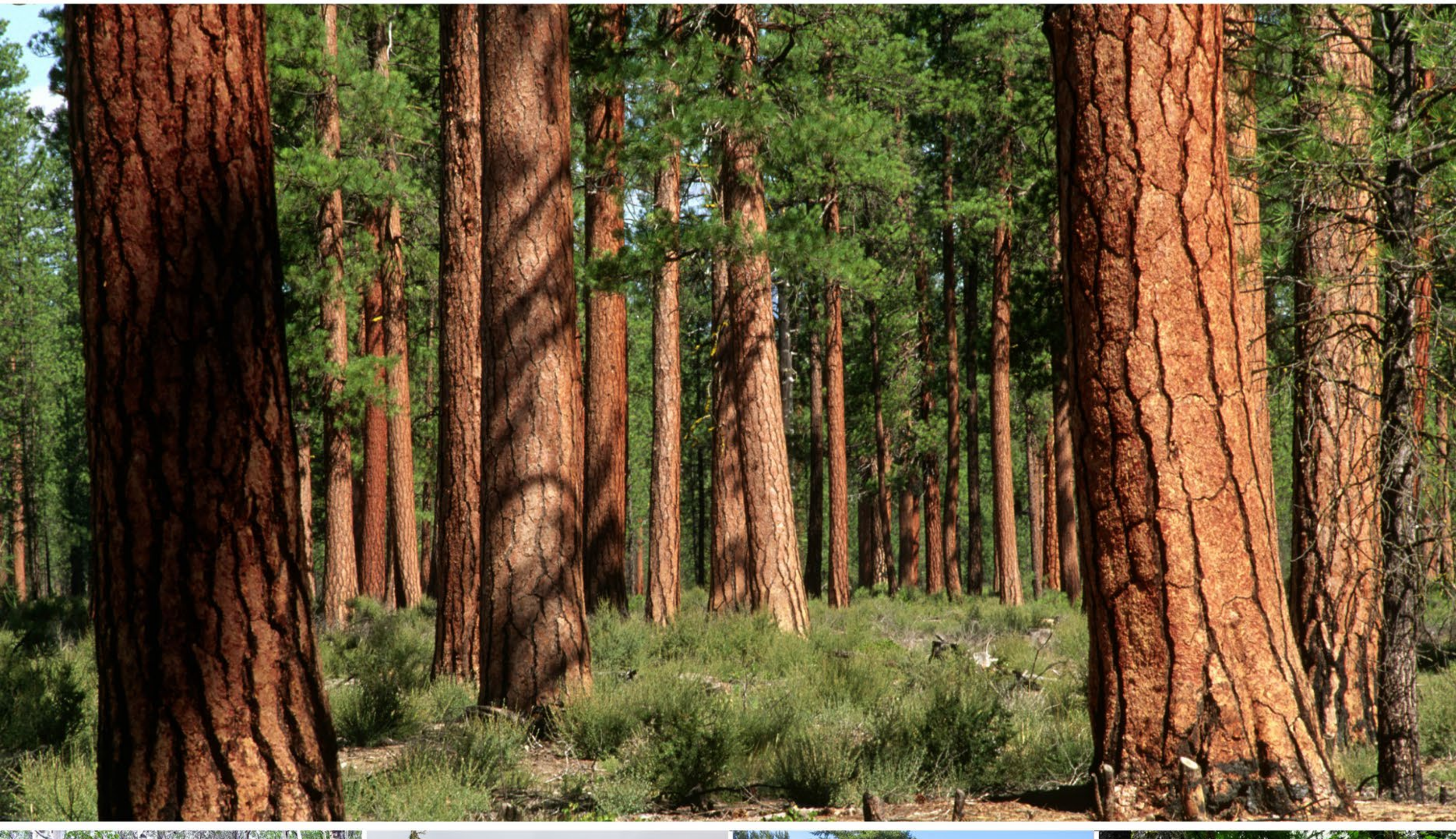
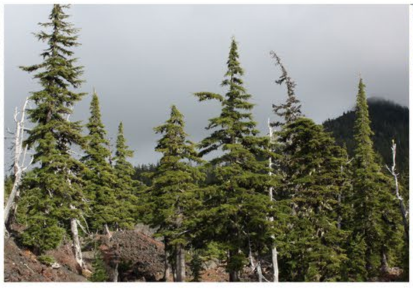
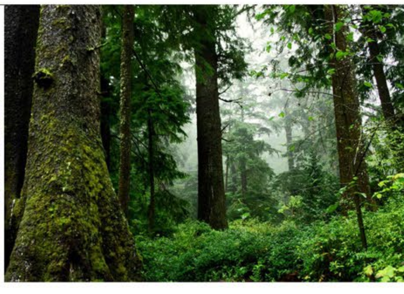
SUSTAINABLE FORESTRY INITIATIVE

SFI-00001

SUSTAINABLE FORESTRY INITIATIVE REGIONAL CLIMATE CHANGE RISK SUMMARY: NORTHWEST US







SFI CLIMATE SMART FORESTRY INITIATIVE

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Recommended citation: Cooper, G., Cooper, L.T., Gadoth, D., Beresford, E., and C.C. Papa. 2025. Regional Climate Change Risk Summary: Northwest US. Sustainable Forestry Initiative. Washington, DC. DOI: **10.5281/zenodo.17466071**

INTRODUCTION

Climate Smart Forestry (CSF) is defined as sustainable adaptive forest management to protect and enhance the potential of forests to adapt to and mitigate climate change (Bowditch et al. 2020, Cooper and MacFarlane 2024). The threats posed to these forests by climate change can be equally diverse, with variations across geographies and forest types in terms of risk level, frequency of occurrence, and severity of impacts. Therefore, implementation of CSF practices across the geographically diverse footprint of SFI-certified forests in North America necessitates regional approaches to promote climate change adaptation and mitigation.

Acting strategically on CSF requires strategic, science-backed approaches that address:

1. How climate change is affecting, or is expected to affect, forests, trees, and forestry operations across different regions
2. Forest vulnerability to climate change impacts
3. Principles and practices for adapting to and mitigating those risks, based on forest type group
4. Guidance to monitor and evaluate the effects of those practices to inform future decision-making

The rapid pace of climate change and the continuous emergence of new data also pose challenges in keeping strategies updated and relevant. Integrating evolving scientific knowledge into practical implementation remains a significant hurdle. Differing priorities and levels of interest can affect the cohesive implementation of CSF strategies. Overcoming these barriers will require continued innovation, investment, and cooperation among stakeholders involved in forest management.

The primary aim of this report is to advance a systematic approach for CSF across various geographies, utilizing diverse data sets and emerging research. This report is intended to reach other audiences interested in this topic including government agencies, users of forest products (e.g., those in building and construction), conservation groups, and interested members of the public including consumers.

The Sustainable Forestry Initiative (SFI) 2022 Forest Management Standard includes a Climate Smart Forestry objective that requires certified organizations to identify and address climate change risk by developing adaptation strategies and identifying opportunities to enhance mitigation. A key aspect of the CSF objective is a requirement to identify and prioritize climate risks based on the best available scientific information. In addition to adaptation, the CSF objective emphasizes identifying and addressing opportunities to mitigate climate change impacts associated with forest operations.

