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MEMORANDUM | July 30, 2024

TO Washington Department of Natural Resources (DNR)

FROM Industrial Economics, Incorporated (IEc) and Haley & Aldrich

SUBJECT Preliminary Findings of the Updated Economic Analyses of Water Typing Rule Options

The Washington State Department of Natural Resources (DNR) engaged Industrial Economics, Incorporated (IEc) to develop a Cost-Benefit Analysis (CBA) and a Small Business Economic Impact Statement (SBEIS) of a rulemaking to amend the forest practices water typing system rules. The IEc Team includes economists and resource management and policy analysts at IEc, and fish biologists at Haley & Aldrich.[1] This memorandum presents the preliminary results of our analysis of six regulatory alternatives in order to support the Forest Practices Board's identification of a proposed rule.

This memorandum begins with a high-level overview of the rule background and objectives (Section 1) and specifies the framework for the economic analysis (Section 2). We then summarize our key findings related to the probable costs and benefits of the regulatory alternatives (Section 3). Section 4 details the technical approach, key assumptions, and data sources relied upon, including the analytical methods applied to evaluate each category of potential costs and benefits that led to our determination regarding 1) whether those effects are probable (i.e., likely to be an outcome of the rule); and 2) the potential magnitude of the effect (i.e., major, minor, or negligible with quantitative information, where feasible). Section 5 includes a discussion on the weighing of probable costs and benefits. Finally, Section 6 describes our initial findings related to the small business economic impacts.

1. Background and Objectives

In 1999, a collaboration of federal, state, tribal, and county governments, and private forest landowners, presented the Forests and Fish Report (FFR) to the Washington Forest Practices Board and Governor's Salmon Recovery Office to recommend, "…biologically sound and economically practical solutions that will improve and protect riparian habitat on non-federal forest lands in the State of Washington." The FFR, which provides the foundation for addressing forest management as part of Washington's Statewide Salmon Recovery Strategy, includes riparian forest management provisions that prescribe restrictions and conservation measures based on "stream type." Stream types are divided into shorelines (Type S), fish habitat (Type F), and seasonal and perennial streams that are neither shorelines nor fish habitat (Type Ns and Np streams, respectively).

In 2001, the Forest Practices Board adopted two rules to work toward a systematic approach for identifying water types. The first rule (WAC 222-16-030), which specified a GIS modeling approach to establish Type F waters, was never implemented as the model did not meet its targeted accuracy requirements. The second rule

[1] IEc is an economics and public policy consultancy with 40 years of experience information environmental and natural resource management decisions (www.indecon.com). Haley & Aldrich is an environmental and engineering consulting firm with significant experience in fish and water resources modeling in Washington State (https://www.haleyaldrich.com/).

(WAC 222-16-031) is currently implemented across the state and specifies an interim water typing system based on fish presence and not fish habitat. The Forest Practices Board is now developing a rule that specifies a consistent, permanent system for determining water types in accordance with the FFR. The Forest Practices Board's objectives for this rulemaking are to reduce the use of electrofishing and to reduce the potential for subjectivity when classifying stream water type. The proposed rule includes two separate elements to identify Type F and N streams across the state:

1. *Specifying an anadromous fish floor (AFF).* The anadromous fish floor delineates the stream extents that support anadromous fish and where anadromous fish are presumed to be present. Stream length specified as the AFF would be managed as Type F and would not require typing by landowners to determine appropriate management requirements.

2. *Prescribing the Fish Habitat Assessment Method (FHAM) as the protocol for all future stream typing surveys.* FHAM provides a consistent means of identifying the extent of fish habitat, removing ambiguity and subjectivity associated with the approach for identifying Type F stream.

Of note, the rule would not affect concurred F/N breaks for Type F or N streams that have already been permanently typed, following the Forest Practice Board's decision in May 2017.

The Forest Practices Board determined that a CBA will be required for the proposed water typing rule pursuant to Revised Code of Washington (RCW) 34.05.328. Once the Board identifies a proposed rule, the objective of the CBA is to provide information to allow the Board to, "[d]etermine that the probable benefits of the rule are greater than its probable costs, taking into account both the qualitative and quantitative benefits and costs and the specific directives of the statute being implemented." (RCW 34.05.328(1)(d))

This memorandum provides information to support the selection of a proposed rule as follows:

1. Results of a preliminary analysis of the probable costs and benefits of six regulatory alternatives (two alternatives for the definition of the AFF each paired with three options for the FHAM survey protocol).

2. Insight to support the Board determination, as required under RCW 34.05.328(1)(e), "that the rule being adopted is the least burdensome alternative for those required to comply with it that will achieve the general goals and specific objectives stated…"

3. Pursuant to RCW 19.85, a Small Business Economic Impact Statement (SBEIS) is required if the agency determines that the proposed rule will impose "more than minor costs" on businesses in an industry. The objective of the SBEIS is to determine whether the rule will have a disproportionate cost impact on small businesses, and if so, where legal and feasible, to reduce the costs imposed by the rule on small businesses (RCW 19.85.30). This memorandum provides insight regarding the need for an SBEIS of the proposed rule, and the initial findings with respect to whether the rule options would likely have a disproportionate effect on small businesses.

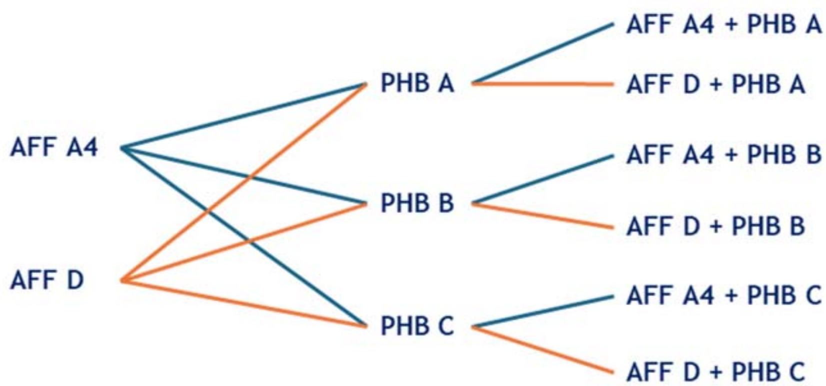
2. Framework for the Economic Analysis

This section summarizes our structured approach to evaluating the probable costs and benefits of the regulatory alternatives identified by DNR and stakeholders. It provides information on the scope and scale of the analysis, a conceptual model of how the regulatory alternatives may generate costs and benefits, and overarching analytical assumptions.

2.1. Regulatory Alternatives

This analysis considers the economic effects stemming from the two AFF alternatives (AFF A4 and AFF D) as well as the three potential habitat break (PHB) options that will serve as guidance for implementing FHAM protocol surveys under the rule (PHB A, PHB B, and PHB C). The combinations of AFF and PHB options result in a total of six regulatory alternatives evaluated in this memorandum, as presented in Figure 1. The costs and benefits stemming from these alternatives are presented separately.

Figure 1. Six Regulatory Alternatives



2.2. Analytic Approach and Methods

This analysis assesses costs and benefits that are "probable" effects of the rule, consistent with RCW 34.05.328. To determine whether an effect is "probable," we employ statistical models and logic to ensure consideration of those costs and benefits that can be considered likely outcomes of the rule. Where we determine the effect is likely, we use the best available information to provide perspective on the magnitude of the effect. Where possible, we describe magnitude in quantitative and monetized terms; otherwise, the effects are described qualitatively. For all probable quantitative and qualitative effects of the rule, we categorize effects as either major, minor, or negligible.[2]

Importantly, we do not estimate a single benefit-cost ratio for each alternative. This is because data limitations prevent a reliable analysis of the economic value for important categories of costs and benefits, particularly the ecological effects. Given this, we provide qualitative descriptions for some categories of costs and benefits that are meaningful to consider in weighing probable costs and benefits. A benefit-cost ratio that relies only on the monetized values would misrepresent the weighing of probable costs and benefits. In regulatory contexts such as this, where important categories of benefits or costs cannot be monetized, representing the findings of a benefit-cost analysis using a single ratio is inappropriate. Further, according to RCW 34.05.328, the objective of the CBA for a proposed rule is to evaluate the alternatives to determine whether the probable benefits of the rule outweigh the probable costs, *taking into account both quantitative and qualitative impacts*. This framing underscores the importance of a comprehensive weighing of all probable cost and benefit categories regardless of whether they are quantified or monetized. Given the limitations in valuing several of the ecological effects, this analysis additionally provides perspective on the potential magnitude of values based on existing empirical research.

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[2] In general, effects are considered "major" if the magnitude at the state level is in the millions of dollars on an annualized basis whereas "minor" denotes hundreds of thousands of dollars on an annualized basis and "negligible" is anything less.

The methods, data sources, and assumptions underpinning this analysis were documented in a Memorandum (dated March 27, 2024) that was circulated to and received feedback from several groups, including the DNR and the Economic Working Group. The evolution of our approach has also benefited from feedback from various stakeholders, including timber industry representatives, conservation interests, Tribes, and other state agencies, including the Washington Department of Fish and Wildlife (WDFW) and the Washington Department of Ecology (Ecology). Each of the sections that follows describes the methods we employed to evaluate specific categories of costs and benefits of the regulatory alternatives.

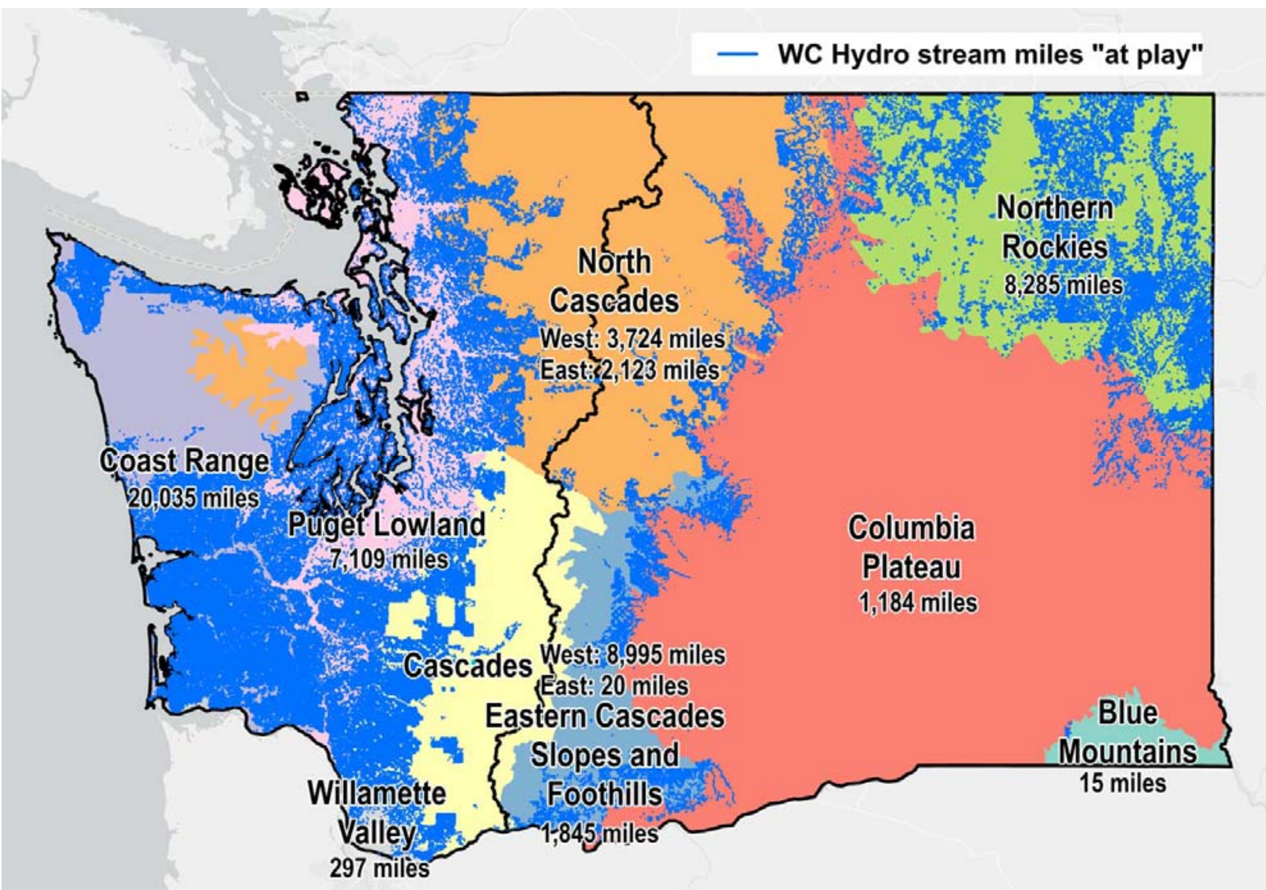
For framework and methods topics for which Washington State guidance and requirements are not prescribed, we generally follow best practices in regulatory cost benefit analysis documented in the White House Office of Management and Budget (OMB)'s Circular A-4 (OMB 2023). Other key considerations include:

- **Rulemaking scope:** The rulemaking applies to private, state, and other local forest landowners in Washington State that require information about whether streams intersecting their forestland are Type F or N. The rule does not apply to Federal and tribal forestland owners and does not influence streams that have been permanently typed. The rule maintains the current option in the interim rule for landowners to type their streams by referring to a set of default physical characteristics (DPCs).
- **Geographic scope and scale:** The main objective of this analysis is to determine statewide effects of the rule alternatives. We disaggregate our findings with respect to western Washington and eastern Washington, where the divide line between the two is the summit of the Cascade Mountains. This is especially important when comparing impacts across regulatory alternatives as PHB A only applies to western Washington. Where feasible, this analysis also quantifies and summarizes effects by ecoregion; these results are presented in tabular format in the attached appendix. While the economic effects findings will vary from the average at any specific site, the aggregated ecoregion-level effects reflect a reasonable estimate. Figure 2 conveys the geographic scope of our analysis and describes the distribution of stream miles by ecoregion and side of the state.
- **Baseline:** We estimate the incremental costs and benefits for each proposed rule option by comparing water typing in Washington under two scenarios: the world with the proposed rule options and the world without the proposed rule options. The world without the proposed rule reflects the regulatory baseline for the analysis. An important aspect of the baseline is the current practice for determining water types under the interim rule. It also includes current and expected future industry practices with respect to water typing approach and implementation.
- **Dollar year of 2023:** For consistency, we report all monetized effects of the rule options in consistent 2023 dollars.
- **Timeframe of 55 years:** The incremental costs and benefits begin to accrue as soon as the rule is implemented, which we define as when the AFF is established and landowners begin implementing FHAM, and will persist as long as the rule is in effect. Where feasible, the analysis evaluates economic costs and benefits over a 55-year time period between the year the rule would take effect (estimated to be 2025) through 2079. This timeframe is tied to average harvest rotations in eastern Washington and balances the need to capture the important benefits of the rule that grow over time (i.e., ecological benefits), with increasing uncertainty regarding the socioeconomic and biophysical state of the world over longer timeframes.
- **Social discount rate of two percent (2%):** Consistent with Circular A-4, the analysis employs a two percent social discount rate to account for the timing over which costs and benefits accrue. OMB's current guidance identifies that a two percent discount rate accurately reflects the real rate of return on

long-term U.S. government debt, which provides a "fair approximation of the social rate of time preference" (OMB 2023, p. 76). We assess the sensitivity of our results to our underlying discount rate assumption by employing an alternate discount rate for some effect categories. In particular, we consider how the magnitude of timberland value changes when applying a private market discount rate. Our discounting assumes 2023 as our base year (same as our dollar year), and we present findings in annualized terms for comparability given that different effects occur at different points in time over our 55-year analysis timeframe.

- **Separate social welfare effects and regional economic impacts:** The regional economic impacts of the proposed rule alternatives (i.e., changes in employment, income, value-added) are distinct measures of economic change and are presented separately, where applicable, and not summed with the social welfare costs and benefits.
- **Uncertainty analysis:** Key sources of uncertainty are documented throughout the analysis. In addition to calling attention to these sources of uncertainty, we describe how the uncertainty may result in under- or over-estimating incremental costs and benefits as well as the implications for the findings of the analysis. In this memorandum, we assess the sensitivity of our results to different assumptions for some effect categories. The Preliminary Draft CBA will include a more robust consideration of uncertainty for the Proposed Rule.

Figure 2. Streams within Forestland Potentially Affected by the Rule Options



Source: IEc map using DNR's WC Hydro

2.3. Potential Effects of the Regulatory Alternatives

The regulatory alternatives have the potential to generate costs and benefits in three primary ways:

1. **Effects associated with conducting stream typing according to the AFF and FHAM.** The AFF will identify the streams that will be established as Type F streams for the protection of anadromous fish. With few exceptions, streams included in the AFF will not require stream typing surveys. All streams outside of the AFF that are subject to the rule and are not already permanently typed would require a FHAM protocol survey to determine stream type.
2. **Effects of reducing electrofishing.** One objective of the proposed rule is to reduce the use of electrofishing in stream typing. This analysis considers the potential for ecological and economic benefits due to this change.
3. **Effects associated with potential changes in the extent of Type F stream.** We consider the effects of both the AFF and the implementation of FHAM protocol survey methods on the extent of Type F stream that would be identified under the rule alternatives relative to the baseline. All stream included in the AFF will be Type F. We then consider, beyond the AFF, whether and how the alternatives for implementing FHAM may identify a different location of the F/N stream break relative to where it would be identified under the baseline. If the F/N stream break identified is upstream under the rule as compared with baseline stream typing practices, the length of Type F streams is increased and the length of Type Np streams is reduced; where the F/N stream break identified is downstream under the proposed rule as compared with baseline practices, the length of Type F streams is reduced and the length of Type Np streams is increased. Differences in the extent of Type F stream under the alternatives in turn influence the size of the riparian buffer and the requirements and constraints on activities within the riparian buffer for Type F versus Type N streams in accordance with existing Forest Practices Act regulations.

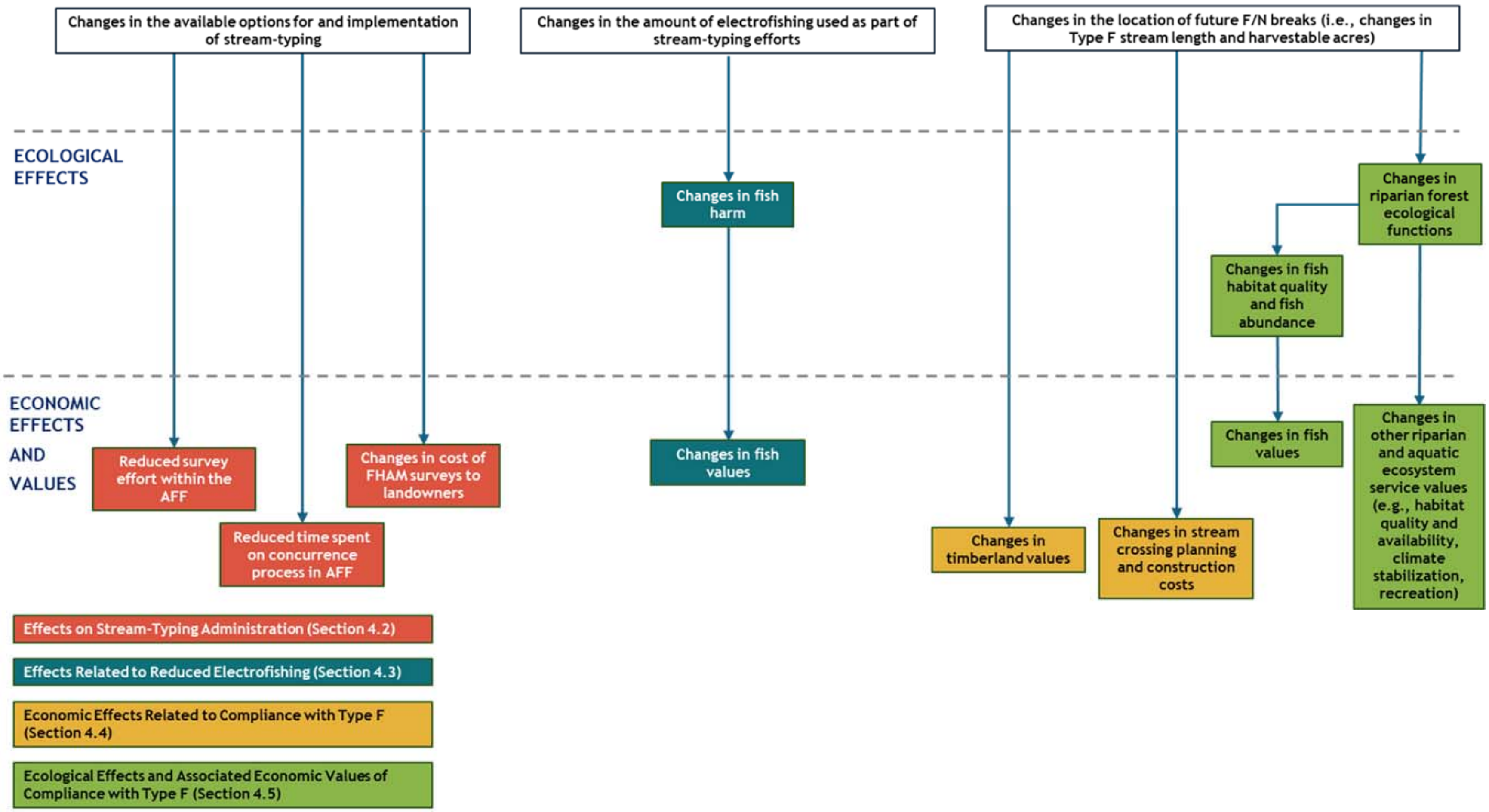
References to "baseline" F/N breaks refer to the predicted location of F/N breaks based on implementation of survey methodology under the current interim rule. This reflects the best available information on the expected location of the stream breaks absent changes in stream typing methods.

References to "differences," "changes," or "movements" in F/N breaks do not imply that the proposed rule alternatives will create new fish habitat. Instead, they refer to the difference in location of baseline F/N breaks and the predicted location of F/N breaks as identified under the proposed rule alternatives.

The PHB options consider different definitions for how to identify habitat breaks when conducting protocol surveys. Given the differences in definition for the PHBs, the spatial analysis identifies different locations of the stream breaks. Ultimately, permanent breakpoints in the future will be determined based on an established concurrence process. However, this analysis is focused on the economic costs and benefits associated with the identified PHB options. The spatial analysis of these options reflects the best available information on the expected locations of the stream breaks under the PHB options.

Figure 3 characterizes these three categories of effects with the consequent ecological outcomes (where relevant) and economic effects. As evident from the figure, most categories of costs and benefits associated with the rulemaking flow from the potential change in Type F stream length.

Figure 3. Potential Incremental Rule Effect Categories



Note: A primary goal of this analysis is to determine which of these effect categories are probable. For the probable categories, we assess the magnitude in terms of major, minor, and negligible effects of the rule.

3. Summary of Findings

Following are the high-level findings of our analysis detailed in Sections 4, 5, and 6 of this memorandum:

1) **This analysis identifies several probable outcomes of the rule options.** These probable outcomes include numerous effects resulting from the changes in extent of Type F stream, in particular changes in timberland values associated with timber harvest restrictions in riparian buffers, changes in costs of stream crossing upgrades, and changes in fish abundance and other ecological effects associated with forested riparian habitat protection. For all rule options, the establishment of an AFF and codifying the FHAM survey protocols result in a reduced risk of future harm to fish through electrofishing.

2) **Data and discussions with experts reveal several other theoretical effects of the rule that are we determined are not probable.** Figure 3 identifies all effect categories investigated as part of this analysis, some of which were determined not probable outcomes of the rule options. The effects we determined are not likely to result from the rule options include 1) changes in the resources devoted to administering surveys and the concurrence process within the AFF (i.e., that landowners within the AFF may still elect to survey and pursue permanent stream typing when they believe the AFF incorrectly identifies fish habitat), 2) changes in the cost of administering surveys beyond the AFF (i.e., that implementing FHAM is unlikely to cost more or less than implementing a protocol survey), and 3) changes in fish harvest allocations (i.e., fish abundance changes are unlikely to reach levels that will affect harvest allocations). The analysis also demonstrates that changes in the area available for timber harvest is unlikely to result in regional economic effects (e.g., employment and value-added effects) and that any changes in recreation activity attributable to the rule is also unlikely to generate economy-wide impacts.

3) **When assessing the magnitude of the probable effects, we find significant differences across regulatory alternatives associated with the AFF options.** The biggest driver of the difference in effect sizes and directions across alternative is driven by the AFF options. Using spatial data from Four Peaks combined with other statistical and geospatial analysis, we determine that the sizes of the AFF A4 and AFF D are significantly different. However, the 3 PHB options are not meaningfully different from one another when applying statistical tests. Therefore, our discussion refers to the rule options that include AFF A4 and the rule options that include AFF D.

4) **The main drivers of the direction and magnitude of the effects of the rule are driven by changes in Type F stream length.** The rule options that include AFF A4 result in a major increase in Type F stream. In total, we identify approximately 5,800 additional Type F stream miles in western Washington and 1,200 stream miles in eastern Washington attributable to these rule options. On the contrary, the AFF D alternatives result in a relatively minor reduction in Type F stream, driven by implementation of FHAM. This includes a reduction in 1,300 Type F stream miles in western Washington and 250 stream miles in eastern Washington relative to the baseline.

