 1, the first module, and the subsequent expansion into Phase 2. Each module is 410 square feet, or 14'x30'. Modules are designed so that the project can be fully built on site as a flat-pack, delivered volumetrically and clad on-site, or built on site with the steel-frame and light-frame core delivered as modules themselves. Modules use 3" Coastal Western Hemlock CLT for the exterior walls and 2" CWH CLT for the interior walls. The Phase 2 home includes a full bath, bedroom for two, galley kitchen, and extensive living room space. While not included in this project for time, the module can expand backwards infinitely using the "horizontal expansion" method discussed in section 02.



A chosen modular system will have set conditions of form. Four common approaches to residential modularity are pictured; the horizontal expansion method was chosen.



Fundamentally, buildings need to resolve structure, cavity, and finish.

a hybrid system provides easy solutions.

Mass timber specific systems used in this project also eliminate time in concealing or integrating common needs.



(1) Rheem RTGH Series Super High Efficiency Condensing Tankless Water Heater (SKU: RTGH-95DVLN-3)



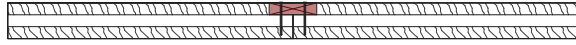
(1) 15,000 BTU Mitsubishi HM-Series 18 SEER2 Single Zone Wall Mounted Mini Split Heat Pump System - R410A (SKU: MUZ-HM15NA / MSZ-HM15NA)



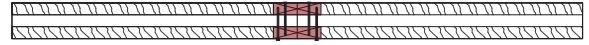
(2) Vents TwinFresh Expert RA1-50-2 Ductless Energy Recovery Ventilator (SKU: TwinFreshExpertRA1-50-2)



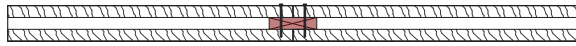
(4) Ener-J Wireless Kinetic Switch Bundle Kit with Reciever (SKU: WS1060X)



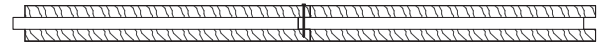
single surface spline



double surface spline



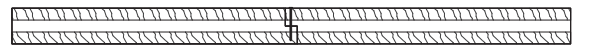
internal spline



tongue-in-groove



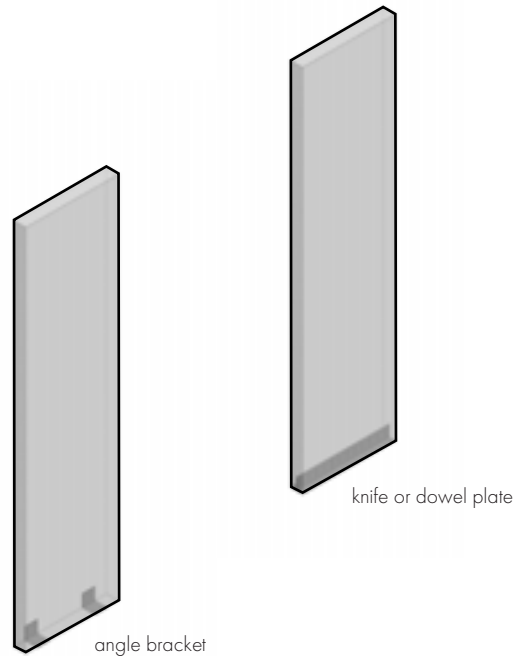
butt joint



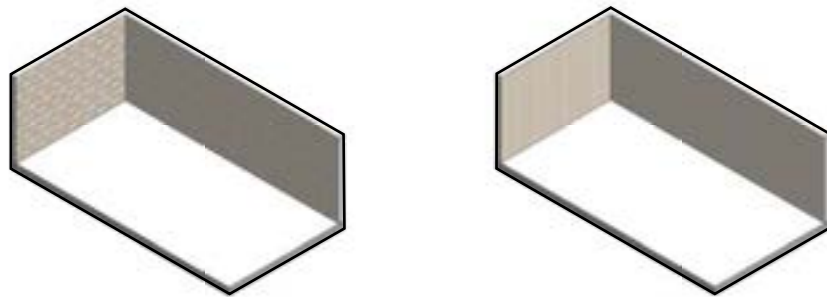
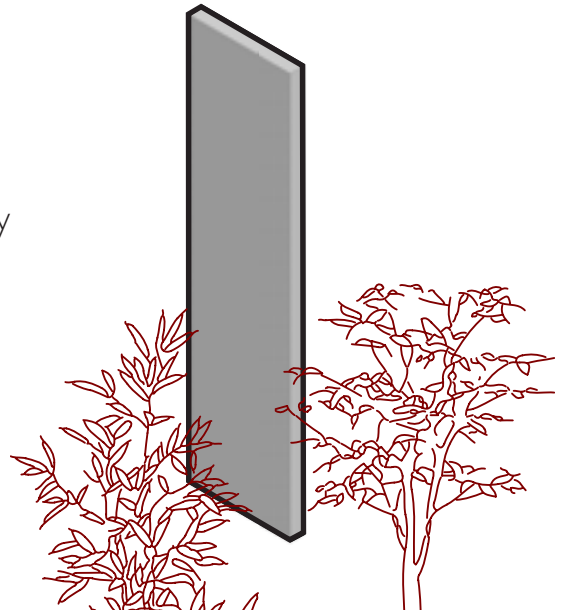
half lap

Chosen wall-to-wall connections and wall-to-floor connections leverage the self-locking tongue-in-groove connections and affordable angle brackets. Interior walls may require baseboards over exposed brackets if desired. Services are consolidated into a central light-framed wall; the choice of helical piles for foundation provides an ample crawlspace.

