A game-changer for wildfire, forests, and climate change

By Sandra Lupien, MPP 2018

Prepared for: Bob Epstein
E2 (Environmental Entrepreneurs)
REMOVING BARRIERS TO CROSS-LAMINATED TIMBER MANUFACTURE & ADOPTION IN CALIFORNIA

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DISCLAIMER
The author conducted this study as part of the program of professional education at the Goldman School of Public Policy, University of California at Berkeley. This paper is submitted in partial fulfillment of the course requirements for the Master of Public Policy degree. The judgments and conclusions are solely those of the author and are not necessarily endorsed by the Goldman School of Public Policy, by the University of California or by any other agency.
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EXECUTIVE SUMMARY
Executive Summary

Public forestlands in California’s Sierra Nevada are dangerously over-crowded—the result of over a century of federal and state policies and budgets favoring fire suppression over active forest management to help forests maintain a healthy density. (Sierra Nevada Conservancy) According to Sierra Nevada Conservancy, healthy, fire-adapted forests¹ in the mid-1800s hosted 50-80 trees per acre, whereas many Sierra Forests today have between 300-400 trees per acre. (Sierra Nevada Conservancy).

The dense conditions force trees to compete for scarce water and nutrients, which makes them more vulnerable to bark beetle infestation, as is tragically evidenced by the 129-million dead trees standing in Sierra Nevada forests.

California’s overstocked forests also appear to increase wildfire spread and intensity (Stephens 2018). The presence of many shorter, smaller-diameter trees helps conduct fire not only horizontally through the forest, but vertically into the crowns of trees, resulting in the most destructive high-severity fires. (Stephens et al.) These wildfires are increasingly costly to taxpayers: From July 2017 to January 2018, the State of California spent $700m, and the US Forest Service spent $632m, fighting fires in the state. (Downey)

These wildfires emit many millions of metric tons of carbon dioxide and other greenhouse gasses, as do beetle-kill pine trees left to burn or rot in forests. These cycles threaten to shift California’s largest carbon sink—forests—into sources of carbon emissions that can undermine the State’s visionary greenhouse gas emissions reduction goals. (Forestry Climate Action Team)

¹ “Most western US ecosystems are fire dependent, meaning that for millennia, the flora and fauna depended on periodic fire to maintain ecosystem integrity.” (Stephens 2018) However, they are not adapted to the types of destructive high-severity fire associated with dry, overstocked forest conditions currently present in Sierra Nevada forests.
Broad consensus among forest managers, ecologists, and policy makers holds that increasing the pace and scale of active forest management, including ecological thinning of smaller-diameter trees and beetle-kill pine, is critical to tackling both the wildfire and GHG emissions hazards associated with the high forest density.

... a well-managed forest will create even more carbon sequestration than a let-grow forest when the wood products are efficiently used. Efficient use of wood products is the ‘best management practice’ in most, but not all, cases in California.

(University of California Agriculture & Natural Resources)

However, public funding for such work is drastically insufficient, and there are few established markets for those small diameter and beetle-kill trees. As a result, most of the forest management work that needs to be done, isn’t done; and when projects do happen, the wood is typically funneled to combustible uses (firewood, bioenergy), burned in enormous piles in the forest, all of which emit CO2 rather than sequester it.

A number of key reports have identified mass timber construction materials, including cross-laminated timber (CLT), as having the potential to create a badly-needed revenue stream to conduct ecological thinning and create a long-lived, carbon-sequestering use for the wood harvested.

This report examines potential California manufacture and adoption of cross-laminated timber (CLT), not only in terms of its viability as a new product and industry, but specifically how a robust California CLT industry can produce a value-added product that a) creates a revenue stream for ecological forest management by sourcing logs exclusively from projects that restore and maintain the health of public forest lands, and b) captures much of that forest carbon in the built environment for decades into the future. Given that about 60% of forests in California are federally owned, this report focuses primarily on management of U.S. Forest Service lands.
Through an extensive literature review, more than 60 expert interviews, a survey of potential CLT adopters, and attendance at the annual Mass Timber Conference in Oregon, the report identifies key opportunities that could help support CLT as a catalyst for ecological, active forest management in California; barriers to supply, industry/manufacture, and adoption of CLT using wood harvested from federal forest management projects; and recommendations to help remove these barriers.

Summary of Opportunities

**Forest Carbon & Greenhouse Gas Emissions Goals**
California is now working to create a forest carbon plan that seeks to maximize carbon sequestration both in the forest, and in long-lived durable wood projects.

**New Funding for Active Forest Management**
The Governor’s two most recent budgets allocated more than a combined $350m, Sierra Nevada Conservancy plans to launch a new fund in 2019, two ballot initiatives would make new funds available, as could several pieces of active legislation, and the March 2018 Fire Funding Fix should free up management funds typically seized for fire suppression.

**Funding for Wood Utilization**
The U.S. Forest Service Wood Innovation Grants offer funds for CLT demonstration projects, market research, prototyping and testing. The state is looking into offering similar grants to support “new wood products manufacturing capacity.”

**Building Code Updates to Streamline Permitting**
California’s 2016 code update, currently in effect, allows some uses of CLT through standard permitting processes but requires special permits for use of CLT for lateral force resistance systems (seismic, wind). If the State adopts upcoming International Building Code Updates, CLT will be allowed in these applications, including in tall buildings, under standard permitting processes.

**Mixed Product Campuses**
At least three such campuses are under development on former mill sites, where developers plan to act as clearinghouses for wood from public forest management projects, sorting it according to highest and best use, and using waste to provide electricity to all operators on the campus. Each campus has identified CLT manufacture as a high priority.

**Rising Cost of Building Materials**
Even as California faces an unprecedented housing crunch, the costs of steel and imported softwood are on the rise due to new tariffs imposed by the federal government. Housing developers will be seeking more affordable options. CLT can provide a domestically-produced alternative.
## Summary of Barriers

### Barriers to Supply

**Federal Funding and Capacity**
- High spending on fire suppression, low budget for forest management
- Understaffed National Forests

**Process & Regulatory Barriers**
- Mismatch between annual appropriation for USFS and multi-year forest project timelines
- Regulatory complexity and expense

**Political Barriers**
- Counterintuitive message: “Cutting trees helps forests”
- Urban/rural divide on understandings and perceptions about forest management
- NEPA/CEQA processed often tied up in litigation

**Sawmill Capacity**
- Few operational mills
- Mills not operating at full capacity due to economic feasibility and lack of skilled labor

### Barriers to Industry

**Supply Reliability**
- Lack of access to long-term contracts
- Lack of research on beetle-kill pine decay rate/viability for CLT in California

**Codes & Permitting**
- High start-up costs
- Site permitting: Brownfield remediation

**Trained Labor Force**

**Misperception: Beetle-Kill Not Allowed in U.S. CLT**
- Education is needed

### Barriers to Adoption

**Building Codes and Permitting**
- California Building Standards Codes only allow limited use of CLT under standard permitting
- Widespread lack of understanding of CLT building codes

**Concerns about Cost**
- Potentially higher for early adopters
- Potential expensive delays due to permitting

**Lack of Familiarity and Technical Expertise**
- Architects, Developers, and Construction Companies

**Perceptions About Fire & Seismic Resistance of CLT**
- Based on assumptions, not test results
### Summary of Recommendations

#### #1 Governor Lead the Way—Executive Order
- Establish/fund Joint Forest Health & Sustainable Wood Products Institute
- ID two State-Owned Buildings for CLT
- Direct Building Standards to Design “Wood First” Incentive
- Direct Contracts & Procurement to Conduct CLT Opportunities Analysis
- Offer a $1m, 1-time Cash Prize to First Jurisdiction to Permit Structural CLT over 8 Stories

#### #2 Joint Forest Health & Sustainable Wood Products Institute
- Appoint “New Master Standards for Active Ecological Forest Management Task Force”
- Research Beetle-Kill Pine Decay Rates in California
- Prototype and Test Beetle-Kill CLT
- Take the Lead on Fire and Seismic Testing
- Solicit Letters-of-Interest from Future CA CLT Adopters

#### #3 Master Stewardship for Sustainable Supply
- With U.S. Forest Service, Contract with National Forest Foundation to Develop/Operate Master Steward Training/Certification Program:
  - Navigate MSA process
  - Scope & Plan Ecological Forest Management Projects
  - Negotiate and Manage Supplemental Project Agreements
  - Distribute logs and biomass for highest use and best value

#### #4 Cracking Codes for a CLT-Friendly California
- California Building Standards Commission:
  - Adopt 2021 International Building Code early in 2018 or 2019
  - Create clear CLT permitting guide for cities and counties based on the new standards
  - Conduct CLT permitting trainings in-district
  - Partner closely with cities on early CLT projects; if possible, take on structural permitting when cities can’t
- California Legislature:
  - Pass a bill designating which wood materials are required to be allowed in CA (like WA SB5450)

#### #5 Incentives for Action
- For suppliers:
  - Per board foot tax credit for milling “low-value timber”
- For adopters:
  - Per board foot tax credit for California-CLT used in projects
ABOUT THIS REPORT
About this report

Purpose

This report examines potential California manufacture and adoption of cross-laminated timber (CLT), not only in terms of its viability as a new product and industry, but specifically how a robust California CLT industry can produce a value-added product that a) creates a revenue stream for ecological forest management by sourcing logs exclusively from projects that restore and maintain the health of public forest lands, and b) captures much of that forest carbon in the built environment for decades into the future. Given that about 60% of forests in California are federally owned, this report focuses primarily on management of U.S. Forest Service lands.

Since 2015, a broad array of stakeholders representing the public (state, federal, regional, local), academic, non-profit, private, and community sectors have, though a variety of task forces, workgroups, and steering committees, produced an impressive amount of literature examining how wood product markets might help increase the pace and scale of active forest management in California. (See p. 15 for an overview of some of the key efforts.) In this literature, “mass timber” products, like CLT, have begun rising to the top as the highest use of “low-value” timber—beetle-kill pine, and smaller-diameter green trees—because its durability and long life as a building material enable it to store carbon that would be emitted in other, combustible uses of the wood.

Some of these reports, most notably, Recommendations to Expand Wood Products Markets in California, by the SB859 Wood Products Working Group, include promising recommendations, many of which are now being explored for

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2 California SB 859, signed into law in September of 2016, in part called for the creation of “a working group on expanding wood product markets that can utilize woody biomass, especially biomass that is removed from high hazard zones...” (SB 859 Wood Products Working Group 859)
implementation by newly-formed working groups coordinated by staff in the Governor’s Office of Planning and Research.

This report seeks, to some extent, to synthesize the literature. But its primary purpose is to explore and recommend interventions to remove barriers that have seen less attention in the literature—especially those related to sourcing wood from projects on U.S. Forest Service land in California, and to widespread adoption by the building construction industry of California-manufactured CLT made from such wood. The report also includes recommendations that augment some of those made by the SB859 Workgroup.

**Research Methods**

The analysis and recommendations herein are based upon extensive review of academic, policy, industry, and other relevant literature; interviews with more than sixty (60) experts in forestry, ecology, policy, wood manufacturing and engineering, architecture, and building construction and development; the results of a survey\(^3\) of building design, development, and construction professionals; a tour of seven cross-laminated timber buildings in Oregon; and attendance at the March 2018 national Mass Timber Conference in Portland, Oregon.

Four University of California at Berkeley undergraduate students conducted supplemental research in support of this report. Franklin Dean Keck researched forest carbon cycle issues related to California forests and CLT, along with decay rates of beetle-kill pine; his work is captured in a memorandum attached as Appendix 3 to this report. Akshey Dhar, Chow Lee Liang, and Andrew Sohrabi researched manufacturing and marketing practices associated with cross-laminated timber.

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\(^3\) Conducted online from March 20-25, 2018. While the survey netted just 14 responses from architects, building developers, and contractors, it does provide some important insights about barriers to CLT adoption; these survey supplement interviews conducted with representatives from these professions.
## Key CA Efforts on Biomass Utilization & Forest Management

**SB89 Wood Products Working Group**
In its October 2017 report, *Recommendations to Expand Wood Products Markets in California* (subtitle: “Investing in communities and California’s climate resilient future”) the SB 89 Biomass Utilization Working Group “determined that the most promising markets for small-diameter trees... include engineered mass timber [CLT] and wood-based composite panel products used in building construction, retrofits, and remodeling.” The report advances a set of recommendations that mostly aim to facilitate mass timber (CLT) manufacture, and to some extent, adoption in California. (Supply chain barriers are outside the scope of the report) Staff from the Governor’s Office of Planning and Research is leading a steering committee and three workgroups to begin implementing some of this report’s recommendations.

**Little Hoover Commission**
In *Fire on the Mountain: Rethinking Forest Management* in the Sierra Nevada (February 2017), the Little Hoover Commission reinforced the SB 859 Biomass Utilization Working Group’s findings about CLT, writing that, “Using California forest products to meet the state’s needs [for cross laminated timber, all of which is currently imported] could create a profitable use from fuels buildup.” (Little Hoover Commission)

**California Tree Mortality Task Force**
This group convened by the Governor’s Office of Emergency Services and the California Department of Forestry and Fire Protection comprises nine working groups, including one focused on wood utilization and market development, which commissioned The Beck Group’s 2017 *Dead Tree Utilization Assessment*, which examined more than 50 utilizations of beetle-kill pine. (The Beck Group, *Dead Tree Utilization Assessment*) Its work is ongoing.

**California Assessment of Wood Business Innovation Opportunities and Markets (CAWBIOM) Phase ii Report (December 2015)**
In this report (subtitle: “Feasibility Assessment of Potential Business Opportunities”) commissioned by the National Forest Foundation, The Beck Group found CLT “has potential for huge market growth and the presence of such a plant(s) in California would help preserve forest products industry infrastructure in the State. The presence of a forest products industry is a prerequisite for cost effective forest restoration.” (The Beck Group, *California Assessment of Wood Business Innovation Opportunities and Markets (CAWBIOM) Phase ii Report: Feasibility Assessment of Potential Business Opportunities*)

**Forest Resiliency, Environment & Economic Development (FREED)**
This group, first convened in October 2017 by Rural County Representatives of California (RCRC) and University of California Agriculture & Natural Resources, is focused on strategies that unlock rural economic development, as well as a reliable supply for a new wood products industry that supports ecological forest management goals.
A Note About Ecological Forest Management

Healthy forests are valuable for their own sake and for the many species that rely on them for habitat. But healthy Sierra Nevada forests also provide critical benefits that millions of Californians rely on for their health, well-being, and survival. Most importantly, more than 60% of California’s drinking water supply is from the Sierra Nevada; that means 22 million people rely on a healthy Sierra to protect both the quantity and quality of their water. (Sierra Forest Legacy) Healthy Sierra Nevada forests also help protect air quality and biological diversity, help control floods, and regulate climate by sequestering carbon, as is discussed in the following sections of this report. (Sierra Forest Legacy)

But, over a century of aggressive fire suppression, and other poor management practices has left Sierra Nevada forest dangerously overstocked, extremely susceptible to drought, riddled with beetle-killed trees, and in danger of hosting more extreme wildfires. (Stephens et al.) Some argue against active forest management in favor of “letting nature do its job;” however, the conditions in Sierra forests are far from “natural.” (Sierra Nevada Conservancy) Given these conditions, all the forest ecologists, forest managers, conservationists, and policy experts interviewed for this report agreed that:

... a well-managed forest will create even more carbon sequestration than a let-grow forest when the wood products are efficiently used. Efficient use of wood products is the ‘best management practice’ in most, but not all, cases in California. (University of California Agriculture & Natural Resources)

However, they tended to be split on questions around whether a CLT industry could create too much pressure on forests, ultimately undermining their health and resilience, along with the benefits they provide in terms of wildlife habitat and water quality and quantity. Respondents fell into two main categories:
1. Those who thought California’s forests are so overstocked that a CLT industry could not have a negative impact, and that current forest management practices are sufficient to protect forest health from over-harvest.

2. Those who thought California’s forests are so overstocked that it is far worse to do nothing than to prioritize active forest management that supports utilization (rather than pile burning) of harvested wood, but who also warned, without clear sustainability practices and limits, an unchecked CLT industry could have a negative impact on California’s forests. Some cautioned that it is important to “leave alone what’s in good condition,” and to target management to “enable greater pace and scale on public lands in California headwaters regions and national forests.”

In its 2012 Conservation Strategy, Sierra Forest Legacy articulated a somewhat more cautious version of the latter position:

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**Mechanical removal of vegetation needs to be carefully designed to remove the vegetation necessary for reducing risk while retaining sufficient habitat structure and diversity to support healthy wildlife populations. Further, we promote the maintenance and development of the necessary infrastructure designed to remove wood fiber, such as biomass and small diameter wood, to achieve our restoration goals. We support the creation of infrastructure to process wood fiber that also supports the removal of biomass in a manner that is ecologically sustainable. It is critical that the capacity of the infrastructure fit the pace and scale of the restoration need and for the infrastructure to adjust to ecosystem needs—not to override them.** (Britting)

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Accepting the hypothesis that California-based manufacture and adoption of cross-laminated timber can play an important role in restoring and sustaining forest health, reducing wildfire risk, and sequestering carbon, this report examines an array of supply- and demand-side barriers to CLT manufacture and adoption, and recommends policy and programmatic interventions to help remove them, making way for a CLT industry that supports and enhances—and does not detract from—forest health. In other words, the industry should be part of an ecological forest management plan—not the other way around.
Acknowledgements

As is the case with any project, this report is the product of the help, support, thought partnership, and good cheer of a great many people to whom I offer my utmost gratitude.

This “Advanced Policy Analysis” or “APA” is the culmination of my Master of Public Policy at University of California’s Goldman School of Public Policy (GSPP), where dozens of students, faculty, and staff provided support, structure, feedback and inspiration throughout this project. I am grateful too all of them. Here I will list those with the most direct involvement: My APA instructor, Hector Cardenas; my APA seminar-mates Brooke Barron, Courtney Colburn, Anna Dunning, Rawan Elhalby, Michael Fleischmann, Lindsey Freeland, Beth Leuin, Colin Mickle, Ruchika Radhakrishnan, and Sonya Zhu; classmates Sanghamitra Mukherjee and Roshni Wadhwani for helping with economic analysis, Irina Titova for thinking through formatting challenges; and Sam Schabacker for too many things to list.

This report is dedicated to my dear partner, Michael Manoochehri, who has in so many ways made graduate school, and in turn, this project, a reality for me, as well as to my long-time companion, Petunia, the 16-year-old medium-sized brown dog.

With many thanks,

Sandra Lupien
PROBLEM OVERVIEW
Problem Overview

Forestlands in California are dangerously overcrowded. (Sierra Nevada Conservancy) The density can increase wildfire spread and intensity (Stephens et al.), and forces trees to compete for scarce water and nutrients, making them more vulnerable to pest infestation. (Boxall) The 129-million California trees killed by drought and bark beetles in recent years (U.S Forest Service Pacific Southwest Region, *2017 Tree Mortality Aerial Detection Survey Results*) offer stark evidence of this pattern.