SFI STANDARDS AND ADVANCING CSF

SFI is an independent, non-profit organization advancing the value of forests as a critical component to our collective future. With over 150 million hectares certified to the SFI Forest Management Standard in North America, and tens of millions more positively influenced by SFI Fiber Sourcing, SFI and SFI-certified organizations have the scale to implement solutions across the landscape. During the 2022 standard revision process, SFI enhancements objectives adding two new objectives focused on Climate Smart Forestry and Fire Resiliency and enhanced requirements on the conservation of biological diversity. These require certified organizations to identify and address climate change and fire risks to forests and forest operations and develop adaptation objectives and strategies.

The SFI 2022 Forest Management Standard, through its Climate Smart Forestry (CSF) objective incorporates performance measures for climate change adaptation and mitigation strategies, enhancing forest resilience and carbon sequestration capacities and reducing emissions associated with forest operations on public and private lands. This includes activities like enhancing climate benefits of forest operations (via implementation of practices to improve forest health, productivity, and resilience), increasing the area and density of certified stands (via afforestation, prompt reforestation, and supplementation of understocked stands), and minimizing carbon losses during forest operations (via protection of advanced regeneration during harvest and retention of productive stems during partial harvest).

Interpreting Climate Impacts and CSF Practices

Because SFI-certified forests span broad geographies across North America, they include a wide array of ecological zones (i.e., distinct elevations, climates), tree species compositions, site conditions, age classes, management histories, productivity levels, and patch sizes. This report provides foundational context to support systematic evaluation of climate risks and appropriate CSF interventions to address those risks. This approach involved a high-level assessment of climate change-related impacts to forests in each region and vulnerabilities of local forest type groups to those impacts. The review used large, recognized sub-national regions, within which ecologically significant information regarding dominant forest type groups, key species, and site considerations was synthesized to tailor to species- and condition-specific threats and vulnerabilities.

Advancing CSF can be supported with hierarchical decision-making linking climate-driven forest threats and impacts from regional geographies (ecoregions), forest type groups, with site- or species-specific concerns. Critical evaluation of climate-driven impacts to local forest communities provides a foundation for which Climate Informed Principles and Practices (CLIPPs) can be applied.

Regional Considerations

Climate change will affect forests and trees differently across North American geographies. This analysis uses sub-national regions in both the US and Canada. Boundaries for US regions largely follow state groupings used by the US Forest Service (USFS), with ecoregions presented at 2 scales (Level II & III) based on definitions by the Commission for Environmental Cooperation (CEC Working Group 1997). The boundaries of the Forest Regions of Canada are based on Rowe (1972) and are characterized by ecological features, climatic conditions, and forest community types.

Forest community groupings align with definitions used by national natural resource agencies. For US regions, definitions of Forest Type follow USFS Forest Inventory and Analysis definitions of Forest Type Groups while for Canadian regions, the framework follows definitions of Species Group used by Canada's National Forest Inventory. Tailoring the design and structure of the decision support framework to account for regional considerations such as subregional delineations, forest type groups, climate impacts, and

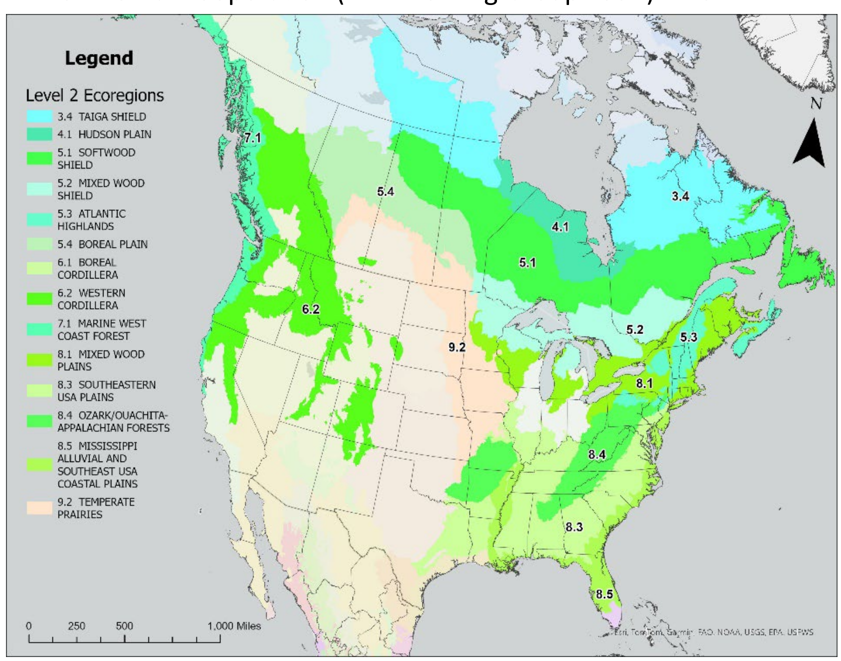


Figure 1. Map of Level II ecoregions (CEC Working Group 1997).

management practices will allow for consistent communication and advancement on Climate Smart Forestry.

Data and information relating to regional climate change stressors to forests were also sourced differently for the US and Canada. For regions of both countries, data on climate change impacts were synthesized from a diversity of scientific resources. Some important resources for US regions included the US National Climate Assessments, Northern Institute of Applied Climate Science (NIACS) Vulnerability Assessments, the USFS Tree Atlas, and feedback from regional forest experts. For Canadian regions, important sources of this data included Natural Resources Canada's *Canada in a Changing Climate: Regional Perspectives Report*, The State of Canada's Forests Annual Reports, and Canada's Changing Climate Reports, among others.

Geographic distinctions were also considered regarding formulation and framing of climate smart forest interventions. For Canadian regions, the Canadian Forest Service Database of Adaptation Options served as a valuable resource and supported identification of adaptation options to address forest vulnerabilities based on peer-reviewed publications. For US regions, adaptation pathways were framed around concepts of strategies, approaches, and tactics published in Adaptation Menus developed by NIACS and the USFS (Ontl et al. 2020 and Swanston et al. 2016). These resources inform the categorization and framing to downscale adaptation responses from broader approaches to specific activities for regions in both the US and Canada.

For the purposes of this report, the Northwest US includes the states of northern California, the panhandle of Idaho, western Montana, Oregon, and Washington. Forests in this region are highly productive and supply a significant share of US domestic timber. These forests are largely comprised of conifers that vary depending on elevation and aspect, the primary tree species used for forest products is the Douglas-fir and forest production comes from both public and private lands (Maher 2024).

Ecoregions of the Northwest

There are two major forested ecoregions in the Northwest US: Marine West Coast Forest and Western Cordillera (U.S. Environmental Protection Agency, 2013). Within these ecoregions are three main ecological forest types characterized by site conditions and climate. The Marine West Coast Forest is characterized as a temperate rainforest, and the Western Cordillera contains moist forests, subalpine/cold forests, and dry forests. These ecoregions consist of 9 Level III ecoregions (Figure 2). A description of each ecoregion, including dominant forest cover types and key climate change impacts are summarized in Table 2 (U.S. Environmental Protection Agency 2013).

