Assessment of the White Salmon Watershed Using the Ecosystem Diagnosis and Treatment Model

Draft Final Report

For the Period: November 2003 to December 2004

May 2005

Brady Allen
Fishery Biologist
and
Patrick J. Connolly, Ph.D.
Lead Research Fish Biologist

U.S. Geological Survey
Western Fisheries Research Center
Columbia River Research Laboratory
5501-a Cook-Underwood Road
Cook, WA 98605

Prepared for:
Yakama Nation
Fisheries Department
P.O. Box 151
Toppenish, WA 98948
509-865-5121 x6358
FAX 509-865-6293
Agreement Number: BGC045052

Table of contents

List of Tables

List of Figures

Introduction

Salmon habitat models provide managers the ability to identify habitat limitations and prioritize restoration activities. Ecosystem Diagnosis and Treatment (EDT) has become a widely used tool for salmonid habitat analysis in the Pacific Northwest. The EDT model is a rule-based habitat rating system that provides reach-level diagnosis of habitat conditions for the major salmonid species of the Pacific Northwest. The EDT process itself is a complex modeling program with defined data needs. The program is a product developed by Mobrand Biometrics Incorporated (MBI) largely through funding by the Northwest Power and Conservation Council (NPCC). The NPCC had provided a free version of the program accessible through a website that required user registration.

The EDT model allows the user to rate the quality, quantity, and diversity of fish habitat along a waterway. The model uses diagnostic species such as steelhead and Chinook salmon to identify the most significant limiting factors in a river and to help identify reaches for protection and restoration. The model includes a set of tools to help organize environmental information and rate the habitat elements that pertain to specific life stages of the diagnostic species. A major benefit of EDT is that it can show the potential of a river under current conditions and possible future conditions. The result is a scientifically-based assessment of fish habitat and a prioritization of restoration needs.

The model helps to rate the quality of river habitat based on salmonid life histories. It uses rating curves to relate habitat conditions to life stage survival and capacity. These life stages are then connected to form life history trajectories (i.e., the tracing of a fish throughout its migratory course). Because habitat is described by reach (homogeneous sections of the river) and as it changes through a one-year cycle (several attributes such as flow and temperature are rated monthly), many potential trajectories can be formed. All successful trajectories are combined to estimate capacity and productivity at a population level. The range of successful trajectories is a measure of life history diversity.

Each reach of a stream has an estimated number of fish or capacity that can be supported for each life stage depending on the quantity of key habitat. For example, a certain amount of food or spawning area is available in the riffles, and pools provide rearing space for a quantifiable number of juveniles. Each habitat type, such as a pool or riffle, has characteristics that affect the survival of a life stage in that habitat. The quantity of habitat is thus measured as capacity. When capacity and survival over the course of a fish's life history is integrated, an overall capacity for the diagnostic species can be estimated as a measure of the quantity of habitat. The number of adult fish that return for each fish that spawns is a gauge of overall survival, which is directly linked with productivity and habitat quality.

The model outputs are designed to identify the potential for a river under historical conditions (prior to 1850), current conditions, and scenarios that might occur in the future. The result is a method for prioritization of restoration needs based on current conditions and inherent historic potential. Since each reach is rated separately, conditions can be critically examined along a river from the perspective of the diagnostic species. By comparing the current conditions in each reach with historic conditions, the model identifies the "restoration potential" and the "protection value" for each reach. The model output should help prioritize actions that are focused on areas with identified problems where the potential for benefit is highest.

The model incorporated 46 environmental attributes (termed Level 2 attributes) reported to affect fish survival (Table 1). A wide variety of information sources (termed Level 1 data) were used to rate the Level 2 attributes. Guidelines for rating the Level 2 attributes were available from the MBI website (http://www.mobrand.com/MBI/pdfs/AttributeRatings-Sept2004.pdf). Each attribute was rated for each reach using current (termed "patient") and historic (termed "template") conditions. Level 2 attribute scores were then combined by MBI through a set of rules, based on extensive literature reviews, into relative survivals for 16 attributes for Level 3. The rules used to combine Level 2 environmental attributes into Level 3 relative survival attributes vary by life stage of the fish.

Table 1. Organization of Level 2 Environmental Attributes by categories of major stream corridor features. Salmonid Survival Factors (Level 3) are shown associated with groups of Level 2 attributes. Associations can differ by species and life stage. (Lestelle et al. 2004).

