BAY AREA COUNCIL
ECONOMIC
INSTITUTE

Harnessing the Private Sector: Opportunities and Challenges for Incentivizing Market-Based Uses of Woody Biomass in the East Bay Hills

June 2024

Acknowledgements

This analysis was authored by Patrick Kallerman, Vice President of Research at the Economic Institute, and Abby Raisz, Research Director at the Economic Institute, together with Lisa Jacobs, Board Member at the Oakland Firesafe Council. The authors would like to thank the following individuals for their contributions to this report in a variety of ways.

Jerry Kent, Assistant General Manager for Operations and Interpretation (Retired), Oakland Firesafe Council (formerly EBRPD)

Chief Khari Helae, Assistant Fire Chief, East Bay Regional Park District

Michael Maguire, Assistant Policy Advisor, Governor's Office of Planning and Research (OPR)

Graham Noyes, Executive Director, Low Carbon Fuels Coalition

Bob Brown, Senior Director, Western States Petroleum Association

Stephen Konig, Director, Government and Public Affairs, Marathon Petroleum Corporation

Brian Hubinger, Senior Public and Government Affairs Representative, Chevron

Nik Weinberg-Lynn, Manager, Renewable Energy Projects, Phillips 66

Michelle Young, Renewables Program Manager, Chevron

Meir Hasbani, Biofuels Program Manager, Chevron

Henry Perea, West Coast Government Affairs Manager, Chevron

Roger Smullen, Wood and Biomass Utilization Project Manager, Earth Foundries, Inc.

Zach Knight, Co-Founder and CEO, Blue Forest

Helena Murray, Wood and Biomass Utilization Project Manager, U.S. Forest Service

Daniel Falk, Owner, Falk Forestry

Jim Spaeth, Bioenergy Technologies Office System Development and Integration Program Manager, U.S. Department of Energy

Valerie Sarisky-Reed, Director, Bioenergy Technologies Office, U.S. Department of Energy

Erin Cooke, Sustainability and Environmental Policy Director, SFO

Susan Wengraf, Councilmember, District 6 (Berkeley Hills), City of Berkeley

David Sprague, Fire Chief, City of Berkeley

Joe Devries, Deputy City Administrator, City of Oakland

Nicholas Luby, Fire Chief, City of Alameda

Dan Kalb, Councilmember, District 1, City of Oakland

John Goia, Supervisor, Contra Costa County

Gayle McLaughlin, Councilmember, City of Richmond

Dave Winnacker, Fire Chief, Moraga-Orinda Fire District

Michael Hunt, Chief of Staff, Oakland Fire Department, City of Oakland

Paul Fadelli, Councilmember, City of El Cerrito

Angel Montoya, Fire Chief, City of Richmond

Maureen Toms, Councilmember, City of Pinole

Christiana Darlington, Project Manager, CLERE, INC (for Fall River Resource Conservation District)

This report was generously supported by the California State Coastal Conservancy.

Contents

Executive Summary and Key Findings

California's wildfire risk is immense. Rapidly advancing climate change has raised average temperatures across the state, stressing ecosystems and increasing fuel loads to unimaginable levels. Eight of ten largest fires in state history have occurred in the last decade alone, with economic losses now regularly exceeding $10 billion per fire season. Communities in the wildland urban interface – an area defined by the close proximity of human development to unoccupied land – now face a nearly never-ending threat to structures, livelihoods, and lives.

The increasing scale and aggressive behavior of recent fires have renewed and increased urgency among Federal, State, and local policymakers, but government and public dollars alone are unlikely to solve the problem. This report explores how jurisdictions of fragmented urban regions with high wildfire risk can come together to mitigate that risk, and how market-based opportunities for the reuse of woody biomass can bring new resources to bear.

Advancing collaboration and fuel reduction across jurisdictions

Several wildfire-prevention joint powers authorities have been launched in California to enhance planning, funding and implementation efforts, but in especially dense communities, other mechanisms may be more feasible, at least in the immediate term.

1. The community of those concerned about wildfire in the East Bay Hills believe that a regional political body, fueled by sound technical advice of fire officials and other experts, could support improved regional wildfire prevention initiatives.

In the aftermath of the deadly 1991 Tunnel Fire, local fire officials, community groups, and elected leaders and their constituents supported efforts to reduce wildfire risks such as removal of hazardous vegetation on public lands, passing stricter local ordinances to mandate firesafe practices, and public-facing education and awareness programs. These efforts however have been unevenly implemented in the region, largely due to inconsistent political and community support, but also resource constraints and implementation challenges. Aligning the region's elected leaders, fire officials, and the community on the priority of wildfire prevention could enhance local fire departments' abilities to implement evidence-based wildfire prevention measures to improve public safety more consistently in the East Bay Hills.

2. Stakeholders decided that a basic legal mechanism – a Memorandum of Understanding – to create an East Bay Hills Regional Wildfire Prevention Coordinating Group (WPCG) is most appropriate now.

Given the diversity of jurisdictional entities in the region and resource challenges, a consensus emerged to use a relatively flexible and simple legal mechanism to create a regional collaboration mechanism. A Memorandum of Understanding that defines WPCG membership, structure, and general intent has been approved by respective governing bodies of interested jurisdictions. The WPCG strategic priorities, functions, operations and budget will be decided by members.

3. Although early in its existence, the WPCG may prove be a promising way for similar regions and communities to enhance safety standards and practices, reduce hazardous vegetation, and reduce wildfire risks in WUI communities.

The process for jurisdictions to adopt the WPCG MOU has been smooth and efficient. Jurisdictions' attorneys quickly cleared the document for adoption. As of March 2024, Alameda and Contra Costa counties, six cities, and two fire districts have already - or are on track to - join the MOU; none have faced constituent or staff resistance. While the WPCG is yet to hold its first meeting, member jurisdictions have identified

code consistency as one of the first issues to address. Thereafter, the WPCG may consider cooperation on: code enforcement and public awareness efforts regarding defensible space and home hardening; reducing hazardous vegetation; planning wildfire evacuations and response especially where these efforts cross jurisdictional boundaries; and influencing legislation at the State level to support resources and policies to mitigate wildfire risk.

Market-based opportunities and challenges for utilizing woody biomass

It is unlikely that there will ever be enough public resources to fully fund the necessary level of fuel reduction efforts across California's vast forested lands. It will therefore be essential to find ways to leverage private sector dollars to support fuel reduction goals and mitigate wildfire threats on an accelerated timeline. To incentivize and stimulate new markets, regions and policymakers should work to create an environment where these developing industries have the long-term support required to implement new technologies, scale up capacity, and build markets.

1. Converting woody biomass into high-value, low-carbon transportation fuels and other products is technically feasible and could one day provide a robust mechanism for fuel reduction across California's forested lands.

Processes to convert cellulose-based feedstocks into low-carbon transportation fuels such as renewable diesel and sustainable aviation fuel exist and have progressed past the research and development phase. These technologies have the potential to simultaneously help California accomplish multiple key policy goals at once: rapid, large-scale forest fuel reduction treatments and the decarbonization of heavy industry and aviation sectors, two sectors where electrification will be particularly difficult if not impossible.

2. While technologies to produce high-value, low-carbon fuels and other products from woody biomass have been technically proven out, production methods, distribution networks, and market building will take a concerted effort and policy support over a sustained period.

Currently, these technologies sit in what is referred to as the "Commercialization Valley of Death," between field validation and full deployment. This is a particularly difficult time in the lifecycle of any technology, let alone one working against cheap fossil fuels, competing for subsidies, and relying on access to vast swaths of public land. In fact, California's first biofuels plant exclusively dedicated to the processing of cellulose-based biomass recently shuttered, a testament to the difficulty of scaling up production in new markets. If harnessing the private sector is to succeed, concerted policy support (and funding) over a sustained period will be essential.

3. Scaling up forest treatment efforts across the East Bay hills, let alone the state of California, will be an immense, multi-decade undertaking that will rely heavily upon positive interjurisdictional collaboration and sustained policy support for nascent markets.

The West is facing a challenge like nothing its ever seen before. The enormous scale of fuel reduction required after a century of suppression and now a rapidly warming climate will take interventions of equal proportion. This is complicated by the fact that wildfire does not respect state or jurisdictional lines, and is now equally impacting both rural and urban communities. This presents an additional set of challenges, that only close cooperation and the correct set of legal mechanisms can solve. There is also immense opportunity for the private sector to assist in these efforts, while simultaneously helping to achieve other climate goals such as climate-friendly fertilizer or a reduction in transportation emissions. However this too will require the right set of supports, both in policy and fiscally.

1

Introduction

Wildfire has long been a part of the California experience. Before 1800, several million acres likely burned every year due to a combination of lightning strikes and burning by Indigenous tribes.[1] When California became a state in 1850 and its population grew, fire suppression strategies eventually became the norm and large fires were more limited in number. In fact, the largest wildfire in the state's history up until 2018 was 1889's Santiago Canyon Fire, which burned more than 300,000 acres across Southern California.

The state's dry summer climate, extensive grassy and wooded areas, and rugged topography create conditions that can turn a spark into a large wildfire event. In recent years, the same factors that are conducive to wildfires have collided with extreme drought conditions and record-breaking heat to produce the largest and most destructive wildfires in the state's recorded history. In the 30 years between 1987 and 2016, California experienced just three years in which the total land burned by wildfire exceeded 1 million acres. Four of the last five years (2017-2021) have exceeded this threshold, culminating with a record-breaking 2020 fire season that burned over 4 million acres in the state and a 2021 fire season that produced nearly 2.5 million acres burned as of October 2021.

As the size and number of these ongoing wildfires has grown, the destruction that they have left behind has also ballooned. In 1991, the Oakland Firestorm caused $1.5 billion[2] in damages. The 2017 North Bay fires far surpassed these costs, with an estimated $9.5 billion in total insured losses in Napa and Sonoma counties.

A year later, Butte County, just north of the Bay Area, experienced the Camp Fire, a devastating wildfire that created over $8.5 billion in insured losses. Estimates for 2020's historic wildfire season—which accounts for five of the seven largest wildfires in the state since 1932—range between $5 billion and $9 billion for insured losses in Northern California.