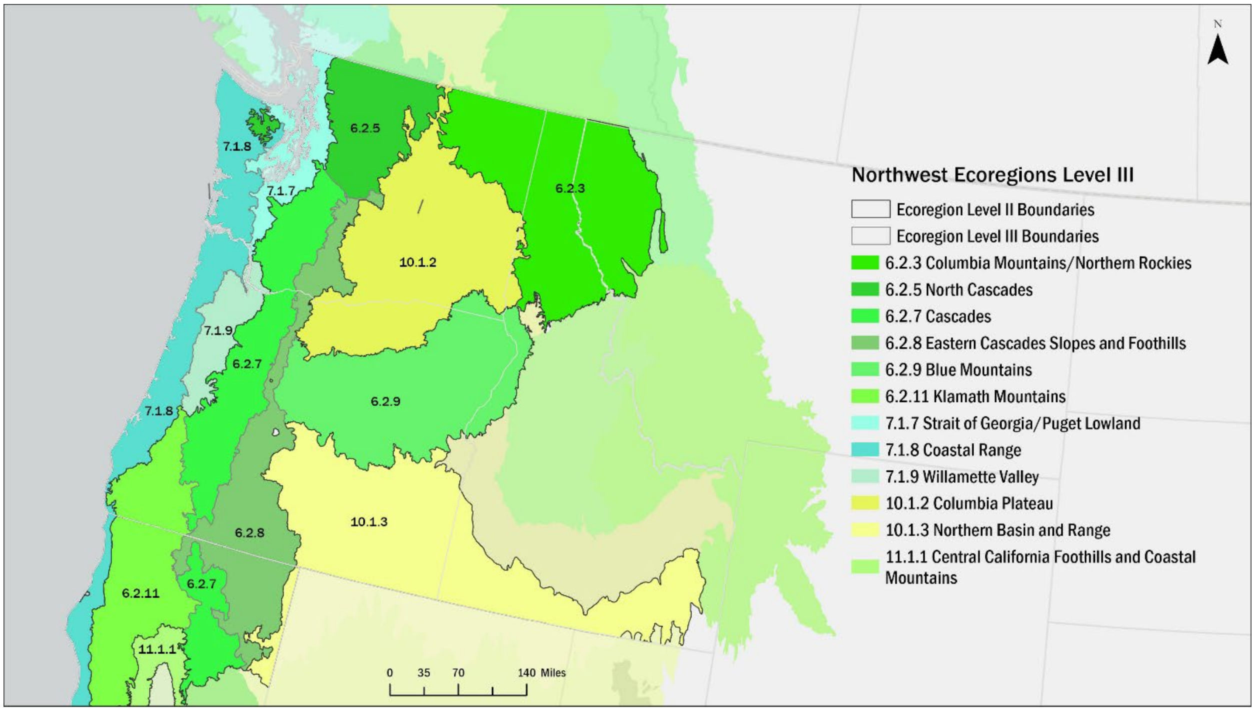


Figure 2. Level III Ecoregions of the Northwest (U.S. Environmental Protection Agency, 2013)

NORTHWEST CLIMATE TRENDS AND IMPACTS ON FORESTS

In the Northwest United States, climate change is having a range of impacts on the forested landscape. The forest impacts that are currently being observed, with anticipated increases, include wildfires, extreme storm events, droughts, and an increase in pests and pathogens including damage from insects. It should also be noted that these impacts can co-occur, and combinations of these impacts can drive stressors that ultimately cause tree mortality.

Temperatures in the northwest are getting warmer. The Coastal North and Mountains generally have a cooler climate, to the south the climate is Mediterranean with warmer summers. Across the region, the temperature reaches an average maximum of 64° F (18° C) in July and August with lows of 32° F (0° C) in December and January. There is a notable increase in winter and summer temperatures greater than 2° F across the region when comparing average temperatures from 20th century temperatures to 21st century temperatures (Marvel et al. 2023).

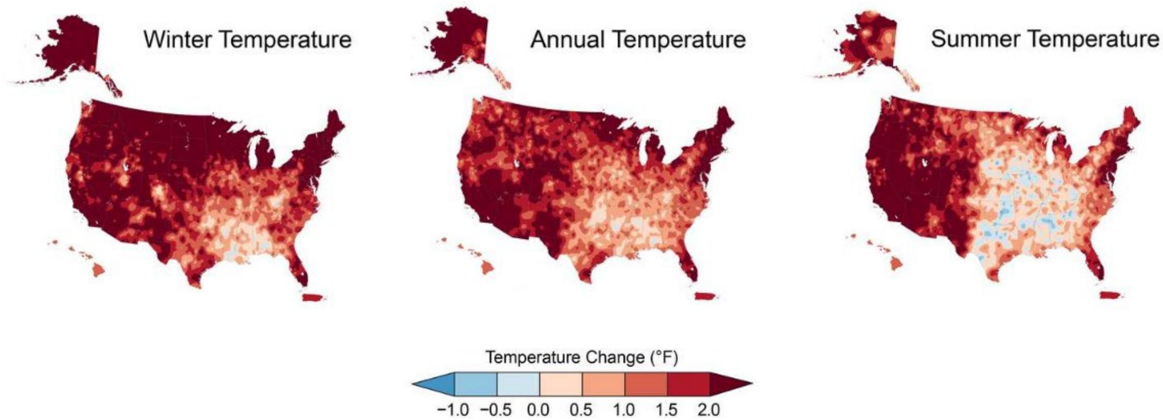


Figure 3. Observed Temperature Change 2002-2021 for the Winter, Annual Average, and Summer across the US based on 1901-1960 Averages (Marvel et al. 2023) (NOAA NCEI and CISESS NC).

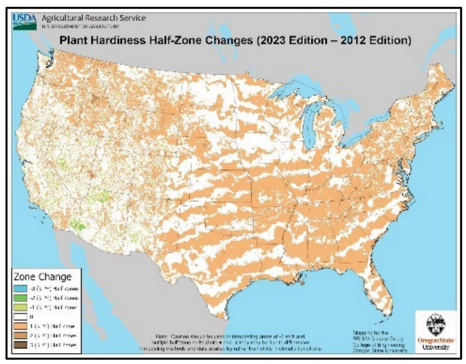


Figure 4. The map shows the shift in the plant hardiness zones based on observed temperature changes between 2023 and 2012 (USDA 2023).

Increasing temperatures are changing the plant hardiness zones (USDA 2023). This trend results in changes to ecosystems that allow northward and altitudinal expansion by species that are adapted to warmer temperatures and potentially outcompete species that are competitive on a site due to their adaptation to colder temperatures.

Precipitation is variable across the region with topographic influence driving these patterns. The Coastal North and Mountains generally have a wet climate, to the south the Mediterranean climate means drier summers, to the east of the Cascades and in southwest Oregon the rain shadow effect leads to drier conditions. Precipitation in this region peaks in December and January. Since the 1900s, the average annual precipitation is decreasing with the greatest decreases occurring in the summer months leading to more frequent and prolonged droughts (Marvel et al. 2023).