5) **Significant differences across ecoregions**. For AFF A4, the increase in Type F stream length is concentrated in the Coast Range ecoregion (western Washington), consistent with the number of untyped stream miles on private, state, and local lands within that ecoregion (see Figure 2). Other ecoregions with the large changes in Type F stream include North Cascades (western Washington) and Puget Lowlands (western Washington). The probable effects of the AFF A4 rule options, as described in more detail below, are therefore clustered in these ecoregions as well. For AFF D, the decrease in Type F stream length is also greatest in western Washington. This is because, based on the GIS sample analysis, we do not have reason to believe that the FHAM protocol survey approaches under the three PHB options are likely to identify F/N break locations different than they would be under the baseline in eastern Washington.

6) **For the AFF A4 rule options, the analysis finds both major benefits and major costs attributable to the rule.** As summarized in Table 1, major costs of the AFF A4 rule options include a reduction timberland values ($11 million on an annualized basis) across over 130,000 acres of land that become unharvestable and the increased costs associated with upgrading existing and building new stream crossings to Type F specifications ($6.3 million). The countervailing ecological effects of conserving forested riparian buffers are also major benefits of the rule. Because AFF A4 presumes the lengthening of Type F streams creates additional habitat, one benefit is improved habitat conditions to support increased fish abundance (on the order of 13,000 fish per year on average), which may result in up to 2,500 new recreational fishing trips primarily for coho salmon and steelhead ($220,000 in annualized terms), as well as non-use values and tribal cultural values that we describe qualitatively.

   Beyond fish abundance, conserving forested riparian habitat also provides other ecosystem service benefits. For instance, we calculate that the increased landscape carbon storage and sequestration associated with the unharvested acres is on the order of $1.8 million in annualized terms. Other non-quantified benefits of the conserved forested buffers include improved wildlife habitat. Finally, while the reduced risk from electrofishing is a minor probable benefit of the rule, this analysis does not find that fish will avoid harm relative to current industry practices. Any benefits to forest- and water-based recreational activities are likely to be negligible given limited public access to the affected areas.

7) **For the AFF D rule options, the probable effects are mostly minor or negligible.** With a reduction in Type F stream, our analysis identifies that the primary costs of the rule are the reduced ecological functions and ecosystem services provided by forested riparian buffers. These include downstream water quality, which affects fish and other aquatic species, as well as other ecological functions maintained by conserving forests near streams. Given the relatively limited reduction in Type F stream estimated for these rule options, we determine these ecological costs are most likely minor, which includes $400,000 in global costs associated with reduced landscape carbon sequestration and storage, as well as other unquantified environmental and ecological costs. With this rule option, the ecological costs are counteracted by major benefits in the form of increased timberland values on the order of $2.4 million in annualized terms across up to 28,000 newly harvestable acres. Landowners also experience minor benefits associated with reduced costs associated with future stream crossing construction, estimated at $380,000 in annualized equivalents.

8) **Many ecological costs and benefits of the rule options are described qualitatively.** Figure 4 presents the total monetized costs and benefits of the rule options alongside the net benefits associated with those categories. As identified in the figure, we are unable to specifically quantify the increased value people derive from conserved riparian buffers and increased fish abundance related to the increase in Type F stream length for the AFF A4 rule options as well as the reduced ecological functions that would be associated with the decrease in Type F stream length pursuant to AFF D. While there is a substantial evidence base demonstrating that people value the services provided by forests and protection of riparian areas, the available economics literature does not meet the guidance and best practices of a benefit transfer analysis in the context of this rulemaking; that is, it does not provide a means to reliably quantify the monetary value of the ecological benefits of the rule options.

9) **All rule options meet the objectives of the rule, and the AFF D rule options are likely the least burdensome.** All rule options establish a consistent water system and reduce the future risk of electrofishing by 1) providing an AFF within which electrofishing is not the default means of determining stream type (although can be used as part of stream typing surveys upon request); and 2) establishing FHAM as the consistent approach to conducting surveys in the future. Based on the analysis findings described above, the rule options that include AFF D have the least cost to the regulated industry and are therefore likely the least burdensome.

10) **Costs of the AFF A4 rule options on businesses are likely more than minor and disproportionately borne by small businesses.** Forestland owners can be either individuals or businesses. The affected businesses are nearly all (99 percent) considered small businesses based on the Washington state definition (i.e., 50 or fewer employees). Businesses in these industries will only incur costs under the AFF A4 rule options, not the AFF D options. The costs that these small businesses may incur will be specific to 1) the amount of timberland per business that becomes unharvestable as a result of the AFF A4 rule options and 2) the number of existing and future stream crossings on the affected stream lengths. However, based on the average annual revenues of businesses in the industries mentioned above, it is very likely that the costs will be more than minor. Therefore, an SBEIS would be required for the AFF A4 rule options but would not for the AFF D rule options.

Table 1. Categories and Magnitude of Incremental, Probable Costs and Benefits by Rule Option (Annualized, 2023$)

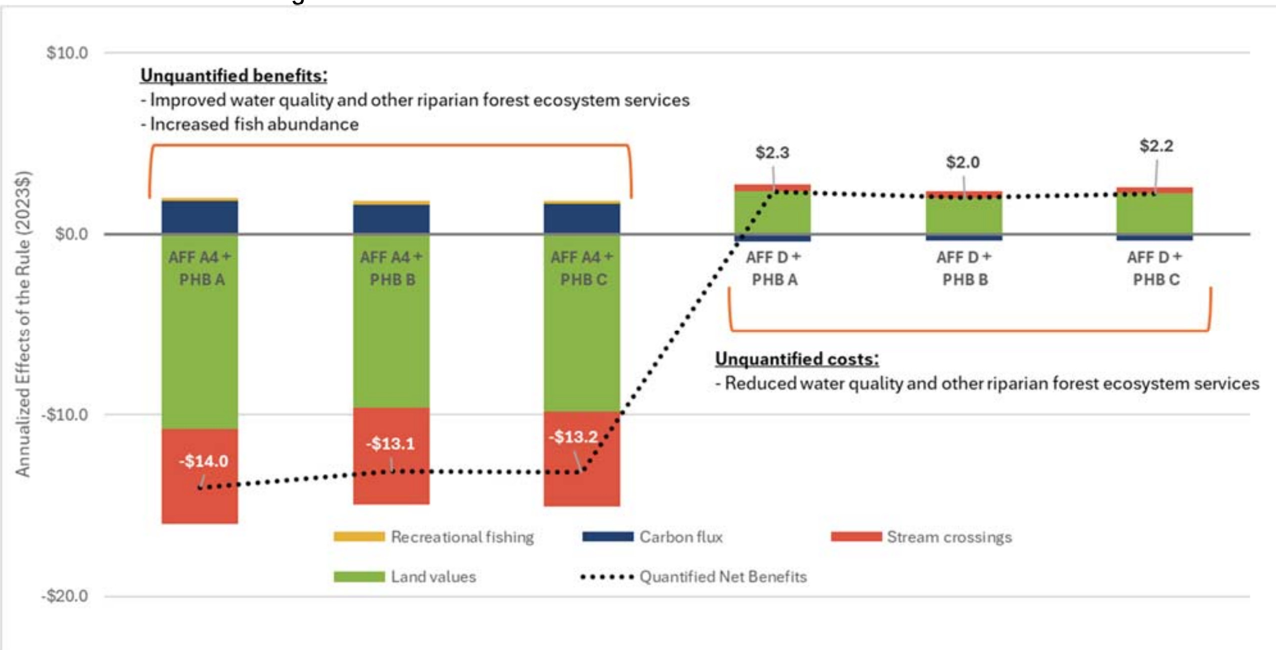
Rule Options	Incremental Costs (or Foregone Benefits)	Incremental Benefits (or Reduced Costs)
AFF A4 + PHB A AFF A4 + PHB B AFF A4 + PHB C	Major costs • Reduced timberland values ($11 million) • Increased costs of stream crossing upgrades ($6.3 million)	Major benefits • Improved water quality and other riparian forest ecosystem services (58% increase in Type F protected riparian buffers resulting in biodiversity and ecosystem service values adjacent to 3% of streams statewide), including: o Increased landscape carbon storage and sequestration ($1.8 million) • Increased fish abundance (13,000 fish per year on average), resulting in: o Ceremonial and subsistence fishing and tribal cultural values (not quantified) o Improved recreational fishing ($220,000, 2,500 new fishing trips each year, primarily for coho salmon and steelhead) o Non-use values (not quantified) Minor benefits • Reduced risk of fish harm from electrofishing (due to codifying FHAM protocol survey process; minor due to limited electrofishing in baseline) Negligible benefits • Improved forest- and other water-based recreation (areas with improved habitat are often on inaccessible private property, improvements may be less perceptible to recreationists)
AFF D + PHB A AFF D + PHB B AFF D + PHB C	Minor costs • Reduced water quality and other riparian habitat functions (limited change in Type F stream effects downstream fish and other organisms at the individual, not population, level), including: o Reduced landscape carbon sequestration and storage ($400,000) Negligible costs • Decreased forest- and water-based recreation (areas with degraded habitat are often on inaccessible private property, habitat changes may be less perceptible to recreationists)	Major benefits • Increased timberland values ($2.4 million) Minor benefits • Stream crossing upgrades ($380,000) • Reduced risk of fish harm from electrofishing (due to codifying FHAM protocol survey process; minor due to limited electrofishing in baseline)

Notes:

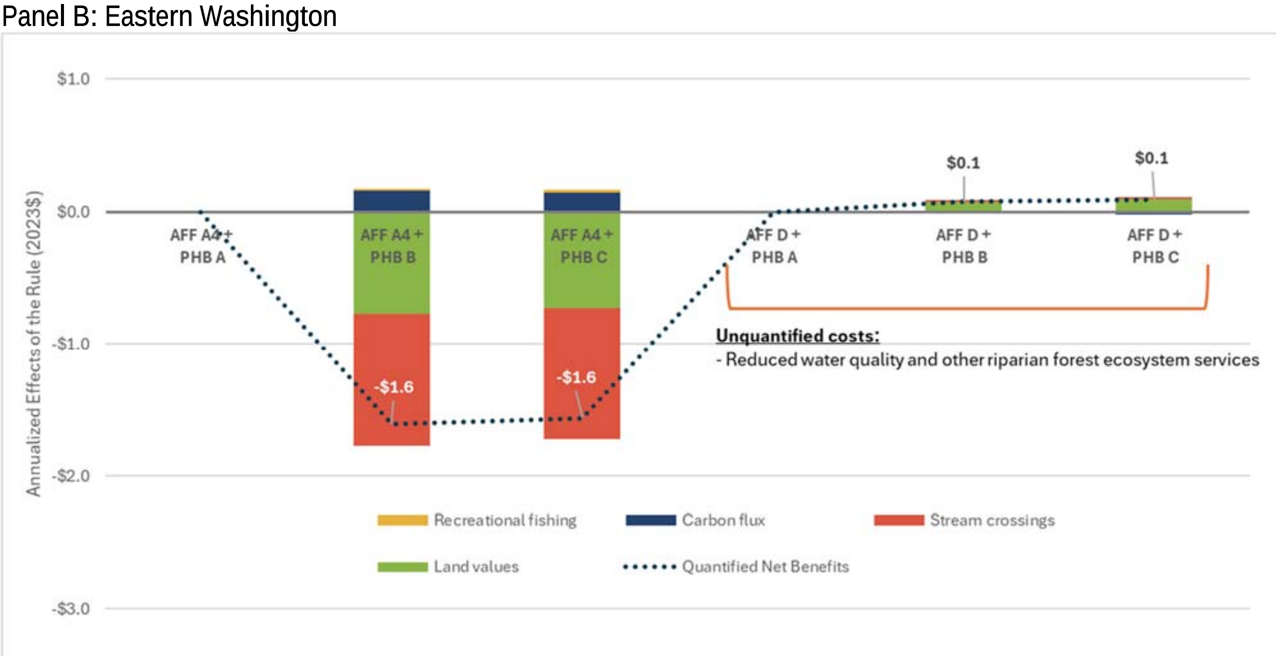
1. For monetized effects, we provide annualized values (assuming a 2% discount rate) and present results rounded to two significant digits. As the ranges across PHB options within an AFF alternative are very narrow, we provide the estimate of the largest magnitude within a given AFF option.
2. For all effects, quantified or qualitative, we categorize effects as major (effects on the order of millions of dollars per year for the monetized categories), minor (hundreds of thousands of dollars per year for the monetized categories), and negligible (tens to hundreds of dollars per year for the monetized categories).

Figure 4. Annualized Net Benefits of the Rule Options, Monetized Categories Only (2023$ millions)

Panel A: Western Washington



Panel B: Eastern Washington



Notes: Axes ranges differ between Panel A and Panel B for readability purposes. PHB A does not apply in eastern Washington.

4. Detailed Approach to Evaluating Costs and Benefits

This section of the memo provides a comprehensive account of the methods employed to quantify costs and benefits. It outlines the specific analytical techniques used to measure and compare the costs, benefits, and uncertainties.

4.1. Change in Type F Stream Lengths

Key findings

- The primary driver of differences across the regulatory alternatives are the two AFF options. AFF A4 and AFF D result in significantly different lengths of stream that would be included as AFF.
- Differences across the PHB options are negligible and all show that FHAM would identify F/N breaks farther downstream relative to where they would likely occur in the baseline. That is, implementation of FHAM protocol surveys under all three PHB options likely results in a reduction in Type F stream.
- Considering both the effects of the AFF and FHAM implementation combined we find the following:
  - The three AFF A4 rule options will result in a net increase in 5,800 Type F stream miles in western Washington and 1,200 in eastern Washington, equivalent to a 58 percent increase relative to the baseline. This influence of AFF A4 in increasing Type F stream extent outweighs the reduction in Type F stream resulting from the PHB options outside of the AFF.
  - The AFF D rule options will result in a net decrease in 1,200 Type F stream miles in western Washington and up to 250 in eastern Washington, representing a 12 percent reduction in Type F stream across the state relative to the baseline. The net reduction in Type F miles is due to the fact that all stream miles within AFF D would most likely be Type F stream in the baseline as they are based on documented fish presence. Therefore, all changes in stream type relative to the baseline are due to the implementation of the PHB options outside of AFF D, which identify the F/N break further downstream relative to the baseline (i.e., less Type F stream).

A key input into several incremental cost and benefit categories is how the AFF and FHAM options will result in more or less Type F stream relative to the baseline (see Figure 3). Our approach to determining changes in the extent of Type F streams attributable to the rule options relies on geospatial modeling results performed by Four Peaks under contract to DNR (Four Peaks 2024). Our analysis builds upon Four Peaks' analysis in three ways for use in the CBA:

1) We apply statistical methods to evaluate the predictive power of Four Peaks' sample data at the ecoregion level;
2) We consider how the AFF will interact with upstream areas that will be typed using FHAM or other existing typing options; and
3) We extrapolate findings of the sample sites only to those streams likely to be typed via protocol surveys in the future.

Our analytic approach benefited from conversations with both Four Peaks and DNR about how best to apply the sample point results for the purposes of the CBA. The sections that follow describe our methods, results, and key sources of uncertainty.

Analysis Approach

- **Step 1:** Determine stream miles and F/N breakpoints likely to be affected by the rule.

- ***Step 1a:*** Identify all stream miles in forestland from DNR's 'DNR Hydrography – Watercourses (WC Hydro)' GIS Open Data.[3]
- ***Step 1b:*** Remove stream miles not subject to the rule. These include 1) existing permanently typed streams (identified in WC Hydro), 2) streams designated as "shorelines of the state" (identified in WC Hydro), and 3) stream segments overlapping with Federal and tribal land (identified using land ownership data from Atterbury Consultants).[4]
- ***Step 1c:*** Remove streams miles unlikely to be typed for forest practices purposes because landowners are unlikely to pursue harvest for other reasons. These include 1) streams abutting unstable slopes (as classified in the DNR LSI spatial layer),[5] 2) forest unlikely to be harvested due to northern spotted owl (i.e., areas within old forest, sub-mature forest, and young forest marginal northern spotted owl habitat),[6] and 3) conservation land (identified in the U.S. Geological Survey (USGS) Gap Analysis Project (GAP) Protected Areas Database of the United States (PAD-US)).[7,8]
- ***Step 1d:*** Sum across the remaining stream miles and determine number of F/N breakpoints in WC Hydro on these stream miles by ecoregion and east and west sides of the state.[9]

- **Step 2:** Determine the portion of stream miles from Step 1 that will fall within each AFF option. *It is important to note that AFF A4 and AFF D have not yet been mapped for analysis. We therefore rely upon the best available information to determine the probable extent of the two AFF options within each ecoregion based on the Four Peaks sample point analysis and communication with DNR.*
  - ***Step 2a:*** Determine the current extent of anadromous fish distribution documented in the Washington Department of Fish and Wildlife (WDFW)'s Statewide Washington Integrated Fish Distribution (SWIFD) (referred to as "SWIFD anadromous")[10] overlapping with potentially affected stream miles identified from Step 1 by ecoregion and east/west side of the state.
  - ***Step 2b:*** Calculate the average distance between the end of each AFF alternative and the concurred F/N breakpoints by ecoregion and east/west side of the state using Four Peaks data and identify which are 1) meaningfully different than the baseline (i.e., where we have confidence that the sample point analysis identified that the location of the F/N breakpoint

[3] The WC Hydo layer is available at https://data-wadnr.opendata.arcgis.com/ and was downloaded on May 17, 2024 for use in this analysis.

[4] This data was compiled by Atterbury Consultants from its database of comparable sales and sent to IEc by Dave Wischer at DNR for analysis on February 26, 2024.

[5] The LSI spatial layer is available at https://data-wadnr.opendata.arcgis.com/ and was downloaded on May 17, 2024 for use in this analysis.

[6] The Northern Spotted Owl habitat layer was provided by Dave Wischer at DNR on June 4, 2024.

[7] U.S. Geological Survey (USGS) Gap Analysis Project (GAP), 2024, Protected Areas Database of the United States (PAD-US) 4.0: U.S. Geological Survey data release, https://doi.org/10.5066/P96WBCHS. Downloaded June 5, 2024.

[8] There may be other reasons that a landowner would not type their streams in the future, for instance because they are part of a conservation easement that precludes harvest. This analysis makes use of available spatial data that provides some information about the extent of forestland where harvest is unlikely but is unable to account for all possible reasons future stream typing may not occur on a given stream segment.

[9] F/N breakpoints in WC Hydro that are not the result of a permanent typing process are determined using computer modeling. For this analysis, we assume those breakpoints represent where the F/N breakpoint would occur absent the rule (i.e., in the baseline).

[10] The Statewide Washington Integrated Fish Distribution is available at https://geo.wa.gov/datasets/wdfw::statewide-washington-integrated-fish-distribution/about and was downloaded on May 15, 2024.

under the PHB would be different than under the baseline) and 2) positive (i.e., the AFF would extend above the existing breakpoint in WC Hydro resulting in more Type F stream).

- ***Step 2c:*** For the ecoregion averages that are meaningfully different than the baseline and positive (Step 2b), multiply the average change per F/N breakpoint by the total number of breakpoints identified in Step 1. For all ecoregion and east/west combinations under AFF D, the average distance between the AFF and F/N breakpoint is negative (i.e., the extent of the AFF does not reach the baseline F/N breakpoint). Therefore, this step only applies to a sub-set of the ecoregion combinations for AFF A4.
- ***Step 2d:*** Identify the linear extent of the AFF streams likely be Type F under the baseline regardless of the rule (i.e., no change due to the rule), and the linear extent of stream that would have been Type N under the baseline but would be Type F due to the AFF delineation in the rule.
  - For AFF A4, determine which portion of the AFF will fall within and beyond SWIFD anadromous using findings from Step 2a and Step 2c. We assume all area within SWIFD anadromous would be Type F absent the rule, and therefore only area outside of SWIFD anadromous may be identified as Type N under baseline water-typing methods. For the area outside of SWIFD, we assume that the distribution of Type F and Type N streams in the baseline would be similar to the distribution across the ecoregion, which we determine using the streams identified in Step 1.[11]
  - For AFF D, we rely on the current extent of SWIFD anadromous from Step 2a as the representation of the AFF. That is, we do not quantify additional stream length beyond SWIFD as part of AFF D based on communication with DNR that SWIFD anadromous served as a proxy for AFF D. We assume that all streams within SWIFD anadromous would be Type F absent the rule because of the known presence of anadromous fish; accordingly, all areas within AFF D would be identified as Type F stream in the baseline, regardless of the rule.

Determining AFF and PHB options that identify F/N breakpoint locations that are "meaningfully different from the baseline"

First, we calculate the average distance between the end of AFF (or PHB) and the concurred F/N breakpoint by ecoregion and side of state. Then, using information about the standard deviation across averages within an ecoregion as well as the number of sample points underlying the averages, we apply a Student's t-test with a 95 percent confidence interval to evaluate which averages are statistically different from zero. We recognize that a t-test assumes the underlying distribution is roughly normal, which we are unable to observe or assess. To assess the sensitivity of our findings to the confidence interval assumption, we also calculate the same statistical tests using a 90th percentile distribution and find that the results are generally consistent.

- **Step 3:** Identify remaining stream length that would subject to either FHAM or use of the DPCs and, of that, the portion that would be surveyed using FHAM.

[11] For example, approximately 28 percent of the stream miles from Step 1 in the Coast Range are labeled at Type F in WC Hydro. Therefore, we assume that 28 percent of the area within AFF A4 would be Type F regardless of the rule, and the remaining 72 percent would be Type N absent the AFF. Therefore, 72 of the area within these stream segments are considered Type F stream attributable to AFF A4 (i.e., stream that would have been Type N under the baseline).

- ***Step 3a:*** Calculate the remaining stream miles and F/N breakpoints affected by the rule (Step 1) outside of the AFF (Step 2). This stream extent would be subject to stream typing methods in the future.
- ***Step 3b:*** Because the likelihood of using FHAM relative to the DPCs varies by landowner type, we calculate the landowner composition of streams from Step 1 using Atterbury Consultants' land ownership data and determine the percent of private land owned by small forest landowners (SFLs) using the Washington State Forestland Database from the Natural Resources Spatial Informatics Group at the University of Washington School of Environmental and Forest Sciences.
- ***Step 3c:*** Apply assumptions about landowner propensity to use protocol surveys based on communication with members of the stream survey industry, state land managers that participate in water-typing, and DNR representatives that provide water-typing support to SFLs. This analysis assumes 1) state and local governments apply protocol surveys 10 percent of the time; 2) SFL survey 20 percent of the time; and 3) other private landowners (including real estate investment trusts [REITS] and timber investment management organizations [TIMOs]) and all other landowners (including utilities, etc.) generally survey 100 percent of the time. We assume that the rule does not affect landowner choice of stream-typing method. That is, if a landowner is likely to rely on DPCs to type a stream in the baseline absent the rule, that landowner will rely on DPCs even if the rule is implemented; similarly, we assume landowners that would likely use a protocol survey under the baseline will apply the FHAM protocols for stream typing following rule implementation.
- ***Step 3d:*** Combine information from Steps 3a through 3c to identify the affected stream miles that will be subject to FHAM. This analysis assumes the remaining stream miles will be typed using the DPCs and are therefore unaffected by the proposed rule options.

- **Step 4:** Calculate whether and how the location of the identified F/N breaks will likely differ under the PHB options for FHAM relative to the interim rule protocol survey.[12]
  - ***Step 4a:*** Calculate the average distance between the location of each PHB option and the concurred F/N breakpoints by ecoregion and east/west side of the state using Four Peaks data to identify which averages identified a meaningful difference from the baseline.[13] For all ecoregion and east/west combinations that are different from the baseline, the average distance between the PHB options and F/N breakpoint is negative (i.e., less Type F stream is identified under the FHAM options than with the current survey method).
  - ***Step 4b:*** For the ecoregion averages that are meaningfully different than the baseline (Step 4a), multiply the average change per F/N breakpoint by the total number of remaining F/N breakpoints outside of the AFF options identified in Step 3.
- **Step 5:** To determine the net effect on Type F stream miles of each regulatory alternative, we sum the total change in Type F stream miles from the AFF alternatives (Step 2d) with the total change in Type F

[12] An assumption implicit in this analysis is that each of the PHB alternatives correctly identify the end of fish habitat. Given this, theoretically there should not be a difference in the locations of the habitat breaks identified by the different PHB options. However, the spatial analysis developed by Four Peaks does identify differences in the locations at which some of the PHB options are likely to identify the end of fish habitat in some ecoregions. We therefore rely on the Four Peaks analysis results to determine the probable effect of the PHB options on the identified locations of the breakpoint.

[13] At the direction of DNR (personal communication on May 28, 2024), this analysis relies on the 5xBFW data provided by Four Peaks.

stream miles resulting from the PHB options (Step 4b). This analysis assumes that all streams will be typed over the 55-year analysis timeframe. We assume streams typed based on inclusion in the AFF are permanently typed upon rule completion (Year 1) whereas streams typed based on the FHAM will be typed at an even rate over the timeframe of the analysis. To determine the reasonableness of this assumption, we compare data on the historical rate of stream typing with the stream typing scenario modeled in this analysis.

Results

This analysis identifies nearly 54,000 stream miles potentially affected by the proposed rule, including 40,000 in western Washington and 13,000 in eastern Washington (Step 1, see Table 8). Of these streams, around 20,000 miles (37 percent of relevant stream miles) are estimated to fall within the AFF A4 option (Step 2a-2c, see Table 10). For AFF D, approximately 9,000 miles (17 percent of relevant stream miles) are estimated to be included in the AFF (Step 2a-2c, see Table 10). Employing the assumptions detailed above, AFF A4 results in nearly 8,100 additional miles of Type F stream (i.e., that would most likely be identified Type N under the baseline absent the rule) while AFF D does not result in additional Type F stream because all areas within SWIFD anadromous would presumably be identified as Type F under the baseline due to the known presence of anadromous fish (Step 2d, see Table 11).

