Economic Impacts of Investing in Climate Resilience through Ecosystem Restoration in Washington State

Eastern Washington Forest Health Strategies and the Snohomish Watershed Resilience Action Plan

JANUARY 2022

WASHINGTON STATE DEPT OF NATURAL RESOURCES

UNITED STATES CLIMATE ALLIANCE

RTI INTERNATIONAL

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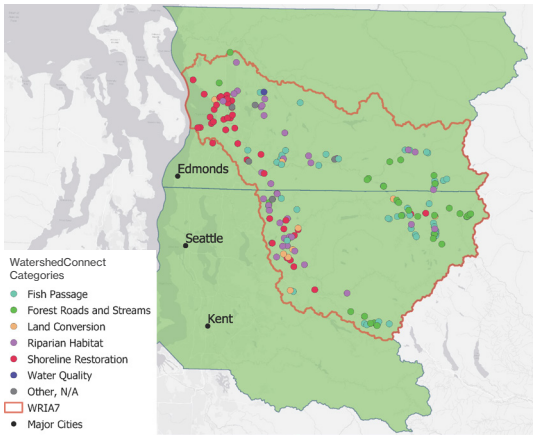
Executive Summary: Salmon Recovery

Salmon habitat in many of Washington's coastal and riparian areas has been lost or degraded by sedimentation, poor water quality, lack of vegetation, and fish passage barriers. The Washington State Department of Natural Resources' Watershed Resilience Action Plan for the Snohomish watershed focuses on restoring and improving riparian health, estuary ecosystems, waterway connectivity, and forest health in ways that can increase economic opportunities and environmental justice. Washington's Department of Natural Resources (DNR) supports salmon recovery through a multistakeholder process to identify projects such as shoreline restoration and culvert removal that will help salmon populations recover. Salmon recovery efforts also support healthy watersheds, biodiversity, and cultural value.

Figure ES-1. WatershedConnect Projects in the Snohomish Watershed by Project Type



The map depicts the Snohomish watershed (WRIA 7, red line) spanning King and Snohomish Counties. Colored dots represent the 275 projects by type assigned for this study (WatershedConnect, 2021).

Washington's Snohomish watershed north and east of Seattle is planning for action to secure additional funding to safeguard the recovery of salmon populations in this area. DNR and stakeholders in the Snohomish watershed have identified 275 projects valued at $273 million (See Figure ES-1). At current levels of funding, these projects would take 29 years to complete, risking salmon populations and the funds spent to support them. Doubling historical funding of $9.6 million per year (10-year average) to $20 million per year could reduce that timeline to 14 years, advancing critical support to salmon populations when it is most needed.

In addition to supporting salmon populations and ecosystems, recovery projects offer economic benefits in the form of jobs and wages. Salmon recovery projects in the Snohomish watershed would support an average of 283 jobs with a low funding increase ($20mm per year) and 360 jobs with a high funding increase ($25mm per year) and $12.5 to 19.0 million in annual wages (See Table ES-1). This study estimated that for every dollar spent on salmon recovery, 77 cents become wages for a Washingtonian, and every million dollars spent on salmon recovery supports nearly 15 jobs, primarily in King and Snohomish Counties.

Table ES-1. Economic Impacts of Increased Salmon Recovery Funding in the Snohomish Watershed

	ANNUAL JOBS	ANNUAL WAGES (MILLION $)	YEARS TO ADDRESS NEED
Low	283	$12.5	14
High	360	$19.0	11

With additional funding, the Snohomish watershed can quicken the pace of salmon recovery, improve local ecosystems, and contribute millions in wages to the local economy. Successfully demonstrating these benefits from increased salmon recovery investment in the Snohomish may also help pave the way for other watersheds throughout western Washington to attract critical support for their efforts.

Executive Summary: Forest Health

Washington State is abundant in public lands and natural resources. With more than 5 million acres of diverse lands and ecosystems to safeguard, Washington's Department of Natural Resources (DNR) must coordinate many stakeholders and priorities in securing the needs of Washington's present and future generations. Climate change is one of the greatest challenges to safeguarding Washington's natural resources. Although Washington's state leaders have made significant progress in advancing greenhouse gas mitigation targets and supporting clean and efficient energy use, climate change is already affecting Washington. For example, greater heat and drought in eastern Washington have supported increasingly devastating wildfires. One of DNR's strategic planning focal points is on increasing resilience to climate change.

Washington's forest health strategies can improve the health of forest ecosystems by using complementary, scientifically grounded treatments in collaboration with other landowners at a landscape scale. Restoring forest health will require a mix of forest harvesting, noncommercial thinning, site preparation, and controlled burning with many acres needing multiple treatments. Healthy forests contribute a range of benefits from wildfire resilience to improved air, water, and soil quality, biodiversity, and cultural value.

Implementing forest health treatments also offers Washington economic opportunity. This study analyzed the economic impacts of low- and high-level implementations of an "All Lands" scenario based on DNR's 20-Year Forest Health Strategic Plan for Eastern Washington. The 20-year Strategic Plan guides forest restoration and management efforts on Washington's east side with a goal to conduct 1.25 million acres of forest treatments in eastern Washington by 2037 across land ownerships. This study also analyzed low- and high-level implementations of a separate "State Lands" scenario covering state trust lands throughout eastern Washington and identifying 336 to 432 thousand acres that could receive forest health treatments.

Table ES-2. Economic Impacts of Implementing DNR's Forest Health Strategies

	ANNUAL JOBS	ANNUAL WAGES (MILLION $)	TOTAL ACRES (000)
All Lands: Low	1,518	$67.6	933
High	2,572	$112.4	1,343
State Lands: Low	199	$9.9	336
High	272	$13.6	432

Implementing the All Lands scenario will incur an estimated annual cost of $85.3 (low) to $145.2 (high) million over a 20-year period, some of which is supported by existing DNR budgets or may be supported by other landowners. Implementing the State Lands scenarios will require $9.8 to $13.2 million annually. Implementing DNR's forest health strategies would provide significant support to eastern Washington's logging and forestry services sectors, their suppliers, and local communities. The All Lands scenario would support an annual average of 1,518 (low) to 2,572 (high) total (direct, indirect, and induced) jobs and the State Lands scenario 199 (low) to 272 (high) total jobs if implemented over the next 20 years (Table ES-2). 78 cents of every dollar spent on forest health supports income for a Washington resident.

Restoring eastern Washington's forest can offer critical support in defending against wildfire risk and offer other ecosystem benefits. DNR strategies outline a clear path for action improving forest health and delivering on these benefits. By continuing to steward its lands and lead on climate change, Washington can also offer significant economic support to its rural economy in the form of jobs and incomes.

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List of Acronyms

ARRA	American Recovery and Reinvestment Act
BLS	U.S. Bureau of Labor Statistics
DNR	Washington Department of Natural Resources
ESHB	Engrossed substitute house bill
FIT	DNR Forest Improvement Treatment program
FTE	Full-time equivalent
GSRO	Governor's Salmon Recovery Office
HB	House bill
HUC	Hydrological unit code
IO	Input-output
MBF	Thousand board feet
MMBF	Million board feet
NAICS	North American Industry Classification System
NOAA	National Oceanic and Atmospheric Administration
OBT	On-board truck
OES	Occupational, Employment, and Wage Statistics
PPA	Priority planning area
RPC	Regional purchase coefficient
SB	Senate bill
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resource Inventory Areas

Ecosystem Restoration and Climate Resilience in Washington

Restoring Washington's ecosystems through forest, riparian, and shoreline management offers a diverse set of benefits, including improvements to water quality and quantity, air quality, soil quality, biodiversity, marketable natural resources like timber products, cultural value, and spiritual value. Healthier ecosystems can also offer critical natural climate solutions that help society adapt and become more resilient to climate change. Environmental solutions that can simultaneously help defend against climate change and improve ecosystem health are valuable win-wins for the environment and society. The increasing hazards posed by climate change make it ever more critical to continue supporting strategic efforts like those advanced by Washington's Department of Natural Resources (DNR) to safeguard healthy and resilient ecosystems.

