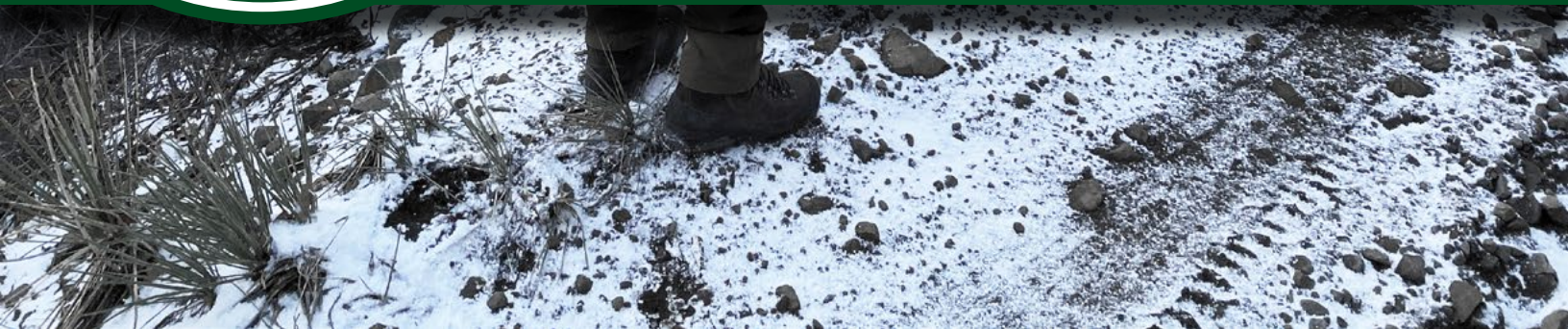
COLORADO STATE FOREST SERVICE
COLORADO STATE UNIVERSITY

Woody Biomass in Colorado:
Quantification, Assessment and Opportunities

Section 2 - Forest Conditions in Colorado



2.1 Introduction

The forests of Colorado cover approximately 24 million acres when oak woodlands are included; these forests are as diverse as the state's topography, ranging from Arkansas River riparian habitat at 3,350 feet, dominated by plains cottonwoods, to spruce-fir forests growing up to approximately 12,000 feet (Colorado State Forest Service [CSFS], 2020). Above tree line, alpine habitat reaches up to 14,440 feet on Mount Elbert, the highest peak in Colorado.

Major forest types in Colorado were categorized in the 2020 Colorado Forest Action Plan by the dominant overstory vegetation; these include conifer-hardwood, conifer, mixed conifer, hardwood (primarily aspen), lodgepole pine, oak shrubland, piñon-juniper, ponderosa pine, riparian and spruce-fir.

Indigenous people used the forests of Colorado for shelter, tools, medicine and fuelwood (CSFS, 2024). Mills arrived in conjunction with the gold rush of the 1860s and continued through the late 1800s as railroads were developed. The focus of harvest and milling was development, which reached its peak in the 1870s. This altered forests in Colorado, particularly pine forests. For example, during this time more than 1 billion board feet were provided from the area now called the Black Forest (Von Ahlefeldt, 1979) for railroad ties and communities in the region. By the early 1900s, all trees of substantial size had been harvested in the Front Range to build Denver and other communities. Wood importation began.

The establishment of national forests in the late 1890s and early 1900s provided a focus on timber management for the long term. New laws such as the National Forest Management Act of 1976 reflected the concerns of society about the impacts of timber harvest on other forest resources. These concerns led to significant declines in timber harvest and the loss of mills. By the late 1970s and early 1980s Colorado was losing large sawmills, including those in Durango, Pagosa Springs and Walden among others, due to a combination of log supply shortages and market conditions. By the late 1990s, there was a high percentage of timber coming from private lands because of the significant decrease in harvesting on national forest lands.

The Colorado State Forest Service was established in 1955, and its mission is to achieve stewardship of Colorado's diverse forest environments for the benefit of present and future generations. Housed at Colorado State University, the CSFS provides many services to Colorado including technical forestry assistance, wildfire mitigation and wood utilization grants, and forest inventory and monitoring. The CSFS Wood Utilization and Marketing program continues to provide information about local markets for forest products to help boost the industry (CSFS, 2025a).

All of Colorado's forests face a collection of interrelated challenges; one is the decrease in wood product utilization and woody biomass removal, which can result in higher fuel loads in forests over time. In 2020, wildfires burned more than half a million acres of Colorado's forests (Ingold, 2020). The largest fire, the Cameron Peak Fire, burned 208,913 acres across state, federal and private lands in the Front Range; an estimated 13% of this area had been treated between 2000 and 2020 to reduce fuel loads (Vorster et al., 2023; CSFS, n.d.). The 2020 fire season in part contributed to large landscapes of the Front Range being designated as part of the USDA Forest Service Wildfire Crisis Strategy (USDA Forest Service, 2022).

The Front Range encompasses the eastern side of the Rocky Mountains in Colorado. It has seen increasingly uncharacteristic wildfires, with four of the five largest fires in Colorado history having occurred since 2018, and the three largest in 2020 alone. Around 5 million residents and millions of visitors feel the impacts. The Front Range has been categorized in the Wildfire Crisis Strategy as high risk due to both the environmental conditions and community exposure.

To better understand how to address the increasing frequency of uncharacteristic wildfires in the state of Colorado, we must first look at the history and current state of health of Colorado's forested ecosystems, then develop strategies for improving forest resilience that include reducing fuel loads where appropriate and sustainable utilization of this woody biomass.