> *Annual Rate of Stream Typing*
>
> Step 1 identifies a total of roughly 54,000 stream miles across the state that may be affected by the rule. This analysis assumes all of these miles will be typed using one of the available methods (including DPCs) over the 55-year analysis period. Applying the landowner distribution and assumptions about the likelihood of each landowner type using protocol surveys absent the rule suggests that 620 miles would be typed using a survey method on an annual basis absent the rule.
>
> To assess the reasonableness of this estimate, we analyzed data maintained by DNR on water type modification forms (WTMFs) submitted, which typically rely upon protocol surveys. Referencing the number of stream miles associated with WTMFs submitted each year between 2019 and 2023, we find that between 378 and 664 stream miles are surveyed each year (average of 527 per year). Because the 620 stream miles typed per year identified by our analysis falls within this historical range, we find that our average annual estimates for rates of stream typing in the future are reasonable.

We identified around 21,000 miles beyond AFF A4, or 28,000 miles beyond AFF D, that may be surveyed using FHAM under the rule (Step 3d, Table 12). Statistical analysis of Four Peaks data on the PHB options reveals that, in several ecoregions, the average distance between the F/N breakpoint as identified under the baseline and the PHB options are not meaningfully different (see Table 13). This arises primarily in eastern Washington and is due to high variability across sample points within the same ecoregion as well as relatively low sample size. Across all three PHB options, these instances include Cascades (in both western and eastern Washington) as well as Blue Mountains (eastern Washington) and North Cascades (eastern Washington). For PHB B, the average breakpoint location in Eastern Cascades Slopes and Foothills (eastern Washington) also is not meaningfully different from the baseline.

Among the averages that are meaningfully different than the baseline (i.e., most ecoregions in western Washington and Northern Rockies in eastern Washington), the Four Peaks analysis identifies that the PHB options identify the F/N break downstream relative to the baseline. *That is, implementation of the FHAM protocol surveys under all three PHB options results in less identified Type F stream length relative to the baseline.*

Assuming implementation of AFF A4, PHB A results in a reduction of 870 Type F stream miles statewide; PHB B results in a reduction of 1,000 Type F stream miles; and PHB C results in a reduction of 1,100 Type F stream miles (Step 4, see Table 14). Assuming implementation of AFF D, PHB A results in a reduction in 1,300 Type F stream miles statewide; PHB B results in a reduction of 1,400 Type F stream miles; and PHB C results in a reduction of nearly 1,600 Type F stream miles (Step 4, see Table 14).

As evident from the similarities across the three PHB options, the PHB alternatives are not significantly different from each other in terms of where they would likely identify the location of the F/N break. When conducting statistical tests to determine how the distance between the PHB and baseline F/N breakpoint compare across PHB options, we found that very few ecoregion averages were meaningfully different from one another. In other words, while the spatial analysis by Four Peaks did identify some ecoregions where the PHB options would place the F/N break at a different location than the baseline protocol survey methods, the differences between the three PHB options are negligible.

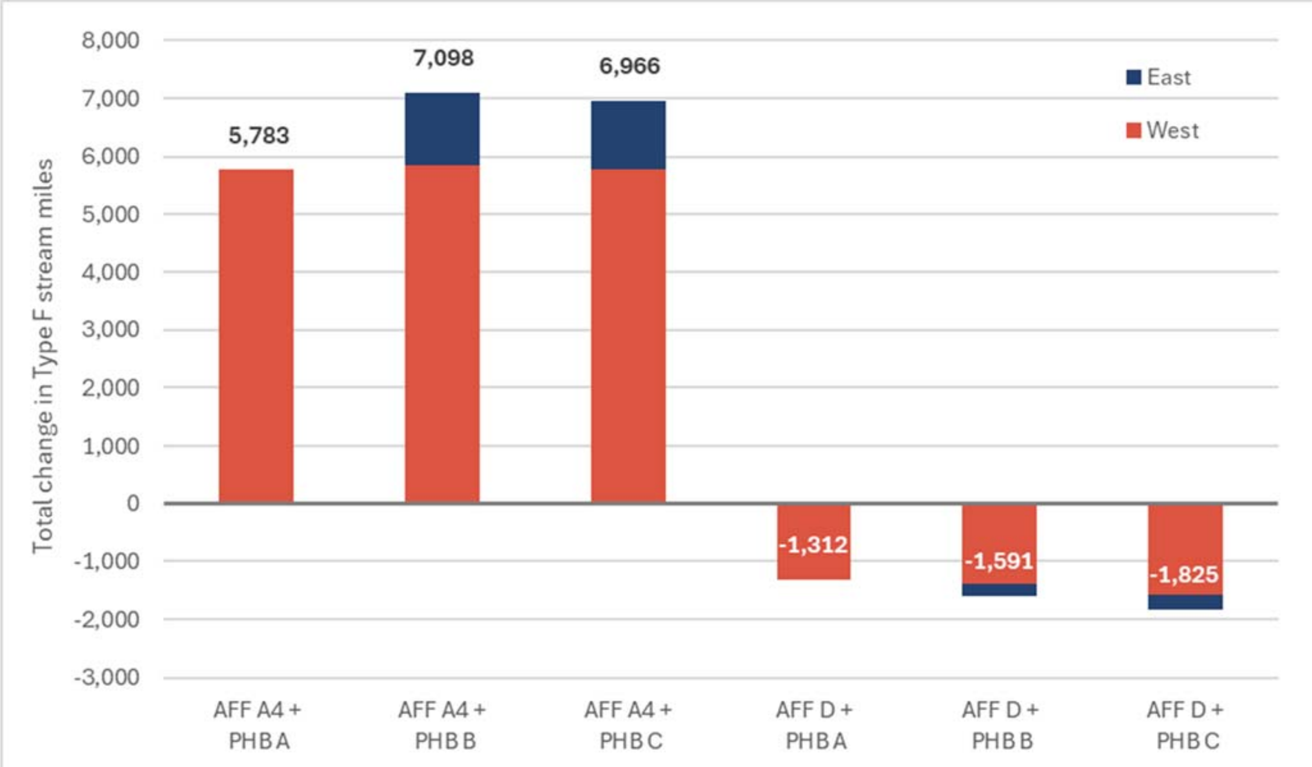
Finally, we combine the findings from the AFF and PHB options to determine the net change in Type F stream under the six regulatory alternatives.

- For the AFF A4 rule options, we identify a net increase in Type F stream length because the additional Type F stream miles within the AFF outweigh the reduction in Type F stream miles outside of the AFF that result from implementing FHAM. We estimate a net increase in Type F stream miles of nearly 5,900 in western Washington as well as 1,200 in eastern Washington (Step 5, see Table 15). Currently, WC Hydro identifies a baseline estimate of 12,000 miles of Type F stream in the total area affected by the rule. Therefore, AFF A4 would result in a 58 percent increase in Type F stream miles across the state relative to the baseline.

- For the AFF D rule options, we identify a net reduction in Type F stream length resulting exclusively from the PHB alternatives. We estimate a net decrease in Type F stream miles of up to 1,300 in western Washington and nearly 260 in eastern Washington (Step 5, see Table 15). Compared with baseline Type F streams in WC Hydro, this represents a 12 percent reduction across the state.

Figure 5 presents these findings and demonstrates which portion of the change in Type F stream length occur in western Washington versus eastern Washington. As shown, the vast majority of changes in Type F stream length are concentrated in western Washington. This is because 1) the AFF occurs mostly in western Washington, and 2) data from Four Peaks does not demonstrate that PHB-induced changes in most of the ecoregions in eastern Washington are probable. AFF A4 results in more Type F stream regardless of PHB option while AFF D results in less Type F stream miles irrespective of the chosen PHB alternative.

Figure 5.Total Change in Type F Stream Miles Attributable to the Rule Options



Note: This figure describes total changes in Type F stream miles anticipated to occur throughout the 55-year analysis timeframe.

Uncertainty

This analysis is subject to uncertainty arising from several facts, as follows:

- The Four Peaks analysis represents a significant effort to understand the effects of the AFF and PHB options. However, the underlying sample points are not randomly selected within an ecoregion and the relatively small sample size in some ecoregions leads to limited predictive power for other non-sampled points.
- The Four Peaks analysis identifies the location of the first PHB above known fish based on the separate definitions for the three PHBs. Ultimately, under all of the rule options, permanently typing streams will require following the concurrence process to identify the concurred F/N breakpoint. The outcome of this process at any given site is uncertain and may or may not identify different locations for the F/N breakpoint under the rule options. The Four Peaks spatial analysis reflects the best available information on how the different definitions of the PHBs would influence where potential breaks would likely be identified as part of future protocol surveys.
- The location and extent of the two AFF options is not yet known. While DNR will eventually map the AFF, the map is not available for this analysis. We, therefore, rely on the best available information about the potential extent of the two AFF options, derived from Four Peaks' analysis and the existing SWIFD anadromous map. Additionally, we note that landowners may elect to implement surveys of land within the AFF to refute the presence of fish habitat. The extent to which this will occur, and the outcome of this process is uncertain. Accordingly, we assume all stream included within the extent of the AFF will be Type F upon implementation of the rule.

- The two AFF options will include tributaries connected with the main stem identified in SWIFD anadromous. Because Four Peaks' analysis focused on the main stem only, our analysis that relies on their data may undercount the extent of the AFF under both options.
- We rely on WC Hydro as the basis for determining the extent of all streams that may be typed in the future absent the rule, although the data layer likely undercounts streams in the state. Further, we rely on this data layer to determine the number and location of F/N breaks that would occur under baseline survey methods although there is uncertainty in whether the model underlying WC Hydro identifies those locations consistent with the baseline survey methods.
- We assume that all streams that are not permanently typed will be typed over the 55-year analysis timeframe. Using data on the historical rate of stream typing, the future rate of stream typing implied by this assumption is reasonable however it is also possible that not all streams will be typed over the next 55 years.

4.2. Effects Related to Stream Typing Administration

Key findings

- ► Establishing the AFF has the potential for cost savings to landowners given the decreased need to survey streams. However, landowners that believe their stream segments do not support fish may still employ surveys within the AFF. On net, influence of the AFF on overall survey effort stemming is uncertain.
- ► The AFF also obviates the need for the concurrence process for the surveys identified above. For the same reason identified above, there is unlikely to be a change in effort devoted to permanent stream typing since landowners are still expected to survey within the AFF where they believe the map overstates fish habitat.
- ► We generally find that the costs of implementing FHAM protocol surveys under the rule are unlikely to be substantively different than the costs of implementing protocol surveys under the baseline.

This section describes whether establishing the AFF and FHAM will result in differences in costs and time devoted to future stream typing. The first two sections describe the likelihood that establishing the AFF will result in avoided survey costs to landowners as well as time savings for the TFW review committee. The final section describes the possibility of increases in survey costs under FHAM relative to baseline survey costs.

4.2.1. Reduced Survey Effort in AFF

Streams within the AFF will no longer require typing through a survey or the DPCs. For landowners that would have conducted a protocol survey absent the rule, establishing the AFF may result in cost savings associated with reduced survey effort and related expenses.[14] However, the proposed rule will also leave open the option to implement surveys within the AFF when landowners believe that the AFF incorrectly identifies fish habitat. Landowners may elect to survey a stream in cases where PHBs are known to fall within the mapped extent of the AFF. Therefore, while the AFF may result in cost savings through reduced survey effort for some landowners, DNR anticipates that, on net, the AFF is unlikely to result in an overall reduction in survey effort.[15]

[14] Relative to other timberland value and stream crossing construction costs incurred by landowners described in Section 4.4, these cost savings are a minor effect.

[15] Personal communication between IEc and DNR on July 25, 2024.

4.2.2. Reduced Effort Devoted to Concurrence Process for Permanent Stream Typing

In addition to the reduced effort associated with surveying, landowners with stream segments that fall entirely within the AFF will no longer need to pursue permanent stream typing because all streams within the AFF are considered Type F by default. The concurrence process, meaning all activities involved in permanently typing a stream as Type F or Type N, requires landowners to submit a WTMF to DNR for review by a four-person TFW review committee (including a representative each from DNR, Ecology, WDFW, and tribes) in the relevant region. The main role of the TFW review committee is to ensure the landowner correctly applied the protocol survey by reviewing details about the survey administration and findings. Accordingly, the reduction in survey effort within the AFF may also result in reduced effort required for the concurrence process.

However, for the same reasons described above, there is uncertainty in whether establishing the AFF will result in fewer WTMFs because some portion of landowners may still elect to survey streams to prove that certain stream segments do not support fish. Therefore, while a possible outcome, available information does not identify this as a probable effect of the rule.

4.2.3. Increased Effort Devoted to Implementing FHAM

FHAM relies on consistent PHBs to identify the end of fish habitat as opposed to professional judgement. Discussions with two firms that implement the majority of surveys offered perspective on how their costs (and prices to landowners) may change with the implementation of FHAM. One company did not anticipate any change in effort required or survey prices. The other company noted the potential for a 15 to 25 percent increase in costs.[16] We note this conflicting information provided by the two data sources. DNR additionally notes that that the approach to conducting the protocol surveys under FHAM is very similar to the baseline and that removing the subjectivity and reliance on expert judgement may in some cases reduce the level of effort required to conduct the surveys by providing a consistent protocol to be applied for every survey. Considering the information available, we identify that it is possible for the FHAM protocol to increase the effort and cost of survey efforts, although it is not a probable outcome of the rule in general.

4.3. Effects Related to Reduced Electrofishing

Key findings

- Neither the AFF options nor the PHB alternatives are likely to result in a probable decrease in electrofishing relative to current industry practices.
- However, codifying the need to limit electrofishing as described in the FHAM protocol reduces the risk that surveyors may increase the use of electrofishing in the future. Under the baseline interim water typing rule, increased electrofishing would not be precluded as it will be under the FHAM protocol.

Research indicates that electrofishing may cause behavioral changes, reduced growth, and spinal injury to fish. However, studies have shown that despite electrofishing impacts to individual fish, abundance of salmonid species in small streams remained stable or increased after intensive backpack electrofishing over multiple years (Kocovsky et al., 1997).

[16] The industry representative did not provide the reason for the increase in costs. We assume the increase is driven by the need to identify PHBs using more prescriptive information from the rule as opposed to professional judgement.

The Electrofishing Technical Group (ETG) for the TFW Policy Committee authored a report regarding the use and effectiveness of protocol electrofishing surveys in detecting fish (ETG 2016). The ETG was asked to consider questions related to the efficacy of backpack protocol survey electrofishing and discuss the evidence supporting conclusions. This evidence included published scientific papers as well as the collective experience of members of the ETG who have strong backgrounds in sampling small streams. Results of the ETG report concluded that:

> *In most situations, protocol electrofishing surveys are unlikely to result in harmful demographic effects on headwater fish populations as long as appropriate precautions are taken to avoid damage to active redds, damage to instream and riparian habitats, or to cause extensive downstream movement of population members[…].The electrofishing technique itself does have the potential to harm individuals and eggs exposed to electrical fields. Spinal injuries are most common. The risk of injury can be minimized by employing modern equipment and using settings that are least harmful to fish. (Electrofishing Technical Group, 2016)*

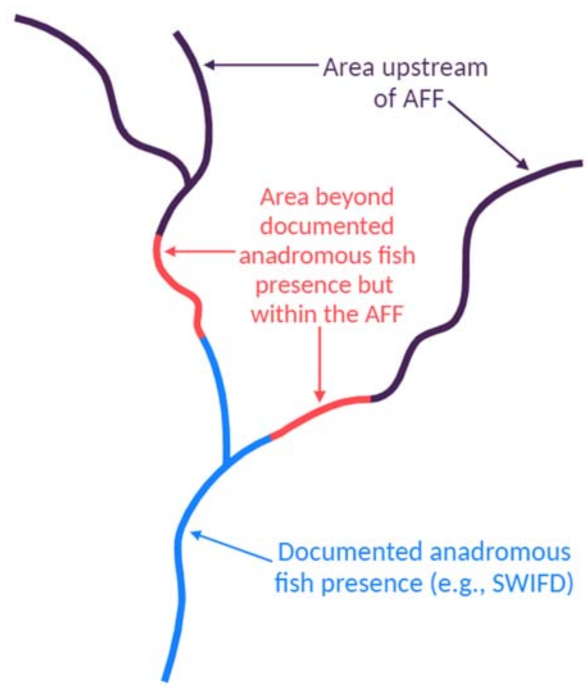
The establishment of an AFF and requirement to implement the FHAM approach for stream typing surveys based on one of several options for identifying PHBs has the potential to change the use of electrofishing in the context of stream typing. However, while this analysis identifies that it is possible for the proposed rule to result in a measurable reduction in electrofishing and therefore harm to fish, we find that it is not a probable effect of the rule for the following reasons:

- ***For areas within the AFF with documented fish presence (AFF A4 and AFF D):*** Absent the rule, landowners are unlikely to implement protocol surveys where there is known fish presence. Therefore, the AFF does not result in less electrofishing relative to current use in this area.

- ***For areas within the AFF beyond documented fish presence (AFF A4 only):*** For stream segments that fall within AFF A4 but are outside of areas with documented fish presence (via SWIFD or otherwise), AFF has the potential to reduce electrofishing. However, landowners in these areas still have the option to use FHAM and may elect to implement a survey to demonstrate the absence of fish. As described in Section 4.2, DNR anticipates landowners are likely to survey if they believe the AFF incorrectly identifies the extent of fish habitat. Therefore, electrofishing may continue to be employed at current levels within these stream segments.

- ***For areas upstream of the AFF:*** Areas upstream of the AFF will require implementation of the FHAM protocol for surveys as opposed to the baseline approach. This analysis finds that implementing the FHAM protocol instead of the baseline approach will not influence the amount of electrofishing in these areas. This is because, based on analysis of WDFW Scientific Collection Permit data and interviews with industry experts, 94 percent of stream typing surveys over the past five years have been conducted using an approach to electrofishing that is characterized by a similar extent of electrofishing to what would be implemented

Figure 6: Areas of Stream Considered in the Electrofishing Analysis



using FHAM. [17] Accordingly, it is unlikely that implementing FHAM will result in a substantive change in the extent of electrofishing relative to the baseline.

We note that a key objective of the rule is to reduce the use of electrofishing in stream typing. We find that all rule options meet this objective. First, establishing the AFF reduces the *need* for electrofishing across the extent of the AFF for all AFF A4 rule options. Second, although we find that surveyors already limit electrofishing effort under baseline protocol survey methods, codifying the need to limit electrofishing as described in the FHAM protocol reduces the risk that surveyors may increase the use of electrofishing in the future. Under the baseline interim water typing rule, increased electrofishing would not be precluded as it will be under the FHAM protocol.

4.4. Economic and Land Use Effects Resulting from Compliance with Type F Requirements

In the context of forestland, once a stream is known to be Type F, harvest restrictions are required across a wider buffer and stream crossings must be constructed to accommodate fish passage. These compliance activities result in costs to landowners in form of reduced harvestable area (measured in this analysis in terms of reduced forestland values) and increased design and construction costs associated with stream crossings to accommodate fish. This section describes how the rule alternatives result in these economic and land use effects. In addition to these benefit and cost categories, we also evaluate the potential for regional economic effects associated with changes in timber harvest attributable to the options.

4.4.1. Forestland Values

Key findings

- Changes in Type F stream length result in requirements to maintain wider riparian buffers, which can take timberland out of rotation.
- Regulatory alternatives that include AFF A4 result in a 1.7 percent reduction in harvestable acres in western Washington and 0.4 percent reduction in eastern Washington. This results in a net reduction in timberland values on the order of $560 million across the state, equivalent to $11 million in annualized terms.
- Regulatory alternatives that include AFF D result in a 0.4 percent increase in harvestable acres in western Washington and 0.04 percent increase in eastern Washington related to the net decrease in Type F stream length. This may result in a net increase in land values on the order of $120 million across the state, equivalent to $2.4 million in annualized terms.

The riparian management zone (RMZ) buffer requirements and associated timber harvest restrictions differ based on stream type (i.e., Type F versus Type Np streams), as well as by geographic location of the stream (i.e., in western Washington, eastern Washington above 5,000 feet, or eastern Washington below 5,000 feet), timberland site class, and stream width.[18] Accordingly, changes in the location of the F/N stream break affect the amount of timber that may be harvested within the RMZ. For circumstances in which a rule alternative results in an increase in Type F stream length relative to the baseline, this incremental change in harvestable area would

[17] Based on personal communication with representatives from West Fork Environmental on May 1, 2024, personal communication with representatives from Terrapin Environmental, May 22, 2024.and analysis of Scientific Collection Permit reporting data provided by WDFW on May 30, 2024.

[18] For more details on the restrictions for western Washington, see https://apps.leg.wa.gov/wac/default.aspx?cite=222-30-021. For more details on the restrictions for eastern Washington, see https://apps.leg.wa.gov/wac/default.aspx?cite=222-30-022.

represent the change from Type Np RMZ requirements to Type F RMZ requirements. For situations in which an alternative results in a decrease in Type F stream length, this incremental change in harvestable area would represent the change from Type F RMZ requirements to Type Np requirements.

Reducing or increasing the potentially harvestable timber affects the value of the timberland. That is, forestland with restrictions on timber harvest is less valuable to the landowner than it would be absent harvest restrictions, all else equal. To monetize these effects, we rely on market prices that reflect the expected value of all of its potential future uses of the land. For forested land, market values include the present value of future tree harvests and may include the value of the alternative for future development. If a given use of a parcel of land is restricted, it will be worth less than its market value in the previously unrestricted state. This reduction in market value is a cost to the landowner. We identify a residual market value for land within the Type F buffer area based on expertise from timberland appraisers familiar with timberland valuation in Washington (i.e., the value of a parcel of forestland with harvest restrictions is not zero). Our analysis also considers the reverse scenario whereby an increase in Type N buffer areas increases associated land values.

Analysis Approach

- **Step 1:** Calculate change in harvestable acres in the riparian zone (i.e., change in acres subject to Type F buffer requirements and Type Np buffer requirements).
  - ***Step 1a:*** Calculate change in harvestable buffer per stream mile using data from Four Peaks.[19] The analysis by Four Peaks provides the total change in Type F stream length per sample point as well as the total changes in harvestable acres per sample point. We use that information to estimate a change in harvestable acres per affected stream mile by ecoregion and side of the state.
  - ***Step 1b:*** Compare site class within Four Peaks buffers and buffers throughout potentially affected stream miles within the state to ensure the Four Peaks sample is sufficiently representative of the characteristics of buffers throughout the ecoregion.
    - For all affected stream miles in the state (see Section 4.1, Step 1) intersect stream miles with Site Class data layer from WA DNR GIS Open Data to assign site class to stream segments. Calculate buffer area according to RMZ widths (i.e., 400' for Class I, 340' for Class II, 280' for Class III, 220' for Class IV, and 180' for Class V) and determine the percentage of the total buffer area that falls within each site class.
    - For stream segments in the sample used by Four Peaks, intersect buffers with WA DNR Site Class data layer and calculate the percentage of the total buffer area that falls within each site class.
  - ***Step 1c:*** Multiply buffer per stream mile (Step 1a) by net change in Type F stream miles (see Section 4.1, Step 5) for each ecoregion and side of the state.
- **Step 2:** Calculate changes in forestland values due to changes in RMZ harvest restrictions.
  - ***Step 2a:*** Calculate average value of harvestable buffers using transaction data from Atterbury Consultants covering the period 2011 to 2018 and convert to 2023 dollars. Averages are

[19] Data from Four Peaks provided to IEc on June 21, 2024.

calculated separately for eastern Washington and western Washington and include transactions among private and public landowners.[20]

- *Step 2b:* Determine the value per acre of unharvestable forestland based on guidance from timber appraisers.
- *Step 2c:* Calculate the 1) decrease in value for new Type F buffers (i.e., value of harvestable buffer – value of unharvestable buffer) and 2) increase in value of new Type N buffers (i.e., value of unharvestable buffer – value of harvestable buffer).

- **Step 3:** Calculate total land value changes by multiplying the output of Step 1c by the output of Step 2c. We assume the land value impacts are experienced upon rule implementation (i.e., in the first year the rule is in affect) and persist in perpetuity.

Results

The increased RMZ buffer requirements around Type F stream result in a net reduction of harvestable timber on the order of 120,000 acres in western Washington and 21,000 acres in eastern Washington among the regulatory alternatives associated with the AFF A4 (see Table 16). Relative to the 7.1 million acres of private, state, and local timberland in western Washington, the net reduction in harvestable acres in western Washington constitutes a 1.7 percent decrease (FIA 2017). For the 4.8 million acres in eastern Washington, these regulatory alternatives would reduce the available timberland by 0.4 percent.

With AFF D, decreased buffering required along streams that change from Type F to Type N due to the influence of the PHB options results in an increase in harvestable acres on the order of 27,000 in western Washington and 2,500 in eastern Washington (see Table 16). When compared with the total private, state, and local timberland area, the increase associated with the alternative in western Washington is equivalent to about 0.4 percent, and 0.05 percent of timberland in eastern Washington.

Available data on timberland values per acre reveals an average market price per acre of about $4,400 in western Washington and $2,000 in eastern Washington (2023 dollars).[21] We considered whether these values may underestimate the value of harvestable timberland because they are derived from large sales transactions that contain some portion of unharvestable land due to other regulatory requirements or operability impediments. To ensure these calculated market prices do not under-value an acre of harvestable timber, we compare these estimates with a model maintained by the forestland industry that calculate the value of timberland using age class and site class information as inputs. When inputting region specific data on the distribution of age and site class across private commercial forest acres, these models identify a 4.5 discount rate for timberland and produce a price per acre of $3,933 in western Washington and $761 in eastern Washington.[22] That is, the market prices derived from historical transaction data are commensurate with, and slightly greater than, values derived from industry models.

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[20] The data contain too few transactions among state and other public landowners to calculate separate averages for these landowners. Contacts within DNR familiar with state timberland appraisal were unable to provide complementary data for state lands specifically.

