CHAPTER 2: FOREST ECOSYSTEMS

CHAPTER 2 **EXECUTIVE SUMMARY**

As the Pacific Northwest faces higher temperatures, more drought, and altered seasonal patterns due to climate change, forest ecosystems in western Washington are projected to undergo significant shifts. Potential impacts include inhibited seed germination, altered habitat distributions, mortality from drought, more severe forest disturbances from fire, insect infestations, and tree disease. These will vary among species communities, elevations, and latitudes. The severity of these impacts calls for a reimagined approach to forest management, placing an emphasis on conservation strategies that not only protect existing mature and old-growth forests but also consider the need for increased connectivity, strategic restoration, monitoring, and adaptive management.

Mature and old-growth forests have relatively cool and moist microclimates, rich biodiversity, resilience to temperature fluctuations, and heightened resistance to drought. These areas are important climate refugia and also serve an outsized role in storing carbon. Preserving these habitats is a critical part of our conservation approach for forest ecosystems.

Brief summaries of our strategies for forest ecosystem are outlined here and detailed within the chapter along with background information and an overview of climate risks for forests.

- **Reduce logging of old forests:** On both state and federal lands, harvest of mature and old-growth forests should be reduced in order to retain these important habitat features and enhance carbon storage.

- **Restoration in mixed-conifer forests:** Targeted thinning and prescribed fire in the mixed-conifer forests in the eastern part of the Gifford Pinchot National Forest (GPNF) can reduce fuel loads, align landscapes with their historical conditions, and improve resilience. This involves a careful consideration of short-term impacts and long-term resilience. Efforts should focus on strategic removal of small diameter trees, retention of large trees, and the use of prescribed fire. Collaborative efforts between agencies and local communities can aid in navigating challenges.

- **Designate new forest preserves and carbon storage areas on state lands:** Using a spatial analysis process, we highlight specific areas within Washington's state forest lands that should be considered for designation as Natural Area Preserves, Natural Resource Conservation Areas, or carbon storage zones. Leveraging tools like the Trust Land Transfer program and other policies and methods, these recommendations aim to balance extraction with conservation, climate mitigation, and ecological resilience.

- **Retain a strong National Environmental Policy Act (NEPA) and public engagement process on federal lands:** It is critical that we retain the strength and full breadth of the NEPA process and ensure that categorical exclusions are limited to small, low-impact projects, ensuring both public inclusion and ecological integrity.

- **Support Tribal involvement in land management:** A key element for promoting resilience should involve a collaborative approach that advances co-management strategies and integrates Traditional Ecological Knowledge and Tribal practices into land management.

- **Post-fire seeding and planting in successive burn areas:** In regions impacted by successive burns, post-fire seeding and planting can hasten ecological recovery, enhance soil health, provide forage for wildlife, and minimize the spread of invasive plants.

- **Increase wildlife crossings along roadways:** We recommend leveraging available funding, including the Wildlife Crossings Pilot Program, to increase the number of wildlife crossings over and under roadways. These enhancements can mitigate the negative impacts of roads by reducing collisions and providing safer pathways for movement between and within habitat patches for both terrestrial and aquatic species. These efforts serve the dual purposes of promoting both biodiversity and public safety. In areas prone to frequent collisions with large fauna, overpasses can improve habitat connectivity and also be economically beneficial, while in others, modified culvert designs can be utilized to address the needs of smaller aquatic and terrestrial species.

- **Support wolf recovery in the region:** The return and recovery of wolves, a keystone species, can yield significant ecological and climate resilience benefits. Advancing coexistence efforts, retaining policy protections, and ensuring multi-stakeholder collaborations can aid in this recovery.

- **Monitor changes to species and habitats:** On-the-ground monitoring to track changes to species and habitats can inform adaptive management, allowing for the fine-tuning of conservation and restoration efforts. Whether tracking the return of wolves or assessing the impact of prescribed burning, monitoring enables a localized and responsive approach that can help us adapt to new challenges and ensure the long-term survival of at-risk populations.

- **Update the Northwest Forest Plan or local forest plans to improve climate resilience on federal lands (outlined in Chapter 4):** We highlight five strategies to be implemented during forest plan updates. These include: 1) transfer a select subset of Matrix areas to Late-Successional Reserve (LSR) allocation, 2) update LSR objectives to include carbon storage and restoration guidance for dry and mixed-conifer forests, 3) protect all trees originating before 1920, 4) retain the Survey and Manage program and ensure the Species of Conservation Concern program is effectively addressing the health and resilience of species, and 6) protect specific areas that would benefit from additional safeguards through new designations.

- **Lengthen harvest durations on private timberlands (outlined in Chapter 5):** We outline a variety of approaches that can be employed to advance and ease a transition to longer harvest durations in order to increase carbon storage and increase the amount of timber coming off a plot of land. This also brings a number of added ecological benefits including less herbicide and fertilizer use, longer durations of favorable habitat conditions for forest wildlife, and fewer negative impacts to soil health, mycorrhizal communities, aquatic habitats, and water quality.

FOREST ECOSYSTEMS

From towering Douglas-fir forests where spotted owls and goshawks soar through the canopy, to mixed-conifer forests where great ponderosa pines stand like pillars on the ridgelines, the landscape of the southern Washington Cascades is a vital sanctuary for diverse wildlife and ecosystems. As the realities of climate change begin to impact these forest ecosystems, it is imperative that we employ management practices and adopt policies that preserve biodiversity and enhance resilience, enabling these forests to weather the upcoming changes.

Timber harvest: then and now

The forests of the Pacific Northwest have sat at the center of national conservation discussions and legislation for decades. Years of intense timber harvest have had a dramatic impact on the current state of the forest ecosystem, and this factor plays into almost every facet of our work developing climate resilience strategies for these areas.

Before the widespread exploitation of timber during the 1800s and 1900s, Indigenous communities managed these forest ecosystems by selectively harvesting trees and using fire to clear undergrowth to improve plant production and create openings for wildlife and access. Over the last two centuries, these forests faced a new form of human influence as a rapidly expanding population of settlers began exploiting the timber for building materials, leading to significant environmental changes and challenges for Indigenous land management practices.[1] In the late 1800s, scarcity of trees near the water and new technological advances pushed timber harvests inland, up steep slopes, and through narrow valleys of the region. By 1905, Washington state had become the top producer of timber in the nation, a position it held for the next several decades. By mid-century, the production of timber from federal lands was significantly increased as private timberlands in the area could not keep up with demand.[2] The rapid increase in timber harvest in the national forests led to Congress enacting the Multiple-Use Sustained-Yield Act of 1960.[1] This act recognized the need to consider a more sustainable approach to timber extraction, and it codified the multiple uses of the national forest, such as supporting

Log train crossing the Cowlitz River in 1949 wildlife, water quality, and recreation. Despite this, timber extraction continued to increase, and clearcuts spread rapidly across the region.

Congress began to take steps to further codify conservation values by protecting ecosystems with the Wilderness Act in 1964, the National Environmental Policy Act in 1969 (signed in 1970), the Clean Water Act in 1972, and the Endangered Species Act (ESA) in 1973. Congress also enacted the National Forest Management Act (NFMA) in 1976, largely as a response to the continued emphasis on timber harvest despite the federal push for more habitat protection. This required the Forest Service to use NEPA procedures and to employ an interdisciplinary team to create Forest Plans for all national forests. Through the 1980s, the Forest Service developed plans, but this only marginally reduced harvest, and habitat protection responsibilities under laws like the ESA were largely ignored.[3]

In the Pacific Northwest, these conflicts came to a head in the 1980s when the NFMA regulations required fish and wildlife habitat to be managed to support "viable populations" of species and also in the 1990s when the northern spotted owl was listed as threatened under the ESA.[4] The agency's Forest Plans were successfully challenged in court due to the Plans' inability to protect the threatened owl as required under the ESA. The court halted harvest in northern spotted owl habitat within national forests until a plan that would meet ESA requirements could be completed.[5] This halt occurred at the same time that automation in mills was increasing and rapidly changing the industry on its own, decreasing the amount of labor needed for lumber production. Decades of unsustainable harvest practices and a dwindling supply of trees were also creating a situation in which severe reductions in timber production were imminent. The combination of these factors had devastating economic impacts on timber-dependent communities of the region.

In response to the court case challenging the current Forest Plans, the agency made several attempts to make a plan that would satisfy ESA requirements as interpreted by the courts. Those attempts were not successful, and, eventually, a series of scientific committees were assembled to develop management alternatives for conserving old-growth forest ecosystems and their constituent species. These efforts culminated in the adoption of the Northwest Forest Plan (NWFP) by President Clinton in 1994. The NWFP reduced timber levels below what was being previously harvested, but enabled harvest operations to restart under a guided framework bounded by site-specific regulations in different types of management areas. The impact of logging on

A northern spotted owl perched in an old Douglas fir

national forest lands has decreased since the 20th century, but remains a primary factor affecting habitat distribution and fragmentation.

Old-growth forests

Old-growth forests are a hallmark of the Pacific Northwest. These forests are characterized by wide and tall trees, multi-layered canopies thriving with biodiversity, standing snags, and decaying logs of fallen giants that feed new life. As a climate refuge for a vast number of species and with the cooler, wetter microclimates they create, it is essential that we focus conservation efforts on stemming the fragmentation and loss of these forests. In recent decades, many old-growth stands throughout the Pacific Northwest have benefited from protective forest management policies that have slowed the destruction of these habitats.[3] This more nuanced management of old-growth resulted in a decrease in the rate of loss of old-growth habitat, however, there is still much work to be done in protecting forests, especially the mature forests that will be the next cohort of old-growth.

Finding a universal old-growth definition is no simple matter, as definitions vary widely and spatial data is imperfect.[6] Age is one of the primary indicators, but minimum thresholds can range from 100 years to 200 years, depending on who you ask and what type of forest is in question. In addition to age estimates, old-growth in our region is defined by metrics of other attributes such

as large living and dead trees, coarse woody debris on the forest floor, and presence of a multi-tiered canopy (also sometimes called a continuous canopy) with small, medium, and tall trees.

It is not uncommon to find old-growth stands with trees well over 200 years old and reaching sizes greater than 150 feet in height and several feet in diameter. In thin patches of sunlight and growing beneath the shadow of the large old trees are more shade-tolerant trees and plants that add to the varied layers of an old-growth system. Rich with life, forests with tall canopies represent distinct ecosystems, harboring a multitude of invertebrate species.[7] As centuries pass, natural disturbances—like wind, insects, and fire—will kill some of the ancient trees. Even in death, the trees perform crucial ecological roles by providing shelter and nutrients for other plants and animals. Taller snags, sometimes called “the standing dead,” are preferred nesting sites for many small mammal and bird species in the forest, and when snags fall, they provide homes for various terrestrial species, reduce erosion, and can benefit streams by creating pools and cover for fish.

Other forest age classes, such as early successional and mid-successional stages, are important too and offer different values for ecosystems and wildlife. But, old-growth forests remain a primary focus for our efforts to improve climate resilience as these forests are relatively rare and of particular importance from a habitat and conservation perspective. Early seral habitats are also relatively rare, but we can expect to see the abundance of this type of habitat expand as wildfire and other climate change-related impacts increase over time.

WHAT IS THE ROLE OF **OLD FORESTS** IN BUILDING CLIMATE RESILIENCE?

With centuries of growth and accumulated biodiversity, old forest ecosystems have developed strong pathways of persistence and are critical for buffering the negative effects of climate change. Old forests serve as climate refugia for many species and can withstand stressors, such as drought and wildfire, that may be devastating to other ecosystem types.[8,9] Old-growth climate refugia is important at the landscape scale (large contiguous areas of old-growth habitat) and at a hyper-local scale (small remnant stands of old-growth forest).

Biodiversity is one of the features of old forests that provide long-term resilience in the face of disturbance and climate impacts. Biodiversity represents a “library of possibilities" for local ecosystems and enables landscapes to have increased resilience in the face of disturbance.[10] With climate change being a force that will bring severe stresses and cause pockets of mortality, these old forests will act as refugia and species "banks."

The regulation of microclimates is a unique trait of old forest stands, and this adds a dynamic defense against climate change. Research has demonstrated the ability of old-growth to minimize temperature variation compared to clearcuts or heavily thinned forests.[8,9,11] Frey et al. (2016) explain the effectiveness of old-growth in microclimate regulation in comparison to simplified plantation stands in a study carried out in the H.J. Andrews Experimental Forest in Oregon:

> Vegetation characteristics associated with older forest stands appeared to confer a strong, thermally insulating effect. Older forests with tall canopies, high biomass, and vertical complexity provided cooler microclimates compared with simplified stands. This resulted in differences as large as 2.5°C between plantation sites and old-growth sites, a temperature range equivalent to predicted global temperature increases over the next 50 years.[11]

In another investigation, this one carried out in southern Washington state, Chen et al. (1993) found a significant difference between daily temperature change in the clearcut to that inside the intact forest. For instance, during the change from hot and sunny weather to windy and cloudy conditions, change in air temperature (maximum minus minimum) was "as high as 25–28 °C in the clearcut and at the edge, but considerably smaller (15–17 °C) inside the forest".[9] And, as it relates to soil temperatures, "[m]ean daily average soil temperatures were the highest in the clearcut" and "lowest in the forest."[9] Chen et al. (1993) also found soil moisture to be lowest and wind to be highest in the clearcut.