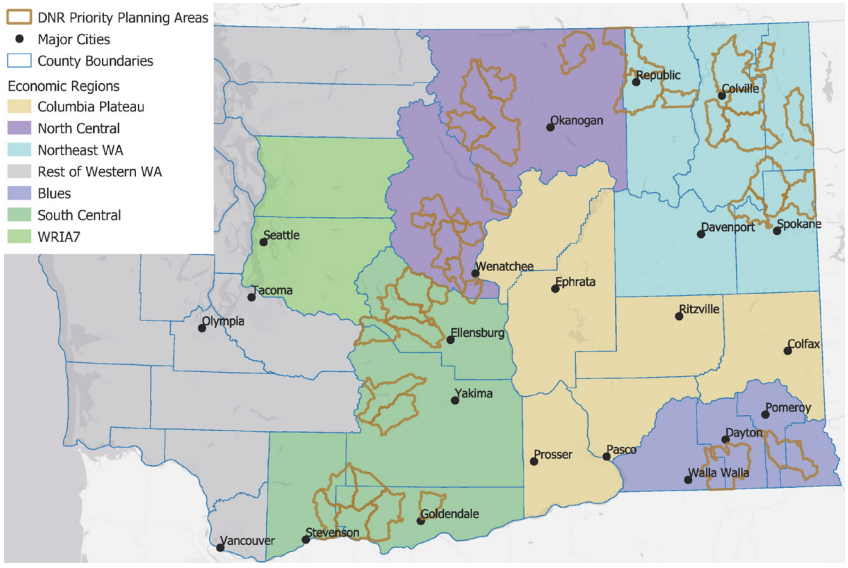
Ecosystem restoration offers benefits beyond ecosystem health and climate resilience. Restoring forests, rivers, and shorelines supports jobs and incomes through a diverse set of economic activities (BenDor, Lester, Livengood, Davis, & Yonavjak, 2014). The current analysis conducted for this report focuses on the scale of economic opportunity that will be supported by implementing three strategic efforts led by DNR across 7 economic regions and 39 priority planning areas (PPAs) in Washington (Figure 1):

1) **Salmon Recovery:** Snohomish Watershed Resilience Action Plan
2) **State Lands:** Forest Health Strategy for State Lands in Eastern Washington
3) **All Lands:** 20-Year Forest Health Strategic Plan, Eastern Washington

Washington DNR's *Salmon Recovery* and *Forest Health Strategies* could support as many as **2,932 jobs** and **$131.3 million in annual income** in Washington State.

These are three of many strategic efforts led by DNR to restore Washington's ecosystems. The results in this study, therefore, cover only a fraction of the total potential economic benefit from DNR's ecosystem restoration work.

Figure 1. Washington Counties, Economic Regions, and Forest Health Planning Areas



The strategic plans developed by DNR are designed to set a more positive trend toward climate resilience for Washington's forest health and salmon populations. The Snohomish Watershed Resilience Action Plan focuses on recovering salmon populations by restoring and improving riparian health, estuary ecosystems, waterway connectivity, and forest health. DNR's forest health strategies are focused on managing for the increasingly dry and fire-prone forests of central and eastern Washington (henceforth "eastern Washington" for all areas east of the Cascade Mountain Range plus Skamania County). The 20-Year Forest Health Strategic Plan for

eastern Washington aims to promote resilience of Washington forests and communities through the planning, implementation, and monitoring of forest health treatments in 39 priority landscapes across multiple land ownerships (WA DNR, 2018a; the basis for the "All Lands" scenario). DNR's state-lands forest health strategy focuses on increasing the economic, biological, and social value of forests on eastern Washington's state trust lands managed by DNR (WA DNR, 2018b, basis for the "State Lands" scenario).

1.1 SALMON RECOVERY

Climate change, combined with increased development, is putting pressure on salmon habitats with many species of salmon remaining threatened despite concerted recovery efforts by local, state, and federal agencies (Crozier et al., 2019). The over $1 billion being invested in salmon recovery across Washington State in the last 20 years still represents only about 22% of the need identified by watershed salmon recovery plans, which is insufficient to recover salmon (GSRO, 2020).

DNR's Watershed Resilience Action Plan analyzed in this study is geographically focused on western Washington's Snohomish watershed, also known as Water Resource Inventory Area (WRIA) 7. The plan provides a landscape-scale approach to salmon habitat restoration by focusing on all lands on which salmon depend throughout their life cycles, from the mountain headwaters to Puget Sound. This watershed was selected because of its declining salmon populations and numerous DNR programs identifying it as a landscape with significant opportunities to improve salmon recovery. Programs such as estuary habitat and nearshore submerged aquatic vegetation protection, restoration and improvement of riparian health, waterway connectivity, and forest health have the potential to support salmon recovery, increase economic opportunity, and support environmental justice in WRIA 7.

DNR is one of many partners working to recover salmon in this watershed. Tribes, local governments, and other partners that form the Snohomish Basin Salmon Recovery Forum (responsible for writing the local salmon recovery plan), the Governor's Salmon Recovery Office, the Department of Fish and Wildlife, nonprofits, and private-sector actors all have a stake in salmon recovery and contribute to planning efforts. DNR's salmon recovery planning includes efforts to mobilize new partners and funding by communicating the economic benefits of salmon recovery projects.

Stakeholders in the Snohomish watershed (WRIA 7), which covers large parts of King and Snohomish Counties and encompassing the Tulalip Reservation and city of Everett north of Seattle, are in the process of developing a Watershed Resilience Action Plan that will guide recovery efforts and offer a valuable planning resource for other watersheds. The plan will provide a 10-year roadmap for DNR to increase its impacts on recovering salmon populations in this critical watershed. The plan will identify numerous opportunities where DNR's core programs can support salmon recovery and improve ecosystem function, including nearshore submerged aquatic vegetation, fish passage across land ownerships, and partnerships supporting healthy forest and riparian areas in the mountain headwaters. DNR's plan will recognize and emphasize the need to work in partnership to support critical restoration projects identified by the local watershed Lead Entity and partners (Snohomish Basin Forum). The economic impacts identified in this study will advance DNR's efforts to implement restoration projects throughout the watershed by fostering greater appreciation of how these activities support economic opportunity.

1.2 FOREST HEALTH

Past forest management practices and a century of fire suppression have left eastern Washington's forests dense and homogenous; overstocked with live and dead fuels; and lacking older, more fire-tolerant trees (WA DNR, 2018a). Climate change is exacerbating issues posed by unhealthy forests and increasing risk of drought, wildfire, and outbreaks of harmful insects and diseases. DNR's efforts to address forest health are focused on transitioning eastern Washington's forests to more healthy and resilient

20-YEAR FOREST HEALTH STRATEGIC PLAN

MISSION STATEMENT: "Restore and manage forested landscapes at a pace and scale that reduces the risk of uncharacteristic wildfires and increases the health and resilience of forest and aquatic ecosystems in a changing climate for rural communities and the people of Washington State."

GOAL: Conduct 1.25 million acres of scientifically sound, landscape-scale, cross-boundary management and restoration treatments in priority watersheds by 2037.

conditions through a combination of science-based active management strategies such as thinning, prescribed fire, and managed wildfire.

To address the growing threats facing forested ecosystems and communities, Washington's legislature provided direction to DNR on forest resilience and wildfire risk reduction efforts. The state legislature designated Washington's Commissioner of Public Lands, who oversees the Washington State DNR, as the state lead in addressing forest health issues across the state. In 2016, the Washington state legislature directed DNR to develop a 20-year plan for forest health, and subsequent legislation directed DNR to develop a strategy for prioritizing state lands to enhance opportunities for effective and safe wildfire response.[1] Collectively, this legislative direction is embodied within and guiding agency efforts in the implementation of the 20-Year Forest Health Strategic Plan: Eastern Washington and the Forest Health Treatment Prioritization and Implementation on State Trust Lands in Eastern Washington.

Addressing Washington's growing forest health crisis requires coordinated actions across multiple ownerships. Wildfire risk, drought, and insect and disease issues transcend land ownership boundaries, and no one landowner or agency will be able to create resilient landscapes and communities alone. Thus, DNR works to connect diverse groups and support collaborative efforts to enable and support each landowner in meeting their objectives while contributing to the goals of the overall forest health plan. The forest and watershed protection initiatives evaluated here span many activities and land ownerships reflective of the diverse priorities and constituencies DNR must address in its work. Section 3.1 discusses these activities in more detail.

1.3 NONMARKET BENEFITS

This study focused on the public and private employment and income impacts of recovering salmon and improving forest health in Washington; however, a broad set of other, nonmarket benefits are likely to arise in implementing these strategies. Healthy forests support nutrient cycling, biodiversity, and water regulation in addition to provisioning services (e.g., timber, game) and cultural and recreational value. Coastal and wetland restoration undertaken for salmon recovery helps provisioning services for commercial fisheries and recreational fishing (Postel, 2005).

Wildfires have become one of Washington's leading sources of carbon dioxide emissions.

Common quantifications associated with ecosystem restoration outcomes such as number of acres treated do not reflect all of the benefits provided by forests (Smith et al., 2011a). When nonmonetary benefits are quantified, decision-makers must still balance multiple objectives often measured in disparate units (e.g., habitat integrity and water quality). Monetizing ecosystem benefits can be challenging and imprecise, but research suggests their values could be quite large. Many of the nonmonetary benefits identified have the potential to support more climate-resilient ecosystems in Washington. In the face of escalating climate hazards, clearly identifying the many ecosystem services and other nonmonetary benefits, including wildfire resilience, watershed services, and cultural value stemming from restoration projects, can help DNR and implementing partners consider and communicate the diverse value communities and society receive from them.