The greenhouse gas (GHG) emissions associated with these more severe forest fires, or with the decomposition of millions of beetle-killed trees, threaten to transform forests from carbon “sinks” into massive sources of greenhouse gas emissions. (Forestry Climate Action Team)

The State of California considers this situation a state of emergency. (Siders, “Jerry Brown Declares Emergency for Dying Trees | The Sacramento Bee”) In addition, broad consensus among foresters, conservationists, and fire ecologists holds that ecological thinning and ongoing active management is the only way to restore forest health, mitigate increased fire risk, and increase long-term storage of forest carbon. (Stewart and Sharma) But, a severe lack of funding and political license prevents this work in all but the most high-hazard forest zones.

Cross-laminated timber (CLT), an engineered building construction material, is widely seen as having the potential to help pay these trees’ way out the forest, and put them to use as a valuable, durable material that sequesters the trees’ carbon for many decades. [(Little Hoover Commission); (SB 859 Wood Products Working Group); (Forestry Climate Action Team); (The Beck Group, *California Assessment of Wood Business Innovation Opportunities and Markets (CAWBIOM) Phase Ii Report: Feasibility Assessment of Potential Business Opportunities*)]
**Condition of Sierra Nevada Forests**

Sierra Nevada forests are in trouble. A combination of fire suppression and insufficient forest management policies have left forestlands dangerously overcrowded (Sierra Nevada Conservancy). According to Sierra Nevada Conservancy, healthy, fire-adapted forests in the mid-1800s hosted 50-80 trees per acre, whereas many Sierra Forests today have between 300-400 trees per acre. (Sierra Nevada Conservancy).

Image 1: Plumas National Forest, Sierra Nevada, Bear Creek Guard Station
Source: Left-Walter Robinson, Forest Guard; Right-Ryan Thompkins, Forest Silviculturalist

The dense conditions force trees to compete for scarce water and nutrients, which makes them more vulnerable to bark beetle infestation, as is tragically evidenced by the 129 million dead trees standing in Sierra Nevada forests. (U.S. Forest Service, *Fiscal Year 2018 US Forest Service Budget Overview*) Although recent surveys by the U.S. Forest Service found the rate of mortality in Ponderosa Pines appears to be slowing down, scientists expect trees to continue to die, even if precipitation remains stable over the next several years (Quiros). While most of the dead trees are in the southern and central Sierra Nevada, where “some areas have

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4 "Most western US ecosystems are fire dependent, meaning that for millennia, the flora and fauna depended on periodic fire to maintain ecosystem integrity.” (Stephens 2018) However, they are not adapted to the types of destructive high-severity fire associated with dry, overstocked forest conditions currently present in Sierra Nevada forests.
experienced (>90%) tree mortality” (Stephens 2018), the effects of the infestation are moving gradually north. Fifty-nine percent of the dead trees are located on national forests. (Beck 2017)

**Worsening Wildfires**

The dense conditions also threaten to increase wildfire spread and intensity (Stephens 2018). The presence of many shorter, smaller-diameter trees helps conduct fire not only horizontally through the forest, but vertically into the crowns of trees, resulting in the most destructive high-severity fires. (Stephens et al.) These wildfires are increasingly costly to taxpayers: From July 2017 to January 2018, the State of California spent $700m, and the US Forest Service spent $632m, fighting fires in the state. (Downey)

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**Fig. 1: Wildfire Suppression costs have risen dramatically over the past decade**

*Source: Los Angeles Times*

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**Rising wildfire costs**

(Fiscal years, in billions)

- U.S Forest Service (nationwide) $2.4 billion
- Cal Fire $699 million

Sources: National Interagency Fire Center, California Dept. of Forestry and Fire Protection
They also destroy buildings and other property in the wildland-urban interface (WUI). As shown in Figure 2 below, WUI fires have become dramatically more destructive over the past several decades, with nearly 8,000 buildings lost in such fires from 2000-2007, (Stephens 2018), and at least 8,400 building destroyed in the October 2017 North Bay Fires alone. (Vives and Winton)

![Fig. 2: Number of buildings lost from the 25 most destructive wildland-urban interface fires in California from 1960-2007](Source: Scott L Stephens et al 2009 Environ. Res. Lett. 4 014010)

Property damage from California fires in October 2017 exceeded $9 billion. (Little Hoover) And, fire spending continues once fires are out, when “water districts must spend millions to remove eroded soil from reservoirs.” (Little Hoover) Research shows that adding the beetle-kill epidemic into the equation is likely to make wildfires even more dangerous. These dry fuels threaten to dramatically increase the spread and intensity of wildfires over time, especially as the dead trees fall to the forest floor in the next 10-20 years. (Stephens 2018).
Carbon Emissions vs. Sequestration

The greenhouse gas (GHG) emissions associated with these more severe forest fires, or with the en masse decomposition of the beetle-kill trees, undermine California’s GHG reduction goals by emitting megatons of carbon dioxide and other GHGs [(Hicke et al.) (Battles et al.)] into the atmosphere as they burn, or “for decades as they [beetle-kill trees] decay.” (Forestry Climate Action Team)
When healthy, California forests are “resilient net sinks of carbon”—the biggest in the state—and thus, “a vital part of California’s climate change policy.” (Forestry Climate Action Team) But, “recent trends and long-term evidence suggest that these lands will become a source of greenhouse gas (GHG) emissions” if policy and management fail to restore and enhance their ability to sequester carbon. (Forestry Climate Action Team) (See Appendix 3 for an overview of forest carbon stocks and sequestration.)

It is important to understand that active forest management, specifically tree thinning treatment, does result in a short-term loss of carbon, but strategically implementing ecological forest management practices can, “minimize ecosystem carbon losses while increasing future carbon uptake, resilience to high severity fire, and climate related stresses.” (Dore et al.) For example, Dore et al. found a net carbon benefit in study areas of Sierra Nevada forests in the seven years following thinning treatments. In contrast, they recorded “delayed capacity for carbon uptake” in study areas that were clear-cut. (Dore et al.) Therefore, active forest management projects should be designed to maximize carbon sequestration.

Currently, trees removed for forest management often end up being burned in one way or another—whether it’s in piles in the forest, as firewood, or in biomass electricity generators—emitting massive amounts of carbon into the atmosphere.

In contrast, CLT can sequester large amounts of carbon in the built environment.

State of Emergency vs. Lack of Resources

A 2015 emergency declaration by Governor Jerry Brown called for the removal of millions of the beetle-killed trees. But, the volume of dead wood is overwhelming, according to The Beck Group, an Oregon-based consulting firm hired by the California Tree Mortality Task Force to investigate how to remove and utilize “as
many dead trees as practically and economically possible.” According to Beck, the 102 million dead trees that were dead in California forests as of May 2017 equated to 65 billion board feet or 178 million bone-dry tons (BDT). For context, according to Beck, California’s total sawtimber harvest per year is just 1.6 billion board feet. (The Beck Group, *Dead Tree Utilization Assessment*)

Beyond the beetle-killed trees, the California Department of Forestry and Fire Protection estimates the rate of treatment [thinning of trees and other vegetation via mechanical and other methods] on State and privately owned forests would need to be increased to approximately 500,000 acres per year” (Forestry Climate Action Team) from the current annual average of 17,500 acres in order to restore forest health and optimize forest carbon sequestration.

On forests owned by the US Forest Service (USFS) and Bureau of Land Management (BIA) which account for nearly 60% of forests located in California (U.S Forest Service Pacific Excluding private industrial forests. In California, the Federal government owns 57% of forest lands, and private interests own 40%. Of those, 14% are industrial private forests. The State of California is responsible for managing the 26% of non-industrial private forests, as well as the 3% of forest lands the State owns. (Cart)
Southwest Region, *French Meadows Project on the Tahoe National Forest Is on Course to Accelerate Forest Restoration and Reduce Forest Fuels | YubaNet* the goal is to increase treatment from about 260,000 acres per year to about 515,000 acres per year by 2020. (Forestry Climate Action Team)

But, public funding sources to tackle forest density at scale are scarce. For context, the U.S. Forest Service’s total 2018 annual budget is $4.73 billion (more than half of which is dedicated to fire suppression), and it would cost tens of billions of dollars for the agency just to mechanically thin all the acres of the national forest system that need it. (Koren) (See *New Funding for Forest Management* on p. 44 and *Funding and Capacity Barriers* on p. 56 for more information on funding for forest management in California.)

**Lack of Markets**

At the core of the problem is a missing market for the beetle-kill pine and smaller-diameter live trees harvested to reduce forest density. The State is currently considering market strategies aimed at increasing the harvest and utilization of these trees. Early analysis of beetle-kill pine utilization focused on low-hanging fruit options, such as firewood, animal bedding, and other combustible or biodegradable products (The Beck Group, *Dead Tree Utilization Assessment*) that emit CO2, rather than sequester it over a long term. There has also been significant and ongoing effort focused on using the trees for biomass electricity generation, a solution considered by most reports, as well as more than a dozen people interviewed for this brief, to be interim due to its inability to compete on price with natural gas without significant subsidies.

A growing body of research and recommendations calls for robust new wood product markets that both help fund the removal of this “low-value” timber, and sequester its carbon, “particularly in buildings” (Forest Carbon Plan, 2017), in the
form of long-lived durable goods, such as structural “mass timber”; a number of analyses highlight cross-laminated timber (CLT) as the having the highest potential to achieve these goals. [(Little Hoover Commission); (SB 859 Wood Products Working Group); (Forestry Climate Action Team); (The Beck Group, California Assessment of Wood Business Innovation Opportunities and Markets (CAWBIOM) Phase Ii Report: Feasibility Assessment of Potential Business Opportunities)]
SOLUTION:
CROSS-LAMINATED TIMBER
Solution: Cross-Laminated Timber (CLT)

Although it has only in recent years begun generating a buzz in California, cross-laminated timber has been proven in structural and finish applications in commercial and residential construction in Europe, where the engineered wood material was developed in the 1990s. (Muszynski et al.) According to Espinoza et al, CLT now “successfully competes [in Europe] with steel, brick, and concrete in selected market segments, such as multi-family building. With more CLT manufacturing facilities launching in Europe, Canada, Japan, and the United States, “global CLT production will potentially reach 3 million m$^3$ by 2026” (Espinoza et al.)—enough to build about 3,600 four-story buildings. (Guo et al.)

California’s Pacific Northwest neighbors, Washington, and—especially—Oregon in recent years have implemented legislative, policy, business, and education strategies to jump-start CLT manufacture and adoption. CLT manufacturers in Oregon and British Columbia are supplying California projects advanced by early adopters; employees of D.R. Johnson Wood Innovations, Oregon’s first CLT manufacturer, and Structurlam in British Columbia both reported in interviews that about one-fifth of their CLT business is in California.

With booming housing and commercial building construction markets, a pressing housing crunch, a shortage of construction laborers, skyrocketing materials costs, and the world’s most ambitious GHG emissions reduction goals, California is ripe for solutions that can help build housing better, faster, and more sustainably. CLT can check all those boxes while providing funding to restore and maintain forest health to reduce wildfire risk.
What is CLT?

Cross-laminated timber is an engineered softwood building material “made of at least three orthogonally bonded layers of solid-sawn [and kiln-dried] lumber that are laminated by gluing of longitudinal and transverse layers with structural adhesives to form a solid rectangular-shaped element intended for roof, floor, or wall applications.” (APA, The Engineered Wood Association and ANSI, American National Standards Institute) CLT can be pressed to form posts or beams, as well as prefabricated panels that are custom precision-cut by CNC (Computer Numerical Controlled) routers to make openings for windows, doors and ducts. (Espinoza et al.)

Image 2: Cross-laminated Timber Concept and Panel
Source: Engineering Exchange

CLT panels are typically “2 to 10 feet wide, with lengths up to 60 feet (or more);” (APA, The Engineered Wood Association) and panels are 3, 5, 7, or sometimes 9 layers (up to 20 inches) thick. But it’s the process of cross-lamination that makes CLT strong, stable, and rigid.

Finished CLT panels, posts, and beams are flat-packed and delivered to residential or commercial construction sites where cranes and small (compared to
teams of workers place the relatively lightweight panels and fasten them with metal connectors. Depending on aesthetic and environmental needs, CLT panels can be left bare, or insulation and/or finish layers (like sheetrock) may be added.

CLT can be used structurally or decoratively. In structural applications, CLT can displace the use of steel or traditional wood framing, although in the United States, most CLT structures built to-date are hybrid systems, using a combination of CLT, steel, and concrete to form the structural system. (King)
What are the benefits of CLT?

Performance:
Competitive with Steel, Concrete, and Wood Framing

Strength:
CLT is strong, stable, and rigid, which is why it can be used for many structural applications, often in place of steel or concrete; “it can be used as a substitute for concrete [cores] in high-rise buildings up to 12 floors.” (Kimani)

Fire resistance:
Fire testing of CLT is ongoing, with the newest tests showing that their thick panels make CLT highly resistant to char. (WoodWorks) Questions remain as to whether strong fire performance relies on covering or coating portions of CLT within a structure, rather than leaving panels, posts, and beams entirely exposed. (King)
Overall, tests find that, “CLT panels are safe and fire resistant because they char on the outside of the panel, which prevents central heat build-up and allows walls to remain structurally sound. (Clemans)

Seismic:
CLT possesses excellent shear properties, and structures built from CLT, “experience less vibration in their floors since most CLT buildings are designed with a uniformly distributed load between the walls and floors,” which “balances CLT buildings and makes them more structurally sound.” (Clemans) Shake tests are being conducted on an ongoing basis with strong results; a 7-story building tested in Japan demonstrated satisfactory results in all tests. (Clemans)

Thermal performance and energy efficiency
Precision manufacture enables tight connections, which, combined with the high insulative values of the dense wood panels, leads to increased building operation efficiency and reduced heat loss. A Canadian Wood Council study reported that,
compared with buildings constructed using traditional techniques and materials, CLT buildings may need just one-third of the energy for temperature control. (The Beck Group, *(CAWBIOM)*)

**Assembly:**

**Faster, Cheaper, More Efficient and Precise**

**Reduced Construction Times:**
Using CLT can reduce construction times by at least 15 percent. *(Risen)* Rather than framing each wall using dimensional lumber or steel and concrete on site, as in traditional building construction, workers can place and fasten large CLT panels, which arrive flat-packed to the job site.

**Reduced Labor Needs:**
Less skilled labor is necessary to assemble the panels on site, compared to traditional framing.

**Less Waste:**
CLT panels are machine measured, controlled and cut, so the dimensions align precisely with architectural drawings. Since fewer materials are stored on site, significantly less waste must be carted away from CLT building sites. For example, the construction manager for Carbon 12, the tallest CLT-framed building in the United States, said the CLT components of the steel-concrete-CLT hybrid structure in Portland, Oregon generated zero wood waste.

**Reduced Cost:**
Although CLT is typically materials-cost-competitive with steel and concrete, *(Clemans)* builders often report significant cost savings due to decreased build times, and the need for fewer workers when building with CLT v. concrete structural systems. *(Clemans) (Green) [Green et al]* In 2012, Green et al reported that the average savings
between CLT and concrete in five regions of Canada in 12-story buildings was just 1.4%, but expected the savings would increase as CLT became more widely used in Canada. (Green)

A 2016 case study by WoodWorks Canada estimated over $2m in project savings in an all-CLT vs. an all-steel 6-story building. (WoodWorks Canada)

**Fig. 5: Costs of 6-Story Steel, Concrete, Mixed Concrete/CLT, CLT Buildings**

*Source: WoodWorks Canada, Atlantic Mid-Rise Wood Case Study 2016*

![Costs of 6-Story Steel, Concrete, Mixed Concrete/CLT, CLT Buildings](image)

Others put the cost savings at as much as 15%. (Risen) CLT’s proponents, including numerous presenters at WoodWorks (U.S.) Mass Timber Conference in Portland, Oregon in March 2018, frequently say CLT is most cost-effective in buildings 8 stories and higher; further research is recommended to understand the economics of building with CLT in California.
Why CLT for California?

Revenue Stream to Pay Trees’ Way Out of the Forest

CLT is widely considered a top contender to help close gaps in public funding that prevent forest management at the pace and scale required to reduce the spread and intensity risk of wildfire, to avoid the carbon loss associated with dead trees burning or rotting in forests, to restore forests to a healthy density, and to sustain forest health into the future.

CLT’s potential as a revenue stream for forest management is based largely on its status as a value-added utilization of otherwise low-value timber. For example, several people interviewed for this report indicated that logging companies don’t like to bid on jobs removing dead trees or smaller diameter trees because there is little to no profit margin available. In other words, the revenue available from selling these logs doesn’t pay their way out of the forest.

Furthermore, interviews and The Beck Group’s Dead Tree Utilization Assessment also revealed that, while mills have the technical capacity to process low-value timber—beetle-kill pine, as well as smaller diameter (4.75-6”) logs—into kiln-dried dimensional lumber (the feedstock for CLT), sawmills aren’t currently doing so because under current market conditions, doing so offers little to no profit margin. (The Beck Group, *Dead Tree Utilization Assessment*) The barrier with beetle-kill pine is that there is little demand for this wood as dimensional lumber, given its visual grade and potential decay barriers (see p. 65). And milling trees smaller than 6” requires a similar amount of time and labor as milling larger ones, but results in significantly fewer board feet of merchantable dimensional lumber.

At the same time, many mills in California are operating at half-capacity—one shift instead of two, (The Beck Group, *Dead Tree Utilization Assessment*) raising the
question of whether harvesting low-value timber for CLT offers a compelling opportunity for mills to operate at full capacity.

**Analysis of Feasibility of Adding A Mill Shift to Process 4.75-6” diameter trees for CLT**

As one person interviewed for this report put it, “The value in CLT is being to add another shift to a mill”—but only if it pencils out for the mill operator. This section analyzes the economic feasibility of a hypothetical medium-sized California mill currently operating a single mixed-products shift adding a second shift to process 4.75-6” diameter trees—green and beetle-kill pine—harvested from U.S. Forest Service land for ecological forest management, into 1”x 4” boards that could be used in the perpendicular layers of CLT. (APA, The Engineered Wood Association and ANSI, American National Standards Institute)

The model in Table 2, below, is sensitive to a number of variables. First, the treatment costs on national forests in California exhibits wide variation, ranging from $500-$3,000 per acre, according to experts interviewed for this report (the model uses $1,000 as the low end because projects in the $500 range are likely to net brushy biomass, as opposed to logs. In addition, the board feet per acre varies widely in these management projects. Table 1, below summarizes this variation. The variation in both of these variables can have dramatic effects on the treatment cost per board foot, which the model uses as the basis for the mill’s materials cost. Variation in prices for milled, kilned, and delivered dimensional lumber also vary across time, across sizes (1x4s are costlier than 2x4s, for example), and across species.