AUTHORS: *Steve Rudolph, Kurt Mackes, Tim Reader, Amanda West Fordham, Ashley M. Prentice, Trent Raddatz, with support from the Beck Group*

COVER: *Colorado's forests provide a variety of recreational opportunities. Here, an elk hunter scans the mountainside in search of his quarry.* ***Credit: Steve Rudolph, CSFS***

2.2 Wildfire impacts and costs

Wildfire continues to make headlines in Colorado. The history of fire suppression leading to fuel buildup in the form of dead and down material, dense undergrowth and ladder fuels (Foreman, 2019; Hanan, 2020) that combined with extensive spans of beetle-killed trees (Blevins, 2021), prolonged drought and changing weather patterns is a recipe for uncharacteristic wildfires. The characteristics of historic wildfires range from frequent, low-intensity fires in lower-elevation montane forests that reduce understory vegetation, to infrequent, high-intensity fires that are critical to regeneration in some high-elevation forest types, such as lodgepole pine. Uncharacteristic wildfires are greater in extent, intensity and severity, and they can occur outside of the historic fire season.

In 2020 Colorado had its three biggest fires in recorded history. These fires from largest to smallest include Cameron Peak (208,663 acres), East Troublesome (193,812 acres) and Pine Gulch (139,007 acres). Recent observations indicate that forests in high-severity patches in these fires are not recovering (Webber et al., 2024). Sampling across more than 150 forest fires in the western U.S., Stevens-Rumann and Morgan (2019) recorded few to no tree seedlings establishing in high-severity post-burn landscapes. Other devastating fires over the past few years include the Grizzly Creek Fire (32,631 acres) and the Marshall Fire, which burned more than 6,000 acres and more than 1,000 homes in a non-forested suburban community in December 2021 and January 2022.

The true economic costs of wildfire are far greater than the costs usually reported to the public, anywhere from 2 to 30 times the more commonly reported suppression costs (Dale, 2010, p. 18). Lynch (2004) identified three key cost brackets of tracking the true cost of a fire:

- **Direct costs occurring during the fire**
- **Rehabilitation costs of erosion control projects**
- **Impact costs, which occurred as a result of but incidental to the fire**

The 2020 Grizzly Creek Fire had its own unique rehabilitation cost. The year after the fire, heavy rains falling on steep slopes that had been severely burned and denuded of vegetation resulted in major mudslides and interstate collapses in Glenwood Canyon. This forced shutting down Interstate 70 multiple times, yielding local and national transportation impacts. The Colorado Department of Transportation had early estimates for repairs reaching $40 million to rebuild the interstate highway itself and stabilize the canyon walls to prevent future mudslides, with another $10 million in repairs for road impacts on detour routes (Minor, 2021). The area's local economies that rely on tourism and outdoor recreation suffered from a lack of visitors.

Some impacts and costs are more serious than others. Although not the largest fire, the Marshall Fire was the costliest fire in terms of housing loss, burning into the cities of Louisville and Superior. The Boulder County Assessor's Office estimated in early 2022 that residential damage from the Marshall fire was nearly $230 million in Louisville, $153 million in Superior and $131 million in unincorporated Boulder County (Fisher, 2022). Along with this monetary damage, the Marshall Fire destroyed more than 1,000 structures and displaced more than 30,000 people.

Large fires have devastating ecological impacts as well, including effects on watershed and soil health. Colorado's forested watersheds deliver clean water to residents, 18 other states and Mexico and promote biological diversity (CSFS, 2020). Tree mortality induced by uncharacteristic wildfires impacts water quality and quantity. Dead trees can no longer aid in water filtration, storage or slow release back into the watershed; the resulting soil erosion increases sedimentation in rivers and streams. This is especially the case in Colorado, where steep slopes can lead to flash flooding downhill, where (as seen in Glenwood Canyon, previously mentioned) we observe the greatest loss in soil, vegetation, structures and sometimes even human lives. The Cameron Peak Fire led to the loss of life with flash flooding in the Cache la Poudre Canyon the following year. Runoff from the Buffalo Creek (1996) and Hayman (2002) fires created large-scale ash and debris flows into Strontia Springs Reservoir, a critical source of water for residents in Colorado. These burn scars continue to threaten Denver's water supply and had cost $27.7 million in rehabilitation as of 2020 (CSFS, 2020).

2.3 Forest health

Forest health can be closely tied to resilience (Ashton & Orefice, 2020). Introduced by Holling (1973), ecological resilience is an ecosystem's ability to absorb disturbances and persist without shifting into a qualitatively different state. Resilient forests remain forests when disrupted by natural forces. Changes to the forest can be affected by biotic agents such as insects or pathogens or by abiotic forces such as major weather events. Colorado's forests are also being impacted by drought and rising temperatures, which cause stress in trees (CSFS, 2022a).

With inadequate amounts of moisture, trees face serious stress factors that make it difficult for them to defend themselves against predators like bark beetles. Periods of drought are when insects and disease start to take their most serious toll on forests. If drought persists year after year, insect attacks will lead to drastic declines in forest health and ultimately to tree mortality. As shown in detail in section 3 of this report, an estimated 22% of Colorado's standing tree volume is composed of dead trees. As of 2020, 65% of the standing dead trees were killed by insects and 23% were killed by disease (CSFS, 2021).

The CSFS performs a yearly aerial survey with USFS partners to map insect and disease outbreaks across the state (CSFS, 2025b). These data and associated information inform the annual Report on the Health of Colorado's Forests. In 2024, the western spruce budworm remained the most widespread forest pest in Colorado, increasing its impact from 202,000 acres in 2023 to 217,000 acres in 2024. Acres affected by the mountain pine beetle totaled 5,600. The western balsam bark beetle remained the deadliest forest pest in Colorado for the third year in a row, affecting 27,000 acres of forests. Other insects damaging Colorado's forests include Douglas-fir beetle and piñon Ips.