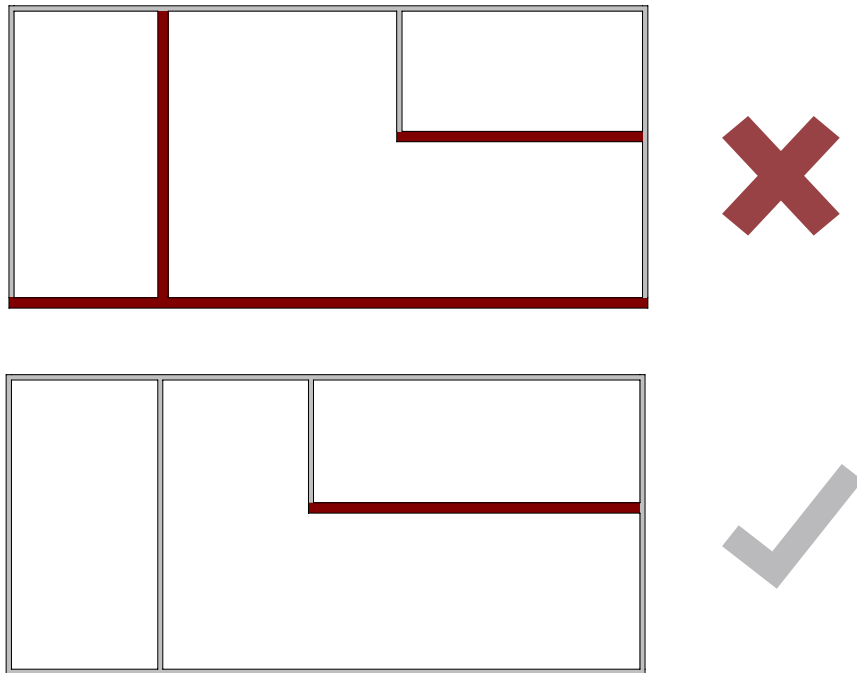
3" exterior wals and 2" interior walls will be using angle brackets as opposed to knife or dowel connectors to cut down on machining time. Given that the angle bracket would be exposed on interior walls, a baseboard may be required to improve interior appearance.



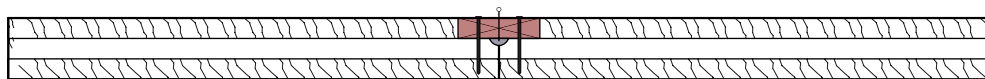
- each 2'x3"x8' panel weighs 104 pounds
- each 2'x3"x8' panel sequesters 52 pounds of carbon
- there are a total of 118 panels that create the primary structure (60 floor panels and 58 wall panels)
- the primary structural CLT used in this project sequesters 14 tons (14,000 pounds) of carbon
- two of the exterior walls are kept uncut to roof profile, making them totally reusable for any new project; these exterior walls also grow the longest with additional modules
- the exterior wall panels which create the face of the initial module can be completely reused within another new construction; windows are also reused throughout expansions
- no panels are longer than 11'11", which means all 2' panels can be cut from existing CLT billet sizes, which typically only reach 12' in height
- **allowing for ten minutes of placement of each panel and assuming two workers (50 pound weight limit for lift), the total erection of the panels would take 20 hours, or 2.5 working days**



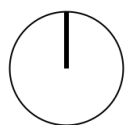
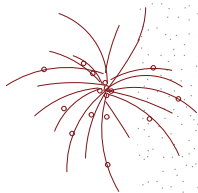
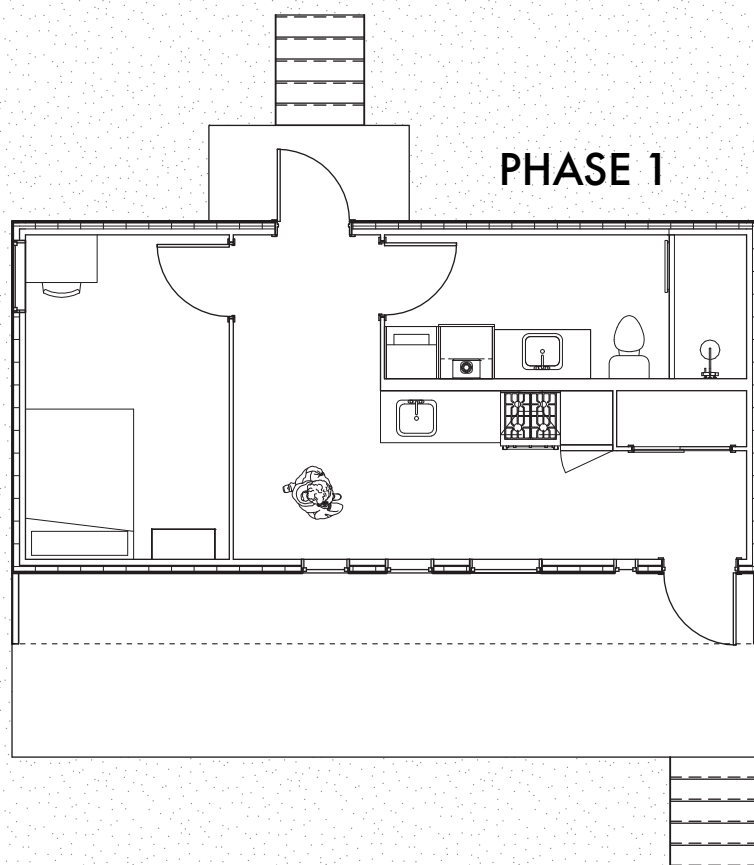
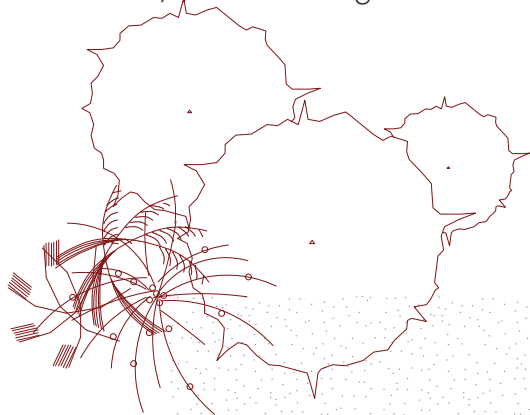
The choice of material was in favor of Cross Laminated Timber as opposed to Mass-Ply Panel. While MPP may be stronger as a structural material, it ultimately provides too many visual challenges in interiors for it to be used in this case.