The variation in treatment costs (from six projects on Tahoe National Forest between 2010-2016) and in lumber prices (using April 2018 data for California Ponderosa Pine in visual grade 2 and 3 in a variety of dimensions) can be seen clearly in Table 1, below. (See Appendix 1 for more detailed data.)
Table 1: Comparison of Average Treatment Costs Across Six Projects in Tahoe national Forest & Prices of Milled, Kilned, Delivered Ponderosa Pine in California

<table>
<thead>
<tr>
<th>Treatment Cost (Based on Scribner Log Scale)</th>
<th>Ponderosa Pine Prices Milled, Kilned, Delivered (Based on Lumber Tally)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per</td>
<td>Average</td>
</tr>
<tr>
<td>Board Foot</td>
<td>$0.45</td>
</tr>
<tr>
<td>1000 BF</td>
<td>$451.12</td>
</tr>
</tbody>
</table>

Sources: BF/Acre from US Forest Service Region 5; Treatment/Acre Figures based on range verified in multiple expert interviews; and Random Lengths (Industry Publication), April 2018

*Scribner log scale is a model used on forest projects to estimate expected board feet. Consensus holds that it significantly underestimates actual board foot yield at the mill—the Lumber Tally—by as much as 50%. This figure is controversial, so the calculations in this analysis find Lumber Tally by a more conservative Log Scale * 1.30.

The model is also sensitive to the mill’s operations costs; it does not account for possible fixed operations costs, which may therefore be double-counted in the model, possibly underestimating the second shift’s net profit.

Table 2: Economic Feasibility of Adding Second Small Diameter Shift to Single-Shift Normal-Mix Mill

<table>
<thead>
<tr>
<th>One Shift—Business-As-Usual (Normal Mix)</th>
<th>Add Second Shift (4.75-6” logs for 1x4” boards)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$/mfb*</td>
<td>$/mfb</td>
</tr>
<tr>
<td>Revenue (Annual)</td>
<td>$34,117,991</td>
</tr>
<tr>
<td>Dimens’l Lumbera</td>
<td>$514.60</td>
</tr>
<tr>
<td>Waste Products³</td>
<td>$102.92</td>
</tr>
<tr>
<td>Costs (Annual)</td>
<td>$31,695,651</td>
</tr>
<tr>
<td>Materials (Logs)</td>
<td>$451.12</td>
</tr>
<tr>
<td>Operating Inc. Labor</td>
<td>$11,395,409³</td>
</tr>
<tr>
<td>Net Shift Profit (Annual)</td>
<td>$2,422,340</td>
</tr>
</tbody>
</table>

Assumptions in the model:

* $/mfb=1,000 board feet.

a Dimensional Lumber refers to logs milled into 2”x4’s, 1”x6’s, 1”x4’s, etc. The prices/mfb assume kiln-drying and delivery.

³ This is the lumber tally amount—the actual amount of product coming out of the mill. Calculated by multiplying the log scale board feet on which the mill’s materials cost is based by 1.30.

⁴ Industry experts estimate about 40% of total log volume is waste biomass. Most mills convert all or most of this biomass into other products, such as wood chips for bioenergy or landscaping, animal bedding, soil amendments, etc.
The model assumes the mill converts 100% of this waste.

The model assumes the mill can sell products made from biomass waste at 20% the price of dimensional lumber.

Based on assumption C, above, this value calculated by 1) Dimensional lumber tally(DLT)/.60=Total Lumber Tally Board Feet(TLTBF); then 2) TLTBF-DLT=Total Waste Products (in lumber tally)

Given in Scribner log scale.

Calculated at one-third Annual Revenue.

The model may double-count fixed costs that would not be incurred on a second shift. Therefore, the model could overestimate the potential net loss associated with the second shift.

Based on the modeled assumptions, a mill would indeed have no incentive to add a second shift to process small-diameter trees into 1x4” boards, even if faced with adequate demand from CLT manufactures. If the mill’s fixed operating costs are equal or greater to $3,454,458 (the difference in net profit between Shift 1 and Shift 2) in the model, then adding the shift could pencil out, if adequate demand for the Shift 2 product existed. The recommendations in this report consider interventions to address a reduced-margin scenario, as well as to catalyze demand for such second-shift products if additional research demonstrates economic feasibility for mills to add shifts.

Sequester Carbon in the Built Environment

While harvesting trees for forest management does release some of their carbon into the atmosphere, transforming those trees into cross-laminated timber can capture some of their carbon in the built environment for many decades. Although research has not achieved consensus on lifecycle sequestration capacity of CLT (see Appendix 3), many estimates indicate the amount of carbon capture is significant. One study by Guo et al. estimated that one (1) cubic meter of CLT sequestered 800 kilograms of CO2. (Guo et al.) In addition, Guo estimated that a four-story building, using 835 cubic meters of CLT, would sequester 668 metric tons of carbon dioxide. (Guo et al.) According to the U.S. Environmental Protection Agency’s Greenhouse Gas Equivalency Calculator 668 metric tons of CO2 is equivalent to the emissions from 75,166 gallons of gasoline consumed, 730,853 pounds of coal burned, or the amount of carbon sequestered by 787 acres of U.S. forests in one year. (US EPA)
CLT also appears to have an advantage over traditional wood framing in that it is comparably easy to disassemble the CLT components of a building for reuse, making it likely that CLT will continue to sequester carbon in new applications, while traditional wood components are likely to go to landfills after use, where they emit carbon and methane during decomposition. (King)

**Create Timber Industry Jobs**

Using North American Industry Classification Data, and based upon job classifications culled from Oregon-based CLT manufacturer D.R. Johnson and Washington-based Katerra (coming online in 2019), one can estimate that a CLT manufacturer producing about 1.1 million board feet per year of CLT, could directly employ about 55 manufacturing technicians, architects, structural engineers, and indirectly support hundreds of jobs, specifically those related to timber harvest, transportation, milling, and kilning in economically vulnerable timber communities of the Sierra Nevada.

**Mitigate the Housing Crunch**

California’s $37 billion residential homebuilding market is forecasted to grow 4% annually through 2022. (Smith) Of that market, 64% are single-family and the rest
are multi-family (and multi-story) dwellings. Both Facebook and Google are spending hundreds of millions of dollars to construct employee housing; (Stangel) the City of Oakland has a goal to build 17,000 more housing units by 2024 as part of its affordability strategy; (Torres) and after devastating fires, Sonoma County is aiming for 30,000 new homes in 5 years. (Morris)

At the same time, California is experiencing an unprecedented housing shortage. McKinsey forecasts that California will need to construct 3.5 million housing units by 2025 to close its housing gap. (Woetzel et al.) A lack of affordable housing puts pressure on middle-income families and is driving spikes in homelessness across the state, in both urban and rural areas.

It is also driving a shortage of skilled construction labor. As workers are priced out of key building markets, this labor shortage has caused major construction delays, exacerbated safety problems, and made housing construction more expensive. Indeed, although residential building permits have exploded by 351% in the San Francisco Bay Area since 2009, the supply of construction jobs has only increased 29%. Developers are recruiting up-and-down the West Coast to find workers, resorting to paying higher wages and/or hiring less-skilled workers who have less safety training. Labor costs comprised 12.5% of total revenue in the California homebuilding industry in 2017. (Smith)

Simultaneously, key homebuilding materials—specifically wood and steel for framing—are increasingly expensive. (See “Rising Cost of Imported Building Materials” on p. 50)

Together, the labor shortage and increased costs of critical building materials are making new building construction cost-prohibitive. Eric Tao, CEO of the builder AGI, lamented the scope and impacts of this shortage in February 2018 (Baldassari):

*There’s probably a few thousand housing units in the San Francisco area, Oakland, that can’t be built because construction costs are too high.*
OPPORTUNITIES
ANALYSIS
Opportunities Analysis

Governor Brown’s 2015 State of Emergency declaration (Siders, “Jerry Brown Declares Emergency for Dying Trees | The Sacramento Bee”) generated headlines about the beetle-kill pine epidemic, raising awareness that, given the reality that California can expect a hotter, drier future, (Abatzoglou and Williams) doing nothing to address the state’s over-stocked forests essentially amounted to playing with fire. This new sense of urgency sparked a number of state and federal efforts to increase the capacity to manage forests, and to identify promising uses for beetle-kill pine and other smaller diameter trees harvested as part of public forest management projects.

This momentum, combined with the unprecedented destructiveness of 2017 California wildfire season that further exacerbated an already severe housing shortage in the state, has led to what many have identified as a watershed moment with the potential to create the political will to revive a timber products industry in California that restores forest health by funding ecological forest management, including the removal of beetle-kill pine.

But, this watershed moment won’t last forever. As one forest manager put it:

_We still have red trees* on the landscape, but they’ll turn gray soon. Once they do, people will forget about the problem until there’s another major wildfire._

*The needles of beetle-kill pine trees turn red (before they fall off) after the tree dies.

This section offers an overview of the key opportunities in policy, legislative, regulatory, and market landscapes that could, if leveraged with urgency, help clear a path for CLT manufacture and adoption in California.
Forest Carbon & GHG Emissions Goals

California boasts the most ambitious greenhouse gas emissions reduction goal in the United States: to reduce emissions to 1990 levels by 2020. Although it did encourage forest carbon sequestration, the original 2008 Scoping Plan to implement the California Global Warming Solutions Act (AB 32) did not emphasize forests as a high priority action area. Recognizing that forests in California store of 1.29 billion metric tons of carbon above ground and 873 million metric tons of carbon below ground and sequester 2.6 million metric tons of carbon annually, (Forestry Climate Action Team) the 2030 Target Scoping Plan set goals related to active management of forest lands in order to maximize carbon storage and sequestration and reduce forest carbon emissions. (Forestry Climate Action Team) A collaboration of state agencies, led by the California Natural Resources Agency, is drafting a comprehensive Forest Carbon Plan, which aims to implement those goals; the January 2017 draft of this plan highlights CLT as a high-value utilization for wood removed as part of active forest management projects.

In addition, Assembly Bill 1504, enacted in 2010, required, among other things, the development of a carbon inventory for California forest ecosystems and harvested wood products. The first report pursuant to this legislation (in 2015) established accounting systems for forest carbon that comply with International Governmental Panel on Climate Change (IPCC) guidelines. The system aims to help the California Board of Forestry and Fire Protection in “evaluating and monitoring progress on meeting California’s carbon sequestration target.” (Christensen et al.)

New Funding for Forest Management

Funding for forest management on federal, state, and private lands comes from a variety of sources, too complicated and plentiful to enumerate here. However, new
funding from state and federal sources aims to enable more forest management projects on publicly managed forest lands and could be a signal of more to come.

**New State Funds**

**CalFire—Greenhouse Gas Reduction Fund (GGRF)**
The 2017-2018 budget for CalFire included $220m for projects focused on: forest health, forest legacy, and fire prevention, and the Governor’s 2018-2019 budget identified $160m more for management work to promote “healthy and resilient forests.”

**Sierra Nevada Conservancy Natural Disaster Resilience Program**
Sierra Nevada Conservancy is developing a Natural Disaster Resilience Program to distribute funds from a U.S. Housing and Urban Development Grant. The funds, which could be administered as grants, or as a revolving loan fund, may be used to remove excess fuels from forests; it’s not clear whether this fund, is set to launch in the first quarter of 2019, may also be a source for potential CLT manufacturers who aim to use some of this wood.

**New Federal Funds and Opportunities**
The Federal Omnibus Bill passed by Congress in March 2018 included a package its proponents referred to as the “Fire Funding Fix” (FFF). While the FFF does not allocate new funds for forest management, it creates a ten-year, $20 billion wildfire disaster fund in order to address the long-running practice of “fire borrowing,” wherein the U.S Forest Service in times of emergency reallocates to fire suppression activities funds originally budgeted for forest management. (Bichell)

Forest managers and forestry experts interviewed for this report frequently highlighted fire borrowing as a critical barrier to planning forest management.
projects, since all or much of the already-scarce funding allocated annually for such activities is practically certain in fire-prone California to be seized to fight fires. Forestry experts expressed hope that the FFF would enable them to “do more work on the ground in the forests.”

The FFF also has the potential to help increase a reliable supply of wood for potential CLT manufacture in three other ways:

- **Expediting environmental review** for forest management projects aimed to reduce wildfire threats in high hazard areas (such as areas with a lot of beetle-kill wood).
- **Increasing the allowable length of Master Stewardship Agreements**, which could help potential manufacturers arrange for a long-term supply, which is key to attracting start-up investment dollars. (see Barriers to Industry, p. 50)
- **Expanding the Good Neighbor Authority**, which allows state agencies to carry out forest management projects on federal lands located in their state.

**Potential Funds in State Ballot Initiatives**

**Proposition 68**, California Drought, Water, Parks, Climate, Coastal Protection, and Outdoor Access for All Act of 2018 is a $4.1B bond measure on the June 2018 ballot. It includes at least $50m that could be used for forest management work. (State of California, *California Proposition 68, Parks, Environment, and Water Bond (June 2018) - Ballotpedia*)

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6 Master Stewardship Agreements (MSA) with the U.S. Forest Service allow entities (non-profit organizations, collaboratives, Joint Powers Authorities, etc.) and jurisdictions (counties, cities, special districts) to manage “large areas [of federal forest land], typically at the regional...or forest level.” MSAs have potential to significantly increase the pace and scale of ecological forest management work on U.S. Forest Service lands by shifting the burden of project planning and management away from USFS onto partners with more capacity and access to different funding streams. Master Stewards are also able to enter into and manage Supplemental Project Agreements (SPAs) for specific project work, which further increases capacity. Finally, when a project generates revenue in excess of the project costs, those “receipts” are “retained,” meaning they are reinvested in the forest for additional management work—this is in contrast to receipts generated in traditional timber sales, which must be deposited with the U.S. Treasury. (National Forest Foundation) (See Appendix 3 for more information about MSAs and other types of forest management mechanisms.)
The Water Supply and Water Quality Act of 2018 is an $8.887b bond measure expected to appear on the November 2018 ballot. It aims to address a breadth of water infrastructure, quality, and distribution priorities identified by the state; relevant to this report, the bond would also provide funds for upper watershed management, which includes active forest management projects. (State of California, Water Supply & Quality Act of 2018)

**Funding for Wood Utilization**

Funding opportunities specific to supporting the utilization of wood harvested as part of forest management projects are limited—particularly for non-energy uses like CLT. (See Barriers to Industry, p. 50 and Barriers to Adoption, p.70) However, the U.S. Forest Service has for several years operated the Wood Innovations Grants program, which funds projects that “significantly stimulate or expand wood energy and wood products markets that support the long-term management of National Forest System and other forest land.” These grants are usually up to $200,000 and are typically used for technical research, demonstration projects, and market research. (Wood Innovations Grants | US Forest Service) Administrators of the program, which requires a 50% cash or in-kind match, reported a significant increase in CLT-related proposals over the program’s three cycles.

The SB 859 report recommends a similar “California Wood Products Small Grants Program,” awarding $50,000 to $150,000 grants, “to small businesses, non-profit organizations, and academic institutions to develop and deploy new wood products manufacturing capacity.” (SB 859 Wood Products Working Group 859)
Building Code Updates to Streamline Permitting

The International Code Council (ICC) updates the International Building Code (IBC) every three years. California typically updates its Building Standards Code (CBC), Title 24, the year after approval of the new IBC, and the updates take effect the following January. When California updated the CBC in 2016, it accepted IBC language that allows, through standard permitting processes, for the use of CLT in gravity structural systems (permanent load bearing), such as floors, ceilings, and walls. The code does not rule out CLT for lateral force resisting systems (those that keep tall buildings stable in earthquakes, wind, etc.), but using CLT for such systems does, under the 2016 CBC, require permitting through an Alternative Means and Methods (AMMR) process. The AMMR process can be a barrier, since its outcomes are unpredictable for building developers, and therefore represents a risk few are willing to accept. Developers, architects, manufacturers, and policy experts interviewed and surveyed for this report frequently identified this code as a key barrier to CLT adoption in California.

The ICC’s draft 2018 IBC update addresses this barrier; it has “proposed 19 code changes for the 2021 edition of the code that would collectively allow for the use of wood structures in a much broader array of building types, including construction of tall wood buildings up to 18 stories or 270 feet in height.” (“National Building Code Changes on November Ballot”) Passage of these updates on the November 2018 ICC ballot offers a key opportunity for California to follow suit in 2019, opening the door to new uses of CLT, and thus to a market for potential California CLT manufacture.

It is possible, however, for California to adopt the code updates sooner than 2019, in order to jumpstart CLT adoption. Interviews conducted for this report revealed
that representatives from a number of California state agencies have inquired about doing so; Oregon and Washington are also taking a close look at early adoption of the new IBCs on CLT.

**Legislative Action**

The watershed moment described in the previous chapter has set off a flurry of legislative activity at the state and federal level. Appendix 2 comprises a list of those bills (active as of May 2018) most relevant to this report’s topic.

**Mixed Product Campuses**

Interviews revealed significant interest in the development of mixed wood product campuses to facilitate the milling, drying, and processing of trees and biomass harvested as part of forest management projects. Such campuses can serve as clearinghouses for this wood, in which it can be sorted into multiple utilizations: CLT, post-and-pole, chips for biomass electricity and thermal energy, etc.). These campuses seem most promising if developed on a site already zoned for timber processing, and, if possible, with some existing supportive infrastructure. At least three mixed wood products campuses are under development in the Sierra Cascade region; interviews revealed that each project operator considers it a high priority to attract a CLT manufacturer.

**Loyalton**

A small group has purchased a mill site formerly operated by Sierra Pacific Industries in Loyalton, California, and has set up a biomass electricity and thermal energy plant facility, which aims to power the other utilizations, including a mill and kiln, its operators are recruiting to the campus.

**Crescent Mills**

Sierra Institute for Community and Environment has been working transform into a
mixed products campus a mill site formerly owned by Louisiana Pacific in Crescent Mills. The need to remediate contaminated soils has caused significant project delays, but the vision for this project is similar to that for the Loyalton campus.

Auberry

The Sierra Resource Conservation District is working to set up a campus on a former mill site in Auberry.

The SB 859 Working Group recommends California support the development of mixed wood product campuses by offering small business grants and technical assistance to facilitate collaboration as well as access to revolving loans. (SB 859 Wood Products Working Group 859)

Rising Cost of Building Materials

According to the National Association of Homebuilders, on average, framing costs for residential construction run 17-19% of the overall project costs. (National Association of Homebuilders) The recent imposition of steel tariffs will drive up steel framing costs. (Reuters) These tariffs come on the heels of a December 2017 decision to impose tariffs as part of the NAFTA renegotiation on softwoods (pine, fir, and spruce) imported to the United States from Canada—driving up home building costs by 7 percent. (Newsweek) As the cost of these important construction materials rises, CLT—a domestic, potentially lower-cost alternative—could provide relief from these increased materials costs for developers and construction companies seeking to fill California’s housing gap (See p. 41).
CLT Interest and Demand in California

Gaining a deep understanding of CLT’s market potential in California requires comprehensive demand-side research and analysis beyond the scope of this report. However, the interviews, surveys, and literature review conducted for this work offer insight into early CLT demand, interest, and awareness.