Wildfires are now an annual concern for many of the state's residents, particularly in and around the Bay Area. Households in fire-prone areas plan for defensible space and exit strategies in the case of a wildfire, and even those in urban areas prepare for the potential of smoke-laden skies and the health impacts they bring. Now, each wildfire season seems to bring weeks of deadly and dangerous air quality, along with destroyed businesses, homes, neighborhoods, and livelihoods.

Without intervention, wildfires will continue to threaten homes, create economic costs, and jeopardize the health of the state's residents. A variety of Federal, State and local programs, grants, and initiatives are advancing, however public-sector programs alone are unlikely to ever reach the scale necessary to completely mitigate the threat. It is therefore essential to co-develop programs and initiatives to leverage the resources within the private sector.

This report aims to share lessons from the East Bay Hills to advance the conversation around collaborative agreements and working structures between jurisdictions, and, inform work relating to incentivizing the use and monetization of excess woody biomass. The East Bay Hills represent a particularly interesting area of study for several reasons. First, the region is very familiar with wildfire, having experienced one of the greatest urban firestorms the West has ever seen. Second, the region is highly fractured, crossing two separate counties and comprising over thirty local jurisdictions and fire districts. And third, in response to the Firestorm, the region set up a variety of local initiatives, as well as collaborative efforts between jurisdictions, to improve wildfire suppression and prevention planning efforts, but community leaders and fire officials agree that additional collaborative efforts are warranted.

This report and the associated map aim to answer three primary questions:

1. Examine the current state of fuel reduction efforts in the East Bay hills;
2. Existing and potential new mechanisms for interjurisdictional collaboration on fuel reduction efforts in the region;
3. An analysis of innovative incentives and market structures that could be used to activate the private sector to speed up the progress of fuel reduction efforts.

2

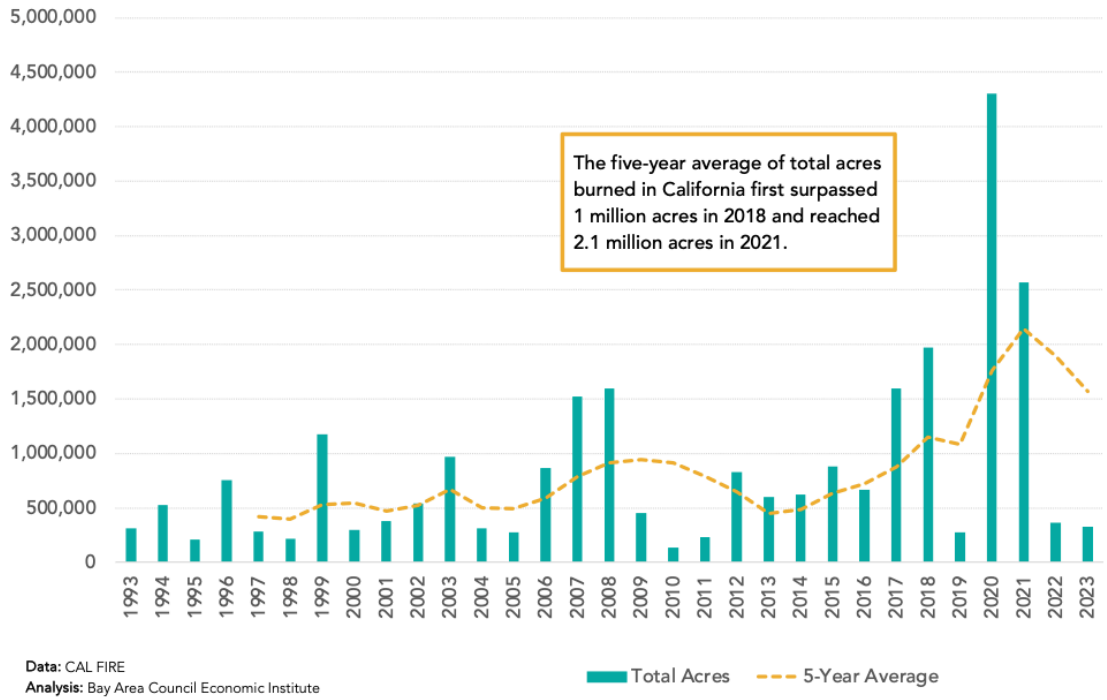
Wildfire in California

Wildfires are California's most frequent and destructive form of natural disaster. Between 1980 and 2020, California experienced 245 (Federal Emergency Management Agency) FEMA-declared wildfire disasters, 234 (or 96%) of which have occurred since 2000. However, the number of individual wildfires occurring annually in California has not necessarily increased over the last 30 years.

What has changed is a significant increase in the annual acres burned in the state. In 2020, California experienced the largest wildfire season recorded. Over 4.2 million acres burned in 2020, which is approximately 4% of the state's total acreage, and more than double the previous annual record in 2018 when just under 2 million acres burned. Through October of 2021, an additional 2.5 million acres have burned in California.

Annual Wildfire Acres Burned in California

with 5-year Moving Average (1993-2023)



Data: CAL FIRE
Analysis: Bay Area Council Economic Institute

A Drastic Increase in Destructive California Wildfires

The growing prevalence of extreme wildfires in recent years can largely be traced back to the effects of climate change in California. Prolonged periods of drought and warmer seasonal temperatures have created an extended wildfire season across many parts of the state. The drought has also led to a higher rate of tree die-off, which creates the fuel necessary for fires to grow if dead trees are not cleared. California's development patterns have shown an increase in residential construction along the wildland-urban interface, increasing the probability of residential property destruction.