Insect outbreaks, including bark beetles, do not necessarily increase wildfire risk in Colorado. Wildfire behavior is primarily driven by climate factors like drought and high temperatures. Outbreaks can temporarily change fuel dynamics, especially during drought, that vary across stages of tree needles turning from green to red, then to gray as they die. These stages of outbreak are commonly seen in forests across Colorado. Forest treatments can improve forest resilience to wildfire, insect attacks and disease outbreaks. Recent long-term research indicates that fuel treatments can reduce crown fire severity for up to 20 years before follow-up maintenance is necessary (Brodie et al., 2024).

This ponderosa pine in El Paso County shows the characteristic "pitch tubes" associated with mountain pine beetle infestation.
Credit: Steve Rudolph, CSFS

2.4 Colorado Forest Action Plan

Colorado's Forest Action Plan is published every 10 years as a strategic document for forest management. Mandated into law by the Cooperative Forest Assistance Act, and amended by subsequent Farm Bills, the CSFS last published a Forest Action Plan in 2020. The 2020 plan sets out to conserve, protect and enhance forests under different themes. The six main themes include forest conditions, living with wildfire, watershed protection, forest wildlife, urban and community forestry, and forest products.

The forest products section of the plan identifies primary threats and challenges to Colorado's timber industry:

- **Decline in the value of timber and resulting products generated from the forest due to insect and disease activity and wildfires**
- **Loss of processing capacity for timber harvesting and forest products**
- **High cost of forest management treatments relative to product value**
- **Increasing competition with forest products from out of state**

Goals, strategies and approaches to addressing these threats and challenges are also outlined in the plan **(Figure 1).**

Figure 1 – *Goals and strategies of the 2020 Colorado Forest Action Plan: Forest Products Theme*

GOALS AND STRATEGIES

GOAL #1

MAINTAIN AND DEVELOP MORE RESILIENT INDUSTRY CAPACITY REQUIRED TO MEET FOREST MANAGEMENT NEEDS

ENHANCE

Maintaining a sufficient forest products industry is often required to achieve forest management objectives. It will likely be necessary to develop additional capacity to align with future treatment goals.

STRATEGY 1: Maintain the capacity of the forest products industry to align with management needs.

Approaches

1. Determine industry capacity requirements based on projected forest management activities
2. Assess the sufficiency of the existing timber harvesting and forest products industry
3. Support workforce development (recruitment and training), focusing on engagement of younger generations to balance an aging wood utilization workforce
4. Promote increased use of existing capacity
5. Build additional capacity as required through development and support of innovative, sustainable financing mechanisms for local industry
6. Provide a sufficient, consistent supply of timber and/or biomass feedstock to the wood processing industry
7. Explore and adopt public and private partnerships for investing in new biomass processing facilities and markets

GOAL #2

INCREASE THE NUMBER OF FORESTED ACRES TREATED ANNUALLY THROUGH COST OFFSETS OF INCREASED UTILIZATION

PROTECT

ENHANCE

Costs of forest management activities have been increasing which, in the absence of cost offsets, limits the number of high-priority acres that can be treated. Increased utilization of timber resources provides opportunity for cost offsets. Development of a diverse forest products industry is crucial for success.

STRATEGY 1: Improve the alignment of industry operating areas with forest management needs in high-priority watersheds and wildland-urban interface areas.

Approaches

1. Highlight where industry operating areas overlap high-priority watersheds
2. Design and implement management projects to take advantage of overlap
3. Develop industry capacity in areas where it is lacking
4. Improve the efficiency of agency processes to increase the pace and scale of forest management activities

STRATEGY 2: Diversify industry products and operations to better utilize timber resources (species composition and size class) and increase industry viability.

Approaches

1. Identify all possible uses for available timber resources
2. Align uses with existing industry product mix
3. Identify opportunities for diversification, including potential industry clusters and facility co-location prospects
4. Conduct research to help identify viable markets and marketing strategies for Colorado wood products businesses
5. Focus on development of value-added niche products
6. Partner with industry to build capacity with a more diverse, profitable product mix

STRATEGY 3: Increase carbon storage by utilizing timber resources.

Approaches

1. Match timber resources to options that maximize utilization and net carbon storage
2. Work with industry to reduce wood residue generation through improved processing efficiency
3. Find product opportunities for underutilized timber resources and processing residues

2.5 Benefits associated with biomass removal and utilization

There are many benefits to utilizing biomass removed from forests. In many forests throughout Colorado the impetus to harvest biomass is to reduce fuels and thus the impacts of wildfire. Biomass harvest, removal and utilization add jobs to local economies. When biomass is utilized, the products are often long-lived wood products that store carbon for many years, thereby reducing the potential carbon dioxide that would be released in a wildfire.

Managing forests with biomass removal can also help reduce the threat of insects and disease, while improving forest health. The reduced fuel loads will make them less vulnerable to fires, protecting life, property and infrastructure. Due to a reduction in competition, growth rates can also increase for seedlings and trees that remain after selective biomass thinning and removal, which can increase carbon sequestration in the long term (Kellomäki, 2024).

Biofuels derived from biomass can be turned into energy sources including electricity (biopower), liquid fuels (biofuels) and heat generated from biomass (Grebner et al., 2009), thus helping reduce greenhouse gas pollution. This process can also create jobs and boost economies, including in rural areas.

2.5.1 Protection of life, property and infrastructure

Of the many benefits associated with biomass removal, protecting life is the most important. Removal of biomass reduces fuel loads, which is increasingly important in wildland-urban interface (WUI) areas of Colorado (CSFS, 2022b), where structures and other human developments meet or intermingle with wildland vegetation. Reduction in vegetative fuels, including trees, can reduce wildfire intensity and wildfire risk to communities.

Biomass removal can help protect road infrastructure, as was evident when crews struggled to keep Interstate 70 open and to stabilize the canyon soil after the 2020 Grizzly Creek Fire in Glenwood Canyon. Large, unstable hazard trees can be removed after fires to enhance safety. The risk to structures and other property can be reduced by removing forest fuels and utilizing the biomass. The area extending up to 200 feet around a home's foundation is referred to as the home ignition zone (National Fire Protection Association, 2025). Reducing biomass in this zone — and near any other infrastructure — can be the difference between a defensible property and one that might be determined as non-defensible when wildfire threatens. Thus, fuels mitigation around homes and other properties increases firefighter safety.