And, CLT is already in use in California, where Oregon-based manufacture, D.R. Johnson, and British Columbia-based Structurlam are reportedly seeing about one-fifth of their demand. Manufacturers Nordic (Quebec), KHL (London, UK) are reportedly selling CLT in California; Katerra (expected to start producing CLT in 2019 from its new Spokane, Washington factory) reportedly has projects in the pipeline for California.

On April 6, 2018, Plumas County held a ribbon-cutting ceremony to celebrate the completion of California’s first all-CLT building in Quincy. The County developed the 2000 square-foot building, which houses a biomass boiler, in partnership with the Sierra Institute for Community and Environment, in part to create an all-CLT demonstration project in California. (Holmes Structures) Experts reported that at least eleven other buildings incorporating CLT have been completed, or are in various stages of construction, permitting, and design, in Northern California, and that at least 30 architects, developers, contractors, and engineers with offices in California have used CLT or are interested in incorporating it into their projects. (See Appendix 4)
A Note About LEED and other Certifications

“Green” or sustainable building programs such as LEED, the Living Building Challenge, and BREEAM may, through a variety of mechanisms related to transportation distance, product carbon life cycle, materials sourcing, insulative value for energy efficiency, etc. create incentives that support the adoption of California-manufactured CLT. While understanding the potential CLT incentives available through these complex and disparate certifications is beyond its scope, this report recommends a comprehensive analysis of the opportunities available through such programs. One potential barrier to track is that LEED and some of the other programs offer points only for wood from third-party certified sources, such as the Forest Stewardship Council and the Sustainable Forestry Initiative. Timber harvested from U.S. Forest Service lands is not certified by any third party.
Case Study
How Oregon Created Opportunities That Jump-Started CLT

The State of Oregon since 2012 made a number of strategic moves and investments that have made the state a leader and incubator for CLT manufacture and adoption in the United States. These can serve as models for California.

**EO 12-16, October 20, 2012**
Then-Governor John Kitzhaber issued this Executive Order *Promoting Wood Products in Commerce as a Green Building Material, Encouraging Innovative Uses of Wood Products and Increasing Markets for Oregon Wood Products*. Among other things, it required state agencies to “identify at least two state capital construction projects that can be improved by featuring wood products in design and construction.” The order ultimately led to the design and development of CLT buildings at Oregon State University (under co-construction), and Western Oregon University (which became the first multi-story CLT building in the state). The buildings have generated significant media attention and have been seen by thousands of people on mass timber building tours. EO 12-16 also required state agencies to support Oregon-grown mass timber development and manufacture, and to develop markets for the new products.

**Studied Third-Party Certifications**
The Oregon Department of Forestry collaborated with several partners to compare Oregon’s timber harvest practices against the criteria for third-party certifiers like Forest Stewardship Council (FSC). Based on this research, Oregon promotes products as environmentally sound.

**Oregon Forest Resources Institute (OFRI)**
This State agency is funded by a portion of the state forest products harvest tax. When it decided to help mobilize stakeholders in support of mass timber, it used a two-year U.S. Forest Service Wood Innovation Grant to create a Forest Products Education Department. That department has been key to the growth in manufacture and adoption of CLT and other mass timber products in Oregon. The team synthesized collaborations among individuals, industry, non-profits, local jurisdictions, elected officials and other public servants, and facilitates and conducts research, gives tours of CLT buildings, and hosts conferences that help CLT manufacturers and adopters advance.

**State Leadership on Permitting Mass Timber Buildings**
Permitting CLT buildings under the evolving codes is a common barrier to new projects, particularly when cities don’t have the capacity to conduct AMMRs for buildings incorporating the relatively new material. (See *California Building Codes and Permitting*, p. 71). Oregon’s Building Codes Division has stepped in multiple times to handle the structural part of the permitting process, which both enables projects to move ahead, and provides the State an opportunity to create and test guidelines that cities can use as they begin to handle permitting CLT projects more regularly. Now the State of Oregon is considering the new, unpublished 2018 IBC standards that provide code guidance for four new types of mass timber buildings. Doing so would make the permitting processes for CLT buildings—including tall ones—much simpler and more straightforward for builders and permitting agencies.

Sources:
Timm Locke, Director of Forest Products. Oregon Forest Resources Institute. www.ofri.org
BARRIERS ANALYSIS
Barriers Analysis

The policy window and opportunities outlined in the previous section hold promise for CLT in California. But, they alone are not sufficient to spark the markets, attract the manufacturers, and unlock the reliable supply of sustainably harvested wood necessary to launch a CLT industry that can create a revenue stream to fund robust management practices that restore and maintain forest health, and capture forest carbon in durable building materials.

In order to unlock the gate to CLT manufacture and to shepherd its adoption in California, proponents of this new industry and material must understand two key contexts emphasized by many of those interviewed for this report: 1) The U.S. Forest Service and the building construction industry are both slow to change, and understandably risk averse; and 2) Political license to conduct work in California forests has for many decades been curtailed due to the concerns of stakeholders that associate forest management with aggressive pre-1970s clear-cutting practices.

These contexts, along with financial, regulatory, business, and other limitations, present a set of challenging barriers to the California manufacture and adoption of CLT. This section categorizes these barriers into three groups—supply, manufacture, and adoption—and provides the analysis that informs the report’s recommendations.
Barriers to Supply

This report examines potential California manufacture and adoption of CLT not only in terms of its viability as an industry; it examines specifically how California CLT can be a viable industry that produces a value-added product that a) creates a revenue stream for sustainable forest management by sourcing wood exclusively from projects that restore and maintain the health of public forest lands; b) captures much of the carbon from those trees.

CLT’s feedstock is dimensional, kiln-dried lumber—most commonly 2”x6” boards, but also 2x8s, 2x4s, and even 1x6s and 1x4s. (APA, The Engineered Wood Association) Sourcing CLT from management projects on public lands presents a unique set of barriers related to supply reliability, which an industry sourcing from industrial private forests in California (which would offer a reliable supply of dimensional lumber) would not face. This section provides insight into those barriers.

Given that about 60% of forest lands in California are federally owned, this report focuses primarily on a CLT feedstock supply sourced from ecological forest management on U.S. Forest Service (USFS) lands.

Funding & Capacity Barriers

Forest managers report the per-acre treatment (including ecological thinning of trees) cost in California is between $500-$3,000, (depending on conditions related to slope, remoteness, and safety). At the current treatment rate of 260,000 USFS acres/year, it costs $130m-$780m actively manage (including thinning) these lands, and it would cost $257.5m-$1.545b to conduct active management on the target 515,000 acres/year of USFS forest lands in California. That leaves a funding
gap of between $127.5m-$765m between the current 260,000 acre/year scenario and the 515,000 acre/year goal.

Table 3: Gap and Acreage Gap Between USFS Forest Annual Actual vs. Target Active Forest Management
Sources: U.S. Forest Service, Forestry Climate Action Team

<table>
<thead>
<tr>
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<th>USFS Acres Managed/Year in California</th>
<th>Treatment Cost Per Acre</th>
<th>Total Treatment Cost</th>
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<tbody>
<tr>
<td>Current</td>
<td>260,000</td>
<td>$130m-780m</td>
<td></td>
</tr>
<tr>
<td>Goal</td>
<td>515,000</td>
<td>$500-$3000</td>
<td>$257.5m-$1.545b</td>
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<tr>
<td>Gap</td>
<td>255,000</td>
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<td>$127.5m-$765m</td>
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Yet public funding for active forest management is drastically insufficient. In 2018, the U.S. Forest Service dedicated 55%—up from 15% in 1995—of its $4.3 billion budget to suppressing fires after they start. (Bichell) In 2017 in California, the USFS spent $632m fighting fires in national forests. (Downy) In contrast, the USFS budget for forest management, including hazardous fuels removal, appears to have been less than $100m for California in 2017.7

But the literature and expert interviews indicate that prioritizing fire suppression over active forest management for fire prevention is often not the best use of scarce funds. For example, a report prepared for the Sierra Nevada Conservancy in 2015 used fire modeling and economic analysis to find that reducing forest density through thinning and other active forest management practices could reduce fire suppression costs by 41-47%. (Buckley et al.) In other words, sustainably managed forests could have reduced USFS’s 2017 fire suppression expenditures to $373m-$335m, freeing up $259-$297m for more mechanical treatment, funds which could

7 Based on correspondence with USFS staff.
help close the $127.5m-$765m between current and target USFS acre/year treatment levels for California.

<table>
<thead>
<tr>
<th>USFS Fire Suppression in California 2017</th>
<th>$632m</th>
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<tbody>
<tr>
<td>Est. USFS Forest Management Budget for CA 2017</td>
<td>&lt;$100m</td>
</tr>
<tr>
<td>Potential Fire Suppression Savings in 2017</td>
<td></td>
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Table 4: Fire Suppression vs. Management in CA

Sources: U.S. Forest Service, Sierra Nevada Conservancy, Forestry Climate Action Team

If USFS Forests in CA Were Actively Managed | $373m-$355m

By reducing the need for “fire borrowing,” (see New Federal Funds and Opportunities” on p. 45), the $20b (national) fire emergency fund created by the March 2018 Fire Funding Fix in the Federal Omnibus Bill could also help close the funding gap between current the present and target number of acres treated per year.

But, in addition to lacking funding, the literature and interviews revealed local National Forests in California lack capacity to plan and manage forest management projects, which are highly complex, span many years from conceptualization to execution, and are often subject to litigation. For example, Lassen National Forest has recently been staffed at anywhere from 20-30% of permanent full-time positions.

While Master Stewardship Agreements, Stewardship Contracts, (See Appendix 4) and the Good Neighbor Authority⁸ are all promising models for increasing the pace and scale of management work on U.S. Forest Service land by enabling other jurisdictions (counties, cities) or entities (non-profit organizations, collaboratives) to

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⁸ “The Good Neighbor Authority allows the Forest Service to enter into cooperative agreements or contracts with States and Puerto Rico to allow the States to perform watershed restoration and forest management services on National Forest System (NFS) lands. Congress passed two laws expanding Good Neighbor Authority (GNA): the FY 2014 Appropriations Act and the 2014 Farm Bill.” (U.S. Forest Service, Good Neighbor Authority | US Forest Service)

Much of the literature, along with several people interviewed for this report pointed to the Good Neighbor Authority as an important way to increase the pace and scale of ecological forest management on federal forests located in California by enabling the state to add capacity.
manage it, (see Recommendation #3, p. 82) numerous people interviewed for this report indicated that, while some USFS forest managers in California are quite open to such collaboration, a barrier to Master Stewardship Agreements may arise with those managers who are not comfortable with the idea of other entities managing projects on lands under their supervision.

But, even when stewardship contracts are in place, or timber sales offered, the current lack of a value-added use for wood sourced from forest management and stewardship contracts means these contracts and sales often go unharvested or unbidded because there is little or no return on investment for contractors to do the work. (See “Create a Revenue Stream to Pay Trees’ Way Out of the Woods,” p. 36)

### Process and Regulatory Barriers

#### Appropriations Process

Although the Fire Funding Fix (see “New Federal Funds and Capacity,” p. 45) could help funds allocated for active forest management on federal forest lands stay available for that purpose, USFS project managers in California still face a key barrier to planning projects due to the fact that federal dollars are allocated to forests on an annual basis, while forest management projects typically span multiple years.

Forest projects, with the exception of those to which emergency exemptions apply, tend to move slowly through a complicated set of permitting processes, and can take 3-10 or more years to implement fully from conception to execution. According to numerous forest managers and experts interviewed for the report, the annual appropriation system is incompatible with such project timelines.

As a hypothetical example, a national forest could spend two years and hundreds of thousands of dollars getting a project through the permitting phases, and plan to do
the work in the third year, only to find out that the budget for their forest has been cut, causing delays that affect not only foresters, but loggers or stewardship partners bidding on contracts, mills hoping to buy logs from the project, and end-users of that lumber or biomass, like manufactures and electricity generators.

**Regulatory Barriers**

All forest lands in California are regulated by multiple agencies and subject to numerous layers of permitting—processes implemented to protect forest health, water quality and supply, wildlife habitat, and historic sites.

For example, seven (7) state and federal agencies regulate private and state-owned forests in California, while five (5) agencies regulate National forests in the state. The disparate priorities, requirements, and permitting processes of these agencies can be difficult and time-consuming for forest project managers to navigate.

According to one forest manager, these permits can add $10,000 to $1m to the project costs and months to years to the project timeline. Project opponents are also able to bring legal action against projects during these processes, which can cause further delays and expense.

**Political Barriers**

Many interviewed for this report attributed the absence of active forest management in California not only to the financial and regulatory barriers covered in the previous sections, but also to forest managers’ “lack of political license to do work on the forest.”

At least five people interviewed for this report observed that different understandings and perceptions about forest management seem to split in
California along an “urban-rural divide: In rural regions, there is a very strong understanding of the problem—when you talk about overstocking, you’re talking to the choir.” But, urban dwellers who remember the post-World War II clear-cutting of Sierra Nevada forests (Beesley) might not trust what the Little Hoover Commission identified as a “counterintuitive message:” that cutting trees can help forests. (Little Hoover Commission)

As one interviewee put it:

*California experienced an enormous timber boom in the years following World War II. The housing and infrastructure demands associated with the “Baby Boom” eventually led to over-harvested forests and threatened species, notably the Spotted Owl and Pacific Fisher. Legislation and regulations (Multiple-Use Sustained Yield Act of 1960, Wilderness Act of 1964, NEPA, CEQA, Endangered Species Act, etc.) began to reflect growing concerns about these unsustainable practices, and led to a significant reduction in timber harvest from public lands. (“History Of National Forest Conflicts”)

One key related political barrier cited by at least a dozen people interviewed is the likelihood that one of handful of environmental organizations will file an injunction against any California forest management project during the NEPA or CEQA process, tying it up indefinitely in expensive litigation. (see *Regulatory Barriers* on p. 60)

### Infrastructure Barriers

#### Sawmill Capacity

The number of sawmills in California has decreased dramatically since regulations began restricting harvest on public lands in the 1960s. Over the past 30 years, 105 sawmills have closed in the state; today fewer than a dozen sawmills operate on or
to the East of Interstate 5 in California. (“California Forest Products and Biomass Power Plant Map”) Only one of these is in the Southern Sierra Nevada, (Daniel) which is “ground zero” for trees killed by drought and bark beetles. This mill, Sierra Forest Products (SFP), operates at just one 8-hour shift, rather than two shifts, which is its full capacity. [(The Beck Group, Dead Tree Utilization Assessment; Daniel)] As a mill surrounded by federal forest land, SFP reported having a historically inconsistent supply of wood to mill due to the unpredictability associated with harvesting from these forests (see “Regulatory Barriers”, p. 60). (The Beck Group, Dead Tree Utilization Assessment) The literature, and several people interviewed for this report indicated that as a value-added product that can provide a revenue stream to increase the pace and scale of forest management on public lands, CLT has the potential to add a second shift to mills that are only running one. (See analysis, p. 38) But, in an interview, SFP’s general manager and co-owner, Kent Duysen said for his mill, adding a
second shift hasn’t been possible—even faced with an abundance of beetle-killed material—due to a lack of trained labor in the region. Duysen also indicated that limited kiln capacity (SFP has five kilns) is a barrier to adding another shift. The lack of a trained workforce, and the unreliability of log supply from public lands were cited in multiple interviews for this report, as well as by The Beck Group (The Beck Group, *Dead Tree Utilization Assessment*) as key barriers for sawmills, and lack of kiln capacity in California as a barrier to CLT manufacture.

Finally, as discussed on page 36, mills have the technical capacity to process low-value timber—beetle-kill pine, as well as smaller diameter (4.75-6”) logs—into kiln-dried dimensional lumber (the feedstock for CLT); however sawmills aren’t currently doing so because under current market conditions, doing so offers little to no profit margin. (The Beck Group, *Dead Tree Utilization Assessment*) Removing this economic barrier is critical to unlocking a supply of low-value timber for CLT production.

**Barriers to industry**

As of May 2018, no one is manufacturing cross-laminated timber in California. In its 2015 *California Assessment of Wood Business Innovation Opportunities and Markets*, The Beck Group analyzed possible CLT manufacture in California, not for its potential to directly create a revenue stream for public forest management by utilizing low-value timber, but for its “potential for market growth,” and because, “the presence of such a plant(s) in California would help preserve the forest products industry infrastructure in the State.” In analyzing wood supply reliability, Beck concluded that, “an adequate volume of lumber is produced in California to supply a CLT plant,” processing 24m board feet of kiln-dried dimensional lumber.
into 1.1m cubic feet of CLT each year.⁹ (The Beck Group, *California Assessment of Wood Business Innovation Opportunities and Markets (CAWBIOM) Phase ii Report: Feasibility Assessment of Potential Business Opportunities*)

While the Beck assessment found CLT manufacture promising for California, it does not address the specific barriers associated with a CLT industry built on feedstock comprising low-value timber harvested from public lands. The following section examines the key impacts of those barriers on manufacture, as well as others identified during the research phase of this report.

**Supply Reliability**

**Long-term Contracts**

CLT has the potential to mitigate a key barrier to supply by providing a revenue stream that helps pay the way out of the forest for beetle-kill and smaller diameter trees. Nevertheless, any one, or combination, of the barriers to supply outlined in the previous “Barriers to Supply” section present substantial supply reliability risk for any CLT manufacturer relying on this “low-value” timber as feedstock.

Not only can these risks undermine sound business planning, they can present a significant barrier to prospective CLT manufacturers seeking financing to build and launch a factory in California.

Investors, policy analysts, and business development experts interviewed for this report consistently highlighted a mismatch between the realities of a feedstock supply reliant on forest management from public lands, and the risk-tolerance of potential investors, who typically require evidence of a reliable raw materials supply

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⁹ The Beck Report assumes the manufacturer is using primarily fir produced from private forestlands, not pine harvested from public forest management project.
for 10-20 years. Bank loans and grant funds are also likely to be tied to some measure of supply certainty.

As discussed in the “Barriers to Supply” section above, the current Federal annual appropriation system makes it difficult for National Forest managers to plan and implement forest projects on a reliable timeline. Furthermore, the U.S. Forest Service, as a public agency, is unable to enter into long-term timber supply contracts; each USFS project must go to competitive bid.

Absent the ability to acquire a long-term contract for timber harvested from forest management projects, or to work with a sawmill that has such a contract, only parties with substantial collateral (such as existing mills or factories) or the ability to self-finance will be able to assume the risk of manufacturing CLT in California using low-value timber harvested from public lands.

Lack of Research on Beetle-Kill Pine Decay Rate/Viability for CLT in California

More than 129-million trees have succumbed to drought and bark beetle infestation in California, and many more are expected to do so over the next decade. (Quiros) Utilizing those beetle-kill trees that can be ecologically harvested as feedstock for CLT could help reduce the potential emissions and wildfire implications associated with leaving these trees to fall to the forest floor (see “Beetle-kill trees falling to forest floor over 10-20 years likely to increase wildfire spread and severity,” p. 25)

But, a lack of clarity about how quickly beetle-kill pines decay in California forests raises questions about how long the dead trees remain viable as a feedstock for CLT. One person interviewed for this report said beetle-kill pine must be harvested in California no more than six months after death in order to be viable. Another said “almost none” of the dead wood could be used for California-manufactured CLT, given the amount of time it will take for a facility to come online. However, the literature is far from reaching consensus on decay timelines for this wood in
California, with estimates ranging from six months to 5 or more years. (See Appendix 3 for more discussion)

Furthermore, while it may be true that decay could quickly make beetle-kill pine inviable for use as dimensional lumber, it remains unclear how decay affects the wood’s viability for CLT, which derives its strength largely from the use of structural adhesives to bond together layers of parallel and perpendicular boards.