1 Cf. ESHB 2376, ESHB 1711, SB 5546, and HB 1784 for more detail on legislation related to forest health and land prioritization.

Arguably the largest nonmarket benefit to improving forest health in Washington is resilience to wildfires. Wildfire suppression costs Washingtonians approximately $150 million per year, and in 2015 alone wildfire suppression cost state and federal agencies $345 million (WA DNR, 2019b). Climate change is now producing longer, hotter, and dryer fire seasons that are projected to worsen, suggesting Washingtonians are likely to face ever higher wildfire costs unless more fire-resilient forest conditions are achieved. Wildfire is both an effect and a cause of climate change. Wildfires are a leading source of greenhouse gas emissions in Washington, the second largest single source in 2015 behind transportation (WA Dept. of Ecology, 2021). Sound forest management practices are an essential component of Washington's climate resilience efforts.

The immediate costs of wildfire include lost lives and property, wildfire suppression, infrastructure damages, and rescue and relief operations. Long-term, full-cost accounting of wildfires can yield much larger impacts. For example, a recent study examining Arizona's 2010 Schultz fire that burned 15,000 acres found that fire and related flood response costs were $30 million in 2010, but the total costs incurred from the event and following 10 years were $100 million (Colavito et al., 2021). Long-term costs from wildfire include lost business and tax revenues, natural resource losses (e.g., burned timber), degraded ecosystem services, negative impacts on human health, and greenhouse gas emissions. For example, wildfires emit large quantities of particulate matter that can travel thousands of miles, negatively affecting health and well-being. Evaluation of multiple wildfires has shown that nearly half of all wildfire costs are paid at the local level as a result of long-term damages (Barrett, 2019).

Managing forests to increase resilience and health helps avoid the short- and long-term costs incurred by local, state, and federal governments and society to respond to wildfire (Headwaters Economics, 2018). Sound forest management can reduce the likelihood, intensity, and extent of wildfires (Buckley et al., 2014; Spies et al., 2017). Although forest health treatments are costly, those costs can be far less than the costs imposed by wildfires (Mason et al., 2006). Rasmussen et al. (2012) found that, in eastern Oregon, for every $1 the Forest Service spends on forest restoration, the agency avoids a potential loss of $1.45, primarily due to reduced potential wildfire suppression costs. Buckley et al. (2014) evaluated a broad suite of economic benefits associated with fuel treatments, finding that the benefits in the form of avoided costs may be three or more times the initial cost of treatment.

Bureau of Land Management Oregon and Washington

Another key nonmarket benefit of forest management and salmon recovery efforts is the benefits to watersheds, which include water filtration and drinking water provision, flood regulation, prevention of soil erosion, fish production, and recreation (Grizzetti, Lanzanova, Liquete, Reynaud, & Cardoso, 2016; Burdon et al., 2020; Smith et al., 2011b; Samonte, Edwards, Royster, Ramenzoni, & Morlock, 2017). Healthy inland water systems retain sediments and accumulate organic matter, which are supporting

services important for soil formation (Hassan, Scholes, & Ash, 2005). Preventing soil erosion and flooding are also beneficial for farmers along waterways, who can plant higher value or more crops (Weinerman, Buckley, & Reich, 2012).

Healthy forests also reduce the cost of drinking water treatment and moderate streambed temperatures (Anderson & Poage, 2014). In the absence of watershed protection activities, cities may be required to invest in infrastructure to perform equivalent services. Watersheds with 60% forest cover have about half the treatment costs of watersheds with only 30% forest cover and one-third the cost of watersheds with only 10% forest cover (Postel & Thompson, 2005).

Furthermore, several cultural benefits arise from salmon recovery and forest management activities. Cultural benefits from waterway connectivity and coastal restoration strategies include recreational enjoyment, aesthetic beauty, and cultural identity. Watersheds and the food, water, and air provided by them are of significant cultural and religious significance for many, especially Washington's indigenous populations (Washington Tribes, 2020). Forest management for resilience and longevity of forests means that future generations can benefit from the resulting beauty and richness. Hunting and fishing are not only of recreational value, but they also have deep cultural significance. Foods such as wild game, roots, berries, and salmon are traditional "First Foods" honored at indigenous ceremonies. The associated traditional ecological knowledge is an invaluable part of cultural practice and identity (Columbia River Inter-Tribal Fish Commission, n.d.). In respect of the cultural significance of salmon, Washington tribes' right to fish is also protected by law, requiring the state to act on addressing barriers to salmon vitality.

1.4 ECONOMIC IMPACTS

This study relies on input-output (IO) modeling methods to assess the broader economic impacts of Washington's salmon recovery and forest health initiatives. IO methods are a common way to measure how economic activity such as project expenditures in one part of the economy contributes to activity in other parts of the economy. IO tables track the flow of value from labor and capital, through intermediate production and exchange, to final consumption and investment by households and government. IO methods employ linear algebra techniques to trace value flows from new sources of demand for goods and services back through the supply chains that deliver them to the income generated for those who make them. Economic impacts in an IO framework are typically divided into direct, the impact in the sector of interest; indirect, the impact in that sector's supply chain; and induced, the impact from spending the direct and indirect incomes earned.

IO methods help provide an appreciation for the greater economic impact that restoration expenditures can have. Calculated impacts should not be interpreted as necessarily new employment or income, though some of the impacts may well be. IO methods do not account for opportunity costs that may arise from scarcity in labor or capital, and results must be compared against prevailing market outcomes to gauge to what extent the impacts are likely to be truly additional to the economy (see Appendix 6.1 for additional limitations of IMPLAN).

ECONOMIC IMPACTS

Direct *Income generated by the businesses implementing the activity.*

Indirect *Income generated by suppliers in the implementing firms' supply chain.*

Induced *Income generated by wage earners spending their income in the economy*

Salmon Recovery

2.1 SALMON RECOVERY IN THE SNOHOMISH WATERSHED

2.1.1 Salmon Recovery Planning

Salmon habitats in many of Washington's coastal and riparian areas have been lost or significantly degraded by sedimentation, poor water quality, inadequate water flow, lack of vegetation, and passage barriers. Salmon require multiple distinct habitats throughout their life stages, spanning hundreds of miles from inland rivers and streams to the ocean. A diverse set of activities is required to safeguard salmon habitat and support thriving populations. Common projects identified in Snohomish Watershed Resilience Action Plan include replacing culverts with bridges and removing bulkheads, dikes, berms, derelict structures and vessels, and other obstacles to salmon habitat and passage. Restoration projects also target improving habitat through removing invasive plant species, dredging sedimented areas, and removing coastal riprap (large rock or similar material placed to prevent erosion). Planting river and streamside vegetation supports water quality, reduces erosion, and helps maintain lower water temperatures. Planting salmon-friendly aquatic vegetation such as eelgrass also supports erosion control and, along with woody debris placement, improves salmon habitat.

Restoration needs are identified, planned for, and addressed through multiyear, multistakeholder processes, led at the watershed by a Lead Entity, with participation that spans local, state, and Tribal governance and key partnerships. Salmon recovery could not be adequately addressed without the knowledge and dedication of local communities that help identify and plan these projects. With sufficient local support and planning, projects are advanced by state and federal agencies for funding consideration and funding for implementation.

Salmon recovery projects are construction-intensive efforts that require architectural, engineering and environmental technical consulting services to plan and implement. According to restoration expenditure grant data from the National Oceanic and Atmospheric Administration (NOAA), expenditures in these sectors account for over 80% of total salmon recovery funding efforts (Samonte et al., 2017).[2] Nearly half of the tens of thousands of people employed in these sectors throughout Washington were in the counties encompassing the Snohomish watershed (IMPLAN Group LLC., 2018).

2.1.2 Salmon Recovery Needs in the Snohomish

The econoic impact assessment of salmon recovery in this study was focused on the range of projects under development in Washington's Snohomish watershed. Assessing the economic impacts of projects that are implemented over time, based on their "shovel-readiness," aligns the timeline of this analysis with the realities of restoration planning, funding, and implementation.

DNR's WatershedConnect tool will provide a detailed list of projects under development and includes dollar estimates of project cost, project urgency, limiting factors addressed (e.g., passage barriers), type of benefit provided (e.g., connectivity, restoration), and location. WatershedConnect currently includes over 275

2 Grant data from Samonte et al. (2017b) were accessed via email correspondence (April 9, 2021) with NOAA, which administered the grants that provided the data.

