Redefining the Wildfire Problem and Scaling Solutions to Meet the Challenge
February 14, 2024
By Ralph Bloemers[1]

Introduction: Our Current Landscape

As the climate warms, extended drought and heat events in the United States are driving an increase in acres burned and homes lost to wildfire. The most devastating wildfires happen when dry winds carry embers long distances, start new spot fires and enter into communities and ignite homes. Burning homes then become the fuel that ignites other nearby homes, causing mass conflagrations. Destructive wildfires are happening more often, burning longer and more intensely, and emerging in places not historically prone to wildfire or mapped as being at risk.

The last five years have broken barriers in fire history. For example, the 2018 Camp Fire burned over 18,000 structures in and around the town of Paradise, California, and took 85 lives. The 2020 Labor Day Fires in Oregon burned over a million acres and destroyed communities identified as low risk. In 2021, the Dixie Fire became California's largest single fire in recorded history,[2] and the Marshall Fire destroyed more structures than any other fire in Colorado history. Over the decade ending in 2020, the western US suffered a 246 percent increase in structures lost to wildfires.[3]

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[1] The author wishes to thank Dr. Jack Cohen, Research Physical Scientist, U.S. Forest Service (Ret.), John Comery, Fire Investigator, United States Bureau of Alcohol Tobacco and Firearms, Drs. Beverly Law and Christopher Dunn, Oregon State University, and many others that have contributed to his better understanding of this subject matter.

[2] Branson-Potts, Hailey. 2021. "Dixie Fire races toward Susanville, forcing some residents to evacuate." The San Diego Union-Tribune, August 18. https://www.sandiegouniontribune.com/news/california/story/2021-08-18/dixie-fire-races-toward-susanville-forcing-some-residents-to-evacuate

[3] Headwaters Economics. (2020, July 14). Communities threatened by wildfires, 2000-2019. https://headwaterseconomics.org/natural-hazards/wildfire-near-communities/ (last accessed on October 10, 2023)

Higuera, P. E., Cook, M. C., Balch, J. K., Stavros, E. N., Mahood, A. L., & St Denis, L. A. (2023). **Shifting social-ecological fire regimes explain increasing structure loss from western wildfires.** Proceedings of the National Academy of Sciences - PNAS Nexus, 2(3). https://doi.org/10.1093/pnasnexus/pgad005

In 2023, smoke drifting hundreds of miles from Canadian fires caused New York City to have the worst air quality in the world. And in early August, the Hawaii Firestorm was a repeat of the Paradise disaster, as wind drove fire into Lahaina and caused structure-to-structure ignition, leaving at least 97 people dead and dozens still missing. In Canada this year, over 45 million acres burned and entire communities were evacuated.

Today wildfire is largely approached as a problem that can be controlled through vegetation treatments and firefighting, but those strategies have reached their limits in a changing climate and they have not prevented the loss of homes and entire communities. To prevent community destruction, experts in wildfire, forests and home safety are telling us that we need to reduce human ignitions, focus on preparing communities to be ignition resistant, recalibrate our suppression activities, grow and adapt our workforce and be ready for more fire on the land.[4]

However, new observational and analytical tools and recent events have given firefighters, governments, and the public a better understanding of the dominant causes of community destruction from wildfire and how to better prepare for and prevent destruction before fire comes. By redefining the wildfire problem as one of too many human caused-ignitions in the wrong place and the wrong time, and one of homes and communities that are vulnerable to inevitable wildfires, experts say that we can prepare communities for more smoke on the land and to survive even extreme fires while safely reintroducing fire to the land.[5]

Leaders within the fire community are embracing paradox and trying to shift the fire story to support the return of beneficial fire to the land while simultaneously preparing

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[4] Cohen, J. Undated. A More Effective Approach for Preventing Wildland-Urban Fire Disasters. https://static1.squarespace.com/static/61ef51b68cfef85e3fed8d43/t/6340520e899c747a294725bf/1665159696338/Dr.+Jack+Cohen+Wildland+Urban+Fire+Primer+for+Elemental+Viewers.pdf

National Fire Protection Association (NFPA). Undated. "Preparing homes for wildfire." https://www.nfpa.org/Public-Education/Fire-causes-and-risks/Wildfire/Preparing-homes-for-wildfire

[5] Schwartz, M. W. and A. D. Syphard. 2021. Fitting the solutions to the problems in managing extreme wildfire in California. Environmental Research Communications 3(8): 1005. https://iopscience.iop.org/article/10.1088/2515-7620/ac15e1

Siegler, K. 2021. "Winds Have Been High as the Caldor Fire Threatens California's South Lake Tahoe." NPR, August 31. https://www.npr.org/2021/08/31/1033002680/winds-have-been-high-as-the-caldor-fire-threatens-californias-south-lake-tahoe

Trisos, C. H., C. Merow, and A. L. Pigot. 2020. The projected timing of abrupt ecological disruption from climate change. Nature 580: 496–501. https://www.nature.com/articles/s41586-020-2189-9

US Forest Service. 2023. Confronting the Wildfire Crisis. https://www.fs.usda.gov/managing-land/wildfire-crisis

communities to be ready for more smoke. Fire management and suppression are evolving to include containment within a perimeter, and letting fire do its work in maintaining natural systems. Firefighters and experts in home assessment are empowering homeowners to prepare their homes to be resistant to igniting in ember storms, and entrepreneurs are harnessing technology to improve situational awareness before, during, and after fire comes.

The impacts of wildfire events have no boundaries. Fire is inevitable, and putting out all fires is impossible. The good news is that preventing community destruction is possible, even in the most extreme conditions. While many strategies may have impact, given limited resources and time ***it is imperative to prioritize the most durable and effective solutions.*** For society to move from unpredictable disasters to prepared and resilient communities that can weather extreme events, policymakers, agencies, and the public will all need to accept inevitable fires and smoke and embrace a new approach to living with fire.

Key Principles.

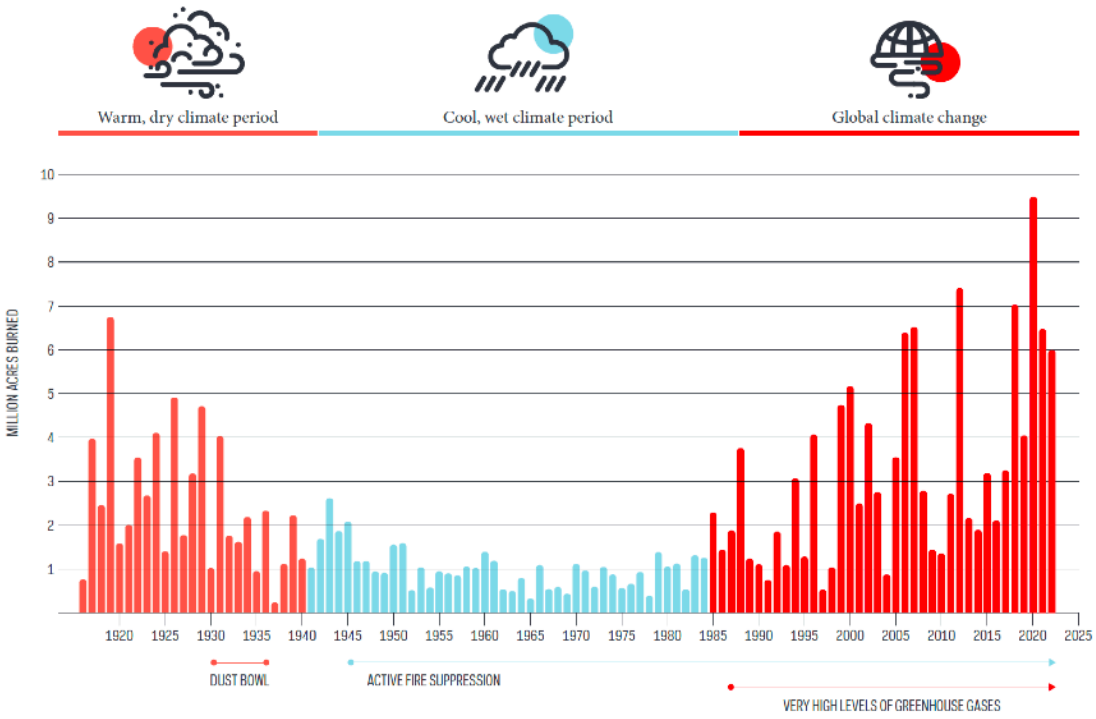
Wildfire History Tells Us That Fires Are Inevitable, Natural Part of Landscape, Largely Driven by Climate.

Wildfires started by people and lightning have been part of the North American landscape since the retreat of ice sheets in the Pleistocene. As settlers colonized the American West, they viewed fire as a destructive force to be controlled and eliminated. In 1850 the governments passed laws and took actions outlawing indigenous fire practices that had been used for thousands of years. After World War II, fire suppression ramped up, just as a cool, wet period from the 1940s to the 1980s gave firefighters a helping hand. These events underpinned the dominant cultural belief that the solution to wildfire is controlling it - either through suppression or vegetation management.

While the annual acres burned since the 1980s have gone up considerably, creating the impression that the amount of fire on the land is unprecedented, ***the amount of acreage burned is a continuation of earlier fire history.*** A review of fire history from the early 1900s confirms that drought and wind—which are increasing in a hotter climate—play an outsize role in the amount of fire on the landscape. New studies and data analysis are teaching us to focus on the dominant role of wind and drought in destructive fires, not on acres burned.

FIRE SUPPRESSION GOT A HELPING HAND

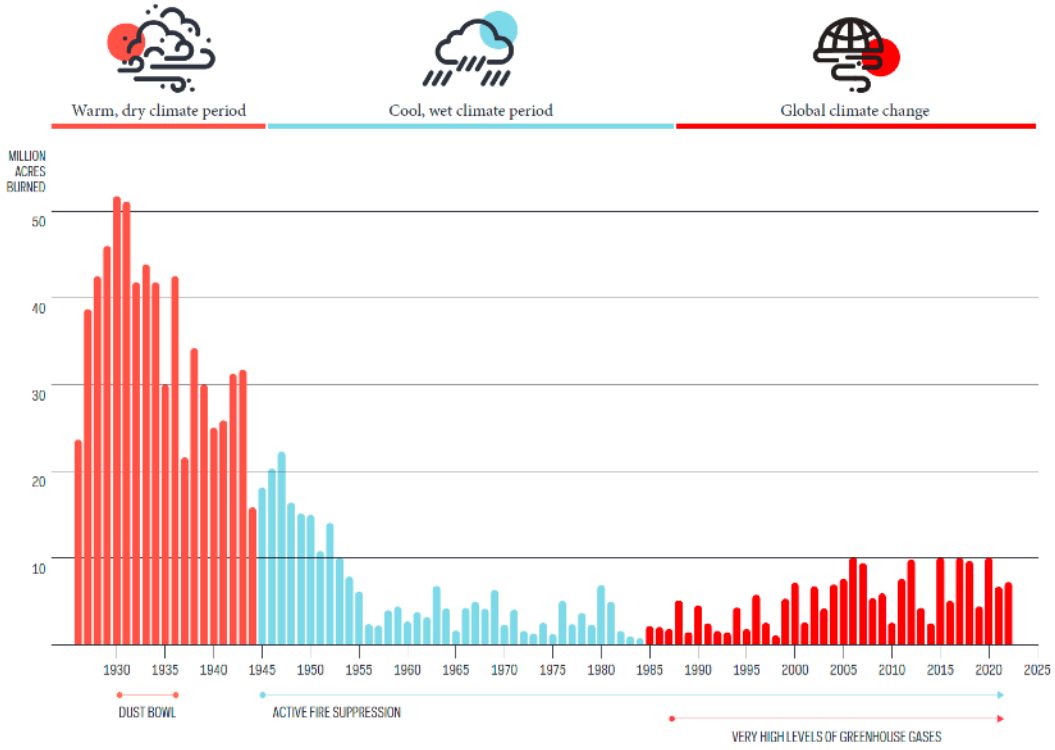
WESTERN U.S. Arizona, California, Colorado, Idaho, Montana, Oregon, New Mexico, Nevada, Utah, Washington, Wyoming