Researchers at Oregon State University are currently testing CLT made from beetle-kill Ponderosa Pine. But, without a robust understanding of how the trees decay in California forests, beetle-kill pine can be neither relied upon nor dismissed as a CLT feedstock.

Costs & Permitting

At least a dozen people interviewed for this report identified costs, regulations, and permitting as potentially critical barriers to CLT manufacturing in California. As one person put it, “The costs and regulatory requirements of doing business in California make people run and scream!” Several people expressed confidence that CLT manufacturing would never happen in California because wood products manufacturing is subject to less stringent regulation and is less costly in neighboring states like Oregon, Washington, and Nevada—even when importing logs from the Sierra Nevada in the case of the latter state. The in-depth economic analysis required to investigate the extent to which these factors are prohibitive is beyond the scope of this report. But, regardless of circumstances in other parts of the Western United States, potential CLT manufacturers do face barriers related to costs and permitting in California.
High Start-up Costs

Developing and launching a CLT factory is capital-intensive. In 2015, the Beck Group estimated a start-up cost of $16.7m for a hypothetical California-based CLT factory that produced 1.1 m cubic feet of panels per year, processing 24m board feet of kiln-dried lumber. Most experts interviewed for this report put the cost of a CLT factory between $15m-$25m depending on whether the site was a “brownfield” project redeveloping a site with some existing infrastructure (buildings, utilities on the property, etc.), or a “greenfield” project starting from scratch and developing from the ground up. One person interviewed thought the start-up cost were likely to go as high as $40m in California once all permitting fees were factored in.

Combined with the supply uncertainty described above, these high start-up costs could make a California-based CLT manufacturing industry that utilizes low value timber a non-starter, especially if manufacturers find neighboring states to be more affordable business environments.

Site permitting:

The literature reviewed, and interviews conducted for this report frequently named site permitting, or costs associated with site permitting as a barrier to CLT manufacture in California. The consensus seems to be that attempting to rezone a site is too difficult in California, and the best strategy is for prospective manufacturers to target for redevelopment sites already zoned for wood processing or manufacture (such as former mill sites). On the other hand, such “brownfield” sites often have polluted soil and water that permit applicants are responsible for remediating, which can be a process both lengthy and costly.10

10 For example, Sierra Institute for Community and Environment has encountered substantial delays in attempts to mitigate brownfield issues on its future mixed wood products campus in Crescent Mills. http://www.plumasnews.com/site-work-begins-old-louisiana-pacific-sawmill-site/
The SB 859 Wood Products Working Group offered robust recommendations to mitigate this barrier (see Appendix 6), so this report does not address it further.

**Trained labor force**

A skilled and trained rural labor force will be necessary to support CLT manufacture in California. The SB 859 Wood Products Working Group placed great weight on this barrier and offered a complement of recommendations to remove it (see Appendix 6); as such, this report does not take it up.

**Misperception: Beetle-Kill Not Allowed in US CLT**

All cross-laminated timber requires third-party product certification for structural and aesthetic integrity. In the United States, the dominant CLT certification is the PRG-320 standard administered by the American National Standards Institute (ANSI) and The Engineered Wood Association (APA) (together, the “ANSI/APA PRG-320”). According to interviews conducted for this report, no U.S.-based CLT manufacturer is using beetle-kill pine in CLT products, however, beetle-kill/blue stain wood is used widely in Canadian-produced CLT, (Spickler) and these products have gone through individual permitting processes for use in U.S. buildings, including the Carbon 12 project in Portland, Oregon, which incorporates CLT consisting of 70% beetle-kill pine.

Nevertheless, research informing this report revealed a common misperception that ANSI/APA PRG-320 does not allow for certification of U.S. manufactured CLT using beetle-kill pine. Part of the confusion might be attributed to a 2016 interpretation of the standards by The Beck Group, which wrote: “most Ponderosa pine lumber produced in the region is graded for appearance properties, not structural properties, and therefore would not qualify under PRG-320 standards. Therefore, a
CLT producer would have to work with supplier sawmills to have special production runs of Ponderosa pine specifically targeted for the CLT plant. This appears to be technically feasible but maybe not economically viable.” (The Beck Group, *California Assessment of Wood Business Innovation Opportunities and Markets (CAWBIOM) Phase II Report: Feasibility Assessment of Potential Business Opportunities*)

However, an interview with Dr. Borjen (B.J.) Yeh, who leads the development of the PRG-320 standards for APA, revealed that Beck’s interpretation of the standards was inaccurate. In fact, the PRG-320 standards require that wood for CLT must be visual (not structural) grade 3 for interior perpendicular layers, and visual grade 2 or better for parallel layers (APA, The Engineered Wood Association and ANSI, American National Standards Institute) According to Kent Duysen, co-owner and General Manager of Sierra Forest Products, about 75% of the beetle-kill pine his mill receives is visual grade 3 or better, which means it could be used in perpendicular layers of CLT, and potentially in parallel layers as well.
Barriers to Adoption:

Building construction has, throughout the history of California, relied on timber stick framing. And even today, “wood [not engineered wood like CLT] remains the most common framing material in North America.” (BONE Structure) For larger, and taller projects, steel and concrete typically comprise structural systems.

As one architect interviewed for this report put it:

_We’ve been building this way for nearly two-hundred years; the whole supply chain and regulatory structure is based on these systems. That’s hard to change._

Unsurprisingly then, although California’s building codes allow for CLT, early-adopter building developers and contractors often face challenges and setbacks to projects that incorporate this new-to-California material. Even though many California firms expressed interest in CLT, in an industry in which time delays are very costly, only those committed to pushing through barriers in the name of design innovation or low-carbon buildings are likely to be willing to take on the substantial risks associated with seeing a CLT project through to completion. One person interviewed for this report encapsulated this chicken-and-egg scenario as follows:

_In the U.S. we’re always in a race to third. No investor, no developer, wants to be first. The same is true for designers, and especially structural engineers. They don’t want to do the new thing until it’s thoroughly proven, and until it’s really easy for them._

This section highlights some of the key barriers to CLT adoption in California revealed through interviews, literature review, and a survey of 14 architects, developers, and construction professionals.
Building Codes and Permitting

California Building Standards Code
The foregoing section, “Building Code Updates to Streamline Permitting,” (p. 48) describes a building codes scenario that is increasingly friendly to CLT both internationally and in California. The State’s current Building Standards Code allows for use of CLT in gravity structural systems (permanent load bearing), such as floors, ceilings, and walls through standard permitting processes. In contrast, builders wishing to use CLT for lateral force resisting systems (those that keep tall buildings stable in earthquakes, wind, etc.), must go through an individual Alternative Means and Methods Review (AMMR) permitting process. An AMMR adds risk and uncertainty to a project since permitting agencies can require expensive and time-consuming testing to prove structural integrity of materials, fire resistance, and seismic integrity. The need to conduct an AMMR for a CLT building may also be beyond the capacity of a local or regional permitting agency; limited staffing and a lack of experience with CLT projects could force a permitting agency to refuse to review a CLT design. So, even though CLT is allowed in California, the AMMR process is likely to pose an ongoing barrier to widespread CLT adoption. Only one building—a 2,000sf biomass boiler building in Plumas County—is currently using CLT for both gravity structure and lateral force resisting systems.

Lack of understanding of CLT building codes
Even though the AMMR process can be a barrier to CLT projects, it does not equate to a prohibition on CLT for California. Survey responses, interviews, and literature review revealed a widespread lack of understanding of this distinction, and, indeed a lack of awareness that the 2016 California Building Standards Code allows for CLT at all. This is a barrier for prospective CLT adopters, as well as for permitting
agencies approached by project developers and contractors submitting CLT projects for review.

**Concerns about cost**

In spite of the cost savings reportedly associated with building with structural CLT versus concrete or steel systems, (see p. 34) concerns about cost remain a key barrier for those interested in using the material. In a survey of 14 architects, contractors, and developers, 11 respondents identified concerns about cost as the number one barrier to their firm designing or building with CLT (or doing so more). Interviews with professionals in those disciplines consistently revealed similar concerns about cost.

In many cases, the concerns were over potential costs incurred due to likely delays in the permitting process (see p. 71), as well as to a preconception that wood materials would be more costly than steel or concrete analogs. Respondents also wondered about whether insurance costs would be higher for a CLT building compared with concrete and steel buildings. According to Clemans (2017), “A poll of European and Canadian insurance companies showed they had no change in premiums for the different construction materials.”

**Lack of Familiarity and Technical Expertise**

As discussed in the introduction to this section, the building industry has relied on essentially the same building materials and systems for many decades. Professionals interviewed for this report frequently pointed out that the building construction industry has certainly adopted innovations and efficiencies since the introduction of steel and concrete, but the efforts needed to do so have been minor and minimally disruptive when compared with the education, training, reskilling and adaptation required to adopt a new structural system—CLT.
Perhaps unsurprisingly, 8 out 14 survey respondents indicated that architects, developers, and contractors do not know how to (design, build, approach permitting), or are unwilling to incorporate CLT into their projects. Several interviews pointed to a specific manifestation this lack of familiarity with CLT: contractors don’t know how to prepare bids for projects that include CLT. According to one architect:

Buildings are bid as whole systems—contractors price the project for a complete system. If it’s a steel system, there are standard fire proofing estimates. But, if you add CLT to a project, you start comparing apples to oranges, and there’s no good way to do that. If you have a full CLT structure, that would be apples to apples, but we’re not there yet.

This barrier seems especially vexing because CLT projects in California (and most of North America at present) are hybrid structures, in part, said architects and other professional interviewed, because it seems more palatable to introduce the new building material into designs as components. The unfortunate result, said architects and other experts interviewed, is that risk-averse contractors overbid CLT projects, forcing developers to choose other designs that don’t include CLT.

Perceptions About Fire & Seismic Resistance of CLT

Fire and seismic resistance and code compliance are critical for any building material in any region, but in California, they carry even more weight with both builders and consumers. Yet, many people mistakenly believe CLT is more vulnerable to both. (Clemans) While CLT testing has shown strong char resistance, as well as “satisfactory seismic performance,” (Clemans) (see p. 33 for more) these results are not well-known to the building construction industry, or to the general public. Given California’s increased fire risk, the intensity of recent wildfires events, and its historic seismic activity, it will be especially challenging to realize widespread adoption of CLT without a robust, data-driven, visually rich public and industry education campaign reporting results on ongoing fire and seismic testing.
Case Study
Framework: The Tallest of the Tall in North America

According to its website, the Portland, Oregon Framework building, is a “90,000 sf, 12-story, mixed-use project anticipated to be the first timber high-rise in the U.S.”

During its permit application and review process, Framework faced many of the barriers outlined in this report, particularly a lengthy AMMR process. But the vision and tenacity of its lead architect, Thomas Robinson of LEVER Architects, along with the creativity and commitment of key partners and access to supportive funding allowed Framework to push through the barriers; it received its shovel-ready building permit on June 6, 2017 and is expected to break ground in 2018.

Specifically, Framework received:

Permitting Support: While the City of Portland, supported the project, it lacked the capacity to manage the structural permitting process, so the State of Oregon took on structural permitting.

Championship of Key Partners: Kat Taylor, the CEO of Beneficial State Bancorp, Inc., which owns the Framework building site and will have offices in the building, has been a champion for CLT for this building.

Funding Support: Framework was awarded $1.5m from the USDA Tall Wood Building Competition (2015) to offset permitting and testing associated with using CLT for its lateral force resistance system, and $6m from the City of Portland’s “Fast Starts” program for affordable housing development.

Sources:
www.frameworkportland.com
Interview with Thomas Robinson, LEVER Architects
Interview with Timm Locke, Oregon Forest Resources Institute
RECOMMENDATIONS
Recommendations

The recommendations outlined in this section primarily target State of California actors in close collaborative partnership with a broad group of stakeholders; they aim to help remove the specific barriers to CLT supply, manufacture, and adoption outlined in the previous chapter. As discussed throughout the report, the objective is to facilitate a CLT industry that supports and protects forest health, in which the industry is part of an ecological forest management plan—not the other way around. The following criteria guided the recommendations’ design.

Analytical Criteria

Does the intervention:

Create a revenue stream for active ecological forest management that reduces wildfire risk, protects and improves watersheds and habitat, and mitigates greenhouse gas emissions?

Facilitate or create incentives for adoption of mass timber in California building design and construction?

Maximize end-use carbon sequestration of low-value timber in buildings?

Help ensure a reliable supply chain for mass timber manufacturers in California?

Create or support infrastructure and industry that complements a new mass timber industry (e.g. transportation, sawmills, kilns workforce development/training)?

Help remove finance or permitting barriers for potential CLT manufacturers?

Have the potential to be a model for other jurisdictions?

Lead to co-benefits, such as good new jobs in rural or urban areas; increased pace/reduced cost of new housing development?
Recommendation #1

Governor Lead the Way—Executive Order

Governor Jerry Brown’s leadership on the California beetle-kill tree die-off helped shine a spotlight on forest health in California, the hazards associated with over-stocked forests, and, to some extent, the potential for low-value timber utilization to create a revenue stream that supports active forest management. As outlined in the Opportunities Analysis section on page 42 of this report, the Governor has also allocated nearly $400 million dollars in funds to support management activities that support forest resilience and mitigate wildfire hazards associated with overstocked forests. To build on this momentum, this report recommends Governor Brown, or his successor, follow in the steps of former Oregon Governor John Kitzhaber, (see Case Study, p. 53) and issue an executive order to help jumpstart a CLT industry that drives ecological forest management on federal and state-managed forests in California. Such an executive order should, at a minimum:

Create the Joint Forest Health & Sustainable Wood Products Institute

One of the key recommendations of the SB859 Wood Products Working Group was to create a “Joint Institute for Forest Products Innovation Institute” (see Appendix 5) in order to research and test products, engage in market development, and other activities. According to people interviewed for this report, the steering committee working (out of the Governor’s Office of Planning and Research) to implement the recommendations was, as of May 2018, beginning to explore the structure of such an institute.

This report recommends the Governor:

1. Formally establish the Institute as a ten-year (with renewal review in year eight) partnership between the Sierra Nevada Conservancy, the Governor’s
Office of Business Development, and the University of California, with the initial priority duties outlined in Recommendation #2, below.

2. Expand the Institutes’ purpose formally to include supply-side planning and monitoring that ensure a wood products industry that includes CLT helps drive active ecological forest management on public lands.

3. Fund the institute as follows:
   a. $500,000 per year for the first two years sourced from Governor’s discretionary funds.
   b. $0.45 per thousand board feet (mbf) from the California timber yield tax for years 8-10. Based on California’s total annual sawtimber harvest of 1.6 billion board feet, this tax would generate $720,000 per year for the Institute [(1.6b/1,000)*0.45)]

Identify Two State-Owned Buildings for Cross-Laminated Timber

Direct the California Department of General Services to identify two planned State buildings that could benefit from being built as hybrid (CLT, steel, concrete), or all-CLT structures, and to prioritize cost-competitive bids that can serve as high-profile demonstration projects for CLT. Direct the California Building Standards Commission to use the permitting process for these buildings to develop streamlined CLT building permitting processes that can serve as models for county and city permitting agencies.

Direct California Building Standards Commission to Design a “Wood First” Incentive for State-Permitted Buildings

The design should focus on speeding up the permitting process for cost-competitive CLT projects by placing them in their own queue—like a grocery store express lane—so they don’t have to compete with other projects for permitting. The goal of the priority queuing is to create an incentive for early adoption for CLT. The incentive could sunset after, for example, ten years.
Direct the Contracts & Procurement Department to Conduct a CLT Opportunities Analysis

This action can help catalyze both CLT manufacture and adoption in California. By giving the direction in a publicized executive order, the Governor can send a strong signal to potential manufacturers that the State of California is preparing to become a customer. And, conducting the analysis will ensure the State is ready to use California-harvested and manufactured CLT as soon as it’s available.

Offer a $1m One-Time Cash Prize for First City/County to Permit a Tall CLT Building

The first California jurisdiction to permit an all CLT building of 8 stories or higher by 2021 would receive the one-million-dollar award, which could be sourced from the Greenhouse Gas Reduction Fund (or another appropriate fund identified by the Governor’s Office) and could be used by the winning city or county to advance local climate resilience or greenhouse gas emissions reduction goals that benefit vulnerable communities. The prize will create an incentive for jurisdictions to develop permitting strategies for CLT buildings, which will prepare them to evaluate tall CLT projects as developers begin to submit more of them.

Recommendation #2

Joint Forest Health & Sustainable Wood Products Institute

Whether or not the Governor issues an Executive Order, as recommended above, to establish the Joint Forest Health & Sustainable Wood Products Institute (the “Institute”), the steering committee working to implement the SB859 working group recommendations should continue to develop the Joint Wood Products Innovation Institute, updating its name as recommended, and expand the Institute’s purpose in order to explicitly marry the goal of wood product development with the need to actively and ecologically manage public forest lands in California. In addition to...
supporting the general duties outlined for the Joint Wood Products Innovation Institute in the SB859 recommendations, (see Appendix 6) this report recommends the following three specific actions as the Institute’s initial priorities:

**Appoint a “New Master Standards for Active Ecological Forest Management Task Force”**

The purpose of the task force would be to create a set of master standards for active forest management on public lands in California that has the buy-in and approval of key stakeholders. In addition, the task force would draft a framework to streamline permitting for forest management projects that comply with these standards. The primary goal of these master standards would be to ensure forest management projects adhere to high ecological standards, and, in turn, to significantly increase public license for forest management work in California, and to reduce the number of projects held up in litigation. The standards could also be utilized as a tool by which to educate urban residents about the differences in implications of unsustainable forest management practices vs. ecologically sustainable practices vs. little-to-no management.

The task force should be coordinated and convened by an organization or agency that has the respect of a broad range of stakeholders, such as the California Association of Resource Conservation Districts.

Task force membership should comprise representatives of key state and federal agencies (U.S. Forest Service, CalFire, California Natural Resources Agency, Sierra Nevada Conservancy), non-profit organizations (specifically including, but not necessarily limited to: Sierra Forest Legacy, Center for Biological Diversity, The Nature Conservancy, National Forest Foundation, Sustainable Conservation, Sierra Institute for Community and Environment, RCRC), tribes, special districts and

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11 Sustainable Conservation’s experience developing the *Partners in Restoration* framework (Sustainable Conservation) for collaborative watershed management of private lands could help inform the work of this Task Force.
partnerships (Sierra Resource Conservation District, e.g., Yosemite Stanislaus Solutions Collaborative), academia (University of California Agriculture & Natural Resources), and logging companies.