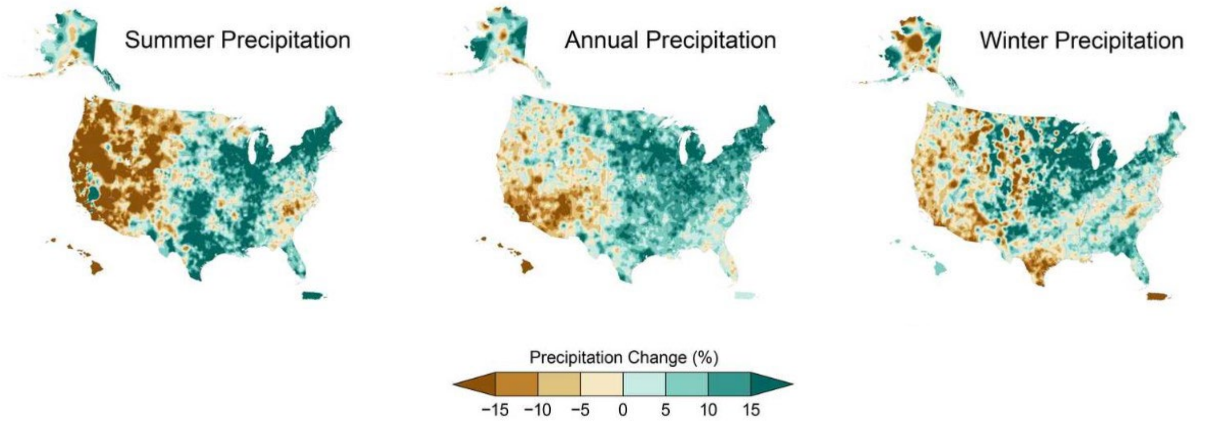


Figure 6. Observed change in Precipitation from 2002-2021 compared to 1901-1960 average for Summer, Annual, and Winter precipitation (Marvel et al. 2023).

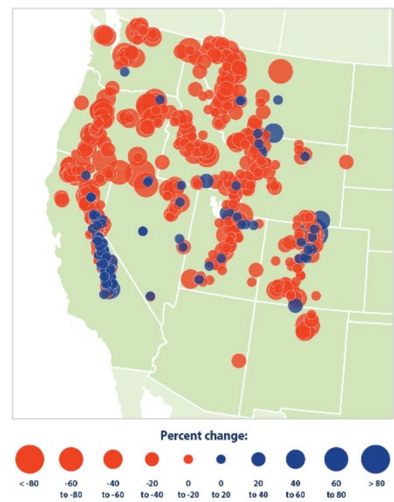


Figure 5. Observed change in April Snowpack, 1955-2023 (USDA NRCS 2024).

Seasonal climate trends across the Northwest are also changing over time. Generally, the total amount of snow has been reduced with an up to 80% reduction in snowpack observed from 1955-2023. There have been some increased in snowpack in California's Sierra Nevada mountains in this same time (USDA NRCS 2024). These changes in snowpack which can be attributed to with warmer winters result in longer growing seasons which means that forests are using more water which can lead to water deficits. It is projected that there will be greater reductions in snow and water across the region by the end of the century.

Wildfires are increasing the area burned across the western United States. This is more pronounced in the interior mountains and northern California in the northwest. These wildfires are exacerbated by drought conditions in addition to past management which suppressed wildfires in forests that co-evolved with fires and historically had fewer trees per unit area. Figure 7 shows the observed trends in wildfires in the western US. The median area burned has remained steady since 1950, however, an increase in the mean area burned demonstrates the occurrence of some very large wildfires or megafires that sometimes surpass 100,000 acres (Weber & Yadav 2020).

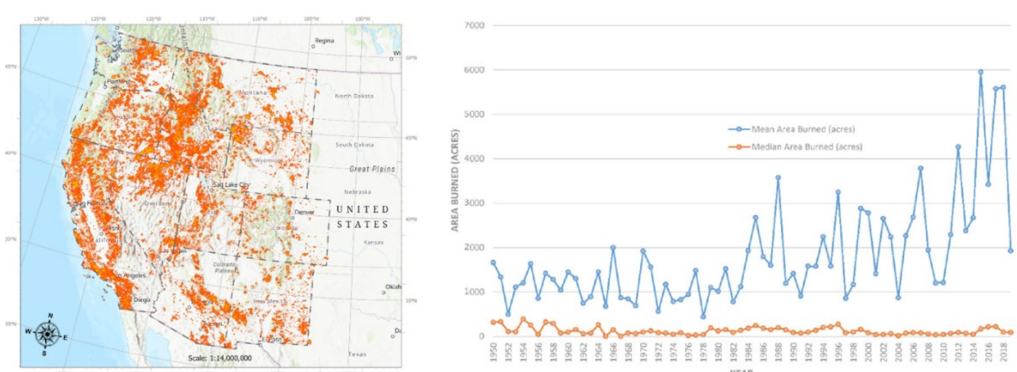


Figure 7. Observed trends in the annual number of large fires in the Western US (1950-2019) (Weber & Yadav 2020)

Pests and Disease For some forest pests, winters act as a moderating factor that limits population spread. Hard freezes can kill eggs or overwintering adults. With warming winters and fewer hard freezes pests have opportunities to expand their ranges and have the potential for population explosions. Figure 9 shows the area of mortality due to Mountain Pine Beetle in western North America, this is a native pest that has been able to expand in elevation and latitude due to moderating winter temperatures (Law and Waring 2015).

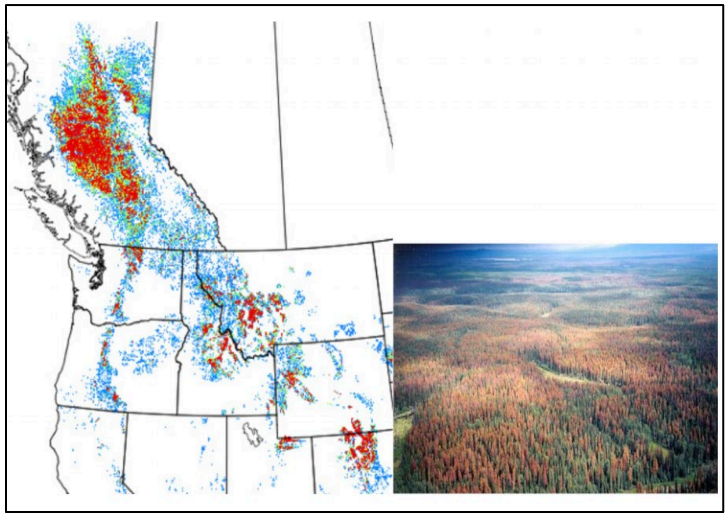


Figure 8. Mortality area within 1 km-2 grid cell: blue (0-5 ha), green (5-15 ha), red (>25 ha). US upper estimate, 1997-2010; British Columbia, 2001-2010 (Law and Waring 2015 (adaptation from Meddens et al 2012)).