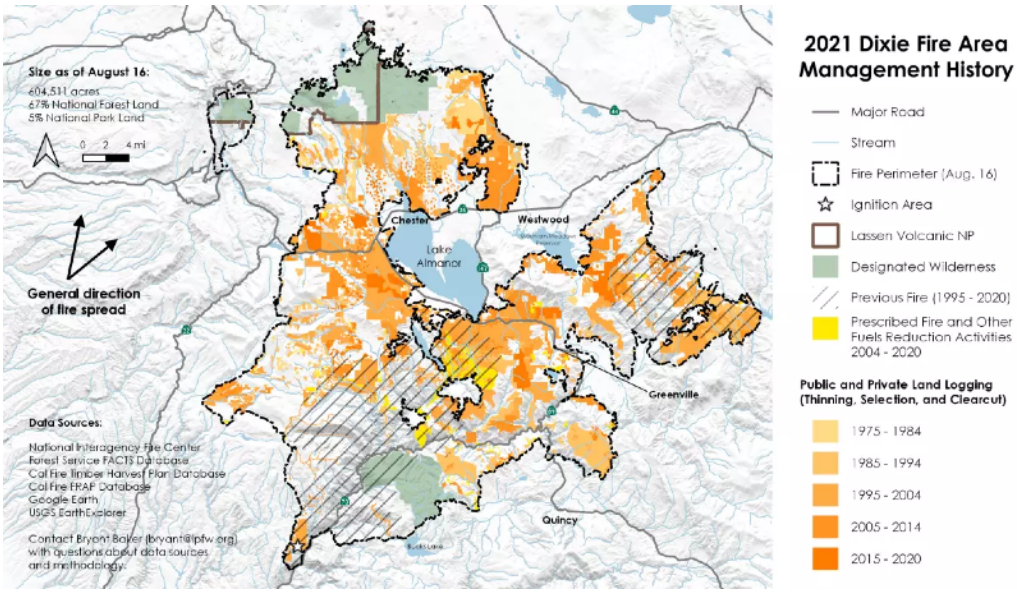
Source: National Interagency Fire Center; nifc.gov, ncdc.noaa.gov/teleconnections/pdo/; Dr. Paul Hessburg, May 2019 testimony to Oregon's Wildfire Response Council

TOTAL U.S. WILDFIRE ACRES 1926-2022

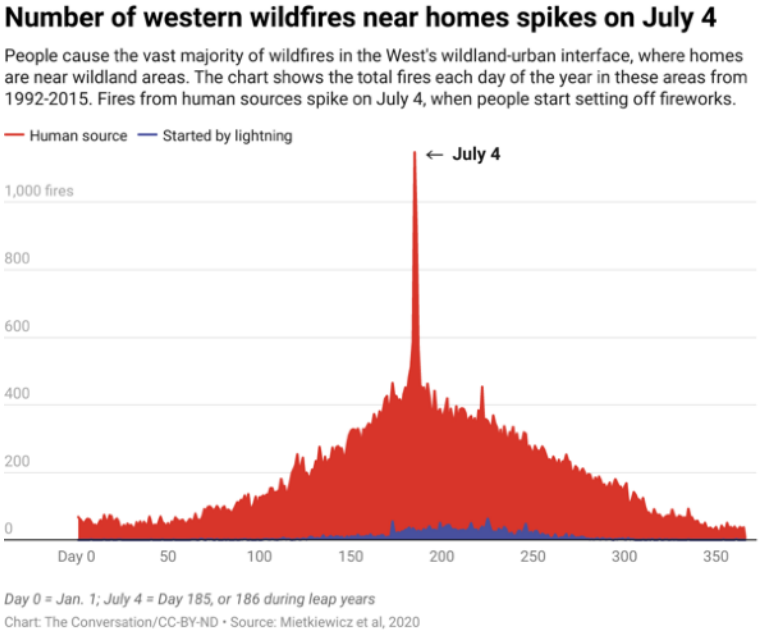
Source: National Interagency Fire Center; nifc.gov



The challenge today is that there are many more communities in the path of these fires. The result: a devastating increase in homes lost, lives lost, and communities destroyed. In the last several years, more communities across the globe have experienced extreme fire behavior and rapid fire spread. The Dixie fire in California, for example, skipped over treated areas, fuel breaks, and roads, and its glowing embers traveled long distances to ignite new spot fires. Strong winds drove the fire and embers into the town of Greenville, igniting homes and creating a domino effect in which flaming homes ignited other homes (Branson-Potts 2021).



A review of the recent destructive fires reveals the dominant influence of downslope winds and drought, which reduces the moisture in dead vegetative fuel, live fuel, and soil. Lack of moisture changes the fire dynamics of fuels, leading to increased fire intensity, energy release, and ignition from wind-borne embers through spotting.[6] ***Wind-driven fires have led to mass urban conflagrations, and most destructive fires have occurred in grasslands and shrublands rather than forests*** (Schwartz and Syphard 2021). Many fires were ignited by live power lines (Gabbert 2021), and most were started by people.



[6] Extreme fire spread events and area burned under recent and future climate in the western USA, Coop et al. 2022, https://onlinelibrary.wiley.com/doi/full/10.1111/geb.13496

Attempts to Control Vegetation Away from Homes & Communities Is Expensive, Unworkable, and Largely Irrelevant to Preventing Home & Community Destruction.

Recent fires have challenged attempts to define and limit the risk to a specific "wildland fire season" or a specific ecosystem type. There is no longer an off-season for wildfires, and they are not confined to forests. The Hawaii Firestorm, the Marshall Fire in the Front Range of Colorado, and the 2020 Almeda Fire in Talent and Phoenix, Oregon, are all part of a pattern and trend of urban mass fire disaster. A focus on forest management ignores the reality that all vegetation types can generate burning embers that ignite homes, and most loss occurs in grassland and shrublands. Besides, many Western states have millions of acres of privately owned and heavily managed tree plantations that are logged on short rotations, and ***these plantations burn faster and hotter than naturally regenerated forests*** (Zald and Dunn 2018, Levine et al 2022).[7]

RESEARCH COMMUNICATIONS 1

Higher incidence of high-severity fire in and near industrially managed forests

Jacob I Levine[1,2*], Brandon M Collins[2,3], Zachary L Steel[2], Perry de Valpine[2], and Scott L Stephens[2]

The increasing prevalence of high-severity wildfire in forests in the US state of California is connected to past forest management, but uncertainty remains regarding the differential effects of land ownership on these trends. To determine whether differing forest management regimes, inferred from land ownership, influence high-severity fire incidence, we assembled and analyzed a large dataset of 154 wildfires that burned a combined area of more than 971,000 ha in California. We found that where fires occurred, the odds of high-severity fire on "private industrial" lands were 1.8 times greater than on "public" lands and 1.9 times greater than on "other" lands (that is, remaining lands classified as neither private industrial nor public). Moreover, high-severity fire incidence was greater in areas adjacent to private industrial land, indicating this trend extends across ownership boundaries. Overall, these results indicate that prevailing forest management practices on private industrial timberland may increase high-severity fire occurrence, underscoring the need for cross-boundary cooperation to protect ecological and social systems.

Front Ecol Environ 2022; doi:10.1002/fee.2499

As to the effectiveness and likelihood that thinning forests might have an impact on fire behavior in forests, the area thinned at broad scales across the United States' public forests to reduce fuels has been found to have little relationship to area burned. ***At subregional to regional levels, roughly 1 percent of treatments (thinning and prescribed fires) experience wildfire each year, and the effectiveness of treatments is only 10 to 20 years, so the treatments likely have little effect on wildfire*** (Campbell et al. 2012, Schoennagel et al. 2017).

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[7] Higher incidence of high-severity fire in and near industrially managed forests https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1002/fee.2499

While there may be a reason to intervene in some degraded or altered ***dry forest types***, there are significant costs to forest carbon, soil, wildlife and other values (See appendices). Leaving those ecological and climate costs to the side, ***dry forest types that may be a candidate for interventions are in the minority — they make up less than 1/3 of our forested landscapes nationwide.*** We hear a lot of talk about "unnaturally dense forests" and the potential for "wildlands that have not seen enough fire" to burn severely. These statements evince an excessive focus on low intensity surface fire regimes, even though most western forest types have historically supported mixed intensity and stand replacement (crown fire) fires (Schmidt et al. 2002) where forest thinning is not appropriate. Restoring ecologically appropriate wildland fire in mixed intensity and high intensity fire regimes do not necessarily involve or require low intensity fires. More importantly, disastrous home and community fire destruction has only occurred during extreme wildfire conditions regardless of whether the fire is burning in grasslands, shrub lands or conifer forests and regardless whether those forests have been thinned or have continuous canopies. Efforts to engage in forest fuel treatments, whether effective or not for protecting wildland values, have proven themselves to be irrelevant for preventing destruction of homes and communities.

In the Pacific Northwest's mesic, temperate rainforests (and other forests like them) efforts to thin forests in the hope that so doing will affect future fire behavior are not even a relevant pursuit or conversation. Why?

1. **Wind Events with Fire in Them.** Large fires have occurred in Oregon westside forests since 1500 and will continue to do so. The 2017 Eagle Creek fire and the 2020 Labor Day fires are emblematic of the kinds of fires that occur in these richly vegetated landscapes. ***These events are dominated by large downslope wind events when combined with an ignition results in big fires that have rapid rates of spread.*** As Dan Donato and Joshua Halofsky describe them - these are "wind events with fire in them."[8]

2. **Suppression Has Limited Utility in Wind Driven Fires.** While fire suppression actions are successful at putting out fires, oftentimes the suppression actions are largely containment actions involving attempts to let the fire burn out within a perimeter. ***Suppression and containment can work, except when the wind picks up and the fire breaks through.*** Take the Camp fire in the Bull Run in the summer of 2023, which worked as there was no significant wind event and the rains eventually came and put the fire out. However, fire containment efforts on the 2022 Cedar Creek fire outside of Oakridge, Oregon were challenged by red flag conditions and the fire was driven by wind over containment lines, fuel breaks and areas that had vegetation treatment. The wind drove significant fire spread beyond the lines.

3. **Industrial Plantations Dominate Landscape and Burn At High Severity.** The forests in Western Washington and Oregon in 2023 are not the same as the forests of 1500, 1600, 1700 and never will be. These forests are crisscrossed by roads and powerlines, older forests have been cut down and replaced with young plantations. In Oregon, around 6.8 million acres of nearly 11 million acres of private forestland are managed as tree plantations. In Washington nearly 3 million of 4 million acres of private forestland are managed as tree plantations. ***These lands are in and around communities and from a fire risk perspective they are like fields of stacked pallets, with an elevated risk of severe fire.*** These lands will very likely continue to be managed for commodity production.