An old forest's ability to withstand temperature and drought variations better than young forests are likely due to a number of factors, including the multi-storied structure of old forest canopies, the wider root distribution, different uses of stored water compared to daily water, and a variety of other factors. Sap flux measurements in young and old Douglas-fir trees, for example, have shown that older and larger trees rely more on stored water than younger trees, with 20–25% of daily water use coming from water stored in xylem in older trees compared to 7% in younger trees, making older trees less sensitive to variable moisture conditions.[12] The tall canopy of an old forest also serves a very important function with its ability to collect a significant percentage of the forest's water through fog and cloud drip on high branches and leaves.[7] This helps mediate changes in moisture as well as temperature.

HOW WILL FORESTS BE **IMPACTED** BY CLIMATE CHANGE?

Western Washington has already seen an average of a 1.7 °F (0.94 °C) rise in temperatures over the past 120 years, and some areas have warmed as much as 3 °F (1.7 °C).[13,14] Climate models under a higher emissions scenario project that by mid-century, temperatures in the region will increase by 5–7 °F (2.8–3.9 °C).[15] Models suggest that the greatest projected temperature increases will occur in summer, which, in combination with a decrease in summer precipitation, will result in drier conditions, affecting a wide array of forest species.[16–18]

Summer drought and heat-related mortality of conifer trees in North America have spiked dramatically since the 1980s and 1990s, and this pattern is expected to continue.[19] Trees located on south-facing slopes, ridgetops, and areas with shallow soils are likely to be most impacted by drought stress.[12] In addition to direct mortality, higher than usual temperatures and drought can also inhibit seed germination.[12,20]

In addition to wildfire impacts, which are discussed on subsequent pages, warmer and drier summer months may also bring higher rates of forest disturbance from insects, diseases, and pathogens. Drought conditions can cause stress for trees and put them at greater risk from these types of disturbances.[21–23] However, climate change may also create unexpected competitive interactions and cause some disturbance types to decrease.[24] Due to the complex nature of these interactions, there is great uncertainty regarding the potential scale and severity of these types of impacts. Hudec et al (2019) reinforces this sentiment:

> Climate change may influence the incidence of tree disease in southwest Washington, but the effects of climate change on host physiology, adaptation or maladaptation, and population genetics that affect host-pathogen interactions are poorly understood (Kliejunas et al. 2009). Nevertheless, we can use existing knowledge of

> tree diseases in western North America to infer that climate change will result in reductions in tree health and advantageous conditions for some pathogens (Frankel et al. 2012, Kliejunas et al. 2009). Warmer, drier summers will probably favor some root and canker diseases. Armillaria root disease (*Armillaria (Fr.) Staude*), laminated root disease (*Phellinus weirii*), and cytospora canker of alder (*Cytospora spp. Ehrenb. Ex Fries, 1823*) are examples of pathogens known to exist in southwest Washington that may increase in severity under a warmer climate (Kliejunas et.al. 2009).[25]

In the absence of climate change, forest disturbances (such as insect outbreaks, tree diseases, and wildfires) would naturally affect the spatial patterning of forests, and these impacts benefit forest ecosystems by culling the weaker trees and creating a mosaic of varying age classes and canopy patterns. While these forces might be part of the natural process, disturbances may become more frequent and severe as a result of climate change.

Regional climate models suggest that forests will experience upward shifts in habitat distribution in which lower elevation species may encroach into higher locations. The following range shift projections have been adapted from Hudec et al. (2019).[25] Warmer temperatures may allow species such as grand fir (*Abies grandis*), western hemlock (*Tsuga heterophylla*), and Douglas-fir (*Pseudotsuga menziesii*) to outcompete upland forest species for nutrients and water, enabling them to move up in elevation into portions of the range currently occupied by Pacific silver fir and subalpine fir. Pacific silver fir (*Abies amabilis*) and subalpine fir (*Abies lasiocarpa*) distributions may move up in elevation in certain areas and displace mountain hemlock (*Tsuga mertensiana*) and whitebark pine (*Pinus albicaulis*), as the latter two species will likely be more impacted by drought stress. The abundance of mountain hemlock at the lower parts of its range "may decrease where growth is limited by low soil moisture in summer." Paleoecological records suggest that as disturbances increase, species such as red alder (*Alnus rubra*), lodgepole pine (*Pinus contorta var. latifolia*), and Douglas-fir may increase in relative abundance.

On the eastern portions of the southern Washington Cascades, ponderosa pine (*Pinus ponderosa*) may be impacted by a trilogy of threats: increases in the scale and severity of wildfire, insect infestations, and drought. Oregon white oak (*Quercus garryana*), western white pine (*Pinus monticola*), as well as giant chinquapin (*Chrysolepis chrysophylla*) may be less sensitive to warming temperatures and may expand into new ranges. Aspen (*Populus tremuloides*) is sensitive to temperature increases and decreases in moisture availability, but it also grows well in post-fire habitats. Therefore, aspen distributions may decrease in certain areas and expand in others, such as in recently burned areas. Halofsky et al. (2020) offer an overview of related projections:

> In Northwest forest ecosystems, warming climate and changing disturbance regimes are likely to lead to changes in species composition and structure, probably over many decades. In general, increased fire frequency will favor plant species with life history traits that allow for survival with more frequent fire (Chmura et al. 2011). These include (1) species that can resist fires (e.g., thick-barked species such as Douglas-fir, western larch [Larix laricina Nutt.], and ponderosa pine); (2) species with high dispersal ability that can establish after fires (e.g., Douglas-fir); and (3) species with serotinous cones that allow seed dispersal from the canopy after fire (e.g., lodgepole pine) (Rowe 1983; Agee 1993).[26]

While there may be suitable locations to support these shifts in species distributions, unexpected climate impacts may produce complex and deleterious interactions as shifts will not happen evenly or in predictable patterns.

Wildfire

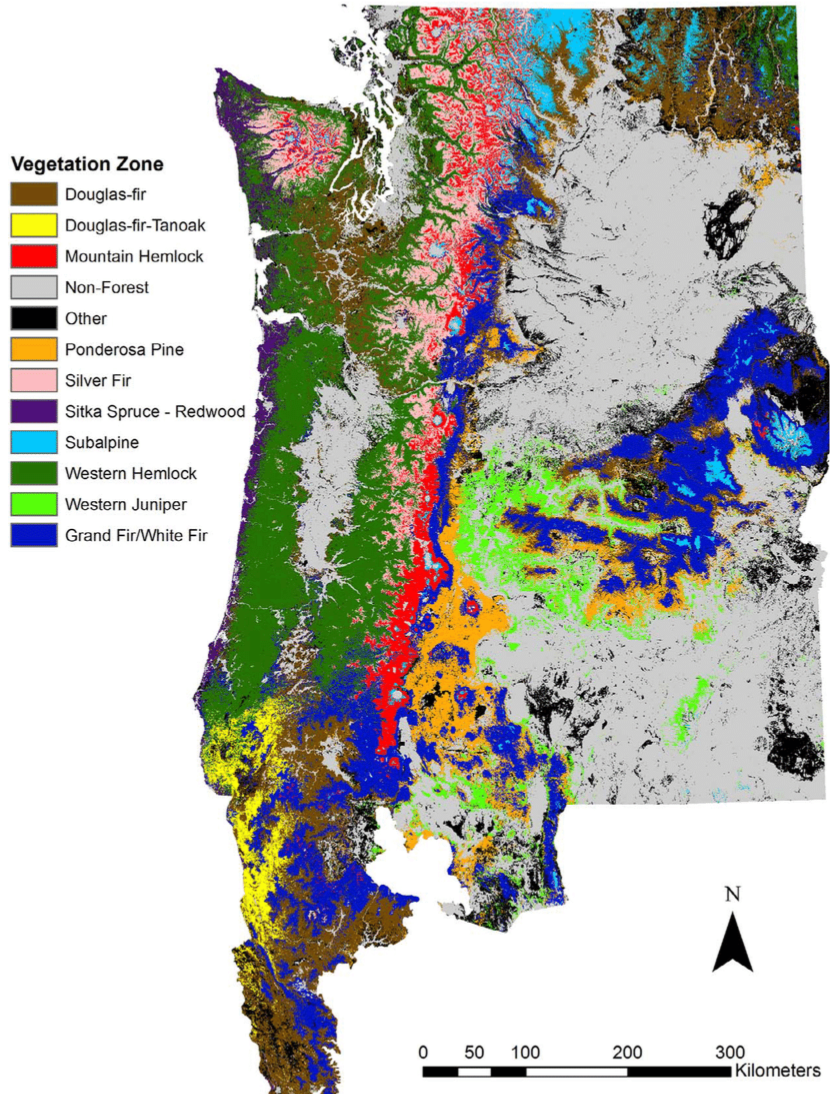
Further complicating the threats and changes discussed above is the changing nature of wildfires. Fires do not burn through an area uniformly—some forest stands will ignite while others escape untouched. Some areas may experience high severity fire effects, including scorched tree crowns, while in other areas, fires will burn less intensely and may stay close to the ground. The resulting pattern of varied habitats supports diverse communities of plants and animals, including some species that specifically thrive in post-fire conditions.[27–29]

To investigate the different fire trajectories in the southern Washington Cascades, we will be using a forest classification method commonly used for forest management and research: potential vegetation types. This methodology classifies forest zones based on potential dominant species in mature stands (those in climax condition).[30] Any classification system of an ever-changing system like a forest ecosystem will be imperfect, and this method is no exception. We chose this method because it allows us to use locally-refined projections of fire potential and history.

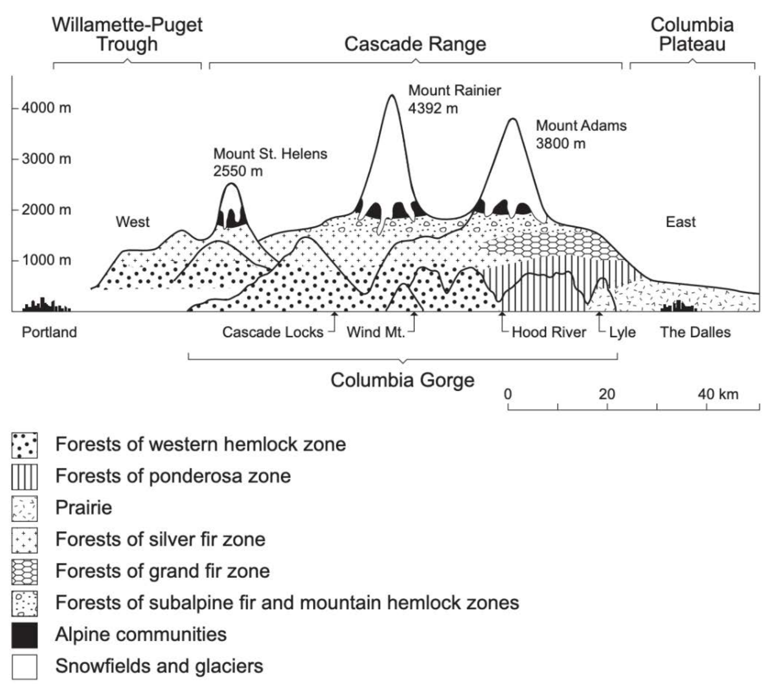
In the southern Washington Cascades, low-elevation forests (below 4,000 feet elevation) on the west side of the Cascade crest are generally part of the western hemlock zone. This zone is dominated by western hemlock and Douglas-fir and encompasses 30% of the Gifford Pinchot National Forest (GPNF) as well as much of the forest land extending west from the GPNF to Interstate-5.[25] The Pacific silver fir zone (approximately 2,800–4,500 ft) makes up 39% of the GPNF, and the mountain hemlock zone (approximately 4,000–6,000 ft) encompasses 28% of the GPNF.[25] There are other zones in the high elevation areas of these westside forests (such as the subalpine fir zone and parkland zone), but they represent a much smaller portion of the landscape.

To the east, the grand fir zone (approximately 3,200–5,000 ft) contains various combinations of ponderosa pine, grand fir, Douglas-fir, and western larch.[30] These forests are located south of Mount Adams, in and around the White Salmon and Little White Salmon River watersheds. The east-side Douglas-fir zone and ponderosa pine zone occupy drier sites farther east, and are largely outside of the focus of this guidebook.

