Final Background Paper for The Forests Dialogue's Bioenergy from Forests - Pacific Northwest Field Dialogue

Virginia H Dale (vdale@utk.edu)
Department of Ecology and Evolutionary Biology
University of Tennessee, Knoxville, TN
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This document has been reviewed by the Advisory Committee of for the Bioenergy from Forests (BEF) Pacific Northwest (PNW) Field Dialogue organized by The Forests Dialogue (TFD). The report was intended for the participants of the BEF PNW Field Dialogue, which took place from June 16-20, 2025.

Scope – This background paper focuses on forest conditions in southern Washington now and over the next decade as they relate to opportunities and constraints for sourcing for bioenergy from forests. It considers ways to improve the environmental, social, and economic conditions of the region. The paper builds from reports posted at https://theforestsdialogue.org/dialogue/bioenergy-forests-scoping-dialogue and does not repeat information that is in the following reports

- Bioenergy from Forests: Background paper bef_background_paper_feb_2024.pdf
- Co-chairs' summary for the February 27, 2024 TFD Bioenergy for Forests Scoping Dialogue: Scoping Dialogue on Sustainable Woody Biomass for Energy

In addition, this report relates to another TFD Initiative that considers mass timber materials as an entry point to explore stakeholder perspectives about the effects that scaling up mass timber construction practices might have on climate, forests, the built environment, and people: https://theforestsdialogue.org/initiative/climate-positive-forest-products-cpfp and https://environment.yale.edu/canopy/2023/cover-story/forests-dialogue-engages-stakeholders-mass-timbers-role-sustainable-future. This background paper serves as a starting point for discussions that occurred during the BEF Pacific Northwest Field Dialogue, June 16-20, 2025.

Table of Contents

Executive Summary

This background paper focuses on forest conditions in southern Washington now and over the next decade as they relate to opportunities and constraints for sourcing for bioenergy from forests. It considers ways to address concerns about environmental, social, and economic conditions of the region while producing wood-based bioenergy.

“Fracture lines” are defined by The Forests Dialogue (TFD) as topics of disagreement or gaps in knowledge or communication that need to be explored via stakeholder dialogues. For Bioenergy from Forests (BEF) – Pacific Northwest Field Dialogue, fracture lines include effects on global climate change, local air quality, worker conditions, forest management practices, and forest species and their habitats. Factors affecting fracture lines include uncertainty in the continuity of incentives to pursue bioenergy options, trust and verifiable compliance, and the perspective of the reference scenario adopted. Understanding past and current forest conditions and factors affecting them in a specific context, with and without bioenergy production, is crucial.

Climate and forest conditions in southern Washington are determined by the Cascade Mountain range that runs from north to south. Western Washington has a mild, wet climate that supports abundant forests, and the east side is drier with forests primarily on the slopes. Wildfires are frequent in eastern Washington and infrequent west of the Cascade Mountains. Massive windstorms are common in the western part of the State. Douglas-fir beetles, spruce beetles, and alder bark beetles breed in injured or windthrown timber in Western Washington. Fungi cause root diseases in all forested areas.

Washington State has a complex mix of landownerships including state, federal, Indigenous, and nonindustrial and industrial private. About 98% of the timber harvested in Washington comes from non-federal forest land, and most of the timber harvest occurs on the westside. Washington forests have always been important to the state’s economy and social structure, but there has been a decline in lumber production in recent decades related to the recession, pandemic, and Government policies, regulations, and trade practices. Even so, western Washington remains a major lumber producer. In regard to the opportunity to source bioenergy from forests, the infrastructure and labor for forestry is still present in the region.

Bioenergy has been proposed for Washington for several decades, and many options have been considered (including production of ethanol, biochar, bio-oil, sustainable aviation fuel, hydrogen, syngas, and pellets). However, few commercial successes exist. Sourcing for bioenergy can be from forest residuals (e.g., thinnings) or industrial residuals (e.g., sawdust). Growing short rotation woody crops in the Pacific Northwest for bioenergy have been explored for several decades. There has been local and NGO opposition to the specific bioenergy production facilities, but the State and port authorities have been actively pursuing business partnerships since, at least, 2011.

Government energy and forest policies affect options for bioenergy. Nearly all academic economists agree that carbon pricing in the form of a tax is necessary to incentivize policies that promote the use of carbon-based material rather than fossil fuels. Washington State Energy Strategy[1] commits the state to greenhouse gas (GHG) emissions being 55% below 1990 levels by 2038, and use of bioenergy is one way to address that goal. Yet Washington is hampered by the

[1] https://www.commerce.wa.gov/energy-policy/state-energy-strategy/

exclusion of federal forests from Renewable Identification Numbers (RINs) (i.e., credits used for compliance under the Renewable Fuel Standard, which requires transportation fuel sold in the US to contain a minimum amount of renewable fuels). However, the US Department of Energy's (DOE's) Office of Indian Energy Policy and Programs[2] recently extended the deadline to apply for a $25 million funding opportunity that aims to support Tribal energy planning and development. Furthermore, international energy policies influence bioenergy in Washington state given its ready access to marine ports and existing marine trade.

State and Federal natural resource management policies also affect the availability of forest and industrial residues that can be used for bioenergy. The Boldt Decision in 1974 confirmed the fishing rights of Indigenous people and tribal sovereignty in Washington state and has more recently been applied to other natural resources. The Northwest Plan in 1994 specified management practices of federally managed lands in western Oregon and Washington and northwestern California to address concerns about threatened and endangered species and also consider the social and economic sustainability of the region. However, recent changes in US Federal policies are causing uncertainties in forest protection and management strategies.

Opportunities and constraints for sourcing wood for bioenergy are determined by the particular products being considered and the local and regional context (including availability of wood and mill residues, socioeconomic condition, workforce availability, and transportation options). Opportunities include managing forests for multiple purposes including reduction of risk from fire and insects, use of forest residuals and thinnings, increases in employment opportunities, growth in bioenergy markets, the economic vitality of working forests, Indigenous forest stewardship, and forest bioenergy combustion capture and geological sequestration (BECCS).

Constraints include the challenges of developing a new market system, long-distance transport, exclusion of federal forests from RINS, uncertainties in Federal policies, absence of strong bioenergy markets and infrastructure in place, concerns about air quality reduction and environmental justice issues, and acceptance of bioenergy industry's standard business practices and operating procedures.

Having a clear definition of sustainable forestry is essential for wood-based bioenergy. The supply of forest and mill residues depends on overall forest sector activities and markets. While there is concern that using forest biomass for bioenergy will increase net carbon emissions from forests and have undesired impacts on habitat and biodiversity, forest management can be designed to conserve carbon and support biodiversity conservation. Timely, transparent, and trusted monitoring and reporting on the forest system and habitat conditions and focusing on indicators that are important to local stakeholders can provide a foundation for learning that is necessary to adapt management to changing conditions and make improvements over time. Public engagement in monitoring and analysis, combined with the provision of timely access to data, findings, and management plans, can help strengthen the social license for sustainable production and use of wood-based bioenergy.

[2] https://www.energy.gov/indianenergy/office-indian-energy-policy-and-programs

1. Introduction

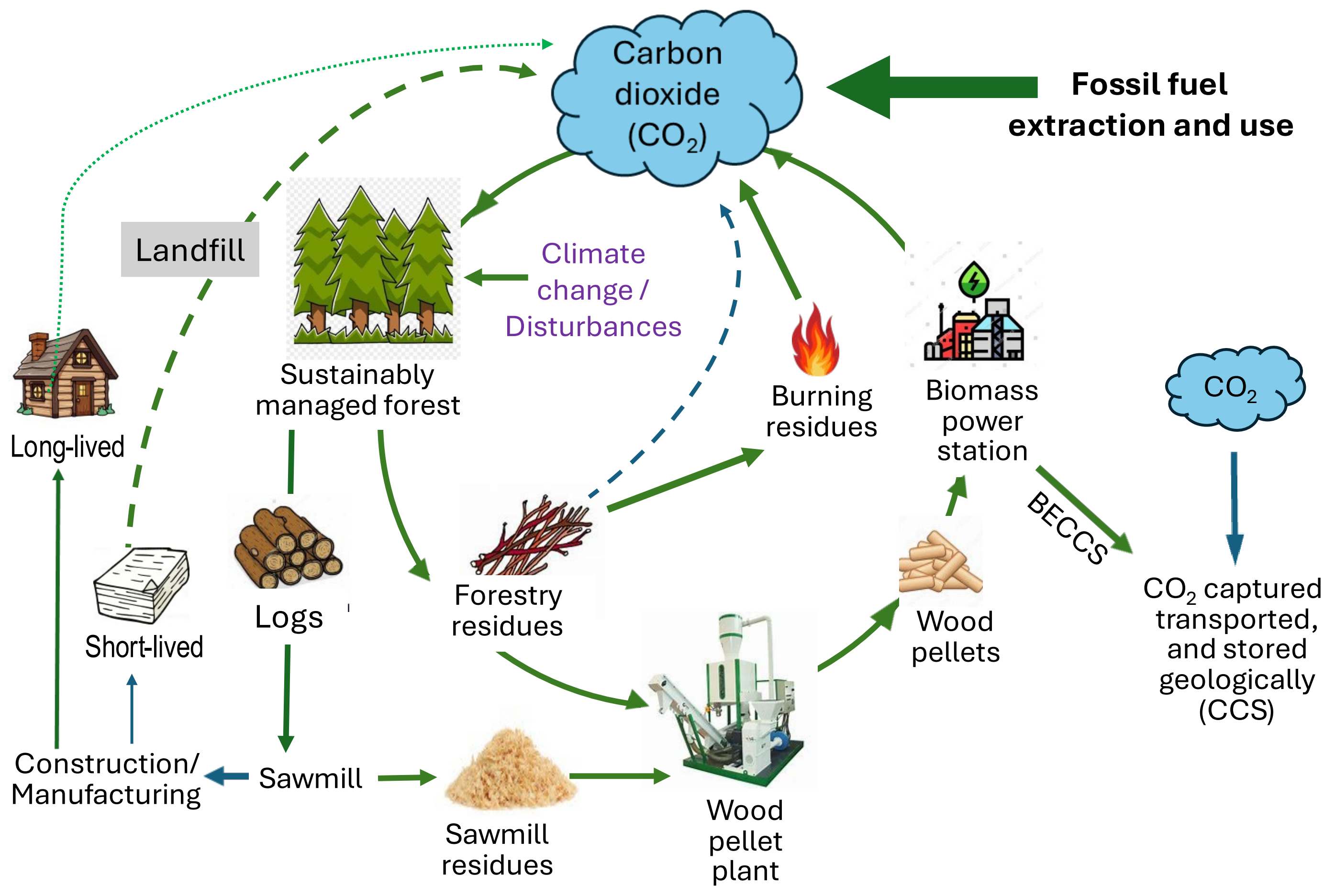
Humans have always burned wood and other forms of biomass for heat and energy. In recent years, biomass power systems and advanced technologies have been developed to offer a renewable alternative to fossil fuels. Because raw biomass tends to be bulky and difficult to transport, more efficient supply chains have been developed based on pellets to fuel biopower systems. Compared to raw biomass resources, pellets made from compressed biomass materials offer a more uniform and densified fuel that is easier to handle, store, transport and utilize in industrial systems. Pellets can be burned instead of fossil fuels to provide a renewable source for the generation of heat and power.

A diagram of how forest-based bioenergy systems affect carbon dioxide (CO_2) is illustrated in Figure 1. Atmospheric concentration of CO_2 are of great concern because, together with other green-house gases, they are affecting global climate change. The major contributor to atmospheric CO_2 is fossil fuel extraction and use, but this report focuses on forest systems. Carbon is removed from the atmosphere as forests grow. Forest and sawmill residues are transported to a pellet mill where the material is pelletized. Then the pellets are transported to a power station, wood heater, or furnace. The CO_2 that is emitted from a biomass power plant is either released to the atmosphere and thereby returned to the atmospheric carbon cycle or it can be stored in a bioenergy carbon capture system (BECCS) in order to reduce atmospheric carbon. Another possible path for carbon is Bioenergy with Carbon Capture and Utilization (BECCU) in which the captured CO2 can be utilized for chemicals synthesis, fuels production, etc., in a manner that not only helps in reducing GHG emissions, but also in creating value-added products. Figure 1 shows that if forest residues are not collected and used to produce pellets or other products, they may be burned onsite, left to rot in “meltdown piles,” or remain on the forest floor where they can increase the risk of wildfires in some regions. All of these cases release their carbon back to the atmosphere: quickly if they burn. Residues remaining on the forest floor decompose more slowly, with some carbon returning to the atmosphere and some carbon moving into the soil carbon pool. Other wood-based products (lumber for construction, cardboard, and paper, etc.) will also eventually release most of their CO_2 into the atmosphere, albeit at rates depending on the longevity of the products and their final disposition. Wood that is harvested and used for construction is one form of carbon storage and contributes to carbon sinks in the United States (US) along with living forests.