4. **Dry Synoptic Winds Drive Fires in Westside Forests.** Large westside forest fires are the result of dry synoptic winds and suppression is ineffective during those events. Likewise, forest thinning for fire protection is ineffective, cost prohibitive, and an unattainable goal in these westside forests. As one expert stated in a recent article in the Oregonian:

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[8] Western Washington wildfires: Managing the risk Daniel Donato and Joshua Halofsky Washington State Department of Natural Resources, November 2019, https://www.nnrg.org/wp-content/uploads/2019/12/Donato_Halofsky_20191105-1.pdf

"Meanwhile, (Daniel) Donato and other researchers suggest that treating big portions of the west side forests through thinning, prescribed burns and other fuel reduction efforts is an impractical, Sisyphean task." "The scale of the problem is so vast, Donato said, and the forests so biologically productive, that "***even if we somehow miraculously caught up with fuels reduction on the west side, it would grow back in a matter of years. It's not even relevant to the west side. It doesn't even need to be a conversation."*** (Oregonian).[9]

5. **Not Practical or Scientifically Defendable.** The scientific consensus on the futility of thinning westside forests is well established. As stated in Reilly et al. 2022: "manipulation of stand structure is unlikely to mitigate fire effects in wind-driven fires on the westside given the minimal differences in burn severity among stand structure classes." This same finding was noted in Evers et al. 2022: "Given the wind-driven nature of fire spread common to these megafires and the heavy fuel loads of these mesic temperate rainforests that are quick to regrow fuels after fuel reduction treatments, **our view is that it is not practical nor scientifically defendable to prevent large conflagrations by mechanically reducing fuels or prescribing fires."**[10]

6. **Costs are Far Beyond Budgets.** Effectively addressing the current backlog of fuels reduction treatments - just on dry forests - as well as the ongoing maintenance of those treatments requires investments at an unprecedented scale. The Forest Service alone has set a goal of using thinning and beneficial fire to treat 20 million acres of national forest land and to support the treatment of 30 million acres of other federal, state, Tribal, and private lands over the next decade in order to mitigate wildfire hazard in the highest priority landscapes (USFS, 2022c).[11] DOI has also identified needs to implement more active management work to maintain past treatments and address additional areas to reduce wildfire risk and improve wildfire resilience (United States Department of the Interior [DOI], 2022). This potentially amounts to enormous costs, with estimates for prescribed fire ranging from $125 to $489 per acre and mechanical thinning ranging from $700 to more than $2,000 per acre (CBO, 2022). Congressman Bruce Westerman recently stated:

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[9] Oregon's historic wildfires: unusual but not unprecedented. https://www.oregonlive.com/news/2020/09/oregons-historic-wildfires-the-unprecedented-was-predictable.html

[10] Extreme Winds Alter Influence of Fuels and Topography on Megafire Burn Severity in Seasonal Temperate Rainforests under Record Fuel Aridity, https://www.mdpi.com/2571-6255/5/2/41

[11] ON FIRE: The Report of the Wildland Fire Mitigation and Management Commission https://www.usda.gov/sites/default/files/documents/wfmmc-final-report-092023-508.pdf

> "If this same funding structure was applied to the 80 million acres of U.S. Forest Service (USFS) lands at high risk for wildfire, it would cost USFS $144 billion to treat all of their lands, not to mention the 54 million acres of land at high risk of fire under Department of Interior management. To put that in context, the entire annual budget for USFS is less than $8.3 billion. These staggering costs are intricately connected to poor policy and planning and are untenable."[12]

A 2001 Forest Service study[13] estimated there were 68 million acres in fire regime condition class 2 (elevated risk) and 34 million acres in fire regime condition class 3 (most elevated risk) on national forest land in the lower 48 States. The study found: "that equates to about 102 million acres of FS land that have missed two or more expected burning cycles, leading to systemic forest health problems and, in areas where frequent, low intensity fire should occur, hazardous fuel accumulation and an increased chance of uncharacteristically severe fire." If the objective were to restore all national forest lands to fire regime condition class 1 ***it would take 60 years to initially treat condition class 2 and 3 fuels, and 90 years if the agency also wished to keep the relatively safe condition class 1 fuels from growing into dangerous conditions."***

Significant Tension Between Managing Forests for Increased Carbon Storage and Thinning Forests to Attempt to Alter Future Fire Behavior. (See Appendix 3 for detailed analysis)

When forests are thinned through the harvesting of trees, carbon previously stored in the trees is released into the atmosphere (Law et al. 2022). ***Studies show that up to five times more carbon is released by thinning trees than by fire*** (Bartowitz et al. 2022). Mature and older trees contain the nation's greatest carbon stores—up to half of the carbon on the landscape—and it takes generations for newly planted trees to make up for these net increases in carbon emissions.

Severe ecological disruption is expected to accelerate in the coming decades (Trisos et al. 2020). The 2040s are projected to reach 2° Celsius of warming with respect to pre-industrial

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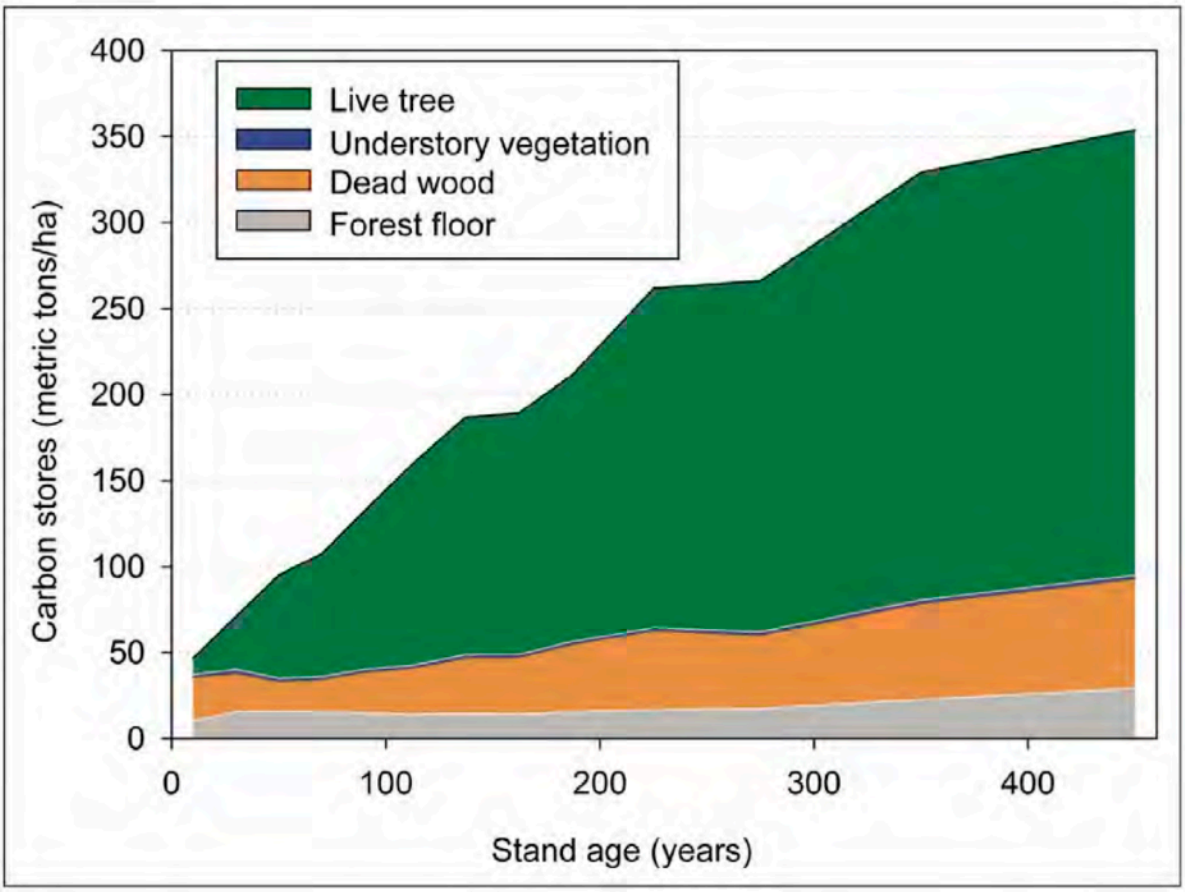
[12] Westerman Releases Statement Ahead of 2023 Fire Season https://naturalresources.house.gov/news/documentsingle.aspx?DocumentID=413384 (Note: Congressman Westerman was drawing upon cost figures from a project in Colorado. The author cites to this statement for illustrative purposes, not because he necessarily agrees or disagrees with the Congressman's policy prescriptions.)

[13] Office of Inspector General Audit - Audit Report - Forest Service - Large Fire Suppression Costs Report No. 08601-44-SF - November 2006 available at: https://www.fs.usda.gov/sites/default/files/media_wysiwyg/fs_large_fire_suppression_costs_oig_audit_final_report_11-20-06.pdf (Note: the author makes no representation about the accuracy or utility of Fire Regime Condition Class (FRCC) modeling and classifications for informing decisions about what forests are out of balance, and may benefit from intervention. Nor does the author opine about the embedded assumptions or rhetoric contained in the medicalized language used (e.g. forest "treatments").

levels, which will exacerbate climate impacts including heat stress and fire danger (Park et al. 2023) and reduce the habitability of some areas for large populations.

To avoid the worst consequences of climate change, the Intergovernmental Panel on Climate Change has underscored the immediate need to significantly reduce emissions and allow natural ecosystems to continue to store carbon (IPCC 2022). ***Permanent protection of mature and old forests is particularly important, as these forests account for a majority of terrestrial carbon stocks and accumulation*** (Law et al. 2022, 2021).

Natural ecosystems are the low-hanging fruit. Existing technology and Earth observations have not been tapped to their full potential to assist us in identifying forests that are the best able to withstand changes. New technologies to remove carbon dioxide from the atmosphere have not been proven to keep it out of the atmosphere and are not to scale (Law et al. 2022, Foley 2023). The climate crisis requires more human intelligence, analysis, and meaningful individual, local, state, and federal action focused on solutions that are durable, scalable, and effective over space and time.



People & Utilities are Primarily Responsible for Wildfire Ignitions.

For almost 80 years, Smokey Bear has been the face of public awareness campaigns asking people to be careful with fire, yet most fires are still caused by people—often through escaped campfires, careless use of fireworks, or energized power lines failing during wind events. Powerline fires have been and continue to be responsible for mass urban fire conflagrations - Tubbs (Santa Rosa, CA), Camp (Paradise, CA), Almeda (Talent & Phoenix, Oregon, Babb (Malden, WA), Marshall (Boulder, CO), Lahaina (Maui), Grey Fire (Spokane, WA). Since 2015, energized power lines have been responsible for 8 of 20 of California's most destructive fires.[14] On average powerline ignited fires are 10 times the size of fires ignited by other sources.[15] Why? Because these fires are ignited during wind events.[16]

Top 20 Most Destructive California Wildfires

	FIRE NAME *(CAUSE)*	DATE	COUNTY	ACRES	*STRUCTURES*	DEATHS
1	**CAMP** *(Powerlines)*	November 2018	Butte	153,336	**18,804**	85
2	**TUBBS** *(Electrical)*	October 2017	Napa & Sonoma	36,807	**5,636**	22
3	**TUNNEL - Oakland Hills** *(Rekindle)*	October 1991	Alameda	1,600	**2,900**	25
4	**CEDAR** *(Human Related)*	October 2003	San Diego	273,246	**2,820**	15
5	**NORTH COMPLEX** *(Lightning)*	August, 2020	Butte, Plumas, & Yuba	318,935	**2,352**	15
6	**VALLEY** *(Electrical)*	September 2015	Lake, Napa & Sonoma	76,067	**1,958**	4
7	**WITCH** *(Powerlines)*	October 2007	San Diego	197,990	**1,650**	2
8	**WOOLSEY** *(Electrical)*	November 2018	Ventura	96,949	**1,643**	3
9	**CARR** *(Human Related)*	July 2018	Shasta County, Trinity	229,651	**1,614**	8
10	**GLASS** *(Undetermined)*	September 2020	Napa & Sonoma	67,484	**1,520**	0
11	**LNU LIGHTNING COMPLEX** *(Lightning / Arson)*	August 2020	Napa, Solano, Sonoma, Yolo, Lake, & Colusa	363,220	**1,491**	6
12	**CZU LIGHTNING COMPLEX** *(Lightning)*	August 2020	Santa Cruz, San Mateo	86,509	**1,490**	1
13	**NUNS** *(Powerline)*	October 2017	Sonoma	44,573	**1,355**	3
14	**DIXIE** *(Under Investigation)**	July 2021	Butte, Plumas, Lassen, & Tehama	963,309	**1,311**	1
15	**THOMAS** *(Powerline)*	December 2017	Ventura & Santa Barbara	281,893	**1,063**	2
16	**CALDOR** *(Human Related)*	September 2021	Alpine, Amador, & El Dorado	221,835	**1,005**	1
17	**OLD** *(Human Related)*	October 2003	San Bernardino	91,281	**1,003**	6
18	**BUTTE** *(Powerlines)*	September 2015	Amador & Calaveras	70,868	**965**	2
19	**JONES** *(Undetermined)*	October 1999	Shasta	26,200	**954**	1
20	**AUGUST COMPLEX** *(Lightning)*	August 2020	Mendocino, Humboldt, Trinity, Tehama, Glenn, Lake, & Colusa	1,032,648	**935**	1