Services inside fire//box housing are consolidated to one light framed wall in the interior of the home. This core makes mass timber far more efficient as a construction technique, as there is not need to unnecessarily hybridize the system with an excess of light framing.

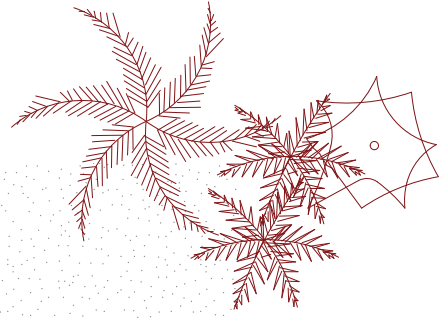


Where necessary, a surface spline with hidden electrical channel can be routed out through the floor or wall so as to provide an opportunity to create a “regular” outlet on a mass timber wall. This method does not use trim or exposed conduit. This method may not be necessary depending on client needs, but is the best way to provide a flush and adequately high outlet for ADA requirements.

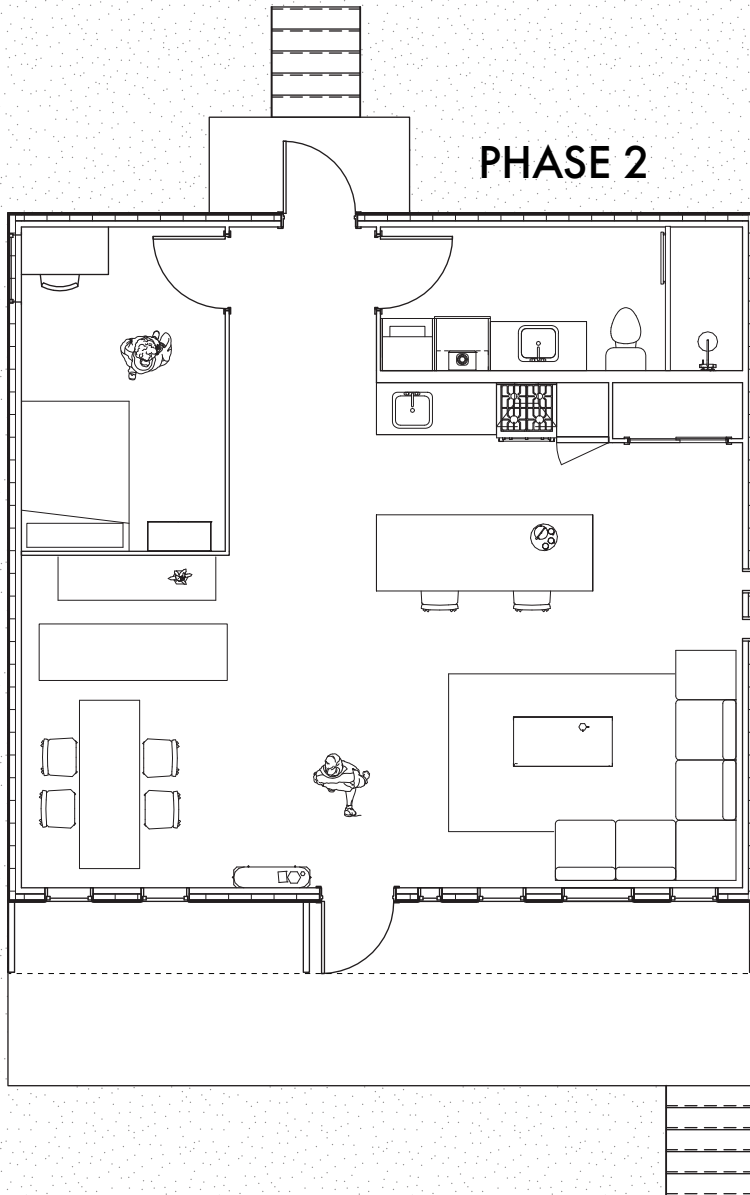


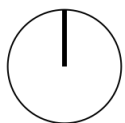
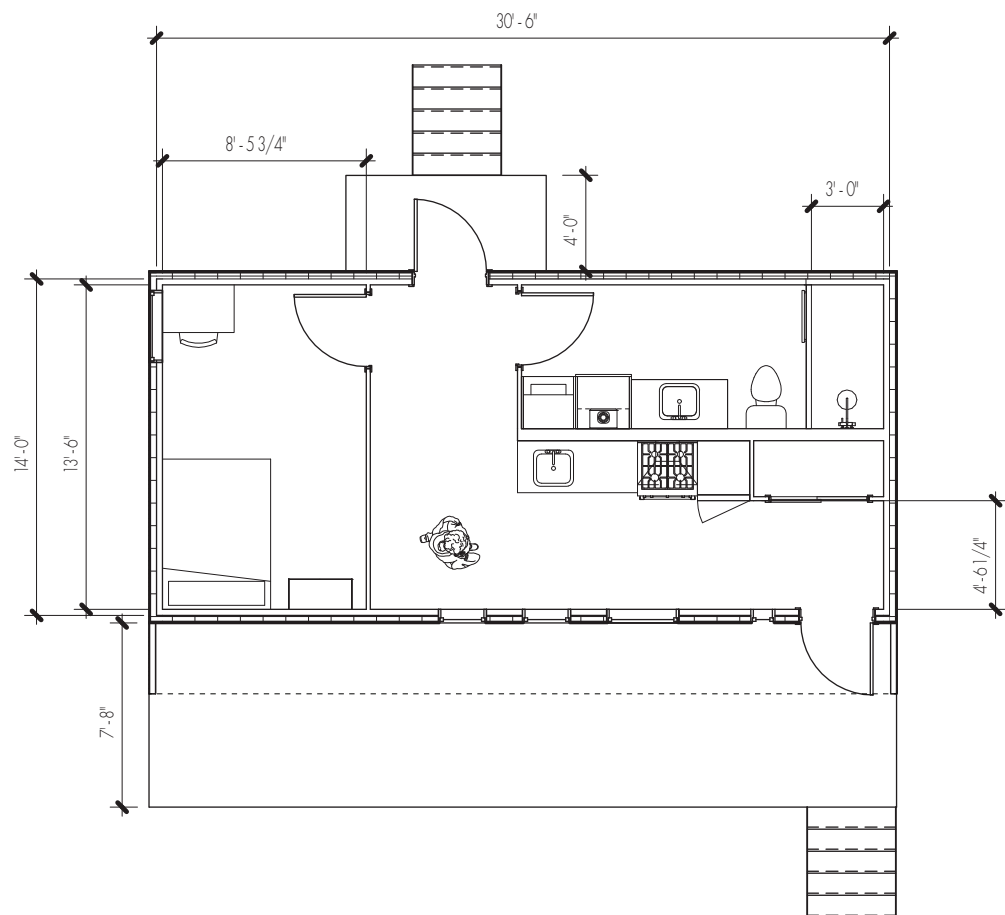
GROUND FLOOR PLANS

1/8" = 1'