Strong markets for wood products and bioenergy can encourage reforestation, sustainable forest management, and the maintenance of large forestry production systems that inherently sequester and store more carbon than alternative land uses such as agriculture or urban sprawl. However, the definition of sustainable forest management and the viability of these markets depends on local conditions.

In some situations, there are concerns about increases in water stress that accompany bioenergy – especially for systems that rely on irrigated feedstocks (Gheewala et al. 2011). While management can alleviate such concerns, bioenergy projects should consider effects on freshwater.

Figure 1. *Diagram of the carbon cycle with pellet production and use. Forest residues may include thinnings, branches, or trees that are not suitable for timber. If residues are not used for pellets or chips, they are burned onsite or moved to "melt-down piles" where they slowly decompose (hence the dotted line to CO_2 release). Sawmills residues include sawdust and woody material transported to a mill and rejected onsite. Construction and manufacturing materials go to long-lived products such as buildings or furniture or to short-lived products such as paper. While both options eventually contribute to atmospheric or soil carbon pools, their rate of emission is quite different. Sustainability of forests and their contribution to atmospheric CO_2 is determined by harvesting and other management practices as well as climate change and disturbances (Sharma et al.2023). When CO_2 from a biomass power station is geologically stored in a carbon capture system (CCS), it is called bioenergy CCS (BECCS). The major contribution to atmospheric CO_2 is the extraction and use of fossil fuels (37.4 gigatons in 2024) whereas forest growth and land-use management contribute about 7 gigatons per year (with the sink being 11.7 and emissions of 4.2).*[3]



[3] Global Carbon Budget | GCB 2024

This report focuses on forest conditions in southern Washington State now and over the next decade as they relate to opportunities and constraints for sourcing for bioenergy. It recognizes that increased bioenergy demand could impact forest carbon stocks in different ways, depending on factors such as the degree to which afforestation and sustainable forest management practices are deployed (Favero et al. 2020). Furthermore, effective and stable policies need to provide incentives for the investments that are required to generate and monitor net carbon changes in both the near and long-term. There are differences in opinions, or fracture lines, about how to appropriately develop and deploy forest-based bioenergy systems in southern Washington and elsewhere. This report first gives an overview of those fracture lines and then presents information about forest, environment, social, economic, and policy conditions in southern Washington that determines opportunities and constraints for bioenergy energy in the region and influences the fracture lines. The report concludes with a few recommendations for next steps to address the fracture lines. This draft report thus sets forth information for the BEF PNW Field Dialogue.

2. Fracture lines

"Fracture lines" are defined by The Forests Dialogue[4] as topics of disagreement or gaps in knowledge or communication that need to be explored in future discussions. For the PNW Field Dialogue, major factures lines are based on perceptions of how bioenergy is or would be sourced and produced and are context specific. Fracture lines relate to social license - that is, the acceptance of a company or industry's standard business practices and operating procedures by its employees, stakeholders, and the public (Acharya et al. 2024). Building on the findings of prior forest dialogues[4], social license depends on the degree to which the effects of a bioenergy project are perceived to be beneficial or harmful to forests, people, climate, and the environment. These perceptions relate to the spatial and temporal boundaries considered as well as the understanding, validity, and acceptance of empirical evidence and model projections. The issues discussed below include perceived effects on global climate change, local air quality, worker conditions, forest management practices, and forest species and their habitats.

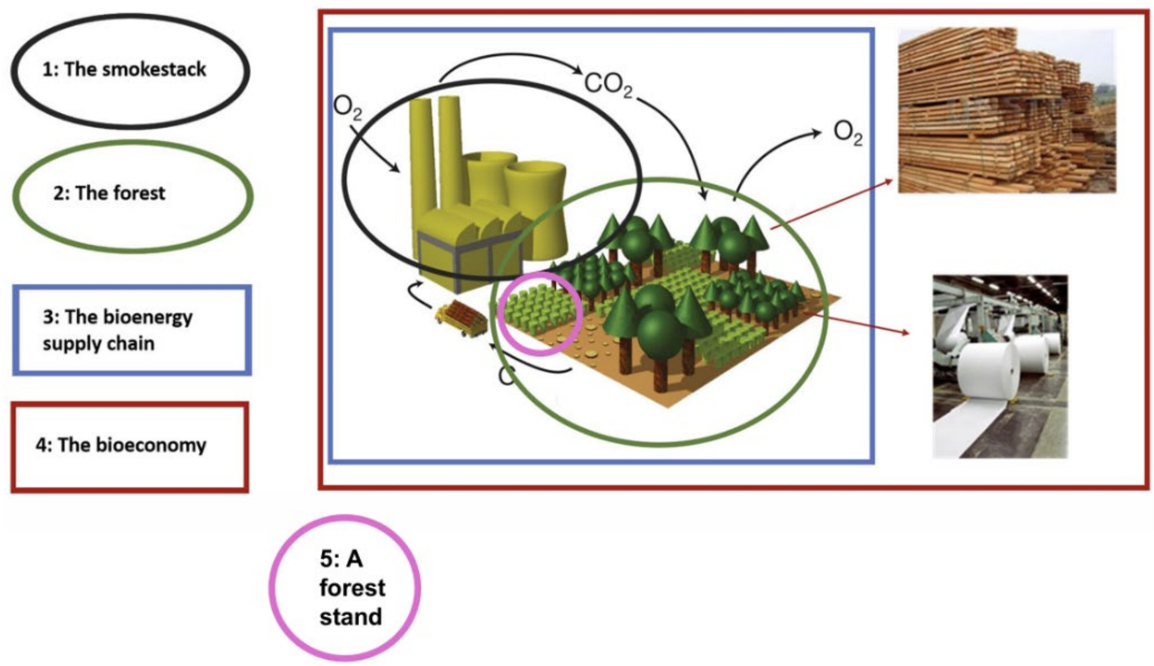
2.1 Effects on global climate change as a fracture line

Understanding the effects of a particular bioenergy project on global climate change requires consideration of the cycling of carbon and other greenhouse gases (Figure 1) with and without the project. From the perspective of a single tree or forest stand, the short-term impact of its removal and use for bioenergy is an increase in atmospheric CO_2. However, when a landscape or global perspective is adopted and effects are viewed over the long-term (Figure 2), the sources and sinks of CO_2 associated with forest-based bioenergy production and use can balance in the forest landscape and worldwide by generating net climate benefits by displacing energy sourcing by fossil fuels. This balance is achieved when forests are harvested in a sustainable manner. The definition of sustainable harvesting can vary and that is why it is important to adopt practices and metrics for sustainability that are used by established and audited forest certification systems

[4] https://environment.yale.edu/canopy/2023/cover-story/forests-dialogue-engages-stakeholders-mass-timbers-role-sustainable-future

such as those provided by the Forest Stewardship Council (FSC), Sustainable Forestry Initiative (SFI), or the Sustainable Biomass Program (SBP).[5] Empirical measures of forest carbon flux in systems that produce bioenergy under long-term forest management reveal little to no effect on carbon pools (Aguilar et al. 2020, 2022; Dale et al. 2017; Parish et al. 2017A, Cowie et al. 2021).

Figure 2. *Perspectives from which carbon flux (and thus effects on climate change) can be viewed in forest-based bioenergy systems (based on Cowie et al. 2021). Option 1 considers emissions from smokestacks. Option 2 considers the forest landscape. Option 3 considers the bioenergy supply chain. Option 4 considers the bioeconomy. Option 5 considers a single forest stand.*



2.2 Effects on local air quality as a fracture line

Air quality emissions are a local to regional dynamic and are an important fracture line. Forest bioenergy sourcing occurs in regions that have abundant forests and industrial residues of little value. These are typically poor, rural areas with limited employment opportunities. All forests produce volatile organic compounds (VOCs) and particulate matter (PM) is released from the production of any wood product (sawlogs, paper, cardboard, and pellets for bioenergy). Hence, air emissions from bioenergy production must be considered in view of natural emission from forests as well as other industries in the local area that produce PM, VOCs, etc. such as sawmills and papermills. An air quality issue that is growing in recognition and importance due to health impacts in recent years is the smoke from wildfires. Attributing air quality conditions to any

[5] https://sbp-cert.org/

specific source is challenging. In the US, all bioenergy production facilities such as pellet mills are required to obtain permits from local air quality authorities that follow established protocols of the Environmental Protection Agency (EPA). Regular monitoring and reporting of air quality conditions is required by those permits.

2.3 Worker conditions as a fracture line

Forestry and industrial work are dangerous activities. Safety of loggers and equipment operators is a priority. Therefore, worker conditions and safety are a great concern. Lack of workforce development and education/training are relevant to work conditions too. While safety must always be addressed, it is not evident that sourcing for bioenergy increases worker risks, and when bioenergy is linked to application of international sustainability guidelines, risks may be reduced This is because bioenergy-focused industries are under social pressures and a microscope for compliance from stakeholders and when exporting, are generally held to higher standards than traditional forest industries.

Uncertainties in the strength, growth, and longevity of the bioenergy industry affect job security. However, unlike other extractive industry jobs (fossil fuels), the potential to continue working in the forest industry is maintained or expands when sustainable forest management practices are employed.

2.4 Forest management practices as a fracture line

Forest management practices in the Pacific Northwest have evolved from even-age clearcutting to variable-retention harvesting that enhances ecological conditions of forests (Franklin et al. 2018). These management practices include both pre-commercial and commercial thinning, which thins small diameter wood (pre-commercial) and merchable diameter (commercial) logs. These practices increase remaining timber diameter and can enhance habitat prior to a commercial harvest. Other forest management practices and tools include thinning-only, understory thinning, and prescribed fire.

Variable-retention harvesting is aimed at higher value lumber and pulp markets where residual byproducts are utilized for bioenergy. There are no large-scale forest operations in the Pacific Northwest that harvest strictly for bioenergy. Furthermore, one way to source for forest bioenergy is to thin forests, which can benefit biodiversity by reducing risks from pests, disease, and wildfire (Thomas et al. 1999) as well as improve soil carbon sequestration by increasing overall stand productivity (Jandl et al. 2007). Even so, some groups are opposed to any forest harvests, regardless of the practice or tool.

Some groups are concerned that a dramatic increase in the use of forest residues will increase removal of biomass from forests and thereby alter forest conditions. However United States (US) wood pellet exports in March 2025 declined from the previous month and the prior year.[6] In addition, forest residues, by definition, are byproducts of a highly valued forest industry. Residues do not drive harvesting practices or market conditions because they have little value in

[6] USDA: US wood pellet exports top 781,576 metric tons in March | Biomass Magazine

comparison to the primary products of timber and pulp. However, where there is no demand for wood products, economically stranded forests[7] can be sourced for bioenergy. To date, the levels of wood pellet production in the southeast US have minimal effects on forest ecosystem services (Aguilar et al. 2020, 2022; Dale et al. 2017, Parish et al. 2017A). Although that region produces more pellets for bioenergy than any region in the world, biomass for wood-based pellets comprised less than 5% of total industrial wood harvest removals in 2018 (Brandeis and Abt 2019; USDA FIA TPO 2020) and has not changed much since that time.

2.5 Effects on forest species and their habitats as a fracture line

Forest species and their habitats can be impacted by any forest operations including sourcing material for bioenergy. Guidelines exist on how to manage plantation and other systems in a manner that fosters biodiversity (Hartley 2002). Attention should be paid to protection of areas of high conservation value (HCV)[8] (Dale et al. 2017). Conservation of HCV areas in forests can be achieved by communities, industries, local governments, and other stakeholders working together to identify and invest in opportunities that improve land management and productivity (Kline and Dale 2020). Certification schemes also play an important role in protecting HCV areas.

2.6 Factors affecting fracture lines

Incentives can provide an impetus to devise and implement low-carbon energy strategies (including those that integrate bioenergy) as well as protection of environmental, social, and economic conditions. Yet, the continuity of incentives is uncertain because of the current political situation. Furthermore, there are concerns about unintended consequences of incentives as well as evidence being insufficient to demonstrate net benefits to forests, biodiversity, climate, environment, and people. These concerns are linked to the inability to predict the future with certainty.

Another factor influencing fracture lines is trust and verifiable compliance. While good practices to protect forests and biodiversity are defined, some stakeholders do not believe that the practices are adequately enforced and verified.

Many of these differences and gaps in bioenergy systems relate to the perspective of the reference scenario or counterfactual conditions being adopted (Parish et al. 2017B). One viewpoint may focus on the forest landscape, while other views are of a specific forest stand location, local smokestacks, the bioenergy supply chain, or the bioeconomy (Figure 2). All perspectives consider what could happen over a future period of time with and without a certain intervention. Different effects are envisioned depending on which perspective is adopted.

Therefore, it is important to understand past and current forest conditions and factors affecting them in a specific context, with and without bioenergy production. Appropriate counterfactual

[7] Stranded assets are those that have lost value due to changed market conditions. For example, a timber stand that was managed in anticipation of sales to a pulp mill or sawmill and that mill closed or became inaccessible.