In light of the urgent need to increase the pace and scale of active, ecological forest management in California, the work of the Task Force should be time-constrained to a year or less. And, given the diversity in opinions and expertise present among the proposed stakeholders (or stakeholder types), securing the services of a professional, skilled, and neutral facilitator for this work is advisable.

More analysis is required to determine the most effective way to implement the New Master Standards for Active Ecological Forest Management, including whether and how they might serve as a proxy for Forest Stewardship Council or Sustainable Forestry Initiative certification to enable wood materials harvested from U.S. Forest Service land in California to qualify for LEED points. (See A Note About LEED and Other Certifications, p. 52)

**Research Beetle-Kill Pine Decay Rates in California**

As discussed in “Lack of Research on Beetle-Kill Pine Decay Rate/Viability for CLT in California,” (p. 65) and in in more detail in Appendix 3, it remains unclear a) how quickly beetle-kill pine decays in Sierra Nevada forests, and b) what level of decay can be present in wood still viable for use in CLT. This report recommends the Institute, led by the University of California, build on existing research (Battles, et al., e.g.) into decay rates, and prototype and test CLT using beetle-kill pine with varied levels of decay (compliant with visual lumber grades 2 and 3. (see p. 69) The results of this research and testing could and should help inform and prioritize management projects to sustainably harvest beetle-kill pine and provide insights into this link of the supply chain for potential CLT manufacturers.
Take the Lead on Fire and Seismic Testing for CLT

As discussed on page 73, and in the SB 859 recommendations, (SB 859 Wood Products Working Group) concerns about the fire and seismic performance of CLT are a barrier to its adoption. With the University of California as a convener, the Institute would be poised to take the lead in addressing this barrier by:

1. Identifying existing reliable test results and communicating them to the California building industry and the public
2. Identifying and prioritizing gaps in CLT fire and seismic performance research
3. Designing and implementing a California research and testing strategy to fill the identified gaps
4. Communicating the results of those tests to the building industry and the public

Solicit Letters-of-Interest from Future CLT Adopters

As part of its efforts to “Accelerate Mass Timber Construction” (SB 859 Wood Products Working Group) in California, the Institute could solicit letters-of-interest from builders and developers eager to incorporate California-made CLT into their projects. Sharing this interest with potential early CLT manufacturers will help them understand initial market size and plan accordingly; these letters can also help manufacturers demonstrate market interest to potential funders.

Recommendation #3

Master Stewardship for Sustainable CLT Supply

Master Stewardship Agreements (MSAs) with the U.S. Forest Service allow entities (non-profit organizations, collaboratives, Joint Powers Authorities, etc.) and jurisdictions (counties, cities, special districts) to manage “large areas [of federal forest land], typically at the regional...or forest level.” MSAs have potential to
significantly increase the pace and scale of ecological forest management work on U.S. Forest Service lands by shifting the burden of project planning and management away from USFS onto partners with more capacity and access to diverse funding streams. Master Stewards are also able to enter into and manage Supplemental Project Agreements (SPAs) for specific project work, which further increases capacity. Finally, when a project generates revenue in excess of the project costs, those “receipts” are “retained,” meaning they are reinvested in the forest for additional management work—this is in contrast to receipts generated in traditional timber sales, which must be deposited with the U.S. Treasury. (National Forest Foundation) (See Appendix 4 for more information about MSAs and other types of forest management mechanisms.) So, although some forest managers are resistant to MSAs for “turf” type reasons (see p. 59), others prefer MSAs for the reasons outlined above.

Importantly, the March 2018 Federal Omnibus Bill included the “Fire Funding Fix,” (see p. 45) which, among other things, increased the allowable length of Master Stewardship Agreements from ten (10) to twenty (20) years. Numerous people interviewed for this report thought these longer MSAs could offer a way for potential CLT manufacturers to access longer-term supply contracts—or at least memoranda of understanding—that could help make a CLT factory a less risky investment. (see p. 67)

This report recommends federal and state managers of federal forest lands in California encourage and actively support both the formation and effective operation of 20-year Master Stewardship Agreements in order to: 1) maximize their potential to increase the pace and scale of active ecological forest management; 2) optimize distribution (sale) of logs and biomass harvested from these projects based on highest use and best value to both maximize product carbon sequestration and retained receipts for investment back onto forests for further ecological management; and 3) potentially offer high-capital wood products (CLT)
manufacturers longer-term supply reliability. Specifically, the U.S. Forest Service and CalFire could:

Contract with National Forest Foundation (NFF) to Develop and Operate MSA Training & Certification Program

As the “non-profit partner to the U.S. Forest Service,” (Who We Are - National Forest Foundation), NFF has the expertise, capacity, and authorities in place to enter into MSAs, as it recently has on Tahoe National Forest. In addition, NFF already offers periodic Stewardship Agreement trainings. Therefore, NFF is well-equipped to develop and operate an expanded MSA training program that results in participant certification as U.S. Forest Service Master Stewards, which could become a requirement (or a preference) to being awarded an MSA.

Participation in the program would be on an application basis, with selection favoring potential master stewards that: a) demonstrate commitments to ecological forest management and engaging the local community in project planning; and b) and have skills and knowledge on staff to successfully plan and implement ecological forest management projects.

The program would train participants to:

1. Navigate and negotiate a Master Stewardship Agreement with U.S. Forest Service.
2. Scope and plan ecological forest management projects (potentially using as criteria the “New Master Standards for Active Ecological Forest Management” suggested in Recommendation #2 above).
3. Negotiate and manage SPAs.
4. Distribute logs and biomass based on highest use and best value. Interviews for this report revealed that forest managers and policy experts consider long-lived durable uses like “CLT” to be “highest use” for wood 4.75” diameter or greater; highest use for smaller diameter logs could be post and pole; highest
use for smaller logs and branches might be on-site biomass electricity generation. As such, this report recommends Master Stewards prioritize buyers that are vertically integrated or that are part of mixed-product campuses and can accept at one site most wood and biomass from a project and sort it according to highest use. “Best value” should be taken to mean the highest price a party is willing to pay to put the most wood to its highest uses (in other words, it should not be based solely on who is the highest bidder).

More research is required to determine both NFF’s interest in developing and operating such a Master Steward Training & Certification program, along with what it would cost NFF to do so.

**Recommendation #4**

**Cracking Codes for a CLT-Friendly California**

In 2015, the State of Oregon made an important strategic move: by adopting an early version of the 2018 International Building Codes and basing the Alternative Means and Methods Review (AMMR) process for CLT buildings on those codes, Oregon paved the way for early adoption of CLT. Now, both Oregon and Washington are making moves to adopt the 2021 IBC before its publication, in order to utilize the new standards drafted by ICC’s Tall Wood Ad Hoc as the basis for AMMR of buildings that use CLT for lateral force resistance, including tall buildings (8 stories or higher). This report recommends California follow Oregon’s and Washington’s lead in the following ways:

**Actions by the California Building Standards Commission**

1. Adopt the 2021 IBC standards for wood buildings as early as possible—in 2018 or early 2019. Doing so will signal that California is friendly to CLT, and
could encourage adoption of CLT by building developers, as well as attract CLT manufacturers.

a. Based on these standards, create a clear, comprehensive CLT permitting guide for county and city permitting agencies, including an in-district training program.

b. Partner closely with counties and cities working to permit their first CLT buildings. If it is allowable by law (more research is needed to make this determination), the CBSC could, as Oregon’s Building Codes Division has done (see Case Study, p. 63), take on the structural permitting aspect for early projects when local agencies lack the capacity to do so.

**Action by the California Legislature**

In early 2018, the Washington State Legislature overwhelmingly (45/2 in the Senate; 91/6 in the House) passed SB5450. The bill, signed by Governor Jay Inslee on March 9, 2018 adds to the building code a requirement that the “building code council shall adopt rules for the use of mass timber for residential and commercial building construction,” and includes a list of which materials, including CLT, are required to be allowed in Washington. (State of Washington) Although it’s unlikely bipartisan support would be quite as strong for such a measure in California, such a bill would certainly provide an opportunity for some across-the-aisle collaboration among legislators in fire-prone rural and wildland-urban interface districts eager to reduce wildfire hazard and utilize harvested wood in a product that can provide economic development opportunities, and those legislators eager to mitigate the housing crunch in their urban districts. Like the other building code recommendations in this section, passage of such a bill could both encourage adoption and manufacture of CLT in California.
Recommendation #5

Incentives for Action

Evidence presented throughout this report demonstrates that cost is a barrier—whether perceived or proven—to the supply, manufacture, and adoption of cross-laminated timber made from trees harvested as part of active ecological forest management on USFS lands in California. This section recommends tax incentives that could help relieve cost pressure throughout a new CLT market.

For Suppliers

A key theme of this report is that CLT’s potential to utilize “low-value” timber harvested from management projects on federal forest land, is zero—even in the face of demand for CLT—if it doesn’t pencil out for sawmills to process those logs into dimensional lumber. As revealed in the model in “Analysis of Feasibility of Adding A Mill Shift to Process 4.75-6” diameter trees for CLT” (p. 38) adding a second shift to run small-diameter trees might not make sense for mills. The model on page 38 (which is sensitive to variation of log costs, dimensional lumber prices, and the assumptions made about operations costs) found that a mill operating one shift at a profit of $2,422,340, would experience a loss of $1,032,118 on a second shift processing 1x4s from small-diameter logs. To address the gap, the State could institute a per-thousand-board-feet (mbf) credit to mills processing into dimensional lumber logs between 4.75-6” from management projects on public forests in California. In the case of the model, the rebate would apply to 33,750mbf (which is equal to the materials input of the second shift). In order to approximate $3,454,458, the modeled difference in profit margin between the mills shift 1 and shift 2, the rebate would need to be about $100/mbf. However, as discussed on page 38, the difference in profit between the two shift scenarios is likely to be (potentially substantially) less due to the fact that the model’s treatment of operating costs does not reflect likely efficiencies associated with fixed operating
costs across the second shift. Therefore, more research is necessary to understand the appropriate tax incidence.

In addition, the Governor’s Office of Business Development (GoBiz) could counsel mills adding equipment retrofits or dry kilns in order to increase their capacity to process small-diameter timber, on accelerated depreciation strategies for the new equipment.

For Manufacturers
The state is looking into how existing programs like revolving loan funds, and grants might help would-be manufacturers get off the ground, (SB 859 Wood Products Working Group). In addition to helping potential CLT manufacturers access such supports, GoBiz could help connect them to counseling on accelerated depreciation, which could help offset substantial equipment costs faced by new manufacturers.

For Adopters
Once the infrastructure (trained contractors, permitting processes) is in place and builders and developers implementing CLT lateral force resisting systems, the building industry in California can expect to see the project cost of such a building come in as much as 15% lower than its concrete and steel counterpart. (Risen) But, for early adopters and smaller projects, CLT materials might be just cost-competitive with concrete, steel, or timber framing, which offers no incentive to incorporate the new material. A sunsetting tax rebate per-thousand-board-feet of CLT used in a building could help offset potential cost burdens faced by early adopters or those using it in smaller buildings. More research is required to understand the appropriate tax incidence for such an intervention.
CONCLUSION
Conclusion

California is experiencing a watershed moment: The historic drought ushered in a bark beetle infestation that decimated more than 129-million trees in California forests mostly in the Sierra Nevada. Headlines about this disaster preceded the unprecedented destructiveness of 2017 California wildfire season that further exacerbated an already severe housing shortage in the state. The housing crunch coincides with an increase in building materials as well as a construction labor shortage that are together making it more expensive and slower to build new housing. The combination of these crises and challenges opens a unique policy window with the potential to educate Californians about the need to restore over-dense public forests to health, and in turn establish the political will to create a sustainable timber products industry, anchored by cross-laminated timber, that funds ecological forest management, including the removal of smaller-diameter trees and beetle-kill pine.

But, as the evidence in this report makes clear, market forces alone will not bring CLT to California; neither will they ensure a potential CLT industry protects and improves forest health rather than depletes it. To realize this vision, the State of California must take the lead, providing incentives that support supply, manufacture, and adoption of ecologically-sound CLT, and facilitate robust collaboration among the U.S. Forest Service, and a broad range of public, non-profit, private, and community stakeholders to help remove the barriers outlined in this report, as well as in other literature cited herein.

The foregoing analysis and recommendations identify areas for priority action to help launch California-based manufacture and adoption of cross-laminated timber that can play a critical role in restoring and sustaining forest health, reducing wildfire risk, and sequestering carbon in the built environment for decades to come.
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Interviews

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APPENDICES
Appendix 1

Data sources for “Economic Feasibility of Adding Second Small Diameter Shift to Single-Shift Normal-Mix Mill” p. 38

Raw Log Board Feet (BF) /Acre for Six Tahoe National Forest Projects 2010-2016
(BF Given in Log Scale & Lumber Tally)*

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<th>Acres in Project</th>
<th>Board Feet Project (Log Scale)</th>
<th>Board Feet/Acre (Log Scale)</th>
<th>Board Feet Project (Lumber Tally)</th>
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Source: US Forest Service Region 5
*Scribner log scale is a model used on forest projects to estimate expected board feet. Consensus holds that it significantly underestimates actual board foot yield at the mill (the lumber tally) by as much as 50%. This figure is controversial, so these calculations find lumber tally by: Log Scale * 1.30.

Raw Log BF Cost Scenarios Based on BF/Acre and Treatment Cost/Acre for Six Tahoe National Forest Projects 2010-2016 (Log Scale*)

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Sources: BF/Acre from US Forest Service Region 5; Treatment/Acre Figures based on range verified in multiple expert interviews
Average Board Foot/Thousand Board Foot (Log Scale*) Cost by Treatment Cost/Acre Across Six Tahoe National Forest Projects 2010-2016

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Sources: BF/Acre from US Forest Service Region 5; Treatment/Acre Figures based on range verified in multiple expert interviews.

Average Prices of Milled, Kilned, and Delivered Ponderosa Pine in California (Based on Lumber Tally*)

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<td>$458.00</td>
<td>$580.00</td>
<td>$585.00</td>
<td>$450.00</td>
<td>$500.00</td>
</tr>
</tbody>
</table>

Source: Random Lengths (Industry Publication), April 2018

Comparison of Average Costs of Treatment and Prices of Milled, Kilned, and Delivered Ponderosa Pine in California

<table>
<thead>
<tr>
<th>Per</th>
<th>Treatment Cost (Based on Log Scale)</th>
<th>Ponderosa Pine Prices Milled, Kilned, Delivered (Based on Lumber Tally)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>Board Foot</td>
<td>$0.45</td>
<td>$0.36</td>
</tr>
<tr>
<td>1000 BF</td>
<td>$451.12</td>
<td>$362.56</td>
</tr>
</tbody>
</table>

Sources: BF/Acre from US Forest Service Region 5; Treatment/Acre Figures based on range verified in multiple expert interviews; and Random Lengths (Industry Publication), April 2018.
Appendix 2

Proposed Legislation Favorable to CLT

State of California

**AB 2551**, the Forest and Wildland Health Improvement and Fire Prevention Program would, among other things, create a revenue stream for forest management by requiring the State to allocate 18% of the funds deposited annually into the its Greenhouse Gas Emissions Fund (GGRF) to the California Department of Forestry and Fire Protection, “for projects that improve or restore forest and wildland health and fire resiliency and activities implemented pursuant to the program that reduce greenhouse gas emissions in the state caused by uncontrolled forest fires.” (Wood)

For context, the 2017-2018 California Spending Plan assumed GGRF deposits would be $1.8b, (Legislative Analysts Office) 18% of which would be $324m for management activities on state, private, and federal forestlands activities in California.

**AB 2672**, Greenhouse Gas Reduction Fund: forestry and fire prevention, would also allocate GGRF funds ($524,805,000 annually), starting in fiscal year 2019-2020, to an array of forest management and fire protection activities, including $5m to California Conservation Corps, and $75m to “memorandums of understanding regarding federal lands for vegetation management that will reduce greenhouse gas emissions and maximize” a variety of forest health, emissions reduction, and fire mitigation goals. (Patterson)

More research is required to understand whether such funding could be used to support training and support for agencies or organizations that wish to operate Master Stewardship Agreements (see Recommendation #3).

**AB 2518** on “Innovative forest products and mass timber,” would require the California Department of Forestry and Fire Protection, in collaboration with the state
Board of Forestry and Fire Protection, to “explore markets...for milling, development, and expansion of innovative forest products and mass timber...that are consistent with the state’s climate objectives on forest lands.” The requires the state to help facilitate apprenticeship and programs to support the manufacture of such products. (Aguiar-Curry, *Innovative Forest Products and Mass Timber.*)

**AB 2966** on Disaster Relief aims to increase to 90% (from 75%) the share the State may contribute to local agencies disaster projects related to the removal of dead and dying trees. (Aguiar-Curry, *Disaster Relief.*) The change could increase the pace and scale at which such trees become available for manufacture.

**AB 2126** would establish (by July 1, 2019) a California Forestry Corps at the Delta and Inland Empire Centers of California Conservation Corps to conduct forest management projects to restore and maintain forest health and to reduce wildfire risk. The Forestry Corps program would support members in obtaining forestry certificates and degrees in order to develop a trained workforce prepared to do work that includes felling trees. (Eggman) Launching these two flagship Corps could offer a replicable model to increase forest management capacity in other regions of the state.

**Federal**

**S. 538**, the Mass Timber Innovation Act of 2017, directs the U.S. Forest Service to “conduct performance-driven research and development, education, and technical assistance for the purpose of facilitating the use of innovative wood products in wood building construction in the United States.” These activities could include important research into CLT performance (fire, seismic, acoustic, including in tall buildings), as well as into Life Cycle Analysis to support a standardized method of carbon accounting for wood products from harvest to disposal. (Stabenow) This report identifies this such research as a key to removing barriers to CLT adoption. (See “Barriers to Adoption” section p. 70)
Appendix 3

Memorandum re:
Review and quantification of current Sierra Nevada carbon stocks, decay rates, and sequestration potential of cross-laminated timber (CLT), utilizing beetle-kill pine and small-diameter, low-value timber

By Franklin Dean Keck
Bachelor of Science,
University of California at Berkeley
May 2018
Memorandum

Date: May 6, 2018

To: Sandra Lupien

From: Franklin Dean Keck
BS Molecular Environmental Biology, University of California at Berkeley, 2018

Re: Review and quantification of current Sierra Nevada carbon stocks, decay rates, and sequestration potential of cross-laminated timber (CLT), utilizing beetle-kill pine and small-diameter, low-value timber

Executive Summary

Over a century of fire suppression in California has left Sierra Nevada forests overstocked. California forests are historically fire-adapted, meaning they relied on routine, low-severity fires to clear the understory of dense brush and trees characteristic of modern forests. With certain areas reaching densities eight times that of historical tree densities, competition for resources leaves millions of trees starved for nutrients and water. Drought conditions in crowded forests are ideal for outbreaks of bark beetles, which together have led to severe die-offs of pine trees across the Sierra Nevada (Christensen et al., 2017; Battles et al., 2014; Draft Forest Carbon Plan, 2017; Sierra Nevada Conservancy). Large volumes of biomass increase the risk of high-intensity wildfires.