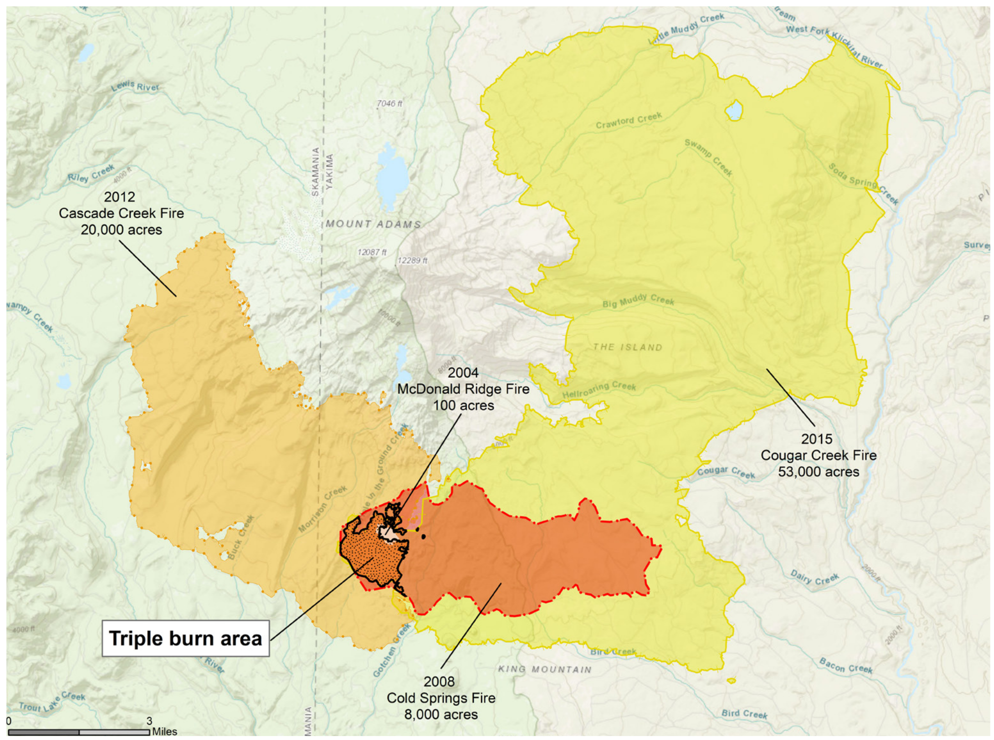
Different forest types have different fire histories and trajectories. The western hemlock, Pacific silver fir, and mountain hemlock zones (encompassing most of the GPNF and loosely fitting under the category of "westside forests") have a fire regime that is notably different from



Map of vegitation zones from Reilly and Spies 2015



Vegetation zones from Hudec et al. 2019



Recurrent wildfires near Mount Adams

In a ten-year span, the south slopes of Mount Adams experienced multiple high-severity fires, resulting in a triple burn area encompassing 82,152 acres. Successive reburns like this, which are exacerbated by climate change, pose significant challenges for ecological resilience, impacting tree regeneration and potentially leading to shifts in vegetation types.

the grand fir zone and the dry forests found farther east and south. In the westside forests, major fires generally swept through at intervals over 200 years, although ranges vary greatly and certain subtypes have experienced fire intervals closer to 50 years.[25] Fires in these areas are often large (>1,000 acres and sometimes even >10,000 acres) with extensive high-severity patches (>70% mortality).[25,31]

Fires in the mixed-conifer forests (largely the grand fir zone), were generally more frequent. Dry subtypes in the grand fir zone may have fire return intervals between 9 and 25 years, but other subtypes and classification methods point to intervals over 100 years.[25] Fires in these areas are often low-severity, with tree mortality under 25%.[32] These more frequent fires would often sweep through the understory and kill off the smaller trees and shrubs in a mosaic fashion. Certain areas (such ridgelines and south slopes) would experience more frequent fire with lower severities, and other areas (valleys and north slopes) would experience lower fire frequencies yet higher severities.[33] Variability is a defining characteristic of these forests, and differences in slope degree, aspect, elevation, plant composition, and soil moisture all affect fire dynamics.[18]

In addition to forest types and on-the-ground conditions, weather plays a large role in determining the onset and dynamics of wildfires. The relationship between low precipitation and widespread fire activity in the western United States is apparent in fire histories.[34,35] For instance, during periods of sustained drought in the early part of the 20th century, the GPNF and surrounding forest lands experienced a series of large fires with footprints and impacts that can be seen today.[36–38]

Wildfire projections

While wildfires play a natural role in patterns of forest ecology in the Pacific Northwest, climate change creates a longer fire season and conditions where fires are likely to burn at frequencies and severities that are different from their historic patterns.[26,32,39] For instance, on the south slopes of Mount Adams, fires have swept through forest stands three and even four times during a ten-year period—a frequency that is far outside the historical pattern.[33] Three of the larger fires in this footprint (Cold Springs Fire of 2008, Cascade Creek Fire of 2012, and Cougar Creek Fire of 2015) burned a combined total of 82,152 acres.[25] Reburns are likely to increase with climate change, especially in drier sites, and this has significant implications for ecological resilience as multiple burns can create compound disturbance effects on tree regeneration and prompt shifts to non-forest vegetation types.[26]

The mountain hemlock and grand fir zones are at particular risk from heightened fire activity. Fires are also expected to increase in low-elevation westside forest areas, such as the western hemlock zone. However, an increase in fire activity from 20th century levels in these westside forests could be expected even without climate change due to the fire deficit documented for these forests over large parts of the last century.[32]

One important difference between the past and present is the current scarcity of old-growth forests on the landscape. When large and high-severity wildfires reach into the small remaining patches of old-growth in the region, the result can be a loss of important and relatively scarce habitat. Western hemlock forests, for instance, evolved with high severity fire, but the current lack of old-growth changes how we view disturbances like wildfire and where we may want to take steps to protect rare old-growth stands, such as through the creation of road-based fire breaks or other experimental techniques that may buffer existing old-growth from high severity fire.

In the mixed-conifer forests on the south side of Mount Adams, fire suppression has resulted in dense stands of small and medium-sized grand fir and other ladder fuels and thicker layers of duff (needles and other small tree material) on the forest floor.[40] This results in a scenario where fires can be expected to be larger and more severe than they would have been historically. Unlike large ponderosa pine, larch, and Douglas-fir, which can persist through frequent, low-intensity fires, grand fir is less tolerant of fire due in large part to its thinner bark. Also, the densely aggregated young and mid-age grand fir trees act as ladder fuels, allowing fires to reach the crowns of larger trees. Higher grand fir densities also increase competition for moisture and exacerbate the impacts of drought, disease, and insect outbreaks.[41] It is not only the greater density of trees that impacts resilience, it is the fact that grand fir, in particular, cannot control their stomatal openings and therefore do not downgrade their water uptake and transpiration in periods of drought. In addition to impacts from grand firs, the uncharacteristically thick layers of duff around the base of trees can increase the residence time of fires, resulting in higher fire severities and increased mortality.

Historical patterns allow a better understanding of these ecosystems and the role fire has played in their evolution, but the current dynamics are not the same as they were prior to fire exclusion, industrial forestry, and climate change. Forest resilience in the era of climate change requires navigating these increasingly complex relationships.

Forest management before, during, and after wildfire

The Forest Service's response to managing a forest before, during, and after wildfire depends largely on the guidance already in a Forest Plan. Discussed in detail in Chapter 4, Forest Plans dictate where the Forest Service should actively suppress a fire, when they can allow the fire to burn naturally, what steps should be taken to decrease fire risk and severity, and under what circumstances salvage logging can and cannot occur.

Recently, there has been an increased focus from Congress on wildfire, with additional spending for the Forest Service to carry out treatments to reduce fire risks. Many people, including some in Congress, are seeing the fires of the recent summers and wondering if there is a solution through increased logging. In the majority of the areas in which we focus—the moist conifer forests on the west side of the Cascade Crest—logging would likely have minimal and/or very short-term impact on wildfire spread and severity.[23,42,43] One important management strategy in moist forests is retaining the amount of old-growth forests

Interactions between fire and other disturbances, such as drought and insect outbreaks, are likely to be the primary drivers of ecosystem change in a warming climate. Reburns are also likely to occur more frequently with warming and drought, with potential effects on tree regeneration and species composition. Hotter, drier sites may be particularly at risk for regeneration failures.

Halofsky et al. 2020 [26]

on the landscape and protecting mature forests that will be tomorrow's old-growth. In dry and mixed-conifer forests, on the other hand, fuel treatments such as mechanical thinning and prescribed fire can be strategically employed to mitigate future wildfire intensity and spread and to promote overall ecosystem health and resilience.[33,44,45]

Following a wildfire event, a common assumption is that immediate actions, such as salvage logging or replanting, are needed to restore the "fire-damaged" landscape.[46] In general, these types of activities are unnecessary and, in the case of salvage logging, can be particularly damaging. Salvage logging can lead to high levels of sedimentation in streams, an introduction of invasive plants, severe soil impacts, disruption of post-fire habitats, and the impairment of the natural revegetation process.[46–50] Also, trees killed or damaged by wildfire can serve important roles for wildlife; the ecological services they previously provided in a pre-fire forest do not disappear, they simply change.[51]

In Oregon, the Biscuit Fire in 2002 burned over 500,000 acres and included the whole footprint of the 93,000-acre Silver Fire that burned 15 years earlier. After the Silver Fire, some of the area was allowed to regenerate naturally and other areas were salvage logged and replanted. Researchers were able to compare these two different areas and measure how they fared through another fire. Compared to stands that were left alone, fire severity was 16–61% higher in areas that were logged and planted after the first fire.[52] There are situations, though, where selective thinning of small diameter trees after a fire in the mixed-conifer forests could possibly reduce future reburn potential.[53] These are rare scenarios, and soil impacts remain a significant issue, so careful planning and a narrowly targeted application would be key tenets of such an approach.

Post-fire area on the south slopes of Mount Adams

Regarding revegetation of burned areas, while it is often ecologically sound to allow a post-fire landscape to recover with minimal human intervention, the current combination of environmental stressors (e.g., fire suppression, previous timber harvest, a hotter and drier climate, and the presence of invasive vegetation) has resulted in some landscapes lacking the resilience, soil health, and seeds banks that would normally aid in successful regeneration.[54] In the portions of this chapter focused on restoration recommendations, we discuss strategies to aid in recovery after successive burns.

An overview of species-specific climate change impacts

The plants and animals of the southern Washington Cascades will respond to climate change in a variety of ways and over varying timeframes. Some impacts, such as those brought on directly by increasing temperatures and changing weather patterns, will sometimes be more readily apparent than other types of impacts, which could occur through shifts of prey, predators, or competitors. Here we will discuss a snapshot of species-specific climate impacts that are potentially relevant for conservation planning.

The fate of certain bird species such as marbled murrelets (*Brachyramphus marmoratus*), northern goshawks (*Accipiter gentilis*), and northern spotted owls (*Strix occidentalis caurina*) will be closely linked to the health and connectivity of old forests, as they provide valuable habitat features, such as large horizontal limbs, hollow snags, and wide trunks for nesting cavities. Compared to younger forests, mature forests are relatively resilient, but increased drought and fires are still likely to decrease habitat abundance and quality.

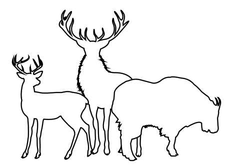
Preferring old Douglas-fir and hemlock forests with large branches as horizontal nesting features with ferns and lichens, marbled murrelets have and may continue to be impacted by a loss of nesting habitat from wildfires.[55] In addition to fire impacts, dry summers may reduce fern and lichen growth, thereby degrading the quality of nesting platforms.[56] Northern goshawks, which also nest in dense patches of old forest, may be impacted by shifting prey distributions.[57,58] For northern spotted owls, patterns observed during a 15-year study suggest that an increase in summer droughts will negatively impact annual survival and population growth.[59] Carroll (2010) found winter precipitation to be an important variable for predicting northern spotted owl abundance and distribution; changes in this cycle can potentially impact populations.[60] Any discussion of northern spotted owl resilience would be incomplete without mention of the range expansion of the barred owl (*Strix varia*), a critically impactful competitor. Wildlife managers are currently navigating barred owl management strategies (e.g., killing barred owls to save northern spotted owls).[61] This approach may prove to be helpful for northern spotted owls, but it brings with it an array of complications and concerns.