Table 1. Snohomish Watershed Salmon Recovery Project Estimated Costs by Project Type (WatershedConnect, 2021)

	PROJECT COSTS	
	TOTAL	MEDIAN
Total Restoration	**$272,842,662**	**$191,750**
Shoreline Restoration	184,230,617	1,000,000
Fish Passage	46,487,828	175,000
Riparian Habitat	12,757,885	200,000
Water Quality	3,401,182	538,569
Forest Roads and Streams	7,455,150	150,000
Land Conversion	18,510,000	500,000

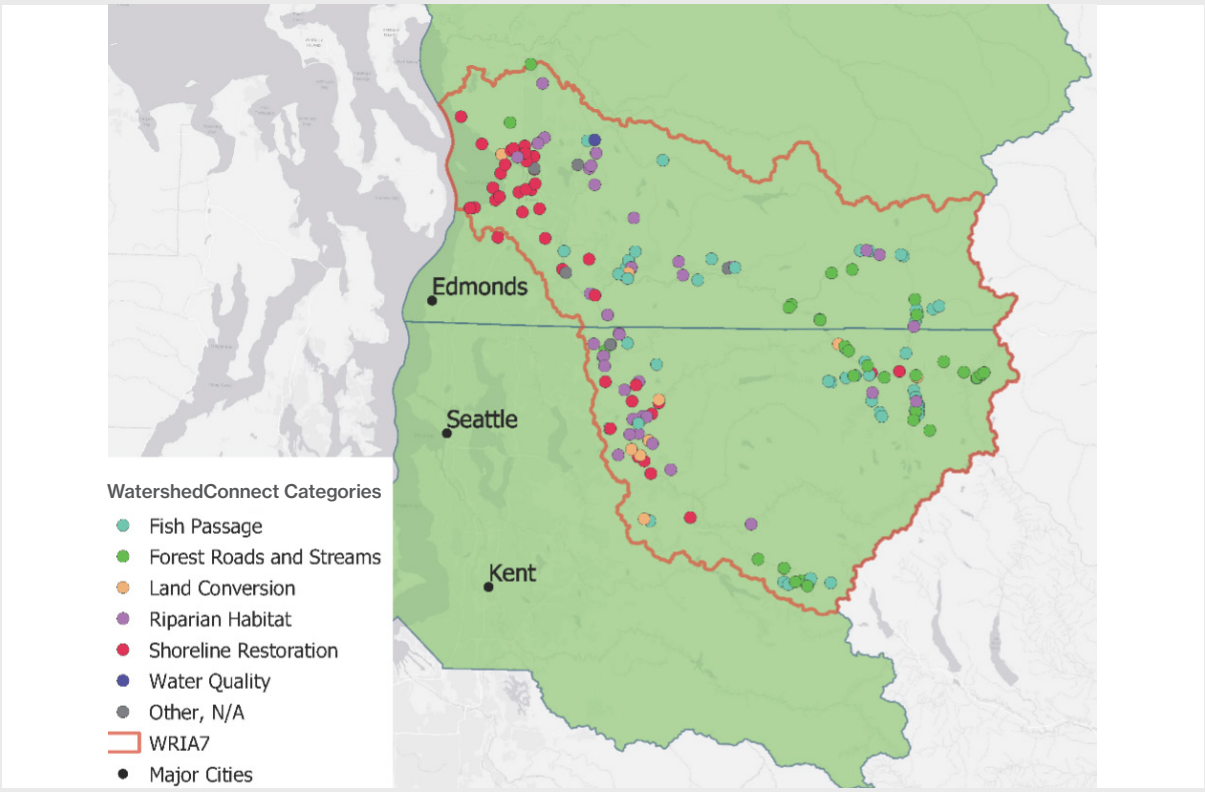
Restoration projects identified in the WatershedConnect tool for the Snohomish watershed total over $272 million with the median project costing $191,750. This study grouped recovery projects into six distinct categories that help characterize their economic impacts.hollow stars indicating half a ranking point.

projects for WRIA 7. The median project cost is $191,750. Table 1 breaks down the full cost of salmon restoration needs ($273 million) into the six economically distinct project types used in this study. More than two-thirds of the total cost is associated with shoreline restoration projects. Addressing this substantial identified need too slowly places salmon recovery in jeopardy. Concern exists among policy makers, scientists, and the public that the timeline implied by current levels of funding carries too much risk for salmon populations.

2.1.3 Implementing Salmon Recovery Projects

A primary goal for salmon recovery efforts in Washington is to increase the pace of implementation. This will require increased, stable public funding and increased private investment (WA GSRO, 2020).To assess the recovery timeline at current funding levels, this study sequenced projects for implementation based on project urgency, phase of development, the

Figure 2. WatershedConnect Projects in the Snohomish Watershed by Project Type



The Snohomish watershed (WRIA 7, red line) spanning King and Snohomish Counties. Colored dots represent the 275 projects by type assigned for this study (WatershedConnect, 2021).

endangerment status of the benefiting salmon species, the number of co-benefits identified (e.g., climate resilience), and longitude for connectivity projects, as identified in WatershedConnect. The Watershed Resilience Action Plan also sets goals for private funding, which is applied in reverse order to projects that may be less likely to be publicly funded in the near term. This ranking is only one possibility for the Snohomish watershed's salmon recovery projects, but it provides a fair estimate of when projects are likely to be completed under different funding scenarios. Historical levels of public funding for salmon recovery in the Snohomish watershed averaged $9.6 million per year over the past decade (WA DNR, 2019a), At that rate, the current salmon recovery need would take at least 29 years to address. This total does not consider the range of additional salmon recovery needs that have yet to be identified or valued (e.g., many passage barriers have been identified in WRIA 7 but lack sufficient information to establish reliable cost estimates).

Salmon recovery projects are varied in nature and in economic impact. Economic impact analyses require detailed characterizations of project costs to understand best how projects will affect the economy. Historical project expenditure records can be challenging to source, but public grantmaking agencies such as NOAA sometimes do record detailed expense records. Salmon Recovery is one restoration activity for which NOAA have recorded detailed expenditure information from grants funded under the 2008 American Recovery and Reinvestment Act (ARRA; Samonte et al., 2017b). These data provide an unusually rich economic characterization of recovery activities to form the basis of the Salmon Recovery multipliers used in this study.

2.2 ECONOMIC IMPACTS OF SALMON RECOVERY PROJECTS IN THE SNOHOMISH WATERSHED

Higher funding levels can significantly advance the timeline for salmon recovery in the Snohomish watershed. This study considered the impacts of approximately doubling historic annual public expenditures to $20 million (Low funding increase) and further increasing funding to $25 million per year (High funding increase). These increased funding levels were found to both accelerate the pace of restoration and increase annual economic impacts beyond what would be accomplished under historical, baseline funding levels. Current restoration needs would take 29 years to address at average historical funding levels but could be addressed in 14 years with Low funding increases supporting 283 total (i.e., direct, indirect, and induced) jobs and $14.9 million in annual wages. High funding increases could further reduce the timeline to 11 years supporting an average of 360 total jobs and $19.0 million in annual wages. Higher levels of funding may also enable more consistent annual project volume and employment under the assumption that projects are not commenced until full funding has been allocated.

Table 2 shows the annual full-time equivalent (FTE) jobs that would be supported under the increased Low and High funding. The FTE job impacts from conducting salmon recovery efforts in the Snohomish watershed will be supported by a diverse set of occupations. In addition to the need for skilled construction crews to work in aquatic environments, engineering and science technical consulting professionals and supporting staff are needed to successfully plan and execute salmon recovery projects. For example, nearly a third of employment in the professional,

Table 2. **Average Annual FTE Jobs and Wages Supported by Salmon Recovery in the Snohomish Watershed by Project Type for Low ($20 million, 14 years) and High ($25 million, 11 years) Funding.**

	LOW				HIGH			
	DIRECT	INDIRECT	INDUCED	TOTAL	DIRECT	INDIRECT	INDUCED	TOTAL
Jobs	65	107	111	283	82	137	141	360
Wages ($ MM)	$ 2.82	5.40	6.70	$ 14.92	$ 3.59	6.88	8.53	$ 18.99

Table 3. Economic Impacts of Spending $1 Million on Salmon Recovery Activities

	WAGES ($) PER MILLION $		JOBS PER MILLION $	
	DIRECT + INDIRECT	TOTAL EFFECTS	DIRECT + INDIRECT	TOTAL EFFECTS
Salmon Recovery	$450,196	$772,691	9.4	14.8
Shoreline Restoration	459,916	780,671	9.7	15.0
Fish Passage	435,646	761,412	9.0	14.4
Riparian Habitat	371,854	703,040	7.8	13.3
Water Quality	467,379	786,734	9.9	15.2
Forest Roads and Streams	426,980	758,608	8.8	14.3

scientific, and technical services sector provides administrative, business, and financial operations, management, or legal roles.