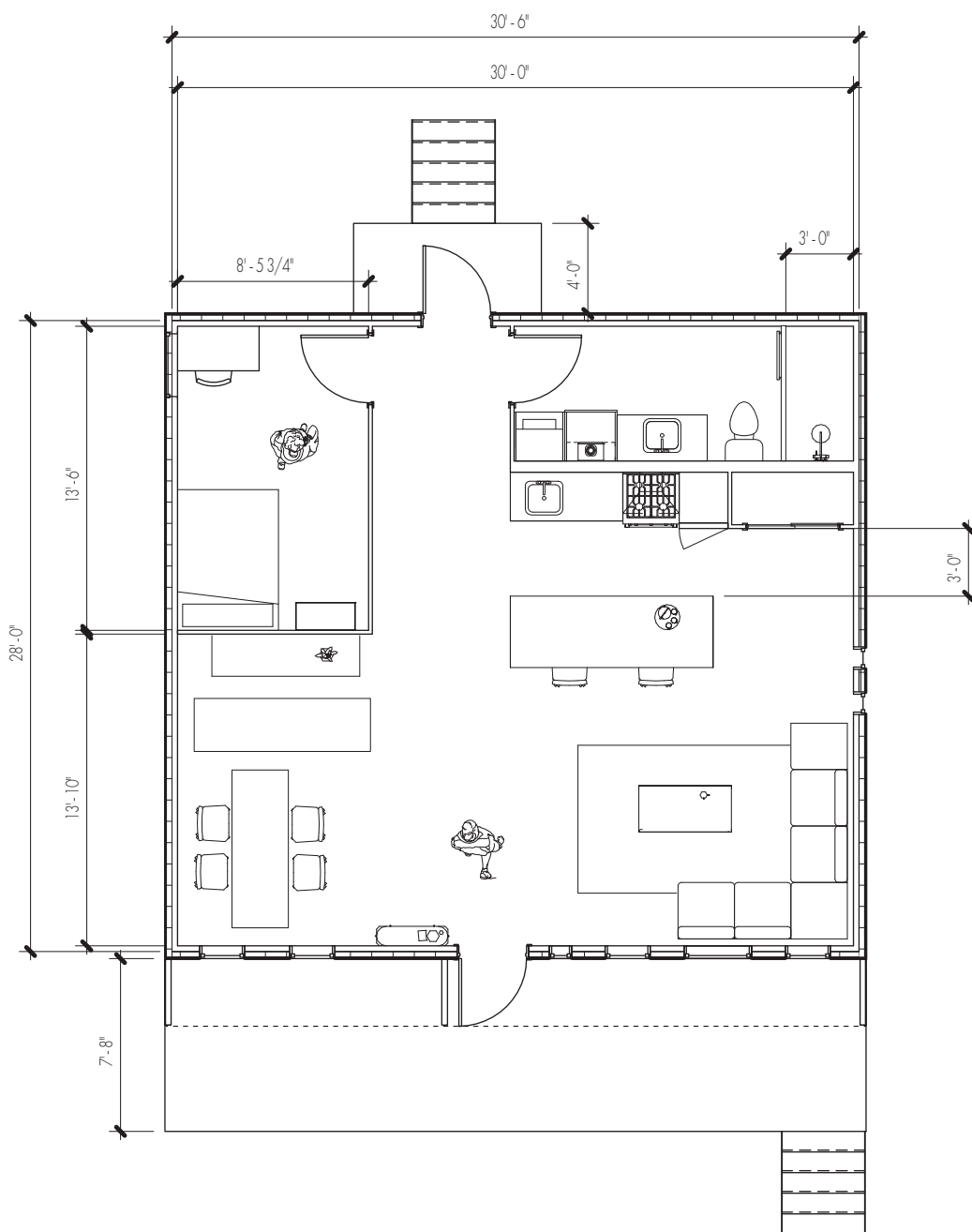
PHASE 2