Bald eagles (*Haliaeetus leucocephalus*), with a diet dependent on healthy fish populations, may be affected by decreasing fish abundance in certain waterways.[62] According to the Audubon Society's climate model, bald eagles may have as little as 26% of their current summer range remaining by 2080 (climate.audubon.org/all-species). Even so, Rubenstein et al. (2019) note that bald eagles are also highly adaptive and are "capable of tracking salmon as they spawn in rivers across the Pacific Northwest," which is a trait that will help them adapt to climate impacts.[63]

The Audubon Society, as part of their "Survival by Degrees" report, has identified a number of other bird species in the southern Washington Cascades that may be at risk from future climate impacts such as increased temperatures, wildfires, and altered precipitation patterns. These include Vaux's swift (*Chaetura vauxi*), northern pygmy owl (*Glaucidium gnoma*), red-breasted sapsucker (*Sphyrapicus ruber*), and Hammond's flycatcher (*Empidonax hammondii*).[64]

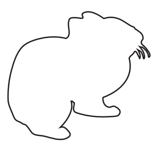
Terrestrial amphibians, like Van Dyke's salamander (*Plethodon vandykei*) and the western red-backed salamander (*Plethodon vehiculum*) that inhabit rock outcroppings, depend on wet microclimates to keep their skin moist, and they have minimal tolerance for dry, warm conditions.[65] Drought and temperature increases can be expected to impact these amphibian species.

Mountain goat caught on a wildlife camera during a CFC wildlife survey



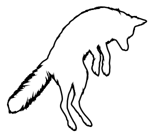
Mountain goats (*Oreamnos americanus*) are found in the high-elevation lands around Mount Adams, Mount St. Helens, Goat Rocks Wilderness, Mount Rainier, and in travel corridors between. They are most typically found in rocky terrain where their natural ability to climb makes them difficult prey for predators such as bears, wolverines, and wolves. Mountain goats are dependent on grasses, low-growing shrubs, and mosses for sustenance. Because of their size and the typically low levels of nutrients in alpine and subalpine plants, mountain goats can also be found ingesting soil and making pilgrimages to known mineral licks to get the essential nutrients they need. Mountain goat populations in the Washington Cascades have declined over the past 50 years. While not currently an endangered species, their populations are expected to face stressors as alpine and subalpine habitats transform. They will likely suffer from a decrease in late-season forage in rocky outcrops due to dry and hot summers.[25] An encroaching tree line is also expected to reduce grazing areas and the amount of accessible food.

The reduction of snowpack is expected to significantly impact the wolverine (*Gulo gulo*), which relies on snow for denning and caching prey.[66-68] Wolverines have specific adaptations to snow, such as enlarged feet and fur that insulates them from the cold. Reproductive dens of wolverines are limited to areas that retain snow during the spring.[68] In 2010, the wolverine was listed as a "candidate" species under the ESA. In 2014, a proposed rule to list the wolverine as "threatened" was withdrawn by the U.S. Fish and Wildlife Service, but that decision was widely questioned and eventually disputed by a federal court. The proposed rule was reconsidered as ordered by the court, yet U.S. Fish and Wildlife Service chose to withdraw the rule again. Conservation groups challenged the agency's decision in federal court, and in 2022, the court sided with the conservation groups and restored the proposed rule, providing some protections for wolverines under the ESA. The U.S. Fish and Wildlife Service is currently considering whether to list wolverines as "threatened" for the third time.[69] With shrinking habitat areas, oftentimes limited to narrow elevation bands, protecting wolverine habitat will require identifying habitat, mapping corridors, and enacting policies to limit influences known to negatively impact wolverine survival and reproduction, such as snowmobile activity near den sites.[70]



The American pika (*Ochotona princeps*) is a charismatic relative of the rabbit, adapted to rocky terrain and cold weather. American pikas are typically found living between the cracks and crevices of talus fields (slopes with loose and medium-sized rocks) often near or above treeline where snow is common in winter and spring. Well-shaded dens and thick snow packs create cooler microclimates that shelter pikas from warm summer temperatures. As a diurnal species, they are active during the day, foraging close to the talus and storing vegetation in haypiles during the summer to supply themselves with food stocks over the winter months.[71] Plant health and availability around talus slopes could be restricted by increasing summer drought. If climate change causes an increase in freezing rain in certain areas, this can encase plants in ice and affect foraging. Earlier snowmelt can reduce snow packs that pikas sometimes depend on for shelter, temperature regulation, and food storage. For pika populations living at elevations between 8,000–14,000 feet, they do not have the luxury of being able to extend their range upward in elevation as they already exist near the upper limits of peaks.[72] Some pika populations live in lower elevations, though, and there is evidence that pikas may be able to persist through potential future changes to high elevation habitats.[73] There are instances of pika retreating to the cool crevices of the talus slopes to evade peak temperatures and foraging during the nighttime if daytime activity is restricted.[75] In the GPNF and the Columbia River Gorge, Cascade Forest Conservancy volunteers and other field survey teams have found pikas living in a variety of elevation bands, including low-elevation sites. Such observations provide hope that pika populations can adapt to a changing climate, but their trajectory remains unclear.

A busy pika gathers leaves and grasses to bulk up its food cache pile for winter

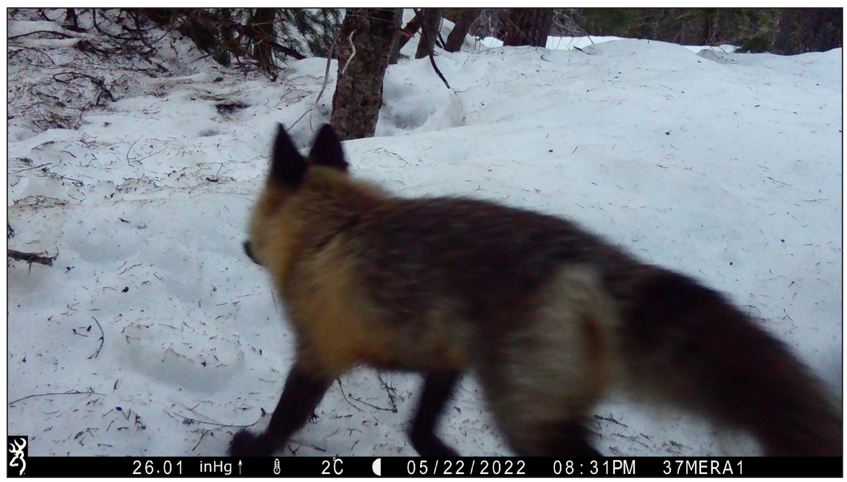


The Cascade red fox (*Vulpes vulpes cascadensis*), an already rare species, is well-adapted to cold but could suffer from a lack of suitable connectivity and habitat quality due to warming temperatures and reduced snowpack. In the mountainous Cascade Range, the sparse distribution of their preferred alpine and subalpine meadow habitat causes them to be limited to small, isolated populations.[75] In a warmer climate, certain alpine habitats may decrease or disappear, and high elevation meadows will likely become drier and degraded. Additionally, prey abundance and stressors from new competitors like non-native foxes (*e.g., Vulpes vulpes*) and coyotes (*Canis latrans*) could reduce success of prey caching, limit den sites, and over-expend dispersal costs.[75,76]

The hoary marmot (*Marmota caligata*) has a highly specific preferred habitat of rocky outcrops next to wet meadows just above the treeline. They hibernate for eight months and rely on availability of favored plant species during their active period. A warming climate and seasonal fluctuations in precipitation and snow cover duration could create a phenotypic mismatch wherein they emerge from hibernation earlier due to warmer temperatures, but the vegetation they rely on for survival and reproduction success is still dormant.[77] Changes in alpine vegetation could also increase competition and populations of predators as it becomes more favorable for new species.[78]

Some animals that benefit from early seral habitats and which are wide-ranging, such as deer, elk, and bear, may experience an increase in habitat availability from fires and losses in forest cover, but drought impacts may negatively affect their forage.[79-81] The black-backed woodpecker (*Picoides arcticus*), a fan of post-fire habitats, may respond positively to the likely increases in wildfires.

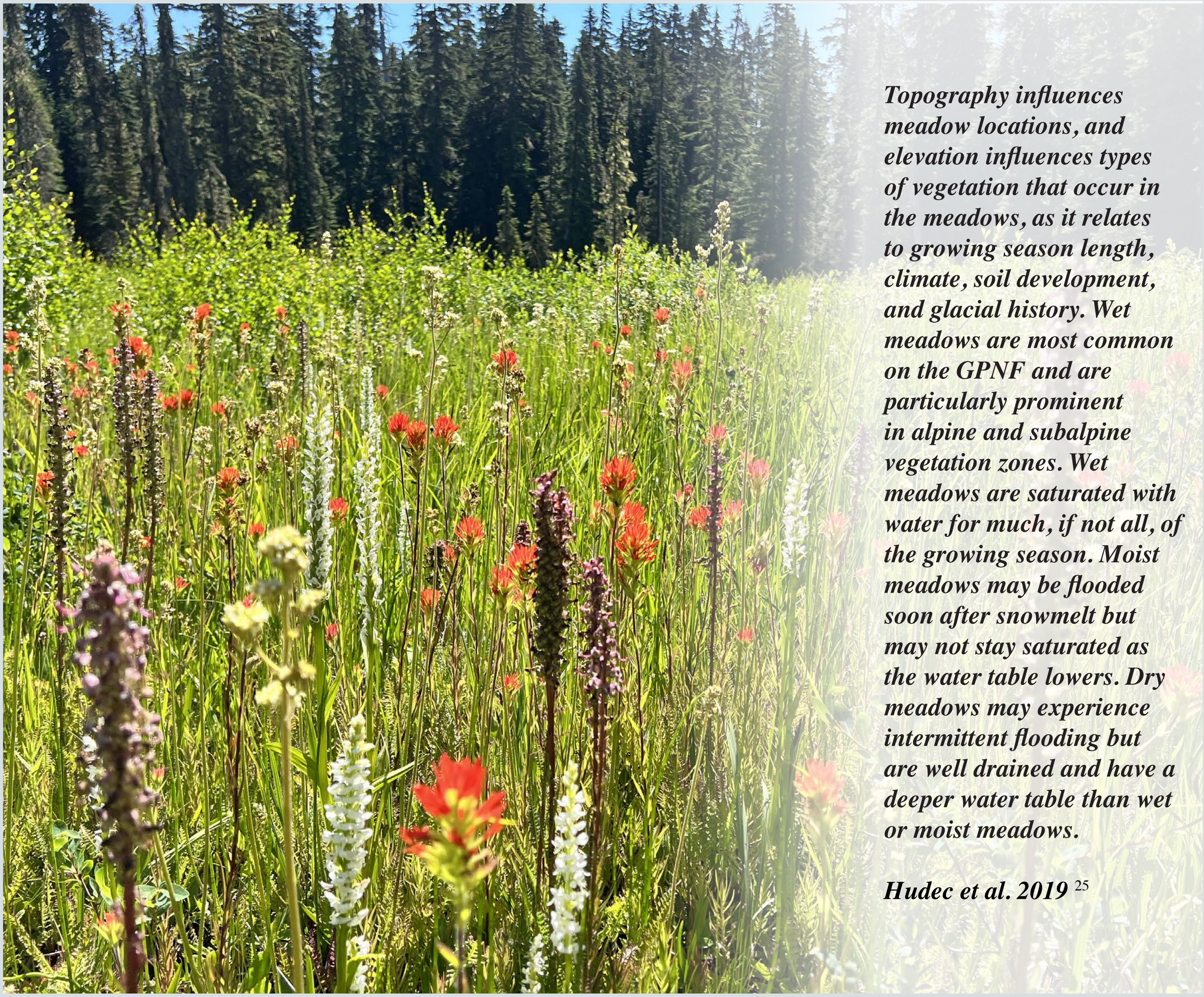
Cascade red fox photographed by wildlife camera in 2020



Cascade red fox photographed by wildlife camera in 2022

Male Columbian black-tailed deer photographed in 2021

Meadow habitats



Topography influences meadow locations, and elevation influences types of vegetation that occur in the meadows, as it relates to growing season length, climate, soil development, and glacial history. Wet meadows are most common on the GPNF and are particularly prominent in alpine and subalpine vegetation zones. Wet meadows are saturated with water for much, if not all, of the growing season. Moist meadows may be flooded soon after snowmelt but may not stay saturated as the water table lowers. Dry meadows may experience intermittent flooding but are well drained and have a deeper water table than wet or moist meadows.

Hudec et al. 2019 [25]

Meadow habitats are vital components of a healthy Pacific Northwest ecosystem. They house unique configurations of plants and animals that are not found in the surrounding forested landscapes. Threatened and rare species, such as pale blue-eyed grass (*Sisyrinchium sarmentosum*) and the mardon skipper butterfly (*Polites mardon*), rely on meadows. The abundance of invertebrates supply food for birds, amphibians, and reptiles. Meadows support a wide array of butterflies, including skippers, checkerspots, fritillaries, sulphers, blues, and swallowtails.[25] Birds such as chipping sparrow (*Spizella passerina*), hermit thrush (*Catharus guttatus*), yellow-rumped warbler (*Setophaga coronata*), and Townsend's warbler (*Setophaga townsendi*) nest at the edges between meadows and conifer forests. A variety of mammals, such as bear, deer, elk, and squirrels also regularly use meadow habitat for forage.[25] Connected meadow habitats help ensure genetic diversity for transitory species, such as the Cascade red fox.