"Structures" include homes, outbuildings (barns, garages, sheds, etc) and commercial properties destroyed.
This list does not include fire jurisdiction. These are the Top 20 regardless of whether they were state, federal, or local responsibility.
*Numbers not final

10/24/2022

[14] Electrical System Safety - California's Oversight of the Efforts by Investor-Owned Utilities to Mitigate the Risk of Wildfires Needs Improvement, available at: https://auditor.ca.gov/reports/2021-117/index.html (last accessed on October 10, 2023)

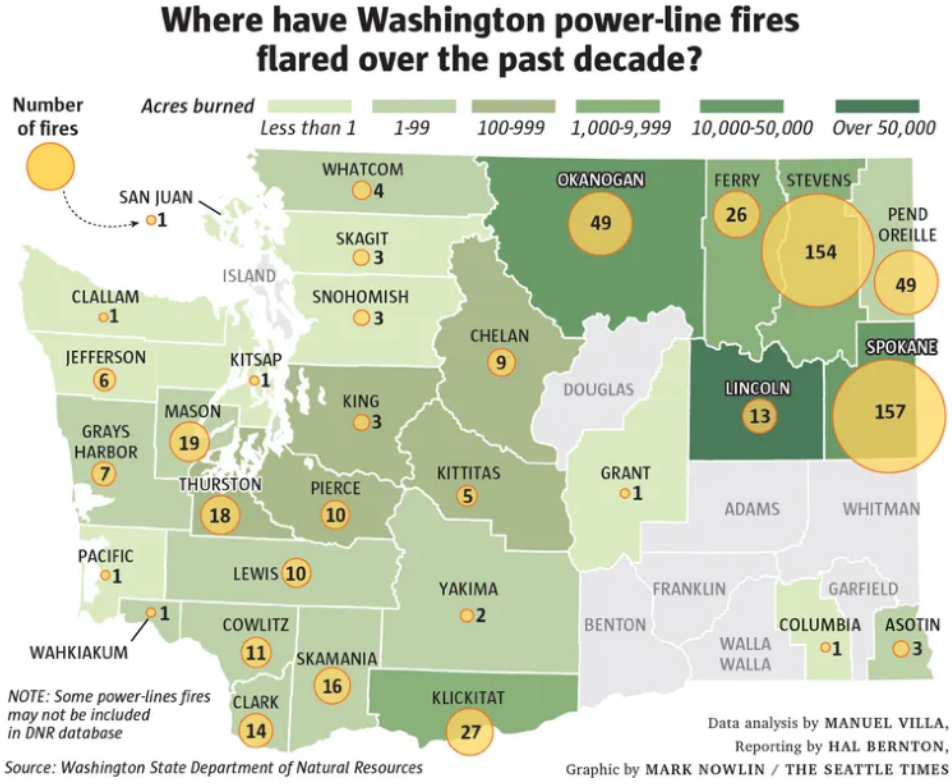
[15] State of Oregon, Utility Preparedness for Wildfires, September 26, 2019 (on file with authors)

[16] State of Oregon, Utility Preparedness for Wildfires, September 26, 2019 (on file with authors)

PG&E, PacifiCorp and other utilities have been found responsible for many of the largest, most destructive fires - and they continue to be responsible for more fires since Paradise in 2018 (PG&E) and the 2020 Labor Day Fires (PacifiCorp). Since 2017 PG&E has been blamed for more than 30 wildfires that wiped out more than 23,000 homes and businesses and killed more than 100 people.

"In these five years, PG&E has gone on a crime spree and will emerge from probation as a continuing menace to California," U.S. District Judge William Alsup wrote in a report reviewing his oversight of the utility.[17] According to Cal Fire, fires caused by electrical power—such as electrical power distribution or transmission equipment—accounted for about 19 percent of all wildfires in the areas for which it has responsibility each year from 2016 through 2020.

Once the fire starts, the same weather conditions that contribute to electrical powerline-caused fires—the most critical of which is *high wind*—also cause the fire to spread rapidly and make the fire very difficult, if not impossible, to control. California, Oregon and Washington have seen a lot of powerline caused fires.



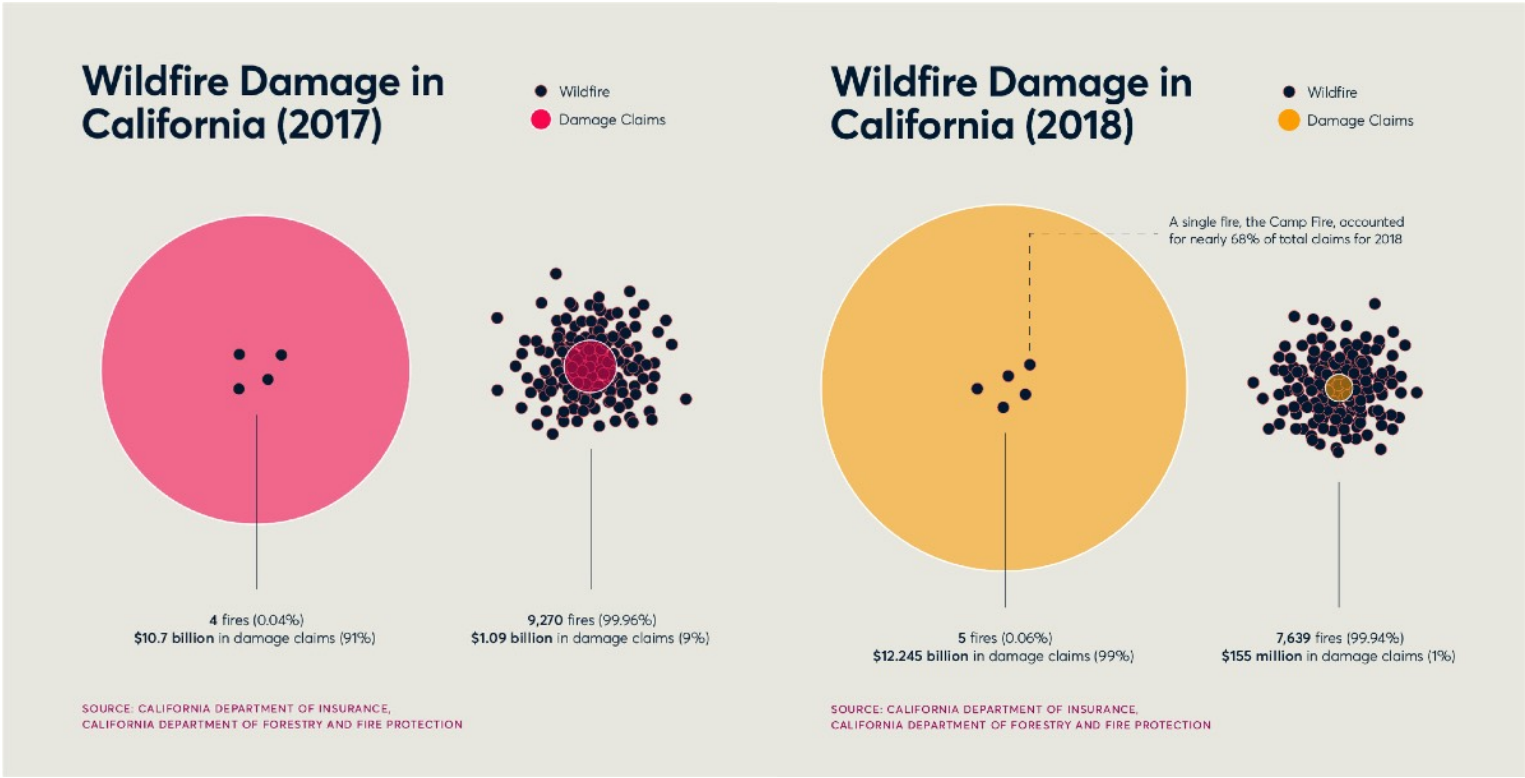
[17] **AP News: PG&E's criminal probation to end amid ongoing safety worries**, available at: https://apnews.com/article/wildfires-business-fires-crime-california-367cb44acf704920a0c2a72d60890bc5 (last accessed on October 10, 2023).

Reaching the Limits of Firefighting.

Earth observations from space combined with field observations reveal that climate forces are driving big fires, and these observations are helping experts identify the dominant forces and pinpoint solutions. While degraded ecosystems are more vulnerable to fire, extended drought and heat events are the main forces driving a dramatic increase in acres burned and homes lost to wildfire.

The changing climate has expanded the periods when fires burn. Recent "heat domes" have brought record high temperatures to the United States and Canada. These heat events further affect downed and dead fuels, vegetation, and soils. For example, the Colorado Front Range drought brought decreased late-summer rain and an absence of early winter snow, leaving cured grasses dry and flammable—conditions that enhanced the spread of the Marshall Fire (Colorado Division of Fire Prevention and Control 2021).[18]

The hard truth is that the big fires of the last several years were not "controlled" until the weather conditions changed.



[18] Colorado Division of Fire Prevention and Control. 2021. Marshall Fire: Facilitated Learning Analysis. https://storymaps.arcgis.com/stories/83af63bd549b4b8ea7d42661531de512

Even though federal and state governments have greatly increased funding for wildfire suppression efforts, there has still been an exponential increase in homes lost to wildfires, particularly fires started by people near communities and even in areas like Los Angeles which have the most advanced firefighting equipment in the world.

Urban conflagrations in Santa Rosa and Paradise, California; Marshall, Colorado; Talent and Phoenix, Oregon; and Lahaina, Hawaii have exceeded the limits of firefighting capacity, and as the numbers show just a few fires cause most of the losses. These are the wind driven fires that escape control and suppression and skip over vegetation treatments. These fires require us to focus on preparing homes and communities before fire comes.

Redefining the Problem As the Vulnerability of Homes & Communities.

Over the past several decades, the focus in the United States has been on ramping up vegetation clearing and management as a means to mitigate and prevent extreme fires (US Forest Service 2023).[19] Yet if one looks at devastating fires, it is clear that during periods of extreme fire behavior in high wind conditions, thinned forest plantations, prescribed burned areas, fuel breaks, dirt roads, city streets, paved multilane highways, and natural barriers such as the barren crest of the Sierra Nevada (Siegler 2021)[20] or the Columbia River Gorge (Vance, Templeton, and Wilson 2017)[21] did not keep fire from spotting great distances or igniting receptive fuels. All it took was an ignition leading to the burning of dry grasses and shrubs outside Superior, Colorado, to generate enough embers to ignite one home and then burn down 1,057 more homes in the Marshall Fire in eight hours.

These events are forcing communities to re-examine strategies that are not working to prevent home loss. The United States Forest Service's Missoula Fire Sciences Laboratory, the National Fire Protection Association, the Insurance Institute for Business and Home Safety, and Underwriters Laboratory's Fire Safety Research Institute are at the forefront of this effort. They have conducted extensive experiments that ***show the design and maintenance of a home and***

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[19] US Forest Service. 2023. Confronting the Wildfire Crisis. https://www.fs.usda.gov/managing-land/wildfire-crisis

[20] Siegler, K. 2021. "Winds Have Been High as the Caldor Fire Threatens California's South Lake Tahoe." NPR, August 31. https://www.npr.org/2021/08/31/1033002680/winds-have-been-high-as-the-caldor-fire-threatens-californias-south-lake-tahoe

[21] Vance, B. M., A. Templeton, and C. Wilson. 2017. "Eagle Creek Fire Jumps Columbia River Gorge Overnight." OPB, September 24. https://www.opb.org/news/series/wildfires/oregon-columbia-river-gorge-wildfires-interstate-84/

the immediate five feet around it, known as the home ignition zone, is the most critical area for preventing or reducing the chance a home will ignite (NFPA undated).[22]

Within the next 30 to 60 feet, known as defensible space, the research shows that homeowners need to reduce fuels from the home outward—for example, by not having shrubs next to the house, removing higher-risk plants like juniper and cypress, and disconnecting fences that can wick fire to a house (Cohen undated). These actions to make homes ignition-resistant should be done collectively by a community, as homes are most often the fuel that ignites and burns other homes.