Environmental Correlates (Level 2)		**Related Survival Factors (Level 3)**
1 Hydrologic characteristics		
1.1 Flow variation	Flow - change in interannual variability in high flows	Flow Withdrawals (entrainment)
	Flow - change in interannual variability in low flows	
	Flow - intra daily (diel) variation	
	Flow - intra-annual flow pattern	
	Water withdrawals	
1.2 Hydrologic regime	Hydrologic regime – natural	
	Hydrologic regime – regulated	
2 Stream corridor structure		
2.1 Channel morphometry	Channel length	Channel length Channel stability Channel width Habitat diversity Key habitat Obstructions Sediment load
	Channel width - month maximum width	
	Channel width - month minimum width	
	Gradient	
2.2 Confinement	Confinement – hydromodifications	
	Confinement – natural	
2.3 Habitat type	Habitat type - backwater pools	
	Habitat type - beaver ponds	
	Habitat type – glides	
	Habitat type - large cobble/boulder riffles	
	Habitat type - off-channel habitat factor	
	Habitat type - pool tailouts	
	Habitat type - primary pools	
	Habitat type - small cobble/gravel riffles	
2.4 Obstruction	Obstructions to fish migration	
2.5 Riparian and channel integrity	Bed scour	
	Icing	
	Riparian function	
	Wood	
2.6 Sediment type	Embeddedness	
	Fine sediment (intragravel)	
	Turbidity (suspended sediment)	
3 Water quality		
3.1 Chemistry	Alkalinity	Chemicals (toxic substances) Oxygen Temperature
	Dissolved oxygen	
	Metals - in water column	
	Metals/Pollutants - in sediments/soils	
	Miscellaneous toxic pollutants - water column	
	Nutrient enrichment	
3.2 Temperature variation	Temperature - daily maximum (by month)	
	Temperature - daily minimum (by month)	
	Temperature - spatial variation	

Continued.

Table 1. Continued.

4 Biological community		
4.1 Community effects	Fish community richness	Competition with hatchery fish Competition with other fish Food Harassment Pathogens Predation
	Fish pathogens	
	Fish species introductions	
	Harassment	
	Hatchery fish outplants	
	Predation risk	
	Salmonid carcasses	
4.2 Macroinvertebrates	Benthos diversity and production	

The tasks undertaken by U.S. Geological Survey's Columbia River Research Laboratory (USGS-CRRL) were designed to implement an EDT modeling process for the White Salmon River Subbasin in southeastern Washington (Columbia River Basin). This report details the resources used and steps taken to populate the EDT model for the White Salmon River up to the uppermost estimated historic distribution of the diagnostic species (steelhead trout, spring and fall Chinook salmon, and coho salmon). The outputs of the model vary depending on the data set or scenario used to generate them. A model run for a single scenario generates a large number of output graphs for each diagnostic species. Therefore, example outputs are presented in this document but not the full set of outputs. The Big White Salmon River Subbasin Plan (NPCC 2004) also analyzes and explains the results, and the entire set of outputs are available for download on the MBI website (http://www.mobrand.com/edt/home.jsp?subbasinID=2).

The success of this endeavor depended largely on a simultaneous effort, through partnership, with the Yakama Nation's Fisheries Department (YN) staff, and the Washington Department of Fish and Wildlife (WDFW). This collaboration to complete an EDT model for the White Salmon River was associated with the subbasin planning effort that occurred throughout the Columbia River basin in 2004. Although a training session and access for technical consultations with MBI were considered mandatory to the success of this task, the partnership with WDFW personnel (who had considerable experience with the model and access with MBI) made the training and access for USGS-CRRL's personnel less essential. While the principal "product" of USGS-CRRL's effort was a dataset populated with the best available information to be used for subbasin planning and future restoration scenarios, the task also enabled us to gather and condense information known about the watershed into a standardized format, which was used to populate the EDT attributes. Included in this report is a summary of the biological data used for each diagnostic species and the rationale and data sources used for each attribute (Appendix A), a list of information gathered for each attribute (Appendix B), and a list of documents reviewed for information that could be applied to the model (Appendix C).

Model inputs

Many types of information, from many sources, were identified, gathered, and organized that had potential to be used to characterize the White Salmon River watershed. Written resources with Level 1 information that could potentially be useful to rate the EDT attributes were collected, and a reference list was created (Appendix C). On December 31, 2003, this reference list was distributed via e-mail to the White Salmon River Subbasin Plan technical working group along with a request for any other potential sources of Level 1 data (Table 2). This technical working group was comprised of representatives from USGS-CRRL, Klickitat County (KC), NPCC, WDFW, YN, and consulting firms. The reference materials were then reviewed by USGS-CRRL and WDFW personnel for information to be used to rate the Level 2 attributes (Appendix B). Unprinted sources of information such as unpublished temperature data or USGS-CRRL flow data were not included in the reference materials list.