Cumulative Effects The interactions of these climate driven impacts can increase the severity of a disturbance, resulting in increased mortality. For example, with increasing temperature, trees will increase their evapotranspiration thus using more water which can then exacerbate droughts increasing the severity of wildfires and susceptibility to insects and diseases. Another example is especially true in higher elevation mountain areas of the northwest, where cold winters and snowpack can act as a deterrent to the spread of insects. When winter temperatures increase and snowpack lessens, these deterrents no longer exist, and pests can have outbreaks in these forest types which can then lead to mortality and increased risk of severe wildfire through the additional fuel loading.

NORTHWEST US FORESTS

The Northwest US is dominated by seven key forest cover type groups: Douglas-fir, fir/spruce/mountain hemlock, ponderosa pine, lodgepole pine, western oak, hemlock/Sitka spruce, pinyon/juniper, and alder/maple. Figure 9 shows region-level data of total forested area and forest carbon per acre for each of the major cover types (data source: USFS FIADB, accessed 2025). Douglas-fir is by far the most widespread cover type and holds the most landscape carbon with >4.6 billion tons stored regionally. Different cover types store different quantities of carbon relative to their regional extent. For example, the lodgepole pine occupies nearly double the area of Hemlock/Sitka spruce, yet the Hemlock/Sitka spruce group contains roughly three times the amount of carbon per unit area as lodgepole pine (Figure 9). The higher levels of carbon in Hemlock/Sitka spruce stands can be partially attributed to the high moisture levels of the sites they occupy, which are often characterized by slow decomposition rates and high accumulations of woody debris on the forest floor.

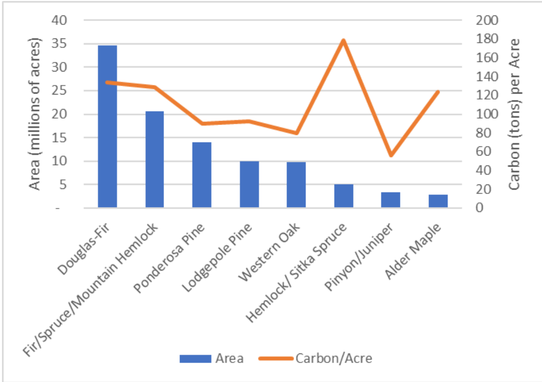


Figure 9. (Bars) Area of forest type groups across the Northwest. (Line) Tons of Carbon per acre by Forest Type Group (USDA FS FIA 2025).

Forest Cover Group Climate Change Impacts

Some of the most significant threats to forests of the Northwest US include wildfires, pests and diseases, warming winters, and drought. Table 1 shows a comparison of major climate-related threats to regional forest cover types. Results presented in Table 1 were drawn from wide-ranging literature, see Barkley 2011, Peterson et al. 2014, Raymond et al. 2014, United States Department of Agriculture Forest Service (n.d.), Reilly et al. 2018, National Park Service 2016, *Pacific Temperate Rainforest* 2019, May et al. 2018, and Burrill et al. 2017.

Table 1. Climate-related threats of key concern to forest cover types of the Northwest US.

FOREST COVER TYPE	DROUGHT	EXTREME STORMS	PESTS & DISEASE	REGENERATION ISSUES	WARMING TEMPERATURES	WILDFIRE
Douglas-fir			x			x
Fir/ Spruce/Mountain Hemlock	x		x	x	x	x
Ponderosa Pine				x		x

FOREST COVER TYPE	DROUGHT	EXTREME STORMS	PESTS & DISEASE	REGENERATION ISSUES	WARMING TEMPERATURES	WILDFIRE
Alder/Maple	x	x	x			x
Hemlock/Sitka Spruce	x		x	x		x
Lodgepole Pine	x		x		x	x
Pinyon/Juniper			x			x

Douglas Fir

Douglas-fir forests are the most economically important species group in the Northwest, especially in the moist inland zones. This forest type group is widespread across the Marine West Coast Forest and Western Cordillera. The most important species in this group is Douglas-fir but can also include ponderosa pine, lodgepole pine, and grand fir (Eyre 1980). The species in this group are long lived and historically fire would have played a role in stand development. This forest-type group is relatively drought tolerant and is predicted to fare well under climate change predictions (Hudec et al. 2019).

Figure 10. Douglas-fir forest and distribution (inset) in the northwestern US. Data: USFS FIA 2024

Hemlock-Sitka Spruce

Hemlock-Sitka Spruce forests primarily occur in the coastal, low elevation areas from California to Alaska. This forest type group is primarily found along the coast range and includes Sitka Spruce, Western Hemlock, with Douglas-fir and Red Alder and Bigleaf Maple. Western hemlock is highly sensitive to changes in soil moisture and drought can affect future distribution of the species. Declines in hemlock are already being observed around the Puget Sound. This forest type group is expected to maintain its extent but move up in elevation and displacing higher elevation forest types (Hudec et al. 2019).

Figure 11.Hemlock-Sitka Spruce forest and distribution (inset) in the northwestern US. Data: USFS FIA 2024

Fir-Spruce-Mountain Hemlock

The fir-spruce-mountain hemlock forest are diverse high-elevation forests. Important species in this group include grand fir, Engelmann spruce, subalpine fir, western larch, mountain hemlock, western redcedar, Douglas-fir, and western white pine. This group includes important species for commercial forestry and are primarily managed with even-age regeneration (Eyre 1980). These forests are sensitive to increasing temperatures and drought events (Hudec et al. 2019). This means that the species in this forest experience reduced growth and vigor and are more susceptible to pest infestation. Pest outbreaks are predicted to occur at higher frequencies and increase the likelihood of catastrophic wildfire. Regeneration failure does occur in this forest type group, particularly for species such as western larch.

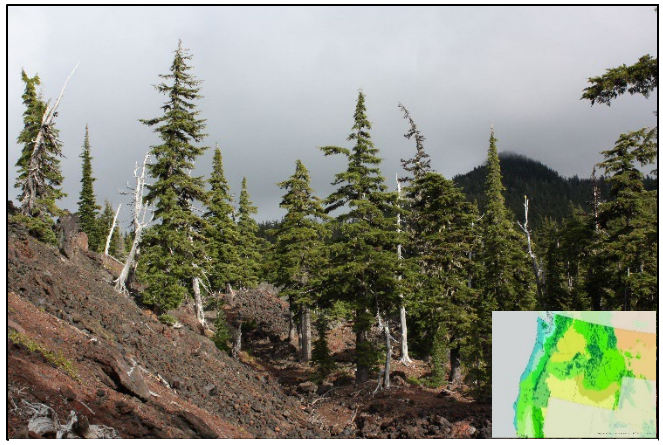


Figure 12. Fir-Spruce-Mountain Hemlock forest and distribution (inset) in the northwestern US. Data: USFS FIA 2024

Ponderosa Pine

Ponderosa pines are among the most common tree species in the western US. They grow at intermediate to low elevations (610 to 1830 m) in eastern Oregon & Washington, stretching into western Idaho. The Ponderosa pine forest type group occurs in pure (>80% spp. composition) ponderosa pine and mixed evergreen stands blended with Douglas-fir, lodgepole pine and western juniper. This forest type group is maintained by frequent, low-intensity fires (Eyre 1980). This group is expected to increase in prevalence along the east side of the Cascades and inland Pacific northwest. However, at the lower elevations across its range Ponderosa Pine is experiencing regeneration failure and this shifting the range higher in elevation (Thorne 2022).