In some meadow habitats, perennial flowering plants have already been replaced by low-lying shrubs and sedges that are better equipped for warmer and drier weather.[82] This decline of floral plants could have severe implications for pollinators, as well as wildlife that depend on nutrients and habitats specific to a meadow environment. Further endangering plant diversity, warmer temperatures will likely bring threats from invasive species, such as Scotch broom and reed canarygrass, which can withstand longer periods of drought.[83]

Meadow restoration—consisting of cutting back small conifers that are encroaching on current meadow systems—can ameliorate some loss of habitat and competition for moisture. In addition, seeding and planting of native meadow species can help boost biodiversity and aid in the establishment of new meadows.

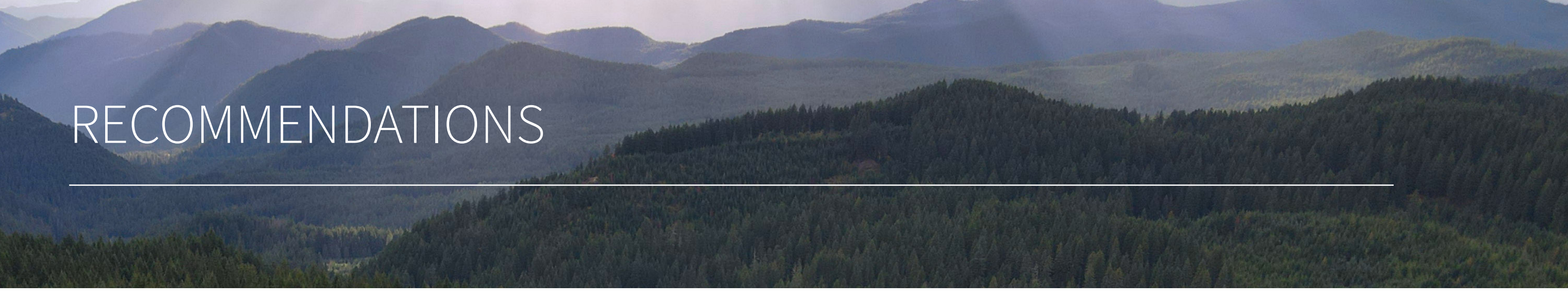
Alpine and subalpine ecosystems

The picturesque scenes of the snow-capped volcanoes that tower above our region draw visitors from far and wide. They are also home to a number of rare species, such as the elusive wolverine and Cascade red fox. These unique habitats also support a variety of plants, many of which cling close to the ground to absorb the heat and avoid the harsh winds.

The subalpine and alpine regions in the southern Washington Cascades can be found at elevations from about 7,000 to 14,410 feet at the peak of Mt. Rainier. The cold climate, rocky soil, heavy winds, and swaths of year-round ice and snow create a unique area that suits a particular suite of species. Timberline marks the transition from the dense conifer forests below to the alpine uplands dominated by low-lying plants and uniquely-adapted wildlife species. A healthy buildup of snow and ice over the winter ensures snowmelt through the summer months, and this snowmelt is an integral part of the region's hydrological cycle, especially for glacial-fed river systems.

Subalpine and alpine ecosystems are considered some of the most threatened in our region. In the face of even mild to moderate warming from climate change, we can expect to see a recession of glaciers and a reduction of snowpacks. We can also expect to see the treeline encroach on upland habitat in certain areas, including subalpine meadows.[84-86] A shift in the timing of flowering has the potential to cause direct mortality for certain species and to disrupt various species relationships.[87] Animals, like the wolverine, that depend on snow and ice for shelter, foraging, and food storage are likely to be severely impacted by climate change. Connectivity between alpine habitats is low due to the wide distances between areas, which can hinder dispersal and movement for species facing climate pressures in certain locations.

Conservation and restoration strategies for alpine systems are limited due to the inability to change snow and rainfall dynamics. Because of this, protection of alpine systems requires strategies to reduce the severity of climate change, such as through carbon storage and forest preservation. Data collection, though, is an important strategy to help managers gauge localized impacts and tailor resilience-building efforts.



ADVOCACY AND POLICY CONSIDERATIONS ON **FEDERAL LANDS**

This section outlines strategies related to policies and projects on federal lands. Forest management strategies relating to Forest Plans are outlined in Chapter 4.

National level: retain valuable aspects of the NEPA process and other federal programs

In the last several years, Congress and presidential administrations have been active on forest management issues. The Forest Service released and began implementing the Wildfire Crisis Strategy in 2021 to increase fuels reduction treatments. Additionally, Congress has been providing new funding for forest management, primarily for addressing wildfire risk. Congress has also enacted public lands packages, like the Great American Outdoors Act, that provides much-needed funding to our underfunded and understaffed land management agencies. This has funded several shovel-ready projects on the GPNF, many of which are ecologically-tuned restoration projects that had otherwise lacked funds.

More recently, the Infrastructure Act invested massive amounts of federal money into climate change mitigation and adaptation.[88] The bill includes several types of funding mechanisms to assist in restoring ecosystems and increasing resilience. It is important that this funding is directed at high priority projects, such as those identified through this guidebook.

The National Environmental Policy Act (NEPA) process is a systematic approach to environmental decision-making in the United States, requiring federal agencies to assess the environmental effects of their proposed actions and engage with the public prior to making decisions. There has been recent focus on weakening NEPA regulations and requirements, including provisions in funding bills aimed at decreasing planning durations, efforts to decrease the emphasis of cumulative impacts, and yet-to-be-seen changes that will be coming from the Council on Environmental Quality.

Also, the categorical exclusion (CE) for salvage logging was greatly expanded by the Trump Administration (from 250 acres to 3,000 acres), but a court recently sided with the environmental community challenging this change. CEs allow certain management projects to bypass the NEPA analysis process and most of the associated public input. CEs are usually for non-controversial projects that are limited in size and have well-understood impacts. Expanding the salvage CE could have had enormous negative implications for how the Forest Service addresses salvage logging after wildfire.

Regional level: retain valuable aspects of the NWFP and increase protections for certain forest habitats

As we move to the regional level, we look to the NWFP, the guiding plan that dictates the limits of timber harvest activities in the Pacific Northwest. For nearly three decades, the management of Pacific Northwest national forests under the NWFP saw minor alterations, such as amendments to guidelines and local revisions, but the original land allocations remained mostly unaltered. However, a potential change to the NWFP is in the works. We delve into Forest Plan recommendations in Chapter 4, where we outline specific strategies that can be employed at the regional and local levels to improve climate resilience through Forest Plan amendments or revisions.

Local level: public involvement with timber harvest planning

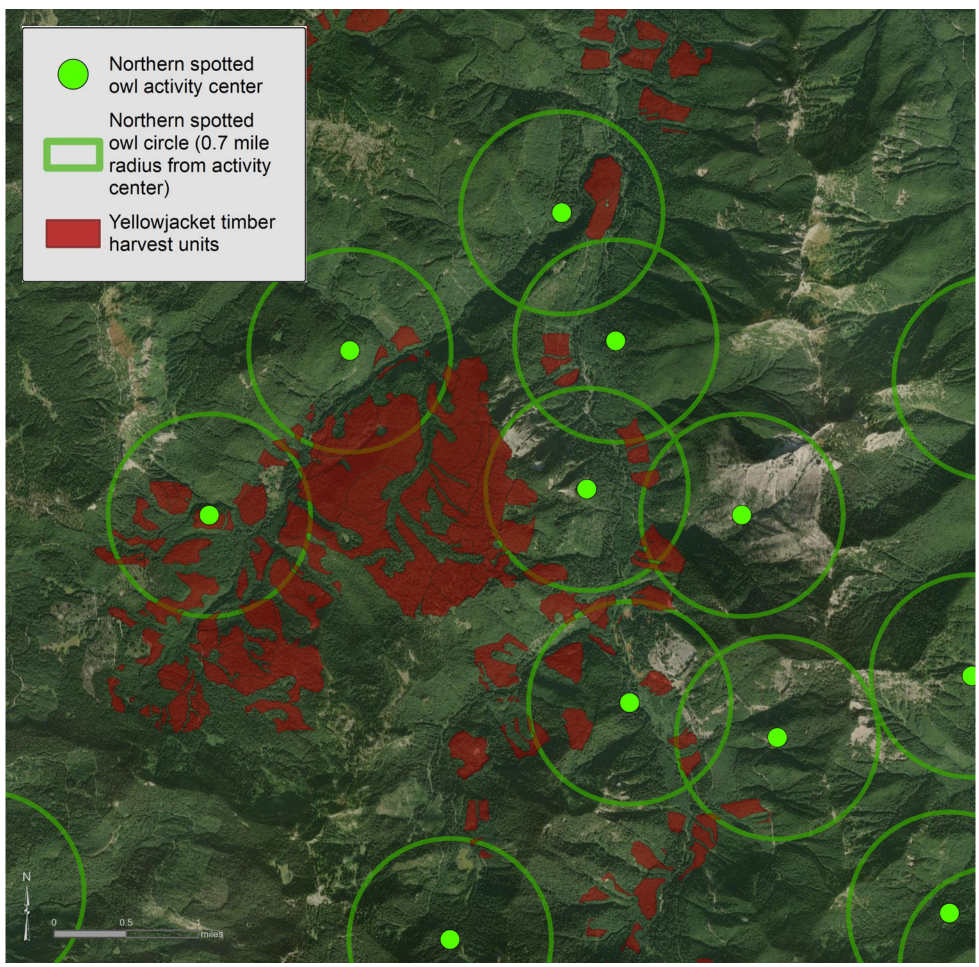
One way to ensure mature forests are left intact and habitat protections are prioritized on federal lands is by getting involved in the process of timber harvest planning. With most forest management efforts on federal land, the Forest Service must follow NEPA, which requires federal agencies to consider public input and environmental impacts when making decisions.

The Forest Service carries out vegetation management planning with a district-level team where a variety of different specialists (such as botanists, wildlife biologists, silviculturists, hydrologists, and others) come together to plan where logging should occur in a certain planning area, how many trees and what types of trees would be removed, where roads would be built or re-opened, which roads would be closed, and what steps will be taken to protect or enhance habitat. The specialists bring various ecologically-driven perspectives into these planning processes, but with timber harvest being the foundation upon which these plans are built, extraction of trees has often been the dominant factor driving which areas are logged and which are protected. After months to years of preparation and analysis, a plan is eventually finalized, a decision is formalized, and the work is carried out by a contracted logger.

We engage with timber planning on federal lands in two ways: 1) submitting official comment letters to the agency to point out any legal and scientific deficiencies found in a proposal and to provide feedback from our on-the-ground investigations; and 2) participating in forest collaboratives, which are stakeholder groups that meet regularly to discuss timber harvest proposals and provide input to the Forest Service planning team. In the Upper Wind federal timber sale, for example, through our multi-year engagement in the process, we prevented forest stands that were over 120 years old from being logged to create early seral habitat (i.e., removal of most trees from a unit to create a condition that is analogous to a post-disturbance/post-fire setting). Writing official comment letters and participating in forest collaboratives allow us to be site-specific and to advocate for the protection of particular forest stands and habitat features. Comment letters and collaborative deliberation are independent but related efforts.

For most timber projects, there are two opportunities to engage in the public comment process: 1) the initial scoping phase where the agency is looking for early feedback on a basic and generalized plan, and 2) after the draft environmental assessment (EA) is released. The EA

A volunteer collecting information to ensure protection of old forest habitats



Map showing the overlap of northern spotted owl circles and timber harvest units in the Yellowjacket planning area on the GPNF is more refined than the scoping notice and includes site-specific information about timber prescriptions and road construction.

The public comment process discussed above is not just available for organizations. Community members can submit comments as well. The federal agency fields all input and takes this information into account when finalizing their management decisions for a particular area.

Members of the public can also join their local forest collaborative. Collaboratives are open to the public and are meant to contain a wide variety of perspectives on forest management, including input from conservation groups, loggers, county representatives, and concerned citizens. In general, the goal of the collaborative is to discuss potential forest management activities early in the planning process (members receive forest management information before it is released on agency websites) and to ultimately work toward finding consensus or areas of agreement around federal forest management projects.