Table 2. Timeline of meetings, actions, and products completed for the White Salmon River EDT model.

Action or product	Date completed
River survey by raft from BZ Falls to Northwestern Lake with YN and USGS-CRRL- river overview and reach break discussions.	9/18/03
Meeting at CRRL with WDFW and USGS-CRRL to establish reach breaks and potential spawning distributions.	12/11/03
References of existing EDT attribute information largely collected.	12/30/03
Field data collected by USGS-CRRL and WDFW such as: habitat types, reach breaks, large woody debris counts, minimum and maximum widths, etc.	12/18/04 and 12/23/04
Reach breaks defined and distributed via e-mail to the Subbasin Plan technical working group (YN, WDFW, KC, and NPCC).	12/14/03
Reference list compiled and distributed for review and comment to the Subbasin Plan technical working group.	12/31/03

Table 2. Timeline of meetings, actions, and products completed for the White Salmon River EDT model.

Action or product	Date completed
Meeting at CRRL discussing EDT attribute information sources and values to be entered with YN, KC, WDFW, and USGS-CRRL.	1/20/04
GIS coverage of reach breaks distributed via e-mail to the Subbasin Plan working group.	2/20/04
References reviewed and EDT attribute ratings entered into the model based on existing information and field data collected by USGS-CRRL and WDFW.	1/04 through 3/04
EDT rankings discussed with USGS-CRRL, YN, WDFW, KC, and NPCC.	3/22/04
Stream Reach Editor with data entered and a document describing rationale for ranking distributed to the Subbasin Plan working group for review and comment.	3/27/04
GIS coverage of White Salmon watershed compiled and distributed to YN and WDFW.	4/1/04
Preliminary model runs completed by WDFW.	4/12/04
Preliminary EDT outputs presented and discussed with USGS-CRRL, YN, WDFW, KC, and NPCC.	4/13/04
Presentation made by USGS-CRRL to the White Salmon River Watershed Management Council discussing the EDT model, its parameters and progress.	4/26/04
Documentation of data sources and rationales used for EDT attribute ratings completed and incorporated into the White Salmon Subbasin Plan, Appendix F.	5/10/04
Two public meeting held with local watershed groups, community councils, county and state representatives invited by USGS-CRRL to provide feedback to attribute ratings and request additional refinement of the ratings.	11/17/04 and 11/22/04

Although the original intent of gathering information for the EDT attributes was to apply pre-existing data, some data gaps were filled with a small field effort. To accomplish this, WDFW and USGS-CRRL collaborated to collect field data on the mainstem of the White Salmon River from BZ Falls to Northwestern Lake and from representative sections of the tributaries Mill, Spring, and Buck creeks. This occurred during low flow conditions on December 18 and December 23, 2003. The information that was collected filled data gaps for attributes such as habitat type, low-flow stream width, bankfull width, woody-debris counts, confinement, hydroconfinement, and riparian function. Extensive field data concerning those attributes had already been collected from 2001 through 2003 by USGS-CRRL on Rattlesnake and Indian creeks as part of a separate Bonneville Power Administration-funded project titled "Assess current and potential salmonid production in Rattlesnake Creek associated with restoration efforts" (Connolly 2003).

An important part of the USGS-CRRL's duties was to assemble and query technical experts and knowledgeable watershed stakeholders. Several meetings with the White Salmon River Subbasin Plan technical working group occurred to ensure that available information and that the best expert evaluations were represented in the data to be used in the model (Table 2). Washington Department of Fish and Wildlife (WDFW) and USGS-CRRL collaborated extensively to populate the model with the available information and make model runs in time to be incorporated into the White Salmon River Subbasin Plan. Diagnostic fish species were selected from the limited array of anadromous salmonids that would have historically inhabited the White Salmon River. These species were: steelhead, coho salmon, fall Chinook and spring Chinook salmon. For more information on the diagnostic species population definitions and spawning distributions, see the Big White Salmon Subbasin Plan (NPCC 2004) and Appendix A of this report. Meetings at CRRL with WDFW and USGS established reach breaks (to separate the river into "environmentally homogenous" sections) and spawning distributions for the diagnostic fish species on December 11, 2003 (Table 3). A geographic information system (GIS) map layer of the reach breaks was distributed for review via e-mail to the White Salmon River Subbasin Plan technical working group. This information was also discussed in a meeting at CRRL on January 20, 2004. (See Appendix A for a more detailed description of the determination of reaches and spawning distributions of the diagnostic species used in the model.)