Figure 13. Ponderosa Pine forest and distribution (inset) in the northwestern US. Data: USFS FIA 2024

Alder/Maple

Figure 14. Alder/Maple forest and distribution (inset) in the northwestern US. Data: USFS FIA 2024

This forest type group occurs on both cool, moist sites and warm, dry sites on low elevations (<1000m) from northwestern British Columbia through coastal northern California. The forest is typically closed-canopy forests with a well-developed understory with conifers and shrubs throughout. Red alder is dominant in early successional stages and bigleaf maple becomes more abundant in intermediate and late successional stages (Eyre 1980). Red alder is the most abundant hardwood in the northwest and a commercially important lumber species while bigleaf maple is not typically managed for. This forest type group is projected to increase in productivity with an expansion of suitable habitat (Cortini et al. 2012). The most vulnerable are on sites with cold winds, frost, and drought which can potentially limit range expansion and regeneration potential. An observed decline of bigleaf maple, speculated to be linked to climate change and drought, may continue or become more severe (Betzen et al. 2021).

Lodgepole Pine

Figure 15. Lodgepole Pine forest and distribution (inset) in the northwestern US. Data: USFS FIA 2024

This forest type group is one of the most widespread types in the Western U.S, it tolerates a broad range of temperatures and moisture regimes. Primary species in this group are primarily lodgepole pine with a component of subalpine fir, Engelmann spruce, white spruce, and Douglas-fir. Lodgepole pine is a mid-successional species over most of its range but can be the dominant species on sites with frequent stand-replacing fires (Eyre 1980). Projections show lodgepole pine may be reduced in abundance in some areas the species is affected by higher temperatures, increased soil moisture stress, and extended summer drought periods. Climate change may significantly alter spatial patterns of productivity and carbon storage in these forests (Case and Peterson 2007).

Pinyon/Juniper

Figure 16. Pinyon/Juniper forest and distribution (inset) in the northwestern US. Data: USFS FIA 2024

This forest type group contains a minimum of 10% juniper crown cover. It occurs in relatively open stands as savanna-type forests with a potential to increase stand density (Eyre 1980). This type has increased in cover throughout the 20th century with the majority on private lands and driven by favorable climatic conditions and reductions in fire intensity and frequency. This forest type is sometimes viewed as invasive. It is also considered the most vulnerable forest type in western US. With 40% of range expected to experience high vulnerability to drought or fire. Its suitable habitat is projected to shift northwards and upslope with increased prevalence in Pacific Northwest projected over coming decades (Shinneman et al 2023).

Western Oak

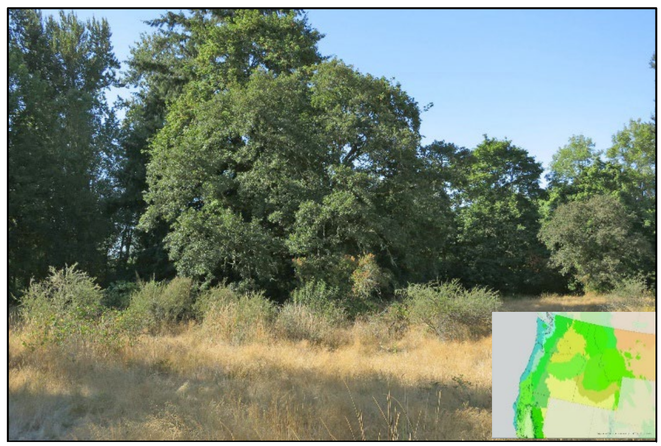


Figure 17. Western Oak forest and distribution (inset) in the northwestern US. Data: USFS FIA 2024

Species include Tanoak, California Black Oak, Oregon White Oak, Pacific Madrone and Douglas-fir. The Western Oak Forest Type Group is best characterized by open-canopied woodlands dominated by oaks, maintained historically by fire, and support rich understory and wildlife diversity (Eyre 1980). Models suggest that the climate will remain suitable for Oregon white oak, and therefore its range may expand to upslope in the western Cascade foothills and eastern flanks of the Coast Range and Willapa Hills (Michalak et al. 2013). Warmer, drier summer conditions leading to increased summer drought may actually benefit the relatively drought-tolerant native prairie and savanna species over the less drought-tolerant tree and other forest species, possibly resulting in prairie/savanna expansion (Bachelet et al. 2011).

ECOREGION IMPACTS WITH SPECIES-SPECIFIC INSIGHTS

This section presents a table with the climate risks by ecoregion and linking with the specific-specific concerns presented in prior sections. Results in Table 2 shows which major Forest Cover Type Groups are present in each Level II Ecoregion (column 1). A description of the forests at the Level III ecoregion scale are provided for context in column 2. Additionally, a summary of the climate change vulnerability on the forests in the ecoregion are summarized in column 3. These data are pulled from wide ranging literature expanded upon in prior sections.

Level II Ecoregion	Level III Ecoregions Descriptions	Climate Change Impacts
Marine West Coast Forest **Forest Cover Groups** • **Douglas-fir** • **Hemlock/Sitka Spruce** • **Alder/Maple** • **Western Oak**	• **7.1.7: Strait of Georgia/Puget Lowland**: Mostly coniferous forests with Douglas-fir, western hemlock, western red cedar, grand fir, red alder, bigleaf maple. Understories contain salal, Oregon grape, and moss. Some small areas of oak woodlands. • **7.1.8: Coast Range**: Coniferous forests. Sitka spruce forests and coastal redwood forests to the south originally dominated the fog-shrouded coast, while a mosaic of western red cedar, western hemlock, and seral Douglas-fir blanketed inland areas. Today Douglas-fir plantations are prevalent on the intensively logged and managed landscape. Other species include red alder, big leaf maple, vine maple, rhododendron, salal, salmonberry, and Oregon grape. • **7.1.9: Willamette Valley:** Mosaic of oak savanna, oak woodlands, prairies, and Douglas-fir forests. Oregon white oak, Douglas-fir, madrone, and some valley ponderosa pine are typical. Riparian areas with black cottonwood, Oregon ash, bigleaf maple, Douglas-fir, western red cedar, and various shrubs. Almost all the native prairies have been converted to other uses.	• ↑ drought frequency & duration • ↑ risk of high-severity fire • ↑ suitable conditions & habitat for damaging pests & disease