There are several issues of concern that we frequently encounter in timber sale planning processes and which are important to keep in mind when hoping to influence land management plans. One of these issues is mechanically-created early seral habitat. Early seral is a habitat type that is early in the successional stages and is characterized by very few trees and many shrubs and other small plant species. Certain wildlife species rely on early seral habitat. Historically, this type of habitat was created through disturbances like wildfire or, in smaller patches, from insects, disease, or windthrow. Due to a century of fire suppression, creation of monoculture plantation stands, and other anthropogenic factors, there is less early seral habitat on the landscape than would have been seen in previous eras. While this might suggest a need to create more early seral habitat, there is more to the story. Most notably, the wider spread and greater intensity of wildfires are already rapidly increasing the amount of early seral habitat in the region. As an example, during the planning for the Upper Wind timber sale, the Big Hollow Fire swept through the GPNF and burned approximately 25,000 acres. There may have been a lack of this habitat in and near the planning area before this fire, but afterwards, that was not the case. We can expect to see this pattern repeated elsewhere as the size and intensities of wildfires increase with rising levels of drought and a longer fire season. Because of this, it is unnecessary and unwise to mechanically create large swaths of early successional habitat, especially by logging mature forests, as these forests are our future old-growth. In addition, it is not clear whether timber harvest is an effective tool for creating early seral habitat. This type of treatment may cause more harm than good, considering the impacts from heavy machinery on soil compaction, understory plants, current habitat features, and the introduction of invasive species.

It is often necessary to advocate for timber plans that adequately protect species like northern spotted owls and fishers. When reviewing timber sale layouts, we pay special attention to known northern spotted owl nest sites to ensure they receive adequate buffers from harvest and to reduce the intensity of logging in adjacent areas. Generally, northern spotted owls thrive in forests with canopy cover levels over 70%, so we aim to ensure that logging levels

A field trip with members of the South Gifford Pinchot Collaborative remain above this threshold in key areas.[31,89,90] Other mature forest species also benefit from similar canopy coverage levels, and maintaining this minimum canopy threshold in key locations can also have the added benefit of helping retain cool and moist microclimates.

We also address impacts to aquatic ecosystems in our timber sale comments. This is explained in greater detail in Chapter 3.

For comments to accurately reflect the details of timber harvest plans and for collaborative processes to be successful, strong communication, transparency, and data sharing from the Forest Service is needed. This helps ensure meaningful community involvement and public participation in the decision-making process, which is critical for community buy-in and social license. Forest Service teams in the southern Washington Cascades model this effectively but this is not the case in all parts of the western United States.

Support Tribal involvement in land management

For generations, local Indigenous communities have actively managed these forest habitats. A key element to promoting future resilience should involve a collaborative approach that integrates Traditional Ecological Knowledge and Tribal practices into the management of federal lands. This can be done in a number of ways, but generally this means supporting co-management mechanisms and other programs meant to enhance coordination with Tribes in the ecological management of national forests.[91] For example, the Tulalip Tribes have used "memorandums of agreement" to collaborate on management of the Mt. Baker-Snoqualmie National Forest for many years. This collaboration has included watershed enhancement, huckleberry enhancement, and wildlife reintroduction work. The Cowlitz Indian Tribe works on a number of projects on the Gifford Pinchot National Forest, including advocating for targeted forest thinning to enhance the growth of huckleberry and working in the Pinchot Partners, the forest collaborative in the Cowlitz Valley Ranger District.

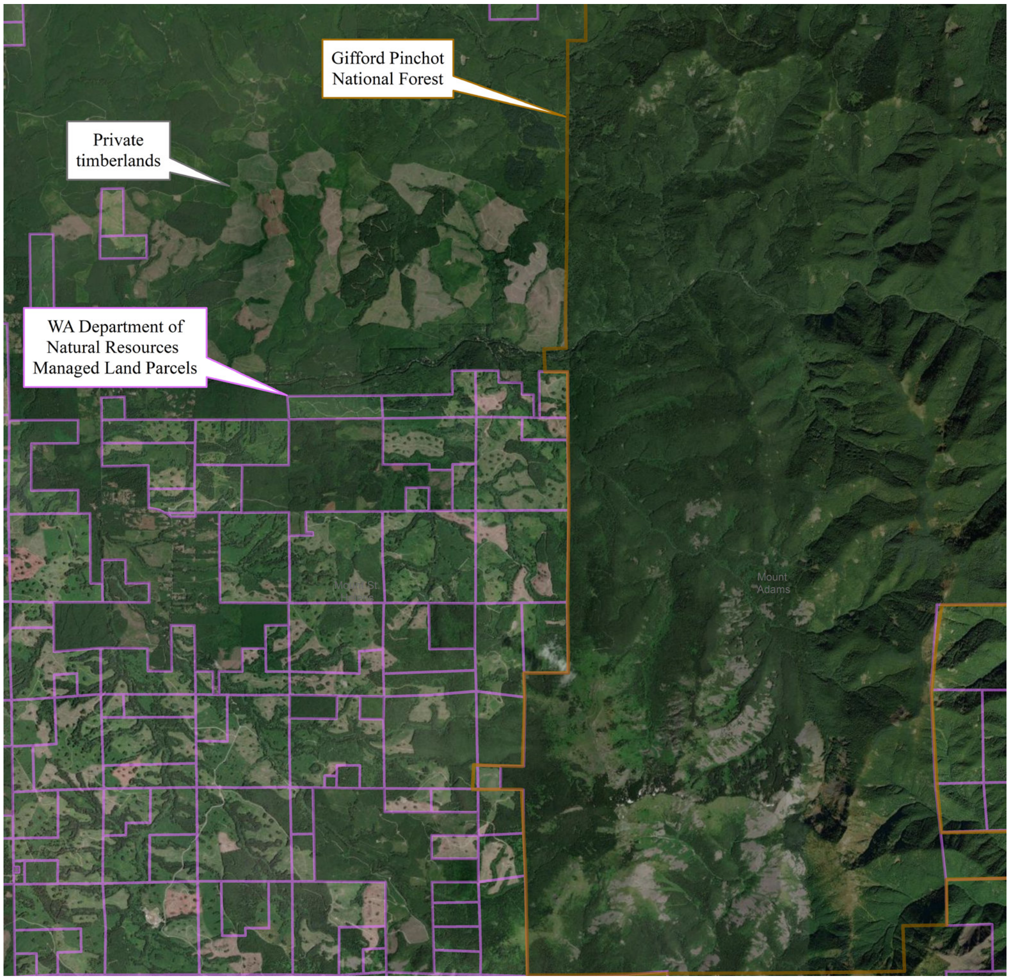
CFC volunteers performing huckleberry surveys at a berry field restoration site

Also, a federal program called the Good Neighbor Authority creates avenues for Tribes, counties, and states to carry out timber harvest and restoration work on federal lands. This enables Indigenous communities to steward and gain income from on-the-ground projects. This authority helps projects move forward more quickly and over larger areas by allowing multiple entities to carry out work on federal lands.

Other mechanisms include the Tribal Forest Protection Act, which has been used to advance collaboration with the Forest Service for managing lands adjacent to Tribal lands. The 2018 Farm Bill added the ability to carry out demonstration projects using this contracting authority. The Tulalip Tribes in 2020 entered into a Tribal Forest Protection Act contract focused on beaver relocation and monitoring efforts using the new demonstration project authority.

The Forest Service also has a special authority that enables Tribes to bypass certain regulatory hurdles and receive natural materials, such as trees, without having to compensate the federal government.[92] This authority can be utilized to advance more mutually-beneficial restoration projects. In the southern Washington Cascades, we helped facilitate the use of this authority by sourcing trees from the Columbia River Gorge National Scenic Area and delivering these for instream restoration work being carried out by the Cowlitz Indian Tribe.

The Forest Service has indicated they are focused on enhancing co-stewardship of national forests and grasslands in a recent action plan titled Strengthening Tribal Consultations and Nation-to-Nation Relationships.[93] We recommend that these plans, authorities, and opportunities be used to advance Tribal co-management and mutually-beneficial projects to improve climate resilience on federal lands.



Map showing forest cover in three different types of land ownership: state, federal, and private lands

ADVOCACY AND POLICY CONSIDERATIONS ON **STATE LANDS**

Climate resilience cannot be achieved by only focusing on federal lands. The management of the roughly two million acres of state forest lands is largely tilted toward extraction, with less emphasis on habitat needs and the role that these forests can play in mitigating climate change through carbon storage.

Washington State Trust Lands

The state of Washington owns several types of forested lands (state trust lands, state forest lands, community forests, natural resource conservation areas, natural area preserves, and wildlife areas). Much of the forest lands are called trust lands. There are two different types of trust lands: 1) those that were granted to the state by the federal government, and 2) others that were forfeited to the counties by private owners and turned over to the state for management. For trust lands, the state has a legal duty to provide a continuous flow of revenue to trust beneficiaries over time. These beneficiaries include counties, public schools, state universities, and prisons, to name a few. The trust responsibilities complicate the management of much of the state's forest lands, as environmental protection and conservation goals on trust lands must be balanced against the state's responsibilities to beneficiaries. It's unfortunate that some county and state public services are tied to logging, but that is the current arrangement through which we must address these issues. In addition to timber harvest, though, the state can employ other activities or methods to produce income for beneficiaries, including leasing land for agriculture, leasing communication sites, mining and mineral leases, wind farms and other types of energy production, rights of way, forest products like biomass, and, currently in a limited capacity, carbon storage.

There is some indication that management of the trust lands is evolving to a small degree. In 2022, the Washington Supreme Court deliberated on the question of whether trust responsibilities only apply to those who receive direct income (certain counties, schools, etc) or whether the state must manage on behalf of all citizens.[94] The Court determined that the agency must manage on behalf of all citizens, not just the direct beneficiaries. The case has not yet solicited any direct changes in forest management, but it may eventually impact how Washington Department of Natural Resources (DNR) can make management decisions in the future regarding their trust lands.

Staying involved in timber sales on state lands

One way to advocate for healthy and resilient ecosystems on state lands is to be involved in state timber sales. Similar to federal lands, the state has a public involvement process under the State Environmental Policy Act (SEPA) where citizens and groups can provide feedback on harvest plans. Anyone from the community can provide feedback on harvest plans on state lands by reviewing the SEPA materials online and commenting before the deadline. DNR will review any comments received and will consider those comments before finalizing their decision. Like with federal timber sales, reviewing and commenting on state timber sales allows the public to be involved on a site-specific level and to help ensure all laws are being followed and that a site's ecological characteristics are more fully considered when finalizing harvest plans.

We regularly monitor several issues, including road-building, aquatic habitat and water quality impacts, protection of older forests and large trees, and potential impacts to species like salmon and the northern spotted owl. On state lands, protections for old-growth-dependent species are measured and considered through a Habitat Conservation Plan under the Endangered Species Act. Under this plan, there are areas of designated high-quality northern spotted owl habitat and a requirement to maintain a percentage (50% per watershed) of that habitat. There are varying perspectives on how to apply this percentage and some conservation groups recommend that future projections of habitat loss (e.g., from wildfire or drought) be considered when determining whether the 50% per watershed requirement will be met after timber sales. With the consideration that we can justifiably expect an increase in the rate of habitat loss in the coming decades, it would be appropriate to maintain a higher percentage of habitat for northern spotted owls to ensure 50% per watershed actually exists in the future.

When reviewing state sales, we pay particular attention to the habitat classification and the age of the stand to ensure state lands are meeting their requirements to support species – this sometimes involves advocating that a higher percentage of habitat be conserved in a certain sale area. We also pay close attention to riparian management zones around streams and rivers (see Chapter 3). In response to the current lack of protections for headwater streams, we frequently advocate for the state to provide greater safeguards for these stream reaches due to the known impacts of logging along waterways.

Preserves for ecological values

The state has one land management tool that can help move ecologically-important lands in trust ownership to other types of public ownership. This tool is called the **Trust Land Transfer Program**, and it is funded by the state legislature. This transfer, in turn, requires the purchase of replacement lands for the trust. In the past, during the legislative budget process, particular parcels would be nominated for transfer, and the legislature would make final determinations on which parcels to transfer. Overall, though, use of this program has not been very consistent or transparent. There are, however, efforts underway to revitalize the program—a recommendation that came out of the 2021 Trust Lands Performance Assessment.[95] DNR introduced bills in the 2023 legislative session to implement some of the needed reforms.[96] Passing these bills is only the beginning of making these programs more consistent and transparent.