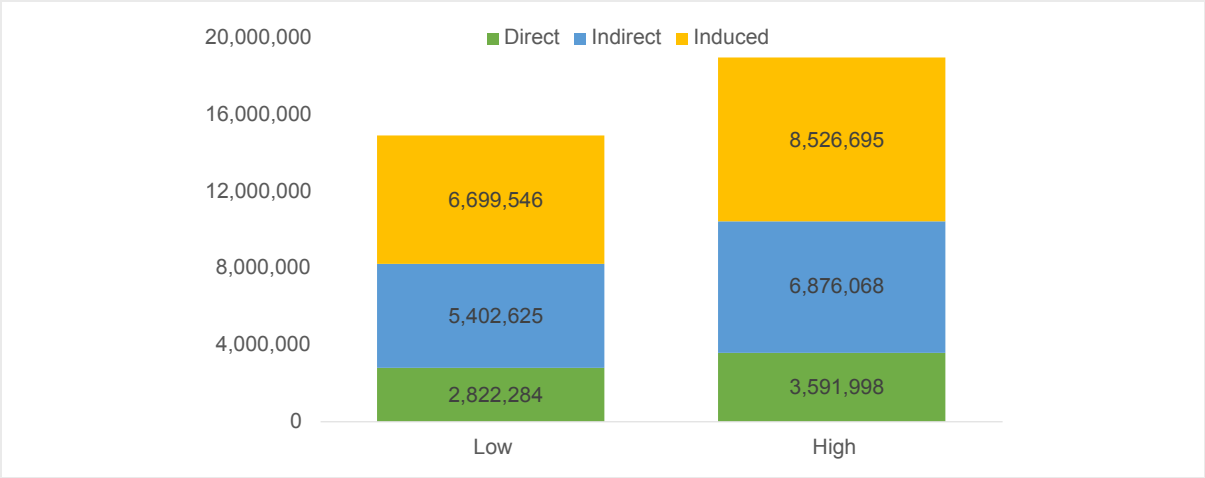
Multipliers calculated in this study based on IMPLAN 2018 and ARRA grant data indicate that $450,196 of every million dollars spent on salmon recovery in the Snohomish watershed stays in Washington as direct or indirect wages. Inclusive of induced effects, $772,691 of every million dollars (77 cents per dollar) spent on salmon recovery become wages for Washington residents. Every million dollars spent on salmon recovery supports 9.4 direct and indirect FTE jobs for a year and 14.8 FTE jobs inclusive of induced effects (see Table 3).

77 cents of every dollar spent on salmon recovery becomes wages for a Washington resident.

Figure 3 shows the total economic impact of increased funding levels under the two scenarios with wage benefits totaling $2.8 – 3.6 million in direct, $5.4 – 6.9 million indirect, and $6.7 - $8.5 million induced. Consistent with the identified need, shoreline restoration projects have the largest impact, supporting $10.3 and $13.2 million in total (direct, indirect, and induced) average annual wage impacts.

The total job and wage benefits of the salmon recovery scenarios identified in this analysis suggest that salmon recovery could offer significant economic benefits for residents in the Snohomish watershed. While offering significant economy opportunity, the job demands can be accommodated by the robust construction, engineering, and environmental consulting sectors, which employ tens of thousands in the surrounding King and Snohomish counties (IMPLAN Group LLC., 2018). While both funding increases address the same restoration need, the higher funding increases allow the need to be addressed sooner and support more jobs than lower funding levels.

Figure 3. Average Annual Wages (dollars) Supported by Salmon Recovery Projects



Forest Health

3.1 FOREST HEALTH IN EASTERN WASHINGTON

3.1.1 Timber Production and Restoration Economy

Eastern Washington's forest health crisis stems from the combination of a hotter and drier climate and overly dense forests that have developed from a century of fire suppression. Dense forest growth offers significant ground fuel that support wildfire spread and "ladder" fuel that enable wildfire to climb into the tree canopy. The forests in eastern Washington today contain as much as 300% more standing carbon relative to historic conditions (Harris, Scholl, Young, Estes, & Taylor, 2019). Restoring forest health and resilience will require mechanical treatment and removal of standing biomass as well as re-introduction of fire (WA DNR, 2018a). In many cases, the removal of timber is a by-product of restoring forest resilience. Commercially viable logging can help offset the cost associated with these restoration activities.

Forest health treatments supports a variety of economic opportunity including program administration, professional and scientific consulting services, forestry, logging and milling, and other goods production and services. Forest health treatments produce timber products that are important to the economic well-being of many rural communities in eastern Washington. Rasmussen and coauthors (2012) found that every $1 million invested in projects on federal lands supports between seven and 24 jobs. This study found that every $1 million spent on forest health supports 20-24 total jobs inclusive of direct, indirect, and induced effects.

Forest health activities rely on forest products infrastructure, including mills, transportation networks, and contracting capacity. Within the past five years, eastern Washington has 11 sawmills have operated at 10% to 30% below capacity and existing infrastructure in eastern Washington can process an estimated additional 20 to 61 million board feet (MMBF) of timber each year (Corrao, Corrao, & King, 2016). This study examined commercial treatments that would produce 245 to 343 MMBF/year inclusive of existing harvesting. Given the scale of the restoration need, additional infrastructure will be required to process restoration by-products and, therefore, capitalize on the economic benefits of increased forest management activities identified in the 20-Year Forest Health Strategic Plan: Eastern Washington. An aging workforce also poses challenges to meeting the identified restoration needs ("Northwest Forest Worker Safety," 2021).

Addressing forest health needs in eastern Washington at a meaningful scale will require significant public and private investments. The anticipated economic benefits of "solving the forest health crisis" need to be placed within the context of the costs associated with treatment. Over time, the cost of maintaining these treatments may be reduced through use of prescribed fire and managed wildfire, but significant up-front investments in mechanical treatments and additional policy changes are likely required to use fire-related tools at a landscape scale.

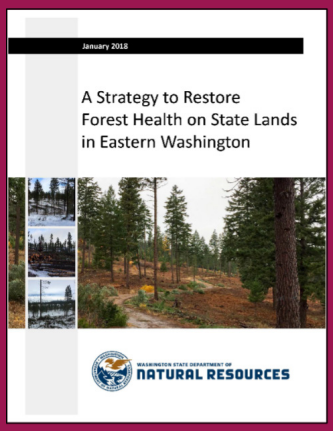
3.1.2 Forest Health Planning

Eastern Washington is home to ten million acres of state, federal, Tribal, and private forestlands (WA DNR, 2018a). More than 2 million of those forested acres are managed as state trust lands, with a codified fiduciary responsibility to generate income for public services for Washingtonians through sustainable timber sales and leasing. Increasing threats from drought, wildfires, insects, and disease in recent decades have led to growing emphasis on forest health as a top priority for forest management on state trust lands. Through programs like the Forest Improvement Treatment (FIT) program and from deeper coordination with managers of other land ownerships, DNR has taken on an expanded mandate to simultaneously address forest health while continuing to deliver revenue to its trustees.

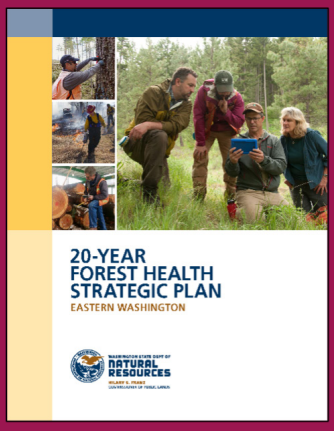
DNR has a long, active history of managing forested state trust lands through a variety of commercial and noncommercial activities. The expanding need for managing non-merchantable acres of forestland to preserve forest health and protect eastern Washington forests and communities has required innovative thinking by DNR. Expanded planning and action by DNR and cross-landscape management supported by Washington's Good Neighbor Authority have supported action across land ownerships.

DNR's multidivisional efforts have supported the identification of several important goals for eastern Washington's forestlands, including conducting 1.25 million acres of restoration treatments by 2037, reducing uncharacteristic wildfire risk, and enhancing economic development. Washington DNR's plans for coordinated, landscape-scale prioritization and action across land ownerships have been guided by complementary State Lands and All Lands strategies for eastern Washington. The State Lands strategy (WA DNR, 2018) outlines DNR's priorities to address forest health and continue providing economic support to eastern Washington in coordination with other land managers.

DNR's goal to support rural economic development through implementation of scientifically sound, landscape-scale forest health treatments will be driven by a wide range of forest management activities. These will necessarily include harvesting and forest thinning activities through commercial sales, in addition to noncommercial thinning, site preparation, controlled burning, and planting activities. The agency implements these activities on DNR-managed lands through a mix of DNR staff and contracted support, annually treating approximately 28,000 acres of eastern Washington state forestlands out of 64,000 total treatment acres across land ownerships. Eastern Washington's logging and forestry services sectors are an important part of its local economies, currently supporting 25,400 FTE jobs and $924 million in wages (IMPLAN Group LLC, 2018).



DNR state trust lands efforts have been supported by engrossed substitute house bill (ESHB) 1711 providing increased funding flexibility through the Forest Health Revolving Account and direction to factor forest health outcomes in prioritizing their work.



Washington's ESHB 2376 (§308) directed DNR to develop a 20-year forest health strategic plan (WA DNR, 2017) and was followed by senate bill 5546 that directed DNR to establish an assessment and treatment framework identifying 1 million acres of treatment by 2033.