Jack Cohen, a U.S. Forest Service research physical scientist (Ret.), says wildfire must be redefined as a home ignition problem, because defining the wildfire itself as the problem is not working or realistic (Cohen undated).[23] Fires are inevitable, and there will always be wind-driven fires that escape control. By redefining the problem, Cohen seeks to ***change the focus from trying to control uncontrollable fires to taking preventive measures that protect homes and communities*** (Joyce 2018).[24]

Widespread efforts to harden homes will also be an effective strategy for preparing communities to better face wildfires, and ***it is what insurance companies say is needed to make the risk acceptable*** (PBS 2023).[25] The tools and technology exist to make these changes, and if homes are built with wildfires in mind, the threat of wildfires destroying entire communities could be eliminated in just a few years.[26]

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[22] National Fire Protection Association (NFPA). Undated. "Preparing homes for wildfire." https://www.nfpa.org/Public-Education/Fire-causes-and-risks/Wildfire/Preparing-homes-for-wildfire

[23] Cohen, J. Undated. A More Effective Approach for Preventing Wildland-Urban Fire Disasters. https://static1.squarespace.com/static/61ef51b68cfef85e3fed8d43/t/6340520e899c747a294725bf/1665159696338/Dr.+Jack+Cohen+Wildland+Urban+Fire+Primer+for+Elemental+Viewers.pdf

[24] Joyce, S. 2018. "Built to Burn." *99 percent invisible* podcast, July 31. https://99percentinvisible.org/episode/built-to-burn/

[25] PBS. 2023. The Insurance Industry Can't Weather Another Wildfire Season. 'Weathered" episode, August 1. https://www.pbs.org/video/the-insurance-industry-cant-weather-another-wildfire-season-5q4yvw/

[26] Because anthropogenic climate change is the driver of increased temperatures and drought, the most urgent and effective strategy is to invest in decreasing total carbon emissions, especially those from fossil fuels. Every other choice, including carbon offsets and misleading assumptions of carbon neutrality (Law et al. 2022), is putting a bandage on a symptom or even increasing emissions. *See* Law, B. E., W. R. Moomaw, T. W. Hudiburg, W. H. Schlesinger, J. D. Sterman, and G. M. Woodwell. 2022. Creating strategic reserves to protect forest carbon and reduce biodiversity losses in the United States. Land 11(5): 721. https://doi.org/10.3390/land11050721

Reintroducing Fire to the Land.

In its September 2023 report, the Presidential Wildfire Mitigation and Management Commission has told us to accept the inevitability of more fire on the land as fire is both central to the crisis and one essential part of the solution. A central part of our challenge is how we navigate this tension, as well as provide mitigation measures for individuals and communities to reduce the impact of smoke in the face of a future with increasing fire.

Understory thinning of shrubs, saplings, and the lower limbs of large trees can help prepare the ground surface for the safe and controlled reintroduction of fire by indigenous, cultural, and prescribed-fire practitioners. This kind of understory thinning more often resembles cutting or pruning, not removal of trees, and it is generally followed by pile and broadcast burning of the ground surface where dead limbs and needles accumulate. These surface and understory fuels are decomposed by soil microbes, providing nutrients for new plants. Fire is the most effective, economical, and natural method for reducing fuels and providing nutrients for vegetation (FDACS undated).[27]

But there are challenges. Today's landscape is very different from the landscape that indigenous cultures stewarded. Forests are now crisscrossed with roads and power lines. Older forests have been logged and converted to young tree plantations. Many forests are lined with suburban development. Some forests have missed many cycles of fire and are not ready to handle intense fires. And the vast majority of homes that are lost to wildfires are not in forests. Still, prescribed fire and indigenous use of fire has great potential to restore and revitalize the land. By removing material from the ground, particularly fine material, land can be readied for more fire in the future.

While all forms of smoke have negative health impacts, there is broad recognition that significantly increasing the application of beneficial fire in a strategic manner is critical to mitigate the risk of wildfires and increase ecological resilience in many North American landscapes (Holland et al., 2022; Prichard et al., 2021; USFS, 2012). Some studies indicate prescribed fire produces fewer smoke emissions than high severity wildfires (Liu et al., 2017) Yet the science of wildfire smoke is developing and the unknowns exceed the knowns. Smoke science is focused on modeling yet the knowledge about the real world combustion of wildland fuels is lacking. As to whether prescribed fire smoke is "better" than "wildfire smoke" nobody can really answer that. Whether we will have less smoke from "treating" forests is also

[27] Florida Department of Agriculture and Consumer Services (FDACS). Undated. Wildfire Fuel Reduction. https://www.fdacs.gov/Forest-Wildfire/For-Communities/Firewise-USA/Wildfire-Fuel-Reduction

unknown, yet still implied. PM2.5 general affects on health are known but the specific details especially threshold concentration and total exposure are not.

Much of the (conflicted) research is skewed to southeastern prescribed fires with little on prescribed fires in the Pacific NW. If total exposure matters (unknown) which is worse for human health. 5 prescribed burns of a dry land forest over 35 years or 1 wildfire? As to the recommendation to avoid exposure by sheltering in your home - it is not that simple. Between 20 -90% of the PM 2.5 makes it into the house. The other issue is the up to 500 other components of smoke, some which could react with household surfaces and residues to make different toxic problems. Air purifiers and N95 masks may protect you to a degree, but maybe not protect you adequately.

Emerging solutions in Fire Tech.

As much as people are the main cause of wildland fire ignitions, scientists, technologists, entrepreneurs, and cultural leaders are delivering solutions to meet today's wildfire challenges. More accurate, timely, and continuous data is the centerpiece of this effort, which involves satellite observations, drones, and artificial-intelligence-generated insights, among other tools.

Coined as "FireTech," this rapidly evolving sector dedicated solely to addressing wildfires consists of data, advanced analytics, and technologies such as robotics (Wildland Technology Funders Group 2022). In recent years, a growing number of companies and nonprofit organizations have devoted significant resources to advancing capabilities to predict, mitigate, and adapt to fire.

Satellite observations are not new, but expanded applications of government-collected space data are attempting to meet the growing needs of traditional users such as the US Forest Service, as well as newer users in the insurance and utility sectors. NASA research plays an important role in helping scientists and tech entrepreneurs better understand the environmental characteristics that are more likely to lead to fires (drought and wind), wildfire behavior, the extent and recovery of burn areas, post-fire erosion, and impacts on air and water quality (NASA undated).[28] The agency's science not only provides insight into the environmental changes occurring, but also helps explain why these changes are happening. The National Oceanic and Atmospheric Administration, for its part, provides real-time weather forecasting and specific fire

[28] NASA. Undated. "Enabling Better Wildlands Fire Management." https://appliedsciences.nasa.gov/what-we-do/wildfires

weather forecasting capabilities along with drought, water, and wind insights (National Weather Service undated).[29]

Because of the growing need for more accurate, timely, and comprehensive global data, commercial satellite companies such as Planet, Maxar, and Capella Space are accelerating efforts to provide data and imagery on the size, intensity, and spread of wildfires. This information helps fire managers and other entities understand fire behavior, movement, and potential threat to nearby communities, infrastructure, and ecosystems. Improved observations and science are critical to making informed decisions about evacuations, resource allocation, and firefighting strategies. Satellites equipped with thermal sensors can detect the presence of wildfires by measuring the heat signature emitted by active fires.

Increased interest in fire prediction and early detection on a global scale is also leading to new players and partnerships in the space domain. The nonprofit organization Environmental Defense Fund is partnering with Muon Space, the Gordon and Betty Moore Foundation, and others to develop a constellation of satellites devoted specifically to fire detection, prediction, and impacts (Environmental Defense Fund 2022).[30] What has been described as a constellation of up to 50 small satellites will launch later this year with a demonstration of three satellites. The potential to provide continuous, global, and near-real-time data at critical peak fire times could significantly advance wildfire intelligence.

Capturing data from space and other sources is only one part of the equation. Applying that data and information to create wildfire intelligence is another. Perhaps one of the best-known companies working to integrate data and interpret findings is San Diego-based Technosylva, which has created a suite of products for advanced wildfire modeling that serves firefighters and the utilities sector (Technosylva undated).[31] Technosylva's Wildfire Analyst service produces wildfire spread-prediction and behavior models. These risk forecasts are integrated with weather-prediction systems and updated hourly, which allows for real-time operational assistance during active fires. Products like this are improving situational awareness during emergencies, allowing fire managers to understand the possible impacts of fires and improving the safety of firefighters and the public.

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[29] National Weather Service. Undated. "Fire Weather." National Oceanic and Atmospheric Administration. https://www.weather.gov/fire/

[30] Environmental Defense Fund. 2022. "Wildfire-First Constellation." Slide presentation, November 30. https://fsapps.nwcg.gov/nirops/docs/upload/5_5_EDF_FireSatelliteConstellation_OverviewForTFRSAC_221130.pdf

[31] Technosylva. Undated. https://technosylva.com/

Dutch start-up Overstory uses artificial intelligence and machine learning to process high spatial- and temporal-resolution satellite imagery and climate data for improved vegetation management (Overstory undated).[32] Overstory provides utilities with real-time vegetation insights, wildfire risk analysis, and recommendations to enable smarter infrastructure management. These insights help utility customers plan vegetation-management efforts near infrastructure to better mitigate wildfire and reduce the risk of power outages.

CoreLogic, an analytics company serving the real estate and insurance sectors, uses artificial intelligence and machine learning to produce its Wildfire Mitigation Score, which evaluates the potential risk of wildfire to a property (CoreLogic undated). CoreLogic is one of many companies delivering products at a property level. These products help the insurance industry, as well as homeowners, identify and understand wildfire risk and make better-informed decisions when purchasing a property. These products use geospatial analytics to analyze slope, aspect (slope orientation), vegetation, and surface composition of a property. Similar products are provided by RiskFactor.com, Verisk, Madronus, and Zesty AI.

While State Farm, Farmers, and other insurance providers have announced they are pulling out of new business in the California market because the wildfire risk is too high, entrepreneurs are stepping in with a boots-on-the-ground approach to help reduce community risk by empowering firefighters to directly assess risk to homes. Fire Aside, for example, has developed software to enable firefighters to efficiently assess how prepared a home is for fire. The homeowner is provided with a customized report that contains a prioritized list of actionable steps, access to grants, and a simple mechanism for reporting steps taken.

In one example of a community-wide approach, ***the Truckee Fire Protection District is doing wildfire risk assessments of every home once every three years***, evaluating the homes for defensible space, vegetation management, and construction standards. The Truckee community is taking a proactive approach, with ***over 70 percent of homeowners taking action to create a wildfire-resilient Truckee and residents using the Fire Aside defensible space report to not only identify defensible space and home-hardening actions but also to qualify for California Department of Insurance Safer From Wildfires discounts*** (Fire Aside, undated).[33]

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[32] Overstory. Undated. https://www.overstory.com/

[33] Fire Aside. Undated. "Our Impact." https://www.fireaside.com/impact

Conclusion: Shifting the fire story.

Scientists, researchers, and front-line firefighters are questioning the old approaches and advocating for an approach that prioritizes improving homes and communities over vegetation management across vast landscapes. In recent years, once-unusual fires have become common, and community loss has increased exponentially. People and power companies continue to ignite fires in extreme conditions, straining resources and causing incredible losses.

Despite these challenges, leaders within the fire community are embracing paradox and trying to shift the fire story to support the return of fire to the land through cultural fire, prescribed fire, and ecological fire use while simultaneously preparing communities to be ready for more smoke. Fire management and suppression are evolving to include containment within a perimeter, and a growing recognition of the benefits of letting fire do its work in maintaining natural systems. Firefighters are stepping forward to empower homeowners to prepare their homes for fire, and entrepreneurs are harnessing existing technology to provide better situational awareness and analysis before, during, and after fire comes.

Solutions to reduce wildfire impacts need to transform how people live with climate change and natural ecosystems, through changes in land use, neighborhood design, and home design to make the built environment safer. While many strategies can have an impact, given limited resources and time ***it is imperative to prioritize the most durable and effective solutions.*** For society to move from unpredictable disasters to prepared and resilient communities that can weather extreme events, policymakers, agencies, and the public will all need to accept inevitable fires and smoke and embrace a new approach to living with fire.

APPENDICES

Appendix 1 - Utility Management & Powerline Ignitions.