With more than half of Coloradans living in a WUI, based on the CSFS 2023 Colorado Wildfire Risk Assessment, it is important to practice wildfire mitigation; the CSFS has 18 field offices throughout the state staffed by highly qualified foresters who provide technical assistance to landowners (CSFS, 2025c). The CSFS also administers the Forest Restoration and Wildfire Mitigation grant program to provide resources for these efforts (CSFS, 2025d).

2.5.2 Watershed protection

Maintaining a sustainable clean water supply is essential to life. Colorado's water bodies provide drinking water within the state as well as 18 other states and Mexico. Healthy forests are key in maintaining water quality. Forested watersheds help hold and filter the water needed for drinking, agriculture, recreation and habitat.

When wildfires occur, soils are loaded with ash; in severe burns, soils might be so loaded they become hydrophobic. This can lead to significant sediment loads from runoff, affecting water quality and potentially harming municipal water systems. The lack of vegetation after a fire exacerbates the problem as rain and snow fall unimpeded on the soil. Without shade from vegetation, faster winter snowpack melts increase runoff. In addition to water quality, erosion also affects post-fire vegetative recovery (Crockett & Hurteau, 2024; Western Fire Chiefs Association, 2024).

2.5.3 Reduced air pollution

Air pollution is defined by the World Health Organization (2023) as "contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the atmosphere's natural characteristics."

Reducing biomass on the landscape can reduce the impacts of wildfire, including the smoke emitted. Wildfires emit pollutants, including small fine particles known as PM2.5, which negatively affect human health (United Nations Environment Programme, 2022). Jones et al. (2020) found that out-of-hospital cardiac arrests increased with wildfire smoke exposure during California's 2015-2017 fire seasons. A separate review by Gould et al. (2024) showed that smoke exposure led to an increase in all-cause mortality and respiratory hospitalizations.

Healthy forests reduce air pollution. Most pollutants are intercepted by trees' leaves during the respiration process. Pollution removal by urban trees in the U.S. has been estimated at 711,000 metric tons per year (Nowak et al., 2006). Having trees reduce pollution instead of creating it is a goal that benefits all.

2.5.4 Renewable resource utilization

Utilizing the biomass removed to encourage forest health and reduce forest fuels is a sustainable method of managing natural resources. Forests are dynamic; when healthy, they continue to grow and add biomass. Without fire or management, forests can become overstocked to the point where trees competing for resources become stressed and more susceptible to insects or disease. Biomass utilization not only contributes to the economy but is also a renewable resource that can replace non-renewable resources in some instances. The more instances in which renewable resources are used to replace those considered limited, such as coal or petroleum, the more activities become sustainable. Long-term sustainability is the goal for utilizing biomass.

Finland was the first country in the world to establish a nationwide circular economy strategy. In 2016 they launched a national roadmap aiming to transition from a linear "take-make-waste" model to a more sustainable, circular approach, including woody biomass utilization. Recently, the Colorado Department of Public Health and the Environment established the Circular Economy Development Center (Circular Economy Development Center, 2025); this initiative can promote woody biomass utilization.

2.5.5 Economic development

Humans have always relied on natural resources. Many Coloradans still make their livelihood extracting natural resources, including harvesting trees. Increasing innovation in the utilization of forest biomass could enhance economies that have forest products segments.

Many rural communities have seen their economies affected as harvest has declined. While the utilization of biomass might not return their economies to past levels, the jobs and economic activity associated with utilizing biomass can provide substantial benefits. It is estimated that in 2023 the direct economic impact of the U.S. bioeconomy, excluding healthcare, was $210 billion and generated 70,000 jobs (Dongoski & Mann, 2025).

Studies of biopower and biofuel industries found the employment multipliers in those industries was over five. This means that for every job created in these industries, four more jobs would be created in support of the operation and the connected economy (Grebner et al., 2009). These jobs include direct positions at the facility, indirect jobs in support of operations (harvesting and delivering biomass) and other jobs induced to the economy as industry employees spend their income on necessities like food, transportation, healthcare and housing.

2.5.6 Recreation

Recreation is an important part of the Colorado economy, as the state's diverse and appealing landscape provides opportunities for many types of outdoor recreation. The Colorado Office of Economic Development and International Trade (2024) reported Colorado's outdoor recreation industry generates annual economic output of $65.8 billion and contributes to 404,000 direct jobs.

This economic activity is linked to healthy forests. As forests become unhealthy and/or burn uncharacteristically, they lose aesthetic value along with some wildlife that draw outdoor recreation enthusiasts. Areas with dead trees also present safety hazards for those visiting the forest. Forest management that utilizes biomass can help keep forests healthy and attract hikers, campers, hunters, skiers and other recreators who share a common interest in healthy forests.

2.5.7 Hedge against volatile energy prices

Biofuels derived from biomass can be used to help save costs in the energy market. With volatile energy prices faced by consumers both at the gas pump and also heating the home, biofuels can compete in the energy market. According to Haase et al., (2005) "Biomass heating systems are most cost-effective when used to offset energy used in electric, oil or propane heating systems. This is primarily because the costs of these heat sources are often higher than biomass fuel costs" (p. 83).

2.5.8 Carbon and Colorado forests

Forests play an important role in the carbon cycle. Trees take in carbon dioxide (CO_2) from the air, a process known as sequestration, and store carbon in their wood, leaves and roots. As trees die, this carbon moves through the forest as it transitions from live trees into dead wood, fallen logs, leaf litter and soils. Carbon returns to the air through natural processes

like decomposition, wildfires and plant respiration. When trees are harvested and turned into wood products, the carbon in that wood is stored until the product eventually breaks down. On average, wood is approximately 50% carbon by dry weight.