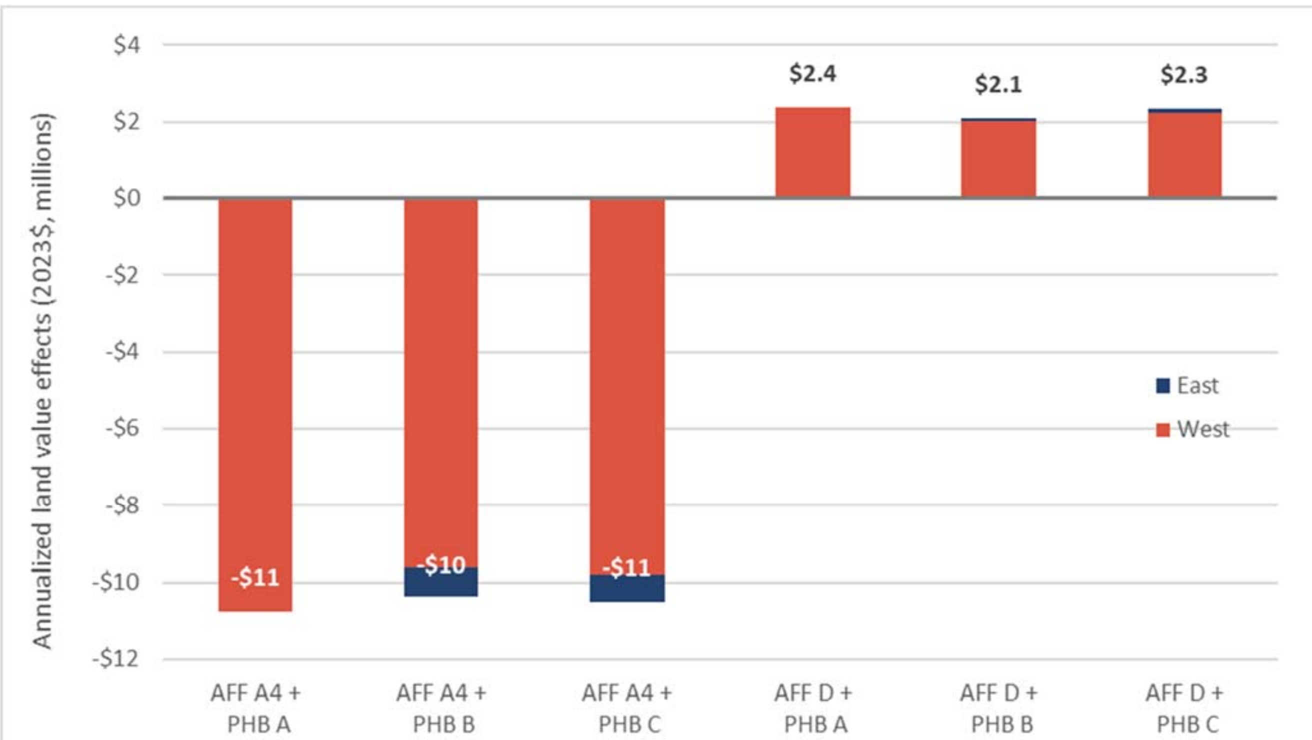
[21] Atterbury Consultants recently provided historical forestland transaction data from 2019 to 2023. Analysis of these data did not identify that more recent transactions indicated notably different prices per acre.

[22] John Ehrenreich of the Washington Forest Protection Association (WFPA) provided the Forest Valuation Model to DNR via email on April 25, 2024. The Forest Valuation Model, which includes separate modules for the westside and eastside of the state, was prepared by Roger Lorder of Mason, Bruce and Girard. These market values per acre were determined by applying a 4.5 percent market discount rate.

Timberland appraisers in Washington state described that the average market value of unharvestable timberland is $100 per acre.[23] Therefore, we calculate the change in market prices using this input as well as the market prices to estimate the change in value per acre. Applying these changes to the total reduction in harvestable area for AFF A4 identifies a reduction in timberland value of up to $520 million in western Washington and $39 million in eastern Washington upon implementation of the rule. Because land value losses are experienced at one point at time and represent a permanent loss in investment (i.e., beyond the 55-year timeframe of this analysis), we annualize the land value impacts for ease of comparison with other annualized estimates in this analysis. For AFF A4, the annualized timberland value losses are on the order of $11 million in western Washington and $780,000 in eastern Washington (see Table 17).

For AFF D, which results in a net increase in harvestable buffers, the regulatory alternatives increase timberland values in western Washington by $110 million, equivalent to $2.4 million when annualized. In eastern Washington, the increase in land values is about $4.7 million in total, or $95,000 in annualized terms (see Table 17). Figure 7 summarizes our findings by rule option and side of the state.

Figure 7. Annualized Timberland Value Changes (2023$, millions)



Note: Negative numbers represent incremental costs; positive values represent incremental benefits. Timberland values occur the first year the rule takes effect and are annualized in perpetuity.

Uncertainty

When annualizing land value changes in perpetuity, we apply the 2 percent social discount rate used throughout this analysis following best practices in welfare economics and Federal guidance on regulatory cost benefit analysis. However, market prices for timberland are typically derived assuming a 4.5 percent private discount

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[23] Personal communication with staff at Atterbury Consultants on February 25, 2019.

rate.[24] For comparison with our results, we conduct a sensitivity analysis applying a 4.5 percent discount rate. Under this assumption, the annualized losses associated with AFF A4 are up to $24 million in western Washington and up to $1.7 million in eastern Washington. For the AFF D, the annualized increase in values is approximately $5.3 million in western Washington and $200,000 in eastern Washington.

This sensitivity analysis demonstrates that the results of this analysis are sensitive to the discount rate assumption. However, we rely upon the 2 percent discount rate as our central estimate because the costs and benefits of the rule options are assessed from a societal perspective consistent with regulatory CBA best practices; the private discount rate is most appropriate for use of private businesses in making investment decisions.

4.4.2. Stream Crossing Construction and Retrofits

Key findings

- ► For regulatory alternatives that include AFF A4, 1,600 existing stream crossing (10 percent of total) may require upgrade to meet Type F requirements. Assuming 30 retrofits per year and 15 new culverts with increased future construction costs, landowners may spend approximately $6.3 million in annualized terms given the increased fish passage requirements.
- ► For regulatory alternatives that include AFF D, future culverts built on Type N stream that would have been Type F under the baseline will result in a cost savings because landowners no longer need to meet the Type F requirements. We identify that 4.5 culverts may experience a total cost savings of $380,000 on an annualized basis.

Accessing timberland often requires constructing crossing streams (including bridges and culverts). The Washington State Forest Practice Rules specify requirements for stream crossings constructed on Type F versus Type N waters; crossings constructed on Type F waters generally require fish passage provisions. Consequently, where the proposed rule alternatives result in the identification of a stream as a type that differs from the baseline scenario (from Type F to N, or the reverse), planning and construction of new stream crossings may be more or less expensive. Additionally, existing crossings may require retrofits or upgrades where the rule results in a Type N stream being classified as Type F.

Analysis Approach

To estimate the effects associated with upgrading **existing stream crossings** on streams that would be Type N in the baseline and become Type F due to the rule alternatives, we take the following approach:[25]

- **Step 1:** Determine the number of existing stream crossings among all stream miles potentially affected by the proposed rule (see Step 1, Section 4.1) using the best available data on the location of existing stream crossings (from WDFW's Fish Passage Barrier Inventory and DNR's Road Maintenance and Abandonment Plan).[26]

[24] For instance, this is the standard discount rate setting in the Forest Valuation Model described in footnote 22. WFPA describes that the 4.5 percent market rate is in line with recent transaction evidence ("Comments on IEc Methods Memo" dated April 25, 2024).

[25] For rule option and ecoregion combinations where our analysis identifies a decrease in Type F stream length, we do not quantify this effect as a cost-savings.

[26] Because the stream crossing data did not exactly intersect with the base hydrolayer, we considered any stream crossing within 200 feet of a stream as an intersection. We also ensure no duplicate stream crossing observations between the two data sources.

- **Step 2:** Estimate the number of existing stream crossings per mile by ecoregion.
- **Step 3:** Multiply the number of stream crossings per mile (Step 2) by the increase in Type F stream length (see Section 4.1) under the assumption that all crossings will be upgraded over the 55-year analysis period.
- **Step 4:** Apply information on the cost to upgrade culverts and bridges to meet the Type F fish passage requirements using average unit cost information from DNR's Forest Roads Division.

To estimate the effects associated with **new stream crossings** that will be built over the analysis timeframe, we take the following approach:

- **Step 1:** Assume there will be a doubling of stream crossings in each ecoregion over the 55-year analysis timeframe, then estimate the total number of new stream crossing that will be built on streams the area that will change from Type F to Type N or vice versa.
- **Step 2:** Apply information on the difference in cost (inclusive of all materials, labor, engineering, and permitting) to build new bridges and culverts with and without Type F fish passage requirement using average unit cost information from DNR's Forest Roads Division. For ecoregion and rule options alternatives with an increase in Type F stream miles, this will represent a cost. Where there is a decrease in Type F stream miles, this represents a cost savings under the assumption that landowners would not incur costs related to fish passage if not required.

Results

The data sources listed above identify approximately 16,000 existing stream crossings on nearly 54,000 stream miles potentially affected by this rule (see Section 4.1), for an average of 0.3 stream crossings per stream mile. The variation across ecoregions is considerable, ranging from 0.07 crossings per stream mile in Northern Rockies at the low end to 1.01 crossings per stream mile in Puget Lowland at the high end. Therefore, our approach relies on ecoregion averages. Available data does not provide information on which stream crossings may already be built to meet fish passage requirements; accordingly, we conservatively assume that all stream crossings on Type F stream that would have been Type N under the baseline, would have been built to Type N requirements absent the rule.

Among the ecoregions and rule options with increased Type F stream length (corresponding to AFF A4), our approach estimates approximately 1,600 crossings will require retrofit across the state, analogous to about 10 percent of all stream crossings found within applicable stream miles. Because we assume upgrades will be made over the 55-year analysis timeframe, this is equivalent to about 30 retrofits per year. Information from DNR identifies that the average cost to upgrade a culvert or bridge to meet fish passage requirements is approximately $188,000 per crossing (2023 dollars), recognizing that costs vary significant by flow rate, span, soil characteristics, location, etc.[27] We apply this average cost to all stream crossing in increased Type F stream areas.

For new stream crossing construction, we consider all rule options and ecoregions with both increased and decreased Type F stream. Engineering staff at DNR note that the cost of new bridge construction does not differ between Type F and Type N streams, and that primarily culvert construction costs are influenced by Type F requirements. Absent information on the distribution of culverts versus bridges among the stream crossings found in the spatial data, we assume half of all future construction will be bridges and half will be culverts. For

[27] Email correspondence with engineering staff within DNR's Forest Lands Division in March 2019 as well as March-April 2024.

the AFF A4 rule options, we assume 800 new culverts will be built on new Type F stream in western Washington (about 15 per year with increased costs) whereas about 125 new culverts will be built on new Type N stream in both western Washington and eastern Washington (about 2 per year with reduced costs). For the AFF D rule options, we estimate that landowners will build about 260 new culverts on streams with a reduction in Type F requirements (about 4.5 per year). DNR estimates that new Type F culverts cost about $165,000 on average, and that Type N culverts require about half of those costs. Therefore, the difference between the Type F and Type N culvert costs is approximately $82,000 per crossing (2023 dollars).[28]

Table 18 presents the combined economic costs of stream crossing retrofits as well as costs and cost savings associated with new culvert construction. As summarized in Figure 8, the AFF A4 rule options result in a net increase in stream crossing costs on the order of $6.3 million on an annualized basis, where the vast majority of increased costs are incurred in western Washington. For the AFF D rule options, there is a net cost savings to landowners on the order of $380,000 on an annualized basis. Available information does not identify the total costs that landowners incur to upgrade and repair stream crossings in a given year for comparison, however the description above regarding the number of affected stream crossings relative to the total existing stream crossing provides perspective on the magnitude of these effects.

Figure 8. Annualized Value of Stream Crossing Cost Changes (2023$, millions)

Note: Negative numbers represent incremental costs; positive values represent incremental benefits.

[28] This difference in price includes (1) reduced material costs (i.e., fish-passable culverts are larger and require additional steal) and (2) reduced excavation costs (i.e., fish-passable culverts require a larger hole and filling with substrate).

Uncertainty

- The numbers and rates of construction of new stream crossings in the future is uncertain. We develop a reasonable assumption for the potential rate of construction for stream crossings; however, this assumption may over- or underestimate activity levels.
- We combine information from two data sources to denote the locations of existing bridges and culverts crossing streams. DNR and WDFW note that these inventories are likely incomplete for the streams relevant to this analysis because efforts to map existing stream crossings are ongoing. Accordingly, we may underestimate the incremental effects of the proposed rule alternatives.
- The timeframe over which upgrades to existing stream crossings will occur is uncertain. Our analysis evaluates costs over the 55-year analysis period, which may over- or under-estimates the effects of the rule options.
- We attribute all stream crossing upgrade and new construction costs related to Type F requirements to the rule. However, landowners may design and construct stream crossings that meet Type F standards regardless of the rule. For example, landowners may consider effects of changing flow rates in streams over time and integrate this information into stream crossing design to ensure adaptation to predicted climate effects on flows. That is, landowners may experience increased costs associated with their stream crossings regardless of this rule. This may result in our estimates overstating the costs and cost-savings to landowners stemming from the stream-typing rule.

4.4.3. Regional Economic Impacts of Changes in Timber Supply

Key findings

- ► For regulatory alternatives that include AFF A4, assuming the acres that become unharvestable would have been harvested at the same rate per acre as all state and private forestland in the state, we calculate a net reduction in annual harvest of 890 Mbf in western Washington (0.04 percent of total) and 27 Mbf in eastern Washington (0.01 percent of total). Under the alternate assumption that all affected acres would have been part of an active timber rotation, then we find a net reduction in annual harvest of 35,000 Mbf in western Washington (1.5 percent of total) and 6,700 Mbf in eastern Washington (1.9 percent of total). While the second scenario has the potential to result in regional economic effects, it is unlikely that all of this buffer acreage would be harvested but for the rule. For example, many tree stands within the buffers are older than 55 years and may not be part of an active rotation.
- ► For regulatory alternatives that include AFF D, a net decrease in Type F stream results in a net increase in harvestable timberland. Assuming an average annual harvest volume consistent with private and state land averages identifies a net increase in harvested volume of 0.01 percent in western Washington and less than 0.01 percent in eastern Washington. Assuming all acres will become part of an active timber rotation suggests a 0.3 percent increase in western Washington timber harvest and 0.2 percent increase in eastern Washington.

We investigate the potential regional economic impacts (e.g., employment, income, value-added) of the proposed rule alternatives on industries that rely on timber volume (including mills, employees of harvest companies, and log export companies) by calculating and analyzing the expected change in yearly timber supply on account of the proposed rule. Given uncertainty regarding how much of the riparian buffers would be harvested absent the proposed rule alternatives, we consider two scenarios to capture the potential range in regional economic impacts.

Analysis Approach

- **Step 1:** Estimate the rate of timber harvest (bf per acre per year) under two scenarios.
  - ***Scenario 1:*** The rate of harvest in the harvestable area affected by the proposed rule is equivalent to the average timber harvest per acre of available private and state forestland in eastern and western Washington. We rely on data from the Pacific Northwest Forest Inventory and Analysis (FIA) to identify the total timberland available and data from the Washington Timber Harvest Reports (DNR 2018) to identify the total timber harvested in 2017. We confine this analysis to private and state lands.
  - ***Scenario 2:*** All affected buffer zones would be managed as part of a timber harvest if adjacent streams are Type Np. We rely on data from the Pacific Northwest FIA to identify the board feet per acre associated with timber stands on private and state lands at age 45 in western Washington and age 55 in eastern Washington.
- **Step 2:** Determine annual change in timber harvest. To do this we 1) divide the total change in harvestable acres (see Table 16) by 45 in western Washington and 55 in eastern Washington to align with the average forest rotation length (in years) in those sides of the state and 2) apply the rate of timber harvest per acre from Step 1.
- **Step 3:** Compare changes in annual timber harvest to typical annual timber harvest by side of the state.

Results

For scenario 1, we calculate average timber harvest per timberland acre of 42 bf/acre in eastern Washington and 325 bf/acre in western Washington. This estimate is inclusive of many acres of harvestable forestland that owners choose not to harvest as well as forestland that is harvested as part of a regular rotation. Therefore, this scenario acknowledges that not all forestland in riparian buffers would be harvested absent the rule. When dividing the total change in harvestable acres by the rotation lengths described above, we identify a net reduction in 2,700 acres harvested annually in western Washington and 370 acres in eastern Washington for the AFF A4 rule options. In total, this translates to a net reduction in annual harvest on the order of 890 Mbf in western Washington and Mbf in eastern Washington. Relative to the 350,000 Mbf harvested annually in eastern Washington and 2,300,000 Mbf harvested annually in western Washington (DNR 2018), the AFF A4 rule options represent a 0.01 percent reduction in total annual harvest in eastern Washington relative to a 0.04 percent reduction in total annual harvest in western Washington (see Table 19). Applying the same analysis approach to the AFF D rule options yields a 0.01 percent increase in timber volume in western Washington and a less than 0.01 percent increase in eastern Washington.

For scenario 2, we find that the average timber volume is approximately 18 Mbf/acre (18,000 bf/acre) in eastern Washington at stand age 55 and approximately 12.6 Mbf/acre (12,600 bf/acre) in western Washington at stand age 45. Applying these rates to the net change in harvestable acres per year for the AFF A4 options yields a net decrease in timber harvest on the order of 35,000 Mbf in western Washington and 6,700 Mbf in eastern Washington, equivalent to up to 1.5 percent of total harvest in western Washington and 1.9 percent in eastern Washington. For the AFF D options, the rule would result in a 0.3 percent increase in timber harvest in western Washington and a 0.2 percent increase in western Washington.

While useful context, the second scenario likely overstates the changes in timber harvest given the existence of other rules limiting forest harvest, conservation easements, and the fact that not all private and state land is managed for harvest and therefore our scenario reflects an upper bound of regional economic impacts. As evidence that many of these buffers are unlikely to be part of an active timber rotation absent the rule, we explored data describing the age of tree stands in the buffers considered potentially affected by the rule. Using gradient nearest neighbor (GNN) data from the Landscape Ecology, Modeling, Mapping, and Analysis (LEMMA) project, we find that 45 percent of trees in buffer areas in western Washington are older than 45 years and 82 percent of trees in buffer areas in eastern Washington are older than 55 years. This signals that, absent the rule, not all buffers are maintained as part of an active timber rotation, therefore our second scenario is almost certainly an over-estimate of reductions in annual timber volume.

Overall, the change in forest acres available for timber harvest based on the proposed rule options is a small fraction of available timberland in Washington. Under scenario 1, we find that it is not likely that the proposed rule options will affect economic activity (e.g., employment, income, revenues) in the commercial timber sector or related economic sectors (timber processing, harvest equipment and construction, etc.). Under scenario 2, the AFF A4 rule options – resulting in changes in total annual harvest of approximately 1.5 to 1.9 percent – do have the potential for regional economic impacts, although the scenario appears to overstate the potential for effects, while the AFF D options are unlikely to result in measurable economic changes.

Uncertainty

- The analysis above assumes that once an acre is no longer harvestable, that there would be no substitutability across other harvestable acres to meet demand for timber. This strong assumption results in our analysis likely overstating the potential change in annual harvest resulting from the rule.

4.5. Ecological Effects and Values Resulting from Compliance with Type F Requirements

DNR's riparian strategy defines RMZ buffers and prescribes management practices on Type F and N RMZ buffers in forested areas to balance the economic importance of active timber management with the protection of important riparian functions, including but not limited to fish habitat. As described in Section 1 of this memorandum, the objectives of the water typing rule do not include increasing the protection of riparian or aquatic habitats or increasing fish abundance. However, as also described in Section 4.1, a probable outcome of applying the AFF and FHAM rule options is a change in the extent of Type F stream, particularly in western Washington. Accordingly, the change in the extent of the riparian area protection generates ecological benefits (where we identify more Type F stream than the baseline) and costs (where we identify less Type F stream). This section describes the expected ecological effects of the rule alternatives.

Riparian buffers provide important ecosystem services across Washington State. Despite covering a small fraction of the landscape, approximately 85 percent of terrestrial vertebrate species in the state depend on riparian habitats, which offer vital resources such as nesting sites, productive food webs, natural corridors for species dispersal, mild microclimates, fertile soils, and shelter (King County 2024, Knutson and Naef 1997, Quinn et al. 2020). Riparian functions on DNR managed forest that serve to protect in-stream fish habitat include stabilizing stream banks, trapping sediment, shading the water, and providing leaf litter and large woody debris. Forested riparian zones are particularly biodiverse, including vegetation with snags, downed logs, and multiple canopy layers that provide habitat for cavity-nesting and insectivorous birds, amphibians, reptiles, and small mammals (Knutson and Naef 1997). In addition to wildlife benefits, riparian buffers also provide flood and erosion mitigation through their diverse vegetation, moderating water volumes year-round by attenuating peak flows during floods and releasing water gradually during dry periods (King County 2024, Knutson and Naef 1997). They also provide supporting services such as nutrient cycling, sediment and pollutant filtering, carbon sequestration, air quality improvement, climate regulation and noise abatement. Moreover, riparian buffers provide cultural value to local communities, including recreational, spiritual, educational, and other benefits (Knutson and Naef 1997, Quinn et al 2020).

The extent to which these riparian habitat services are provided is correlated with the length of intact riparian habitat present along streams, the width of the buffer, and the total acreage of riparian habitat. Changes in any of these factors likely affects the extent of services provided by the habitat. Table 2 describes the categories of ecological effects stemming from changes riparian habitat management for Type F versus Type N streams. Data limitations prevent quantifying all of these changes; however, we provide perspective on the magnitude and values of these changes, where feasible, and provide qualitative discussion for other categories.

Table 2. Categories of Ecological Effects and Resulting Costs and Benefits Considered

Ecological Effect	Categories of Costs or Benefits Considered
Fish abundance or other population-level effects on fish. Where rule options increase the extent of Type F stream and associated buffer, there will be population-level benefits to fish in the immediate area of the new Type F stream length. Where a rule option finds a reduction in Type F stream length, the reduced riparian habitat protection may adversely affect fish in interconnected Type F streams.	Ceremonial and Subsistence Fishing and Tribal Cultural Values Recreational Fishing Non-Use Values Commercial Fishing
Water quality and in-stream habitat. Changes in the net extent of Type F stream will affect water quality and other habitat characteristics both within and beyond the immediate area in which Type F riparian buffers would be added or reduced. A net increase in Type F stream would result in improvements in water quality and in-stream habitat, while a net reduction in Type F stream would result in decreased water quality and in-stream habitat. Where these changes occur over a significant proportion of the stream network, they could result in population-level effects to fish.	Water quality and other riparian habitat services Recreation Social cost of climate damages
Other riparian habitat functions. Beyond effects of riparian buffers on habitat quality within adjacent streams, riparian habitat provides other key ecological services. Increases or decreases in Type F streams and buffers can affect a variety of other ecological services including habitat for riparian wildlife, air quality, soil stability and erosion, and flood control.	

4.5.1. Fish Abundance

Key findings

- Under AFF A4 there is a probable increase in abundance of resident and anadromous fish populations, primarily including cutthroat trout and coho salmon in western Washington, and cutthroat trout in eastern Washington. The overall change in fish abundance is an annual average increase of 11,000 cutthroat trout, 1,000 coho salmon, 560 rainbow trout, 156 steelhead, and less than 100 bull trout and chinook salmon.
- Under AFF D, the rule may reduce in-stream habitat quality and adversely affect fish populations downstream of areas that are identified as Type N stream under the rule and would have been identified as Type F under the baseline.

The purpose of the rule is to prescribe a single, consistent approach for identifying Type F streams and to reduce the use of electrofishing for stream typing. The rule alternatives are based on the best available scientific information describing how to identify fish habitat. Thus, the rule may benefit fish by identifying the stream lengths for which Type F stream buffers will most benefit fish. Where the rule results in an increase in Type F stream, the AFF or FHAM protocol has identified that additional riparian habitat should be protected, providing a benefit to the fish at these locations. On the other hand, where the rule results in a decrease in Type F stream relative to the baseline, we assume that the FHAM protocol has identified that the riparian buffers for some of the stream lengths are not directly adjacent to fish-bearing stream habitat. A reduction in the extent of Type F stream does, however, have the potential for adverse effects to fish downstream of the identified F/N break location as the reduction in Type F stream and corresponding buffers could result in increases in water temperature and decreased water quality in hydrologically connected streams (see discussion in Section 4.5.2).

This analysis is focused on the benefits to fish occurring with the stream reaches identified as Type F under the rule that would have been identified as Type N under the baseline. The in-stream fish habitat benefits conferred in these areas are due to the increased buffer around these streams and the associated protection in riparian function. We consider benefits to fish populations in locations within the AFF where streams will change from Type N to Type F due to the rule as well as, separately, potential effects on fish populations in locations upstream of the AFF where we find that stream type changes due to implementation of FHAM protocol surveys instead of the baseline interim rule protocols.[29]

Analysis Approach

The effect of the proposed rule options on fish abundance is calculated as a product of the incremental changes to the quantity and quality of stream habitat.

Habitat quantity is represented by three factors:

- Total linear distance of stream length affected by implementation of the proposed rule options **(L)**,
- Average width of stream at the location at which streams that would have been typed as N in the baseline will be typed as F following the rule **(W)**, and
- The proportion of total habitat relevant to each species **(N)**.