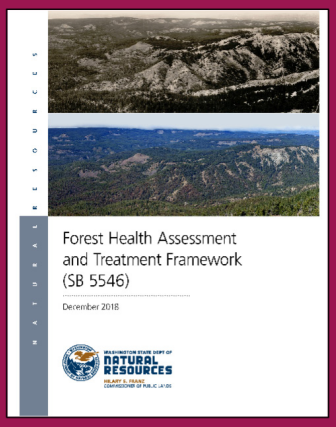
3.1.3 Forest Health Needs in Eastern Washington

Given the complementary forest health efforts across state trust lands and other land ownerships in eastern Washington, this study examined the economic impact of implementing (1) an All Lands forest health scenario to implement the 20-Year Forest Health Strategic Plan: Eastern Washington across multiple land ownerships, and (2) a State Lands forest health scenario based on expanding historical treatment efforts on state trust lands, exclusively, throughout eastern Washington. The scenarios assume different treatment levels for state trust lands. They are not additive for state trust lands and should be considered separately.

All Lands Scenario

To identify the areas of greatest forest health need in eastern Washington, DNR established a Forest Health Assessment and Treatment Framework ("the framework"). To date, DNR scientists have evaluated 4.4 million acres over 39 Priority Planning Areas (PPAs) identified within hydrological unit code (HUC) 6 watersheds throughout eastern Washington (Figure 4).

These landscape evaluations guide DNR in planning forest management activities and establish the acreages and treatments for the All Lands scenario in this study. Across 39 PPAs, the landscape evaluations have identified between 932,700 and 1.34 million footprint acres in need of treatment, most of which are likely to support commercial logging that could produce 245 to 343 MMBF of timber per year. Accounting for the number of treatments each acre receives yields 1.36 to 1.95 million treatment acres (Table 5). Most of the identified acres fall on



DNR prioritizes treatment with its assessment and treatment framework to:

1. Identify priority planning areas,
2. Conduct landscape evaluations,
3. Develop a landscape prescription, and
4. Develop a prioritized list of treatments (WA DNR, 2018c).

Table 4. All Lands Scenario Treatment Acres by Land Ownership and Treatment Type

	COMMERCIAL		NONCOMMERCIAL FOOTPRINT		NONCOMMERCIAL FOLLOW-UP		UNDER BURN		TOTAL	
LAND OWNERSHIP	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
U.S. Forest Service	325,827	454,405	20,817	31,457	174,911	246,484	27,170	45,668	548,725	778,015
Private	244,826	328,284	68,659	107,252	164,147	231,250	98,276	161,181	575,907	827,968
State Trust	84,831	119,926	3,044	4,460	76,388	110,968	17,046	30,056	181,310	265,410
Other Public	12,325	17,596	26,703	37,359	13,626	19,508	3,152	5,480	55,806	79,943
TOTAL	**667,810**	**920,211**	**119,224**	**180,529**	**429,071**	**608,211**	**145,643**	**242,385**	**1,361,748**	**1,951,335**

The All Lands scenario includes state trust lands + all other ownership types (listed in rows). Treatment acres equal the number of acres treated times number of times those acres are treated. Commercial treatments include those supporting logging activity such as certain thinning treatments and harvesting. Noncommercial treatments include planting, pile burning, and vegetation management. Under burn treatments include prescribed burning of vegetation not including pile burning. All acres except follow-up treatments are footprint acres. Follow-up treatments include additional non-commercial treatments on acres initially treated with commercial, non-commercial, or under burn treatments. Rows may not sum to total due to rounding.

U.S. Forest Service-owned and privately owned lands, underscoring the importance of DNR's Good Neighbor Authority for federal lands and DNR Landowner Assistance Office technical assistance and cost sharing on private lands.

Table 4 summarizes the total acres of treatment for the All Lands scenario. Restoring forest resilience at a landscape scale often requires conducting multiple forest health treatments on the same acre. For example, an area that received a mechanical thinning may require a follow-up treatment of prescribed fire. On average, DNR assumes that 50% of the commercially treated acres and 25% of noncommercial and prescribed burn treatments outside of state trust lands will receive follow-up noncommercial treatments. Follow-up treatments on state trust lands are higher due in part to DNR's fiduciary responsibility to generate revenue for trust beneficiaries, with 80% of commercial and 50% of prescribed burn acres receiving follow-up treatments such as site preparation and replanting. Thus, total treatment acres are higher than the anticipated footprint acres (see Table 5).

State Lands Scenario

The State Lands scenario includes only acres under the state trust lands ownership and covers the entirety of eastern Washington (i.e., not just PPAs). Similar to the All Lands scenario, the State Lands scenario considers low- and high-level implementations of intended treatments that differ from state trust totals under the All Lands scenario. Acreage totals for state trust lands in the State Lands scenario were distributed based on historical activity, with the addition of 9,000 to 15,000 acres of prescribed burning. Total acreage in the State Lands scenario on state trust lands throughout eastern Washington ranges between 336 (low) and 432 (high) thousand total footprint acres (Table 5, excluding follow-up treatments). State Lands acreage in all of eastern Washington is approximately two times larger than the acreage identified for state trust lands in the All Lands cases.

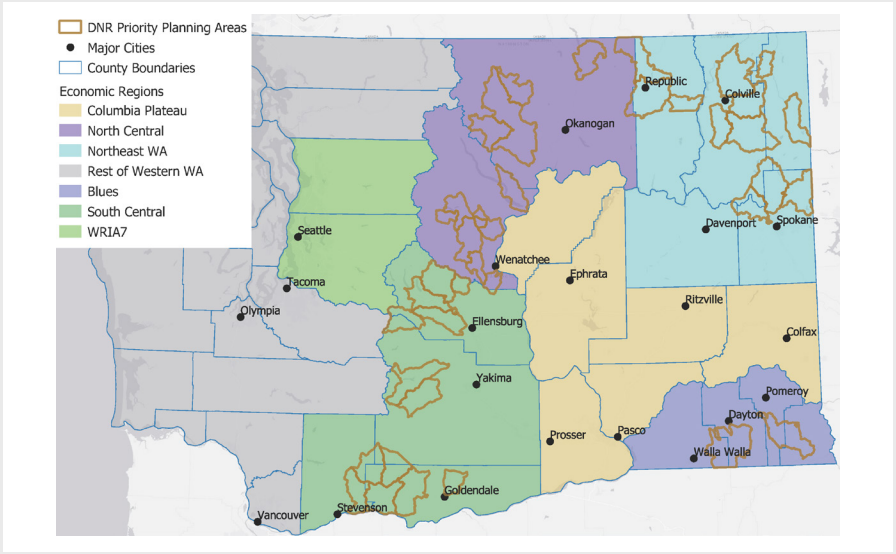
Considering implementation occurring between now and 2037, the State Lands scenario acreage implies 16,800 to 21,600 footprint acres producing 65 to 85 MMBF of timber per year. Treatment acres in the State Lands scenario total 507,000 to 643,000 acres (see Table 5).

Table 5. State Lands Scenario Treatment Acres by Treatment Type and Implementation Case

	LOW	HIGH
Commercial	184,134	241,958
Noncommercial Footprint	80,736	87,416
Follow-Up Treatments	171,300	211,531
Total Burn	71,601	102,977
Total	**507,771**	**643,882**

The State Lands scenario includes only state trust lands. Treatment acres equal the number of acres treated times number of times those acres are treated. Commercial treatments include those supporting logging activity such as certain thinning treatments and harvesting. Noncommercial treatments include planting, pile burning, and vegetation management. Total burn treatments include prescribed burning of vegetation and pile burning. All acres except follow-up treatments are footprint acres. Follow-up treatments include additional non-commercial treatments on acres initially treated with commercial, non-commercial, or under burn treatments. Rows may not sum to total due to rounding.

Figure 5. Washington Counties, Economic Analysis Regions, and Forest Health Priority Planning Areas



3.2 ECONOMIC IMPACTS OF FOREST HEALTH TREATMENTS IN EASTERN WASHINGTON

DNR has outlined an ambitious and necessary vision for restoring forest resilience in eastern Washington in the coming decades. The scale of forested acreage and its spread across land ownerships underscore the importance of DNR's "all hands, all lands" approach to forest health. This study estimated that the annual cost of implementing the All Lands scenario over a 20-year period range between $85.3 (low) and $145.2 (high) million per year. These costs, summarized in Table 6, cover only the first 39 priority planning areas (PPAs) DNR has evaluated. More PPAs are undergoing evaluation for forest health needs. State lands have more treatment acres in the State Lands scenario than the All Lands scenario, but total costs remain lower. Treatments on state lands in the All Lands scenario include higher cost commercial treatments such as cable logging that are not included in the State Lands Scenario. Table 6 also summarizes total costs for the State Lands scenario, which totaled $9.8 to $13.2 million.