[8] Common Guidance for the Identification of High Conservation Values – TNFD

scenarios can be developed by identifying major influences on forest conditions, developing potential futures with clear assumptions and uncertainties, specifying likely alternative feedstock fates, and estimating the implications of no bioenergy production in the region on future forest conditions (Parish et al. 2017b). The rest of this background paper presents conditions for southern Washington that influence bioenergy production and use.

3. Conditions in southern Washington

3.1 Climate conditions

Climatic conditions in southern Washington are largely determined by proximity to the Pacific Ocean and to the Cascade Mountains, which run north to south and divide the state into two climatic regions. In the fall and winter, prevailing winds from the southwest bring cool temperatures and moisture-borne clouds to western Washington and produce abundant rain or snow at higher elevations. A rain shadow effect occurs as the moisture-laden clouds induce precipitation as they rise and cool on approaching the Cascade Mountains causing the west side to have high precipitation and the east side to be dry. As a result, Western Washington experiences mild temperatures, wet winters, and dry summers whereas eastern Washington is relatively dry. High elevations of the Cascade Mountains and volcanoes support several glaciers. Eastern Washington experiences dry, arid conditions, has only 15 to 50 cm (6 to 20 inches) of precipitation annually, and undergoes extreme temperature fluctuations.

3.2 Forest composition and distribution in southern Washington

Forests cover about half of the land area of Washington state and exist in four distinct regions: Coastal, Lowland, Mountain, and Eastside (Figure 3). Each region is characterized by unique climate conditions and supports different tree species and habitats. The Coastal region averages 330 cm (130 inches) of annual rainfall, which supports the growth of very large sitka spruce, western red cedar, and western hemlock (and Douglas-fir on drier slopes). The Lowland forest region has more than 178 cm (70 inches) of rainfall annually and experiences mild temperatures, which supports Douglas-fir, western hemlock, western red cedar, and other species. It is both the largest forest region and the most harvested in the state resulting in much second- and third-growth forests. The Mountain region varies in climate and growing conditions depending on elevation and have few trees as tree line is approached. Tree species vary, with Douglas-fir, western hemlock, and others being common in the western Cascades, and lodgepole pine, ponderosa pine, grand fir, Douglas-fir, western white pine, and western larch common in the eastern Cascades.

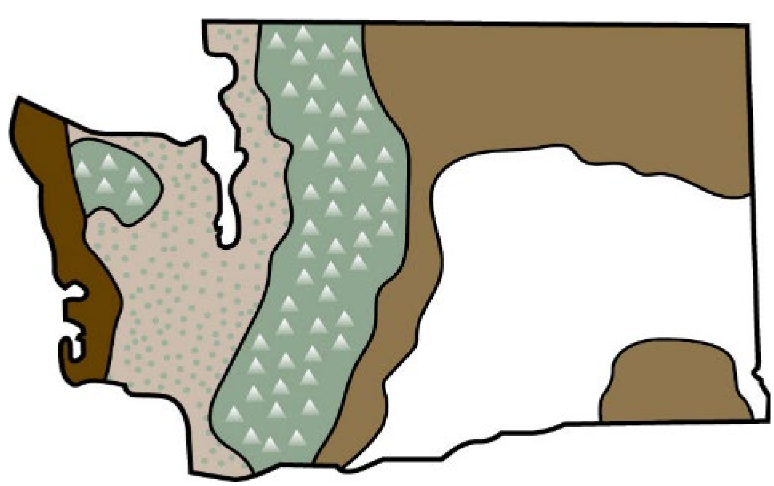


Figure 3. Forest regions of Washington: Coastal (dark brown), Lowland (tan with green dots), Mountain (green with white trees), and Eastside (light brown) (map from https://www.wfpa.org/forest-facts/washington-forests/).

3.3 Current forest conditions

3.3.1 Disturbance regimes

3.3.1.1 Wildfire

Wildfires are a prominent part of forest history in the State despite abundant rainfall (Table 1). Wildfires are frequent in eastern Washington and infrequent west of the Cascade Mountains. Based on records from 1984 to 2018, Barros et al. (2021) found that wildfires in Washington and Oregon burned less than expected in managed US Forest Service forested lands, private non-industrial, private industrial, and state lands, which implies that enforcement of strong fire protection policies is effective. The Climate Reality Project recently reported that increasing wildfires not only reduces air quality but also threatens fresh water supplies and habitat (due to subsequent erosion).

Table 1. Major wildfires in Washington State since 1800 (some of this information is from Wilma 2023, https://www.historylink.org/File/22785)

Date	**Name of wildfire**	**Area burned ha (acres)**	**Instigator**	**Location**
Ca. 1800	Indigenous fire	101,171 (250,000)	Human activities	Between Mount Rainier, Mount St. Helens, and Centralia
1902	Yacolt Burn	96,687 (238,920)	unknown	Clark, Cowlitz, and Skamania Counties
1910	The Big Burn	1,214,100 (3,000,000)	lightning	Idaho, Montana and Northeast Washington
1951	Great Forks Fire	13,355 (33,000)	Sparks from a logging train	Forks on the Olympic Peninsula
1970	Entiat Burn	45,325 (112,000)	lightning	Wenatchee National Forest (Okanogan County)
1991	Spokane Firestorm	14,164 (35,000)	Power lines	Spokane County
1994	Tyee Creek Fire	>16,187 (>40,000)	lightning	Wenatchee National Forest (Okanogan County)
2001	Thirty-mile Fire	3,773 (9,324)	campfire	Okanogan County
2014	Carlton complex Fire	103,643 (256,108)	lightning	Okanogan County
2015	Okanogan Complex Fire		lightning	Okanogan County
2023	Newell Road	24,430 (60,369)	unknown	Klickitat County

In 2023, the Washington State Department of Natural Resources planned controlled burns on more than 850 ha (2,100 acres) to prevent larger fires from occurring. Even so, in that year, nine wildfires occurred between July 2 and September 1 that burned more than 400 ha (1,000 acres). In 2023 and 2024, 1,515 fires burned at least 59,170 ha (146,220 acres) according to the Washington state Department of Natural Resources (DNR).

3.3.1.2 Windstorms and Ice Storms

Massive windstorms and ice storms are common in the western part of the State. The Columbus Day storm in 1962 had winds exceeding 160 km/hr (100 mph) and caused over $280 million worth of damage from California to Canada. The Inauguration Day storm in 1993 had wind gusts up to 120 km/hr (75 mph). The Hanukkah Eve storm in 2006 attained winds gusts of 182 km/hr(113 mph). As the result of a storm in January 2012, over 476,000 people lost power for 8 days. A so-called "bomb cyclone" in November 2024 brought winds of 124 km/hr (77 mph) to western Washington.

Massive tree blowdowns are part of such windstorms, and damaged forests are highly susceptible to wildfire, insects, and diseases. However, windstorms also help maintain biological diversity and wildlife habitats. Broken tops or limbs and large downed wood offer habitat for wildlife, which is limited in many forest areas.

3.3.1.3 Disease and insect outbreaks

Fungal infections instigate at least 18% of the annual conifer mortality and cause large losses of timber in Pacific Northwest forests (Hadfield et al. 2025). All conifer species and all forested areas are susceptible to root diseases. They cause a slow and spreading progression of death in affected stands and may persist from one year to centuries in forest soils.

Pests include insects such as Douglas-fir, spruce, and alder bark beetles, and the newly arrived emerald ash borer. Douglas-fir beetles, spruce beetles, and alder bark beetles breed in injured or windthrown timber in Western Washington (Washington State DNR 2025). These beetles can give rise to epidemics that kill healthy or injured trees. In early spring (April to June), Douglas-fir and spruce beetle adults lay eggs under the bark of large, recently downed logs that are in shady locations. The larvae mature over the year. Therefore, the following spring (two springs after a winter windstorm) this second generation of adult beetles seek damaged Douglas-fir or spruce or healthy trees and can attract large numbers of beetles that kill the trees. Vigorous green trees may survive depending on how many beetles and larvae there are. Events that instigate massive accumulations of large diameter blowdown trees can foster beetle epidemics that last three years.

Alder bark beetles breed in logs and injured trees during the first spring following a windstorm. Salvage of infested trees and logs must be deployed promptly, for no pheromones are available commercially for managing alder bark beetles and they have two generations a year.

Emerald ash borers (EAB), introduced to the US and first detected in Michigan in 2002, has made its way to Oregon in 2022 (Oregon EAB Taskforce 2025). Oregon Ash is the only ash tree native to the Pacific Northwest and is found in bottomland riparian forests and wetlands (Zobrist et al. 2023). Furthermore, EAB is affecting olive and white fringe trees as well (Oregon Department of Agriculture 2025). In the Eastern US, EAB has induced a 90-99% mortality rate in all ash species after infection (Herms & McCullough 2014). Oregon ash is a dominant tree riparian and wetland species in Oregon's Willamette Valley, and with the potential to induce 90-100% mortality of over the next 20 to 40 years, thousands of tons of residuals will be produced that must be processed in place according to Oregon's quarantine against moving any material of affected trees beyond county boundaries.

3.3.2 Forest land ownership

Washington State has a complex mix of landownership. The Northern Pacific Land Grant Act of 1864 granted square-mile sections of land in an alternating, "checkerboard" pattern across Washington Territory to the Northern Pacific Railroad. At the turn of the century, 364,217 ha (900,000 acres) of this railroad land was sold to Frederick Weyerhaeuser. By 1903 the Weyerhaeuser Company owned 607,028 ha (1,500,000 acres) in the State and kept on buying timberland. When the State was established in 1889, millions of acres were retained by the federal government, and over 1,214,100 ha (3 million acres) were granted to the State to support public institutions. During the middle of the 19th century, several tribes negotiated treaties with the US government, which typically ceded large areas of tribal land and created reservations. For example, the Yakama reservation was created in 1855.in southeast Washington on 557,266 ha (1,377,034 acres) Thet complex pattern of landownership is still retained (Figure 4).Today about half of Washington is in forest land, of which 63% is managed by the government and almost 37% of the forestland is privately owned (Figure 5).

Figure 4. Major land ownership classes in the Pacific Northwest (Barros et al. 2021) (Springer Nature holds the copyright on this map).

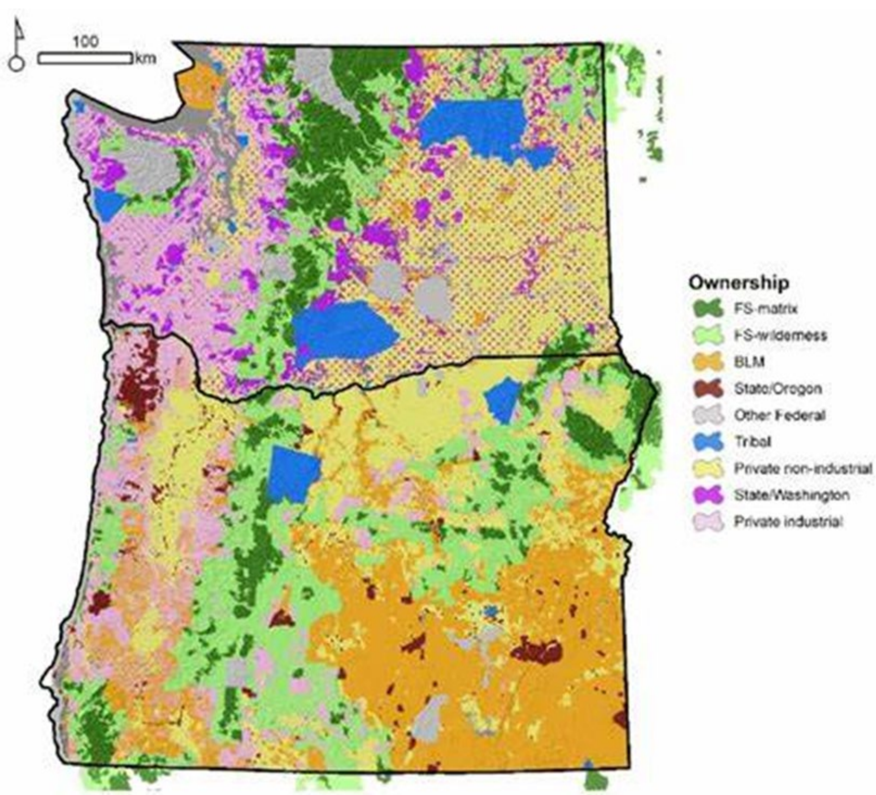
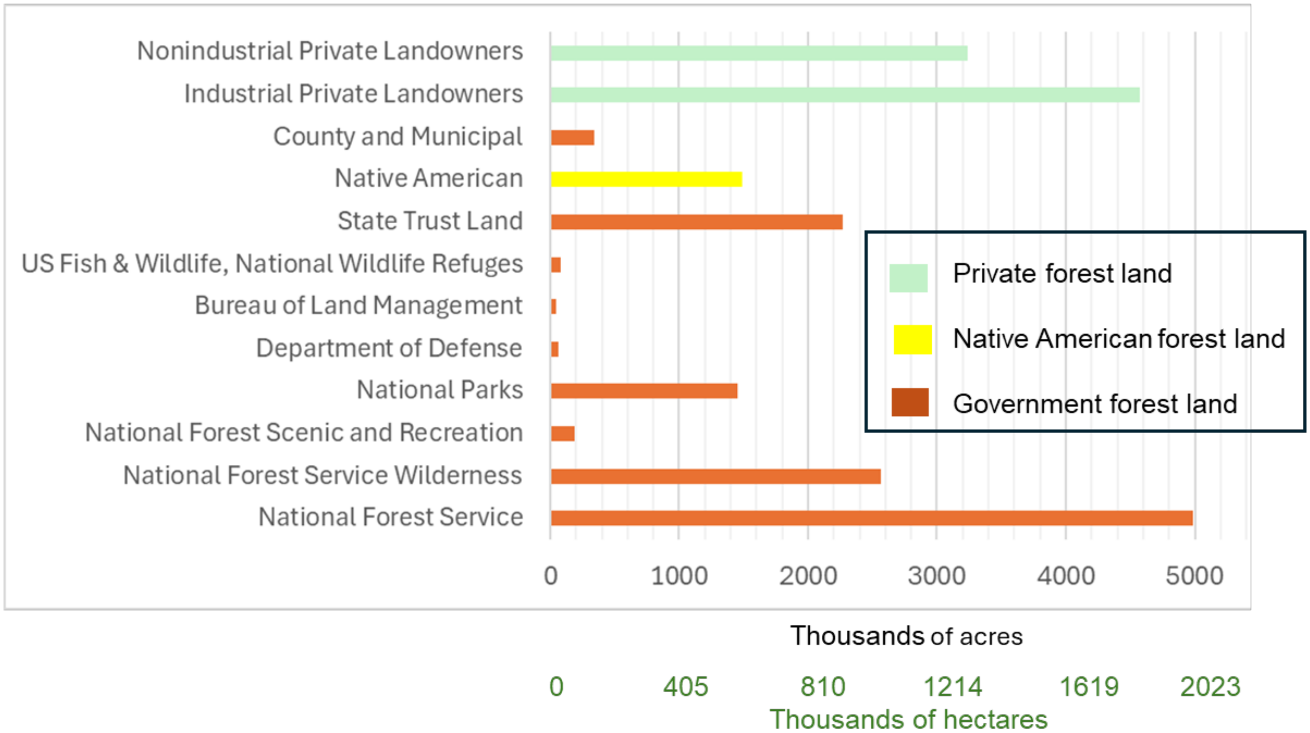