Habitat quality is represented by two factors:

- Typical density of juvenile fish in a functioning stream of a comparable size **(D)**, and
- Habitat Index representing the influence of riparian zones on aquatic habitat function and the subsequent response in fish productivity **(H).**

The formula can be written as:

$$\Delta Fish = L * W * N * D * H$$

[29] This analysis is based on the premise that the fish benefiting from changes from N habitat to F habitat are those located directly in the vicinity of that change. As such, for this analysis, we separately consider changes in stream type within AFF, and upstream of AFF, rather than focusing on the net change in F habitat across the ecoregion.

where ΔFish is the change in smolts produced.[30] Finally, the number of smolts is converted to adult fish by applying a generic survival rate, also known as the smolt-to-adult-return (SAR) ratio.[31] We implement this approach using the following steps:

- **Step 1**: Identify relevant fish species likely to benefit from increases in Type F stream lengths.
- **Step 2:** Calculate the change in length of Type F/N stream (L) individually for areas within AFF, and above AFF (described in Section 4.1).
- **Step 3:** Identify the average width of stream at a typical Type F/N water break (W)
- **Step 4:** Identify the proportion of total habitat relevant to each species (N) based on frequency with which individual species are identified in stream surveys and other available literature describing fish presence at upper extents of fish habitat.
- **Step 5:** Identify typical fish density in headwater streams for each species.
- **Step 6:** Calculate the difference in the habitat quality index (H) under baseline conditions and under the rule options based on tree age class distribution and assumed harvest rotation.
- **Step 7:** Multiply L*W*N*D*H to calculate the total number of smolts (i.e., juvenile fish) per species "produced" by the rule option.
- **Step 8:** Multiply the number of smolts by an identified smolt-to-adult return rate (SAR) to calculate total number of adult fish produced under each rule option.[32]

Results

Under all rule options that include AFF D, there is no change in the length of Type F streams within AFF (Table 11), and a decrease in the length of Type F stream in the area above the AFF under each PHB option (Table 14). Accordingly, our analysis does not identify probably changes in fish abundance associated with these AFF D rule alternatives.

Under all rule options that include AFF A4, we find an increase in the length of Type F streams within the AFF in multiple ecoregions (Table 11). On both the east and west side of the state, cutthroat trout are expected to benefit the most from these changes, with an annual average increase in adult fish of 11,000 fish (Figure 9 and Table 20). These benefits are driven both by cutthroat trout's high rate of presence in affected streams, as well as its relatively high smolt density per square foot of habitat. While at a site-level these population increases may be meaningful, cutthroat trout are relatively abundant in Washington State and this change represents a very minor change at the state level.

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[30] The ecological monitoring and harvest management of many of the key species in this analysis, particularly anadromous salmonids, is generally quantified in terms of numbers of fish rather than biomass. Because the ultimate purpose of quantifying the ecological benefits to fish for this analysis is to consider the economic costs and benefits of those changes, it is most straightforward to quantify those ecological benefits using the metric upon which harvest quantities and values are generally reported. This analysis thus quantifies productivity in terms of numbers of fish.

[31] Modeled increases in fish abundance are a result of linear ecological (riparian) recovery over time. The number of adult fish available to reproduce in a given year is not a variable included within the model, and reproductive strategies such as iteroparity or semelparity are thus not a factor within the model. The output of the model is smolts per year, and each year's output is independent of the previous year.

[32] The term "SAR" is used in this report generically to refer to the rate at which both resident and anadromous fish survive from juvenile to adult life phase.

Figure 9. Average Annual Number of Fish per Time Period (AFF A4)

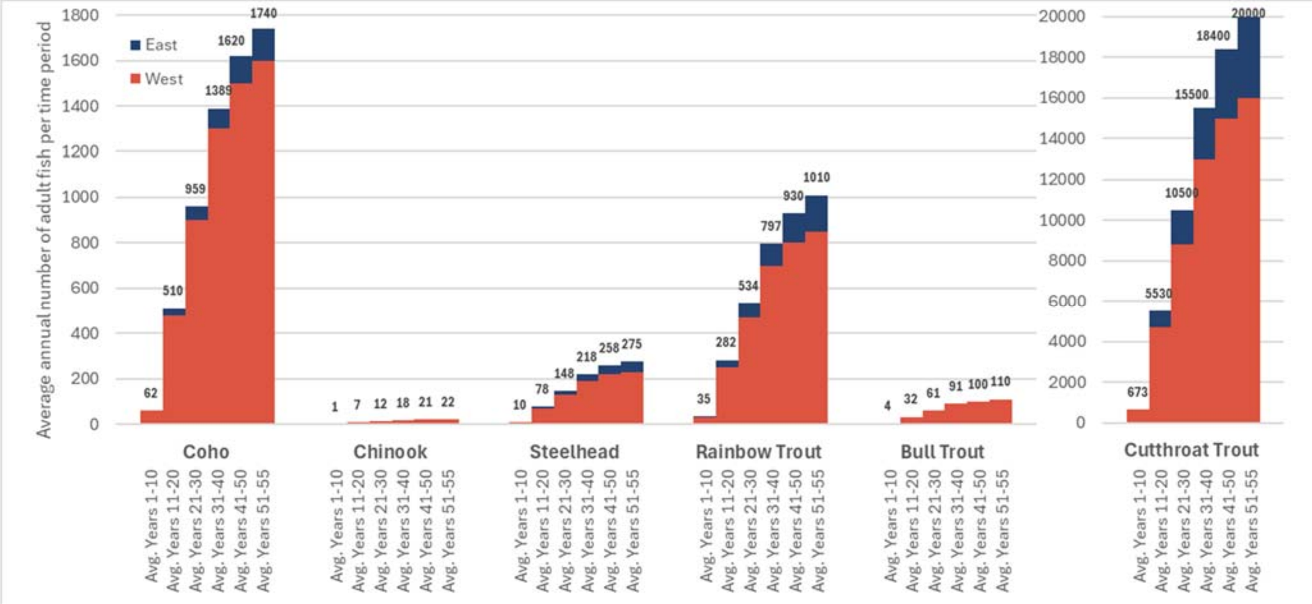
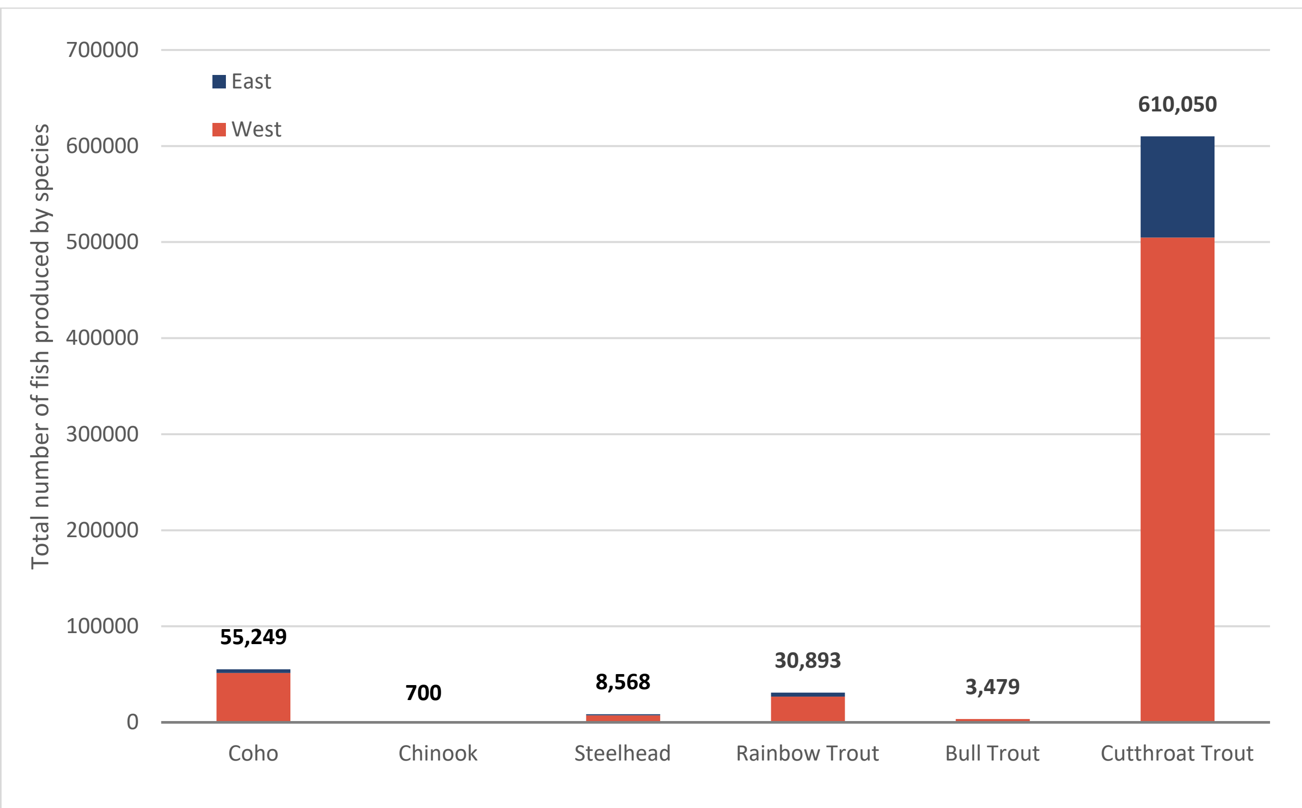


Figure 10. Total Increase in Fish Abundance by Species (AFF A4) Over 55 Years



Rule options that include AFF A4 represent a 58 percent change in the expected extent of Type F streams statewide relative to the baseline. This results in improved riparian and in-stream conditions for stream lengths representing 16 percent of stream miles with known anadromous fish use represented in SWIFD.[33] This increase in Type F streams improves habitat conditions to support increased fish abundance for multiple anadromous species, as shown in Figure 9 and Table 20. To provide context for the relative magnitude of these numbers, we compare results to WDFW's escapement data aggregated for all naturally produced salmon stocks in western Washington (see Table 3). While these data are not complete, average annual escapement between 2000 and 2017 was approximately 46,000 Chinook salmon, 135,000 coho salmon, and 56,000 steelhead. For the time periods with the highest expected increase in adult coho due to the rule, that production represents 1.2 percent of average escapement.

Table 3. Average Annual Escapement for Naturally Produced Chinook, Coho, and Steelhead in Western Washington

Species	Min	Max	Average
Chinook salmon	25,042	68,745	46,487
Coho salmon	54,143	220,987	135,289
Steelhead	23,842	85,053	55,574

Source: WDFW (2019)
Note: Includes Coastal, Puget Sound, Hood Canal, and Lower Columbia salmon recovery regions between 2000 and 2017. Hatchery and composite type stocks were not included.

Escapement is not a complete estimate of abundance of adult fish as it does not include adults harvested in commercial or recreational fisheries and does not include hatchery-produced or composite stocks. Therefore, total run sizes for these species were substantially larger. For example, in 2018, the total run size for naturally produced coho salmon was approximately 250,000 in Puget Sound watersheds alone, with hatchery production adding over 300,000 more (WDFW 2019). The greatest total average annual increase in coho salmon abundance anticipated under any rule option across all of western Washington is 1,600 adult fish, or 0.6 percent of the natural production in Puget Sound. Given that the 250,000 fish estimate of naturally produced coho salmon in Puget Sound does not include coho salmon produced in other regions such as coastal rivers or Columbia River tributaries, the percent of total natural coho salmon abundance represented by the estimated increased abundance is likely much smaller.

Above the AFF, there is a reduction in Type F stream, and thus no increases in fish abundance are expected in areas outside of the AFF.

Uncertainty

This analysis requires assumptions to evaluate the potential effects of the rule options on fish abundance that are subject to uncertainty, including the following:

- An improvement in riparian habitat quality alone, without expansion of accessible habitat or improvements in other factors limiting fish population abundance, may lead to an increase in fish populations; and
- Anadromous fish populations may expand into areas of the AFF that may not be presently occupied if in-stream habitat is improved.

[33] There are a total of 43,219 stream miles of known occupied anadromous fish streams documented in SWIFD.

With respect to the first factor, this analysis assumes that depressed anadromous fish populations are a result of several limiting factors, including lower quality riparian habitat associated with Type N buffers. It is in fact likely that additional site-specific factors influence fish populations, including the presence of barriers. A site-specific analysis with detailed site characteristics would be required to determine the influence of these factors on the actual influence of riparian habitat protection on fish abundance. However, our model identifies the extent of the area over which fish habitat improvements would benefit fish populations; absent a barrier to upstream movement, it is likely fish will come to occupy habitat that presents favorable conditions.

Additionally, this analysis intends to capture on average at an ecoregion and statewide level anticipated changes in fish abundance under the rule options. Doing so requires simplifying assumptions that characterize average conditions for all parameters either at a statewide or ecoregion level. In reality, the response to individual fish species is highly dependent on site-specific characteristics, and there is some uncertainty associated with each of the model's parameters, though our estimates of these inputs are based upon the best available data, professional judgement, and the input of stakeholders and other fish experts.

As described above, increases in fish abundance are limited to the area above already established anadromous fish presence (represented by SWIFD anadromy) and the outer extent of AFF where there is an increase in Type F streams. This outcome is limited to rule options that include AFF A4. While previous modeling efforts focused on and characterized increases in Type F habitat at the upper limits of any fish use (i.e., "end of fish"), the geographic area of focus here represents a slightly different location and includes areas further downstream of that point. Uncertainty exists related to the relative presence of individual fish species in these areas and the average width of streams in these locations, both of which are factors in our fish abundance model. Table 22 presents the results of sensitivity analyses that consider an average width of streams changing from N to Type F of 10 feet, and an increased assumed presence of the fish species most affected by the rule. As shown, the model results are highly sensitive to both of these parameters. Nonetheless, we believe the assumptions made in the base analysis are reasonable ones for the following reasons:

1. The breakpoint between Type F and N habitat identified by the PHB options in our analysis often falls lower in the watershed than the outer extent of AFF, suggesting that some portion of the AFF extends beyond end-of-fish, and is in fact in the upper extent of fish habitat. These areas are characterized by narrow streams and limited anadromous fish presence.

2. Our estimates of fish presence by species within these areas is based primarily on data collected during stream typing surveys conducted under WDFW Scientific Collection Permit data, which is the best available information regarding fish presence in streams typed for forest practices. This information is supplemented by information from the literature and provide by stakeholders and other stream typing experts.

4.5.2. Valuing Changes in Fish Abundance

Key findings

- Rule options that include AFF A4 will result in an increased abundance of resident and anadromous fish populations, as well as other benefits associated with riparian habitat function and in-stream habitat quality. Collectively, these outcomes will result in probable beneficial effects on tribal cultural values.
- Rule options that include AFF D will not result in changes in resident or anadromous fish abundance and will result in minor adverse effects to riparian habitat function and in-stream habitat quality. AFF D may result adversely affect tribal cultural values held for these resources.
- Rule options that include AFF A4 will result in an increased abundance of resident and anadromous fish populations, and probable benefits to recreational fisheries. Increased abundance of coho salmon and steelhead will result in additional fishing trips and a minor increase in recreational fishing value of approximately $200,000 in annualized terms. This value includes only the recreational value of these fish and not potential non-use values and cultural values. It also does not capture values associated with fish that are not targeted in recreational fisheries. Thus, this value should not be considered an approximation of the full value of the increased fish abundance under the AFF A4 rule options but as a low bound.
- Rule options that include AFF A4 will result in an increased abundance of anadromous fish populations targeted in commercial fisheries. However, those improvements are unlikely to result in changes in fish abundance that would result in increased allowable harvest. Changes in commercial fisheries are not a probable outcome of the rule options.

As described previously and show in Table 20 and Table 21, rule options that include AFF A4 are expected to improve habitat conditions to support increased abundance of fish species primarily including cutthroat trout, coho salmon, and rainbow trout due to additional Type F habitat above SWIFD anadromous but within the established AFF. While fish may also benefit from reductions in electrofishing or be positively or adversely affected by changes in water quality, these changes are not expected to have population-level effects. As such, this evaluation of the costs and benefits associated with rule effects on fish are focused on the predicted changes in abundance under AFF A4.

This section begins with a description of the concept of total economic value and each of the components that contribute to economic value as it relates to fish species, highlighting salmon as an example. It then evaluates the range of values associated with the affected fish populations to describe the potential benefits of the rule with respect to effects on fish.

Total Economic Value

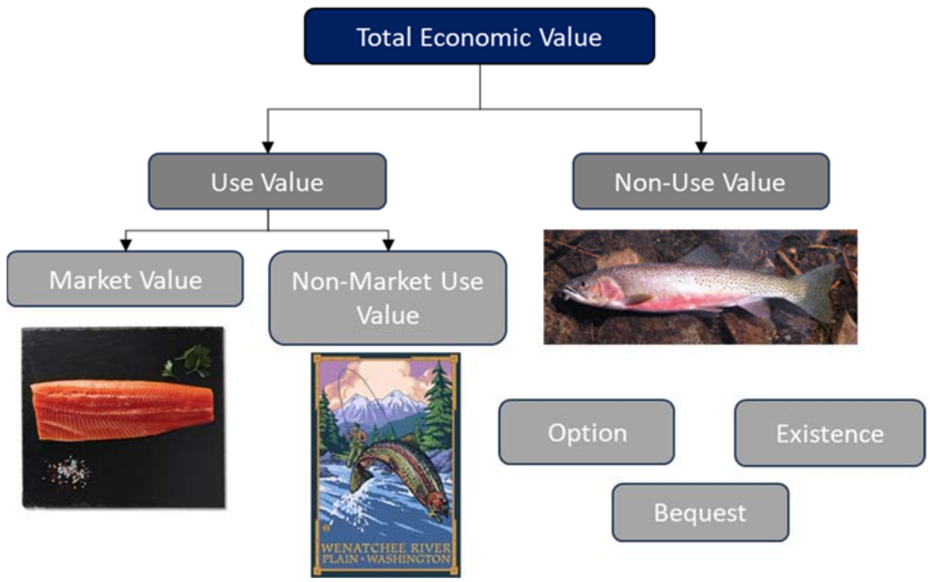
From an economic perspective, the "total economic value" of an animal or species reflects the full range of contributions the species makes to people's well-being. Value is frequently measured in terms of the public's willingness to pay (WTP) for the species, inclusive of all use and non-use services. This type of valuation is generally focused on endangered and threatened species. For example, salmon and steelhead provide value to society through multiple pathways that are difficult to disentangle. That is, their "total economic value" has multiple components, and individual members of society may value salmon and steelhead for multiple reasons (Figure 11).

First are the direct use values for which markets exist, namely commercial harvest. Next are the direct use values for which no markets exist, such as recreational fishing. Tribal harvest is unique in that it provides direct use value as both a marketed (commercial fishery) and nonmarketed (subsistence fishery) good. In contrast to the direct uses, which involve extraction, some non-consumptive use values may exist as well, including viewing spring salmon runs by nature enthusiasts. Additionally, the economics literature demonstrates that

Pacific salmon and steelhead hold significant non-use values. These types of values (existence, option, and bequest) are common for threatened and endangered species. Studies of the total economic value of salmon attempt to capture all of these components of value collectively, though not individually.

Importantly, Pacific salmon and steelhead are part of the spiritual and cultural identity of regional tribes. *As these cultural values cannot be measured in monetary terms, they are not captured in estimates of total economic value for the species.* However, it is important to consider the cultural significance of the species in any comparison of costs and benefits of policies affecting the species.

Figure 11. Components of Total Economic Value of a Species



Ideally, quantifying the total economic value of the fish effected by the rule options (primarily cutthroat trout) would involve careful estimation of each value component individually using market and nonmarket economic valuation techniques, recognizing that distinct subpopulations hold distinct values. Given the scale of the task and the complexities involved, most existing valuation studies focus on the collective total economic value held by a population within a particular geography based upon stated preference (i.e., survey) methods. Stated preference methods are designed to elicit a population's willingness-to-pay (WTP) for a carefully described environmental change (in this case, increases to salmon and/or steelhead populations). Table 25 summarizes relevant primary studies in terms of the valuation context (e.g., species, magnitude of change), the geographic location, the survey population, and WTP (per household and aggregated across the survey population). Studies included are those appearing in either peer-reviewed journals or the grey literature that estimate the total economic value of Pacific salmon and/or steelhead recovery to residents of Washington state. Of these studies, one also compares average WTP for Washington households to average WTP for households across the United States, demonstrating that Pacific salmon recovery is valued by people who may not directly interact with the species. As previously noted, the values in these studies do not incorporate tribal cultural values. Literature on total economic value is more limited for other fish species (i.e., cutthroat trout) affected by this rulemaking.

The literature consistently finds that the public places a high value on recovery of Pacific salmon and steelhead. However, the specific WTP estimates are difficult to compare across studies due to differences in the resources being valued (specific subpopulations of salmon), the study scope (i.e., both the number of species and the magnitude of increases), geographic scale of restoration (e.g., whether the change occurs in a single river system or region-wide), and elicitation methodology. Additionally, studies completed at different points in time may reflect variation in the ecological baseline (i.e., current abundance) or shifting preferences for restoration over time. Each study has advantages and disadvantages, and none perfectly match the context of valuing the changes induced by the proposed rule (i.e., marginal increases to coho, Chinook salmon, and steelhead populations attributable to improvements in riparian habitats).

At the low end, the most recent study (ECONorthwest, 2019) estimates the total economic value of restoring wild salmon (and improving water quality) in the Lower Snake River is between $142 million and $195 million.[34] At the high end, Layton et al. (1999) estimate a total economic value of $1.927 billion to $2.984 billion for increasing migratory fish populations by 50 percent throughout the state.[35] Of note, however, this study was completed over twenty years ago and no longer reflects the baseline status of salmon populations and may not accurately represent current preferences of Washington State residents.

As mentioned, none of the studies identified match the context of this analysis of this rulemaking, which identifies relatively limited changes in the populations of fish, including but not limited to salmon, in Washington. Accordingly, the remainder of this section provides insight into specific categories of value related to the identified changes in fish abundance, beginning with tribal cultural values and then assessing components of total economic value.

Ceremonial and Subsistence Fishing and Tribal Cultural Values

Washington State tribes and indigenous communities more broadly value the natural environment as an interconnected and inseparable system where all components play a critical role.

> *It's all interconnected. Almost all cultures seem to have a word or phrase for this. For Nuu-chah-nulth, the words are hishuk'ish tsawalk, meaning everything is connected, everything is one. It is definitely a principal that is first and foremost in dialogue, discussion, and documents. Not giving lip service to it, but real meaning, that this is so fundamental to our existence. That protecting and caring for all—air, water, animals—that are in First Nations' territories, all interconnected.*
>
> *Dr. Don Hall, PSC Canadian First Nations Caucus*

As such, Tribes place a high value on all of the ecological changes that may result from the rule including changes in fish abundance, as well as changes in the services provided by riparian habitats. Recognizing this indivisibility, this analysis focuses specifically on those components most likely to be affected by the rule alternatives. Of the ecological resources potentially affected by the rule options, tribes are most directly affected by changes in fish populations. While tribes recognize the critical role played by all fish species within the natural system, salmon are recognized as ecological and cultural keystone species to Indigenous communities (Garibaldi and Turner 2004). In the words of Wilbur Slockish, Kilkitat Chief, "All of the animals have a role in this world, in our belief. Rocks and water was the first one, the last one, but [salmon] is the first one that said he would take care of the people, providing them with drink to quench the thirst" (Earth Economics 2021). As a result, efforts to document the importance of fish to Pacific northwest tribes have focused almost exclusively on salmon, and no information is readily available to support evaluation of the value of other species to Tribes (personal communication with CRITFC, May 28, 2024).

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[34] Of note, the results of this study are based upon a single question telephone survey. Best practices for valuing unfamiliar nonmarket goods such as species recovery generally dictates providing sufficient information to ensure respondents understand the valuation context.

[35] Obtained by summing the values for "Eastern Washington and Columbia River" and "Western Washington and Puget Sound".

Tribal cultural and social values typically reflect a higher intensity and range of use of natural resources by tribal communities than the general population. In addition to the market value derived by tribes from their involvement in commercial and recreational fishing activities, tribal communities hold other values for the affected fish species that are unique and distinct from those held by the general public. These values derive primarily from the harvest and use of the salmon through ceremonial and subsistence fisheries (C&S). C&S fish refers to non-commercial fish caught by tribal members for purposes related to ceremonies or subsistence. Tribal members fishing commercially may designate a portion of their catch as "take home fish' (i.e., C&S fish), or a tribe may open a fishery expressly to harvest C&S fish for an intended purposes when there is no ongoing commercial fishing activity (NMFS et al. 2004). To the extent that the proposed rulemaking may impact tribal C&S fishing, tribal cultural values may be affected.

Importantly, Tribes do not support the concept of monetizing the value of natural resources:

> *We don't want to put a dollar value on fish. It means more to us than that. One of the sayings that First Nations have—both in Canada and in the United States—is that when the last tree is gone, when the last fish is gone, only then will people find out that you can't eat money. That's something that we have in common with the folks that we work with in the United States is that we have the same kind of belief system because we are family. Because before Canada and the United States existed, we existed, and we had those feelings about fish.*
>
> *Grand Chief Ken Malloway, Stó:lō Nation*

For this reason, this analysis focuses on a qualitative description of the potential costs and benefits of the rule options to tribes. Washington is home to 29 federally recognized Indian tribes, as well as numerous additional tribes and bands without federal recognition. Despite diversity across these tribes in terms of values and practices, one commonality is that all indigenous communities within the region identify as "Salmon Nations and People" (Conarro 2020). Washington tribes are culturally connected to all five species of Pacific salmon (genus *Oncorhynchus*). For these tribes, salmon are considered to be more than simply a resource to be utilized but is seen as "family and relations gifted by the Creator" (Earth Economics 2021). Of these tribes, 20 nations in Western Washington and five nations in Eastern Washington hold treaty-reserved rights to fishing at usual and accustomed areas (Earth Economics 2021).