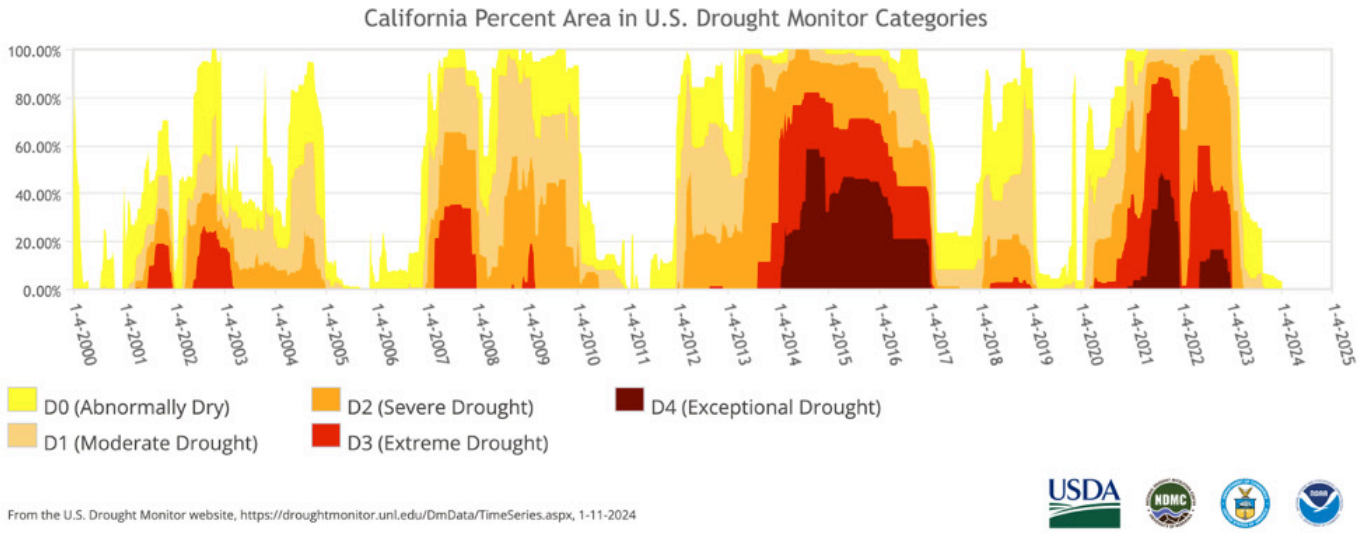
1. Severe Drought

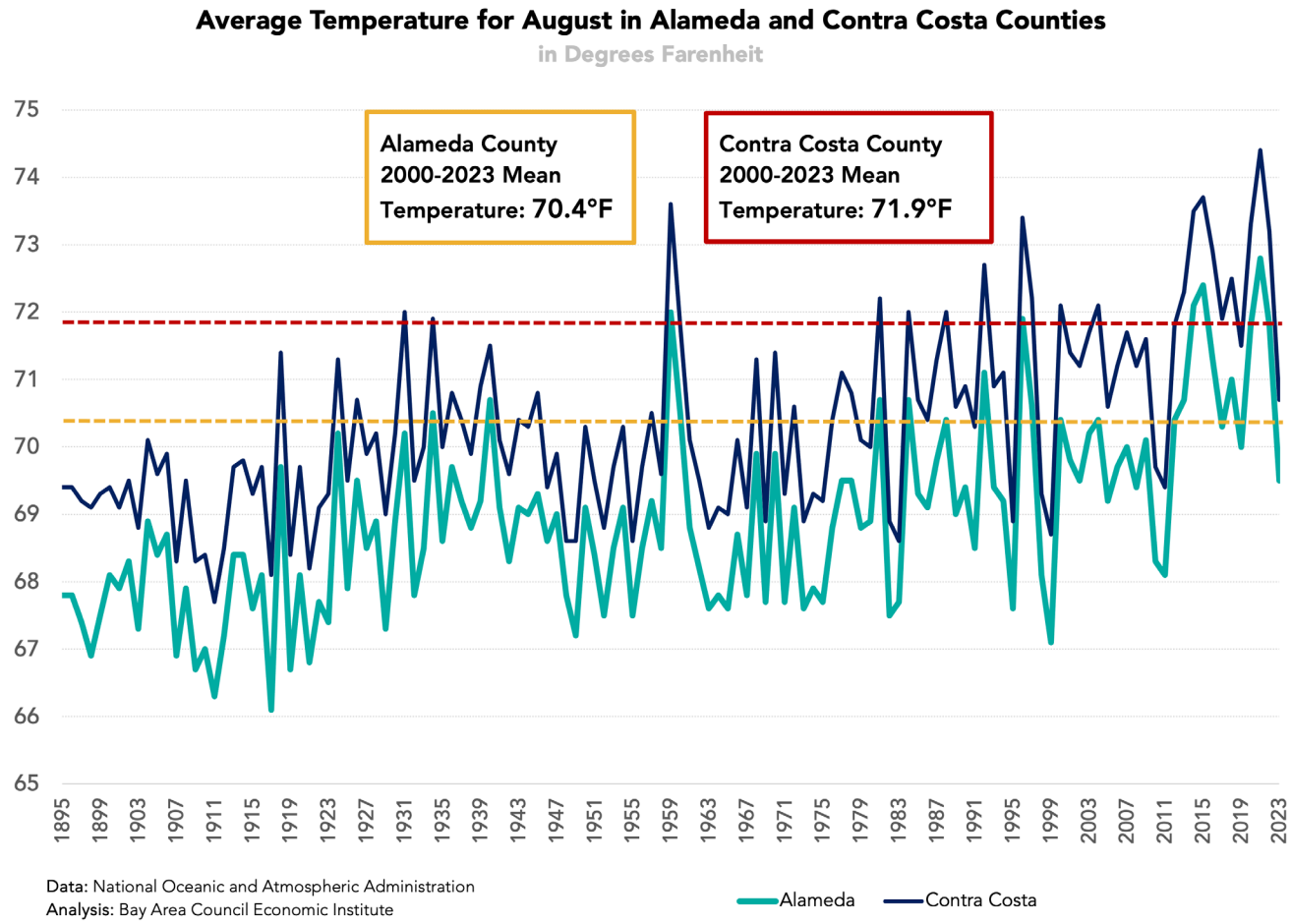
The rapid increase in the acreage burned by wildfire in California is closely associated with record-breaking drought that much of the state has experienced during the last decade. An extended period of drought, spanning 2014 through 2016, helped create conditions for larger wildfires that would begin the following summer. While dry conditions are conducive to fire, they also dehydrate trees and can lead to extensive die-off. As of October 19, 2021, much of California has again gone a prolonged period without substantial rain—88% of the state is classified as experiencing extreme drought, as defined by U.S. Drought Monitor in the chart below. Of the 50 states, only Utah is currently experiencing a similar prevalence of extreme drought (85% of the state) as California—though its ecology makes it less prone to wildfires.

2. Long-term Warming Trend

Hotter temperatures also contribute to greater risk for wildfire, as they dry out fuel sources and are correlated with lower levels of moisture in the air. Much of the U.S. is being impacted by climate change, as average surface temperatures across the contiguous 48 states have risen by between 0.31°F to 0.54°F per decade since 1979.[4] California is not immune, as the state's average temperatures have increased by 2°F since the late 1980s. Alameda and Contra Costa Counties offer one stark example of the state's changing climate. The counties average temperatures in the month of August has been above the 100-year mean in 19 of the last 30 years, as shown in the chart on the following page. Recent research has also linked drought with heatwaves, finding that heatwaves in Southern California increased by 42% in frequency and 26% in duration during severe drought conditions.[5]

Extended Drought Periods The chart below depicts the percentage of California's land mass by drought category. In the last decade, the state has experienced two extended periods of extreme drought.





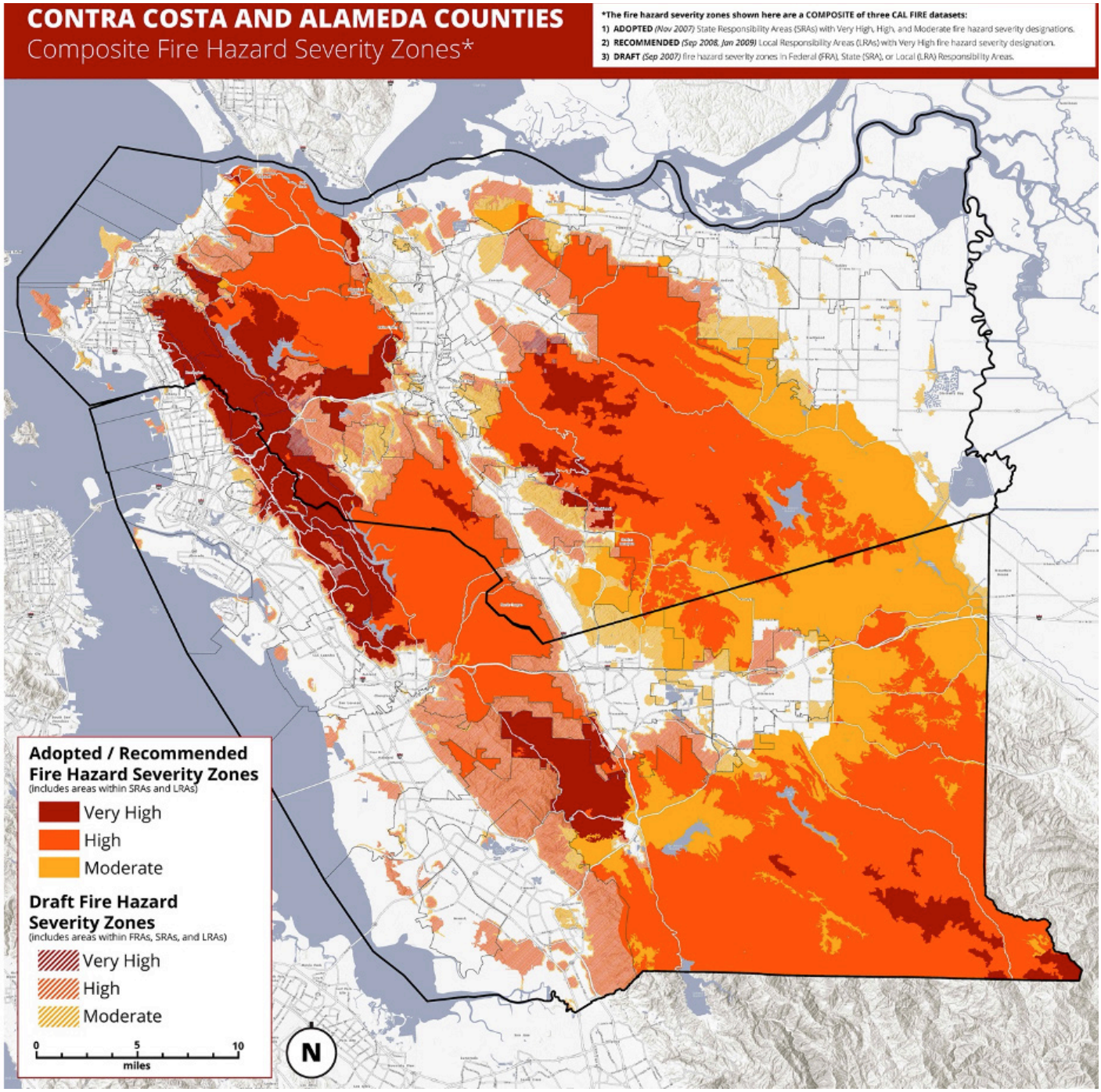
3. Extensive Tree Mortality

Drought and hotter temperatures have led to elevated levels of tree mortality in California, as parched trees are less able to produce the resin that protects them from bark beetle infestations. Aerial surveys completed by the U.S. Forest Service found that over 147 million trees had died in the state between 2010 and 2018, with the greatest level of die-off in the Sierra foothills as shown in the map. These dead trees are the fuel that can lead to bigger conflagrations. This record tree mortality has reduced large tree density per acre, while recent research has shown that fire suppression strategies dramatically increase the density of smaller trees in California forests—between two to three times denser than in the early 1900s.[6] Denser forests with smaller trees have more burnable biomass, which create faster-moving and harder-to-control fires.

4. Housing Development in the Wildland-Urban Interface

Nearly 11,500 structures were destroyed in California during the 2020 fire season.[7] Property destruction from wildfires is generally concentrated in the wildland-urban interface (WUI), defined as the transition zone between wilderness and land developed for human activity. As wildfires have grown bigger and development in the WUI has increased, the destruction they leave in their wake has grown in turn. Land defined as WUI in California has grown by 4,400 square kilometers between 1990 and 2010, now encompassing 6.4% of the state's total land area. Additionally, 45% of homes constructed in the state between 1990 and 2010 were built in the WUI. As of 2010, 32.4% of the state's housing units could be found within the WUI, up from 29.6% as of 1990.[8]

Fire Hazard Zones The map below highlights the risk to housing units that wildfires pose in the Bay Area by showing areas with elevated fire severity threats (as defined by CAL FIRE) and relatively high population density.



3

Literature Review

This literature review includes findings from previous research on existing fuel reduction efforts in the Bay Area and California, as well as the state and market potential of woody biomass conversion into byproducts like biochar or biofuels.

Fuel Reduction

In California, there are 56 million bone dry tons (BDT) of biomass available per year from trash, agricultural waste, sewage and manure, logging, and fire prevention. The East Bay Hills produces about 412,000 BDT per year, or 1% of the state's annual tonnage, mostly from construction/demolition wood waste, and residential tree trimmings.[9] **Fuel reduction**, a process that removes overgrown vegetation through prescribed fire, tree thinning, pruning, chipping, and roadway clearance, helps remove what fires need to spread or become more severe.[10] Biomass produced by fuel reduction efforts has historically played a small role in the East Bay's overall biomass supply (around 3%), but holds the greatest potential for negative CO2 emissions.