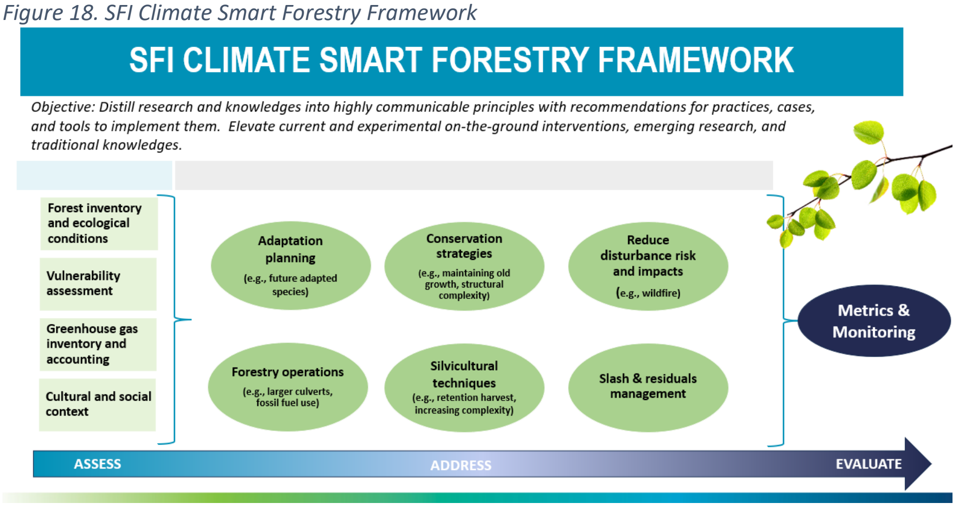
Western Cordillera
 	
Forest Cover Groups
• **Douglas-fir**
• **Fir/Spruce/Mountain Hemlock**
• **Ponderosa Pine**
• **Lodgepole Pine**
• **Pinyon/Juniper**
	• **6.2.3: Columbia Mountains/Northern Rockies:** Forests have some maritime influence. Pacific indicators such as western hemlock, western red cedar, mountain hemlock, and grand fir occur, and are more numerous than in Ecoregions 6.2.4, 6.2.10, and 6.2.15. Douglas-fir, subalpine fir, Englemann spruce, western larch, lodgepole pine, and ponderosa pine are also typical.
	
	• **6.2.4: Canadian Rockies:** Predominantly composed of subalpine and alpine ecosystems, characterized by mixed forests of lodgepole pine, Engelmann spruce, and alpine fir. In addition, stands of Douglas-fir intermixed with trembling aspen and grassland ecosystems occur on the warmest, driest sites in the major valley systems of the Bow, Saskatchewan, and Athabasca rivers. At upper elevations, usually between 1600 m and 2100 m asl, open stands of alpine fir are found. Limber pine can be found on rock outcrops. The alpine vegetation is characterized by low-growing heather with sedges and mountain avens occurring on warmer sites.
	
	• **6.2.5: North Cascades**: Lower western forests of western hemlock, western red cedar, and Douglas-fir. Subalpine forests include Engelmann spruce, subalpine fir, and lodgepole pine. Ponderosa pine and Douglas-fir in the east, along with some pine grass parklands.
	
	• **6.2.7: Cascades**: Extensive and highly productive coniferous forests. At lower elevations, Douglas-fir, western hemlock, western red cedar, big leaf maple, red alder. At higher elevations, Pacific silver fir, mountain hemlock, subalpine fir, noble fir, lodgepole pine. To the south, Shasta red fir, white fir. Subalpine meadows and rocky alpine zones occur at highest elevations.
		High Elevation Forests (6.2.4, 6.2.9, 6.2.10, 6.2.15)
		• most vulnerable
		• sensitive to increasing temperatures & associated impacts
		  ○ ↓ snowpack
		  ○ ↑ precipitation falling as rain
		  ○ ↑ pathogens
		
		Moist Forests (6.2.3, 6.2.5, 6.2.7, 6.2.11, 6.2.15)
		• ↑ risk of high-severity fire
		• highly susceptible & slow to recover
		• ↑ drought frequency & duration
		• ↑ risk of high-severity fire
		• ↑ suitable conditions & habitat for damaging pests & disease
		
		Dry Forests (6.2.8, 6.2.9)
		• less vulnerable to climate change than other types
		• adapted to frequent disturbances
		• vulnerable to severe, stand-replacing fires that cause extensive mortality

Level II Ecoregion	Level III Ecoregions Descriptions	Climate Change Impacts
	• **6.2.8: Eastern Cascade Slopes and Foothills**: Open forests of ponderosa pine and some lodgepole pine distinguish this region from the higher ecoregions to the west where fir and hemlock forests are common and lower dryer regions to the east where shrubs and grasslands are predominant. The vegetation is adapted to the prevailing dry continental climate and is highly susceptible to wildfire. Higher elevations have Douglas-fir and other fir species such as grand fir and white fir. Lowest elevations grade to sagebrush steppe vegetation. • **6.2.9: Blue Mountains:** At low elevations, grasslands of bluebunch wheatgrass, Idaho fescue, basin big sagebrush, mountain big sagebrush, and juniper woodlands. In forested areas, ponderosa pine, some Douglas-fir, grand fir. At higher elevations, subalpine fir, Engelmann spruce, whitebark pine, and lodgepole pine, with krummholz and alpine meadows in the alpine zone. • **6.2.10: Middle Rockies:** Douglas-fir, lodgepole pine, aspen, subalpine fir, and Engelmann spruce forests. Forests can be open, and Pacific tree species are never dominant. Alpine grasslands, meadows, and krummholz. Ponderosa pine in the Black Hills. Foothills are partly wooded or shrub- and grass-covered. Intermontane valleys are grass- and/or shrub-covered. • **6.2.11: Klamath Mountains**: It supports a vegetal mix of northern Californian and Pacific Northwest conifers and hardwoods. Mixed conifer forests with Douglas-fir, white fir, incense cedar, tanoak, Jeffrey pine, Shasta red fir, sugar pine, ponderosa pine, chinkapin, canyon live oak. In some lower areas, chaparral and western juniper. Oregon oak woodlands with Oregon white oak, madrone, California black oak, ponderosa pine, and grasslands. • **6.2.15: Idaho Batholith**: Grand fir, Douglas-fir and, at higher elevations, Engelmann spruce, and subalpine fir occur; ponderosa pine, sagebrush and other shrubs, and grasses grow in very deep canyons.	

DECISION-MAKING FOR FORESTS AND CLIMATE

The threats posed from climate change to forests can be diverse, with variations across geographies and forest types in terms of risk level, frequency of occurrence, and severity of impacts. Implementation of climate-informed forestry practices across the geographically diverse footprint of SFI-certified forests in North America inherently needs regional approaches to promote climate change adaptation and mitigation, however, there are cross-cutting themes that can shape climate-informed forestry across the entire geography and at multiple scales. For example, managing forests for climate benefits requires key input information like a vulnerability assessment and greenhouse gas inventory. Drawing from this foundational information, forest managers can determine which practices to deploy (e.g., fuel treatments, adaptive management, or conservation strategies). The effects of such interventions can be monitored over time and inform future decisions. See the figure below for more details along with an accompanying table that includes descriptions in Appendix A.

Figure 18. SFI Climate Smart Forestry Framework



SFI Climate Informed Principles (CLIPs)

In line with the2025-2030 SFI Strategic Direction, SFI has launched a Climate Smart Forestry Initiative that reaches across our Canadian and US landscapes. As part of this, SFI is developing Climate-Informed Principles (CLIPs), which aim to:

- Support systematic decision making for climate-informed interventions,
- Improve understanding of climate implications of different management options,
- Enhance the communicability of climate benefits of forestry interventions, and
- Support certified organizations in meeting the SFI Forest Management standard.