Rule options that include AFF A4 are expected to directly benefit fish populations, and coho salmon are the primary salmon species expected to benefit from the rule options in terms of increased abundance, though some minimal benefits are expected for Chinook salmon and steelhead.

As described by Lane et al. (2004) and summarized in NMFS (2014), tribes in the region rely upon salmon for numerous purposes including:

- **Personal and family consumption.** Salmon is a main staple of the diet of tribal communities in the region, with tribal members consuming nearly all parts of the salmon in a wide variety of preparations. Tribes often offer community resources such as smoke houses, pressure cookers, or other processing equipment to facilitate salmon preparation and consumption;
- **Informal inter-personal distribution and sharing**. Salmon is shared and distributed among community members, facilitating connections between them and establishing a network of relationships and obligations;
- **Formal community distribution and sharing**. Salmon is expected or required to be served at a variety of occasions such as elders' dinners, cultural dinners with other tribes, and dinners for guests from outside the community; and

- **Ceremonial uses**. Salmon play a central role in a variety of ceremonies important to regional tribes including winter ceremonials, the first salmon ceremony, naming ceremonies, giveaways and feasts, and funerals.

In addition to these uses, salmon also facilitates the intergenerational transfer of knowledge and culture. Young people are taught by elders the use of fishing gears, preparation and preservation of salmon (e.g., smoking), and an appreciation for and awareness of their environment and the place of salmon within it. To tribal communities, their obligation to salmon revolves around the concepts of renewal, reciprocity, and balance (Lane et al. 2004).

Earth Economics (2021) identifies a sociocultural framework for describing the significance and value of Pacific salmon for Tribes and First Nations around five cultural themes. Within each, based on engagement with Northwest Tribes and First Nations and available research, they identify concepts or "codes" that emerge as particularly important values associated with salmon within those themes. These themes, as well as the concepts most frequently identified during interviews, include:[36]

- **Social**. The role of salmon in Tribal social structures.
    - *Gatherings and ceremonies* – Referring to salmon's prominent role in community events and social gatherings. (This was the fourth most mentioned concept by interviewees).
    - *Passing to future generations* – Conveying to youth and future generations the importance of salmon to their communities.
- **Health**. Salmon's influence on human health.
    - *Physical health* – Salmon's contribution to the physical well-being of Tribal members.
    - *Mental health* – Salmon's role in promoting individual mental health.
- **Livelihood**. Salmon's contribution to how Tribal members and communities can obtain necessities.
    - *Food* – Salmon's place as a food source for families and communities. (This was the second most mentioned code overall).
    - *Tribal commercial fishery* – Employment and income from engagement in commercial fisheries.
- **Indigenous Management**. Intra-tribal current and traditional forms of salmon management, as well as participation in non-Indigenous management forums.
    - *Rights* – The right reserved by Tribes to fish for salmon at usual and accustomed locations.
- **Knowledge and Practices**. Tribal cultural norms and traditions tied to salmon.
    - *Spiritual, belief* – Spiritual connections to salmon (This was the fifth most mentioned code).
    - *Traditional knowledge* – Understanding of ecosystem and processes therein that informs Tribal activities.

[36] The frequency with which interviewees mentioned each concept does not necessarily indicate its importance relative to other concepts but can serve as a proxy for understanding the associations and weight Tribal members place on it.

As the rule options that include AFF A4 are expected to result in a small increase in abundance of coho salmon, and to a lesser extent, steelhead and Chinook salmon, the cultural value that tribes derive from C&S use of these fish could increase. However, the predicted increases in abundance for these species is quite limited. Additionally, as detailed in the Environmental Impact Statement for Operations and Funding of Mitchell Act Hatchery Programs, (NMFS 2014), tribal harvest in C&S fisheries does not vary greatly between years because the number of fish harvested is driven by need, rather than availability. In years where tribal allocation is low, C&S harvest is prioritized, with any deficit in the need for C&S harvest taken from the tribal commercial harvest (NMFS 2017). As such, this increase in the number of fish would not necessarily result in an increase in the number of fish taken by tribes in C&S fisheries.

Recreational Fishing Value

Recreational fishing in Washington occurs in marine and fresh water throughout the state. The species most frequently targeted recreationally in Washington of relevance to this analysis include salmon, steelhead, and trout.[37] Regardless of whether the changes in fish abundance trigger a change in allowable recreational *harvest* (i.e., catch and retention) of these species in Washington, the increased fish may improve the quality of recreational fishing experiences in given areas. In particular, more fish in the water may increase the catch rate (number of fish caught per trip, which may be harvested or caught and released) or increase the catch per unit effort (i.e., more fish caught per unit of time spent fishing). These improvements in recreational fishing experiences may increase the value that anglers derive from participation in the activity. Improved quality or quantity of recreational fishing trips may therefore be measured in terms of the effect on people's value for (i.e., WTP) for fishing in an area.

We employ the following analysis to quantify the recreational fishing effects of the rule options:

- **Step 1:** For the anadromous and resident fish species/stocks of recreational importance in Washington expected to benefit from the rule alternatives, identify the total number of additional adult fish by species for which the rule options are anticipated to result in increases in abundance.
- **Step 2:** Estimate the proportion of those fish identified in Step 2 that will be caught by recreational fisheries taking into account accessibility of the increased fish abundance relative to the baseline, desirability as a recreational target given size, and whether the species is supply limited in terms of recreational fishing.
- **Step 3:** Evaluate whether increases in abundance of individual fish species are likely to result in generation of additional trips.
- **Step 4:** For species for which the generation of new trips is unlikely, describe qualitatively the potential benefits to recreational fisheries that could result from the rule alternatives.
- **Step 5:** For species for which additional trips may result from increased numbers of fish, identify available estimates of average catch rates per fishing trip that will be used to estimate the total number of fishing trips generated by the additional fish.
- **Step 6:** Using the identified catch rates, multiply the total number of adult fish by the proportion of fish anticipated to be harvested, and divide the result by the catch rate per trip to identify the number of additional trips generated by the estimated additional fish.

[37] Species whose lifecycle occurs strictly in marine waters such as halibut and rockfishes will not be affected by the rule and thus are not discussed in this analysis.

- **Step 7:** Identify baseline value of recreational fishing for affected stocks (WTP for fishing trips).
- **Step 8:** Multiply the value of each type of trip by the estimated additional trips.

Of the species expected to benefit from the rule options in terms of increased abundance, coho salmon, Chinook salmon, steelhead, rainbow trout, and cutthroat trout are all targeted recreationally. Some anadromous fish species are supply limited, suggesting that an increase in the ability/likelihood of harvesting one may result in generation of new trips. For other (e.g., cutthroat trout), it may be less likely that additional fish would result in additional trips. This analysis concludes that increased abundance of resident species including rainbow trout and cutthroat trout are unlikely to result in increased numbers of trips/value of recreational fishing for the following reasons:

- Rainbow and cutthroat trout species are abundant in Washington, and the value of recreational fisheries for these species is not limited by supply.
- The locations where these resident fish will benefit from increased extents of Type F stream and associated buffers are generally located relatively high in the system, near the upper extent of fish distribution, and on private property, making them less accessible or inaccessible to anglers.
- Trout species found in these locations are generally very small[38], making them less desirable targets for recreational fishing.

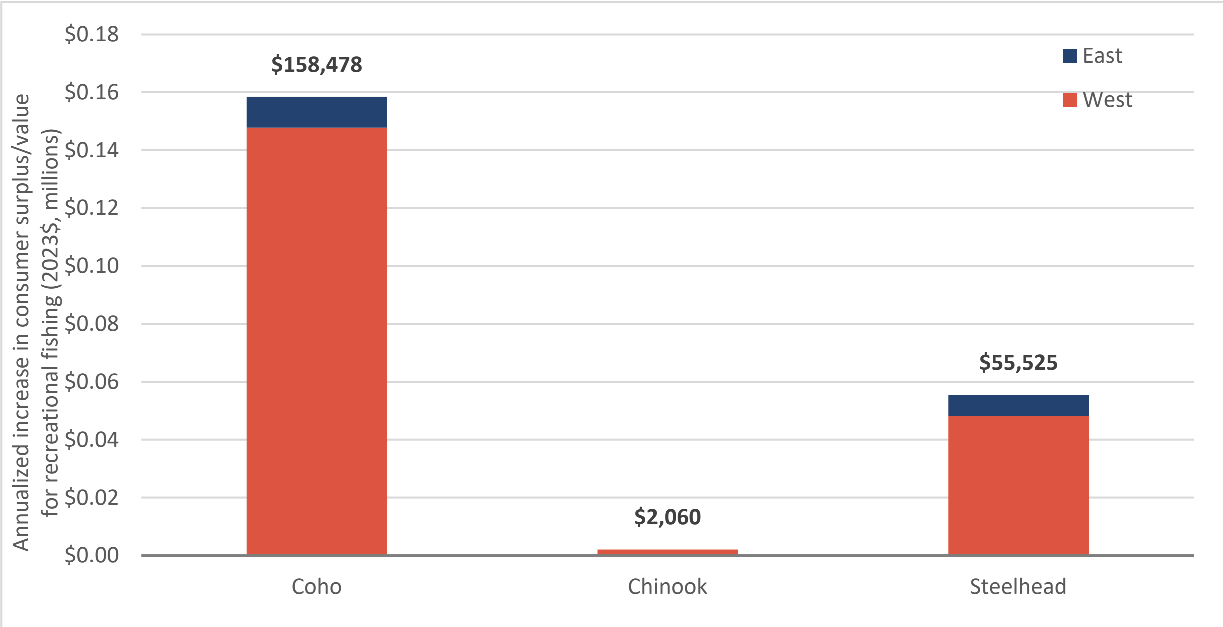
Although predicted increases in populations of coho salmon, steelhead, and Chinook salmon are modest, they are highly desirable as a target species in recreational fisheries and have relatively low harvest rates per trip. Additionally, as anadromous fish, they move throughout the system and could be accessible to anglers at locations beyond where new Type F stream is identified. Thus, even small increases in populations could result in the generation of additional fishing trips and an increased WTP for recreational fisheries targeting these species. Figure 12 presents the increased value of recreational fisheries expected to result from rule options including AFF A4, equivalent to $220,000 in annualized terms. Detailed results of this analysis are presented in Table 23.

As recreational values are tied directly to expected increases in abundance of anadromous fish, this analysis is subject to all of the same uncertainties described for the fish abundance analysis. Table 24 presents a sensitivity analysis of recreational fishing values. Under the modified assumptions regarding stream width and fish presence considered in the fish abundance analysis, we would expect corresponding increases in recreational fish values. Under a likely overestimate of anadromous fish presence in areas with increased Type F stream, the increase in recreational value is expected to be $1.8 million annualized.

This analysis also assumes that all additional anadromous fish resulting from the rule options would be accessible and available to recreational anglers. For these types of fish that migrate throughout the steam network and are not tied to locations of streams through private lands, we believe this is a reasonable assumption. One additional area of uncertainty is the extent to which additional anadromous fish would result in a generation of additional fishing trips with the assumed values per trip. Input from stakeholders, however, suggests that the base assumption that recreational fishing for anadromous species is supply limited and each additional fish will result in more trips is reasonable (Mason, Bruce, and Girard 2022).

[38] Based on analysis of WDFW Scientific Collection Permit data and comments provided on the 2019 Preliminary Cost Benefit Analysis of the DNR Stream Typing Rule.

Figure 12. Increase in Consumer Surplus/Value for Recreational Fishing (2023$) - AFF A4



Non-Use Values

Changes in the quality or quantity of fish resources may affect the non-use values that people hold for those resources. As described previously, non-use values reflect the positive preference that people may have for a resource beyond any current or planned future use. Non-use values are thought to reflect an environmental ethic and may be motivated by a desire to preserve the resource for future generations or based on the resource's intrinsic importance. Theoretically, people may have non-use values for any fish affected by the rule. Research on total economic values for fish species are theoretically inclusive of use and non-use values. While existing research demonstrates that total economic values do include non-use components, the total economic value studies are generally not able to parse the fraction of the value associated with non-use. Information on the magnitude of non-use values for fish species is very limited.

The proposed rule options that include AFF A4 are expected to result in increases in cutthroat trout populations, and more modest increases in anadromous fish (coho salmon, Chinook salmon, and steelhead) and other resident fish species (rainbow trout and bull trout). Reliably quantifying non-use values requires either implementation of primary research, or identification of existing research that is sufficiently similar in terms of the resources being valued, the anticipated change in that resource, the affected population, and the policy context. Neither criterion is met for the present analysis; thus, we are not able to quantify potential changes in non-use values of the fish although we find that there are probable non-use value benefits of the AFF A4 rule options.

While existing research focuses mostly on the total economic values of species due to the difficulty in distilling non-use values, some research attempts to specifically quantify non-use values of fish and wildlife. These studies are generally developed for and specific to endangered populations, and largely focus on anadromous salmonids. Thus, there is limited information available to compare non-use values across all of the fish species included in the analysis. However, these studies provide evidence that the public holds a positive value for efforts that increase salmon populations or the probability of recovery for ESA-listed populations.

The following studies have quantified the public's WTP for actions that increase salmon and steelhead populations in Washington and have specifically attempted to isolate and quantify the non-use value respondents hold for the fish benefitting from the change being proposed.

- Bell et al. (2003) quantified the WTP (attempting to reflect non-use value only) of coastal residents of Washington for a doubling or quadrupling of coho salmon in two Washington estuaries. They found an average WTP per household of between $130.89 and $209.82 (2023 USD) per year for five years for this change.

- Johnston et al. (2015) quantified the WTP (non-use only) of US residents for the delisting of Puget Sound Chinook salmon within 50 years. Respondents had a WTP per household for this change of $32.24 (2023 USD) per year for 10 years.

- Olsen et al. (1991) quantified the WTP (non-use only) of Pacific Northwest residents for a doubling of salmon and steelhead runs from 2.5 million to 5 million. They found an average WTP specifically for the non-use of these fish per household of $58.12 (2023 USD) per year in perpetuity for this change.

- Layton, Brown, and Plummer (1999) quantified two baseline estimates for 2 million Washington households WTP (passive value) for increases in fish populations for 20 years. Under the low status quo condition, where Eastern Washington and Columbia River migratory fish populations (CM) increase from 0.5 million to 2.0 million and Western Washington and Puget Sound migratory fish populations (PM) increase from 2.5 million to 5 million, household WTP was approximately $61.36 per month (for both populations). In the high status quo scenario, where CM increases from 2.0 million to 4.0 million and PM increases from 5 million to 10 million, households were WTP approximately $36.19 per month for a doubling of fish populations.

Overall, the findings of these studies suggest that people hold a positive value for increasing salmon populations and recovering ESA-listed populations to a level sufficient to justify delisting. The absence of research on total economic values or non-use values for other fish species does not indicate that people do not hold value for these species. The focus of the current literature on salmon is due to the fact that it is actively managed and information on the economic benefits of improving conservation of these fish allows managers to compare costs of the conservation actions with the economic benefits to society.

Commercial Fishing

The commercial fishing industry in Washington targets a variety of species including shellfish (e.g., geoduck clams and Dungeness crabs), groundfish (e.g., sablefish and Pacific whiting), highly migratory species (e.g., albacore tuna), and salmon. Of the species identified as potentially affected by the proposed rule options, coho salmon, Chinook salmon, and steelhead are targeted in commercial fisheries. This analysis predicts only modest increases in abundance of coho salmon, and very limited increases of steelhead and Chinook salmon under rule options that include AFF A4, primarily in rivers and tributaries in western Washington. The increased abundance of coho salmon, Chinook salmon, and steelhead theoretically has the potential to benefit the commercial fisheries that target those species. However, that value is only created if harvest of those fish is permitted. Prior interviews with fishery managers representing WDFW did not believe that an increase in the abundance of fish of the magnitude predicted by the original cost benefit analysis alone would result in an increase in allowable commercial harvest. Given that predicted fish abundance benefits associated with the current rule options are far lower than what was found previously, this analysis assumes that determination holds true.[39] As a result, we do not anticipate economic impacts to commercial fisheries to result from the rule options.

4.5.3. Instream Habitat Conditions and Downstream Fish Effects

Key findings

- Under AFF A4, increases in Type F stream across over 3 percent of the stream networks statewide benefit fish and other aquatic and aquatic-dependent species. This outcome is particularly notable in the Coast Range and North Cascades (East and West) ecoregions.
- Under AFF D, there is a decrease in riparian buffer habitat quality across approximately 1 percent of the stream network in Washington. This change could result in minor population-level reductions within those ecoregions, and some limited degradation of water quality and other instream habitat features both within the stream length that has change from Type F to Type N, as well as downstream of those locations.

Increased riparian buffer improves instream habitat, including water quality, in several ways. Some of the ecological functions of a vegetated riparian zone as they relate to cold-water fish including salmon, steelhead, and other trout are described by Quinn et al. (2020), and include 1) bank stability and sediment filtering, 2) shade and water quality, 3) large wood, and 4) leaf litter and nutrients (Table 4). These habitat conditions can extend beyond the fish populations that rear within the habitat directly adjacent to the stream length experiencing a change in riparian buffer width (which is the benefit described in Section 4.5.1). Improved riparian buffers can benefit fish populations located downstream from the habitat improvements, lower trophic level organisms that form the base of the aquatic food web, and other aquatic and aquatic-associated wildlife such as birds, mammals (e.g., mink and otter), turtles, and amphibians (e.g., frogs and salamanders). Conversely, where the proposed rule alternatives reduce the extent of Type F waters and their associated RMZ buffers, a loss of these benefits would be likely.

Analysis Approach

Quantification of the ecological benefits of changes in riparian buffers that are less direct and/or more geographically distant, such as improvements in water quality and other habitat conditions lower in the watershed, and in other services provided by riparian habitats, are difficult to measure and subject to uncertainty. The available literature supports the finding that an increase in buffer length and width will improve bank stability, sediment filtering, water quality (i.e., temperature), large wood, and leaf litter/nutrients. Conversely, a reduction in the extent of Type F stream likely results in adverse effects to fish both adjacent to and downstream of the reduced Type F buffer, as the reduced buffer width may result in increases in water temperature and decreased water quality in individual hydrologically connected streams. These effects, in turn, result in effects on fish including changes in mortality and sub-lethal effects for individual fish; where in-steam habitat improvements are substantial, there is potential for local population-level effects.

While we are unable to quantify the downstream effects of changes in riparian buffer management on water quality and fish, this analysis considers the effects of the proposed rule options on water quality and fish based on the scientific literature according to the following general approach.

[39] Personal communication with Kyle Adicks, Kirt Hughes, and Laurie Peterson, WDFW on March 25, 2019.

- **Step 1:** Describe the types of benefits provided by riparian habitat with respect to in-stream habitat conditions, including water quality.
- **Step 2:** Describe the scale of expected change in Type F buffers relative to the overall length of streams in the state and ecoregion.
- **Step 3**: Evaluate the direction and degree to which those services will change under each of the rule options.

Table 4. Ecological Function and Downstream Effects on Salmon and Trout from Riparian Buffers

Ecological Function	Effect on Salmon and Trout
Bank Stability and Sediment Filtering	The riparian canopy protects soil from direct exposure to rainfall and moderates surface runoff, erosion, and the transport of fine sediments into the stream. Vegetated floodplains disperse and slow water velocities during high flows. Root networks increase soil cohesion and protect streambanks against erosion, avulsion, and mass wasting in the uplands. Embeddedness of streambed gravels—filling of interstitial spaces with fines—determines spawning success and the rate at which eggs survive to become juvenile fish (i.e., egg-to-fry survival). Indirectly, the percentage of fines in the substrate determines the health of macroinvertebrate communities that serve as the food base of juvenile salmon.
Shade and Water Quality	Vegetation along the banks of streams provides shade, which helps to regulate water temperature, dissolved oxygen concentrations, and evaporation rates. Temperature is an important determinant of habitat quality for salmon: it helps determine the timing of upstream migration and spawning, the duration of incubation, timing of fry emergence, and may have lethal effects when temperature exceeds 25° C. Vegetated riparian buffers are also effective at filtering contaminants that would otherwise be carried via surface runoff into the stream.
Large Wood	Mature trees that fall into the active channel or floodplain interact with flows to create hydraulic conditions and stream morphology that juvenile salmon prefer. Wood promotes the formation of pools that are a preferred habitat type for many species of rearing salmon and it regulates the flux of sediment through the stream corridor, sorting and retaining gravels important for spawning.
Leaf Litter and Nutrients	Leaves falling from the forest canopy are an important contributor to the base of the aquatic food web. Primary production drives the secondary production of benthic macroinvertebrates, which in turn become the prey base for juvenile salmon. Additionally, streamside vegetation can produce and concentrate terrestrial insects, which fall into the stream and become available as prey for fish. Especially in small, low-order streams, terrestrially derived inputs are a major driver of the aquatic food web.

Source: Quinn et al. (2020)

Results

As described above, the quality of instream habitat improves with the addition of increased riparian habitat. Rule options that include AFF A4 will result in increases in Type F streams and associated improved riparian habitat across approximately 7,000 stream miles statewide.[40] This represents an improvement of riparian buffer habitat in 3 percent of streams and rivers in the state identified in WC Hydro. In certain ecoregions, the increase in Type F streams represents a significant proportion of the total stream network and these types of riparian buffer improvements could result in marked improvements in in-stream habitat conditions; for example:

- In the Coast Range, AFF A4 results in an increase in Type F stream miles of approximately 3,900 miles, 9.2 percent of the total stream network in that ecoregion. This represents a meaningful improvement in

[40] The extent of new Type F habitat created under AFF A4 ranges from 5,783 miles under PHB Option A to 7,098 miles under PHB Option B.

anadromous fish habitat, as 27 percent of stream miles documented in SWIFD as occupied by anadromous fish occur in this ecoregion.
- In the North Cascades, increased F stream of 1,900 miles in the West and 1,400 miles in the East represents improvements across 9.4 percent and 5.4 percent of the streams in the two ecoregions, respectively. Over 11 percent of the streams miles in the state documented as occupied by anadromous fish in SWIFD occur in this ecoregion.

In these cases, there could be substantial improvements in water quality and other in-stream habitat conditions that could result in population-level increases in the number of individuals locally, as well as other benefits to amphibians, and other aquatic organisms (including those that form the prey base for salmon and other fish).

Under rule options that include AFF D, there is a reduction of approximately 1,400 miles of Type F stream and associated buffer habitat.[41] This represents a decrease in riparian buffer habitat quality across approximately one percent of the stream network in Washington. The most substantial decrease in Type F streams in any ecoregion (a reduction in Type F stream over 2.1 percent of the stream network) occurs in the Coast Range, with 1.3 percent of the stream network in the Puget Lowland ecoregion going from Type N to Type F stream and riparian habitat. Under this rule option, we may see minor population-level reductions within those ecoregions, and expect there to be some degradation of water quality and other instream habitat features both within the stream length that has change from Type F to Type N, as well as downstream of those locations.

Uncertainties

- While the scientific literature demonstrated that larger forested riparian buffers improve water quality and aquatic habitats beyond the stream directly adjacent, the magnitude of this improvement is site-specific and dependent upon multiple other environmental and ecological factors that influence water quality.

4.5.4. Other Riparian Habitat Ecological Functions and Ecosystem Services

Key findings

- ► Under AFF A4, approximately 4 percent increases in protected riparian habitat acreage on state and private timberlands in Washington. Given the scale of this change, this rule option could result in potentially major ecological benefits for riparian habitat ecosystem services. This outcome is particularly notable in the Coast Range and North Cascades (East and West) ecoregions.
- ► Under AFF D, there is a decrease in riparian buffer habitat acreage conserved on state and private timberlands of approximately 1 percent. This change could result in minor decreases in riparian habitat functions beyond in-stream effects, particularly in the Coast Range ecosystem.
- ► Areas where improved riparian habitats will occur under AFF A4 rule options and where reduced riparian habitat protection will occur under AFF D rule options are often on inaccessible for recreation, or the changes are unlikely to be perceptible to recreationists. Effects on other aquatic and riparian recreation activities (outside of recreational fishing) are possible in specific areas but likely to be negligible.

In addition to the water quality and other in-stream habitat benefits offered by intact riparian habitat described in Section 4.5.2, riparian habitats provide a range of other ecological services. Changes in the acreage of land

[41] The reduction in Type F habitat under AFF D ranges from 1,312 miles under PHB Option A to 1,570 under PHB Option C.

protected as intact riparian habitat will increase or decrease riparian habitat functions. Shifts in the location and amount of harvestable forestland may have implications for the habitat of forest-dwelling wildlife, including the northern spotted owl and marbled murrelets. The shifts in habitat may contribute not only to changes in location, but also to changes in the population or health status of the wildlife. The wildlife benefitting from the rule may support recreational activities – either within the protected riparian and aquatic habitats or in accessible recreational areas nearby.

While not the objective of the rulemaking, we highlight these probable outcomes of the rule options for consideration. Information is not available to quantify the potential effects of the rule options on these types of other riparian habitat functions. As such, this analysis focuses on a qualitative description of likely affected riparian habitat functions, and how they may be affected given the scale of change in intact riparian buffer anticipated under the rule options.

Analysis Approach

- **Step 1:** Describe the types of benefits—beyond water quality and in-stream habitat effects—provided by riparian habitat.
- **Step 2:** Describe the scale of expected change in Type F buffers relative to the overall area of riparian habitat currently conserved as buffer habitat on state and private timberland in the state.
- **Step 3**: Evaluate the direction and degree to which those services will change under each of the rule options.