Federal and State managers of California forests have significant interest in managing forests to remove from the Sierra Nevada large quantities of beetle-kill pine and smaller-diameter trees that can act as wildfire fuel, and use this biomass to produce durable goods, such as cross laminated timber (CLT).

This memorandum acts to synthesize the current understandings of carbon stocks in the Sierra Nevada and their flux over various time scales. In doing so, it applies carbon dynamics to analyze ecosystem carbon loss, and sequestration potential of employing active ecological forest management practices to restore and sustain Sierra Nevada forest health, minimize the incidence of high-intensity fire, and utilize wood from forest management products to manufacture CLT. Understanding the decay rates of beetle-kill trees is important for CLT product development and supply planning, and therefore is also addressed in this memorandum.

In summary, the memorandum seeks to provide basic understandings of the potential for CLT production using trees harvested to improve ecosystem health and reduce wildfire hazard through ecological forest management.
Introduction

California’s Sierra Nevada forests are overstocked with small-diameter trees at unprecedented levels—by as much as eight times historic tree densities recorded in the 1800s (Sierra Nevada Conservancy). High densities of trees are often misconstrued as indicative of healthy forests, however, overstocked forests create fierce competition between individuals that becomes particularly pronounced in times of resource scarcity. For example, the recent extreme drought left crowded, thirsty trees susceptible to a bark beetle infestation that has killed nearly 130 million trees in California forests (Draft Forest Carbon Plan, 2017). Left in place, these trees emit large volumes of carbon dioxide and other greenhouse gases (GHG) as they decay (Battles et al., 2014); they also act as fuel that can intensify wildfires (Stephens et al., 2018). Unchecked, these phenomena will contribute to global climate change and threaten developed areas of California (Draft Forest Carbon Plan, 2017).

Efforts to mitigate these hazards by increasing the pace and scale of active forest management, including ecological thinning, on public forests are hampered by a lack of available public funds. A number of state, federal, and local entities are investigating markets for smaller-diameter timber and beetle-kill trees that can help provide a revenue stream for this work. Several reports identify cross-laminated timber (CLT), an engineered structural wood product, as especially promising, not only because it is a value-added product, but because it can sequester carbon in the built environment (Draft Forest Carbon Plan, 2017; Jones et al., 2016; Guo et al., 2017; Oregon BEST, 2017; Czinger, 2018). Keeping carbon out of the atmosphere in the form of greenhouse gases, and slowing the progression of global climate change is a major driver for expanding these markets.

Research into CLT’s carbon sequestration potential is ongoing, as is research into carbon stocks and flux in the Sierra Nevada. Similarly, research continues to seek to understand decay rates of beetle-kill pine in California forests; this information is important to understanding how much of this dead wood could potentially be utilized in CLT.

This memorandum acts to synthesize the current understandings of carbon stocks in the Sierra Nevada and their flux over various time scales. In doing so, it applies these carbon dynamics to analyze ecosystem carbon loss, and sequestration potential of employing active ecological forest management practices to restore and sustain Sierra Nevada forest health, minimizing the incidence of high-intensity fire, and utilizing wood from forest management products to manufacture CLT. Accordingly, what follows is a statement of current carbon stocks in the Sierra Nevada, potential positive impacts of enacting ecological forest management on a larger scale in California, opportunities to sequester carbon in CLT, and a discussion of decay rates in California mixed conifer forests.

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1 CLT confers considerable carbon footprint advantages when the growth of timber and manufacturing of CLT panels are considered as a life-cycle. Some estimates show that carbon footprints of high-rise timber buildings could be 60-75% less than that of a concrete high-rise. While evidence shows more than 50% reduction in carbon footprints for CLT structures when compared to concrete or steel (Oregon BEST, et al., 2017).
Carbon Stocks and CLT Potential

Between 2010 and 2017 alone, drought and bark beetles killed more than 129 million trees in California, the majority of which are in the Sierra Nevada (Draft Forest Carbon Plan 2017). This section surveys multiple reports in order to encapsulate variation in methodology used to quantify carbon stocks in the Sierra Nevada.

Tubbesing, et al. (2018) report a massive increase in standing, dead, “bone-dry” mass in the Sierra Nevada since 2014, as a result of tree die-offs (Figure 1). Under active management scenarios, this area of land could yield significant amounts of usable timber for the production of CLT in the coming years. For example, Tahoe National Forest in Placer county, has seen significantly less die-off compared to other Sierra Nevada forests. Nevertheless, 500,000 recently dead trees in Tahoe National Forest hold 150,000 metric tons of carbon, equivalent to 550,000 tons of carbon dioxide equivalents (Draft Forest Carbon Plan 2017). If harvested and processed into CLT, calculations estimate the capacity to produce as much as 180,000 tons of usable lumber for building construction (Czinger 2018)\(^2\). According to data presented by Guo (2017), this alone is enough CLT to construct nearly 450 four-story buildings in California.\(^3\)

*Calculations:*

\[
150,000 \text{ metric tons carbon} \times 2 \quad \text{carbon to tree biomass ratio} \quad \times (3.67/2) \quad \text{metric tons CO}_2 \text{ to metric tons of tree biomass} = 550,000 \text{ metric tons CO}_2
\]

– Ecotrust (2016)

\[
150,000 \text{ metric tons carbon} \times 2 \quad \text{carbon to tree biomass ratio} \quad \times 0.6 \quad \text{yield of standard CLT processing} = 180,000 \text{ metric tons CLT}
\]

– Ecotrust (2016); Czinger (2018)

\[
180,000 \text{ metric tons CLT} / 417.5 \text{ metric tons CLT per 4-story building} = 431 \text{ 4-story buildings}
\]

– Guo et al. (2017)
Small-diameter, low-value trees in the Sierra Nevada also provide greater opportunity. Under a century-long fire suppression regime across the United States, massive amounts of small trees have accumulated in forests across the West. Some areas have seen an increase from 50-80 trees per acre in the 1800s to 300-400 trees per acre (Sierra Nevada Conservancy). Presence of small-diameter, low-value timber in a forest is inherently variable, and therefore difficult to accurately quantify. Recently, however, in a study exploring fuel loads of the fire-excluded Sierra Nevada, Lydersen, et al. (2015) report biomass of varying size classifications. Trees larger than 7.6 cm (3 in) in diameter were found to total 8.6 metric tons of biomass, per acre, on average (Lydersen et al. 2015). Theoretically, based on calculations described above, the average acre of harvested small-diameter trees could produce 5 metric tons of CLT, and act to sequester roughly 9 metric tons of carbon dioxide (Czinger/USNR, Ecotrust). It is necessary to note that this size classification includes trees less than half the diameter suitable for CLT production (≥ 5 in), but these values are reported to communicate the vast quantities of woody biomass existing in California’s forests (suitable biomass is assumed to be less on an average per-acre basis).

Thinning Sierra forests of beetle-kill pine and small-diameter trees is an important first step in actively managing forests on an ongoing basis to minimize fire fuel loads and encourage restoration of healthy ecosystems. Looking forward to a managed Sierra Nevada, Stewart and Sharma (2015) have created a carbon calculator to track climate benefits of managed forests for private land-owners. These calculators are comprehensive, with specification of forest type, evenness of tree stand, and outputs covering centuries of management.

For this report, a sample calculation was run for an uneven (composed of trees of varying ages) mixed conifer forest, characteristic of Tahoe National Forest. Initial outputs summarize benefits over 1.5 management cycles (after 120 years), characterized by thinning of a ~40 year-old forest, a partial harvest 40 years later, followed by routine harvesting every 20 years. Measured in megagrams (1 Mg = 1 metric ton) of carbon, one acre of forest managed in this way could sequester nearly 3,000 megagrams, or tons, of carbon at a rate of 31 tons per year, per acre (Carbon Calculator data output). This stock of standing carbon is equivalent to over 55 metric tons of CO2 being sequestered from the atmosphere for each acre of managed forest. If this management were scaled to an area the size of Tahoe National Forest (~870,000 acres), 48 million megagrams of carbon could be sequestered each year. According to the EPA’s Greenhouse Gases Equivalency Calculator, the amount of carbon that could be sequestered under this management scheme is equivalent to the GHG emissions by 10.2 million vehicles each year (epa.gov, 2017). In contrast, leaving forests unmanaged will reduce amounts of carbon sequestered by 25% after 120 years, and up to 44% reduction after 240 years (calculated from Table 1).

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4 Nine metric tons of carbon dioxide equivalents sequestered per acre of forest is equivalent to the emissions of nearly 10,000 pounds of coal burned, per acre of forest (epa.gov, 2017).

5 Mills in California typically mill logs that are >6” diameter at the short end. As such, trees <5” are typically left in forests or pile burned as part of forest management. CLT manufacture could help create a revenue stream to pay these trees’ way out of the forest, and offer mills a price that makes it worthwhile to mill them.
This model for carbon capture looks far into the future, making it difficult to understand the significance of reported values, but management perspectives need to have outlooks which extend well beyond one’s lifetime in order to successfully manage our forests, and our planet.

**Table 1:** Carbon stock scenarios under unmanaged (let grow) and management regimes for uneven mixed conifer forests, representative of areas within Tahoe National Forest. Input selections for calculations set to 60% usage ability (per estimates of CLT production efficiency), remainder (40%) allocated to bioenergy production, 100% removal of waste residual production material exported form site (no decomposition), and an estimated 20% energy production with sawmill products (with the remaining 80% going into products).

<table>
<thead>
<tr>
<th>Carbon Stock Scenario – let grow forest</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvest cycles – management years</td>
<td>Mg C/acre (Total)</td>
<td>Mg C/acre/year</td>
</tr>
<tr>
<td>1.5 cycles – 120 years</td>
<td>2,740</td>
<td>23</td>
</tr>
<tr>
<td>2 cycles – 160 years</td>
<td>4,990</td>
<td>31</td>
</tr>
<tr>
<td>3 cycles 240 years</td>
<td>10,100</td>
<td>42</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Carbon Stock Scenario – managed forest + all products</th>
<th>Managed : let grow ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvest cycles – management years</td>
<td>Mg C/acre</td>
</tr>
<tr>
<td>1.5 cycles – 120 years</td>
<td>3,675</td>
</tr>
<tr>
<td>2 cycles – 160 years</td>
<td>7,360</td>
</tr>
<tr>
<td>3 cycles 240 years</td>
<td>18,000</td>
</tr>
</tbody>
</table>

*Data outputs by Stewart and Sharma (2015) Carbon calculator tracks the benefits of managed private forests

Decay and Loss of Above-Ground Carbon from Beetle-Killed Trees

Understanding rate of decay of California beetle-kill pine is crucial to the determining its viability as a feedstock for CLT; this area of forestry research is only beginning to emerge. Harmon & Cromack report decay rates of white fir, and other species in the Sierra, suggesting ‘rapid’ rates of decay in fallen boles (Figure 2). This 1987 data, however, is not thorough or current enough to provide clear timelines for mixed conifer forests in the present decade. Rapid climate change has shifted temperature and moisture levels across California enough to warrant in-depth decay rate studies under more modern climatic conditions. In addition, Harmon & Cromack’s results concern rates of decay once trees have fallen, while, many of the recent beetle-kill pines are still standing. Data reported by Battles (2018) suggests a multi-year lag time between death of trees and their falling (Figure 3). These data, when considered together, suggest there is a window of time for harvesting dead trees, though the length of that window has yet to be determined. Furthermore, Harmon and Cromack (1987) report an average rate of decay by colonizing decomposers (such as various species of fungi) penetrating fallen white fir boles at ~1 cm/year. This should provide optimism when considering future harvesting of still-standing dead trees for potential use in CLT production. Granted, the lack of replication of these observations, and the time passed since this initial decay study was published call for a great deal of research to be undertaken to understand decay rates in present and future stocks of beetle-kill trees.
**Figures 2 & 3:** (Left) Figure 2 illustrates data from Harmon and Cromack (1987) showing decay rates of fallen white fir trees, measured by tree trunk density over time. (Right) Figure 3 illustrates data from John Battles (2018) concerning rates of falling for various species, measured in years since death.

This notion of massive decay has much broader implications in the context of global climate change. With recent drought and bark beetle outbreaks, facilitated by a century of fire suppression, there is evidence suggesting that once-resilient carbon sinks of the Sierra Nevada forests may soon become net emitters of carbon dioxide into the atmosphere. (Draft Forest Carbon Plan, 2017, Sierra Nevada Conservancy) A recent study by Gonzalez et al. (2015) reported above-ground carbon stock values across the state from 2001 to 2010, and used remote sensing technologies to calculate an estimated loss of 29 teragrams (Tg) (equal to 29 million metric tons) of forested biomass, over this nine-year period in California alone. An ongoing loss of forest-sequestered carbon through forest fire and the mass decay of the millions of known standing dead trees in the Sierra Nevada call for active forest management practices in order to return these systems to resilient carbon sinks (Draft Forest Carbon Plan, 2017). These losses in standing carbon stock are depicted in Figure 4, excluding losses due to urbanization and conversion to agricultural land.

**Conclusions**

A survey of current understandings of forest carbon dynamics, the potential implications of active forest management on those dynamics, and on the carbon sequestration potential of CLT indicates that further research is required. While carbon stocks in the Sierra Nevada are understood well enough to justify ecological forest management further development of remote sensing technology for large-scale monitoring over the course of the coming years is crucial to ensuring effective management practices for ecosystem health. Similarly, continued data collection in the field will facilitate understandings of acute dynamics within a mosaic of forest environments. Primary among these acute dynamics is the rate at which dead trees,

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6 This value accounts solely for those lands that have not transitioned from forested land to other land uses (urban, agricultural, etc.); including them shows an overall loss of above-ground biomass in California of 79 Tg carbon since 2001 (Gonzalez et al. 2015).
standing and fallen, decay in their natural environments. Development of accurate models for specific species within their varied environmental conditions can facilitate coordinated and reliable harvest of biomass for reliable building material and reveal the most effective means of sequestering carbon within the built environment. Information presented in this memorandum should encourage such research, as current understandings of CLT provide reason to pursue the proposed actions of this report. Furthermore, fine-tuning our understanding of the environment is crucial to thriving economies and ecosystems of California.

Figure 4: (Left) Mapping of aboveground carbon biomass in forests and other terrestrial ecosystems in California in 2010. (Right) Mapping of change in aboveground carbon biomass across terrestrial ecosystems between 2001-2010. Gonzalez et al. (2015).
References


Presentations


Tubbesing C. “Mapping dead tree biomass from the recent California mortality event.” 2018.


*All presentations sourced from: http://ucanr.edu/sites/forestry/Tree_Mortality/Tree_Mortality_Data_Collection_Network_ /
Appendix 4

Stewardship & the National Forest Service

By National Forest Foundation
Stewardship & the U.S. Forest Service

What is the Stewardship Authority?
Congress created the stewardship program to give the U.S. Forest Service (USFS) and Bureau of Land Management (BLM) the authority “to perform services to achieve land management goals for the national forests and the public lands that meet local and rural community needs.” The seven land management goals include:

- road and trail maintenance or obliteration to restore or maintain water quality;
- soil productivity, habitat for wildlife and fisheries, or other resource values;
- setting of prescribed fires to improve the composition, structure, condition, and health of stands or to improve wildlife habitat;
- removing vegetation or other activities to promote healthy forest stands, reduce fire hazards, or achieve other land management objectives;
- watershed restoration and maintenance;
- restoration and maintenance of wildlife and fish habitat; and
- control of noxious and exotic weeds and reestablishing native plant species.

When was the Stewardship Authority Developed?

<table>
<thead>
<tr>
<th>Year</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>Congress Granted Pilot Authority</td>
</tr>
<tr>
<td>2003</td>
<td>Congress granted Authority for 10 years</td>
</tr>
<tr>
<td>2013</td>
<td>Authority expired and was extended temporarily</td>
</tr>
<tr>
<td>2014</td>
<td>Permanent Authority granted as part of the Farm Bill</td>
</tr>
</tbody>
</table>

How is the Stewardship Authority Implemented?
The USFS or BLM can award both stewardship contracts and stewardship agreements. This overview describes the process and details within the U.S. Forest Service.

How are Stewardship Contracts Different From Timber Sale Contracts?
First, all stewardship contracts and agreements include both forest product removal and service work items. Stewardship work is also awarded on a “best value” basis, and excess funds remain on the forest as “retained receipts,” whereas timber contracts go to the highest bidder and excess funds are returned to the U.S. Treasury or collected in trust funds.

What do we mean by “Best Value?”
Best value is the basis for evaluating all proposals for stewardship contracts based on price criteria and non-price criteria. Non-price criteria may include, but are not limited to, past performance, work quality, experience, and benefits to the local community. Some criteria are unique to the Forest Service. For example, Forest Service stewardship agreements also take into account mutual benefit/mutual interest.

What do we mean by “Retained Receipts?”
Stewardship contracts and agreements involve trading goods (usually timber) for services (stewardship work). When goods and services are traded, receipts or credits are generated. If a contractor is awarded a stewardship contract and builds two miles of new roads, he will receive credit for the work. The contractor can then be reimbursed for the work by removing timber equal in value to the credit he received and then selling the timber to a mill. Alternatively, if a contractor removes timber from a forest as part of a stewardship contract, he will then be responsible for performing stewardship work equal to the value of the
receipts. If the value of the timber exceeds the value of the service work the remaining funds are kept by the forest as retained receipts which can be used on future stewardship contracts.

**WHAT ARE THE DIFFERENT TYPES OF STEWARDSHIP CONTRACTS AND AGREEMENTS?**

**Integrated Resource Timber Contracts (IRTCs)** are used when the value of goods is greater than the value of services. All service work is identified up front in the form of mandatory and optional work. IRTCs can produce retained receipts.

**Integrated Resource Service Contracts (IRSCs)** are used when the value of goods is less than the value of services, so funds must be added to the contract in the form of appropriated dollars or retained receipts. Funding can be added to the contract but receipts cannot be retained.

**Stewardship Service Contracts** do not involve a goods-for-services trade (they are used to spend retained receipts). Usually Service Contracts are awarded for a single task or category of work, and are designed for small and/or highly specialized projects that do not involve timber removal.

**Stewardship Agreements** provide for the mutual interest and benefit of the land management agency and a partner (which can be a state or local government, tribe, and/or non-profit). Agreements can be terminated by either party, require ongoing involvement from the agency, and require cost-sharing from the partner. Therefore, in addition the best value criteria described above, considerations for agreements include the extent of mutual interest and benefit and the advantages and effectiveness of mutual participation. Stewardship agreements do not require a trade of goods for services.

Agreements are very flexible, and additional work can be added after the agreement is finalized.

Partners are required to provide a 20% project match (cash, non-cash, or in-kind contribution) based on 20% of the total project value less the value of timber. The funding levels of the agency and partner should reflect the benefit each receives.