The benefits are three-fold: 1) fuel reduction efforts can create fire resistant forests without causing long-term harm to other resources, 2) the wood waste produced by such efforts may be converted into value-added byproducts, and 3) low-carbon and carbon-negative fuels from forest biomass can help the region attain its greenhouse gas (GHG) reduction targets.[11]

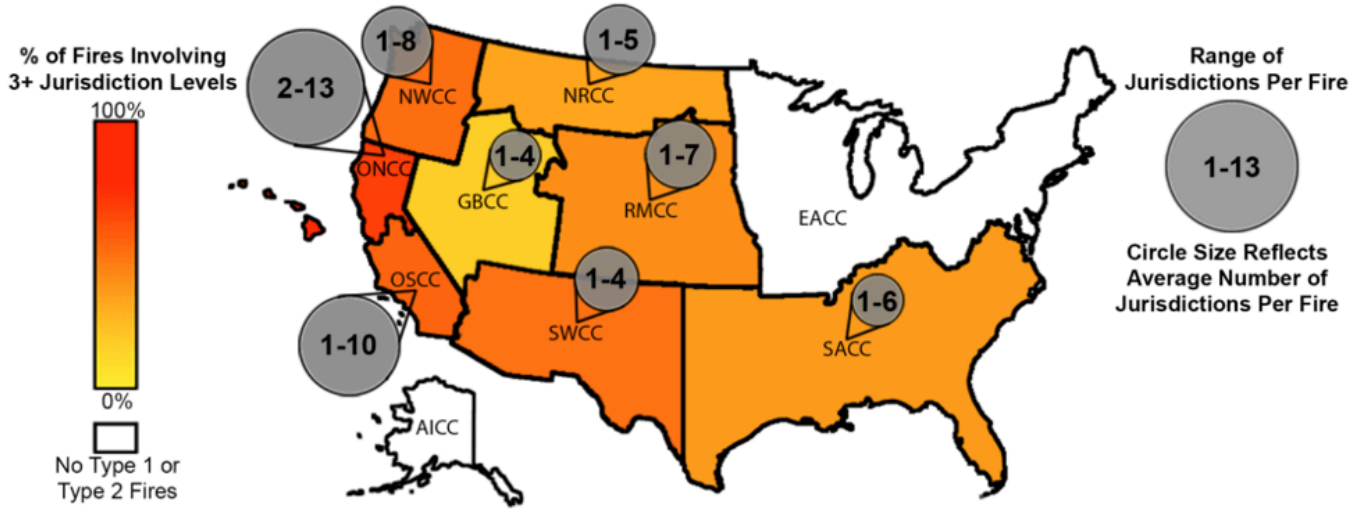
There are two conversion options with the most potential: conversion of woody biomass to biochar through pyrolysis (heating biomass in the absence of oxygen); and conversion of woody biomass into gaseous fuels through gasification, or liquid replacement fuels for petroleum-based gasoline, diesel and jet fuel, also through pyrolysis.[12] Despite growing interest and technological readiness, the viability and growth of these two markets will face challenges if there continue to be no significant changes to public policy.[13]

Importance of Inter-jurisdictional Collaboration

Wildfires are one of many natural hazards that are not confined to a single jurisdiction, landowner, or stakeholder group. For example, the Canadian wildfires that made headlines in June 2023 crossed two provinces and mobilized Canadian federal, provincial, and local firefighting resources – requiring additional firefighting assistance from ten other nations.[14]

California has the greatest jurisdictional complexity, as seen in the map on the following page. Nearly one third of incidents in California involve four levels of government – with the highest complexity within the Northern California Geographic Area Coordination Center (ONCC), whose fires often require co-management among federal, tribal, state, and local levels of government.[15]

Complex Governance Among the nine Geographic Area Command Centers in the continental United States – entities tasked with coordinating the mobilization of resources for wildfires – the Northern California center has the highest rate of jurisdictional complexity, with up to 13 different jurisdictions responding to any given wildfire incident.



Geographic Area Command Centers (GACC)

Biochar

One potential use of widely available biomass is the conversion to biochar, is a specialized form of charcoal produced at high temperatures in limited oxygen environments. Biochar has been used by many cultures and communities for thousands of years to improve soil conditions and increase crop production, and more recently to filter water and air, to reduce methane emissions, to add to building materials, and to reduce odors and nutrient leaching in commercial composting operations.[16]

California, and the Bay Area in particular, is an important emerging biochar market due to the availability of low-value biomass resources. While the market for biochar is growing, many companies cite no stable demand or market assurance. Major barriers include a lack of awareness about the product, slow production processes, and a lack of carbon offset credits that could help commercialize biochar at scale.[17]

Biofuels

Extensive resources have been dedicated to studying how to convert biomass into carbon-neutral, environmentally friendly fuels over the last decade. Still, the woody biomass fuels industry is in the early stages of commercialization and requires long-term favorable business conditions to meet the twin goals of establishing substantial demand for woody biomass feedstock and providing a reliable supply of low carbon bio-based fuels.[18]

Gaseous Biofuels

Woody biomass has been emerging as a potential feedstock in the production of biofuels, like biogas and biohydrogen, for several reasons: it's widely available, uses non-arable land, does not require synthetic fertilizers, and can sequester carbon. However, widespread use of wood as a gaseous biofuel feedstock is still far from mass production, largely constrained due to the rigid structure of wood that necessitates many

lengthy and costly steps and treatments.[19] Researchers are slowly overcoming technological barriers, but many are skeptical that wider adoption of wood derived gaseous biofuels will be scalable for at least a decade.

Sustainable Aviation Fuels

The current sustainable aviation fuel (SAF) market is nascent, and there are many emerging business opportunities, infrastructure, and financial mechanisms to facilitate the future of the SAF industry. It has a relatively small market worldwide and additional production facilities are currently under development.

The vast majority of SAF feedstocks are derived from waste fats, oils and greases, though some scientists have found new industrial processes to convert the lignin within woody biomass into jet fuel.[20] However, these processes are relatively novel, and the growth of SAF production, even from more easily convertible feedstocks is largely limited due to the price gap between fossil fuels and SAF. In one study, engineers found that there are major still major challenges to convert woody biomass into jet fuels at costs competitive with those of fossil fuels. Researchers found that the conversion costs were comparable to those reported for the petrochemical industry.[21]

4

Interjurisdictional Collaboration in the East Bay Hills

The East Bay Hills region is located in a complex wildfire environment – one of the highest-risk in the country for especially dangerous wildland urban interface fires. The Wildland Urban Interface (WUI) is where natural forests comingle with urban development, creating novel wildfire dynamics and unique fire suppression and evacuation challenges. Some of the most devastating firestorms in recent memory have occurred in WUI communities, dating back to the 1991 Tunnel Fire in the Oakland-Berkeley Hills, to the Sonoma County 2017 Tubbs fire, to Paradise in 2018, to the 2023 lethal firestorm in Maui.

Further complicating wildfire prevention effort is the number of separate jurisdictions touching the East Bay Hills high fire hazard zone– two counties encompassing more than 30 cities and unique fire districts, each with their own fire departments and governing structures, plus EBRPD, EBMUD, University of California, and Lawrence Livermore lab, each with their own fire departments and governing structures.

A Fractured Region Confronts Increased Risks

Counties, cities and fire districts in the region each have the responsibility to protect their residents and businesses from wildfire, and jurisdictions largely pursue their own approaches to the many issues that contribute to fire-hazard reduction. Approaches include: adopting, implementing and enforcing fire codes on private land including vegetation abatement standards, defensible space and home hardening requirements in communities most susceptible to wildfire risk; communication programs to inform residents of safe practices; developing and implementing vegetation management plans to remove hazardous vegetation on public lands; applying for local and regional grants to fund and implement wildfire hazard identification and mitigation programs; and engaging in separate and joint wildfire emergency response readiness activities such as evacuation planning and drills.

Jurisdictions in the region have been unevenly successful in raising funds to support wildfire prevention efforts, drafting and implementing local ordinances to protect citizens, and planning for and implementing programs to reduce hazardous vegetation on public lands.

For example, in 2003 residents living in Oakland's fire-prone hills approved a parcel tax to create a Wildfire Prevention Assessment District (WPAD). The WPAD funded efforts including but not limited to: removing hazardous vegetation from public property, developing and implementing a program to inspect and enforce

defensible space in private properties, and educating WUI residents about wildfire risks. While the WPAD had measurable success, due to misperceptions about the WPAD and its scope, in 2013 voters did not approve its continuation. Since then, Oakland has had to rely on core budget and grants to fund its private property inspection program and public property vegetation management efforts.

More recently, in 2020 all residents of the City of Berkeley approved a ballot measure to pay for fire services, emergency response, 9-1-1 communication, hazard mitigation and wildfire prevention. This funding has enabled Berkeley to develop and implement a private-property inspection program, begin to develop a vegetation management plan, and improve emergency response mechanisms.

Pursuing Improved Collaboration

Fire officials in the region have engaged in several activities to enhance collaboration, especially since the Berkeley/Oakland Tunnel Fire of 1991. During that incident, several critical gaps in coordination enhanced the fire's ability to overwhelm local emergency responses. For example, jurisdictions used different and incompatible communication technology and fire hydrant mechanisms leading to predictable delays in communication and suppression. These gaps led fire officials, residents and leaders to demand new collaborative efforts.

Two of the most visible and lasting examples of new regional efforts that rose from the Tunnel Fire ashes are the East Bay Regional Communications System Authority (EBRCSA) and the Hills Emergency Forum (HEF):

- The EBRCSA has a focused mission: "To build, own and operate a state-of-the-art P25 compliant communications system for the public agencies within Alameda and Contra Costa Counties." As a Joint Powers Authority launched in 2007, the EBRCSA has 40 member agencies and is governed by a Board of Directors comprising 23 representatives including elected officials, police chiefs, fire chiefs, and city managers. It holds public meetings and has secured several federal and state grants to support its programs.
- The Hills Emergency Forum (HEF) was launched in 1993 from the ashes of the Tunnel Fire. It comprises the largest landholders in the East Bay Hills including Berkeley, Oakland, the Moraga-Orinda Fire District, East Bay Regional Parks District, East Bay Municipal Utility District, UC Berkeley, and Lawrence Berkeley National Laboratory, with El Cerrito and CALFire joining later. The HEF mission is "to coordinate the collection, assessment and sharing of information on the East Bay Hills fire hazards and, further, to provide a forum for building interagency consensus on the development of fire safety standards and codes, incident response and management protocols, public education programs, multi-jurisdictional training, and fuel reduction strategies."