Figure 5. Forest land ownership in Washington State (source: Washington Forest Protection Association 2025)



3.3.3 Land use and land-use management practices

About 98% of the timber harvested in Washington comes from non-federal forest land, and most of the timber harvest occurs on the westside (Washington Forest Protection Association 2025). (Table 2). In the conterminous US, high biomass forest covers <3%, and the Pacific Northwest has 56.8% of that cover (Krankina et al. 2014). While 7.6% of those high biomass forests in National Forests were lost to fire between 2000 and 2008, the loss of logging on private land was greater (Krankina et al. 2014). Further loss is expected in the future.

Table 2. Timber harvest in 2017 by ownership (Washington Department of Natural Resources 2018)

	Volumes of harvested trees (thousand board feet, Scribner)		
Owner	Eastside	Westside	Total
Private	289,150	1,789,044	2,078,194
State	58,187	471027	529,214
Federal	62,794	41021	103815
Other public	3,228	38432	41660
Native American			191,117
Total	413,359	2,339,524	2,944,000

Today forested State Trust Lands exceed 971 thousand ha (2.4 million acres) and are managed by the Washington State DNR under a legal responsibility to generate revenue for designated beneficiaries, such as schools, counties, and critical local services. DNR management focuses on long-term timber production (including biomass byproducts and other forest products), specific habitat objectives, protection of clean, abundant water, and public recreation. All of DNR's forested lands are certified under the Sustainable Forestry Initiative® (SFI), and 71,225 ha (176,000 acres) of those lands are also certified by the Forest Stewardship Council® (FSC). Certified forests are required to have environmentally responsible, socially beneficial, and economically viable management practices. Similarly, the Oregon Forest Practices Act establishes rules for logging, reforestation and habitat conservation and applies to commercial timber harvesting such as clearcutting, thinning, and salvage logging on non-federal lands (state, county and private land).[9] It ensures compliance with standards for soil stability, water protection, and habitat conservation.

Interest in the use of Indigenous fire practices is growing. Coughlan et al. (2023) provide a thorough review and discussion of Indigenous fire stewardship (IFS) for fire management and ecological restoration in the Pacific Northwest, and only a small part of that rich discussion can be captured here. They point out that there are many definitions of IFS, for it is a suite of cultural fire practices specific to the heritage of local Tribes and First Nations in the region. In addition to cultural fire, IFS can involve such diverse practices as harvesting techniques, tending, and coppicing (i.e., cutting a tree to encourage shoot growth). Coughlan et al. (2023) make clear that IFS is not "prescribed fire." Furthermore, efforts to revitalize IFS face several constraints (Coughlan et al. 2023). While there is rising recognition of the benefits of IFS in wildfire management, major barriers to its use are biophysical and regulatory constraints. For example, in the Klamath River Basin changes in climate are affecting plant production cycles, which makes it difficult for Tribes to determine the appropriate times to burn (Mucioki et al. 2021).

A pertinent example of the Forest Service working with tribes is the Clear & Clearwater Creek Restoration Project.[10] The plan is to thin up to 26,000 trees across 388 ha (960 acres) in the Gifford Pinchot National Forest. . Thinning will only harvest a fraction of the trees on the landscape to acquire coarse woody debris (logs with attached root wads) for instream restoration and to improve forest conditions. The trees remaining after thinning typically experience less competition, and the thinned trees will either go into Clear Creek, Clearwater Creek, or other streams that the Cowlitz Indian Tribe deems are needed for stream restoration to increase habitat complexity for ESA listed Chinook, Coho and Steelhead or will be left in the stand as down woody debris to meet wildlife habitat needs. No trees will leave the forest.

The use of thinning to improve forest conditions is a recognized practice that increases diversity and improves soil and water conditions. For example, the Washington DNR has a project on

[9] Oregon Forest Practices Act: Key Regulations and Compliance - LegalClarity
[10] https://www.fs.usda.gov/project/?project=66996&exp=overview

National Forest land focused on thinning out small diameter young trees that are overcrowding forest stands to the detriment of large trees.[11]

3.3.4 Climate change effects

Climate change has already caused some negative effects in Washington including drought inducing crop failures and trees being damaged or killed by expanding insect populations (Carroll et al. 2004, Niemi et al. 2009). Growth declines have occurred in at least 15 native Pacific Northwest tree species (Bennett et al. 2023). Projected future climate change is likely to cause the following additional economic impacts (Niemi et al. 2009):

- Increased energy costs
- More frequent and intense storms and associated damage
- Reduced food production
- Increased wildland fire costs
- Increased public health costs
- Lost recreation

Climate change projections for northwestern Oregon suggest there will be minimal effects on carbon storage in those forests, unless there are changes in disturbance regimes (Creutzburg et al. 2015, 2017).

Given that climate change is expected to affect Indigenous peoples increasingly and disproportionately, investments need to be made to increase Tribal and non-Tribal partnership capacities and climate change adaptation capabilities (Dent et al. 2023). While the Tribal Climate Change Principles (TCCPs) (Gruenig et al. 2015) are designed to address Indigenous needs for climate adaptation, they are not fully adopted to (1) strengthen tribal sovereignty, (2) support tribes facing immediate risks, (3) provide tribal access to resources, and (4) make sure there is good understanding of when and how traditional knowledge should be used (Dent et al. 2023).

3.4 Economic and social conditions of the region

Washington forests have always been important to the state's economy[12] and social structure, but perspectives about this resource have changed over time. In 2022, 0.7% of the workers in Washington state were employed by forest products industries.[13] Chiang and Reese (2025) identified four distinct time periods for the history of Washington's forest. Prior to 1848, expansive forests of large trees supported several Indigenous tribes and then explorers and traders. The first lumber mill was established in Fort Vancouver in 1828 by the Hudson Bay Company. The California Gold Rush that began in 1848 brought new investors to the Pacific Northwest, and several new lumber mills were built in Puget Sound. During the third period (1883 to 1940), technological advancements and large capital investments fostered logging

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[11] DNR, Forest Service Continue Forest Restoration Partnership near Mount Pilchuck | WA - DNR
[12] https://fred.stlouisfed.org/series/WAAGRRQGSP
[13] https://research.fs.usda.gov/pnw/products/dataandtools/production-prices-employment-and-trade-northwest-forest-industries-1958

activities in new areas. Railways reached the Northwest; the government became more involved in forest management and preservation; and labor unions became active. After 1940, the forest industry declined in importance in the state, for it was no longer that largest employer. In 1990, 5,849 million board feet were harvested in the state, and in 2017 only 2,944 million board feet were harvested (Washington Department of Natural Resource 2018).

This decline in lumber production in Washington can be attributed to several factors. In 1994, the Northwest Forest Plan was implemented on public lands. The Northwest Forest Plan covers Oregon, Washington, and Northern California forests where land-use allocations and forest practices ensure habitat protection for the Northern spotted owl and other endangered species (USDA 2020). Land-use allocations create designations where specific land management practices are implemented such as “late-successional reserve” or “adaptive management areas.” Each allocation has specific management guidelines, but all areas intend to protect specific species and their habitat (USDA 2020). Additionally, any area where timber harvest and silviculture activities occur (typically in “matrix” areas, which equates to ~4 M acres from northern California to Washington) require extensive monitoring before harvests occur (USDA 2020). These protections, while vital, significantly slowed the pace of harvest when compared to previous decades.

Between 2005 and 2023, there was a 50% reduction in chip demand related to recession and pandemic effects.[14] Government policies, regulations, and trade practices have had a negative effect on timber and the forest products industry.[15] Lumber mills shut down related to surplus production capacity, price volatility, and drought and extreme weather events that affected timber harvest and lumber production.[16] In regard to the opportunity to source bioenergy from forests, it is useful to note that much of the infrastructure and labor for forestry are still present in the western part of the region – particularly on private lands. As the environmental movement grew, so grew efforts to protect and better manage the forests.

Even so, western Washington is still a major lumber producer (Figure 6) and counties with a larger amount of lumber production tend to have higher per capita income (Figure 7). The forest products sector employs more than 73,000 workers, and annual industry earnings exceed $4.2 billion statewide. Also, the State has become a major partner with Asia in marine trading.

[14] Wood Chip Demand Fell Off a Cliff: What Now?
[15] The-Dismantling-of-the-American-Timber-Industry-ALC.pdf
[16] The Continuing Reduction in the Number of Sawmills in the Pacific Northwest — Andy Kerr | Oregon Conservationist, Writer, Analyst, Operative, Agitator, Strategist, Tactician, Schmoozer, Raconteur

Figure 6. Percent of Washington state counties that are forested and number of direct, indirect, induced jobs related to forestry in 2022 (from the Washington Forest Protection Association https://data.workingforests.org/# and https://www.wfpa.org/forest-facts/)