Forests can reduce the amount of CO_2 in the air by sequestering and storing more carbon than they release. In this case, they act as carbon sinks. But forests can also release more carbon than they take in, especially after major disturbances like wildfires or insect outbreaks. In this case, they are carbon sources.

The CSFS released a Colorado framework to track carbon dynamics in forested ecosystems and harvested wood products. The Colorado Forest Carbon Inventory (Vorster et al., 2024) summarizes carbon trends from 2002 to 2019. Colorado's forests hold over 1,500 teragrams of carbon (TgC), most of which is stored in soils and the aboveground parts of live trees. **Figure 2** shows carbon stocks by forest-type group (TgC), measured from 2010 to 2019, with 95% confidence intervals (red).

Between 2012 and 2019, Colorado's forests were, on average, a slight net source of carbon. Tree mortality from severe insect and disease outbreaks and wildfires outpaced tree growth during this time, especially in certain forest types. As a result, more carbon was released than sequestered, though this trend varies by region, county and forest type. Forests that remained undisturbed generally acted as carbon sinks. **Figure 3** shows average annual carbon flux (TgC/year) by forest type group. Positive values indicate a net carbon sink, while negative values indicate a net carbon source. These flux estimates do not include down woody material.

Figure 2 – *Carbon stock by FIA forest type group for forested lands from FIA plots measured between 2010 and 2019. 95% confidence intervals are shown in red.*

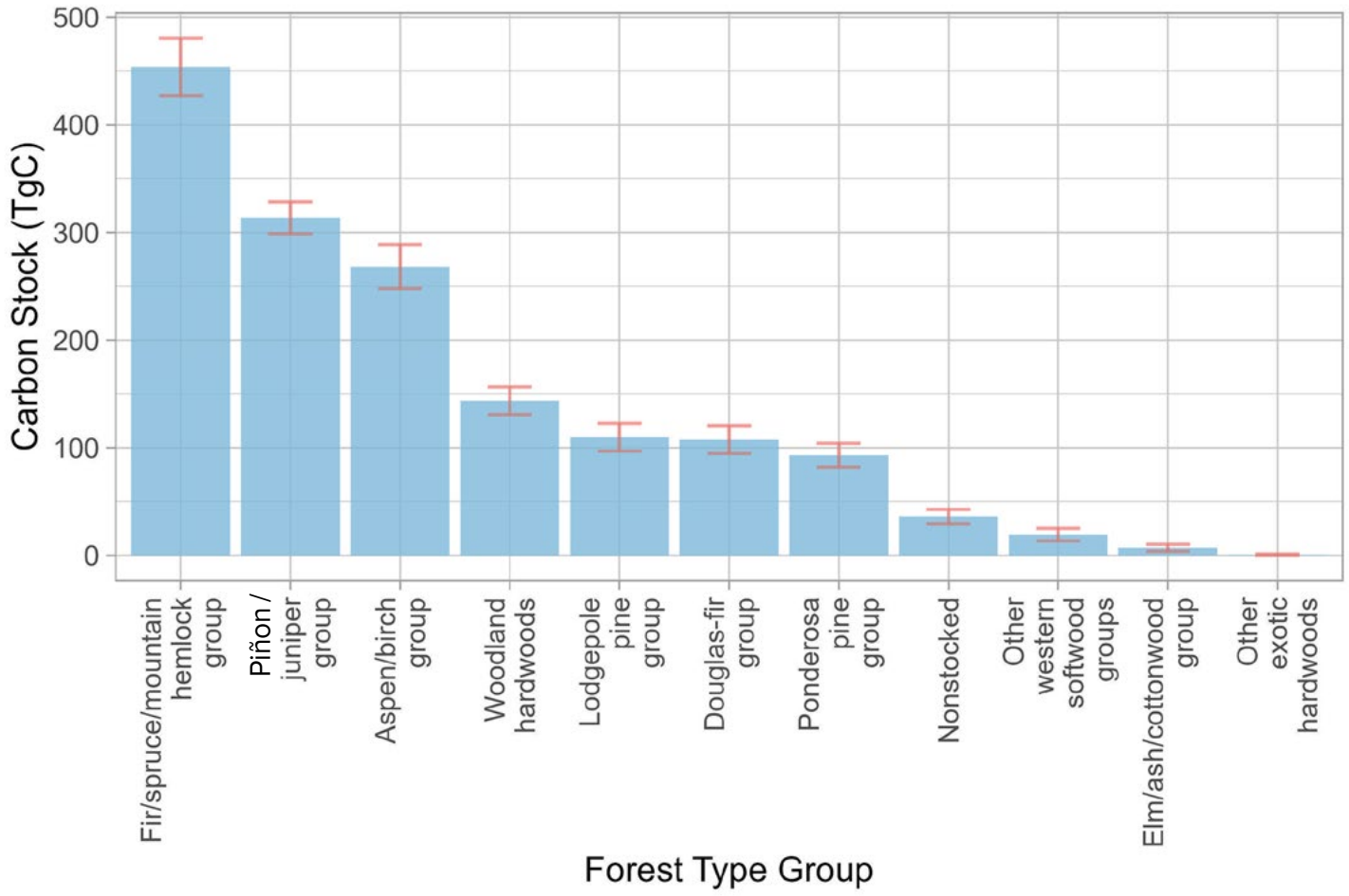
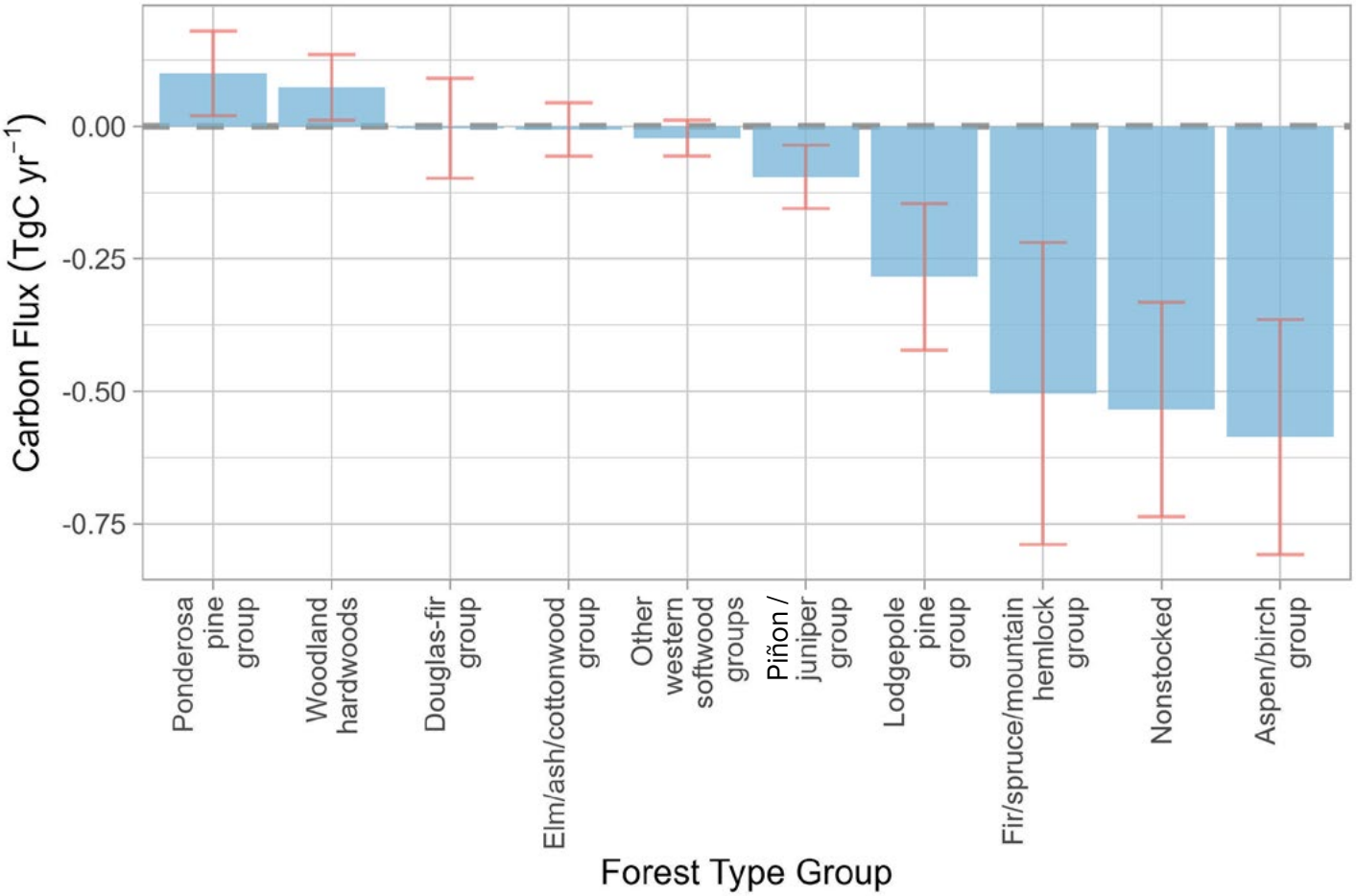