Several elected officials and community leaders in the region had originally envisioned that the HEF would become a Joint Powers Agency. Instead the HEF came to be governed by a "Letter of Intent" first signed in 2006. This informal collaboration relies on member fire departments' annual membership dues to support its activities which are largely implemented by independent consultants.

Other collaborations include:

- Countywide Fire Chiefs' Associations in Alameda and Contra Costa Counties provide a forum for fire officials to communicate and meet. These associations are informal with rotating leadership of members.
- Contra Costa released its updated Community Wildfire Protection Plan (CWPP) in 2019; it included survey results from 89 individuals in the county. Alameda County's CWPP has not been updated since 2012.
- The Alameda and Contra Costa County Regional Priority Plan (RPP), developed under the auspices of the two counties' Resource Conservation Districts, focuses on protecting natural resources in the region and does not include attention to the specific risks in East Bay WUI communities.

So while there are several existing wildfire prevention coordination efforts in the region, none of them include all three components that many feel are critical to raising standards and practices to acceptable levels: 1) a focus on the unique wildfire risks in WUI communities in the East Bay Hills; 2) an ability to solicit and accept grants; and 3) inclusion of political level members and active solicitation of input from affected communities.

A Need for Political-Level Collaboration

Community leaders in the East Bay were frustrated that their local governments were struggling to fund proactive, state-of-the-art vegetation management plans and wildfire preparedness efforts. Furthermore, many jurisdictions in the region did not have the community support - or political will amongst elected officials – to pass local ordinances that would requiring private property owners and real estate developers to uphold more fire safe practices in WUI communities, let alone the capacity to enforce these practices.

In 2019 a few individuals associated with the Oakland Firesafe Council (OFSC) began speaking to stakeholders and elected officials in the region about more and better coordination and alignment on wildfire prevention, especially at the political level. Following the successful launch of the Marin County Fire Prevention JPA they felt a Joint Powers Authority would be the most appropriate regional structure in the East Bay.

Member agencies create JPAs to deliver more cost-effective services, eliminate duplicative efforts and consolidate services into a single entity. Commonly, joint powers are exercised to work on projects like groundwater management, transportation planning, road construction, or habitat restoration to name a few. They can also be created to provide a service or manage energy procurement.

Recognizing that the effort needed professional support they began raising money from community groups, individuals, and foundations concerned with wildfire in the East Bay Hills, with OFSC as the 501(c)(3) sponsor. With significant funding from the Bay Area Air Quality Management District, in 2021 OFSC hired the consulting company Placeworks for strategic, communication, and facilitation support to make a strong case and bring stakeholders together. A website was launched and the first meeting of stakeholders was organized for December 2021.

At a series of meetings amongst more than 25 local staff and elected officials, options for collaboration were discussed. Many felt a new robust entity in the form of a Joint Powers Agency was needed. Others were concerned that without a guaranteed income stream such as fees or parcel taxes, a JPA would be a more complicated and resource-heavy structure than was needed. Several felt that existing mechanisms such as the Hills Emergency Forum, which was created after the 1991 Tunnel fire to improve coordination on fire suppression in the region and comprised most of the large landowners in the region, should expand to include all jurisdictions in the region, and open itself to involvement of elected officials.

After much discussion, stakeholders decided to request the Hills Emergency Forum (HEF) to consider expanding its membership and mandate; the Forum demurred. Thereafter, stakeholders explored whether a Memorandum of Understanding (MOU) could serve as a legal tool enhance coordination amongst all interested jurisdictions. It was felt that a structure created under an MOU could serve the same purpose as a JPA, but without creating a new level of government.

A Simple Structure Gains Support

By Summer 2022 there was a consensus that no existing entity was appropriate for expansion, and that a Memorandum of Understanding (MOU) among the jurisdictions and agencies would be the most suitable structure. The Oakland Firesafe Council hired a law firm, Hanson Bridgett, to create a draft MOU for stakeholders to adopt.

A subgroup of stakeholders reviewed several drafts and by Summer 2023, a draft was approved to be shared with the larger group of stakeholders.

Over the next months, OFSC conducted outreach to jurisdictions in the region, seeking interest from the governing bodies of the Counties of Alameda and Contra Costa, and all interested municipalities and fire districts in the East Bay Hills that include areas in high wildfire risk zones (as determined by CAL FIRE).

The MOU is a basic document that defines membership as one elected (or appointed) official and one alternate from each member's jurisdiction. It does not include requirements for how jurisdictions must select members, outline frequency of meetings, committee structures. or operational guidelines. It does require that one member be selected as fiscal agent; administrative and staff support can be provided by members, nonprofit organizations and/or consultants. Any fee structure will be decided by unanimous approval of members.

A subgroup of stakeholders reviewed several drafts and by Summer 2023, a draft was shared with the larger group of stakeholders. The draft MOU was approved to be shared with interested jurisdictions. Over the next months, OFSC conducted outreach to jurisdictions in the region, seeking interest from the governing bodies of the Counties of Alameda and Contra Costa, and all interested municipalities and fire districts in the East Bay Hills that include areas in high wildfire risk zones (as determined by CAL FIRE).

As of February 2024, the MOU to create an East Bay Hills Wildfire Prevention Coordinating Group (WPCG) has been signed by five jurisdictions: Alameda and Contra Costa Counties and the cities of Berkeley, Richmond, and Oakland. In March 2024 five additional jurisdictions are expected to sign on: El Cerrito, Pinole and Hayward, and the Hercules-Rodeo and Kensington Fire districts. With this critical mass of ten members, the first meeting of the Wildfire Prevention Coordinating Group is anticipated in the first half of 2024.

While the ultimate activities of the WPCG will be decided by its members, the MOU describes potential planning and coordination activities, including: developing model fire codes; joint vegetation management plans; applying for state, federal or other funds to assist with wildfire risk mitigation activities; influence legislation at the State level to support resources and policies to mitigate wildfire risk and to make wildfire safety a priority.

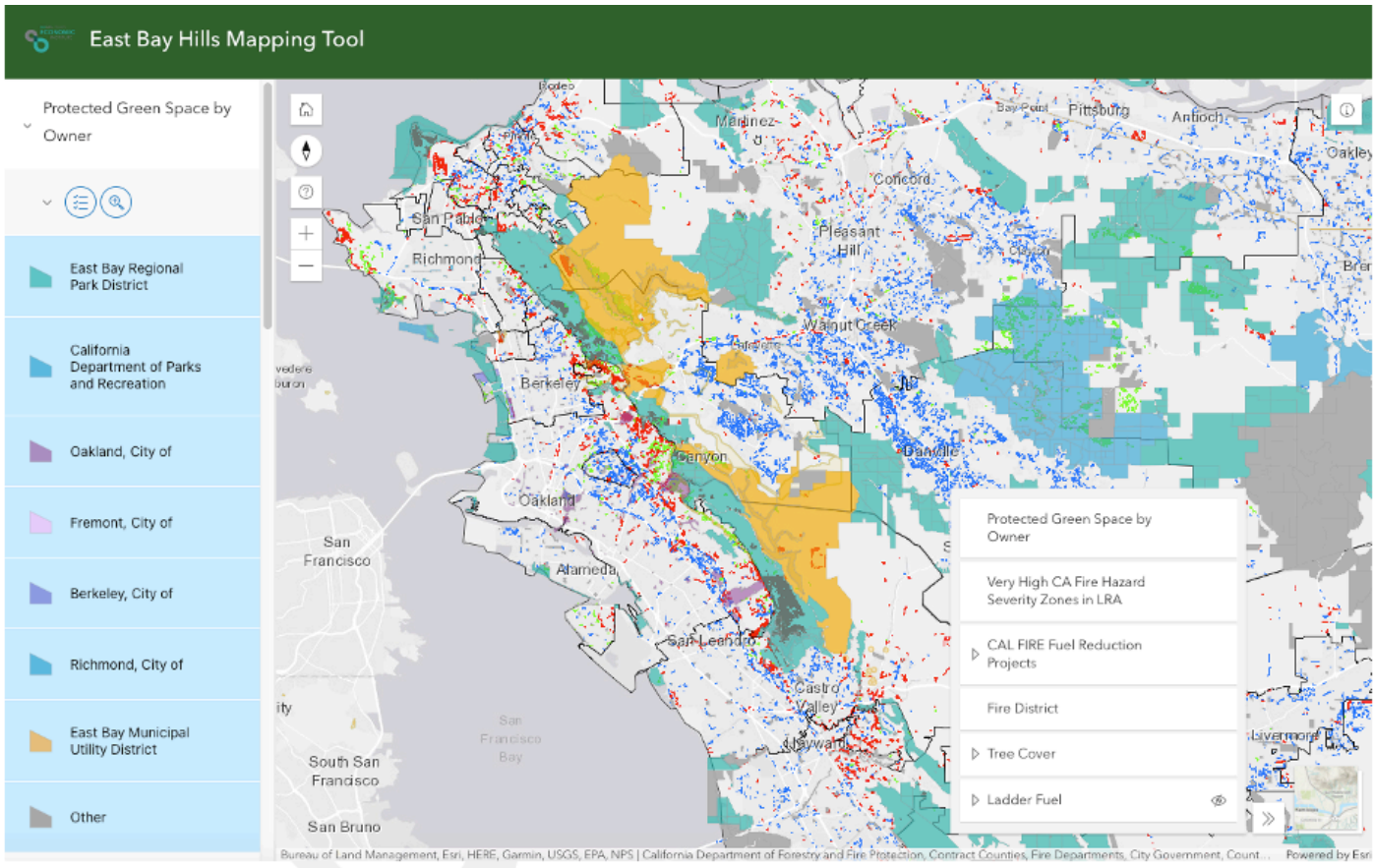
Interactive Mapping Component

In order to better understand existing fuel reduction efforts, high risk zones, and potential areas for feedstocks, the Bay Area Council Economic Institute generated a dashboard of interactive, dynamic maps drawing on data from the East Bay Regional Parks District (EBRPD) and Tukman Geospatial's lidar mapping of Eucalyptus and other non-native vegetation, California Department of Forestry and Fire Protection's Fire and Resource Assessment Program (FRAP), the California Protected Areas Database (CPAD), Alameda and Contra Costa County GIS databases, among other sources.