> **Principle**: The vision and direction for sustainable forest management as embodied in the principles of the SFI 2022 Standards.
>
> **Practice(s):** The actual application or use of an idea, belief, or method, as opposed to theories relating to it.
>
> *Source: SFI Standards, Section 14: Definitions (2022)*

Each CLIP will present a principle, its scientific rationale and a list of related practices, potential resources and tools, and case study examples. The SFI CLIPs will leverage and align with existing frameworks from partners like the United States Forest Service, the Adaptive Silviculture for Climate Change (ASCC) network, and Natural Resources Canada (Brandt et al. 2016, Ontl et al. 2020, NRCan 2025, Swanston et al. 2016).

Conclusion

Managing forests in a changing climate requires multiple temporal and spatial scales of information and decision-making. Like tree ring growth on a tree, climate interactions with forests and benefits of forestry interventions accrue over time. This creates immediate challenges for forest managers making decisions in forests with both observed and projected climate changes. These uncertainties mean strategies that work today may fail in the future, requiring that managers balance immediate needs with long-term resilience.

However, there are range of potential interventions and practices that can be applied to reduce uncertainty and pursue net positive outcomes. Practices to improve forest resilience and climate contributions depend on the site and the goals of the individuals managing it. Some actions will result in more stored carbon, others keep current levels steady, and some cause losses to ensure forest health and maintain carbon over time such as thinning forests to reduce wildfire risk or reintroducing fire. Ultimately, the best approach will likely be a mix of strategies that balance immediate outcomes with the forest's future health and resilience.

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Appendix A. Initial SFI Climate Smart Forestry Themes

	Climate Informed Principle	Climate Rational	SFI Standard
ASSESS	Access the best data on **Forest Inventory and Ecological Condition**	Forest inventory and ecological condition data provide critical insight into carbon storage, forest health, and biodiversity. In turn, this information supports efforts to enhance carbon sequestration and increase forest resilience, which are essential for climate change adaptation and mitigation.	SFI FM Objective 1, PM 1.1.4; Objective 4.1.7-8; Objective 9, PM 9.1.2.a-c
ASSESS	Complete a ***Vulnerability Assessment of climate change impacts on forests and forestry operations***	Vulnerability assessments identify regions, ecosystems, or communities most at risk from climate change impacts, enabling targeted adaptation and mitigation strategies. By understanding these vulnerabilities, mitigation efforts can focus on reducing climate-related risks to forests and forestry operations and enhancing resilience to future climate change.	SFI FM Objective 9, PM 9.1.1
ASSESS	Develop a robust **Greenhouse Gas Inventory**	Greenhouse gas inventory and accounting track emissions from forestry activities, providing a clear picture of the sources and quantities of greenhouse gases. These data help identify emission reduction opportunities, set targets, and measure progress toward mitigating climate change.	SFI FM Objective 9, PM 9.2.3
ASSESS	Determine relevant **Social and Cultural Context** including priorities and sources of knowledges	Ensuring management practices reflect the values, traditions, and needs of the people who depend on the forest. Integrating this knowledge helps build community support, protect culturally important species or landscapes, and create strategies that are both ecologically effective and socially acceptable.	SFI FM Objective 1, PM 1.1.6; Objective 5.4.1; Objective 6.1-2; Objective 8
ADDRESS	Develop and implement **Adaptation planning** for Forest Management (e.g. assisted migration, conversion to future adapted species)	Forest adaptation planning involves adjusting forest practices to anticipate and respond to changing climate conditions, such as introducing future-adapted species. This helps maintain carbon sequestration capacity, ecosystem health, and biodiversity and supports both adaptation and mitigation objectives.	SFI FM Objective1.2.2a; 2.5.1; 9.1.2.c

	Climate Informed Principle	Climate Rational	SFI Standard
ADDRESS	Implement climate mitigation and adaptation strategies in **Forestry operations**	Forestry operations contribute to climate change by using fossil fuels and disrupting stored carbon. Adjusting operations can help mitigate climate change and reduce greenhouse gas emissions by reducing fossil fuel use, increasing operational efficiency, and using forest biomass for renewable energy instead of fossil fuels. In addition, forestry operations can be adapted to be resilient to climate change impacts such as shorter winters, severe storms, and wildfire.	SFI FM Objective 9.2.1
	Implement **Conservation strategies** for climate and biodiversity	Forest conservation strategies protect and restore vital ecosystems, enhancing forests' ability to sequester carbon and maintain biodiversity. By reducing deforestation and degradation, these strategies help prevent the release of stored carbon and strengthen the forest's role in climate change mitigation.	SFI FM Objective 4.1.2,4-8; 4.2.2
	Modify **Silvicultural techniques** for adaptation and mitigation outcomes	Forest silvicultural techniques, like retention harvesting, can help maintain forest structure and health, allowing forests to continue sequestering carbon and supporting biodiversity, contributing to climate change mitigation. Maintaining or increasing forest complexity, such as promoting diverse tree species and varied age structures, enhances ecosystem resilience and carbon storage. This approach strengthens forest ability to adapt to climate change, supports biodiversity, and boosts long-term carbon sequestration, aiding in climate change mitigation (Messier 2019).	SFI FM Objective PM 1.1.1.i; PM 2.3.4; PM 2.4.2; PM 9.2.2.a-d
	Taking action to **address and reduce the impacts of climate-driven disturbance** (e.g. catastrophic wildfire)	Activities that reduce the risk of disturbance and impacts from disturbance (such as wildfires) prevent the release of large amounts of carbon stored in forests. Implementing strategies like controlled burns and creating firebreaks, help maintain forest health, resilience, and carbon sequestration capacity, thus supporting climate change mitigation. (Beverly et al. 2021). Post-disturbance forest restoration helps mitigate climate change by enhancing carbon	SFI FM Objective 2.4.1-3; SFI FM Objective 10.1.1-2

	Climate Informed Principle	Climate Rational	SFI Standard
		sequestration and storage, reducing soil erosion, further supporting ecosystem resilience in the face of climate impacts.	
	Minimize waste and ensure efficient utilization in **Slash & Residuals management**	Changes to slash management can mitigate climate change by reducing emissions from slash burning, increasing carbon stored on the landscape, or reducing wildfire risk. Residuals management can mitigate climate change by reducing waste and preventing the release of greenhouse gases from woody waste materials. Repurposing waste materials for energy production, new final products, or recycling decreases fossil fuel use and promotes a circular bioeconomy.	SFI FM Objective 2.3.3; Objective 7.1.1
EVALUTATE	Utilize appropriate **Metrics and Monitoring** to measure impacts of adaptation and mitigation strategies over time	A program that measures and monitors the impact of any action that addresses climate change risk can assess change over time. With these measurements, metrics can be established. Information gathered through a monitoring program can then be used to guide future steps to Assess and Adress climate change impacts.	SFI FM Objective 4.4.2; SFI FM Objective 4.4.1; Objective 9.1.4; 9.2.4

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