**Master Stewardship Agreements (MSAs) with Supplemental Project Agreements (SPAs)** are used to designate large areas, typically at the regional level, where a series of projects may take place across a landscape, and may be entered into at the region or forest level. SPAs tier from a MSA and outline the details of a specific project. SPAs cannot serve as stand-alone agreements. MSAs with SPAs are useful mechanisms for partners who intend to have multiple stewardship agreements with the agency.
Appendix 5

Overview of CLT Demand in California

Based on interviews conducted for this report.

The following CLT building projects are reportedly in various stages of completion in Northern California, based on interviews and correspondence conducted for this report. The list is not exhaustive.

**Complete**
- Boiler building in Quincy. California’s first all-CLT building
- Condo development in Sacramento used CLT mezzanines
- Educational facility with a CLT roof in a City of Palo Alto park
- Building at Stanford University with CLT roof
- Single family residence in Walnut Creek incorporates CLT
- Private high school in Santa Rosa with CLT in roof system
- Campus of child care buildings with SLT roofs in South San Francisco

**Under construction**
- Building at Stanford University with CLT roof and walls.
- Two-story library in Brentwood with CLT roof and floors, and some CLT walls

**Permitted**
- Building at a junior college in Hayward with CLT in its roof

**In permitting**
- Church in San Jose with CLT roof

**In design**
- UC-Davis community center with a CLT roof

The following Architects with California offices that have, reportedly, based on interviews and correspondence conducted for this report, utilized mass timber design. The list is not to be interpreted as exhaustive.
- Applied Architecture
- BAR Architects
- Fog Studio
- Gensler
- HED Design
- Perkins+Will
The following contractors and developers with California offices have reportedly, based on interview and correspondence conducted for this report, either had experience with CLT or are friendly towards mass timber construction. The list is not to be interpreted as exhaustive.
Arbor Building Group
DPR
Lend Lease Construction
Fisher
Hathaway Dinwiddie
Nibbi Brothers
Richard Hancock, Inc
SKS
Turner Construction
Vance Brown
Webcor Builders
Whiting-Turner
XL Construction

The following engineers with California offices that have reportedly, based on interviews and correspondence conducted for this report, utilized mass timber design. The list is not to be interpreted as exhaustive.
ARUP
Buehler & Buehler
DCI
Holmes Structures
KPFF
KPW
Rutherford & Chekene
Walter P Moore
Appendix 6

Recommendations to Expand Wood Products Markets in California
(p. 4-11)

By the SB 859 Wood Products Working Group
disciplines to accelerate research, development, and adoption, including forestry, wood engineering and nanotechnology, business administration, marketing, architectural design, and forestry workforce development. These efforts would be coordinated through the Steering Committee and assist the Steering Committee in meeting its goals, although, activities need not be limited to those that directly serve the Steering Committee. The interdisciplinary Joint Institute should engage with the Steering Committee and working groups therein to facilitate outreach activities and contribute to human capital development as needed and as resources allow. The Steering Committee will collaborate with California’s higher education institutions and private industry and other partners to pursue the authorities and funding necessary to support creation of the Joint Institute.

Some of these recommendations can be accomplished using existing resources and state authorities. Others will require new investments and legislated authorities. The recommendations in this report should be viewed as one element of a broader set of efforts taking place. The State’s role in market development will by nature be limited. The main actors are entrepreneurs, investors, wood products industry leaders, local governments, community based groups, tribes, local land owners, and the USDA Forest Service. These recommendations reflect actions that the State could engage in to encourage and enable market development in partnership with these key actors.

RECOMMENDATIONS

STRATEGIES AND ACTIONS
The Rural Economic Development Steering Committee, in coordination with the Joint Institute for Wood Products Innovation, would serve to advance the three core strategies – remove barriers to market and create pathways for success, promote innovation, and invest in human capital – through the following set of actions. The work of the Steering Committee will be carried out by cross-sector working groups assigned to each strategy as appropriate, with the following agency and institutional leads:

1. **Remove barriers to market and create pathways for success:**
   
   *Redevelopment and Innovation*– California Environmental Protection Agency (CalEPA) and OPR
   
   *Financing* – Governor’s Office of Business and Economic Development (GOBiz)

2. **Promote innovation:**
   
   *Rural Economic Development Steering Committee and Joint Institute for Wood Products Innovation*

3. **Invest in human capital:**
   
   *Employment Development Department (EDD)*
1. **Remove Barriers to Market and Create Pathways for Success**

A good market environment will appeal more broadly to investors. Facilitating permitting prerequisites, supporting product testing, aligning regulatory requirements, and addressing financing challenges could eliminate some of the real and perceived barriers to investing in and developing wood products manufacturing.

The focus of this strategy would fall into the following two categories:

- **Redevelopment and Innovation:** CalEPA will lead a team focused on navigating site permitting, liability, and other barriers related to the remediation and redevelopment of former mill and other previously developed sites and barriers to the use of engineered mass timber in building construction.

- **Financing:** GOBiz will lead a team focused on creating pathways for success by providing financing and business development assistance targeted to rural businesses, better communicating existing financial assistance programs, and addressing resource gaps as needed.

CalEPA, OPR, and GOBiz will identify appropriate federal, state and local agency, business community, and non-governmental partners for these actions in consultation with the Steering Committee.

**Working Group Actions: Remove Barriers to Redevelopment and Innovation**

1. **Improve Process for Remediation and Redevelopment**

   The Steering Committee will establish an interagency team charged with identifying and, where appropriate, navigating state barriers to redevelopment of former sawmill and rural industrial sites in a manner that protects public health and the environment. The team may engage regional or local permitting agencies where appropriate. The team will assist in navigating liability, financial assurance, and regulatory processes associated with the cleanup and reuse of sites, with an initial focus on community-owned or prospective community-operated sites.

2. **Accelerate Use of Mass Timber Construction**

   Mass timber[7] is a growing category of wood products that has the potential to grow significantly in California and advance the State's climate change and green buildings objectives. Mass timber is more commonly used for construction in Europe and saw a dramatic increase in use as a structural element in the past decade; Canada and Oregon have recently pushed to mainstream its use in North America. As a construction material, mass timber is favored by designers for its strength, affordability, aesthetics, construction efficiency, structural performance, small carbon footprint, and ability to achieve substitute for or work alongside concrete, steel or masonry as a structural element.

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[7] Mass timber is typically characterized by the use of solid wood panels for wood, floor, and roof construction. It refers to products including cross-laminated timber, nail-laminated timber, glue-laminated timber, dowel-laminated timber, structural composite lumber, and wood-concrete composites. For additional information, see Footnote 4.
The 2016 version of the California Building Standards Code,\(^8\) which went into effect in January 2017, defines the allowable wood use in buildings and includes references to Mass Timber systems, such as the decade-old mechanically laminated decking (2304.9.3) and, more recently, cross-laminated timber (2303.1.4). Informing developers and design professionals of these recent code provisions and encouraging low-carbon building may help facilitate the increased use of mass timber, build its acceptance within the building industry, and encourage the development of mass timber manufacturing in California.

The state could facilitate greater use of mass timber in construction through:

a. **Building Code Outreach**
   The State could engage local and county planning offices, developers, and architects on the use of wood and mass timber in buildings by providing a targeted description of current California Building Standards Codes, particularly new elements that went into effect in 2017.

b. **Encouraging Low-Carbon Building Statewide**
   The state could develop and use life cycle assessment of building materials and encourage builders and local and county planning offices to select and incentivize, respectively, those materials which have the lowest lifecycle GHG emissions and support other statewide climate change mitigation policies, as described in the 2017 Scoping Plan Update and the Forest Carbon Plan. Acceptable methods of such a whole building life cycle assessment are codified in the voluntary measures of the 2016 Green Building Standards Code (CALGreen Part 11 of Title 24) Section A5.409.

c. **Encouraging Low-Carbon Building for State Facilities**
   The state could establish guidelines that encourage use of cost-effective building materials with lower lifecycle GHG emissions for new State-owned and/or state-occupied buildings.

**Working Group Actions: Removing Financing Barriers**

1. **Create a Finance Information Clearinghouse**
   The State could create an information clearinghouse on financial resources and incentives through online tools, resource fairs, and workshops that are applicable to wood products industry investors and developers. This information clearinghouse would include information on the range of GOBiz and California Infrastructure and Economic Development Bank (iBank) programs that may apply to the wood products industry, including, but not limited to, the California Competes Tax Credit, the Small Business Loan Guarantee Program, and Industrial Development Bonds.

2. **Identify Resource Gaps**
   The State could identify and seek to address gaps that exist in state and federal financial assistance programs, either through existing programs at GOBiz and iBank or through

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\(^8\) The 2016 Edition of the California Building Standards Code, California Code of Regulations, Title 24 (CBC) was published July 1, 2016 and has been effective statewide since January 1, 2017. It is based on based on the 2015 Edition of the International Building Code.
new financing programs. These may include *grants and subsidies* for product testing, wood products innovations, value-added processing, and the expansion of processing facilities; *tax incentives or deductions* for new wood products businesses or the use of wood in building infrastructure; and/or *loans or loan guarantees* to businesses for small-scale equipment purchases or facility expansions.

2. **Promote Innovation**

Innovation and expansion into new markets will be imperative in order for the California wood products industry to be competitive and sustainable in the long-term. However, expanding into new markets comes with a certain amount of risk. Addressing financial challenges and assuring a fertile environment for innovation could help to address these risks. The long-term success of new wood products innovations could be bolstered by building California’s capacity for research and product development and supporting the academic experts and entrepreneurs already leading wood products innovation within the State. New cross-disciplinary partnerships may be needed to ensure that this research and development is relevant to industry partners’ needs and is ready for market.

The Steering Committee will initiate a working group focused on promoting innovation while developing the resources and authorities to launch the Joint Institute for Wood Products Innovation. Once the Joint Institute is functioning, the Steering Committee will shift to an advisory role for strategies related to promoting innovation and the Joint Institute will assume a leadership role.

**Working Group Actions: Promoting Innovation**

1. **Applied Research and Development**

   The State could support businesses and academic institutions performing early-stage research and development in cutting-edge materials and industries such as cellulosic *nanotechnology*. This work could be coordinated by the Joint Institute and should include industry partners, business associations, local forested communities, and the USDA Forest Service and other federal agencies, at a minimum. The “Waste to Wisdom” Biomass Research and Development Initiative at Humboldt State University, which is investigating the conversion of forest residues into renewable fuel and other bio-based products, is an example of focused research in this space.  

2. **Product Testing**

   The State could incentivize and encourage investment in any necessary seismic, fire, and other material testing within California for mass timber construction, building off of testing underway for specific projects in California and elsewhere. The State could utilize academic institutions and third-party testing, inspection, and certification organizations to perform product testing that accelerates the development, utilization and commercialization of new wood products, including mass timber, biochar, and nanotechnology.  

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9 For more information on the “Waste to Wisdom” initiative, see: [http://wastetowisdom.com/](http://wastetowisdom.com/).

10 For example, QAi Laboratories is a third-party testing organization in California that performed a flame spread test that assured the flame spread and fire resistance of CLT made by D.R. Johnson. For more
be coordinated by the Joint Institute.

3. **Promote California-grown and California-manufactured Wood Products**
   By promoting California wood products in domestic and international markets, the State, with assistance from industry partners, could increase the competitiveness of California’s wood product industry. The State could help conduct outreach and education on California wood products and wood construction.

4. **Strengthen Partnerships Between the Wood Products Industry, Rural Economic Development Organizations, and Academia**
   California’s colleges and universities are hubs of incubation and innovation. Stronger partnerships across industry, rural economic and community development organizations, and academia could harness the resources needed to accelerate market growth. For example, university extension programs could assist businesses with planning, outreach, training, and education, as well as strategic business planning tailored to match supply from nearby forests.

3. **Invest in Human Capital**
   This strategy will aim to develop a well-trained workforce of individuals prepared to enter wood products and forestry-related jobs as those jobs become available. The following recommendations are designed to create a work force pipeline that provides economic development opportunities for residents of forested communities and supplies the human capacity that companies will need to develop and expand wood products operations.

The Employment Development Department (EDD) will lead this work group and will identify additional work group members in consultation with the Steering Committee. The recommendations will be refined and implemented in coordination with impacted communities, educational partners, businesses, and experts in workforce development, among others.

*Working Group Actions: Investing in Human Capital*

1. **Assess Workforce Potential**
   EDD will perform an analysis of the current jobs available to the work force in forestry and wood products sectors.

2. **Expand Accredited Associate Degree and Certificate Programs**
   Based on EDD’s expertise, the state could expand the reach of existing accredited associate’s degree and certificate programs for forestry, forestry technician, and wood products technology at community colleges throughout the state to create a larger pipeline of students entering these fields as the industry develops. There are at least 15 community colleges that offer certificates and associate’s degrees in forestry, engineering and industrial technologies, woodworking and cabinetmaking, woodworking manufacturing technologies, and other related topics (see Appendix C for listing).

3. **Strengthen Career Pathways**
   Stronger connectivity between wood products-related high school, work force training, and

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college programs would help to develop workforce capacity. Career pathways could be strengthened in the following ways:

a. **Create Career Pathway Roadmaps**

   The Human Capital Work Group could create clear pathways that guide students into the field directing them to accessible and appropriate certificate and vocational school programs, providing information and guidance on transferring to bachelor and advanced degree programs such as the accredited forestry schools at Humboldt State, Cal Poly San Luis Obispo, and UC Berkeley. Assuring that graduates are connected to job opportunities available at each level of educational attainment would increase the likelihood that students will enter and remain in the field.¹¹

b. **Increase Partnerships with the California Conservation Corps**

   California Conservation Corps could increase their partnerships with forestry and wood products industries and interested community colleges. This would (1) help Corps members obtain forestry and forest technician degrees and certificates; (2) train individuals to operate equipment in forestry and related industries, and; (3) create pathways from the Corps to degree programs and well-paying jobs.

c. **Invest in Scholarships**

   The State could expand scholarships to improve accessibility to related training and higher education for low-income students. The UC Berkeley Forestry Field Camp¹² in the Sierra is one example of a program that could improve access through scholarships.

d. **Invest in Youth Programs**

   Youth programs help expose young people to the idea of a career in forestry. The State could invest in existing youth programs such as the California Forestry Challenge,¹³ an academic event for high school students in technical forestry and current forestry topics; the Forestry Institute for Teachers,¹⁴ which trains K-12 teachers to teach their students about forest ecology and forest resource management practices; the Sierra Outdoor School Science Program, a hands-on exploration of the Stanislaus National Forest¹⁵ and Project Learning Tree, which provides forest-related instructional materials for children through grade 12.

e. **Foster Apprenticeship Programs**

   The State could expand apprenticeship and on-the-job training programs with industry

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¹² At the UC Berkeley Forestry Field Camp, students spend eight weeks in the Plumas National Forest immersed in topics such as wildland ecology, range and wildlife management, forest resource inventory, forest products and harvesting practices, and many other subjects. The program costs approximately $7,000 for UC Berkeley Undergraduate Students and $8,000 for non-UC Berkeley Students: [https://forestrycamp.berkeley.edu/experience-camp/costs/](https://forestrycamp.berkeley.edu/experience-camp/costs/). Accessed Oct. 10, 2017.


partners, especially for key populations like veterans, recent high school graduates, and recent community college degree earners. Apprenticeships could benefit both industry and communities. Veterans programs have the added benefit of utilizing military training veterans already possess.16

ORGANIZING BODIES
To assure implementation of the recommendations, the Working Group identified the need for a steering committee made up of state and federal agencies, local governments, tribal governments, local community organizations, entrepreneurs, industry leaders and other appropriate partners. The Governor’s Office of Planning and Research will convene the recommended Steering Committee, which would begin implementing recommendations within existing authorities and resources. The Working Group also identified the need for an academic center to promote interdisciplinary research and development and supplement state agency activities.

RURAL ECONOMIC DEVELOPMENT STEERING COMMITTEE
The Governor’s Office of Planning and Research (OPR) will establish the Rural Economic Development Steering Committee to prioritize sustainable rural economic development in alignment with the State’s existing climate goals. The initial focus of the Steering Committee will be to encourage economic development in forest-dependent communities; to advance businesses and jobs that improve forest health and restoration, increase the harvesting and utilization of smaller-diameter trees and other biomass, and make the transportation of wood products more fuel efficient; to align these activities with bioenergy programs and policies; and to complete all other activities the Steering Committee deems necessary to achieve expansion of wood products markets. The California Natural Resources Agency will serve as co-lead for the Steering Committee’s wood products agenda. This Steering Committee will serve as a coordinating body for implementation of many of the recommendations described in this report where the state has existing authority and resources. The Steering Committee will also identify gaps in authorities and resources and coordinate activities to address those gaps. Finally, the Steering Committee will coordinate actions with other actors, such as local governments, tribes, the USDA Forest Service, and others to achieve the goal of expanding the wood products market in California.

Steering Committee Actions: OPR
OPR and CNRA will first establish Working Groups and agency leads for each working group focused on advancing each of the three strategies. The Working Groups will recommend Steering Committee members. Once established, the Working Groups will report to and be coordinated by the Steering Committee. Each Working Group will identify and engage additional participants, as necessary, to advance the recommended actions described in this

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report and other actions to be determined by each Working Group.

Steering Committee members will be selected based on recommendations from the Working Groups and others to achieve a balance among State agencies, federal agencies, local governments, tribes, industry leaders, and others essential partners. The Steering Committee may include representatives from the following agencies and groups:

- Governor’s Office of Planning and Research (OPR)
- California Natural Resources Agency (CNRA)
- Governor’s Office of Business and Economic Development (GOBiz)
- California Employment Development Department (EDD)
- California Environmental Protection Agency (CalEPA)
- Department of General Services (DGS)
- California Department of Housing and Community Development (HCD)
- California Department of Food and Agriculture (CDFA)
- California Department of Forestry and Fire Protection (CAL FIRE)
- Liaison from the Joint Institute for Wood Products Innovation and additional representatives from public and private academic institutions as needed
- Federal agencies with forest management and rural development responsibilities
- Local and Tribal governments and community organizations
- Industry leaders
- Others as determined by the Steering Committee and Working Groups

**JOINT INSTITUTE FOR WOOD PRODUCTS INNOVATION**

The Wood Products Working Group proposes establishment of an interdisciplinary academic Joint Institute for Wood Products Innovation across universities and community colleges in California to assist in meeting the goals of the Rural Economic Development Steering Committee. The Steering Committee would identify appropriate initial partners. Together with the identified partners, the Steering Committee would collaborate to identify funding to support creation of the Joint Institute. This Joint Institute would align academic centers to perform product research, development, and testing; promote business innovation; and connect diverse disciplines to accelerate research, development, and adoption, including forestry, wood engineering and nanotechnology, business administration, marketing, architectural design, and forestry workforce development. Emphasis should be placed on sharing knowledge and skills from diverse disciplines to advance common problems and market challenges. The leading partners should ensure that their efforts align with the “Invest in Human Capital” Working Group to create a pipeline for professional development and ongoing education of students and workers. The Joint Institute should include representation from California accredited forestry schools and related interdisciplinary departments, among others.