Quantifying the Problem

While there is no way of knowing exactly how many trees could contribute to potential biochar or biofuel feedstocks, many estimates have been calculated by various landowners with operations in and around the East Bay Hills. Some estimates have found that there are an estimated 2,785 eucalyptus trees across 2,920 acres in the East Bay Regional Parks District alone.[22] Most agencies say unofficially that they hope to convert to safer native woodlands but are reluctant to estimate the number of trees that they have or may need to remove.

Mapping Tool Users have a range of options for exploration of the East Bay Hills fuels and fuel reduction efforts. Users may toggle for specific agencies or jurisdictions of interest, layering on different variables related to wildfire management and fuel reduction.



Mapping the East Bay Hills

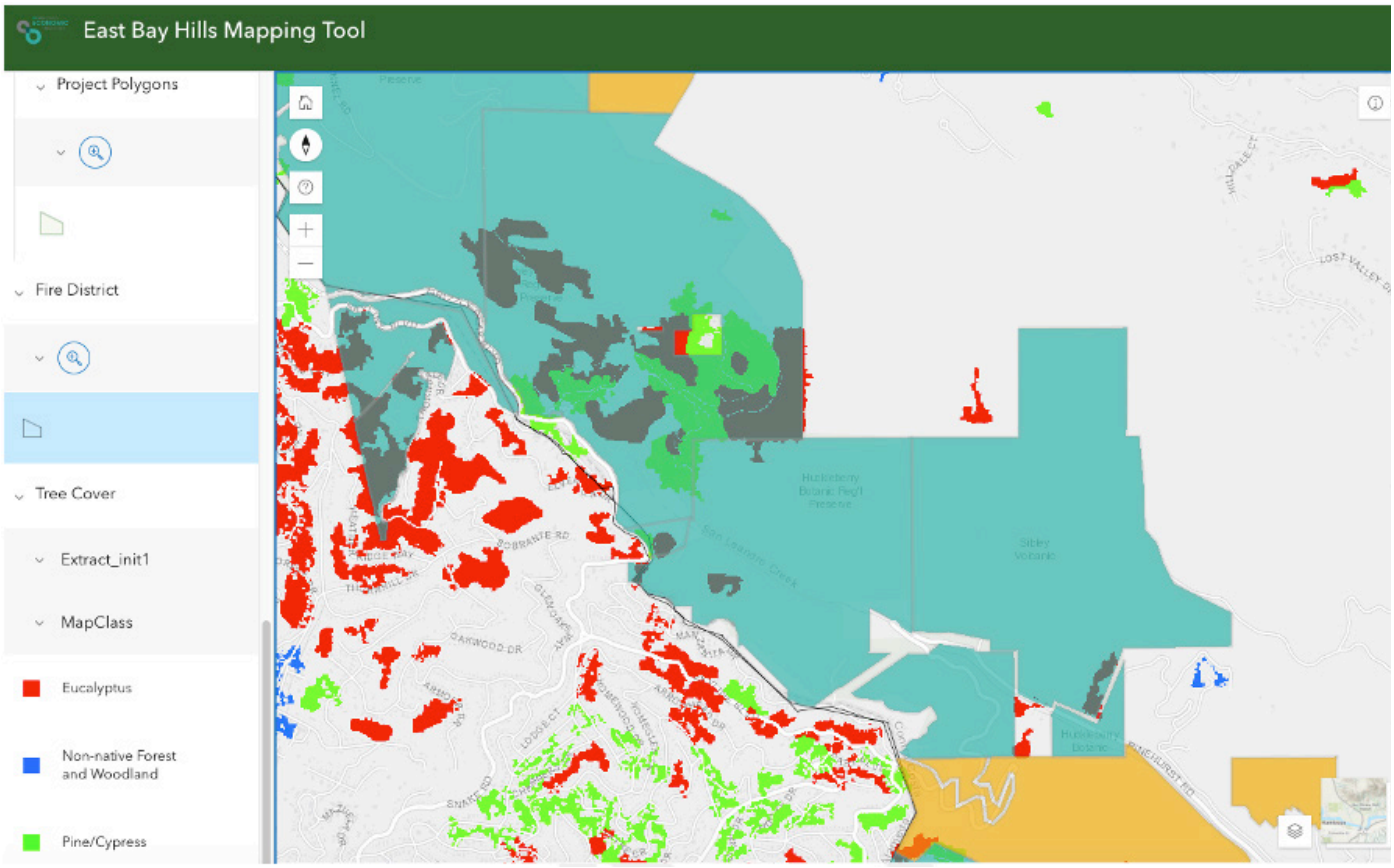
The images on the previous page and below show screenshots of the mapping tool. The main goal of this tool is to allow users to identify areas with potentially high fire hazard severity and convoluted ownership.

Variables include: tree cover (eucalyptus, pine, cypress, non-native tree species), fire district boundaries, CAL FIRE fuel reduction projects, fire hazard severity zones in local responsibility areas (very high severity only), and protected green space by land owner/agency.

One example of the map's utility can be seen in the zoomed-in image below. There is a large concentration of eucalyptus trees (in red) as well as pine/cypress (in green), the teal overlay shows land owned and operated by the East Bay Regional Parks District, but the black boundary shows that some of this land lies under the Moraga Orinda Fire District, and some lies under the Oakland Fire District. Land with no polygon overlay is not considered protected green space[23] and is usually considered privately owned, or publicly owned and not intended for public use.

The overlapping political boundaries and unclear geographic definition of enforcement responsibilities has proven to be an obstacle in the region's wildfire prevention activities. For example, efforts to enforce prohibition on fireworks and loitering along Grizzly Peak Drive, especially on and around Independence Day, required significant effort and several specially scheduled meetings to develop a plan for communication and enforcement around this threat. It is therefore critical that these agencies engage in collaborative fuel reduction efforts.

Mapping Tool The interactive map combines protected green space by owner and jurisdiction; fire severity zones in local responsibility areas (LRAs); lidar mapping of existing eucalyptus, non-native forest and woodland, and pine/cypress tree cover; current CAL FIRE fuel reduction projects; and fire district boundaries.



5

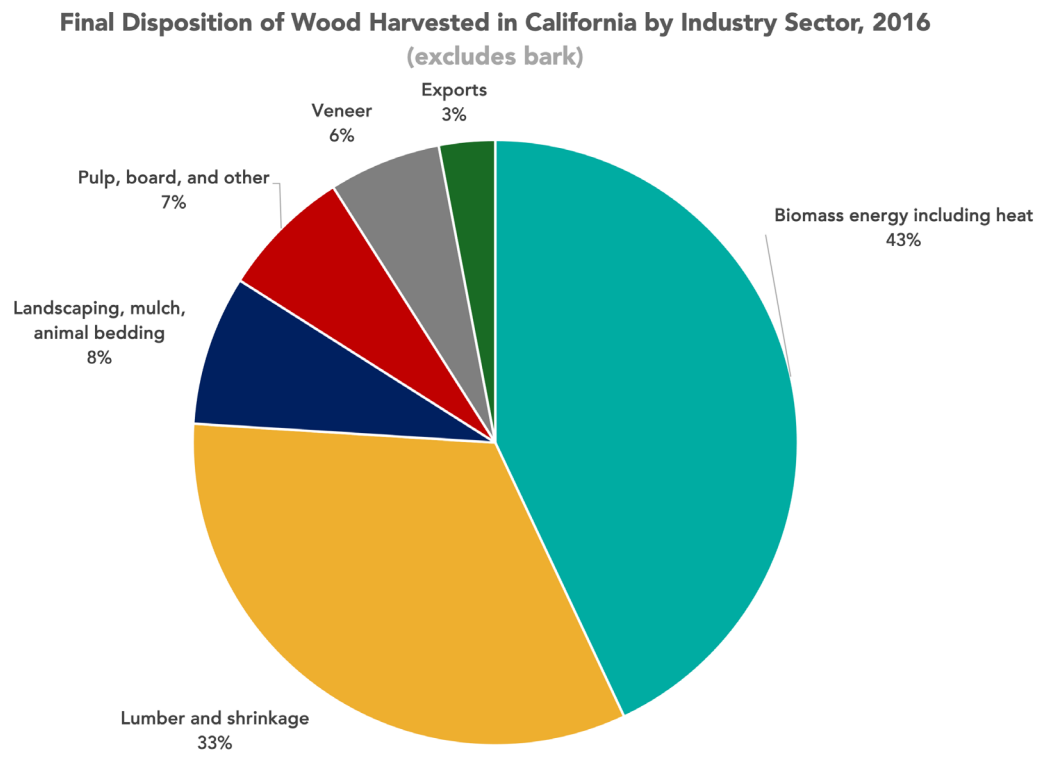
Examination of Market-Based Uses for Woody Biomass

As previously noted, the East Bay is no stranger to wildfire. Following the Oakland Firestorm of 1991, the region has made significant strides in developing management strategies to mitigate wildfire threat. Among many causes of the fire were the highly combustible eucalyptus and Monterey pine trees planted in the area. Native to Australia, an estimated one to three million invasive Eucalyptus seedlings were planted in the East Bay hills between 1910 and 1914, causing an abundance of ecologically problematic and thin tree canopies that are highly prone to fire.[24]