One type of public ownership that trust lands can be, and have been, transferred to is the network of natural areas intended to preserve vital populations of important species and ecosystems in existence over the long-term. These areas (**Natural Area Preserves** and **Natural Resource Conservation Areas**) are managed by the DNR in the Natural Heritage Program. Natural Area Preserves are areas that "protect the best remaining examples of many ecological communities including rare plant and animal habitat." [97] Natural Resource Conservation Areas are areas that "protect outstanding examples of native ecosystems, habitat for endangered, threatened and sensitive plants and animals, and scenic landscapes." [97] The Trust Land Transfer Program, although worthwhile, has fallen short in efforts to ensure species and ecosystems important to the state will survive in the face of climate impacts, especially considering the high degree of impact and development on the private lands that surround most of DNR's properties. In a 2022 report to the legislature, the state acknowledged that a majority of the species and ecosystems listed as a priority for the natural preserve system are still not adequately represented in preserves, i.e., their population numbers are too low in these areas.[98]

If the Trust Lands Transfer Program is revitalized into a more functional program in a future session, this tool could be used to move priority conservation areas identified on page 34 into a more protected status, e.g., the Natural Area

Preserves and Natural Resource Conservation Areas. In summary, we recommend that DNR use the updated and revitalized transfer tool to protect key habitats in southwest Washington and ensure the Natural Heritage Program goals are achieved.

Efforts to set aside trust land for carbon storage

While still attending to the beneficiary needs, DNR has recently taken small steps to address carbon storage by creating a Carbon Project. This effort set out to identify 10,000 acres for conservation in order to preserve forest carbon and to bring in funding through credits for carbon storage as an ecosystem service. This is a step in the right direction and serves as a foundation upon which to modernize the state's management of forest carbon. Currently, though, these efforts are being challenged in court by some of the trust beneficiaries. If the Carbon Project survives litigation or if future efforts are brought forward, expansion of that program beyond the initial 10,000 acres should focus on protecting the priority areas identified below.

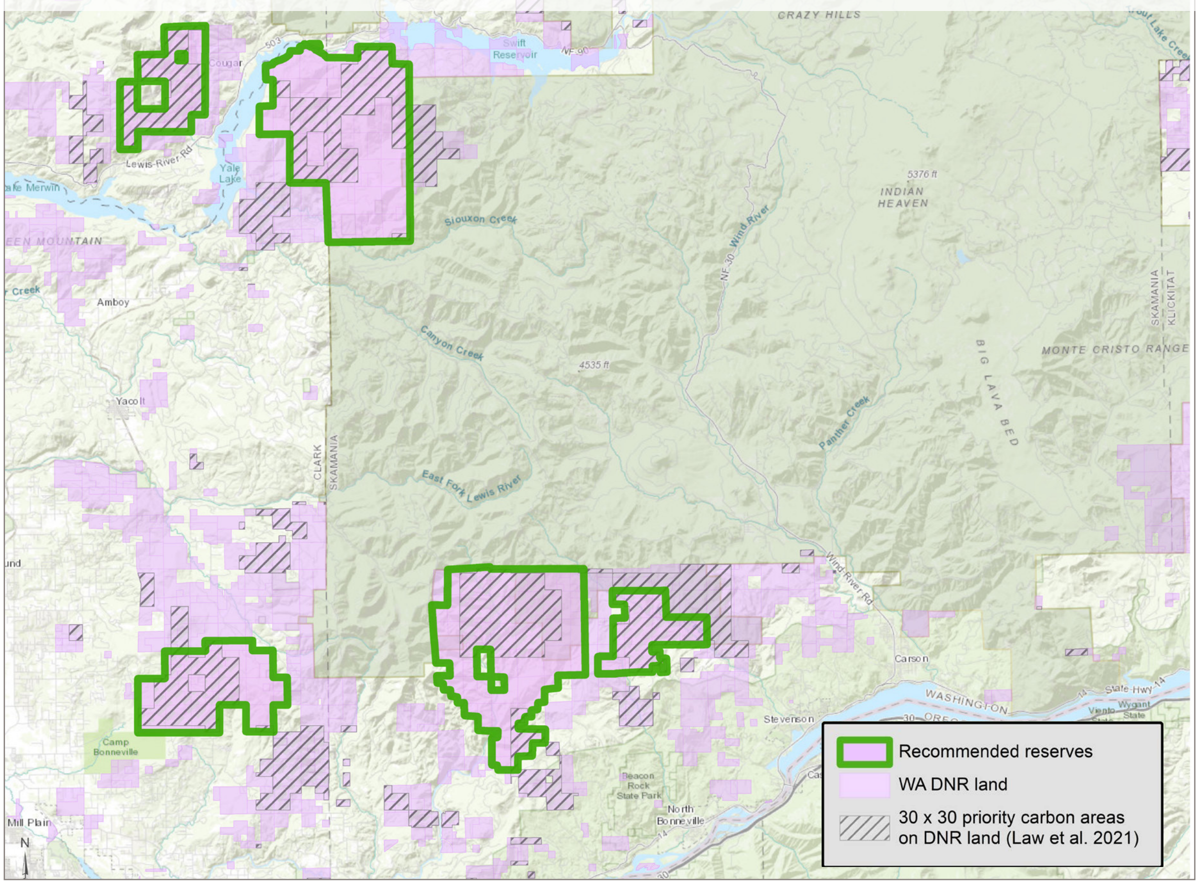
Relatedly, recent efforts in legislative sessions have focused on expanding DNR's authority to participate in carbon markets and sell carbon credits and offsets. Currently it is unclear what the limitations of this expanded authority will be, if an expansion happens at all.

Regardless, these bills, which were at the request of DNR, are an indication of the state's desire to manage certain forest parcels as carbon storage areas. We designed our recommended areas of protection (in the map below) to align with both carbon storage goals and habitat needs.

State forest areas recommended for long-term protection

Here we identify five areas on DNR land where we recommend a comprehensive analysis and consideration for future protection from logging using either the Trust Land Transfer Program or a future carbon storage project.

These areas were identified by overlaying three datasets in order to highlight areas that would bring multiple benefits, including protection of mature forest habitat, connectivity, and carbon storage. The layers we used were: 1) a recently completed scientific analysis showing priority areas for carbon storage (Law et al. 2021), 2) a forest age layer, and 3) our previously completed connectivity model.

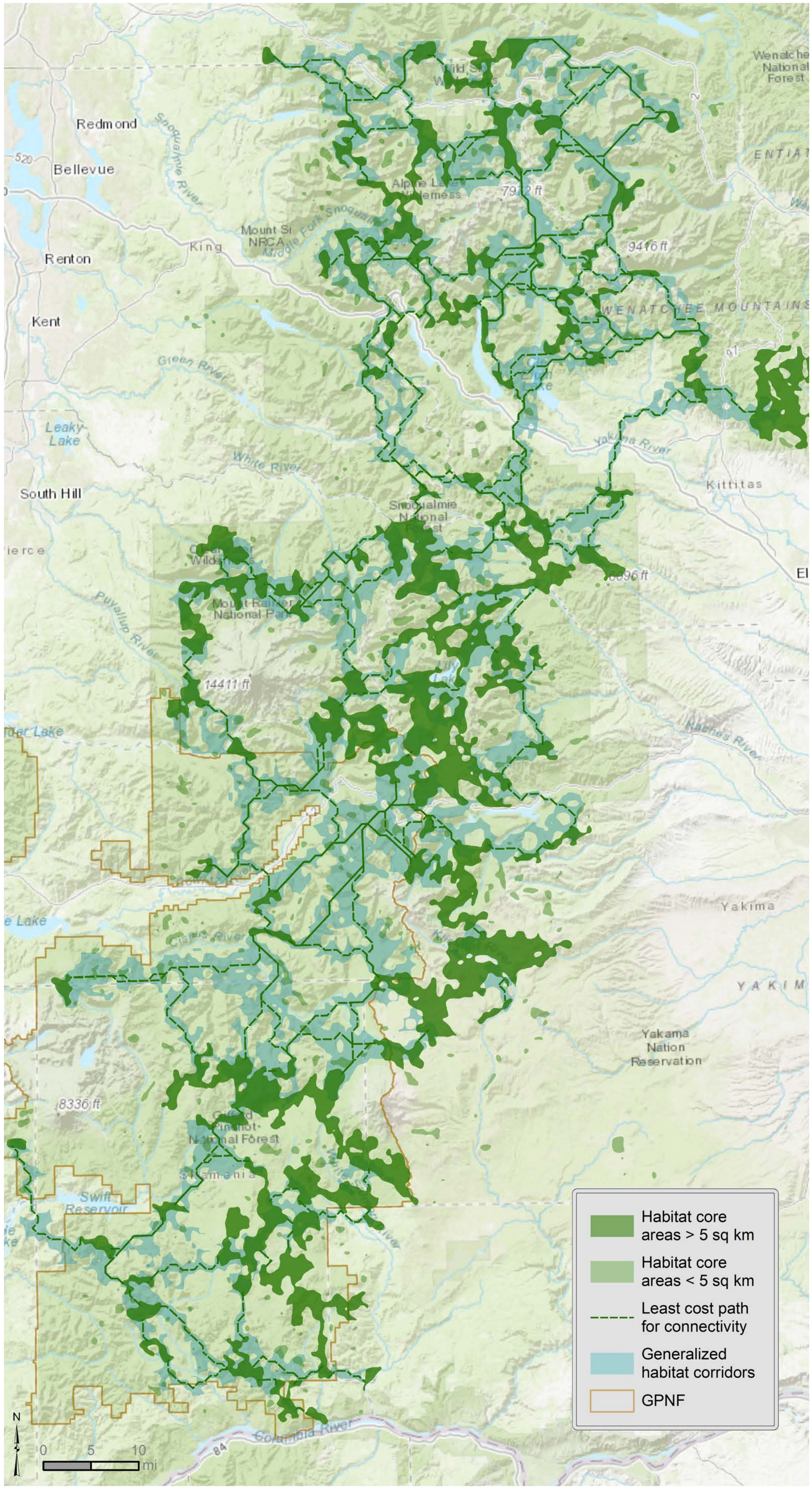


Connectivity

Connectivity is a key component to consider when developing strategies to conserve species and habitats. It represents the critical arteries that sustain ecosystems. Robust connectivity throughout the landscape enables wildlife populations to be more resilient to climate impacts by allowing movement to alternate habitat areas and decreasing the degree to which disturbances in a specific habitat patch will jeopardize the overall viability of a population. For example, if a certain area is dramatically affected by wildfire or drought, the availability of nearby suitable habitats, linked by corridors of viable dispersal habitat, becomes critical in preventing population extirpation.

In developing conservation strategies for species, we must consider a landscape perspective of connectivity that anticipates potential shifts in habitat patterns and dispersal needs. Refugia areas must correlate to the dispersal and resource needs at particular times in the life cycle of plants and animals.[99,100] It is also important to prioritize areas with high conservation value (such as old-growth forests or other rare habitats) or areas with relatively high inherent resilience (such as mature or old-growth forests).[101] By conserving these areas and the areas of connectivity in-between, we can support the movement, resilience, and long-term survival of species.

In 2017, Cascade Forest Conservancy carried out a connectivity analysis to assist in conservation planning for old forest habitats. This analysis identified core habitat areas (referred to as "habitat core areas" or HCAs) and potential connectivity corridors. The analysis parameters set for this analysis were broad and were intended to encompass habitat needs for a suite of species that depend on old forest habitats, such as fishers, martens, and northern spotted owls. We used this connectivity model to help refine our Forest Plan-related conservation strategies outlined in Chapter 4.



Walking among the pines in a mixed-conifer forest near Mt. Adams where prescribed fire is planned

RESTORATION RECOMMENDATIONS

In this section we outline restoration strategies for forest ecosystems. Interwoven within these restoration strategies is an understanding of the fundamental significance of biodiversity, as it provides a box of tools to mitigate threats from climate change. Another crucial theme weaving together these strategies is an implicit understanding of the value of gathering on-the-ground information. Community members play a pivotal role in monitoring ecological changes over time and collecting data that can inform adaptive management efforts, species recovery initiatives, and the classification of threatened or endangered species at both federal and state levels. By developing a comprehensive understanding of local wildlife populations, such as pikas and rare carnivores, policymakers can target specific policy changes and reintroduction endeavors to ensure long-term survival of at-risk populations.

Increasing resilience through strategic restoration of mixed-conifer forests

There are actions we can take to help improve the resilience of certain forest areas. Our recommendations for fire risk reduction in forest ecosystems specifically focus on the drier mixed-conifer forests on the south side of Mount Adams, as thinning for fire risk reduction in moist, westside forests is not well supported by the literature.[23,42,43]

In the mixed-conifer forests, where we see uncharacteristically large influxes of grand fir amongst the ponderosa pines and Douglas-firs and where thick layers of duff increase the potential for tree mortality, restoration thinning and prescribed fire can reduce fuel loads, improve resilience, and set these landscapes on a trajectory that is more analogous to their historic conditions and more likely to persist amidst future changes. The consequences of logging and active management (e.g., prescribed fire and skid trails) can bring impacts of their own, though, such as loss of certain habitat features, the introduction of invasive plants, and soil compaction. Because of this, careful planning and thorough consideration of near-term impacts need to be integrated into management plans.