Solutions to Powerline Ignitions

If powerlines have the capacity to cause such devastating fires, why not put them all underground or insulate all the lines? Unfortunately, both replacing uninsulated lines with insulated lines and undergrounding lines are very expensive undertakings.[34] The latter also may make it harder to locate and address any problems, should they arise.

Another way in which power companies can and have attempted to reduce the risk of powerline ignitions is by maintaining the vegetation surrounding its powerlines. This is a very effective way to help prevent powerline ignitions. Unfortunately, because power companies' service territories are typically so vast, the notion that they can achieve 100 percent safety just through vegetation management alone is unlikely.

An extremely important tool that power companies have at their disposal to prevent utility-caused fires is shutting off the power for a temporary period of time when certain metrics are met. This is called a Public Safety Power Shutoff ("PSPS"). PSPS as a tool is effective, because if there is no power in the electrical lines, the lines cannot start a fire even in extreme weather conditions. Nevertheless, some power companies have resisted instituting a PSPS during weather events.

Recent Cases Involving Powerline Ignitions in Washington, Oregon & California

<u>Washington</u>

Fowlkes v. Inland Power and Light Company, Case No. 23-2-04004-32 - **Gray Fire (2023) –** Two lawsuits have been filed against Inland Power and Light Company, alleging that its electrical equipment contacted or caused sparks to contact surrounding vegetation, and

[34] **Why Doesn't PG&E Bury the Power Lines to Prevent Wildfires?** https://www.kqed.org/news/11851411/why-doesnt-pge-bury-the-power-lines-to-prevent-wildfires (last accessed on October 10, 2023)

subsequently starting the Gray Fire in eastern Washington.[35] This fire killed a man and burned approximately 240 homes.

Babb Road / Babb-Malden Fire (2020) – The Babb Road Fire nearly destroyed the towns of Malden and Pine City in 2020. According to the DNR, this fire started when a branch from a Ponderosa pine contacted a power line owned and operated by Avista Utilities. One of the allegations in this case is that Avista knew this Ponderosa pine was unhealthy and categorized as a hazard tree yet failed to address it prior to the fire. The Babb Road Fire was one of at least 47 blazes ignited by powerlines on September 7 and 8, 2020.[36]

Boyd's Fire (2018) - *Washington DNR v. Avista Power* (2019). DNR contends that Avista Utilities was negligent in not maintaining trees and brush around its power line near Kettle Falls, causing the 4,000-acre Boyd's Fire in 2018. The DNR concluded it started from a "hazardous dead ponderosa pine tree that collapsed onto electrical lines owned, maintained and operated by Avista." The DNR sued for firefighting costs.[37]

Oregon

***James, et al. v. PacifiCorp, et al*. (2020)** – 17 named plaintiffs sued PacifiCorp on behalf of a putative class for damages arising out of four fires – the 242, Echo Mountain Complex, Santiam Canyon, and South Obenchain fires – alleged to have been caused by PacifiCorp's powerlines. After an eight-week trial on the issue of liability, a Multnomah County jury found PacifiCorp liable for starting each of these fires and rendered $72 million in compensatory damages for the 17 plaintiffs and an additional $18 million in punitive damages.

***Willamette Valley Vineyards v. Pacificorp, et al.* (2023)**. Willamette Valley Vineyards has filed a lawsuit against electric utility Pacific Power and parent company PacifiCorp for $8.1

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[35] *Fowlkes v. Inland Power and Light Company*, Case No. 23-2-04004-32, Complaint available at: https://drive.google.com/file/d/1tdzjLFgiWcnzRt2sZt7X39LXsg983H5A/view (last accessed on October 10, 2023)

'This community will never be the same' | Lawsuits filed against Inland Power & Light for allegedly sparking Gray Fire https://www.krem.com/article/news/local/wildfire/gray-fire-lawsuits-filed-inland-power-and-light/293-a05c43b5-3f83-4416-813e-e821346e20ec (last accessed on October 10, 2023)

[36] **'When the sparks just flew': How power lines ignited dozens of Washington state fires during fierce Labor Day winds**, available at: https://www.spokesman.com/stories/2020/nov/15/when-the-sparks-just-flew-how-power-lines-ignited-/ (last accessed on October 10, 2023)

[37] **Washington DNR files lawsuit against Avista for 2018 Boyds Fire in Ferry County**, available at: https://www.krem.com/article/news/local/wildfire/washington-dnr-files-lawsuit-against-avista-for-2018-boyds-fire-in-ferry-county/293-ac91281d-a25e-4973-b695-366338e08bc4 (last accessed on October 10, 2023)

million over what the vineyard claims is the utility's role in the 2020 Labor Day wildfires that affected grape harvests.[38] The vineyards allege that smoke from the fires damaged its harvest.

There are numerous other lawsuits pending against Pacificorp for the 2020 Labor Day fires by homeowners owners, timber companies, forestland owners and insurance companies.[39]

Table 1
Wildfires Caused by Electrical Power Account for 19 Percent of Cal Fire-Reported Acres Burned 2016 Through 2020

	WILDFIRES		WILDFIRES CAUSED BY ELECTRICAL POWER			
YEAR	TOTAL WILDFIRES	TOTAL ACRES BURNED	NUMBER	PERCENT	ACRES BURNED	PERCENT
2016	2,816	245,000	270	10%	3,000	1%
2017	3,470	467,000	408	12	250,000	54
2018	3,504	1,063,000	297	8	247,000	23
2019	3,086	130,000	304	10	84,000	65
2020	3,501	1,459,000	335	10	59,000	4
Totals	**16,377**	**3,364,000**	**1,614**	**10%**	**643,000**	**19%**

Source: Cal Fire's Wildfire Activity Statistics reports, 2016 through 2020.

California

Camp Fire (2018) – A strong gust of wind blew down a power line owned and operated by PG&E, which ignited dry vegetation and started a fire that would become the deadliest, most destructive fire in California's history, destroying over 18,000 structures and killing dozens of

[38] Complaint available at: https://s3.documentcloud.org/documents/23898091/willamette-valley-vineyards-lawsuit.pdf (last accessed on October 10, 2023)

[39] **Southern Oregon wildfire victims ask judge to consolidate their cases against PacifiCorp and expedite a jury trial**, available at: https://www.oregonlive.com/business/2023/01/douglas-county-wildfire-victims-ask-judge-to-consolidate-their-cases-against-pacificorp-and-expedite-a-jury-trial.html (last accessed on October 10, 2023)

people. Multiple suits were filed against PG&E by individual fire victims, municipalities, and insurance companies demanding accountability. PG&E later filed for bankruptcy protection and later pleaded guilty to 84 counts of involuntary manslaughter. Since it declared bankruptcy, PG&E has since drafted a plan to spend $50 billion by 2026 on grid protection and repairs.

Yet, even after the Camp Fire (2018), PG&E continued to be responsible for powerline ignitions and destructive fires in California, including the 2021 Dixie Fire in California that burned down the town of Greenville, California.[40]. The Dixie Fire, which started on 13 July 2021 and burned for more than two months, was caused by a tree falling on PG&E's electrical distribution lines. Dixie ended as the second-largest wildfire in California's history, burning more than 963,000 acres of land across multiple counties and destroying more than 1,300 homes.[41]

As a result of lawsuits, and high risk from powerline ignited fires, companies are hiring in-house meteorologists, investing in fire modeling, installing sensors across their grid networks to identify high-risk areas, and designing PSPS plans that can actually be executed.

[40] **Wildfire Today, A list of some of the fires attributed to PG&E powerline equipment**, available at: https://wildfiretoday.com/2021/04/06/a-list-of-some-of-the-fires-attributed-to-pge-powerline-equipment/ (last accessed on October 10, 2023)

[41] **California regulator proposes $45m fine for PG&E over 2021 wildfires**, available at: https://www.power-technology.com/news/california-regulator-proposes-45m-fine-for-pge-over-2021-wildfires/?cf-view (last accessed on October 10, 2023)

Appendix 2 - Forests, Fire & Carbon Cycles - Key Scientific Findings & Context

Carbon in forests is carbon that is not in the atmosphere. The emission of below ground carbon (oil, gas) is different in kind from above ground tree and soil carbon.

Young forests take up carbon at a faster rate but do not take up more carbon from the atmosphere annually than mature and older forests (Luyssaert et al. 2008) (i.e. think of a bank account, what makes more? $500,000 earning 4.5% return or $10,000 earning 5.5%). The first 10 to 20 years after harvest or stand-replacing disturbance, young forests are a net emission to the atmosphere (Amiro et al. 2010, Law et al. 2001).

Forest harvest results in net carbon emissions versus leaving forests unharvested. Significant amounts of carbon are lost at each stage of timber harvest, manufacturing, and the end of useful product life (Hudiburg et al. 2011, Law et al. 2018).

Forests actively withdraw carbon from the atmosphere and store and conserve it more effectively and for longer periods of time than do products derived from harvested trees (Hudiburg et al. 2009, 2013, Law & Harmon 2011, Harmon et al. 1990). Forest carbon can be increased by reducing harvest, i.e. increasing harvest cycle (Law et al. 2018).

Wildfires - Key Findings:

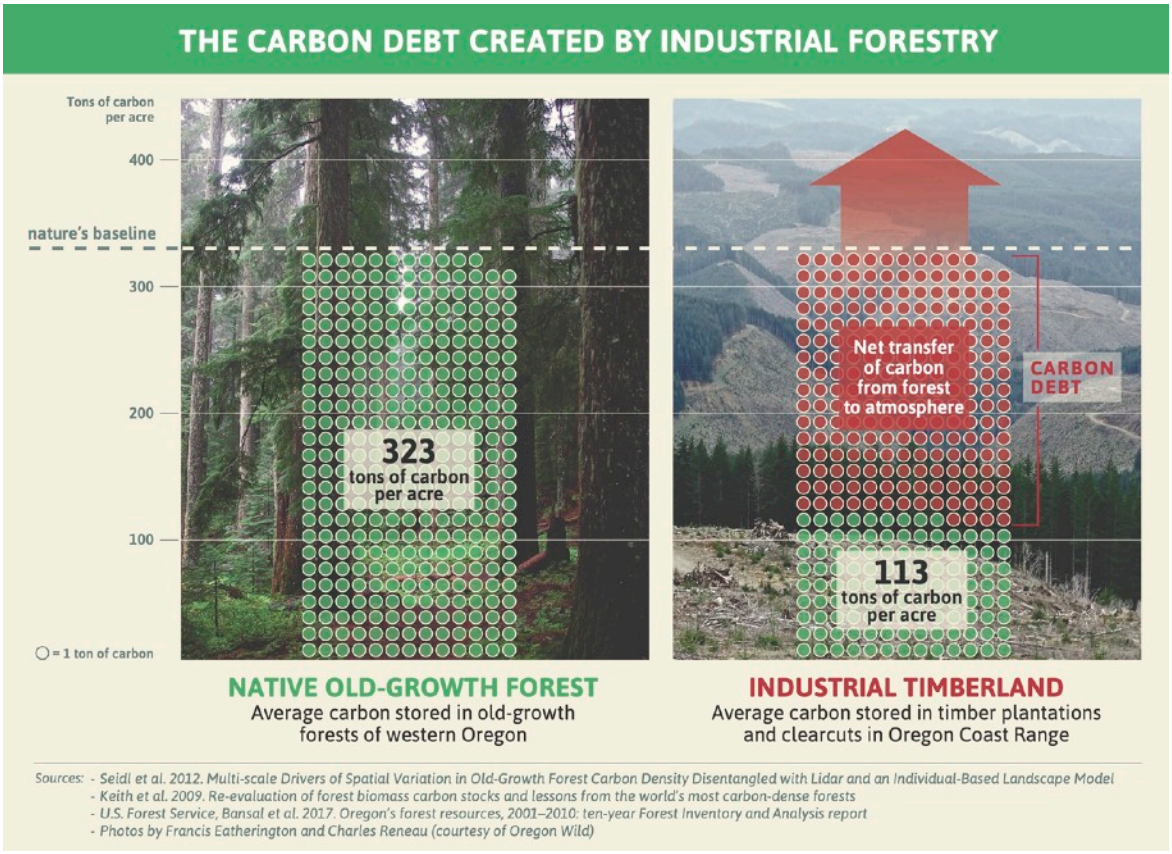
Wildfire is an essential ecological process. The dominant fire regime is mixed severity (Law & Waring 2015). Burned landscapes have shown prolific recovery and diversity of species (Tingley et al. 2016, Fontaine et al. 2009). Most Pacific Northwest fires release a small fraction (~5%-10%) of the biomass carbon (Law & Waring 2015). Fire emissions are <10% of Oregon Global Warming Commission reported non-forest emissions (Law et al. 2018).