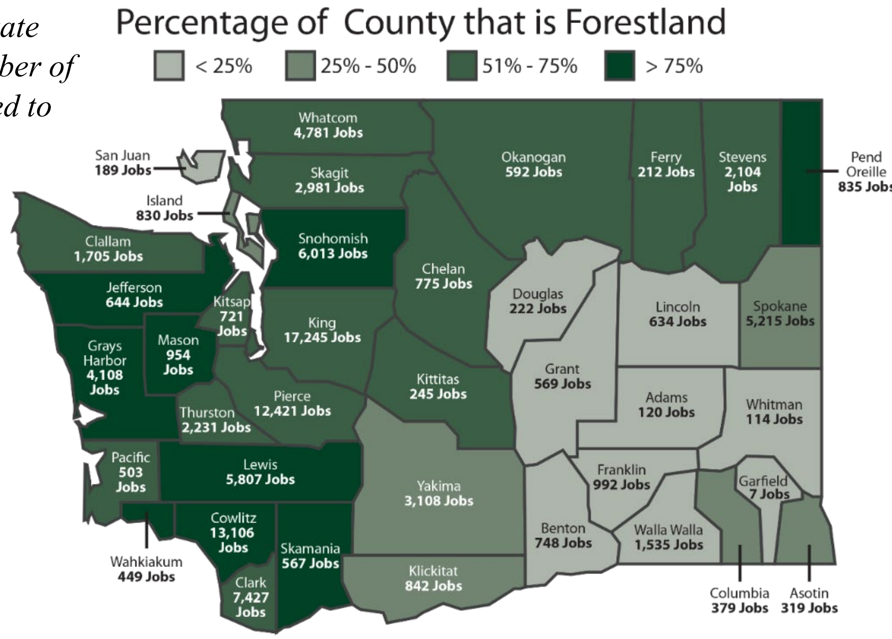
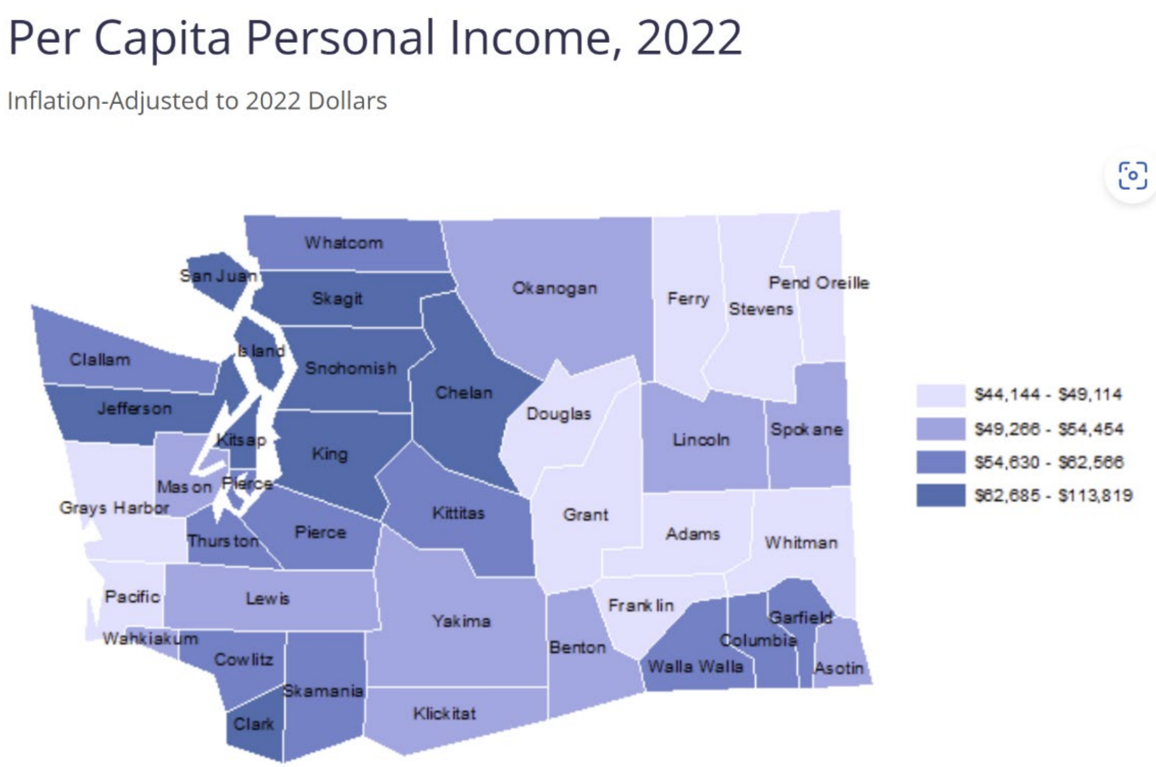


Figure 7. 2022 per capita income by county in Washington state (source: [Per capita personal income by county | Office of Financial Management]() as derived from [U.S. Bureau of Economic Analysis]() and the [Washington State Revenue Forecast Council]()



Forestry has also declined in Southwestern Oregon and Northwestern California, and the socioeconomic condition of that region is similar to southwestern Washington. Kammin (2024) interviewed people living in the logging communities of Coos Bay, Oregon, and Humboldt Bay, California, to identify challenges and opportunities for that region. He found that those communities most desire the following

- Affordable and healthy housing
- Sustainable economic opportunities
- Community leadership development opportunities
- Tribal-to-tribal networks for sharing information
- Realignment of policies, markets, utilities, and funding
- Local workforce training for weatherization jobs and for construction in general
- Opportunities for youth workforce development
- Increased broadband access

In response to plans to build an offshore wind facility near those communities, Kammin (2024) suggests that particular attention be given to where infrastructure is located and training of local residents. These desires and suggestions are also applicable to southern Washington as options for bioenergy are explored. Addressing those community needs must be done in view of ongoing climate changes in the region.

3.5 Bioenergy activities in Washington

Bioenergy has been proposed for Washington for several decades, and many options have been considered (Table 3). However, few commercial successes exist. To explore ways to foster growth of this industry, the Northwest Bioenergy Summit[17] held in October 2024 discussed the following topics:

- Feedstocks and process technologies for biogas, biofuels, and biomass energy and coproducts
- Practical challenges of bringing bioenergy to market, including sitting, permitting, and utility relations
- Case studies of bioenergy projects in the state, from preliminary planning to lessons learned
- Impact of state and federal carbon emission reduction policies on regulation and funding
- Local government responses to new organic waste requirements
- Status of sustainable aviation fuel R&D, and other biofuel opportunities
- Methane reduction and nutrient recovery for dairies and other agricultural producers
- Building a value chain for low-grade biomass through biochar
- Innovative approaches to methane reduction at landfills and wastewater treatment

[17] https://bioenergysummit.com/

Table 3. Types of processed bioenergy products building from discussion in the ***Bioenergy from Forests: Background paper*** *bef_background_paper_feb_2024.pdf. These bioenergy products are only a few of the more than 5,000 different products including resins, glues, cosmetics and food that come from trees.*

Processed bioenergy products	**Forest resources and production processes**
Pellets	Pelletization (compression and densification) of forest residuals, chips, sawdust, bark, or other cull
Wood charcoal, biochar, and bio-oil	Pyrolysis or destructive distillation (in the presence of limited oxygen) of wood chips, sawdust, leaves, bark, or forest residuals
Ethanol and other chemical precursors	Biochemical conversion or gasification of logging residues, forest thinning, branches, and others
Hydrogen and syngas (a mixture of hydrogen and carbon monoxide)	Gasification or pyrolysis of wood chips, sawdust, or others

In addition, biogas, the production of gaseous fuel via fermentation of organic matter occurs mostly associated with large animal operations. Its production can benefit from the addition of a limited amount of woody material. The American Biomass Council estimates that up to 930,640,900 metric tons (33.4 billion ft^3) of methane could be produced annually in Washington State.[18]

Saul et al. (2018) compared three bioenergy modeling scenarios that sourced woody biomass from eastern Washington and other inland northwest forests. They considered a small-scale system that produces drop-in transportation biofuel and biochar, a large, regional system that produces bio-aviation fuel, and a midsized pellet production system. Via interviews, Newman et al. (2017) found widespread stakeholder support for all three systems that enhance forest restoration and economic development, but many people preferred small-scale, locally oriented bioenergy development. Wood-pellet production was found to be profitable and feasible under current prices and conditions, however neither the large nor small liquid biofuel system would be economically viable unless prices increased greatly.

The quality of biomass feedstock available for pellet production vary greatly. Nevertheless, woody material following wildland fires can be used in profitable supply chains (Mansuy et al. 2015). Pellets can be made from thinned materials and beetle-killed timber (Qin et al. 2018), which are in large supply in the northwest.

Examples of recent efforts to establish bioenergy in the State are presented below.

[18] https://americanbiogascouncil.org/resources/state-profiles/washington/

3.5.1 Landfill gas–to–pipeline quality gas facility

Bio Energy Washington[19] located on 372 ha (920 acres) in King County, is one of the largest landfill gas resources in the US. The source material is the Cedar Hills Landfill [20]that contains waste from businesses and households in King County. Wells are drilled into the landfill and channel methane gas to a facility where it is refined into pure methane and then pressurized and directly injected into the Puget Sound pipeline that goes to homes in the greater Seattle area. This landfill gas–to–pipeline quality gas facility opened in 2009 and annually displaces 120,000 tons of CO_2 and 350,00 barrels of oil.

3.5.2. Sustainable aviation fuel (SAF)

Feedstock conversion technology for wood-based ethanol is still under development (Masum et al. 2019). Energy Vision (EV) strives to advance sustainable energy and transportation solutions, especially for difficult to decarbonize segments of the economy. Much of this effort examines production and use of ultra-low-carbon waste-based renewable natural gas.

A Washington State University project demonstrated that garden waste (dried leaves, grass, and small tree branches) could be collected, dried, hammered, sieved, and subjected to microbial decomposition (predominately using *Clostridium sensu* stricto 12) to produce caproic acid, a potential precursor for Sustainable Aviation Fuels (SAF) (Harahap and Ahring 2024). Implementing a continuous fermentation process to further improve caproic acid titter and productivity is the next step for this study.

The Northwest Advanced Renewables Alliance (NARA) has explored the use of forest harvest residuals to make aviation biofuel and co-products[21]. The project is led by Washington State University and supported by USDA's Agriculture and Food Research. The goals of NARA are to develop a sustainable biojet fuel industry in the Pacific Northwest using woody food feedstock, create valuable coproducts from lignin, sustain and enhance rural economic development, facilitate and promote supply chain coalitions, and improve bioenergy literacy to enhance the workforce and improve stakeholder understanding (Millman et al. 2015).

3.5.3 Other demonstration projects and supporting organizations

Several demonstration projects have been proposed; some have received financial support; but few of these projects have come to fruition. In 2009, the Washington State Legislature authorized the DNR to move forward on four biomass-to-energy demonstration projects:[22] While Atlas Pellets (Omak), Borgford Bioenergy (Colville), and Parametrix Inc. (Bingen) are still moving ahead, none seem to have achieved their stated ambitions.

[19] https://www.bioenergy-wa.com/
[20] https://kingcounty.gov/en/dept/dnrp/waste-services/garbage-recycling-compost/solid-waste-facilities/cedar-hills
[21] https://nararenewables.org/
[22] https://www.dnr.wa.gov/Publications/em_biomass_leg_rprt_2011.pdf

- Borgford BioEnergy initiated establishment of a biomass-to-energy project at a lumber mill in Springdale, Wash., about 40 miles northwest of Spokane in 2011.[23] Using wood waste from the local mill and biomass from forest thinning and logging on state and private forest land, an octoflame gasifier will be used to produce steam, heat, bio-char, and bio-oil and eventually 1 megawatt of electricity. To date, no Borgford waste-to-energy plants are in operation although the company is still seeking to expand.[24] Under legislative authority, DNR is working with Borgford BioEnergy and other bioenergy projects to enter into long-term contracts to supply of biomass from the state forests it manages.
- Atlas Systems LLC[25] has been operational since 1959 to store and reclaim sawdust, wood shavings, bark, biomass, wood chips, hogged wood wastes, and other bulk material. It sourced to a $71 million biomass boiler and steam turbine generator that provided energy for a paper mill near Port Angeles.[26] Excess power was sold to electrical utilities. The system replaced a boiler fueled by oil and wood waste. The mill closed in 2017 but was purchased, retooled, and began production in late 2019. However, the mill closed again late summer 2024 and is currently idle.
- Parametrix plans to use fast pyrolysis technology to rapidly convert forest biomass to liquid fuels and bio-biochar. The demonstration project is to be located at SDS Lumber, in Bingen, Washington, with the commercial facility becoming operational as well.
- There are several collaborations between the dairy industry and bioenergy innovations that attempt to reduce greenhouse gas emissions and improve resource efficiency (e.g., Burnham & Pasco Resource Recovery Center). Some efforts are designed to convert forest residue to biochar.
- The Devonshire Group is introducing a new direct gasification-to-renewable-hydrogen process, in a modular, scalable platform from Ways2H Corporation. This new patent pending process increases H2 yield to 140 kilograms per ton of woody biomass, which is about a three times increase over Ways2H prior process. The platform accepts paper, cardboard, plastic, any tree part, or a streaming variable mixture of all, in any form less than one inch, including sawdust. Carbon is fully sequestered in carbonate co-products. There are no emissions of particulates and no noxious gases. Module capacities are 8 tons, or 24 tons of feedstock per day. Scale is achieved by either vertical or horizontal arrays of the 24-ton module. A single 24-ton module will produce about 3,400 kilograms of H2 per day (using Douglas Fir and Western Hemlock as feedstock) with a cost between $20 M and $30 M and pay for itself within 5 to 7 years. The H2 produced is drop-in ready. Markets for the carbonate co-product already exist within concrete and building products industry. The Ways2H platform is readily deployable on

[23] https://www.spokanejournal.com/articles/8726-biomass-to-energy-project-starts-at-mill-in-springdale
[24] https://www.wrangellsentinel.com/story/2024/12/11/news/waste-to-energy-developer-interested-in-6-mile-mill-property/14007.html
[25] https://www.atlassystems.net/
[26] https://www.spokanejournal.com/articles/9018-valley-company-to-develop-west-side-biomass-system

either a distributed topography of small systems, or a regional array of many modules. Sites are in development in Washington, Oregon, and California.

In addition, several organizations support the development of the bioenergy industry.