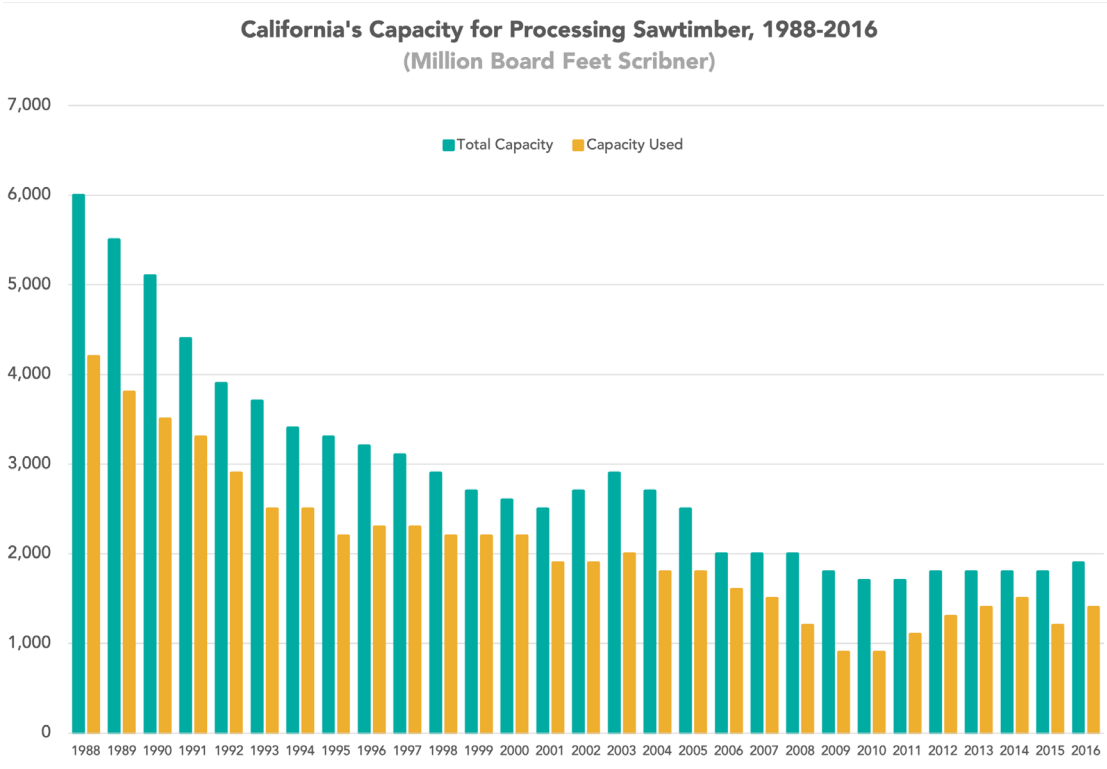
California's Wood Product Industry

Today, California's total timber harvest has fallen to less than a third of what it once was during the 1950s. This contraction has brought with it a reduction in both the scale and variety of wood products California produces, the closure of processing facilities and reduction in the supply of professional foresters, as well as significantly higher fuel loads in forests across the state. Presently, California's approximately 30 sawmills process softwood trees into low and mid-grade lumber and veneer for building, and then use the remaining forest residues to produce biomass energy for operations.[25] Little else is produced with forest products or residues in the state given market conditions, the capacity of existing sawmills, and the overall cost of doing business.

Most bone-dry tonnage produced in the East Bay is logged and turned into wood chips or pellets, a useful product with an established market, but at a cost: wood chipping is less energy dense than biochar or biofuels, and transportation and storage can be challenging, costly, and emissions-intensive. For example, a biochar pilot project in the East Bay Regional Parks District saw a wood volume reduction of 90%, a massive decrease for a district that sends an estimated 600 tons/year of green waste offsite each year.



Source: Chart reproduced from 2017 Montana Economic Report, Bureau of Business and Economic Research, University of Montana



Source: Chart reproduced from 2017 Montana Economic Report, Bureau of Business and Economic Research, University of Montana

SPOTLIGHT

Opportunities for Biochar Usage in EBRPD Operations: Developing a Reliable Supply of Feedstock and Catalyzing Investment

In late 2022, the East Bay Regional Parks District (EBRPD) received a $1 milliongrant from the State Coastal Conservancy to treat 80 acres of predominantly eucalyptus forest in Anthony Chabot Regional Park with the goal of reducing the wildfire threat and improving the forest health on the treated acres. The pilot project also evaluated the viability of biochar (a form of charcoal that offers a wide array of positive benefits for soil and plant health) production on site using the Tigercat 6050, also known as the "Carbonator." Over the course of the project, nearly 2,200 tons of biomass was processed into 88 tons of biochar, tonnage that would have otherwise been hauled off site by dozens of diesel-operated trucks.

The parks district found more than 10 different operations that could benefit from biochar, including: composting, stormwater remediation, landscape development, grazing/marshland rehabilitation, farming operations, forest floor, and public outreach, consuming more than 225 tons of biochar per year. Despite these benefits and potential for carbon sequestration, the biochar market remains nascent. Addressing the following challenges include limited awareness and education, upfront costs, supply chain logistics, sourcing reliable feedstocks, and regulatory frameworks, all of which hinder widespread adoption.[26,27,28,29]

The Private Sector as a Partner

In the heavily populated East Bay, successful commercialization would have the primary benefit of reducing fuel loads and mitigating wildfire risk, a task that landowners, many of whom are public agencies (EBRPD, EBMUD, cities and counties) throughout the region have yet to keep up with. Without enough public dollars to overcome these problems, and with limitations by current agency plans and environmental impact reports (EIRs) (or even potential lawsuits due to public anger for removing trees even until a final plan/EIR for conversion is developed), the public sector cannot solve these problems on its own.

It is going to require a significant effort to create favorable business conditions: a combination of climate-friendly public policy incentives and subsidies must be paired with private sector dollars towards market-ready solutions for woody biomass utilization. Only then can these industries be scaled up to reduce fuel loads.

Many experts agree: key technological breakthroughs to commercialize woody biomass conversion processes have already been made, the bigger issue is finding a reliable revenue stream with a long enough horizon to spur investment.

While most biomass markets remain relatively nascent, private and public sector funding could jointly further existing agricultural applications of biochar as a soil amendment and carbon sequestration tool, as well as further advance gasification techniques for biomass conversion at scale. In one case regarding Red Rock Biofuels (case study featured below), a producer of biofuels that attempted to open a refinery through public grants and private investment, ultimately ran into many obstacles and faced foreclosure after failing to make payments a decade later.

SPOTLIGHT

Lessons from Red Rock Biofuels: Attempts to Fund and Produce Low Carbon Fuels at Scale

Founded in 2011, Red Rock Biofuels was a producer of low-carbon biofuels – the first to gasify woody biomass feedstocks into high quality liquid fuels at a commercial scale. It was born to tackle the growing need for low-carbon fuels and the growing problem of catastrophic wildfires. Red Rock was able to take residual woody biomass and deliver sustainable aviation fuel (SAF) and renewable diesel (RD) in support of the aviation, trucking and other industries striving to reach net-zero emissions.

Over a decade ago, Red Rock started the planning process of a large biofuels refinery in Lakeview, Oregon, finally breaking ground in 2018. Construction was funded by a $75 million award from the Department of Defense, SAF purchase commitments from FedEx and Southwest Airlines, more than $2 million in infrastructure improvements funded by the town of Lakeview and Business Oregon, and about $300 million in tax-exempt economic development bonds issued in 2018 through the state of Oregon. However, in early 2023, before the refinery was set to open, Red Rock faced foreclosure after backers failed to make principal and interest payments on nearly $300 million in debt.

Following threats of foreclosure, Red Rock was acquired by NEXT Renewable Fuels in April 2023. A glimmer of hope to the possibility of converting woody biomass into biofuels at scale, NEXT created a redevelopment plan to complete the construction of the Lakeview site. With local facility permits, state facility permits, and federal facility permits approved, NEXT expects operations to start in late 2025 or early 2026.

If successful, this facility could pave the way for renewed investor and public interest in low-carbon biofuels produced with wood waste; offer a new feedstock to a slowly depleting supply of fats, oils and greases currently used to produce biofuels; and prove that this form of clean energy can be produced at scale.

A Question of Scale

While leveraging the private sector holds immense promise for California's forested landscapes, urban communities in the WUI – like the East Bay hills – present unique challenges. Being heavily urbanized, not as heavily forested, and not as large in scale as say, the Sierra, the East Bay hills present a challenge to developing a critical mass of activity to build a market.

From biochar to biofuels, the economics of processing of excess woody biomass rely completely on very large scales. Roads, staging areas, mobile processing plants, and enough material removal to make the economic pencil out all favor larger operations. In some cases, as with biochar, mobile carbonators can serve to mitigate some of the need for such scale. However, because biochar is inherently a lower-value product and markets have yet to develop, even it is a difficult product to make revenue-positive.

The Sustainable Aviation Fuel (SAF) market is expected to hit $15 billion in revenue by 2035, up from $435 million in 2022. However, existing infrastructure to convert woody biomass into renewable fuels is not local (NEXT Renewables for instance, featured in the case study on the previous page, is located in Oregon), and would require a level of hauling and trucking making the climate benefits negligible. In the future, there could be an opportunity to pool resources from smaller markets like the East Bay Hills and send all feedstocks to one, centrally located facility. But something like this would require significant public and private investment.

Concerns of Resource Extraction on Public Lands

Of course, developing any market with the ability to generate enough profit to offset to costs of fuel reduction means removing materials from public lands. In the case of the National Forests, a well-developed set of rules and regulations exist for this purpose. On other lands, such a precedent may not yet be established, or the removal of materials in exchange for compensation is not allowed at all, such as the case in the East Bay Regional Parks. If markets were to be successfully developed, therefore increasing the scale of materials being removed from public lands, there would almost certainly be increased debate over such policies.

6

Policy Recommendations

1. Update California Air Resources Board (CARB) policies to reflect the carbon intensity of California's forested lands.

Currently, state policy does not have an adequate mechanism for quantifying the carbon intensity of California's forested lands, and therefore does not recognize the enormous amount of greenhouse gasses emissions that are released from wildfire events. Without an adequate accounting of the carbon released during these events, it is impossible to weigh the development of strategies and incentives (and in turn develop markets) to pull excess woody biomass out of California's forests before they burn.

2. Establish regional working groups to bring stakeholders across jurisdictions together and evaluate the appropriate framework for cooperation.

Wildfire does not respect traditional jurisdictional boundaries. This is especially true in the Bay Area, where the nine counties contain 101 cities. To address the unique challenges faced by communities in the Wildland Urban Interface (WUI), these communities should seek to develop frameworks (e.g., an MOU or JPA) to pool resources, coordinate activities and gain economies of scale in hazardous vegetation removal. Critically, these frameworks allow regions to apply for and receive grants as the development of private markets for woody biomass matures.