Figure 3 – *Average annual net carbon flux by FIA forest type group for forested lands remaining forested from FIA plots measured between 2002 to 2009 and 2012 to 2019. These fluxes do not include down woody material. 95% confidence intervals are shown in red.*



Forest management can change how Colorado's forests store and release carbon over time. Harvesting immediately reduces carbon stored in the forest but can transfer some of that carbon into wood products. These products hold carbon for the duration of their use, such as lumber in homes, and, in some cases, replace energy-intensive materials such as steel or concrete. From 1954 to 2019, timber harvesting activities resulted in 5.8 TgC transferred from forests to wood products. Most of the products entered the system before 1979, and since then harvest volumes have dropped by nearly 50%. Now, the bulk of the remaining carbon sink is sustained by older wood products disposed of in landfills (Vorster et al., 2024).

Although harvested wood products represent a relatively small share of the state's total forest carbon, they highlight the importance of forest management treatments and the wood products industry in sustaining this carbon sink. In some cases, management actions can provide climate benefits when compared to the no-action alternative, where severe disturbances such as wildfires occur. For example, management treatments can help maintain stable carbon storage over time or increase storage, while wildfires often release large amounts of carbon and leaves forest at risk of poor recovery. Maximizing the use of harvested material, especially in longer-lived products, further extends carbon storage and adds climate benefits (Colorado Department of Natural Resources, 2023). Utilizing mill residues or low-value woody biomass for energy can also reduce fossil fuel use, but burning this material releases carbon. The overall outcome depends on factors such as feedstock type, supply chain emissions, forest regrowth and the alternative scenario (Berndes et al., 2020).

The 2018 Spring Creek Fire in Costilla and Huerfano counties was the second largest in Colorado's recorded history at 108,045 acres before it was surpassed in size by three separate fires in 2020. ***Credit: Steve Rudolph, CSFS***

2.6 Summary

Colorado has many acres of diverse forests, mostly coniferous but some deciduous. Their usage by Indigenous people dates back millennia. When settlers of European descent began coming westward, they accelerated the pace of forest harvesting. By the early 1900s, most of the accessible timber had been utilized. It became essential to manage timber resources for the future, and the establishment of the CSFS and USFS brought a new era of forest resource management, with practices enhanced by science to inform ecosystem resilience.