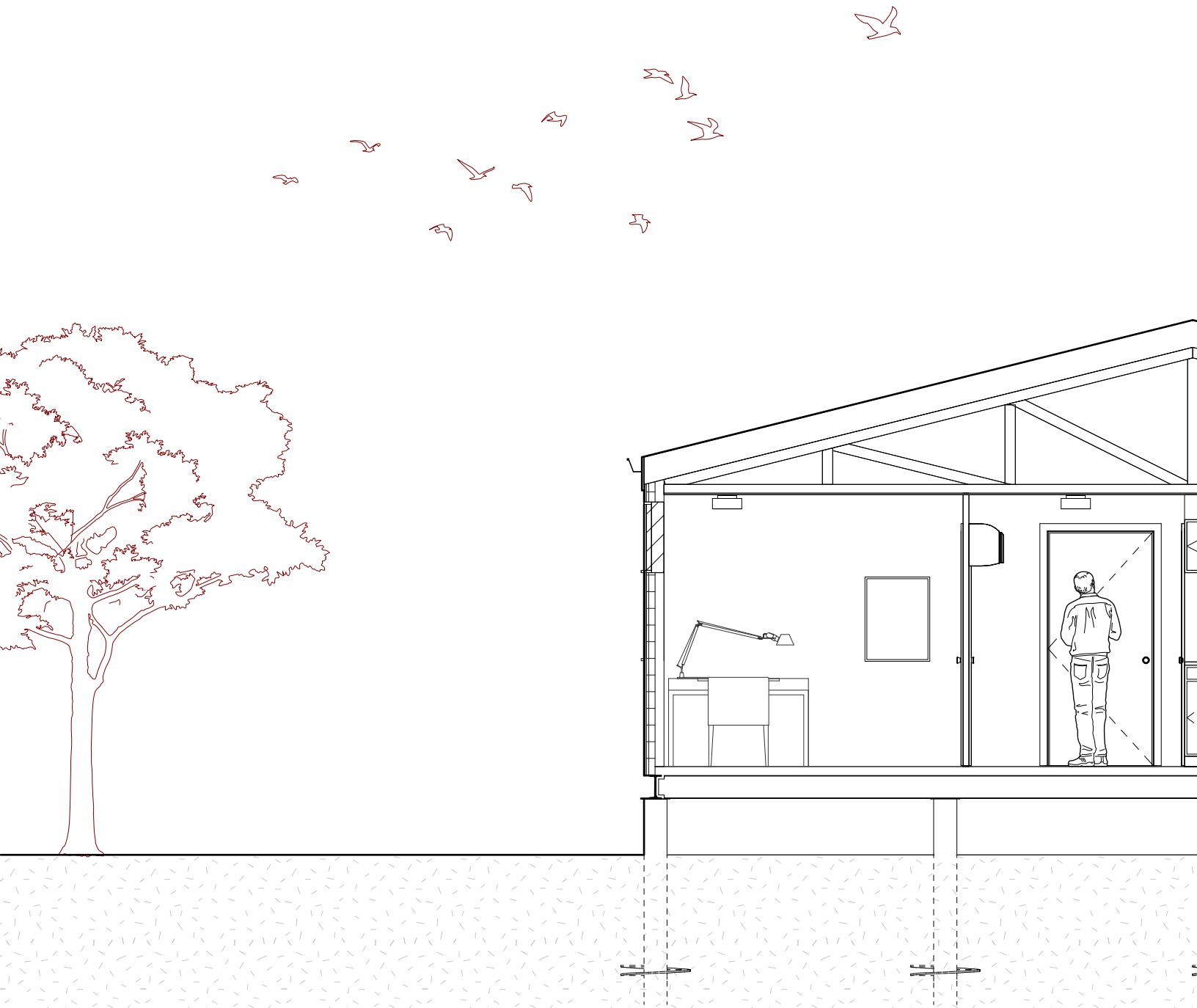




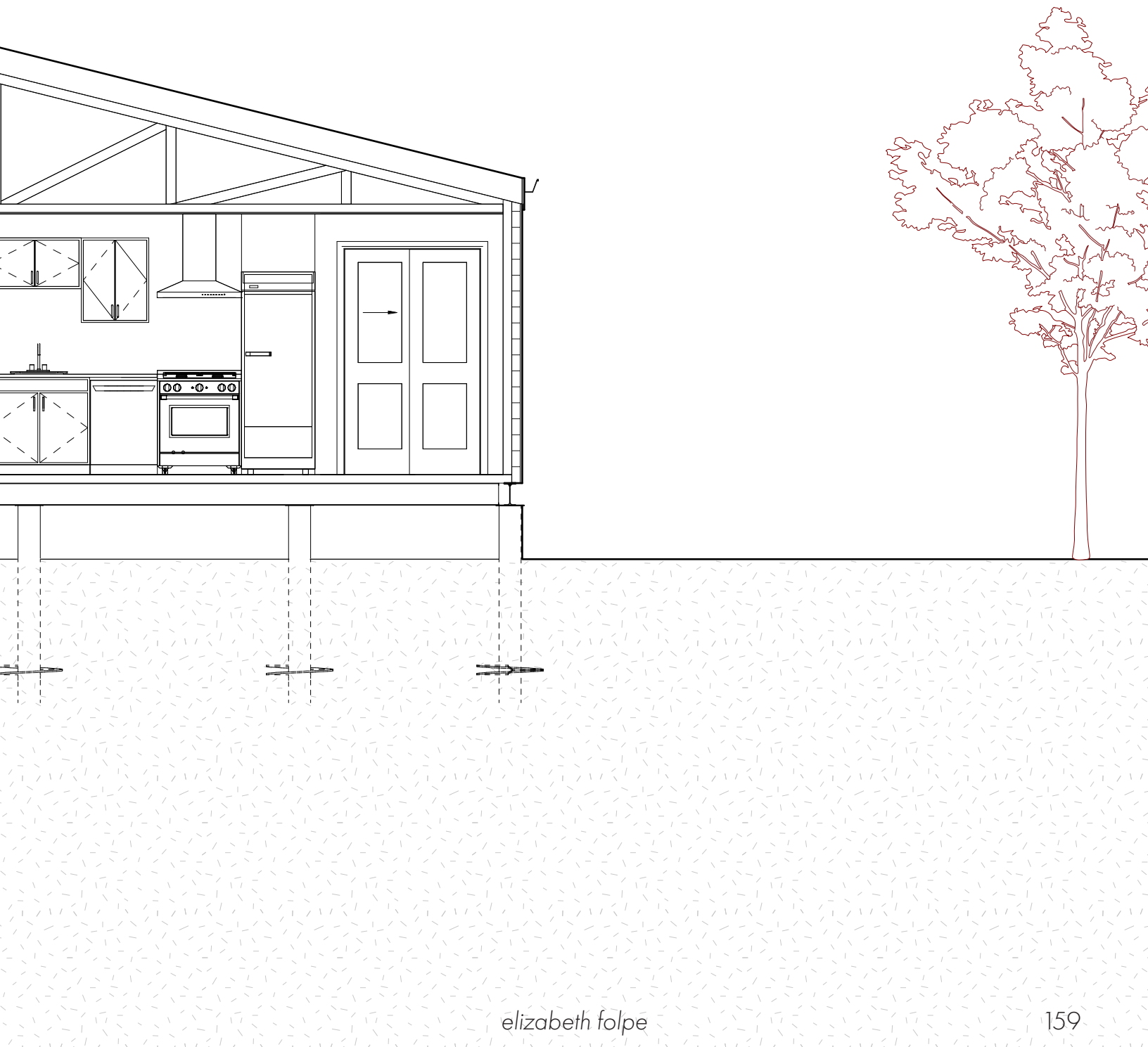