Results

Rule options that include AFF A4 will increase the total acreage of riparian buffer habitat by between 120,000 acres and 130,000 acres (Table 16). This would increase the total acreage of state and private timberland conserved as riparian habitat by approximately 4 percent.[42] This extent of improvement in the quantity of intact riparian habitat is expected to meaningfully increase the ecological services provided by these habitats.

Under rule options that include AFF D, there is a reduction in the total acreage of riparian buffer habitat by between 25,000 acres and 28,000 acres. This acreage reduction represents a reduction of less than one percent of the total acres currently conserved as riparian buffer habitat on state and private timberlands. Under these rule options, there will likely be a reduction in ecosystem services provided by riparian habitat.

As previously noted, riparian buffers provide a wide array of benefits ("ecosystem services") to humans, including food, water, flood mitigation, nutrient cycling, sediment and pollutant filtration, carbon storage, recreational and spiritual value, including tribal cultural values, yet many of these benefits often remain unquantified and unnoticed until they are diminished or absent (Rentz et al. 2020, Quinn et al. 2020). Existing scientific and economics literature identifies riparian buffers as having a positive economic value both in terms of private and public benefits, and this economic value of buffers increases with both the width and the length of the buffer (American Rivers 2016).

We consider whether the improvement or degradation in riparian ecosystem functions, including wildlife habitat provisioning, may affect recreational experiences beyond recreational fishing, such as paddling, swimming, and wildlife viewing. Changes in the quality of riparian habitat resulting from stream typing occur on both private and state-managed timberland. Terrestrially based recreational activities such as bird watching, hunting, wildlife viewing, and swimming (which requires a land-based point of access) are unlikely to be affected on private

[42] The total area of conserved riparian habitat on timberland in the baseline is 5,042 square miles or 3.2 million acres.

timberlands that do not offer direct public access for recreation. There is the potential for these activities to experience either costs or benefits on accessible state lands, for example if abundance of wildlife increases resulting increased viewing opportunities. Given that these types of effects are largely limited to public lands, that they will only marginally change habitat for terrestrial species, and that the expected changes in terrestrial habitat are unlikely to be to a degree that they will be perceived by recreationists, we expect costs and benefits to terrestrially based recreational activities to be possible but negligible.

River-based activities such as kayaking, canoeing, and rafting occur throughout Washington's rivers, including on rivers and stream running through private timberland. American Whitewater, a non-profit river conservation organization representing whitewater enthusiasts, identifies that riparian buffers "define our paddling experiences" (American Whitewater 2024). American Whitewater describes the benefits of riparian buffers to rafters and kayakers as including improving aesthetics,[43] improving water quality (particularly clarity and pollution), reducing flooding, providing shade, and providing habitat to terrestrial and aquatic species. Under rule options that increase the extent of Type F buffers, these services are expected to increase, while they will decrease under rule options including AFF D. Although these changes in the extent of F stream and quantity of intact riparian habitat could have meaningful ecological benefits, they are not expected to be to such a degree as to noticeably change the experience and value of recreational activities. We therefore expect costs and benefits to water-based recreational activities to be negligible.

Uncertainties

- Specific changes in services wildlife habitat, recreation, cultural values, and other measures of services provided by riparian habitats are probable. However, the magnitude of these changes is uncertain.
- While the scholarly literature identifies people benefit from and hold positive values for riparian buffers and related ecosystem services, and that the benefits increase with wider buffers, the existing literature does not provide sufficient information to quantify the economic value associated with the incremental changes in riparian habitat protection triggered by the rule options.
- The changes in riparian habitat function, including improving quality of riparian and aquatic habitats for recreationally valuable wildlife (outside of fish) are possible but most likely negligible.

4.5.5. Forest Carbon Flux

Key findings

- ► Regulatory alternatives that include AFF A4 result in a net increase in carbon sequestration and decrease in carbon emissions associated with harvest. Considering a 50-year timeframe consistent with the underlying data, and applying a social cost of CO2, these alternatives are associated with a net reduction in global climate related damages on the order of $1.8 million in annualized equivalents associated with reduced atmospheric carbon related to forest management.
- ► Regulatory alternatives that include AFF D result in the net increase in atmospheric carbon given the increase in harvestable areas. We identify an annualized net increase in global climate damages on the order of $400,000 stemming from increased harvest.

The rule options may affect the amount of timber harvested from, and the tree biomass remaining within, the buffer areas. The rule may therefore affect the carbon sequestration and storage potential of the landscape.

[43] Although the difference between a complete lack of a riparian buffer and presence of a buffer would affect the aesthetics experienced by individuals transiting streams and rivers, boaters are less likely to note a difference between Type N and Type F riparian buffers.

Carbon fluxes in forested landscapes are a function of multiple factors including stand type, age, health, and management approach. The benefits of carbon sequestration and storage reflect the avoided marginal climate change-related damages associated with the reduction in atmospheric carbon. That is, in economic terms, the benefits of reductions in atmospheric carbon dioxide (and other greenhouse gases), reflect the value that people derive from avoiding additional climate change-related impacts (e.g., to crops, human health, infrastructure, etc.). The social cost of carbon dioxide (SC-CO_2) measures the public's willingness-to-pay to avoid climate change-related impacts. Because carbon accumulates in the atmosphere and contributes to climate change at a global level, metrics of the SC-CO_2 reflect global benefits, not benefits experienced in Washington specifically.

Carbon fluxes in forests, particularly commercially managed forests, are complicated. Therefore, comparing carbon sequestration between Type F and Type Np buffers requires significant assumptions about how specifically the buffers are managed for timber harvest absent the proposed rule. This analysis relies on data, methods, and a tool from the U.S. Department of Agriculture's "Quantifying Greenhouse Gas Fluxes in Agriculture and Forestry" (USDA 2024) as the basis for estimating the differences between Type F and Type N buffers alongside assumptions about typical forestland management in Washington. The diversity of tree ages the year the rule goes into effect means harvest occurs throughout the state each year as trees reach these age thresholds; therefore, our analysis captures many of the effects of the rotations.

Analysis Approach

- **Step 1:** Evaluate existing stand characteristics within riparian buffers (dominant tree species and distribution of age) using gradient nearest neighbor (GNN) data from the Landscape Ecology, Modeling, Mapping, and Analysis (LEMMA) project.
- **Step 2:** Determine assumptions about baseline management of forests in Type F and Type Np buffers.[44]
    - ***Type F:*** Landowners adjacent to Type F streams will comply with harvest restrictions and their trees will age continuously over the analysis timeframe.
    - ***Type Np in western Washington:*** We assume 1) 50 percent of trees 45 and older when the rule takes effect are cut at an even rate over the analysis timeframe; and 2) trees younger than 45 when the rule takes effect are part of an active 45-year timber rotation and are cut at age 45.
    - ***Type Np in eastern Washington:*** We assume 1) 50 percent of trees 55 and older when the rule takes effect are cut at an even rate over the analysis timeframe and 2) trees younger than 55 when the rule takes effect are part of an active 55-year timber rotation and are cut at age 55.
- **Step 3:** Identify carbon fluxes among Type F and Type Np buffers using the USDA (2024) "Excel Workbook to Support Level 1 Quantification Approaches for the Managed Forest Systems Chapter within the 2024 update to the USDA's Publication *Quantifying Greenhouse Gas Fluxes in Agriculture and Forestry: Methods for Entity-Scale Inventory*."[45] This tool considers many aspects of GHG flux, including carbon sequestration as well as carbon emissions associated with forest management under harvest and no harvest conditions. The estimates we use are specific to the Pacific Northwest (and separated by Westside and Eastside) as well as the tree species and tree age distribution identified in Step 1 and the harvest rotation assumptions delineated in Step 2.

[44] These assumptions leave some room for conservation of trees in RMZs adjacent to Type Np streams, because data characterizing tree age identifies that many trees in riparian buffer areas are more than 45 years old.

[45] This tool is available for download at: https://www.usda.gov/oce/entity-scale-ghg-methods/download

  - ***Type F:*** We apply the "Basic projection under forest management" scenario that identifies the total change in living and dead carbon pools over 50 years.
  - ***Type Np:*** We apply the "Basic projection under forest management, with harvest" scenario that considers carbon sequestration until the specific harvest time as well as carbon impacts from harvest and post-harvest over 50 years.

- **Step 4:** Estimate total change in carbon fluxes (measured in metric tons of CO_2) by year and ecoregion by differencing the carbon flux findings for Type F and Type Np buffers (Step 3) throughout the 50-year analysis period.
- **Step 5:** Apply the SC-CO_2 per metric ton from the most recent guidance from the Federal government regarding the social costs of GHG emissions by year in which carbon flux changes are experienced (EPA 2023). For consistency with the social discount rate used in this analysis, we apply the 2 percent rates presented in EPA (2023) as our central estimate and conduct the analysis with alternative discount rate assumptions reflecting this uncertainty.

Results

The carbon flux changes differ by analysis year to capture the rotation dynamics described above. For perspective, AFF A4 results in a net decrease of around 6,000 metric tons of SC-CO_2 in flux western Washington per year on average. For eastern Washington, the net change under the AFF A4 rule options is a net decrease of 500 metric tons of SC-CO_2 per year on average. For the AFF D options, the net increase in atmospheric SC-CO_2 equivalents are around 1,300 tons in western Washington relative to 70 tons in eastern Washington. As a point of comparison, data from the Washington Department of Ecology shows that the total emissions in Washington state across all sectors in the year 2019 was 102.1 million metric tons of CO_2 equivalents (Ecology 2022). The changes we estimate from affected forest buffers represent a very small fraction of the overall CO_2 emissions in Washington state.

Not only do carbon fluxes vary by year given changes in stand age and harvest, but we also apply the SC-CO_2 per metric ton matched with our analysis years. Estimates from EPA (2023) are equivalent to $220 per metric ton between 2025 and 2030 and increase to $441 per metric ton between 2070 and 2075 (2023 dollars), reflecting an overall increase in climate damages per unit of carbon over time. Table 26 presents our annualized results by rule option and ecoregion while Figure 13 summarizes the findings. As shown, the AFF A4 rule options are associated with a net reduction in global climate related damages on the order of $1.8 million in annualized equivalents associated with reduced atmospheric carbon related to forest management in western Washington and approximately $150,000 in annualized equivalent from eastern Washington. For AFF D, we identify an annualized net increase in global climate damages on the order of $400,000 stemming from changes in western Washington whereas a net increase from eastern Washington of approximately $18,000.

Figure 13. Annualized Value of Carbon Flux Changes (2023$, millions)

Note: Negative numbers represent incremental costs; positive values represent incremental benefits. To match the underlying data from USDA (2024), we apply a 50-year analysis timeframe and annualize accordingly for comparison with other rule option effects.

Uncertainty

- This analysis requires modeling a timber harvest rotation absent the rule that may differ from on the ground management practices. Further, the GNN data may not capture the exact age of specific trees within buffers. However, this is an order of magnitude analysis and is intended to capture the range of carbon-related effects.

- EPA (2023) provide SC-CO_2 estimates across three near term target discount rates (1.5 percent, 2 percent, and 2.5 percent) "based on multiple lines of evidence on observed real market interest rates" (EPA 2023, p. 2). The main analysis presented above relies on the 2 percent discount rate.

  - When applying the SC-CO_2 estimates derived from a 2.5 percent discount rate, the beneficial impact of carbon flux from AFF A4 is on the order of $1.1 million in annualized terms from western Washington and $110,000 from eastern Washington. For AFF D, the model identifies a net cost in global climate damages of approximately $250,000 from western Washington and $13,000 from eastern Washington.

  - When applying the SC-CO_2 estimates derived from a 1.5 percent discount rate, the beneficial impact of carbon flux from AFF A4 is on the order of $2.8 million in annualized terms from western Washington and $270,000 in eastern Washington. For AFF D, the model identifies a net cost in global climate damages of approximately $620,000 in western Washington and $37,000 in eastern Washington.

4.5.6. Regional Economic Impacts of Changes in Fishing and Other Water-Based Activities

Changes in market activity associated with recreational and commercial fishing or other types of water-based recreation could result in changes in regional economic productivity. To the extent that there is increased market activity associated with resources affected by the rule alternatives, this could result in changes in regional economic productivity. This analysis consists of the following approach:

- **Step 1:** Identify economic activities dependent on fish, water quality, and other ecological resources potentially affected by the rule options that contribute to the regional economies of Washington.
- **Step 2:** Qualitatively discuss whether and how the change in these activities may affect the regional economy.

Economic activities dependent on fish, water quality, and other habitat conditions potentially affected by the rule options include commercial and recreational fishing, and other recreation, such as boating and wildlife-viewing. To the extent that the proposed rule options increase the allowable harvest for commercial fisheries, the commercial fishing industry and interrelated economic sectors (e.g., for fishing equipment, fuel, fish processing, etc.) may experience an increase in productivity (e.g., in the form of revenues and employment opportunities). As previously described, however, Washington State fisheries managers do not anticipate that the fish effects resulting from the proposed rule options alone would necessarily result in a change in allowable harvests. As a result, this analysis does not anticipate measurable effects on commercial fishing businesses or interrelated sectors (i.e., businesses that provide inputs to commercial fishing production, such as equipment manufacturers, or rely on the outputs of commercial fishing operations, such as processors).

Additionally, to the extent that the additional fish attracts increased visitation to the region for recreational fishing, the associated spending in the regional economy (e.g., on food, fuel, lodging, equipment) can provide an economic stimulus. As previously discussed, however, Additionally, the extent to which the proposed rule options increased trips to and spending within the region, as opposed to improving the quality of the experience for existing trips, is largely uncertain. Due to this uncertainty, this analysis does not quantify regional economic impacts associated with the changes in fish abundance.

5. Weighing of Probable Costs and Benefits

As described in Section 1 of this memorandum, the objectives of the water typing rule do not include ecological outcomes, such as increasing the protection of riparian or aquatic habitats or increasing fish abundance. The objectives of the rule are focused on codifying a consistent method for typing streams. Thus, the majority of the benefits and costs of the rule are unintended consequences, including changes in timberland values and stream crossing costs, as well as the ecological changes, including fish abundance and riparian and aquatic habitat ecosystem services. However, it is important to consider the full scope of probable costs and benefits of the rule options.

Section 4 details our determinations about which effects of the rule are probable by rule option and provides perspective on the magnitude of each. Table 5 summarizes our findings, which include:

- **For the AFF A4 rule options, the analysis finds both major benefits and major costs attributable to the rule.** With a considerable increase in Type F stream, major costs of the AFF A4 rule options include timberland values ($11 million on an annualized basis) across over 130,000 acres of land that become unharvestable and the increased costs associated with upgrading existing and building new stream crossings to Type F specifications ($6.3 million). The countervailing ecological effects of conserving forested riparian buffers are also major benefits of the rule. Because AFF A4 presumes the lengthening of Type F streams creates additional habitat, one benefit is improved habitat conditions to support increased fish abundance (on the order of 13,000 fish per year on average), which provide tribal cultural value, non-use values, and may result in up to 2,500 new recreational fishing trips for primarily for coho salmon and steelhead valued at $220,000 in annualized terms.

Beyond fish abundance, conserving forested riparian habitat also provides other ecosystem service benefits. For instance, we calculate that the increased landscape carbon storage and sequestration associated with the unharvested acres is on the order of $1.8 million in annualized terms, in addition to provide important riparian and aquatic wildlife habitat improvements. Finally, while the reduced risk from electrofishing is a probable benefit of the rule, this analysis does not find that fish will avoid harm relative to current industry practices. Benefits to forest- and water-based recreational activities are also likely to be negligible given limited public access to the affected areas.

- **For the AFF D rule options, the probable effects are mostly minor or negligible.** With a less sizable reduction in Type F stream, our analysis identifies that the primary costs of the rule come in the form of reduced services provided by forested riparian buffers. These include downstream water quality, which affects fish and other aquatic species, as well as other ecological functions maintained by conserving forests near streams. Given the relatively limited decrease in Type F stream estimated for these rule options, we determine these ecological costs to be minor, which includes $400,000 in global costs associated with reduced landscape carbon sequestration and storage as well as other unquantified environmental costs. An additional negligible cost of the rule is a reduction in value provided to recreationalists who pursue forest- or water-based recreation near the affected buffers. With this rule option, the ecological costs are counteracted by major benefits in the form of increased timberland values on the order of $2.4 million in annualized terms across up to 28,000 additional harvestable acres. Landowners also experience minor benefits associated with reduced costs associated with future stream crossing construction, estimated at $380,000 annualized. Lastly, the reduced risks of fish harm from electrofishing are also a minor probable benefit of the rule.

Table 5. Quantified and Unquantified Effects of the Rule Options

Rule Options	Incremental Costs (or Foregone Benefits)	Incremental Benefits (or Reduced Costs)
AFF A4 + PHB A AFF A4 + PHB B AFF A4 + PHB C	Quantified costs • Reduced timberland values ($11 million) • Increased costs of stream crossing upgrades ($6.3 million)	Quantified benefits • Increased landscape carbon storage and sequestration ($1.8 million) • Improved recreational fishing ($220,000) Unquantified benefits: • Other values associated with improved riparian forest ecosystem services • Other values associated with increased fish abundance • Reduced risk of fish harm from electrofishing
AFF D + PHB A AFF D + PHB B AFF D + PHB C	Quantified costs • Reduced landscape carbon sequestration and storage ($400,000) Unquantified costs: • Other values associated with reduced riparian forest ecosystem services	Quantified benefits • Increased timberland values ($2.4 million) • Stream crossing upgrades ($380,000) Unquantified benefits: • Reduced risk of fish harm from electrofishing

Note: This table omits categories determined to be negligible effects of the rule options. For a complete accounting of the probable effects identified in this analysis, see Table 1.

As evident from these descriptions as well as Table 5, we identify important ecological effects of the rule options that cannot be quantified or monetized. These include:

1. most values people derive from conserved riparian forest buffers and increased fish abundance related to an increase in Type F stream length for the AFF A4 rule options as well as;

2. most values people lose stemming from reduced ecological functions associated with the decrease in Type F stream length pursuant to AFF D.

While there is a substantial evidence base demonstrating that people value the services provided by forests and protection of riparian areas, it is challenging to apply the available literature in the context of this rulemaking. In order to conduct the weighing of probable benefits and probable costs of each rule option, we explore this literature to provide perspective on the potential magnitude of these unquantified effects.

Perspective on Unquantified Values of Fish Abundance

To provide perspective on the potential value of the expected changes in fish abundance, we reference estimates of WTP for fish population increases on a *per fish* basis obtained from Layton et al. (1999). The study reports these numbers for five categories of fish: eastern Washington freshwater species (approximately $15 per fish in $2023), eastern Washington migratory species ($600/fish), western Washington freshwater species ($27/fish), western Washington migratory species ($500/fish), and saltwater species. Based on the average annual changes in fish abundance identified in this report, the WTP values would be on the order of $900,000 annually.

While we include this information to communicate some perspective on unquantified benefits in our analysis, we do not include these values as a quantified benefit because the Layton et al. (1999) study, while high-quality and policy-relevant, is dated and is unlikely to reflect either the baseline ecological condition of fish populations in Washington or the current values held by Washington state households today. Of additional note, these values do not reflect the tribal cultural values of the fish and should therefore not be considered a full accounting of the benefits of increased fish abundance.

Perspective on Unquantified Values of Riparian Forest Services

Literature demonstrates that people hold values for the many ecosystem services provided by riparian buffers. For instance, a study from western North Carolina found that residents were willing to pay for riparian restoration projects along tributaries of the Little Tennessee River that generated game fish, water clarity, wildlife habitat within buffers, water access opportunities, and more “naturalness” (Holmes et al. 2004). Using a contingent valuation approach, the authors found that individuals were willing to pay between $19.02 and $89.50 per foot of stream restoration (2004 dollars). However, we did not identify any studies specific to Washington state that illuminate the values people derive from protection in Type F buffers versus Type N buffers.

Another perspective on the value people derive from forested buffers comes from the literature on ecosystem services associated with forests more generally. A frequently cited study first published in 2007 and most recently updated in 2014 employs a large-scale benefit transfer approach to assess the global value of ecosystem services (Costanza et al. 2014). This type of study is often referred to as a “rapid assessment.” The general approach is to scale average values per hectare from existing studies across landscapes based on ecosystem type (e.g., $/acre of forest multiplied by total acre of forest). These studies are especially difficult to apply at smaller scales or to value changes in ecosystem health because they implicitly assume ecosystem service values are scalable by area of an ecosystem and they do not provide information to value incremental changes in the production of an ecosystem service (e.g., due to habitat degradation as opposed to complete loss). Nonetheless, they provide some perspective on the range of values from the scientific literature that characterize the order of magnitude of ecosystem service values. Costanza et al. (2014) value temperate forest ecosystem system services at $10,746 per acre per year, with "habitat" and "recreation" services accounting for approximately 60 percent of this value.

Table 6 describes the values resulting from the Costanza et al (2024) synthesis of literature on ecosystem service values of forests. We remove the categories of values either not relevant to the riparian forest that is the subject of this analysis or that we otherwise account for in this analysis. Specifically, we focus on the ecological values related to the forest and remove human use value categories, including raw material harvest, recreation, and cultural values. The resulting estimate is equivalent to $6,736 per acre per year.

Table 6. Value Per Acre of Temperate Forest from Costanza et al. 2014 (2023$)

Service	All	Estimate for Type F in Washington
Climate Regulation	$521	$521
Water Supply	$655	$655
Soil Formation	$47	$47
Nutrient Cycling	$318	$318
Waste Treatment	$411	$411
Biological Control	$806	$806
Habitat/Refuge	$2,953	$2,953
Food Production	$1,025	$1,025
Raw Materials	$620	
Recreation	$3,388	
Cultural	$3	
Total	$10,746	$6,736

Source: Values derived from Costanza et al. (2014). We adjust 1) from hectares to acres and 2) from 2014 dollars to 2023 dollars using the GDP deflator.

Notes: The "Estimate for Type F in Washington" removes 1) "raw materials" to account for the fact that Type F buffers cannot be harvested, 2) recreation because most land is inaccessible to recreators, and 3) cultural because tribes do not monetize the values they experience.

For the AFF A4 options, the total cost of the rule is $17.3 million in annualized terms, approximately $11 million of which is driven by limiting harvest on 145,000 riparian forest acres. We note that the adjusted value per acre of temperate forest ecosystem from Costanza et al. (2014) attempts to capture many of the values we were unable to quantify. However, we recognize that not all of this value would be gained with the added Type F stream or lost with added Type N stream. This is because the area of the Type N buffer without harvest restrictions would still be expected to provide some level of ecosystem service benefit.

6. Approach to Considering Impacts on Small Businesses

Key findings

- Regulatory alternatives that include AFF A4 are likely to result in more than minor costs to small businesses in affected industries. Therefore, an SBEIS must accompany a proposed rule that includes AFF A4. Because 99 percent of businesses in the affected industries are small businesses, small businesses are disproportionately affected by these rule options.
- Regulatory alternatives that include AFF D are unlikely to result in costs to costs to small businesses due to the net reduction in Type F stream requirements. Therefore, an SBEIS would not be required for a rule that includes AFF D.

The Washington Regulatory Fairness Act (RFA), RCW 19.85, requires that DNR prepare an SBEIS if the proposed rule "will impose more than minor costs on businesses in an industry." Per the SBEIS *Frequently Asked Questions* guidance, agencies are required to consider "costs imposed on businesses and costs associated with compliance with the proposed rules" (WA Attorney General Office 2021). Agencies are not required under 19.85 RCW to consider indirect costs not associated with compliance with the rule. The SBEIS also requires consideration of whether small businesses are disproportionately affected by the costs of the rule. The sections that follow provides to determine whether or not an SBEIS will be required for each of the rule options by assessing 1) whether the rule options are likely to impose more than minor costs and 2) whether small businesses are likely to be disproportionately affected.

Small Businesses in Affected Industries

The rule options primarily affect the owners of forestland immediately adjacent to water. The main driver of the effects of the rule options is a change in the identified location of waters delineated as "fish habitat" (i.e., Type F waters), which has implications for harvest restrictions and the construction of stream crossings to enable fish passage. Thus, where the proposed rule options result in new Type F streams, the landowners of adjacent properties may experience reductions in land values and increased costs of upgrading or constructing stream crossings. Landowners within the AFF may experience a cost savings with reduced survey effort, although these effects are likely very small relative to changes in forestland values as well as the cost associated with affected stream crossings.

In some cases, these forestland owners are businesses; in other cases, these landowners are private individuals and public entities, including state and local government. Analysis by the U.S. Endowment for Forestry and Communities reports that about 43 percent of all forestland in Washington is privately owned, and approximately half of that is owned by private corporations (Alvarez, n.d.). Even among the forestland owners that are incorporated as private businesses, they likely span a wide variety of industry classifications given the diversity of ways that forestland is used for business purposes. For example, due to recent interest in holding forestland as a financial asset, financial institutions (including Timber Investment Management Organizations and timberland real-estate investment trusts) are among the industry types that could be affected by the proposed rule (Alvarez, n.d.). As the proposed rule options are relevant to all forest landowners (except federal and tribal forests, which are exempt from the proposed rule) across the state, the scale of the analysis constrains our ability to accurately characterize the nature of all businesses that own forestland across Washington State and may be affected by the proposed rule options.[46] To our knowledge, no publicly available data source exists that identifies the locations and Uniform Business Identification (UBI) information of small businesses landowners.

Instead, we identify three North American Industry Classification System (NAICS) codes with businesses that will most likely be affected by the proposed rule because they are most likely to want to harvest timber tracts that may be affected by the rule:

- 113110 – Timber tract operations
- 113210 – Forest nurseries
- 113310 – Logging

Data provided by the Washington Department of Revenue reveals that there was a total of 811 businesses identified using these NAICS codes in 2022 (and virtually the same number in 2021).[47] Of these, approximately 99 percent meet Washington's definition of small business, i.e., a business with 50 or fewer employees. Of note, all businesses in the "113110 – Timber tract operations" and "113210 – Forest nurseries" industries qualify as small businesses. Table 7 presents these findings. Because the vast majority of businesses in the affected industries are small businesses, this analysis concludes that small businesses are disproportionately affected by the effects of the rule.