Broad-scale thinning of forests conflicts with carbon sequestration goals and results in higher emissions (Law et al. 2013, Hudiburg et al. 2011). The amount of carbon removed is often much larger than the amount saved, and more area is harvested than would actually burn (Mitchell et al. 2009, Rhodes et al. 2009, Law & Harmon 2011). Post-fire logging frequently damages ecosystems, particularly on steep slopes. Impacts include soil erosion and degraded river hydrology (Karr et al. 2004).

Protecting forests is a key strategy in meeting net zero carbon goals, halting climate change.

The Pacific Northwest US stands out as having mature and old forests with high carbon and biodiversity that are worthy of protection, and a majority of them are on public lands with the potential for permanent protection at the highest international levels. These mature and old forests, whether or not they are vulnerable to disturbance, store vast amounts of carbon and hold the potential for significant future carbon accumulation, and are also sources for clean drinking water (Law et al. 2021, Mildrexler et al 2020).

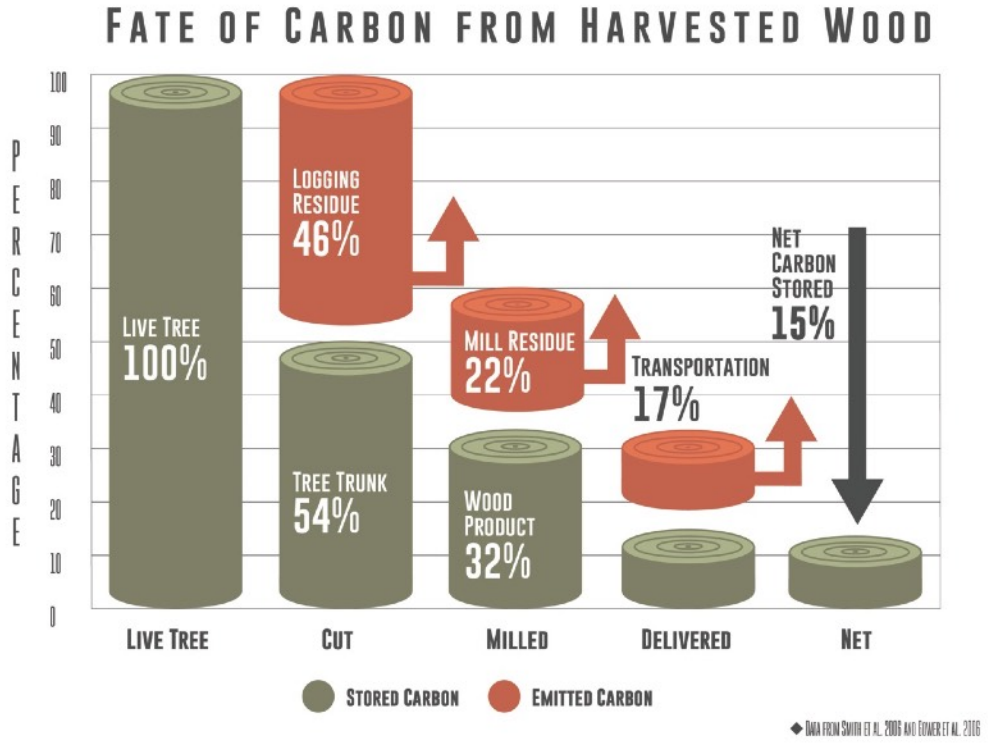
Mature and old forests store more carbon in trees and soil than young forests store, and continue to accumulate it over decades to centuries making them the most effective forest-related climate mitigation strategy. High carbon density forests in the western US contain high biodiversity, store water, and promote resilience to climate change. Converting mature and older forests to younger forests results in a significant loss of total carbon stores, even when wood products are considered. Young plantation forests significantly decrease streamflow compared with that of mature and old forests, particularly in drier months (Perry & Jones 2017, Segura et al. 2019). Forestlands account for almost 60% of the most important areas for surface drinking water in the western US, yet only about 19% are protected at the highest levels (Law et al. 2021).



Harvesting forests for bioenergy production conflicts with climate goals.

Promotion of the use of wood biomass as a substitute for coal is not helpful for mitigating climate change. First, burning wood pellets to displace fossil fuels still emits carbon dioxide into the atmosphere at the point of combustion and during harvest, transport and processing. The combustion and processing efficiencies are lower than for coal (Sterman et al. 2019). Wood has less energy per unit of carbon, and therefore requires more removal to produce the same amount of energy. A 500-megawatt power plant burning wood pellets would emit 437,300 tons of carbon as carbon dioxide annually, whereas the same plant burning coal would emit 392,000 tons/year.

Second, forests stored carbon and were growing and storing more carbon before being cut for bioenergy production. For example, if a 40- year old forest was harvested and burned, it would take another 40 years to reach the initial carbon stocks and accumulation of the previous forest. But if not harvested the same forests would have continued to accumulate carbon, adding to the carbon that is already in the forest. This is why burning biomass creates a long-term carbon debt. To mitigate climate change, there is a need to reduce consumption and shift to carbon-free energy sources (e.g. solar), while protecting mature and older forests so these forests continue to accumulate carbon from the atmosphere and protect habitat, biodiversity, and surface drinking water.



Broad-scale thinning to reduce fire severity results in more carbon emissions than would be released by fire, creating a multi-decade carbon deficit that conflicts with climate goals.

The amount of carbon removed by thinning is much larger than the amount that might be saved from being burned in a fire, and far more area is harvested than would actually burn (Mitchell et al. 2009, Rhodes et al. 2009, Law & Harmon 2011, Campbell et al. 2011). Most analyses of mid- to long-term thinning impacts on forest structure and carbon storage show there is a multi-decadal biomass carbon deficit following moderate to heavy thinning (Zhou et al. 2013). A thinning study in a young ponderosa pine plantation vulnerable to drought in Idaho found that removal of 40% of the live biomass from the forest would subsequently release about 60% of that carbon over the next 30 years (Stenzel et al. 2021). Although thinning is commonly used to reduce fire severity and associated tree mortality, a comparison of thinned with adjacent unthinned stands after a California fire showed that is not always the outcome. In the study area, thinning resulted in more tree mortality than unthinned stands, i.e. fire killed more trees than thinning prevented from being killed (Hanson 2022).

As to the effectiveness and likelihood that thinning might have an impact on fire behavior, a multi-year study of forest treatments like thinning and prescribed fire across the western US found that only 1% of those treatments experience wildfire each year. The potential effectiveness of treatments lasts only 10-20 years, diminishing annually and then expiring (Schoennagel et al. 2017). There are high forest carbon losses associate with thinning, only minor differences in the combustive losses associated with high severity fire and the low-severity fire that fuel treatment is meant to encourage, and a low likelihood that thinned forests will be exposed to fire during treatment effectiveness (Campbell et al. 2011).

While moderate to high severity fire can kill trees, most of the carbon remains in the forest as dead wood and it takes decades to centuries to decompose that wood. Less than 10% of the total ecosystem carbon in live and dead trees, litter, and soils combined has been found to enter the atmosphere as carbon dioxide in Pacific Northwest forest fires (Campbell et al. 2011; Law & Waring 2015). Recent field studies of combustion rates in California's large megafires show that carbon emissions were very low overall at the stand- (0.1-3.2%) and landscape-level (0.6-1.8%) because larger trees with low combustion rates comprise the majority of biomass and high severity fire patches are less than half of the area burned (Harmon et al. 2022). The results are consistent with field studies on Oregon's East Cascades wildfires and the large Biscuit Fire in southern Oregon (Campbell et al. 2007, Meigs et al. 2009), where most of the material that

combusts is small twigs, forest floor litter and duff. A small fraction of stemwood combusts and deadwood remaining onsite slowly decomposes.

The vulnerability of forests to wildfire will increase, but the vulnerability will vary spatially in the next decades. Vulnerability to future fire is projected to be highest in the Sierra Nevada and portions of the Rocky Mountains, while high carbon-density forests in the coastal forests are expected to experience low vulnerability to fire (Buotte et al. 2018). Put into context, fire emissions are small relative to harvest emissions. Harvest-related emissions in Oregon, Washington and California average about 5 times fire emissions (Hudiburg et al. 2019). In California, fire emissions are just a few percent of the state's fossil fuel emissions. In the lower 48 states, harvest-related emissions are 7.5 times the emissions from all natural causes (fire, insects, windthrow) (Wilson et al. 2016).

Climate change mitigation is expected to be part of decision-making, therefore potential impacts of treatment options on forest carbon stocks must be assessed

Increasing the use of prescribed fires and managed wildland fires may promote resilience to more frequent fire (Schoennagel et al. 2017). Local reduction of understory vegetation may reduce the chance of mortality of large trees in some fire-prone dry forests with high future vulnerability to fire, yet there is only a small chance those treated patches will burn before growing back unless fire is intentionally introduced. However, cutting the small- to medium-size trees significantly reduces whole ecosystem carbon storage, while protecting all the remaining large mature and old trees will not only store and accumulate the most carbon they are also more drought- and fire-resistant than young trees (Law et al. 2021, Mildrexler et al. 2021, Irvine et al. 2004, Hurteau et al. 2019).

Post-fire cutting versus natural regeneration.

Many western US forest fires are mixed-severity where a large portion of the fire burns at low and moderate severity in patches and a smaller portion burns at high severity where a majority of trees are killed (Law & Waring 2015). After fires, the remaining live and dead trees in the burn area and those on the periphery provide seed sources for natural regeneration (Donato et al. 2009). Allowing natural regeneration to occur ensures that the genetic and species diversity that existed prior to the fire will have the potential to grow. This diversity increases the possibility of resilience of the ecosystem to future disturbance.

The complex early seral forest habitat that develops in high severity burns is important to a broad range of wildlife associated with these conditions (Fontaine et al. 2009). Both early- and late-successional forests can support equally complex functioning and biodiversity. Post-fire harvest and felling of live and dead trees can negatively affect soil integrity, hydrology, natural regeneration, slope stability, and wildlife habitat (Beschta et al. 1995). Large live, standing dead and downed trees help forests recover and provide habitat for more than 150 vertebrates in the Pacific Northwest (Rose et al. 2001). By adding another stressor to a burned watershed, post-fire logging worsens degraded conditions that have accumulated from a century of human activity (Karr et al. 2004). In sum, the current body of research indicates that the loss of ecosystem services that can result from post-fire treatments is significant (Beschta et al. 2004).

Summary.

The first priority of fire spending is on protecting the public in the wildland-urban interface (Radeloff et al. 2005). Studies suggest focusing on residential loss in the home ignition zone rather than treating the larger WUI, because home materials, design and maintenance in relation to surroundings were main factors in residential losses (Calkin et. al 2014).

To meet climate mitigation goals and conserve forest carbon and the co-benefits to forest ecosystems, there is the potential to keep carbon in existing forests and store more carbon in forests by reducing harvest and afforestation of areas that used to be forests long ago. Forests play an important role in offsetting fossil fuel emissions.

Trees and forests older than 80 years continue to store carbon as they grow In fact, older trees tend to store more carbon compared to younger ones. As trees mature, their trunks and branches grow larger, allowing them to accumulate more carbon in the form of wood. Additionally, older trees often have a greater number of leaves, enabling them to carry out more photosynthesis and absorb more carbon dioxide from the atmosphere. So, even though the rate of carbon storage may slow down as trees age, they still play a crucial role in sequestering carbon and mitigating climate change.