GROUND FLOOR PLANS

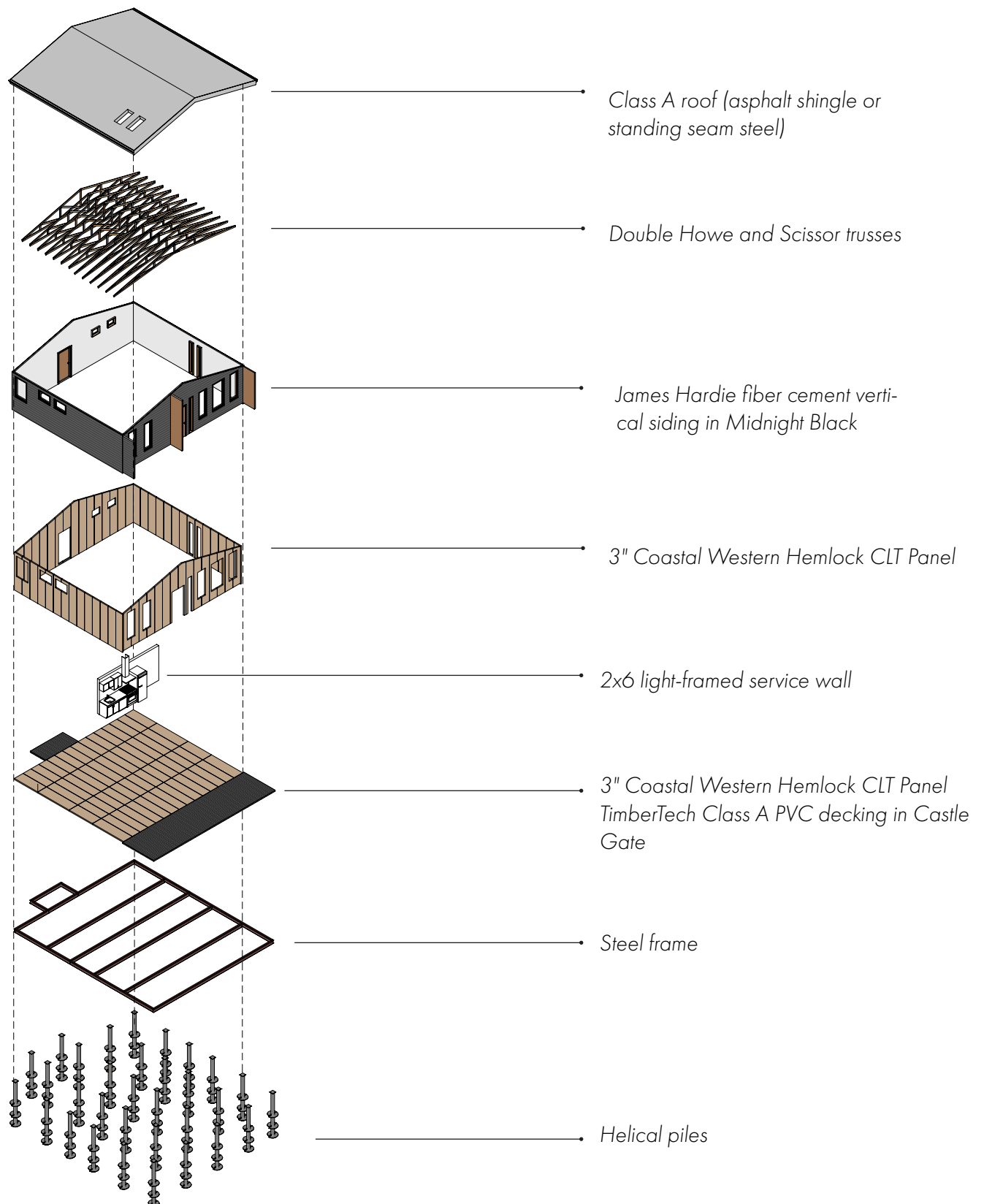
1/8" = 1'