Colorado was already a net importer of forest products when concerns about the loss of other benefits from forests led to laws such as the National Forest Management Act of 1976. Further pressure to protect forests from logging decreased log supplies enough to cause some major Colorado mills to cease operations. The decline in forest management and aggressive fire suppression allowed many forests in the state to become overgrown, and this led to excessive fuel loads and trees more vulnerable to insect and disease infestations.

The result was a major increase in wildfire frequency, speed of spread and intensity. The combined harm to Colorado has been massive — in terms of money, lives and scarring of its prodigious natural beauty. Fires have destroyed homes, damaged water quality, enabled mudslides and resulted in flash flooding.

The CSFS monitors forest health in the state and has observed trends of increased tree mortality for a variety of reasons. Insects are the largest cause of tree death in Colorado and their effects are intensified as trees are stressed by drought and high temperatures. Fuels reduction treatments can play an essential role in reducing wildfire risk and restoring forest health.

To help guide forest management practices, the CSFS publishes a Forest Action Plan every 10 years based upon observed conditions and fresh data. The 2020 Colorado Forest Action Plan highlights the importance of the forest products industry to utilize forest management biomass and to lower the costs of treatments. The benefits of judicious, orderly biomass removal are many: Safety for people and infrastructure, watershed protection, pollution control, use of renewable resources, economic gains (especially in rural areas), hedging against energy cost increases and carbon sequestration and storage. If wood is utilized in wood products, those products store carbon for the life of the product. This is beneficial because, due to mortality from insects, disease and wildfire, Colorado forests on average have released more carbon than is being sequestered.

We have a moral and ethical responsibility to steward Colorado's forests for the benefit of present-day society and future generations. An investment in forest health is a local investment in the protection of watersheds, property, recreation and life.

2.7 References

Ashton, M., & Orefice, J. (2020, December 16). *Yale experts explain healthy forests.* Yale Sustainability. https://sustainability.yale.edu/explainers/yale-experts-explain-healthy-forests

Berndes, G., Cowie, A., & Pelkmans, L. (2020). *The use of forest biomass for climate change mitigation: Dispelling some misconceptions.* International Energy Agency. https://www.ieabioenergy.com/wp-content/uploads/2020/08/The-use-of-biomass-for-climate-change-mitigation-dispelling-some-misconceptions-August-2020-Rev1.pdf

Blevins, J. (2021, May 31). The slow fade of Colorado's mountain pine beetle triggers shifts in timber industry. *The Colorado Sun*. http://coloradosun.com/2021/05/31/colorado-pine-beetle-epidemic-waning-timber-industry/

Brodie, E. G., Knapp, E. E., Brooks, W. R., Drury, S. A., & Ritchie, M. W. (2024). Forest thinning and prescribed burning treatments reduce wildfire severity and buffer the impacts of severe fire weather. *Fire Ecology*, 20(1), 17. https://doi.org/10.1186/s42408-023-00241-z

Circular Economy Development Center. (2025). *Colorado circular communities*. https://coloradocedc.org

Colorado Department of Natural Resources. (2023). *Colorado's strategic plan for smart natural and working lands*. https://ag.colorado.gov/conservation/agricultural-drought-and-climate-resilience-office-adcro/strategic-plan-for-climate

Colorado Office of Economic Development and International Trade. (2024). *Annual report fiscal year 2023-2024.* https://oedit.colorado.gov/sites/coedit/files/documents/FINALAnnualReport_2024_12-19.pdf

Colorado State Forest Service. (n.d.) *Colorado forest tracker.* https://experience.arcgis.com/experience/7eac80a824a64d77864e3e0948ff4f1e

Colorado State Forest Service. (2020). *Colorado forest action plan 2020.* https://csfs.colostate.edu/forest-action-plan/

Colorado State Forest Service (2021). *2020 report on the health of Colorado's forests: Protecting our future after a historic wildfire year.* https://csfs.colostate.edu/wp-content/uploads/2021/02/CSFS_2020_Forest_Health_Report_WEB.pdf

Colorado State Forest Service. (2022a). *2021 report on the health of Colorado's forests: Managing Colorado's forests during drought.* https://csfs.colostate.edu/wp-content/uploads/2022/03/2021_Forest_Health_Report.pdf

Colorado State Forest Service. (2022b). *Colorado's wildland-urban interface.* https://csfs.colostate.edu/wildfire-mitigation/colorados-wildland-urban-interface/

Colorado State Forest Service. (2024, November 18). *Tribal heritage and collaborative forest stewardship.* https://csfs.colostate.edu/2024/11/18/tribal-heritage-collaborative-stewardship/

Colorado State Forest Service. (2025a). *Colorado wood utilization and marketing program.* https://csfs.colostate.edu/cowood/

Colorado State Forest Service. (2025b). *2024 report on the health of Colorado's forests.* https://csfs.colostate.edu/forest-management/forest-health-report-2024/

Colorado State Forest Service. (2025c). *Areas and field offices.* https://csfs.colostate.edu/areas/

Colorado State Forest Service. (2025d). *Forest restoration and wildfire risk mitigation.* https://csfs.colostate.edu/grants/forest-restoration-wildfire-risk-mitigation

Crockett, J. L., & Hurteau, M. D. (2024). Climate limits vegetation green-up more than slope, soil erodibility, and immediate precipitation following high-severity wildfire. *Fire Ecology, 20*(41). https://fireecology.springeropen.com/articles/10.1186/s42408-024-00264-0

Dale, L. (2010). *The true cost of wildfire in the Western U.S.* Western Forestry Leadership Coalition. https://academiccommons.columbia.edu/doi/10.7916/c490-r123

Dongoski, R., & Mann, J. (2025). *Projected impact and growth of a fully unleashed bioeconomy.* Biotechnology Innovation Organization. https://www.bio.org/sites/default/files/2025-03/Bioeconomy%20Impact%20Modeling%20Final%20Report_March%202025_1.pdf