The relative scale of effort is evident across the expenditure categories. Forestry sectors (i.e., logging and forestry services) constitute the largest share of expenditure in the All Lands scenario at 50%. Lower average commercial treatment costs in the State Lands scenario makes the labor required to plan and manage the public administration of commercial treatment programs ("planning labor") the largest expenditure category there at 44%. Administrative labor costs in the All Lands scenario are higher proportional to the total treatment acres and are unlikely to be met by DNR staff alone, particularly at current staffing levels, suggesting a potential need for additional labor support.

Figure 6 and Figure 7 tally average annual wage impacts by impact type across the different analysis regions over the assumed 20-year period. Total wage impacts (i.e., direct, indirect, and induced) are comparable to total scenario expenditures in the State Lands scenario ($9.9 – 13.6 million per year) and slightly less than total

Table 6. **Estimated Annual Range of Costs of Implementing All Lands (state trust lands + all other ownership types) and State Lands (state trust lands only) Scenarios**

	LOW	HIGH	LOW	HIGH
Total	85,334,607	145,154,005	$9,774,320	$13,179,830
Road Construction	4,622,296	8,333,796	327,738	433,303
DNR Equipment and Materials	254,366	415,141	59,312	92,717
Forestry Sectors	42,938,474	73,609,931	3,554,992	4,540,065
Transportation	21,561,794	38,730,070	1,538,557	2,025,402
Planning Labor	15,957,678	24,065,068	4,293,720	6,088,343

Figure 6. **State Lands Scenario Average Annual Wage Impacts by Region, Including Direct, Indirect, and Induced Effects across Economic Analysis Regions**

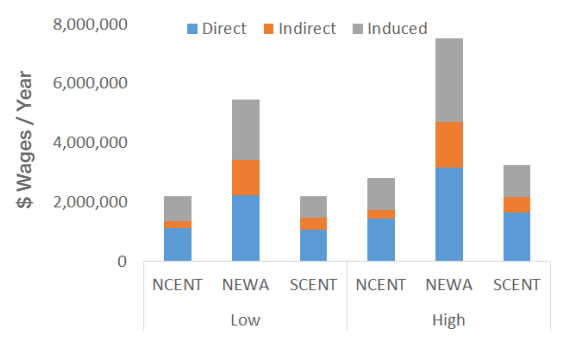
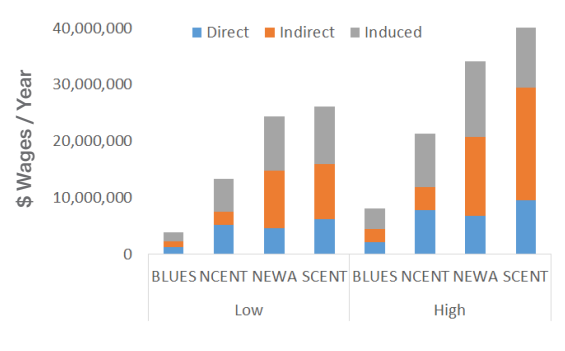


Figure 7. **All Lands Scenario Average Annual Wage Impacts by Region, Including Direct, Indirect, and Induced Effects across Economic Analysis Regions**



Economic analysis regions: North Central (NCENT), Northeast Washington (NEWA), South Central (SCENT), and Blues (BLUES).

expenditures in the All Lands scenario ($67.6 – 112.4 million per year). Total economic impacts are highest in the South Central region in the All Lands scenario and in Northeast Washington in the State Lands scenario as a result of higher acreages and, for All Lands South Central acres, higher treatment costs. Treatment costs vary depending on land ownership, treatment types, and harvest volume for commercial activities in the All Lands scenarios.

Addressing the treatment needs identified in the All Lands scenarios will require 270 to 415 direct FTE jobs in the low and high cases, respectively, sustained over the modeled 20-year implementation period. Public-sector employment including public sector jobs to manage and administer forest health treatments could alone require the creation of 232 (low) to 350 (high) FTE jobs. Direct jobs totals are unlikely to place an undue growth burden on Eastern Washington's forestry sectors (i.e. forestry, logging, and support services), which collectively support approximately 29,000 jobs (IMPLAN Group LLC., 2018). The All Lands scenario will also support 1,248 (low) to 2,156 (high) indirect and induced FTE jobs throughout Washington's economy. Total job impacts are 1,518 (low) to 2,572 (high) average annual FTE jobs supporting the All Lands scenario's implementation (Table 8). Job impacts for the State Lands scenario range from 199 (low) to 272 (high).

Indirect and induced jobs will be active throughout the Washington economy supporting a variety of types of employment. The significant amount of labor required to implement the All Lands strategy will require coordination and management effort in addition to frontline skilled-trade work. For example, 22% of Washington's agriculture, forestry, and fisheries workforce is employed in office and administrative support roles and 9.2% is employed in management roles (BLS, 2021a, 2021b). For each job active in production, transportation, and materials-moving occupations in the agriculture and forestry sectors, 2.4 are active in other occupations such as administration, management, and maintenance and repair occupations.

Table 7. Average annual FTE job impacts from implementing the All Lands scenario

	DIRECT		INDIRECT		INDUCED		TOTAL	
	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
Blues	21	35	25	60	49	107	95	203
N. Central	91	143	67	114	164	267	323	524
NE. Washington	68	98	202	280	228	320	498	698
S. Central	90	140	230	468	282	540	602	1,147
Total	**270**	**415**	**525**	**922**	**723**	**1,234**	**1,518**	**2,572**

Conclusion

Washington State DNR's strategic planning is designed to support delivering on DNR's mission to "manage, sustain, and protect the health and productivity of Washington's lands and waters to meet the needs of present and future generations" (WA DNR, n.d.). The challenges facing Washington's forests, fish, and communities have become more complex and urgent with a changing climate. Extreme heat, drought and wildfire are becoming more frequent and intense, leading to increasing costs to agencies, forest ecosystems, and communities. In the last decade, Washington State has experienced hundreds of millions of dollars in wildfire suppression expenses with longer-term consequences still unfolding. The rising costs of wildfire could far outstrip the costs to prevent them through sound forest management. With public support, DNR's strategies and public investment can help improve fire resilience, restore ecosystems, and support Washington's rural economies with over 2,000 jobs and $80 million in annual wages.

Changes in precipitation patterns, warming temperatures, and expanding infrastructure are also making salmon recovery efforts more critical than ever to save species threatened by extinction and restore our watersheds to more resilient states. Significant recent investments and partnerships have helped the Hood Canal Summer Chum and Snake River Fall Chinook make important strides toward recovery, and renewed investments can continue to support salmon recovery in the Snohomish and other watersheds across the state. Doubling historical funding for salmon recovery in the Snohomish watershed can cut the restoration timeline by 15 years and support over 283 jobs and $12.5 million in wages annually for 14 years.

DNR efforts to address climate resilience will require the support and engagement of the state legislature, community leaders, and agency partners. DNR's strategic plans can guide the identification and prioritization of restoration projects worthy of public investment through continued collaborative efforts with its many stakeholders. As the agency continues to expand salmon recovery and forest health efforts, it will be important to monitor ecosystem and economic progress. Restoring Washington's public lands for a more climate-resilient future has the potential to offer a diverse set of shared environmental and economic benefits across Washington's ecosystems and communities.

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Appendices

6.1 IMPLAN DISCLAIMER

The following disclaimer is provided and recommended by IMPLAN Group, LLC, which provided the underlying data for our study. The multipliers used in our study were independently calculated (see Miller & Blair, 2009) from underlying IMPLAN data, not exported from the IMPLAN software.

IMPLAN is a regional economic analysis software application that is designed to estimate the impact or ripple effect (specifically backward linkages) of a given economic activity within a specific geographic area through the implementation of its Input-Output model. Studies, results, and reports that rely on IMPLAN data or applications are limited by the researcher's assumptions concerning the subject or event being modeled. Studies such as this one are in no way endorsed or verified by IMPLAN Group, LLC unless otherwise stated by a representative of IMPLAN.

IMPLAN provides the estimated Indirect and Induced Effects of the given economic activity as defined by the user's inputs. Some Direct Effects may be estimated by IMPLAN when such information is not specified by the user. While IMPLAN is an excellent tool for its designed purposes, it is the responsibility of analysts using IMPLAN to be sure inputs are defined appropriately and to be aware of the following assumptions within any I-O Model:

- Constant returns to scale
- No supply constraints
- Fixed input structure
- Industry technology assumption
- Constant byproducts coefficients
- The model is static

By design, the following key limitations apply to Input-Output Models such as IMPLAN and should be considered by analysts using the tool:

- **Feasibility:** The assumption that there are no supply constraints and there is fixed input structure means that even if input resources required are scarce, IMPLAN will assume it will still only require the same portion of production value to acquire that input, unless otherwise specified by the user. The assumption of no supply constraints also applies to human resources, so there is assumed to be no constraint on the talent pool from which a business or organization can draw. Analysts should evaluate the logistical feasibility of a business outside of IMPLAN. Similarly, IMPLAN cannot determine whether a given business venture being analyzed will be financially successful.
- **Backward-linked and Static model:** I-O models do not account for forward linkages, nor do I-O models account for offsetting effects such as cannibalization of other existing businesses, diverting funds used for the project from other potential or existing projects, etc. It falls upon the analyst to take such possible countervailing or offsetting effects into account or to note the omission of such possible effects from the analysis.
- **Like the model, prices are also static:** Price changes cannot be modeled in IMPLAN directly; instead, the final demand effects of a price change must be estimated by the analyst before modeling them in IMPLAN to estimate the additional economic impacts of such changes.