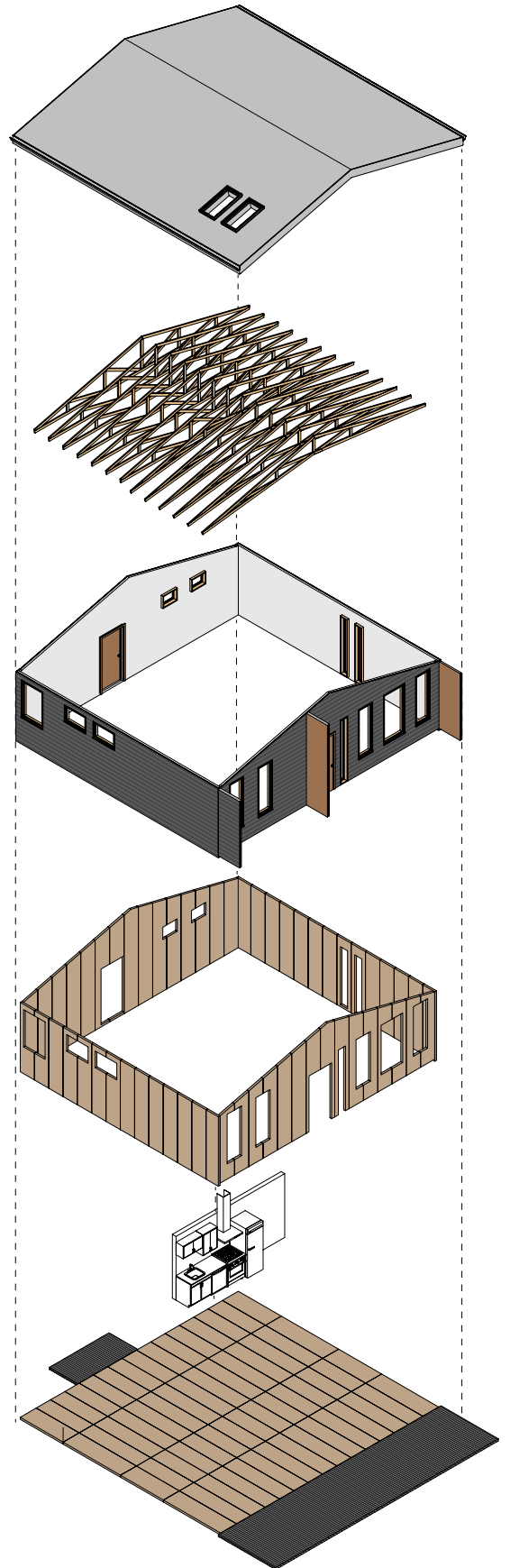


EW SECTION
1/4" = 1'





Primary structure











Thank you.

Other Conclusions

Many of the issues in Oregon relate to a legal system that works against its inhabitants. To improve, Oregon should work towards:

Property Tax Reform

- *Reform Measures 5 and 50 with bills like HB 2321 so as to replace MAV assessments with RMV*
- *Continue and promote special assessment of property tax burden for wildfire victims as created in SB 1545, create a program for special assessment of property tax burden as compared to yearly income for temporary relief for low-income residents, so as to ease transition after dissolution of Measures 5 and 50*

Fire Protection Funds

- *Approve one-time use of Kicker funds to create a permanent wildfire relief fund*
- *Use small taxes such as HB 3940's tax on nicotine pouches to pay for wildfire relief*
- *Redirect tourist tax revenue away from promoting tourism and towards infrastructure costs in HB 3962*
- *Propose small flat rate fee collected with property tax to spread costs for wildfire protection across the state to help ease the burden on rural communities*
- *Cap rural land management fees*

Land use reform

- *Encourage fast tracks to UGB boundary expansions with measures similar to Governor Kotek's one-time UGB expansions in SB 1537*
- *Allow conversion of unusable farmland only under the precondition of building a certain percentage of affordable homes, using community ownership models, and requiring homes to be Fire-Wise planned and built w/ resilient materials*

Housing

- *Build many more homes*
- *Replace or retrofit aging affordable housing and endangered mobile home communities*
- *Build more homes using mass timber as a resilient material*
- *Develop a diverse range of modular and non-modular options for new affordable housing*
- *Provide tax benefits to local mass timber companies for participation in sustainable forestry practices*

This project invited the possibility of many other projects including:

A comprehensive GIS effort to track the age and construction methods of Oregon's buildings, something accomplished in many parts of California and in Portland, but not afforded to Oregon as a whole. Collecting this data would be an expensive and complicated effort but could illustrate further how cycles of recession, housing and zoning law, boom and bust of timber industry, and seismic code characterize Oregon's building stock.

A study of resiliency in commercial buildings, such as the Regional Resiliency building proposed by the UO's State Resiliency Officer, and exemplified in Oregon's State Treasury Building. I had a major interest in large community resiliency centers at the beginning of the project. Eugene, for example, has had cries for a market hall, science museum, and a number of urban housing projects, all of which could not only become hubs for resiliency but wonderful parts of a new urbanism.