The success in creating a two-county multijurisdictional wildfire prevention entity in the East Bay Hills under an MOU may prove helpful to similarly complex regions throughout California facing similar land management issues.

3. Directly support these community working groups.

Formally bringing stakeholders together under the recommended frameworks takes professional support. In the case of the East Bay Hills, this professional support was funded by community groups, individuals, foundations, and with a significant contribution from the Bay Area Air Quality Management District. Without professional staffing, consulting, and legal assistance it would be impossible for a collaborative entity focused on wildfire prevention to gain the stature and credibility needed to engage with the private sector about market-based solutions.

4. Partner with and support professional foresters to determine the fuel reduction strategy that works best for the landscape.

There is currently a dearth of professional foresters within the nine-county Bay Area region. This is unsurprising, as prior to repeated catastrophic wildfire seasons the region had little use for such professionals, public or private, and they generally worked in the Sierra or other large ranges with significant National

Forest. However, working with professional foresters will be essential moving forward to efficiently manage fuel reduction projects. The U.S. Forest Service is currently moving forward with using its lands as laboratories to test market-based ideas, like using national forests for biomass utilization, fuels treatments, and carbon credits pilots.[30] Professional foresters who understand the relationship between providers and beneficiaries of wood products will achieve greater success in fuel reduction and wood utilization efforts in the East Bay.

5. Examine and potentially modify existing laws and regulations to allow for reasonable extraction and sale of woody biomass and its byproducts from public lands within or adjacent to the Wildland Urban Interface (WUI).

Public lands within or adjacent to the WUI – such as regional parks – generally do not allow the removal and sale of materials like National Forests do. Historically this was good policy, however with more fuel reduction projects than public dollars alone can achieve, it's time to rethink how private sector investment could be brought to bear.

6. Consider supporting biopower projects to achieve near-term fuel reduction goals and utilize excess woody biomass.

Biopower plants have powerful benefits for the objective of utilizing biomass, and in smaller communities they can even be competitive as an energy source. They serve existing energy markets, are rapidly scalable, and emit far fewer particulates and carbon emissions than forest residues burning through wildfire. No other technology can consume as much biomass, as soon, for as safe an investment. However, they often face extraordinary permitting requirements and lengthy delays in development, leading to fewer biopower plants than there might otherwise be. To quickly utilize additional woody biomass, regulatory and permitting guidelines should be analyzed and potentially relaxed so that more facilities can be developed.

7. Update the Federal Renewable Fuels Standard (RFS) and California's Low Carbon Fuels Standard (LCFS) to be fuel agnostic.

The RFS and LCFS should be amended to treat low-carbon biofuels and the technology used to produce them more favorably. Existing incentives for biofuels favor biodiesel production for trucks and other wheeled transport at the expense of things like sustainable aviation fuels (SAF). Policy should not pick winners this early on in low-carbon fuel commercialization efforts.

8. Support the nascent industries working to commercialize products developed using excess woody biomass at all levels.

Successfully developing and commercializing products from excess woody biomass, such as biochar and low-carbon fuels, will take a concerted and sustained effort over the course of many years. The successful commercialization of these products could go a long way in supporting California's fuel and GHG reduction goals. Therefore, the state should support these efforts with all the policy levers available to it, including grants, subsidies, regulatory support, and agency support and facilitation. Partnering with companies with successful facilities in other states (like NEXT Renewables in Oregon) could allow California to adopt best practices and increase the likelihood of success in scaling up emerging industries.

9. Work to connect potential end-users to emerging industry.

Many of the emerging products being developed using excess biomass have a number of uses that are not yet readily known by potential end users. For example, biochar can be used to increase crop yields, treat wastewater, and potentially even reduce the CO2 emissions of structural concrete. Low-carbon biofuels like renewable diesel (RD) and sustainable aviation fuel (SAF) can reduce the climate impact of bus fleets, heavy industry, and the aviation sector where a transition to electrification is currently impossible. Some refiners in the Bay Area are expanding commercial scale production of RD, like Philips 66, whose Rodeo facility now only processes renewable feedstocks, producing 30,000 barrels of RD per day.[31] The Rodeo facility is also expected to start production of SAF later this year. By connecting potential end users to emerging industry through tradeshows, awareness campaigns, or otherwise, the transition phase can be accelerated.

Appendix

Appendix Figure 1. Reference map of the Bay Area and its subregions

Source: Wikipedia Commons

Endnotes

1. Stephens, Scott L., Martin, Robert E., and Clinton, htm. Nicholas E. (2007) Prehistoric fire area and emissions from California's forests, woodlands, shrublands, and grasslands. Forest Ecology and Management 251. Accessed at: https://nature.berkeley.edu/stephenslab/ wp-content/ uploads/2015/04/Stephens-et-al.-CA-fire- area-FEM-2007. pdf
2. $3.4 billion in 2023 inflation-adjusted dollars using Consumer Price Index.
3. Estimate from RMS. Accessed at: https://www. insurancejournal.com/news/west/2020/12/15/594028.htm
4. United States Environmental Protection Agency, Climate Change Indicators.
5. Hulley, G.C., Douset, B., & Kahn, B.H. (2020). Rising trends in heatwave metrics across Southern California. Earth's Future, vol. 8. Accessed at: https://agupubs. onlinelibrary. wiley.com/doi/epdf/10.1029/2020EF001480.
6. Goldenstein, Taylor. "Denser California forests raise firefighting questions, study says," Los Angeles Times, January 19, 2015.
7. Data taken from National Interagency Coordination Center, Wildland Fire Summary and Statistics Annual Report, 2020.
8. Radeloff, V. C., D. P. Helmers, H. A. Kramer, M. H. Mockrin, P. M. Alexandre, A. Bar-Massada, V. Butsic, T. J. Hawbaker, S. Martinuzzi, A. D. Syphard, and S. I. Stewart. 2018. Rapid growth of the U.S. Wildland Urban Interface raises wildfire risk. Proceedings of the National Academy of Sciences, 115(13): 3314-3319.
9. https://tssconsultants.com/wp-content/uploads/2016/09/ HEF-final-report-20160817.pdf
10. https://www.fire.ca.gov/what-we-do/ natural-resource-management/fuels-reduction
11. https://static1.squarespace.com/ static/586eba3b15d5db8b6432c77d/t/6266e5d2c2744b35 7a4aaa72/1650910726895/Turning+Wildfire+Tinder+Into+ Low+Carbon+Fuels_White+paper+for+Policymakers.pdf
12. https://static1.squarespace.com/ static/586eba3b15d5db8b6432c77d/t/6266e5d2c2744b35 7a4aaa72/1650910726895/Turning+Wildfire+Tinder+Into+ Low+Carbon+Fuels_White+paper+for+Policymakers.pdf
13. https://www.scienceforconservation.org/products/ accelerating-forest-restoration
14. Canadian Wildland Fire Information System, 2023
15. https://www.iawfonline.org/ article/2020-01-profile-jurisdictional-complexity-wildfire/
16. EBRPD BIOCHAR PILOT REPORT
17. https://bof.fire.ca.gov/media/oobbtosm/thengane_2021_ ca_biochar_market-002-_ada.pdf
18. https://static1.squarespace.com/ static/586eba3b15d5db8b6432c77d/t/6266e5d2c2744b35 7a4aaa72/1650910726895/Turning+Wildfire+Tinder+Into+ Low+Carbon+Fuels_White+paper+for+Policymakers.pdf
19. https://link.springer.com/article/10.1007/ s11274-021-03102-6
20. https://news.mit.edu/2023/ making-aviation-fuel-biomass-0823
21. https://www.sciencedirect.com/science/article/abs/pii/ S0961953420304748
22. The Claremont Canyon Conservancy by Jerry Kent, former AGM at the EBRPD.
23. Turner, Ani. "The Business Case for Racial Equity: A Strategy For Growth." National Civic League. W.K. Kellogg Foundation, April 2018. https://www.nebip.org/ wp-content/uploads/2018/04/BCRE-National-Report.pdf.
24. https://slicesofbluesky.com/eucalyptus-in-east-bay-hills/
25. 2017 Montana Economic Report, Bureau of Business and Economic Research
26. https://www.oregonlive.com/business/2023/01/ never-opened-300-million-plus-biofuels-refinery-facing-foreclosure-in-southern-oregon.html
27. https://nxtclean.com/projects-facilities/lakeview-rng/
28. https://www.columbiacountyspotlight.com/news/ next-moving-forward-on-clatskanie-lakeview-projects/ article_1a15d66c-b961-11ee-83cb-bfcd1b6a6a77.html
29. https://oregonbusiness.com/tech-acquisition-company-cancels-merger-with-nxtclean-fuels-formerly-next-renewable-fuels/
30. https://www.fs.usda.gov/speeches/ forest-services-role-markets-ecosystem-services
31. https://investor.phillips66.com/financial-information/news-releases/news-release-details/2024/Phillips-66-Announces-Major-Milestone-in-Production-of-Renewable-Diesel/ default.aspx

Image Credits

Cover: Photo of Carbonator by East Bay Regional Parks District, accessed via www.dropbox.com/scl/fo/ gzrikf509jvzytmdfujd0/h?rlkey=kjyr3o43d3r4c5sc3p6776m lk&dl=0

Page 6: Photo by Christina Amaretto on Unsplash

Page 7: Photo by Rod Stevenson on Unsplash

Page 8: Photo by Ross Stone on Unsplash

Page 12: Photo by Marcus Lenk on Unsplash

Page 14: Photo by Memento Media on Unsplash

Page 15: Photo by Dominic Krainer on Unsplash

Page 21: Photo by Hannah Busing on Unsplash

Page 25: Photo by Christian Andrade on Unsplash

Page 26: Photo by Israel Palacio on Unsplash

Bay Area Council Economic Institute
The Historic Klamath, Pier 9, San Francisco, CA

www.bayareaeconomy.org
bacei@bayareacouncil.org
@bayareaeconomy