Fisher, A. (2022, December 30). Marshall fire anniversary: Assessing the true cost. *Longmont Leader.* https://www.longmontleader.com/local-news/marshall-fire-anniversary-assessing-the-true-cost-6308699

Foreman, M. (2019). Reduction of surface fuel should be a forest service priority. Colorado State University. https://cfri.colostate.edu/wp-content/uploads/sites/22/2019/12/MF_Treatment-of-Forsythe-Surface-Fuels.pdf

Gould, C. F., Heft-Neal, S., Johnson, M., Aguilera, J., Burke, M., & Nadeau, K. (2024). Health effects of wildfire smoke exposure. *Annual Review of Medicine, 75*, 277-292. https://doi.org/10.1146/annurev-med-052422-020909

Grebner, D. L., Perez-Verdin, G., Henderson, J. E., & Londo, A. J. (2009). Bioenergy from woody biomass, potential for economic development, and the need for extension. *Journal of Extension, 47*(6). https://tigerprints.clemson.edu/joe/vol47/iss6/7

Haase, S., Rooney, T., Tietjen, J., Whittier, J., Crooks, A., & Moriarty, K. (2005). *Jefferson County biomass facility feasibility study.* McNeil Technologies, Inc.

Hanan, E. (2020, September 18). Megafires: Climate change or land management? Unfortunately, both. *NSights, Nevada Today*. University of Nevada, Reno. https://www.unr.edu/nevada-today/blogs/2020/megafires

Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecology and Semantics, 4,* 1-23. http://www.jstor.org/stable/2096802?origin=JSTOR-pdf

Ingold, J. (2020, October 20). Five charts that show where 2020 ranks in Colorado wildfire history. *The Colorado Sun.* http://coloradosun.com/2020/10/20/colorado-largest-wildfire-history/

Jones, C. G., Rappold, A. G., Vargo, J., Cascio, W. E., Kharrazi, M., McNally, B., & Hoshiko, S. (2020). Out-of-hospital cardiac arrests and wildfire-related particulate matter during 2015-2017 California wildfires. *Journal of the American Heart Association, 9*(8). https://doi.org/10.1161/JAHA.119.014125

Kellomäki, S. (2024). Commercial thinning and selective cutting with impacts on forest carbon. *Managing Forest Ecosystems, 44.* doi:10.1007/978-3-031-71575-4_10

Lynch, D. L. (2004). What do forest fires really cost? *Journal of Forestry, 102*(6), 42–49. https://doi.org/10.1093/jof/102.6.42

Minor, N. (2021). Colorado asks feds for $116 million to fund Glenwood Canyon I-70 repairs and alternative routes. *Colorado Public Radio.* https://www.cpr.org/2021/08/09/federal-funding-glenwood-canyon-i-70-repairs-alternative-routes/

National Fire Protection Association. (2025). Preparing homes for wildfire. https://www.nfpa.org/education-and-research/wildfire/preparing-homes-for-wildfire

Nowak, D. J., Crane, D. E., & Stevens, J. C. (2006). Air pollution removal by urban trees and shrubs in the United States. *Urban Forestry & Urban Greening, 4*(3-4). 115-123. https://doi.org/10.1016/j.ufug.2006.01.007

Stevens-Rumann, C. S., & Morgan, P. (2019). Tree regeneration following wildfires in the western US: A review. *Fire Ecology, 15*(15). https://doi.org/10.1186/s42408-019-0032-1

United Nations Environment Programme. (2022). Air pollution from wildfires expected to surge as world warms. UNEP. http://www.unep.org/news-and-stories/story/air-pollution-wildfires-expected-surge-world-warms

USDA Forest Service. (2022). *Confronting the wildfire crisis: A 10-year implementation plan.* https://www.fs.usda.gov/sites/default/files/Wildfire-Crisis-Implementation-Plan.pdf

Von Ahlefeldt, J. (1979). *Thunder, sun, and snow: The history of Colorado's Black Forest.* Century One Press.

Vorster, A., Stevens-Rumann, C., Young, N., Woodward, B., Tsz-Hin Choi, C., Chambers, M. E., Cheng, A. S., Caggiano M., Schultz, C., Thompson, M., Greiner, M., Aplet, G., Addington, R. N., Battaglia, M. A., Bowker, D., Bucholz, E., Buma, B., Evangelista, P. Huffman, D., Mueller, S., Rhoades, C., Romme, W. H., Sánchez Meador, A. J., Tinkham, W. T., Tuten, M., & West (Fordham), A. (2023). Metrics and considerations for evaluating how forest treatments alter wildfire behavior and effects. *Journal of Forestry, 122*(1), 13-30. https://doi.org/10.1093/jofore/fvad036

Vorster, A. G., Choi, C. T. H., Prentice, A. M., Young, N., Kuegler, O., Gaetani, M., West Fordham, A., & Bucholz, E. (2024). *Colorado forest carbon inventory: Forest ecosystem and harvested wood product carbon accounting framework through 2019.* Colorado State Forest Service. https://csfs.colostate.edu/wp-content/uploads/2025/01/CSFS_CarbonAccountingReport_2024_FINAL_accessible.pdf

Webber, T., Peterson, B., & Fassett, C. (2024, September 29). As many forests fail to recover from wildfires, replanting efforts like in Colorado face huge odds and obstacles. *CPR News.* https://www.cpr.org/2024/09/29/colorado-forest-wildfires-replanting-efforts/

Western Fire Chiefs Association. (2024, April 14). How does wildfire affect soil and vegetation? https://wfca.com/wildfire-articles/wildfire-affect-soil-vegetation/

World Health Organization. (2023). Air pollution. https://www.who.int/health-topics/air-pollution#tab=tab_1