- Wisewood Energy has projects throughout the western US West that deploy wood energy systems at a range of municipal, commercial, tribal, and industrial applications. They explore which biomass technologies are best suited for a given context and objectives and identify appropriate steps for implementation.
- The Wood Innovations Program in the Cooperative Forestry Programs with the State, Private, and Tribal branch of the Forest Service in Oregon and Washington supports forest products and markets including biomass utilization and wood energy.
- T.R. Miles, Technical Consultants, based in Portland, Oregon, is a biomass energy consulting firm, which designs, develops, installs, and commissions systems for processing wood, agricultural, and urban residues to feed, fiber, and energy products including large biomass power plants. One focus is biochar as a means of managing nutrients while increasing soil carbon.
- The non-profit Kulshan Carbon Trust strives to conserve and sequester carbon through collaborative natural climate solutions by supporting land stewards with the knowledge, financial resources, suppliers, and workforce needed to establish a 'carbon farm.' Solutions include agroforestry and biochar.
- CleanFuture, Inc. connects clean vehicle fleets with zero and sub-zero carbon intensity fuels. It identifies innovative fuel pathways and holds certifications on the lowest carbon intensity (CI) pathways in clean fuel standard / transportation fuel programs such as the Washington Clean Fuel Standard (CFS). CleanFuture provides full-service low carbon consulting to its clients including low carbon fuel pathways; lifecycle assessment; fleet efficiency; transportation electrification; clean vehicles and vehicle technologies; and monetization strategies.
- Precision Forestry Cooperative in the University of Washington's School of Environmental and Forest Sciences in Seattle quantifies Washington State's forest land base, with a focus on small forest landowners. It has identified lands suitable for woody biomass crops in the Pacific Northwest, completed a residual forest biomass assessment for Washington, Oregon and California, developed an online biomass calculator for Washington and maintained the state's Forestland Database – a comprehensive source for understanding Washington's forest lands. Current research includes evaluating net recoverable energy on forestlands from logging residuals, developing an open-source forest and ecological management system, and building statewide forest structure and species maps to assess and track forest conditions over time.
- The Oregon State University Clean Fuels Project is exploring several objectives.[27] It is identifying clean fuel pathways that use forest biomass residues and performing a carbon life cycle analysis and financial analysis. It is also estimating the environmental impacts

[27] https://olis.oregonlegislature.gov/liz/2023I1/Downloads/CommitteeMeetingDocument/284048

on Oregon forest systems by comparing the use of forest residues to generate renewable fuel in contrast to letting them decay onsite.

3.5.4 Pellet production facilities being established in Washington

The first industrial-scale, export-based wood pellet plant in Washington is the Pacific Northwest Renewable Energy (PNWRE) pellet production facility being built on 24.3 ha (60 acres) leased from the Port of Grays Harbor in Hoquiam, Wa. Subsequent to reviewing dozens of comments about this facility from nongovernmental organizations (NGOs) and the public, the air quality permit for this facility was approved in May 2024.[28] That permit established limits and requires control of plant emissions of particulate matter smaller than 10 micrometers (PM_{10}), nitrous oxide (NO_x), carbon monoxide (CO), volatile organic compounds (VOC), hydrochloric acid (HCI), mercury (Hg), and opacity using established EPA methods. The plant will open in 2027 and is projected to use diverse feedstock consisting of 50% forest residuals, 30% sander dust, and 20% planer mill shavings. Forest residues will be sourced from forests within a 50-mile radius of the faculties and are likely to come from both State and private land. About 400,000 metric tons of wood pellets will be produced each year, and the majority should be shipped to Asia to generate electricity. About 75 direct jobs and over 100 indirect jobs are anticipated. The plant and port costs should be in the range of $230 M to $270 M.

Drax, a British electrical power generation company, has discussed establishing a pellet production facility in Longview, Wa. The plant would use sawdust and shavings from sawmills within 96 km (60 miles) to produce almost 1 million pounds of wood pellets each year that would be shipped to Asia to generate electricity as a coal alternative.[29] The plant in Longview would support 50-60 direct jobs and about 200 indirect jobs as well as about 225-275 construction jobs. The biomass fuel plant would cost approximately $250 M on 19 ha (48 acres). In 2023 an application was submitted to the Southwest Clean Air Agency (SWCAA) for the air permit necessary to begin operating the Longview facility. The Longview plant aims to control about 95 percent of the pollution it produces in accordance with Southwest Clean Air Agency standards, according to a technical support document accompanying an Air Discharge Permit Application.[Error! Bookmark not defined.]

There was local and NGO opposition to the PNWRE plant as well as the Drax Longview pellet facility. Brenna Bell, 350PDX Climate Forest Manager states, “Drax is proposing a new wood pellet production plant and export facility in Longview, WA, but we won’t let them sacrifice the climate, local forests and communities to increase their bottom line. That’s why we’re launching a new campaign to keep Drax out of the Northwest.”[30]

On the other hand, the Manager of Business Development for the Port of Longview, recently noted that the port has been actively pursuing the wood pellet industry for business partnerships

[28] https://www.orcaa.org/final-determination-issued-pnwre-application/
[29] https://getfea.com/mill-capacity-changes/drax-begins-construction-on-longview-washington-wood-pellet-manufacturing-facility
[30] https://350pdx.org/in-2024-were-stopping-the-drax-biomass-plant-in-longview-wa/

at the port since 2011. She said, "we made Longview a go-to choice for future pellet plants. Pinnacle Renewables, now Drax, saw this potential in 2018."Error! Bookmark not defined.

3.5.5 Production of short rotation woody crops for bioenergy

Growing poplar and other short rotation woody crops in the Pacific Northwest for bioenergy has been explored for several decades (e.g., Stanton et al. 2020, Morales-Vera et al. 2022). Bioconversion is the major contributor to environmental degradation when considering feedstock production of poplar, harvesting, transport to a biorefinery, bioconversion of the biomass process, and fuel use (Morales-Vera et al. 2022). Short-rotation plantation management has benefits over long rotation of poplar but requires herbicide application and use of fossil fuel for harvesting that can be reduced by appropriate management practices (Vasquez et al. 2017). For crops grown in both the eastern and western parts of the region, current market pricing for forest biomass results in negative financial returns and is most sensitive to changes in price, yield, and land costs (Chudy et al. 2019).

4. Relevant policies

A recent review by Köppl and Schratzenstaller (2023) found that nearly all academic economists agree that carbon pricing in the form of a tax is necessary to incentivize policies that promote use of carbon-based material rather than fossil fuels. As this concept moves into the policy arena, concerns are raised about its environmental effectiveness, macroeconomic effects, impacts on competitiveness and innovation, distributional implications, and public acceptance. The review also found that carbon taxes can effectively reduce or dampen carbon emissions while having no negative effects on economic growth, employment, and competitiveness. Attention should be paid to distributional effects, i.e., variation of impacts of the carbon tax on differing income, demographic, or other groups. While the effects of a carbon tax depend on the type of energy used, the indicators measured, and the political and socioeconomic context, the authors suggest that public acceptance of carbon taxes can be enhanced by providing information, ongoing communication, avoiding negative distributional effects, and directing some revenues into environmental projects. However, the US does not have carbon tax. Energy and timber policies that are relevant to bioenergy are reviewed below.

4.1 State energy policies

The Washington State Energy Strategy was enacted in 2020 and commits the state to greenhouse gas (GHG) emissions being 45% below 1990 levels by 2030, 70% below 1990 levels by 2040, and net zero emissions by 2050. Bioenergy is part of the renewable energy mix being deployed to reduce, and eventually eliminate, reliance on fossil fuels. The strategy will also address environmental justice issues such as health impacts resulting from air pollution in marginalized communities. The State established the Agriculture and Forestry Carbon Capture & Sequestration Advisory Panel to support the Department of Ecology's Clean Fuel Standard Program. Among other obligations, the charter for the Panel[31] specifies that the Panel develop recommendations for:

[31] https://www.ezview.wa.gov/Portals/_1962/Documents/afccsap/AF-CCSAP_Charter_Final.pdf

- Quantifying the carbon sequestration impact of current agricultural and forestry production and conservation practices and estimating the potential due to future practices.
- Identifying agricultural and forest land practices that have measurable GHG benefits.
- Identifying and developing standards for optimizing/maximizing carbon sequestration for practices on agricultural and forestlands
- Developing mechanisms for quantifying and allocating credits to incentivize carbon sequestration on agricultural and forestlands.

Bioenergy is certainly a part of these recommendations. The Panel is also considering ways to coordinate with small forest landowners and components of life cycle analyses.

On May 17, 2025, Washington Governor Ferguson signed a bill that update the state's Clean Fuel Standard, setting more ambitious carbon reduction goals that would require up to a 55% reduction in greenhouse gas (GHG) emissions by 2038.[32]

4.2 State and Federal timber policies

Timber harvesting is controlled by several state and federal regulations (Table 4). Landowners of less than 32 ha (80 acres) statewide and with parcels less than 8 ha (20 acres) are exempt from some state regulations. The 1974 Forest Practices Act, and its amendments require balance between protection of public resources and timber production.

Table 4. Timber industry regulations (Washington Forest Protection Association 2025).

Year established	State Environmental Law	Federal Environmental Law	Administered by.
1947		Federal Insecticide, Fungicide & Rodenticide Act	Environmental Protection Agency (EPA)
1949	Hydraulics Code Guidelines		Wash. Dept. of Fish & Wildlife
1969		National Environmental Policy Act[33]	EPA's Council on Environmental Quality
1970		Federal Clean Air Act	EPA
1971	Washington Clean Air Act		Wash. Dept. of Natural Resources (Wa DNR), Wash. Dept. of Ecology
1971	State Environmental Policy Act		Wash. Dept. of Ecology
1971	State Shorelines Management Act		Wash. Dept. of Ecology

[32] https://ethanolproducer.com/articles/washington-governor-signs-bill-to-update-the-states-clean-fuel-standard?utm_source=Ethanol&utm_campaign=8e92012bc8-EMAIL_CAMPAIGN_2025_05_20_02_09&utm_medium=email&utm_term=0_-8e92012bc8-96421993

[33] President Trump intends to rescind regulations under the Council on Environmental Quality.

1971	Washington Pesticide Control Act		Wash. Dept. of Ecology
1972		Federal Clean Water Act[34]	EPA
1973	State Water Pollution Control Act	State Water Pollution Control Act	Wash. Dept. of Ecology
1973		Federal Endangered Species Act[35]	US Fish and Wildlife Service, NOAA Fisheries
1974	State Forest Practices Act		Wa DNR's Forest Practices Board
1999	Forests & Fish Law		Wa DNR's Forest Practices Board

Timber harvesting methods in Washington include commercial thinning, partial cuts, selective harvest, and clearcuts (Washington Forest Protection Association). Clearcutting is most common in Douglas-fir forests, west of the Cascades, for optimal growth of that species occurs under high light conditions. Clearcut size is limited to 48 ha (120 acres) without a special review, and the average clearcut is less than 24 ha (60 acres). Rotations (the timing of tree harvesting) tend to occur every 40 to 60 years. Patterns of timber harvest are affected by natural disturbances such as fire, windstorms, insects and disease; supply and demand fluctuations resulting from market conditions, management practices; and public policies (Washington Forest Protection Association 2025).

In the aftermath of a disturbance, Washington DNR (2025) suggests retaining some larger trees with broken tops and/or limbs and larger downed wood to provide wildlife habitat. However, to avoid epidemics of bark beetles, salvaging blown down and beetle-infested wood before the second spring after the initial event is recommended. Alternatively, pheromone chemicals can be used to confuse insect communication and reduce tree damage.

Timber productivity of sites infested with fungal diseases can be significantly improved by control efforts such as removal of infected trees (Hadfield et al. 2025). In addition, State law requires reforestation within three years of harvest with the result that in 2003 private landowners replanted 34,160 ha (84,412 acres), state and local landowners planted 5,382 ha (13,300 acres), and federal landowners replanted 1,229 ha (3037 acres) (Washington Forest Protection Association 2004). Furthermore, all forest operations are required to operate in a way that prevents sediment from entering streams, . , otherwise known as a riparian buffer zone.

4.2.1. Boldt Decision

The Boldt Decision is a court ruling made in 1974 that confirmed the fishing rights of Indigenous people and tribal sovereignty in Washington state. It also allows tribes to challenge state-authorized forest practices and state and federal timber sales if they damage habitats of

[34] The Clean Water Act has been weakened by a recent decision of the US Supreme Court: https://waterkeeper.org/news/supreme-court-decision-again-undermines-clean-water-act-protections/
[35] The Trump Administration intend to weaken the ESA: https://www.sciencenews.org/article/endangered-species-act-trump-esa

anadromous fish (Phillips 1983). More than 50 years after the decision, the implications for forestry are still being worked out and litigation continues to determine which fish are included in the 50% allocated to tribes that were parties to treaties. Even so, there has been great improvement in the lives of the tribes over the past five decades partially due to the Boldt Decision (Geranois 2024). However, cooperative restoration efforts between land management agencies and tribes are needed to overcome social-ecological traps resulting from Euro-American colonization including declining quality and abundance of forest resources (Long and Lake 2018).