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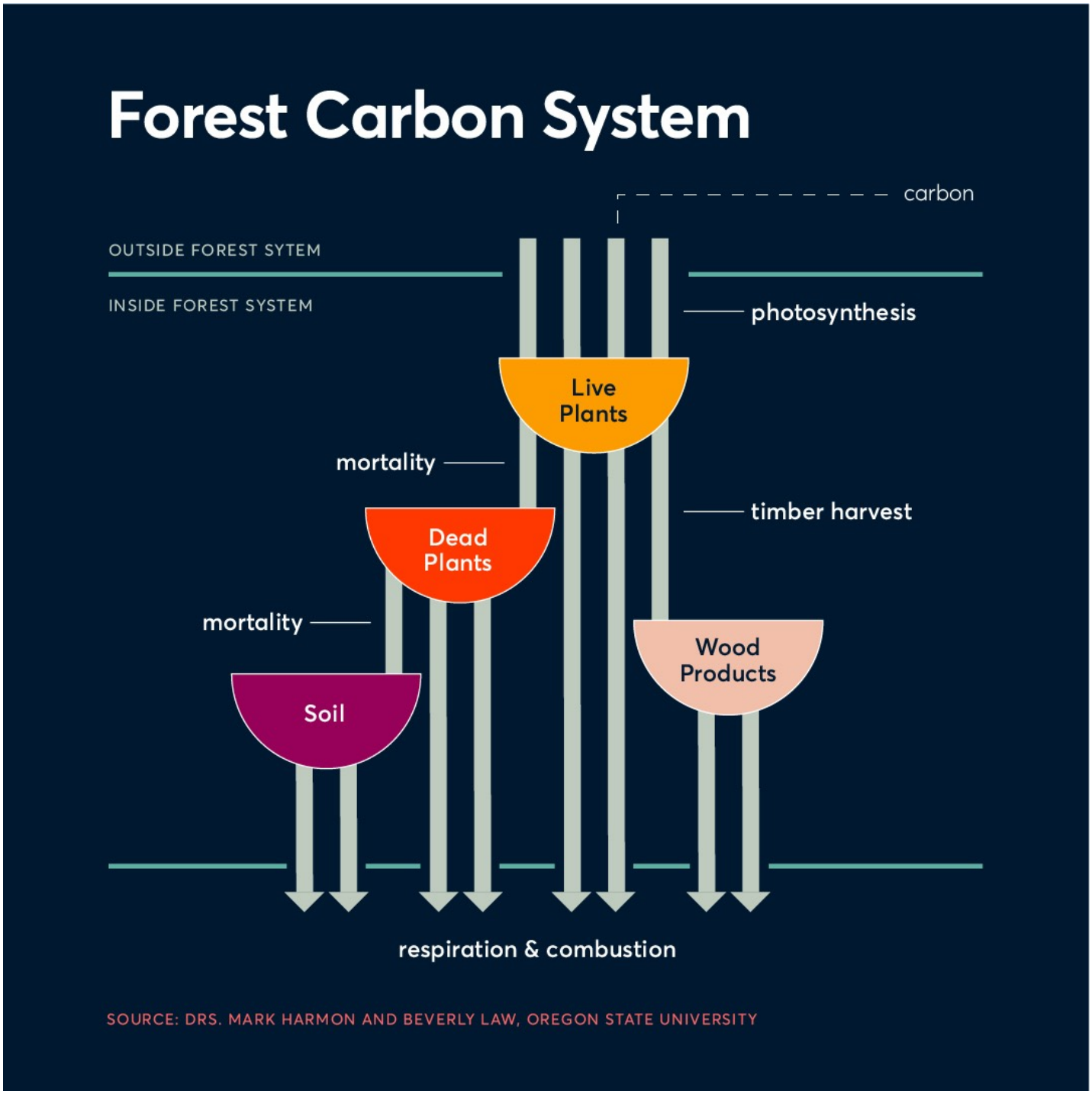
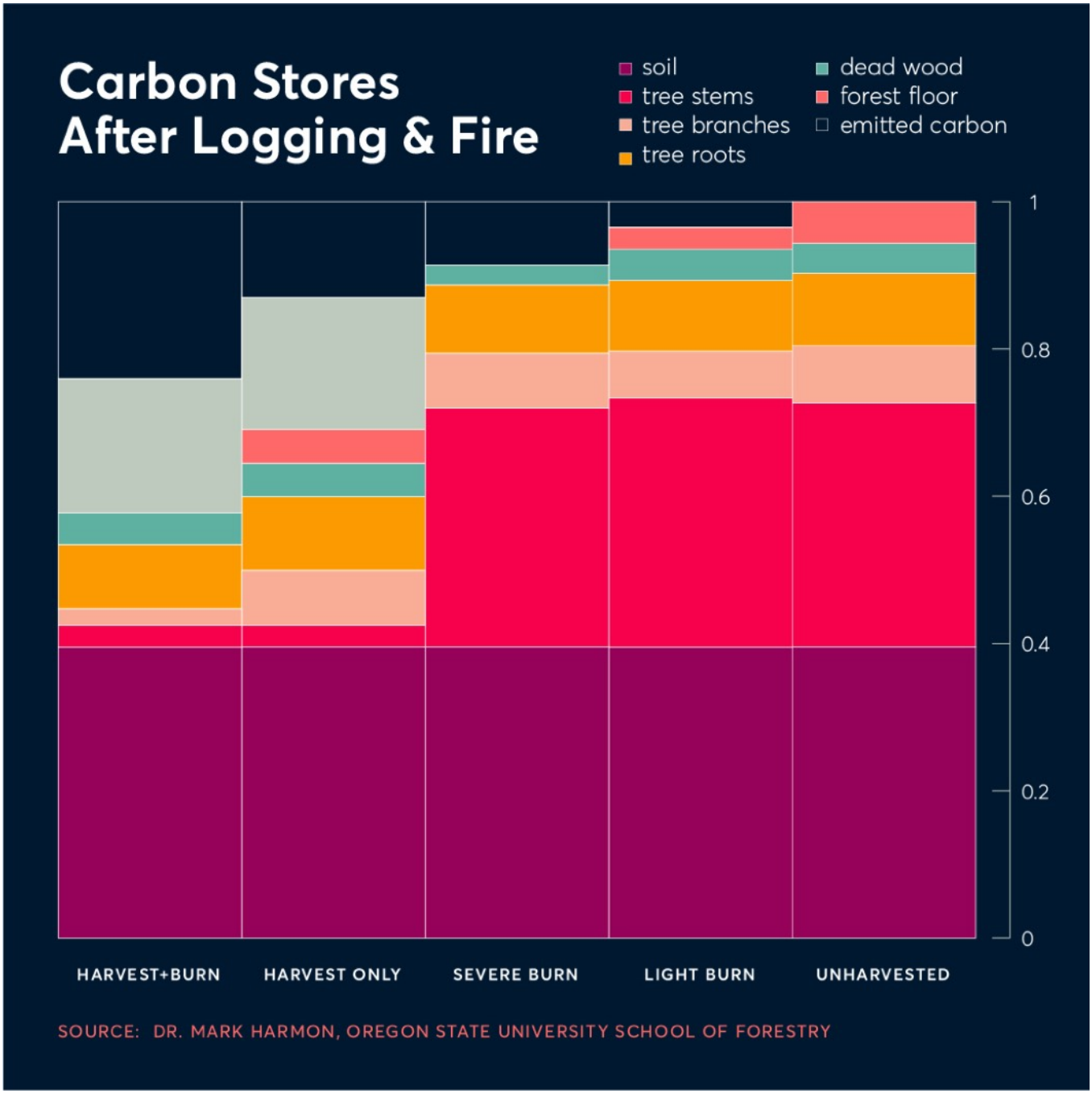
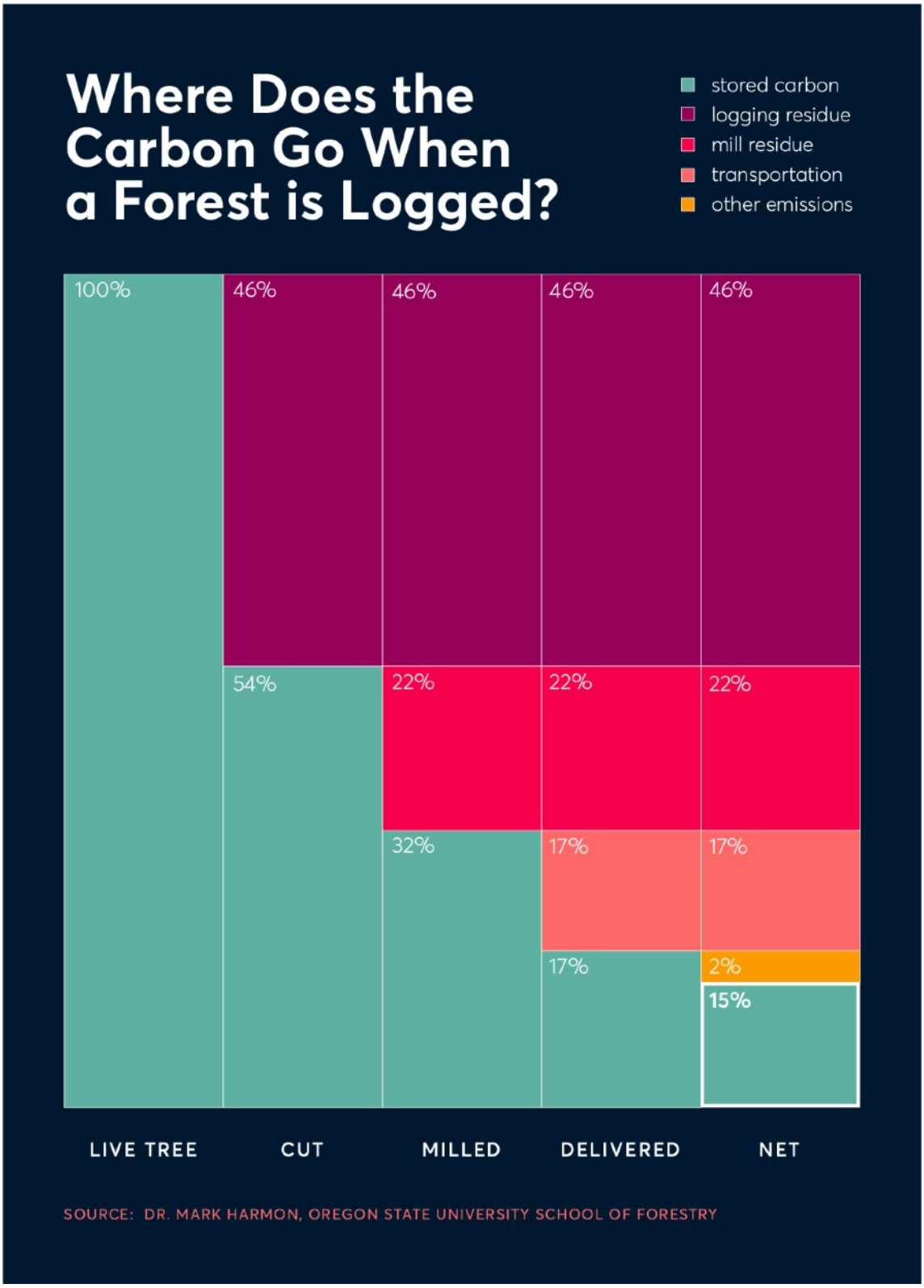
Infographics




Carbon Stores
After Logging & Fire
soil
tree stems
tree branches
tree roots
dead wood
forest floor
emitted carbon
1
0.8
0.6
0.4
0.2
0
HARVEST+BURN
HARVEST ONLY
SEVERE BURN
LIGHT BURN
UNHARVESTED
SOURCE: DR. MARK HARMON, OREGON STATE UNIVERSITY SCHOOL OF FORESTRY


Where Does the Carbon Go When a Forest is Logged?
stored carbon
logging residue
mill residue
transportation
other emissions
100%
46%
46%
46%
46%
54%
22%
22%
22%
32%
17%
17%
17%
2%
15%
LIVE TREE
CUT
MILLED
DELIVERED
NET
SOURCE: DR. MARK HARMON, OREGON STATE UNIVERSITY SCHOOL OF FORESTRY