To ensure that management efforts sufficiently balance both short-term and long-term resilience, it is important that the following measures are taken:

- Conduct pre-treatment surveys to protect rare plants and sensitive wildlife;
- Maintain intact forest patches within treatment units to promote fine-scale heterogeneity;
- Preserve higher tree densities in valley bottoms and north slopes as these areas naturally have higher stem densities and cooler microclimates;

- Leave streamside (riparian) areas undisturbed to protect waterways;
- Avoid regeneration harvest (clearcut) and gaps larger than ¼ acre to retain carbon and limit habitat fragmentation;
- Focus thinning on small diameter trees, with particular focus on grand fir;
- Retain large trees, such as Douglas-firs and ponderosa pines over 30” in diameter, due to their value for wildlife, soils, and carbon storage; and
- Ensure strategic use of prescribed fire to increase efficacy of restoration.

Prescribed burning has been underutilized in the recent past due to limited burn windows and procedural hurdles. The omission of this crucial step hinders the full potential of restoration thinning. The Forest Service, the state, and local communities approach the use of fire as a management tool with varying levels of caution. The Forest Service, for example, exercises prudence due to limited resources, limited opportunities with desirable weather and fuel conditions, and instances of escaped burns in other areas. Local communities express concerns about impacts on air quality as well as the potential risk of escape. Addressing this issue requires increased collaboration and communication between agencies and local communities regarding prescribed fire, associated risks, and the time frames within which burning is allowed.

Furthermore, it is essential to continue monitoring restoration actions and their effects on forest conditions and future wildfire patterns. By doing so, we can gather valuable local evidence to determine the best practices and inform adaptive management strategies.

Post-fire restoration

There are certain instances where post-fire restoration can make a difference in accelerating revegetation. When conditions for natural recovery are limited due to successive burns, size and severity of the fire, or pre-fire conditions that will hinder recovery, actively facilitating the establishment of diverse native plant species can be beneficial to a post-fire landscape. This type of restoration can protect soils from erosion and compaction, minimize encroachment of invasive plants, provide resources to a variety of pollinators and other wildlife, and speed up the re-establishment of other ecological functions. Depending on budgets and the size of the landscape, sowing seeds via helicopters, drones, hikers, and even dogs can allow for dispersal with minimal additional soil disturbance. Attention should be paid to maintaining the genetic diversity of the local plant communities; as such, the

CFC volunteers and staff working with a botany expert from the Forest Service to restore fire-impacted forests

collection of seeds from multiple locations within close proximity to the burned area is recommended. An alternate strategy, and one within the realm of assisted migration, is selecting seeds from an area where plants have been experiencing conditions similar to what the future conditions are predicted to be at the restoration site.

Assisted migration

Future climate conditions will change which plants can thrive in certain areas.[102-104] This has led researchers to explore adaptation strategies such as assisted migration, which involves humans physically relocating plants to a location beyond their historical distribution.[105] Assisted migration is not a new concept, Indigenous cultures practiced this when planting culturally-important plants, and forest managers replant forest stands with particular species for lumber and other uses.[106] Regardless, assisted migration is a controversial topic. It offers the potential to reduce some of the adverse effects of climate change, but opponents argue there is significant risk of the practice having unintended consequences by disrupting natural ecological and genetic processes or introducing invasive species, especially if using plants from far-off locations.[107,108]

A recent synthesis by Twardek et al (2023) collated the results from various assisted migration studies and concluded that there is a paucity of data paucity of data to support assisted migration as a climate adaptation strategy. The GPNF is participating in an assisted migration and silviculture study with the Pacific Northwest Research Station. The Experimental Network for Assisted Migration and Establishment Silviculture (ENAMES) is a long-term study being conducted at ~25 sites from California to Washington, including a 16-acre plot of Douglas-fir seedlings planted in 2021 on the GPNF. The seeds were chosen from lower elevation areas and moved to cooler, higher elevations within their general habitat range.[109] As years pass, the results of this study will offer insight into the value and utility of this practice.

Increasing our understanding of local wildlife to help sustain populations

On-the-ground research on wildlife distributions, trends, and behavior can help us in designing effective conservation strategies.

Some species, like pikas, can be monitored through surveys carried out by conservation professionals or volunteers out in the field. On-the-ground surveys, both opportunistic and systematic, are crucial for American pika research as they provide direct observations of their presence in specific elevation bands and habitat zones. Opportunistic surveys involve individuals reporting random pika sightings encountered during recreational activities. Systematic surveys involve surveyors visiting sites with known pika presence to assess whether pika populations have sustained at those locations. This hands-on approach allows us to collect valuable data that contribute to a comprehensive understanding of the pika's distribution. This helps us understand how they have been impacted by current temperature patterns and how they might be impacted by future changes, such as changing habitat zones along elevation gradients.

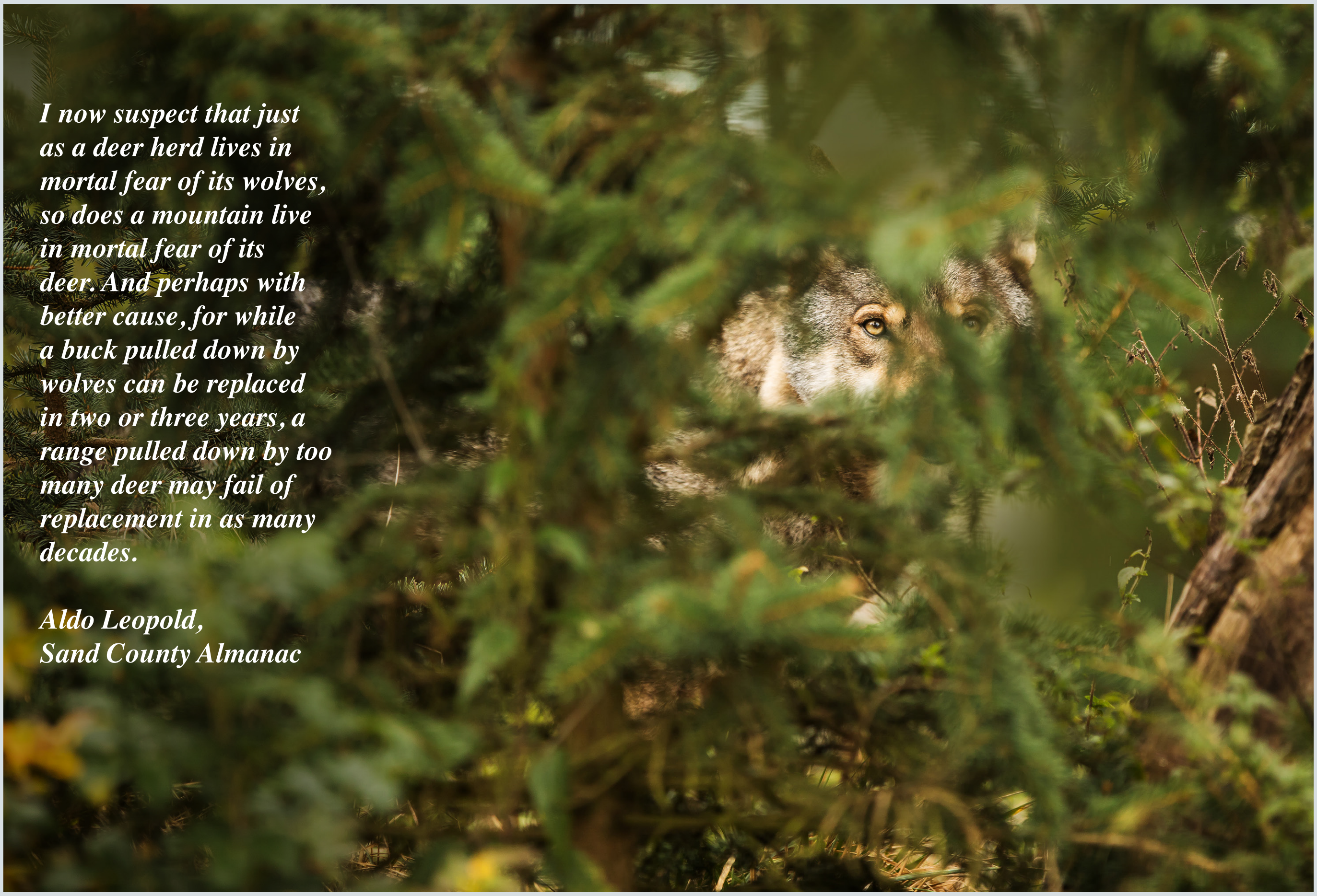
Wildlife camera surveys offer another approach to monitoring at-risk and recovering wildlife populations, allowing more fine-tuned conservation and climate adaptation planning. This is especially valuable for monitoring rare and elusive species. This work involves the use of remotely-triggered cameras that capture photos when animals pass in front of the camera. Studies can be set up to use either baited or non-baited stations.

Camera traps can track the movement patterns of elusive carnivores across different seasons, offering insights into their breeding, feeding, and movement patterns. This information can be useful for adjusting timber harvest plans to minimize disruption to key habitats. Additionally, these cameras can aid in determining the success of reintroduction programs by monitoring the acclimation of species to new environments and their interactions with existing wildlife. Over time, the collected data helps in shaping effective policy decisions and management strategies aimed at enhancing the resilience of these species to climate change and habitat alteration.

Moreover, wildlife surveys can play a significant role in community science initiatives. By engaging local communities in camera setup and field monitoring efforts, these projects foster a deeper connection between people and the natural world, encouraging a more inclusive approach to wildlife conservation. This collaboration not only broadens the scope of data collection but also promotes awareness and support for conservation efforts among the general public.

Photos from CFC's wildlife survey project carried out in partnership with Oregon State University. This project aimed to monitor the success of fisher reintroduction and capture on-the-ground information on species assemblages in survey areas across the GPNF. Species pictured clockwise from top left include bobcat, fisher, elk, marten, deer, and mountain lion.

The return of wolves



The return of wolves to the southern Washington Cascades—which will most likely be realized through dispersal from nearby packs—can enhance the health of ecosystems. Wolves were nearly eradicated across the continental U.S. by the early part of the 20th century. The gray wolf was listed as endangered under the ESA when it was passed in 1973 and was also listed as endangered by the state of Washington in 1980. The species briefly lost its federally-protected status in January 2021, but protections were restored in February of the following year. As wolf populations recover in the northeastern parts of Washington, the ESA status will likely shift accordingly.

Wolves are a keystone species that play a vital role in bringing balance to ecosystems. For example, the now-famous 1995 reintroduction of wolves to Yellowstone National Park led to a surprising number of positive impacts for ecosystems in the region. Without their primary predator, elk had overgrazed much of the park. The riparian and aquatic areas suffered and the loss of vegetation negatively impacted a variety of wildlife species, including beavers. After wolves returned, there was a strong rebound in ecosystem health.

Here is southwest Washington, we can see the impacts that a century of elk and deer populations living without their main predator have had on riparian and aquatic systems. Wolves have already begun to return to this area but it will take many years before packs grow and we are able to observe ecological impacts. As this recovery progresses, we can expect their return to play a role in building climate resilience.

The wolf, perhaps more than any other animal in North America, elicits strong feelings and spurs passionate debates. To some ranchers and others, wolves represent an unwelcome danger or a threat to rural livestock. And, although there are effective coexistence strategies and compensation policies that ranchers and agencies can employ, fear and distrust can end up dominating the conversation. As we monitor the return of wolves to the southern Washington Cascades, it is essential that we work to support multi-stakeholder collaboration and advance coexistence efforts.

Wildlife overpass in Banff, Canada. Image sourced from Canadian Geographic (2022)

Example of a culvert that blocks fish passage and doesn't facilitate movement for terrestrial wildlife. Photo courtesy of Washington Department of Fish and Wildlife

An aquatic organism passage (AOP) culvert that facilitates movement for fish and other species such as frogs, salamanders, small mammals, insects, and microorganisms

Increase the number of wildlife crossings over and under roadways

It is critical that we direct attention and funding to increasing the number of wildlife crossings over and under roadways. In many cases, such as areas with high rates of elk or deer collisions, costs for this work are often offset by savings gained from fewer car-animal collisions which are expensive for agencies and individuals. In other areas, culvert upgrades can present a prime opportunity to modify the construction design and create underpasses that service both the migratory needs of aquatic species and permeability for terrestrial species.[110,111] Washington Department of Transportation, the Forest Service, and other agencies are all working in different ways to advance wildlife connectivity over and under roadways. As road restoration is carried out and as funding comes online to address needed culvert upgrades or long-overdue wildlife overpasses, it is important that we direct attention to efforts that benefit a multitude of species.

In addition to funding for salmon-related culvert improvement projects, there are infrastructure funding routes through which to create new wildlife crossings. For instance, the Wildlife Crossings Pilot Program is a federally funded initiative aimed at reducing wildlife collisions through competitive grants. Also, the Bipartisan Infrastructure Law recently allocated $350 million to be spent between 2022 and 2026.

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