16 See https://implan.com/citation-guidelines/#section3, accessed July 23,2021.

6.2 TECHNICAL APPENDIX

6.2.1 Multiplier Calculations

To calculate the economic impacts of salmon recovery and forest health, RTI relied on county-level IMPLAN 2018 data for Washington. RTI aggregated the county-level data to the analysis regions shown above and 35 sectors, including commercial logging (NAICS 113310) and forestry support services (NAICS 115310). RTI calculated direct, indirect, and induced multipliers using regional purchase coefficients (RPCs) based on IMPLAN's interstate and international trade estimates by sector for Washington. RPCs are a standard way of isolating the economic impact on a given region, excluding the impacts on regions outside the study area. RTI calculated multipliers for all 35 sectors across the six Washington regions. Reported economic impacts are on the entire state from activity originated in the analysis regions (differences between regional and statewide impacts were modest). RTI converted IMPLAN employee compensation and job counts to wages and FTE jobs using conversion tables from IMPLAN. Expenditures for each scenario were mapped to aggregated sectors including construction (e.g., forest roads), commercial (e.g., equipment and materials), and logging and applied using a "bill of goods" approach to input-output estimation. Direct impacts are based on planning labor and forestry expenses for the forest health scenarios and construction expenses for the salmon recovery scenarios. Direct and indirect impacts for other expenses under the bill of goods approach are counted as indirect. Impacts of direct planning labor wages are calculated as induced impacts based on local household spending patterns.

In the salmon recovery scenarios, spending patterns established by project category using American Recovery and Reinvestment Act (ARRA) grant data from NOAA formed the basis of a weighted average multiplier for the bill of goods approach. This approach provided RTI with six distinct salmon recovery project multipliers for each economic impact (e.g., wages, jobs). Salmon recovery land conversion projects were modeled as a direct payment benefit to households with induced impacts only. RTI calculated household induced multipliers based on prevailing consumption and investment patterns in the analysis regions for all scenarios. In the forest health scenarios, RTI counted the direct employment impacts from our bill of goods expenditure approach as direct employment because other expenditures are supported by DNR staff labor.

6.2.2 Salmon Recovery Data

ARRA-funded grants used in the Salmon scenario were required to report detailed expenditures by North American Industry Classification System (NAICS) code. Grantees completed these projects in 23 states across the United States. To maximize sample size, all ARRA projects with habitat types

and recovery activities relevant to Washington DNR salmon recovery efforts were included for cost characterization purposes in this study. The projects selected from the ARRA data included 38 relevant restoration projects with total expenditures broken out at the six-digit NAICS code level. Project descriptive variables between the WatershedConnect and ARRA data – project descriptions, habitat type, and limiting factor/technique – helped define common categories to which both sets of data could be mapped. Aggregated expenditures by project category and NAICS code established a pattern of actual expenditures on which economic multipliers for each of the project types were be established. In all categories of restoration, construction-sector costs are the plurality of the, if not most, expenditures. Table 8 summarizes the resulting expenditure shares for each restoration activity. Each column provides the fraction of total expenses for the restoration activity (column) spent in each economic sector as identified by the 6-digit NAICS codes in the ARRA data (rows).

Table 8. Expenditure Shares by Sector for Restoration Activities Relevant for Salmon Recovery

CODE	DESCRIPTION	RIPARIAN HABITAT	FISH PASSAGE	SHORELINE RESTORATION	WATER QUALITY	FOREST ROADS AND STREAMS
CNS	Construction	35.2%	59.3%	71.5%	76.0%	58.9%
AFS	Ag Forestry Support	2.2%				
AGR	Agriculture	3.2%	0.5%			
BOM	Balance of Manufacturing	0.4%				
COM	Commercial	27.0%	38.0%	28.5%	22.7%	212.3%
LOG	Logging		0.3%			
MAC	Machinery	7.6%				
PUB	Public sectors	24.4%	0.6%		1.3%	19.7%
TRA	Air Transportation		0.1%		0.1%	
WAT	Water utilities		1.2%			

DNR provided supporting data on identified salmon recovery projects in the Snohomish watershed. WatershedConnect data include location, type, and cost attributes for projects in addition to the stage of readiness for funding consideration. RTI approximated the readiness of projects for implementation by their benefit category, phase, whether they supported endangered salmon species, and the number of co-benefits identified in the WatershedConnect tool. Annual funding was then allocated to each project in order with no projects commenced until fully funded.

6.2.3 DNR Landscape Evaluations

The landscape evaluations for each PPA relied on remote sensing data to estimate the forest structure and composition relative to historical conditions, which informed an estimate of total restoration need. DNR estimated treatment needs by land ownership based primarily on land ownership acreage shares within a given PPA. Forest conditions for each PPA, including the type, size, and location, indicated probable treatment needs of commercial logging, noncommercial treatment, or prescribed burning.

DNR scientists estimated both low and high footprint acreage totals by PPA, land ownership, and treatment type. Footprint acres are the number of physical acres to be treated at any point. Treatment acres multiply footprint acres by the number of times they receive treatments, which provides a better indication of total treatment cost. DNR provided treatment specific costs and the identified acreages by land ownership and scenario in the PPAs for this analysis.

6.2.4 Forest Health Treatment Costs

The long history of conducting commercial and noncommercial treatments on state trust lands has afforded DNR valuable information on the costs of performing a variety of treatments. DNR provided historical treatment acreages and costs in addition to treatment-specific estimated acreages and timber volumes by land ownership from the PPA landscape evaluations. DNR defined the economic analysis regions on county boundaries and provided PPA acreages by county as some PPAs span multiple counties. The study required mapping treatments from non-state land ownerships to common treatment categories for cost assignment (cost assumptions discussed below). DNR provided historical contract costs for non-commercial treatments and additional cost estimates for certain treatments without historical contract activity or treatments on other land ownerships. All costs are in 2021 dollars.

DNR cost data delineate contract labor hired from logging or forestry support services businesses. Although the level of treatment costs on other landownerships is less well covered by DNR data, treatment levels are well documented. This study includes a combination of state trust land costs and historical treated acres for forest service lands to estimate a weighted average cost per acre for noncommercial treatments. Noncommercial treatments and costs on ownerships outside of state and federal lands were provided by DNR staff based on intra-agency communication with DNR Landowner Assistance Program staff. In part because of the smaller scales, noncommercial costs on private lands were significantly higher than on state and federal lands. DNR staff also provided estimates for commercial logging and prescribed burning costs.

To disaggregate commercial logging costs, this study relied on DNR expenditure data from the FIT program delineating on-board truck (OBT), transportation, and road construction costs. DNR OBT costs ranged from $105 to $160 per thousand board feet (MBF) for ground removal to $395/MBF for sky removal. DNR also provided administrative staff cost information for commercial sales of $35 to $41/MBF, which were applied to all commercial activity for this study based on landscape evaluation estimated (All Lands scenario) or historical (State Lands) timber volumes per acre. These costs cover DNR staff time to plan and administer the state's timber sales programs. This study assumes the same relative costs would apply to timber sales on other land ownerships. Total staff costs to facilitate commercial and noncommercial treatments comprise approximately 45% of total direct costs in both the All Lands and State Lands scenarios.

DNR indicated that 87% of DNR noncommercial agency treatment costs were labor related, with the remaining 13% going to equipment and transportation expenses. Contract labor and seedlings constituted additional DNR noncommercial treatment costs. DNR provided cost estimates for noncommercial treatments on private lands ranging from $850-1,300 in addition to DNR staff costs to facilitate these treatments. Total costs per acre averaged across commercial and noncommercial treatments in the State Lands scenario were approximately $400 per acre. Average costs per acre for the All Lands scenario are higher at $1,401 per acre owing to higher-cost land ownerships (e.g., private lands), more extensive use of prescribed burning and cable logging, and higher assumed commercial treatment costs.

6.2.5 Labor Force Assessments

Occupational data were compiled for the state from the Bureau of Labor Statistics' Occupation, Employment, and Wage Statistics (OES) data at a 2-digit NAICS-code level (BLS, 2021a, 2021b; Standard Occupational Classification System codes 43-0000 and 11-0000, respectively). Iterative proportional fitting techniques were used to estimate the number of people employed in Washington in a given industry and in a given occupation from OES data.

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