Table 7. Number of Small Businesses and Minor Cost Threshold in Affected Industries (2022)

NAICS code – Industry name	Total Number of Businesses in WA	Percent that are Small Businesses	Minor Cost Threshold for SBEIS Consideration (Based on Annual Revenue)
113110 – Timber tract operations	19	100%	$5,537
113210 – Forest nurseries	25	100%	$5,740
113310 – Logging	767	99%	$6,970
Total	811	99%	-

Source: IEc analysis of data provided by the Washington Department of Revenue on May 2, 2024.

Minor Cost Thresholds in Affected Industries

For these industries, we calculate the "minor cost" threshold associated with each. 19.85 RCW requires that the relevant agency prepare an SBEIS if the proposed rule "will impose more than minor costs on businesses in an industry."[48] "Minor cost" is defined in RCW 19.85.020 as a cost per business that is less than 0.3 percent of annual revenue or income, or $100, whichever is greater, or one percent of annual payroll.[49] Table 7 presents the

[46] Land ownership data from Atterbury Consultants (provided by DNR with permissions) shows that there are approximately 3,500 unique landowners outside of federal and tribal land. There are 2,116 unique landowners of among the streams determined to be potentially affected by the proposed rule (see Section 4.1, Step 1).

[47] Data provided by the Washington Department of Revenue on May 2, 2024. Analysis was prepared by the Research and Fiscal Analysis department by combining Department of Revenue and Employment Security Department data. While a longer time series of data was requested, the Department of Revenue cautioned against using data from 2020 given the influence of the COVID-19 pandemic.

[48] RCW 19.85.030 Agency Rules – Small Business economic impact statement reduction of costs imposed by rule. Available at: https://app.leg.wa.gov/RCW/default.aspx?cite=19.85.030

[49] RCW 19.85.020 Definitions are available at: https://app.leg.wa.gov/rcw/default.aspx?cite=19.85.020

minor cost threshold established for each of the three industries. For all three, we determine that the minor cost measure derived from revenue data is the greatest of the three options (i.e., based on revenue, payroll, or $100).

Complying with the proposed rule requires that a landowner 1) determine if relevant water falls within the AFF and, if not, 2) conduct a survey to establish the end of fish habitat, either using DPCs or the new FHAM protocol. While conducting an individual survey has a cost to a business owner, our analysis presented in Section 4.2.3 does not identify the change in the cost of implementing FHAM (relative to the cost of conducting a protocol survey) is a probable effect of the rule.

However, once water has been typed using one of the available methods outlined in the proposed rule, landowners are expected to comply with the harvest and stream crossing restrictions specific to the water type stipulated in existing regulations. For businesses that fall under Type F waters, harvest restrictions result in a loss of property value and higher costs for the construction of stream crossings in order to accommodate fish passage. The magnitude of these costs depends on the amount of land adjacent to waterways and the number of existing stream crossings that will require upgrade as well as the number of new stream crossings that will be built in the future.

Data does not identify the expected magnitude of impacts at the entity level to compare with the minor cost thresholds presented in Table 7. However, available information leads us to the following conclusions by rule option:

- **For the rule options that include AFF A4, we find that small businesses are likely to experience more than minor costs.** This is because the minor cost thresholds for the affected industries are surpassed if businesses 1) have a net reduction in 1.6 areas of harvestable land, 2) are required to upgrade one existing stream crossing to meet Type F fish passage requirements, or 3) are required to build one future stream crossing to Type F specifications as opposed to Type N specifications. Therefore, an SBEIS would be required for any rule option that includes the AFF A4.
- **For the rule options that include AFF D, landowners do not experience more than minor costs.** This is because rule options associated with AFF D result in a net decrease in Type F stream relative to the baseline, therefore landowners do not incur additional compliance costs. In fact, under these rule options, landowners experience cost savings. Therefore, an SBEIS would not be required for any rule option that includes the AFF D.

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8. Appendix: Results Tables by Ecoregion

Table 8. Total Number of Stream Miles Potentially Affected by the Proposed Rule

Ecoregion	Stateside	Total	Annual Average Number of Miles that Would be Typed Using a Survey
Blue Mountains	East	15	0
Cascades	West	8,995	121
	East	20	0
Coast Range	West	20,035	277
Columbia Plateau	East	1,184	9
Eastern Cascades Slopes and Foothills	East	1,845	9
North Cascades	West	3,724	36
	East	2,123	14
Northern Rockies	East	8,285	80
Puget Lowland	West	7,109	71
Willamette Valley	West	297	3
West		40,158	508
East		13,472	112
Statewide		53,630	620

Table 9. Average and Statistically Significant Differences between AFF Options and Existing F/N (Stream Feet per F/N Breakpoint)

Ecoregion	Stateside	AFF A4	AFF D
Blue Mountains	East	2,670*	-1,203
Cascades	West	774*	-2,006
	East	2,198*	-19,026
Coast Range	West	1,300*	-4,986
Columbia Plateau	East	Not in sample	Not in sample
Eastern Cascades Slopes and Foothills	East	940	-9,488
North Cascades	West	4,939*	-4,865
	East	5,428*	-15,421
Northern Rockies	East	-47,859	-29,582
Puget Lowland	West	3,683	-2,030
Willamette Valley	West	Not in sample	Not in sample

Note: * and shading indicate combinations where the mean difference between the AFF option and existing F/N is both statistically significantly different from zero and positive.

Table 10. Total Extent of AFF (Stream Miles)

Ecoregion	Stateside	AFF A4			AFF D		
		Within SWIFD	Outside of SWIFD	Total	Within SWIFD	Outside of SWIFD	Total
Blue Mountains	East	5	6	11	5	0	5
Cascades	West	905	320	1,225	905	0	905
	East	0	5	5	0	0	0
Coast Range	West	3,634	6,188	9,822	3,634	0	3,634
Columbia Plateau	East	32	0	32	32	0	32
Eastern Cascades Slopes and Foothills	East	15	0	15	15	0	15
North Cascades	West	526	2,305	2,831	526	0	526
	East	0	1,742	1,742	0	0	0
Northern Rockies	East	0	0	0	0	0	0
Puget Lowland	West	3,939	0	3,939	3,939	0	3,939
Willamette Valley	West	297	0	297	297	0	297
West		9,301	8,813	18,113	9,301	0	9,301
East		52	1,754	1,806	52	0	52
Statewide		9,352	10,567	19,919	9,352	0	9,352

Table 11. Total Change in Type F Streams Due to AFF (Stream Miles)

Ecoregion	Stateside	AFF A4	AFF D
Blue Mountains	East	5	0
Cascades	West	273	0
	East	4	0
Coast Range	West	4,451	0
Columbia Plateau	East	0	0
Eastern Cascades Slopes and Foothills	East	0	0
North Cascades	West	1,929	0
	East	1,431	0
Northern Rockies	East	0	0
Puget Lowland	West	0	0
Willamette Valley	West	0	0
West		6,653	0
East		1,440	0
Statewide		8,093	0

Table 12. Total Number of Stream Miles Surveyed with FHAM (Outside of AFF)

Ecoregion	Stateside	Outside of AFF A4	Outside of AFF D
Blue Mountains	East	2	5
Cascades	West	5,737	5,974
	East	12	16
Coast Range	West	7,761	12,464
Columbia Plateau	East	457	457
Eastern Cascades Slopes and Foothills	East	480	480
North Cascades	West	474	1,697
	East	137	767
Northern Rockies	East	4,404	4,404
Puget Lowland	West	1,747	1,747
Willamette Valley	West	0	0
West		15,719	21,881
East		5,492	6,129
Statewide		21,211	28,009

Table 13. Average and Statistically Significant Differences between PHB Options and Existing F/N Breaks (Stream Feet Per F/N Breakpoint)

Ecoregion	Stateside	PHB A	PHB B	PHB C
Blue Mountains	East	-	-585	-692
Cascades	West	-109	-102	-121
	East	-	-9	-86
Coast Range	West	-177*	-156*	-178*
Columbia Plateau	East	Not in sample	Not in sample	Not in sample
Eastern Cascades Slopes and Foothills	East	-	164	-303*
North Cascades	West	-369*	-322*	-360*
	East	-	-162	-152
Northern Rockies	East	-	-275*	-307*
Puget Lowland	West	-481*	-469*	-481*
Willamette Valley	West	Not in sample	Not in sample	Not in sample

Note: * and shading indicate combinations where the mean difference between the PHB option and existing F/N is statistically significantly different from zero.

Table 14. Total Change in Type F Streams Due to FHAM (Stream Miles)

Ecoregion	Stateside	AFF A4 + PHB A	AFF A4 + PHB B	AFF A4 + PHB C	AFF D + PHB A	AFF D + PHB B	AFF D + PHB C
Blue Mountains	East	-	0	0	-	0	0
Cascades	West	0	0	0	0	0	0
	East	-	0	0	-	0	0
Coast Range	West	-605	-533	-608	-971	-856	-976
Columbia Plateau	East	-	0	0	-	0	0
Eastern Cascades Slopes and Foothills	East	-	0	-24	-	0	-24
North Cascades	West	-29	-26	-29	-105	-92	-103
	East	-	0	0	-	0	0
Northern Rockies	East	-	-207	-231	-	-207	-231
Puget Lowland	West	-236	-230	-236	-236	-230	-236
Willamette Valley	West	0	0	0	0	0	0
West		-870	-789	-872	-1,312	-1,178	-1,314
East		-	-207	-255	-	-207	-255
Statewide		-870	-995	-1,127	-1,312	-1,384	-1,570

Table 15. Total Change in Type F Streams Due to AFF and FHAM (Stream Miles)

Ecoregion	Stateside	AFF A4 + PHB A	AFF A4 + PHB B	AFF A4 + PHB C	AFF D + PHB A	AFF D + PHB B	AFF D + PHB C
Blue Mountains	East	-	5	5	-	0	0
Cascades	West	273	273	273	0	0	0
	East	-	4	4	-	0	0
Coast Range	West	3,846	3,918	3,843	-971	-856	-976
Columbia Plateau	East	-	0	0	-	0	0
Eastern Cascades Slopes and Foothills	East	-	0	-24	-	0	-24
North Cascades	West	1,899	1,903	1,900	-105	-92	-103
	East	-	1,431	1,431	-	0	0
Northern Rockies	East	-	-207	-231	-	-207	-231
Puget Lowland	West	-236	-230	-236	-236	-230	-236
Willamette Valley	West	0	0	0	0	0	0
West		5,783	5,864	5,781	-1,312	-1,178	-1,314
East		0	1,234	1,185	0	-207	-255
Statewide		5,783	7,098	6,966	-1,312	-1,384	-1,570

Table 16. Total Change in Harvestable Timberland (Acres)

Ecoregion	Stateside	AFF A4 + PHB A	AFF A4 + PHB B	AFF A4 + PHB C	AFF D + PHB A	AFF D + PHB B	AFF D + PHB C
Blue Mountains	East	-	-71	-66	-	0	0
Cascades	West	-5,181	-5,293	-5,134	0	0	0
	East	-	-24	-78	-	0	0
Coast Range	West	-79,098	-76,812	-74,685	19,965	16,782	18,968
Columbia Plateau	East	-	0	0	-	0	0
Eastern Cascades Slopes and Foothills	East	0	0	227	0	0	227
North Cascades	West	-44,444	-33,197	-37,697	2,463	1,601	2,036
	East	-	-22,490	-21,622	-	0	0
Northern Rockies	East	-	2,037	2,283	-	2,036	2,283
Puget Lowland	West	4,810	4,723	4,810	4,810	4,723	4,810
Willamette Valley	West	0	0	0	0	0	0
West		-123914	-110,578	-112,705	27,238	23,106	25,813
East		-	-20,549	-19,256	-	2,036	2,510
Statewide		-123,914	-131,127	-131,962	27,238	25,143	28,323

Table 17. Annualized Timberland Value Effects (2023$)

Ecoregion	Stateside	AFF A4 + PHB A	AFF A4 + PHB B	AFF A4 + PHB C	AFF D + PHB A	AFF D + PHB B	AFF D + PHB C
Blue Mountains	East	$0	-$2,688	-$2,481	$0	$0	$0
Cascades	West	-$450,222	-$459,926	-$446,099	$0	$0	$0
	East	$0	-$889	-$2,948	$0	$0	$0
Coast Range	West	-$6,873,264	-$6,674,650	-$6,489,802	$1,734,851	$1,458,281	$1,648,248
Columbia Plateau	East	$0	$0	$0	$0	$0	$0
Eastern Cascades Slopes and Foothills	East	$0	$0	$8,572	$0	$0	$8,572
North Cascades	West	-$3,862,022	-$2,884,665	-$3,275,668	$214,055	$139,088	$176,883
	East	$0	-$849,492	-$816,708	$0	$0	$0
Northern Rockies	East	$0	$76,923	$86,235	$0	$76,921	$86,233
Puget Lowland	West	$417,947	$410,450	$417,947	$417,947	$410,450	$417,947
Willamette Valley	West	$0	$0	$0	$0	$0	$0
West		-$10,767,560	-$9,608,790	-$9,793,623	$2,366,853	$2,007,819	$2,243,078
East		$0	-$776,146	-$727,330	$0	$76,921	$94,805
Statewide		-$10,767,560	-$10,384,937	-$10,520,953	$2,366,853	$2,084,740	$2,337,883

Note: Negative numbers represent incremental costs; positive values represent incremental benefits.

Table 18. Annualized Stream Crossing Cost Effects (2023$)

Ecoregion	State side	AFF A4 + PHB A	AFF A4 + PHB B	AFF A4 + PHB C	AFF D + PHB A	AFF D + PHB B	AFF D + PHB C
Blue Mountains	East	$0	-$1,408	-$1,408	$0	$0	$0
Cascades	West	-$177,411	-$177,411	-$177,411	$0	$0	$0
	East	$0	-$3,670	-$3,670	$0	$0	$0
Coast Range	West	-$3,771,692	-$3,841,830	-$3,768,509	$171,509	$151,217	$172,429
Columbia Plateau	East	$0	$0	$0	$0	$0	$0
Eastern Cascades Slopes and Foothills	East	$0	$0	$2,122	$0	$0	$2,122
North Cascades	West	-$1,460,844	-$1,463,745	-$1,461,417	$14,587	$12,715	$14,217
	East	$0	-$1,008,413	-$1,008,413	$0	$0	$0
Northern Rockies	East	$0	$13,744	$15,357	$0	$13,744	$15,356
Puget Lowland	West	$171,252	$167,038	$171,163	$171,252	$167,038	$171,163
Willamette Valley	West	$0	$0	$0	$0	$0	$0
West		-$5,238,694	-$5,315,948	-$5,236,174	$357,347	$330,970	$357,809
East		$0	-$999,746	-$996,012	$0	$13,744	$17,478
Statewide		-$5,238,694	-$6,315,694	-$6,232,186	$357,347	$344,714	$375,288

Note: Negative numbers represent incremental costs; positive values represent incremental benefits.

Table 19. Annual Change in Timber Harvest Relative to Total Stateside Timber Harvest

Rule options	Scenario 1		Scenario 2	
	East	West	East	West
AFF A4 + PHB A		-0.04%		-1.50%
AFF A4 + PHB B	-0.01%	-0.03%	-1.92%	-1.34%
AFF A4 + PHB C	-0.01%	-0.04%	-1.80%	-1.37%
AFF D + PHB A		0.01%		0.33%
AFF D + PHB B	0.00%	0.01%	0.19%	0.28%
AFF D + PHB C	0.00%	0.01%	0.23%	0.31%

Table 20. Average Annual Number of Adult Fish Per Time Period (AFF A4)

Period	Coho	Chinook	Steelhead	Rainbow Trout	Bull Trout	Cutthroat Trout
West						
Avg. Years 1-10	59	1	9	31	4	580
Avg. Years 11-20	480	7	69	250	32	4,700
Avg. Years 21-30	900	12	130	470	61	8,800
Avg. Years 31-40	1,300	18	190	700	91	13,000
Avg. Years 41-50	1,500	21	220	800	100	15,000
Avg. Years 51-55	1,600	22	230	850	110	16,000
East						
Avg. Years 1-10	3	N/A	1	3.6	N/A	93
Avg. Years 11-20	30	N/A	9	32	N/A	830
Avg. Years 21-30	59	N/A	18	64	N/A	1,700
Avg. Years 31-40	89	N/A	28	97	N/A	2,500
Avg. Years 41-50	120	N/A	38	130	N/A	3,400
Avg. Years 51-55	140	N/A	45	160	N/A	4,000

Table 21. Total Number of Fish Produced by Species (AFF A4)

Ecoregion	Stateside	Coho	Chinook	Steelhead	Rainbow Trout	Bull Trout	Cutthroat Trout
Blue Mountains	East	15	0	4	16	0	402
Cascades	West	1,274	20	126	1,107	144	20,857
	East	15	0	4	16	0	402
Coast Range	West	41,221	540	5,079	17,919	2,326	337,471
Columbia Plateau	East	0	0	0	0	0	0
Eastern Cascades Slopes and Foothills	East	0	0	0	0	0	0
North Cascades	West	8,942	140	2,204	7,774	1,009	146,418
	East	3,783	0	1,151	4,062	0	104,500
Northern Rockies	East	0	0	0	0	0	0
Puget Lowland	West	0	0	0	0	0	0
Willamette Valley	West	0	0	0	0	0	0
West		51,437	700	7,408	26,801	3,479	504,747
East		3,812	0	1,160	4,093	0	105,303
Statewide		55,249	700	8,568	30,893	3,479	610,050

Table 22. Sensitivity Analysis for Fish Abundance

Period	Base Analysis			Increase W to 10 feet			Increase N (Coho West = 75%, Coho East = 25%, Steelhead West = 50 %)		
	Coho	Steelhead	Cutthroat	Coho	Steelhead	Cutthroat	Coho	Steelhead	Cutthroat
West									
Avg. Years 1-10	59	9	580	200	29	1,900	480	96	580
Avg. Years 11-20	480	69	4,700	1,600	230	16,000	3,900	770	4,700
Avg. Years 21-30	900	130	8,800	3,000	430	29,000	7,300	1,500	8,800
Avg. Years 31-40	1,300	190	13,000	4,500	650	44,000	11,000	2,200	13,000
Avg. Years 41-50	1,500	220	15,000	5,100	740	50,000	12,000	2,500	15,000
Avg. Years 51-55	1,600	230	16,000	5,400	780	53,000	13,000	2,600	16,000
East									
Avg. Years 1-10	3	1	93	8	3	230	26	1	93
Avg. Years 11-20	30	9	830	75	23	2,100	230	9	830
Avg. Years 21-30	60	18	1,700	150	46	4,100	450	18	1,700
Avg. Years 31-40	91	28	2,500	230	69	6,300	690	28	2,500
Avg. Years 41-50	120	38	3,400	310	94	8,600	940	38	3,400
Avg. Years 51-55	150	45	4,000	370	110	10,000	1,100	45	4,000

Note: The base analysis assumes the following: W = 3 feet West/4 feet East; N Coho 9.3% West/3.3% East; N Steelhead 4.4% West/3.3% East; N Cutthroat 83.6% West/83.6% East.

Table 23. Increase in Consumer Surplus/Value for Recreational Fishing (2023$) - AFF A4

Species	Total Present Value (55 Years)	Annualized
West		
Coho	$5,001,709	$147,812
Chinook	$69,707	$2,060
Steelhead	$1,630,276	$48,178
Total	$6,701,693	$198,051
East		
Coho	$360,939	$10,667
Chinook	$0	$0
Steelhead	$248,609	$7,347
Total	$609,547	$18,014
Statewide		
Coho	$5,362,648	$158,479
Chinook	$69,707	$2,060
Steelhead	$1,878,885	$55,525
Total	$7,311,240	$216,064

Note: Negative numbers represent incremental costs; positive values represent incremental benefits.

Table 24. Sensitivity Analysis of Recreational Fishing Value

Species	Base Analysis		Increase W to 10 feet		Increase N (Coho West = 75%, Coho East = 25%, Steelhead West = 50 %)		Assume Only 50 Percent of Anadromous Fish are Caught in Recreational Fisheries	
	Present Value	Annualized	Present Value	Annualized	Present Value	Annualized	Present Value	Annualized
West								
Coho	$5,001,709	$147,812	$16,672,364	$492,707	$40,423,297	$1,194,602	$2,500,855	$73,906
Chinook	$69,707	$2,060	$232,358	$6,867	$69,707	$2,060	$34,854	$1,030
Steelhead	$1,630,276	$48,178	$5,434,254	$160,595	$18,358,968	$542,550	$815,138	$24,089
Total		$198,051	$22,338,977	$660,169	$58,851,972	$1,739,213	$3,350,847	$99,025
East								
Coho	$360,939	$10,667	$902,347	$26,666	$2,734,384	$80,807	$180,469	$5,333
Chinook	$0	$0	$0	$0	$0	$0	$0	$0
Steelhead	$248,609	$7,347	$621,521	$18,367	$248,609	$7,347	$124,304	$3,673
Total	$609,547	$18,014	$1,523,868	$45,034	$2,982,992	$88,154	$304,774	$9,007
Statewide								
Coho	$5,362,648	$158,479	$17,574,711	$519,374	$43,157,680	$1,275,410	$2,681,324	$79,239
Chinook	$69,707	$2,060	$232,358	$6,867	$69,707	$2,060	$34,854	$1,030
Steelhead	$1,878,885	$55,525	$6,055,776	$178,962	$18,607,576	$549,897	$939,442	$27,763
Total	$7,311,240	$216,064	$23,862,845	$705,203	$61,834,964	$1,827,367	$3,655,620	$108,032

Note: Negative numbers represent incremental costs; positive values represent incremental benefits.

Table 25. Select Literature Describing the Total Economic Value of Anadromous Fish in the Northwest

Study	Valuation Context	Site	Sampled Population	Annual WTP per Household (2023 USD)[1,2]	Aggregate Annual WTP[3] (2023 USD)
Lewis et al. (2022)	Increase Coho salmon returns by 1,000	All Oregon Coast Coho salmon runs	Pacific Northwest residents (including WA)	0.09-0.23	NA
Lewis et al. (2019)	Increase Coho salmon returns by 100,000 (least aggressive) to 375,000 (most aggressive, includes delisting)	All Oregon Coast Coho salmon runs	Pacific Northwest residents (including WA)	62 (least aggressive); 179 (most aggressive)	NA
ECONorthwest (2019)	Restore wild salmon and improve water quality by removing four dams	Lower Snake River, WA	Active voters in WA	49-67	142-195M (WA state)
Stratus Consulting (2015)	Restoration of salmon at limited (25-50%) or extensive (60%) increase	Elwha River, WA	WA residents	310 (limited); 369 (extensive)	1.040B (WA state, limited); 1.220B (WA state, extensive)
Bell et al. (2003)	Doubling of local coho runs and harvest	Two estuaries in WA	Residents within 30 miles of estuary	126-196	NA
Layton et al. (1999)	Increase migratory fish populations by 50%	Eastern WA and Columbia River	WA residents	212-406	621M-1.189B (WA state)
Layton et al. (1999)	Increase migratory fish populations by 50%	Western WA and Puget Sound	WA residents	446-612	1.306B-1.795B (WA state)
Loomis (1996)	Increase salmon and steelhead (4 species) from 50,000 to 300,000	Elwha River, WA	Three samples: Clallam County, WA state, national	111 (Clallam); 138 (WA); 129 (national)	406M (WA state); 15.987B (national)

Notes:

1. Dollar values reported in studies are adjusted to 2023 dollars in this table.
2. Total economic value includes both use and non-use values. However, it does not quantify significance to tribes, which is a potentially large source of additional (nonquantifiable) value.
3. Aggregate values are estimated at the Washington state level and national level where appropriate based on the sampling frame of the original study. Number of households obtained from United States Census Bureau “Quick Facts”: 2,931,841 (WA); 124,010,992 (United States).

Table 26. Annualized Forest Carbon Flux Effects (2023$)

Ecoregion	Stateside	AFF A4 + PHB A	AFF A4 + PHB B	AFF A4 + PHB C	AFF D + PHB A	AFF D + PHB B	AFF D + PHB C
Blue Mountains	East	$0	$521	$481	$0	$0	$0
Cascades	West	$75,932	$77,569	$75,237	$0	$0	$0
	East	$0	$172	$571	$0	$0	$0
Coast Range	West	$1,159,213	$1,125,715	$1,094,540	-$292,592	-$245,947	-$277,986
Columbia Plateau	East	$0	$0	$0	$0	$0	$0
Eastern Cascades Slopes and Foothills	East	$0	$0	-$1,662	$0	$0	-$1,662
North Cascades	West	$651,351	$486,514	$552,459	-$36,101	-$23,458	-$29,832
	East	$0	$164,685	$158,330	$0	$0	$0
Northern Rockies	East	$0	-$14,913	-$16,718	$0	-$14,912	-$16,717
Puget Lowland	West	-$70,489	-$69,225	-$70,489	-$70,489	-$69,225	-$70,489
Willamette Valley	West	$0	$0	$0	$0	$0	$0
West		$1,816,006	$1,620,574	$1,651,747	-$399,182	-$338,629	-$378,307
East		$0	$150,466	$141,002	$0	-$14,912	-$18,379
Statewide		$1,816,006	$1,771,040	$1,792,749	-$399,182	-$353,541	-$396,686

Note: Negative numbers represent incremental costs; positive values represent incremental benefits.