A study of the impact on the environment via offgasing when buildings burn, comparing differing methods of residential construction, including mass timber. A variety of interior and exterior finish materials and combinations could be included, as could pricing of each structure.

The application of mass timber structures in manufactured housing, using the universal HUD code.

A project which focuses on the seismic resilience of Oregon at large; this was an element I had interest in at an earlier phase of the project, but eliminated for clarity. However, coastal communities in Oregon shoulder a high tsunami risk, and the entire state would be affected by a CSV event. Seismic engineering at large, the widespread success of and access to seismic retrofit in Oregon, and new seismic resistant building materials such as mass timber could all be considered.

The use of mass timber in areas which will be affected by disaster and have a timber stock, but which may have different climate factors to consider such as tropical weather or an active termite population; applications in Alabama, Georgia, and Mississippi, where yellow pines are abundant, rural communities are numerous, and disaster is frequent, come to mind. Thermally and chemically treated wood may be technologies that advance to aid these regions.

Post-occupancy surveys of mass timber housing projects in Oregon. Feedback for these projects by people who are not architects or artists, but regular consumers, will inform further development of successful design principles.



backmatter

Acknowledgments

I would like to firstly thank the whole of the team at PIVOT Architecture, particularly including Scott Clark AIA and Kelly Howell AIA, who organize and guide the PIVOT Fellowship and provided great mentorship along the path. I would also like to thank John Stapleton, Abby Brown, Craig Runyon, Emil Good, John Miller, and Burke Wardle for their help in understanding my road towards a successful project.

I would also like to in particular thank two key former teachers at the University of Oregon, Young-tack Oh and Mark Fretz. YT's guidance led me to pursue and explore forensic architecture, which uses the CAD skills and building knowledge of an architect to examine and predict for disaster. YT's own nontraditional approach to architecture and his passion for research and community outreach pushed me to learn more about my own surroundings and ultimately, to explore the topic of wildland fire. Mark's studio, which explored the use of mass timber in health-care, introduced me to designing with the material and drove my interest in mass timber's material properties. Mark's own work in developing the Mass-Ply Flat Pack house and in designing the Solar Cottage Clusters was immensely helpful in work shopping how to make mass timber feasible at a residential scale. The challenges and lessons learned in the MPP house helped inform many of the best practices I developed for designers in this booklet and considerations that I will take in designing with mass timber in the future.

I want to extend another thank you to Geoff Wood and the members of the CRTC for extending their time and opening their workspace to me. Without their insight, this project would have not been possible. I would like to credit the CRTC's unique approach to mass timber construction and their panel sizes as a precedent for my own work.

I would finally like to thank William Robbins of Oregon State University, Jay Raskin of Jay Raskin Architect, Kimiko Barrett of Headwaters Economics, Yumei Wang of Portland State University, André Le Duc of the University of Oregon, Genievieve Hale-Case of Green Canopy Node, Steve Marshall of Mass Timber Strategy, Adrienne Fainman and Cuyo Cataldo of CedarStone, and Alex Zink at Miller Hull. Because of their conversations with me, I was able to gain key insight into designing with mass timber and for communities.

Credits

All research made possible by PIVOT Architecture.

<https://pivotarchitecture.com/>

front cover

Profita, Cassandra. A roadside reminder in southwest Washington's Gifford Pinchot National Forest that homes in the "wildlands urban interface" need special landscaping, building materials and maintenance to reduce the risk of being destroyed by a wildfire. OPB,

<https://www.opb.org/news/article/homes-wildfire-wildland-urban-interface-washington-oregon-california/>.

section 01

bootleg_maranie-staab-bloomberg-scaled.jpg. Inside Climate News, https://insideclimatenews.org/wp-content/uploads/2021/08/bootleg_maranie-staab-bloomberg-768x512.jpg.

thesis statement

naturalresources_forestrytimber.jpg. Cowboy State Daily, https://cowboystatedaily.imgix.net/naturalresources_forestrytimber.jpg.

section 02

Shigeru-ban-modular-parition-for-Ukrainian-refugee-in-Europe-by-Nicholas-Grosmond.jpg. Dezeen, https://static.dezeen.com/uploads/2022/04/ppa-shigeru-ban-gymnase-victor-nicolas-grosmond_dezeen_2364_col_3.jpg.

section 03

Staircase of Sierra home showing the thick wooden construction of the stair. Atelier Jones, https://images.squarespace-cdn.com/content/v1/6529df54131b0256855b37e9/88d79e1c-1810-45a1-b4ef-94638b315ff7/LS20230820_greenvillemicrohouses_016.jpg?format=2500w.

section 04

heartwood_toppingout-1.jpg. Swinerton, https://swinerton.com/wp-content/uploads/2022/12/heartwood_toppingout-1.jpg.

section 05

Image taken by author.

section 06

A lush green forest is depicted, with the view overlooking a mountain range covered in trees. Oregon Forest Resources Institute, Oregon Forest Resources Institute, https://oregonforests.org/sites/default/files/2023-08/2.1_Sustainable_Management_0.jpg.

backmatter

A mass timber jobsite depicts a set of wooden columns and an elevator core made from wood. . Seagate Mass Timber, https://media.licdn.com/dms/image/v2/C561BAQGLgsC1eWRI6g/company-background_10000/company-background_10000/0/1593706395962/seagate_mass_timber_cover?e=2147483647&v=beta&t=cHye_3y0ToSi4K0pYeS_mTtlZ-B4AlxgHiRULO3_Ovo.

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