4.2.2 Northwest Plan

The Northwest Plan was established in 1994 to specify management practices for 9.9 million ha (24.5 million acres) of federally managed lands in Oregon and Washington and northern California (USFS and BLM 1994). It was designed to address concerns about threatened and endangered species and also consider the social and economic sustainability of the region. It changed the focus of forest management from logging for economic gain to conservation and preservation. Amendments to the Northwest Plan are currently in process.[36]

Creutzburg et al. (2017) note that the Pacific Northwest is still seeking a way to balance sustainable timber yields and habitat for sensitive species. Their model projections suggest that private lands will continue to supply much of the timber from the region and public (especially federal) lands will provide habitat and continue to increase in C storage. However, this trend likely will not continue if catastrophic fire continues to burn into 2030. Furthermore, soil carbon sequestration may be approaching a plateau. Additionally, Federal land have missed critical thinning benchmarks, which limits habitat for many species.

Twenty-five years after the Northwest Forest Plan was enacted, Spies et al. (2019) evaluated what has been learned. They found that, while old-growth forests and some wildlife species were protected, other objectives such as timber production were not achieved. In addition, new threats of climate change, wildfire, and invasive species were not considered. Furthermore, they surmise that ecological and socioeconomic goals can only be achieved by addressing trade-offs and customizing land management to specific attributes of ecosystems and human communities. In other words, context matters. They also point out that thinning and careful use of prescribed fire enhance resilience to wildfire and climate change - especially in dry-forest zones. Finally Spies et al. (2019) make clear that trust in effective stewardship is built by collaborative decision making and community engagement.

4.2.3. Uncertainties

Changes in US Federal policies cause uncertainties in forest management. For example, under the Biden Administration, there was an Executive Order to identify mature and old-growth forests on Federal land, but that initiative was terminated by President Trump. Also, recent wildfire policies and reorganization of the US Forest Service and wildfire response units add to uncertainty regarding the ability to deal with wildfire and other forest disturbances. And, in June

[36] https://workingforest.com/us-forest-service-proposes-changes-to-northwest-forest-plan/

2024 the White House issued an Executive Order on Empowering Commonsense Wildfire Prevention and Response. This order is meant to streamline Federal wildfire capabilities.

In early March 2025 President Trump signed Executive Order 14225 that allows the US Forest Service (USFS) and the Bureau of Land Management (BLM) to streamline approvals for forestry projects that could be halted by the Endangered Species Act (ESA) in an effort to increase domestic timber and lumber production.[37] The order also calls for the USFS and BLM to use Categorical Exclusions (CE) in timber thinning and salvage activities that fall under the National Environmental Policy Act (NEPA).US energy policy is in flux and uncertain. The Inflation Reduction Act (IRA) passed in 2022 was designed to decrease the U.S. contribution to climate change dramatically and reduce GHG emissions by shifting the economy away from fossil fuels. Incentives were being put in place for almost every sector of the economy to adopt renewable energy and other low-carbon technologies. However, in early 2025, President Trump ordered the US to withdraw from the Paris agreement, ordered a 90-day pause on IRA funding, and cancelled almost all grants associated with IRA funding. While a repeal of the IRA is unlikely, for it passed with bipartisan support, it is not clear what the future holds. Furthermore, President Trump plans to reduce research and development dollars for new clean energy technologies. The Trump administration has supported production and use of biofuel (e.g., by issuing emergency fuel waivers to allow the year-round sale of E15 gasoline). Nevertheless, the Administration's perspectives on bioenergy are uncertain.

4.3. Federal energy policies

On March 7, 2025, the US Environmental Protection Agency (EPA) announced its intent to revise the 2024 Renewable Fuel Standard (RFS) renewable volume obligation (RVO) for cellulosic biofuel. However, with its large area of National Forests, Washington is hampered by the exclusion of federal forests from Renewable Identification Numbers (RINs) (i.e., credits used for compliance under the Renewable Fuel Standard, which requires transportation fuel sold in the US to contain a minimum amount of renewable fuels). Yet Werner (2008) points out that including federal forest in the RFS would have the benefits provided by the abundance of forest residues available, having no GHG emissions, and providing a cost-effective tool for sustainable forest management. Slash and pre-commercial thinnings from non-federal forestland that is not ecologically sensitive do qualify as renewable biomass for purposes of RFS.

On March 19, 2025, the U.S. Department of Energy's (DOE's) Office of Indian Energy extended the deadline to apply for a $25 million funding opportunity that aims to support Tribal energy planning and development. Biomass power projects are eligible for this funding.[38] DOE is offering funding to support energy planning activities, projects to assess the feasibility and

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[37] https://www.snopes.com/fact-check/trump-clear-cutting-national-forests/ and https://www.whitehouse.gov/presidential-actions/2025/03/immediate-expansion-of-american-timber-production/

[38] DOE extends application deadline Tribal Energy Planning and Development funding | Biomass Magazine

viability of deploying energy technologies, and projects focused on energy design and development activities.

4.2.4. International energy policies

International energy policies are likely to influence bioenergy in Washington state given its ready access to marine ports and existing marine trade. For example, Japan has opportunities to further utilize bioenergy by replacing coal with pellets and increasing the use of biofuels for transport (IEA Bioenergy 2024). Globally, bioenergy is 95% of heat production by renewables and only 8% of renewable electricity generation (World Bioenergy Association 2024). Hence there is room for growth, and there is increasing demand for biomass energy. The market for pellets is projected to nearly double to $16 billion between 2024 and 2033, given the shift away from fossil fuels by most countries worldwide. However, there is uncertainty associated with the future of the Japanese, South Korean, and other Pacific markets because the global economy is in flux.

5. Opportunities and constraints in sourcing wood for bioenergy

Opportunities and constraints for sourcing wood for bioenergy are determined by the particular products being considered and the local and regional context (including availability of wood and mill residues, socioeconomic condition, workforce availability, and transportation options). In all cases the goal is to achieve a positive balance between the negative and beneficial effects of bioenergy production, which requires considering effects on soil, water, forest conditions, GHG emissions, and socio-economic conditions at local and global scales (as discussed by Clark and Yin 2007). Selecting tradeoffs in benefits achieved is often a part of the decision process. As an example of how to identify appropriate strategies for bioenergy, Zamora-Cristales et al. (2014) developed a tool for determining the optimal option for processing forest biomass and transport in the Pacific Northwest that depends on the residue pile location, volume, available equipment, and road access. One way to assess the achievement of this goal is to consider progress toward the Sustainable Development Goals (SDGs) of the United Nations. For example, Kline et al. (2021) found that production of woody pellets in the SE US for bioenergy in Europe generates positive effects on the five SDGs considered: SDG 7: affordable and clean energy, SDG 8: decent work and economic growth, SDG 9: industry innovation and infrastructure, SDG 12: responsible consumption and production, and SDG 15: life on land. However, difficulties in attaining the SDG goals occur in regard to potential impacts on air, water, and biodiversity (Kline et al. 2021). They suggest that the bioenergy industry can provide an incentive for better resource management.

Benjamin et al. (2009) considered the challenges and opportunities for producing northeastern forest bioenergy, which are likely similar to those found in the northwestern US. The strengths include the abundance of forest resources and an established forest sector. Challenges include needed improvements to the forest operations community, integration of new technologies, and effects of social values on the supply of raw materials and processing. However, they point out that attention should be paid to existing infrastructure, resource conditions, forest operations, public policy, and the range of social values that are likely to be expressed as the industry grows.

5.1 Opportunities to maintain or improve forest health and resilience while improving social and economic conditions by deploying bioenergy

A flyer from the US Department of Energy notes that biofuel production and use in Washington has several advantages:[39]

- "Abundant forests and wood products industry could provide 6.6 million metric tons of wood waste annually for biofuel production
- Robust agriculture industry could provide 1.7 million metric tons of excess cellulosic crop residue annually for advanced biofuels
- Developing in state resources reduces dependence on imported petroleum products
- Biomass resources could supply aviation in Washington with sustainable alternatives to petroleum"

In addition, developing bioenergy in Washington would build on the State's success in **managing its forests for multiple purposes** including wildlife habitat, ecosystem function, timber production, biodiversity, and recreational opportunities. Currently, Washington forestlands cover 9,301,100 ha (22,983,438 acres) and 47% are working forest and 53% are protected (Washington Forest Protection Association 2025). Forests in the State and derived wood products offset 35% of the state's carbon emissions and protect 60,000 miles of forested streams (Washington Forest Protection Association 2025). Given strong State and Federal regulations, wide use of forest certification, and adaptive management designed to achieve diverse goals, there are ways to enhance benefits from the forests – including production of bioenergy products.

While using sawmill residuals is one option for fiber utilization in the wood pellets production process, the use of **forest residuals from precommercial and commercial thinning** is also an effective choice that would reduce buring slash piles burning and wildfire risk. While some harvests are used to enhance fish habitats, other precommercial and commercial thinning residues, such as tree limbs and tops are left in the forest to slowly "meltdown" or are burned at the roadside. Depending on the time scale assumed, forest management approach and feedstock quality, assumptions about alternative scenarios, and approaches to emissions accounting (Franzen et al. 2025), use of these forest residues after responsible timber operations would not compromise forest carbon (Creutzburg et al. 2015). Furthermore, thinning overcrowded and unhealthy forests improves forest health by limiting resource competition while providing woody biomass for bioenergy.[40]

Enhanced forest management to **reduce risks** of wildfires, disease, and insect infestations can produce residues that could be used for bioenergy (Nicholls et al. 2008).

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[39] https://www.energy.gov/sites/prod/files/2015/10/f27/washington_biofuels_benefits.pdf
[40] https://www.wfpa.org/forest-products-and-jobs/biomass/

Bioenergy production would increase **employment** opportunities- especially in rural areas that have been impacted by economic decline in the timber and construction industries. Working forests in Washington state support more than 102,000 workers and generates about $6 billion in annual wages (Washington Forest Protection Association). This work includes growing, planting, harvesting, and producing wood products. Adding jobs focused on collection, processing, and transport of woody material for bioenergy production would create many more jobs.

Bioenergy is a **growing market** – especially in Asia. Western Washington is ideally situated with abundant woody material near marine ports. Eastern Washington also produces much wood that is accessible via 8 dams and navigations locks on the Columbia-Snake River system.

The **economic vitality of working forests** is enhanced by having another financial return from biomass harvesting. This additional benefit is critical for private forests that are at risk of development.[40]

Use of wood for bioenergy in the Pacific Northwest could build from **Indigenous forest stewardship**. Largely because of the current wildfire problems, forest managers are exploring Indigenous Fire Stewardship as a providing tools and practices for more resilient ecosystems and communities (Coughlan et al. 2023).

Forest bioenergy combustion capture and geological sequestration (BECCS) is another opportunity.[41] This process combines bioenergy production with capture and geologic storage of the resulting CO_2. The Pacific Northwest has great potential for sequestration and supports an abundance of managed forests (Favero et al. 2023A). CO_2 reservoirs in Washington include (Figure 8):

- Primary sink: Columbia River Basalt Group (east side)
- Secondary sink: Eocene Sandstone (west side)

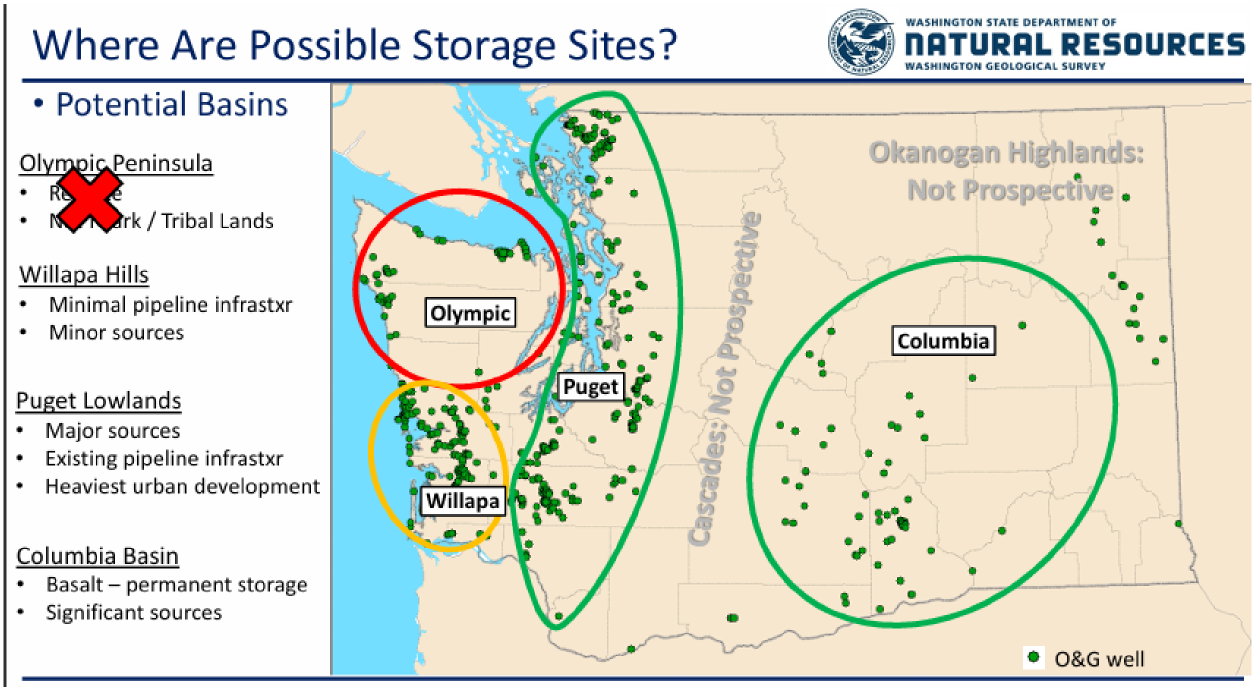
BECCS can relieve corporate tax burdens while promoting forest health and permanently sequestering CO_2. A recent report from McKinsey projects that the market for carbon removals could grow to $1.2 trillion by 2050.[42] Success of this markets depends on transparency, sustainable fuel sourcing, and regulation.[42]

On a global scale, bioenergy displaces fossil fuels and reduces reliance on petroleum and coal. However, some Nongovernmental organizations (NGOs) are concerned that the same amount of fossil is getting used regardless of biofuel use, and that some biomass projects are used to extend life of old conventional power plants, and bioenergy systems are not considered as clean or green as solar and wind.

[41] William Gallin 2022. https://www.cuspwest.org/wp-content/uploads/2022/08/WG_CUSP_AnnualMtg_WGS_v2.pdf

[42] Renton E. 2025. From biomass to Billion Dollar Carbon Removals Market. Biomass Magazine. https://biomassmagazine.com/articles/from-biomass-to-billon-dollar-carbon-removals-market

Figure 8. Possible storage sites for BECCS in Washington.[41]



Biomass can be managed as a dispatchable energy source to complement and supplement other renewable energy options that are intermittent such as wind and solar power. Estimates of carbon-beneficial forest management from California suggest what might be available in Washington. With increased demand for forest health and residues, thinning targets in forest conditions in California could produce as much as 7.3 million (M) oven-dry tonnes of forest residues per year, an eightfold increase over current levels (Cabiyo et al. 2021). Such treatments could reduce wildfire risks on 4.9 M ha (12.1 M ac) and, when combined with improved forest management, carbon storage in products, and displacement of fossil carbon-intensive alternatives over a 40-y period, could produce net climate benefits between 6.4 and 16.9 million tonnes of carbon dioxide equivalent (M tCO2e) per year (Cabiyo et al. 2021).

5.2 Constraints

Developing a new market system is always a challenge. Without strong economic and policy incentives, the Pacific Northwest is not in a position to support an industry that sources woody material for bioenergy from forest residues. There is limited infrastructure, transportation distances are long, and the skilled workforce is minimal. In spite of the need for forest thinning and removal of residues to reduce risks of wildfire, disease, and insects, one industry representative said that such an industry in the western US is 5 to 10 years in the future (and others say 10-10 years). For now, many industries are focused on the southeastern US where timber and pulp mills are active, wood markets are strong, and travel distances are shorter.

Long trucking distance is an obstacle to the use of woody biomass in the Pacific Northwest as it is in the northeast US (Louis et al. 2024). Cost to haul a low-value material make it not worth the effort. In addition, both regions would benefit from more incentives for woody biomass harvesting. As it is, there is limited support from the government and essentially no market. Louis et al. (2024) surveyed foresters, loggers, and landowners in the northeast US, and they recommended new and improved markets, improved awareness regarding the importance of sustainable woody biomass harvesting, and the need to consider harvested woody biomass as equal to other renewable energy sources. Similar responses would be likely in the Pacific Northwest.

Another constraint is **exclusion of federal forests from Renewable Identification Numbers** (RINs) (i.e., credits used for compliance under the Renewable Fuel Standard, which requires transportation fuel sold in the US to contain a minimum amount of renewable fuels). This policy was supported by the environmental community's concern that woody biomass energy would compromise ecosystem services and biodiversity of forest systems – especially if the industry expanded. However, that fear has not occurred largely because of the low value of biomass for bioenergy resulting in less than 5% of total industrial wood harvest removals going to bioenergy even in the largest market (Brandeis and Abt 2019; USDA FIA TPO 2020). It is not clear if this policy will continue under the Trump administration. However, only about 2% of the timber harvested in Washington comes from federal forest land.

Uncertainties in Federal policies are a major constraint to any industry moving forward. In particular, changes to tariffs and the agreement between the US, the United Mexican States, and Canada [that replaced the North American Free Trade Agreement (NAFTA)] affect imports and exports of wood products.

While avoiding risks of wildfire is of great interest for the western states, without **strong markets and infrastructure** in place, little progress can be made in reducing wildfire risks. However, this situation may be improved by the May 2025 announcement of USDA that additional funds ($23M) would be available to transport hazardous fuels such as dead and down trees.[43]

Air quality reduction and environmental justice issues have been raised regarding bioenergy facilities.[44] However, burning residues and increasing wildfires also induces respiratory and cardiac problems. And using woody biomass for electricity generation and production of biofuels/biochemical/bioproducts can lead to reduced respiratory health effects compared to coal-produced electricity, and use of mill residues rather than forest residues had fewer respiratory health impacts (Huang and Bagdon 2018).

Social license of producing bioenergy from forest biomass is a challenge. Acceptance of a company or industry's standard business practices and operating procedures typically relies on availability of information about how the industry operates and its costs and benefits to the community and the environment (Acharya et al. 2024). There is concern that increased use of biomass will drive forest management in ways that will be socially and environmentally undesirable. Several national and local NGOs are concerned about bioenergy. Therefore, the Sierra Club asks that individual projects be assessed independently against their Energy

[43] USDA acts to boost timber production, reduce wildfire risk | Biomass Magazine
[44] Resolution in Opposition to Wood Pellets Manufacturing and Use of Wood-Bioenergy | NAACP

Resources Policy.[45] Many factors should be considered in determining whether a new project or established facility contributes to carbon emissions.

Social license is closely related to the concept of sustainability. **Having a clear definition of sustainable forestry** is essential. While all DNR's forested lands are certified under the Sustainable Forestry Initiative® (SFI) and many are also certified by the Forest Stewardship Council® (FSC), determining sustainability of harvesting on private lands is more challenging. A recent poll of voters in public elections in the Seattle and Spokane by the Washington Forest Protection Association[46] found that

> • "82% of voters believe active forest management, which includes commercial timber harvest, is important to maintain healthy forests. (February 2024)
> • 83% agree that managed forests are a critical tool for fighting climate change and preventing catastrophic wildfire. (February 2024)
> • A majority (61%) feel that we should maintain the current levels of harvest and sustainable replanting. (February 2024)
> • 89% of Washington state voters support managed forests, recognizing their importance in promoting sustainable harvesting for wood products, and keeping forests healthy, including replanting. (June 2023)
> • 83% of respondents believe that managing forests significantly reduces the risk of wildfires by thinning dead and dying trees and removal of underbrush. (June 2023)."

Other Washingtonians may have different views, for perceptions regarding the growth and harvesting of woody biomass vary depending on age, gender, education, risk decision-making ability, environmental and economic considerations, and energy policies (Acharya et al. 2024).

The **supply of forest and mill residues depends on overall forest sector activities and markets**. Forest residues and pulp wood were the historical supply for paper. As demand for paper declines, there is less demand for pulp wood, which means that residues remain unused at the mill. Fluctuations in the housing market also affect the amount of both forest and mill residues. Bioenergy production requires a stable local supply of biomass. In addition, technological advances in wood processing may alter the efficiency of converting wood into various products and thereby affect supply of biomass and bioenergy production (Acharya et al. 2024).

Fluctuations are occurring in the demand of bioenergy as a function of policies, investments, and priorities for the bioeconomy (Acharya et al. 2024). Demand for wood for bioenergy, chemicals, and materials is also in flux.

There is also **concern that using forest biomass for bioenergy will increase net carbon emissions from forest** (Favero et al, 2023B). Distrust of bioenergy undermines social license. Both advocates and critics of bioenergy are accused of distorting facts.[40] For example, some studies emphasize carbon neutrality without adequately acknowledging the emissions involved in

[45] See pages 16-17 of https://www.sierraclub.org/sites/default/files/Energy-Resources-policy_0.pdf
[46] https://www.wfpa.org/news-resources/news/voters-support-sustainable-forest-management/

the entire production and use cycle. Other studies assume that bioenergy relies on whole trees grown specifically for biomass rather than on the coproducts of other forestry activities that generate residues. Additionally, some studies do not take into account the wildfire emissions or increased cost on the healthcare system ,which, in turn, leads to increased fossil fuel use for travel. The analysis is complicated due to the important influence of temporal and spatial scales and counterfactual assumptions (i.e., what would occur in the absence of the bioenergy market). For example, some studies focus on a single forest stand and assume it would remain intact rather than considering the landscape and the likelihood of disturbances and harvests for non-energy purposes. However, Sohngen et al. (2024) make clear that understanding carbon dynamics associated with wood harvesting requires an integrated economic and natural systems approach that considers forest systems. Choices of the temporal and spatial system boundary and the reference (counterfactual) scenarios strongly influence results (Cowie et al. 2021). Some model studies show significant long-term losses in carbon stocks and increases in carbon emissions, while other studies find that a short-term decrease in forest carbon sequestration occurs but persists only under specific assumptions regarding carbon accounting, markets, policies, and future biomass demands (Favero et al. 2023B). Many analyses do not account for bioenergy system emissions displacing emissions related to use of fossil fuel exploration, collection, transport, production, and use.

There are concerns that harvesting forest residues for bioenergy will have **undesired impacts on habitat and biodiversity**. However, forest management can be designed to support both biodiversity conservation and GHG gas mitigation by combining incentives for management, restoration, conservation, production, and monitoring in a single package adapted to local conditions (Kline and Dale 2020).

Timely, transparent, and trusted monitoring and reporting on the forest system and habitat conditions, focusing on indicators that are important to local stakeholders, can provide a foundation for learning necessary to adapt management to changing conditions and make improvements over time. Public engagement in monitoring and analysis, combined with the provision of timely access to data, findings, and management plans, can help strengthen social license.

6. Recommendations for next steps

The next step is to discuss opportunities and constraints during the field tour. This discussion must be in light of the importance of context. In particular, approaches for southeastern Washington will differ from those for southwestern Washington because of differences in supply (as determined by climate, tree species, growth rates, and accessibility), demand (as influenced by transportation options, markets), and work force availability. Factures line and paths toward clarifying and resolving them should also be discussed. It is important to determine a way to define and measure progress toward sustainability of bioenergy in particular contexts.

Glossary

Best Management Practices[47] – Methods established by regulation that have been scientifically determined to be the most effective, practical means of managing timber land while protecting the environment. The term originated from the rules and regulations developed pursuant to Section 208 of the federal Clean Water Act (40 CFR 130).

Commercial thin— occurs about 30 years after planting in the PNW depending on forest type. These trees are 5-inch diameter or greater and are removed and sold to reduce stand density and promote increased growth in remaining trees. The acre density remaining also depends on forest type.

Commercial harvest– Typically occurs at 40-60 years after planting in the PNW (also known as a 40- to 60- year rotation. These trees are all 5-inch diameter or greater but ideally less than 18-inches. At this time, very few mills can handle logs greater than 18-inches, so a commercial harvest has a defined timing to be merchable.

Pre-commercial thinnings occur in the first 5 to 10 years after planting in the PNW. The trees and other woody biomass removed are not considered to be of merchable size (less than 5-inch diameter) or are unhealthy or diseased. These trees are removed trees, removed to reduce stand density and to promote growth of more desirable, healthy trees.[48]

Slash is the residue, including treetops, branches and bark, Piled or chipped onsite after logging or accumulating as a result of a storm, fire, delimbing or other similar disturbance.[48]

Sustained yield[47] – Harvest practices which, over time, ensure the rate of forest harvest does not exceed the rate of forest growth.

Thin[47] – Tree removal in a forest stand that reduces tree density and tree-to-tree competition, encouraging increased growth of fewer, higher quality trees.

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[47] Defined by the Washington Forest Protection Association - https://www.wfpa.org/forest-facts/forestry-definitions/

[48] As defined by 40 CFR 80.1401 under the Renewable Fuel Standard (RFS) program

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Appendix A. Native tree species commonly found in Washington state

- Big-leaf maple – *Acer macrophyllum*
- Douglas-fir – *Pseudotsuga menziesii*
- Grand fir – *Abies grandis*
- Incense cedar – *Calocedrus decurrens*
- Lodgepole pine – *Pinus contorta*
- Noble fir – *Abies procera*
- Oregon ash – *Fraxinus latifolia*
- Oregon white oak– *Quercus garryana*
- Ponderosa pine – *Pinus ponderosa*
- Red alder – *Alnus rubra*
- Silver fir – *Abies amabilis*
- Sitka spruce – *Picea sitchensis*
- Western hemlock – *Tsuga heterophylla*
- Western larch – *Larix occidentalis*
- Western red cedar – *Thuja plicata*

- Western white pine – *Pinus monticola*
- White alder – *Alnus rhombifolia*
- White fir – *Abies concolor*
- Yellow cedar – *Callitropsis nootkatensis*