After USGS-CRRL and WDFW collaborated to develop the attribute ratings for each reach, a meeting with the Subbasin Plan technical working group was held on March 22, 2004 to present and review the data and rationale used to rate the model attributes, as well as the life history patterns for life stages of the diagnostic species. During the meeting, some clarifications and small adjustments to the ratings and rationales were discussed. A draft document describing rationale for ranking, similar to Appendix A, and a completed Stream Reach Editor (MBI's Microsoft Access database, which is used to input "patient" and "template" attribute values and reach specific comments) was distributed to the Subbasin Plan technical working group for review and comment on March 27, 2004.

Several meetings were held with watershed stakeholders to discuss the EDT model and attribute ratings. An introductory presentation was given by USGS-CRRL on April 26, 2004 in

Trout Lake, WA to the White Salmon River Watershed Management Council discussing the EDT model, parameters, and process. Additionally, local watershed groups, community councils, and county and state representatives were invited, by USGS-CRRL, to provide feedback to attribute ratings and request additional refinement of the ratings during two public meetings held on November 17, 2004 and November 22, 2004 in White Salmon, WA.

Current status

As of January 2005, the EDT model attributes have been researched, documented, entered into the stream reach editor, a GIS layer defining the reaches for the model has been created, and several EDT datasets for the White Salmon River have been produced (Figure 1, Table 2). The dataset that USGS-CRRL collaborated with WDFW and YN to produce, titled "Current without Harvest", describes Condit Dam and its reservoir in the "patient" dataset as it currently exists. The dataset registered by WDFW on the MBI website, titled "BigWhite Removal4_21_04", contains changes to attributes in the reservoir and downstream reaches that describe the White Salmon River with Condit Dam removed and given time for those reaches to adjust to an equilibrium (about 20 years post-removal). This dataset is readily available for download from the MBI website (http://www.mobrand.com/edt/home.jsp?subbasinID=2), and the attributes that have been changed in each reach were largely evident and noted in the comments portion of the stream reach editor. Appendix A of this report does not describe the changes made to the dataset that is registered. However, all of the "template" attributes and rationales remained the same, and the majority of "patient" attributes remained the same when comparing the two datasets. Appendix A describes the rationales and information used to populate the model, which was the primary task for USGS-CRRL. The "BigWhite Removal4_21_04" dataset was produced by WDFW to aid in the analysis used for the subbasin planning process. We will present and discuss the results of the registered dataset below, because these were the results available to the public.

Any alterations in the dataset to describe the White Salmon River with Condit Dam removed were done by WDFW. While many of the changes to describe the removal scenario were straightforward and reasonable, the changes, and the rationale for those changes, will not be described here, because USGS-CRRL was not involved in that effort. However, in general, the

WS11 reach was used as a guideline for altering the relevant attributes in the reservoir reaches. The WS11 reach is a lower mainstem reach that is confined in a basalt canyon; much like the pre-reservoir reaches appear to have been. To describe the removal scenario, changes in the reaches below Condit Dam took into account changes in flow and sediment, among others, that would occur after dam removal and an equilibrium has been re-established. Because of the unknown status of historic fish access into Little Buck and Mill creeks, WDFW assumed they would be inaccessible and removed these creeks in the model runs described here.

Another dataset was created with the habitat attributes rated in a way that would be considered “properly functioning conditions” (PFC) using the MBI scenario builder. Created originally by the Bureau of Land Management, PFC is a concept designed to assess the natural habitat-forming processes of riparian and wetland areas (Pritchard et al. 1998). Although less favorable than the template conditions when these habitat-forming processes are functioning properly, it can be assumed that environmental conditions are suitable to support productive populations of native anadromous and resident fish species. The MBI scenario builder translates the PFC concept into a set of EDT Level 3 attribute ratings that define a PFC environmental condition relevant to anadromous salmonids within Pacific Northwest streams. This scenario was not available on the MBI website at the time of this writing.

Preliminary runs of the model by WDFW, including some alternate scenarios such as dam removal, were completed on April 12, 2004. The outputs from those runs were discussed with the technical working group on April 13, 2004. Results from the preliminary runs of the model and some alternate scenarios were used to help guide portions of the White Salmon River Subbasin Plan prepared for the NPCC in 2004. These outputs were well described in the White Salmon River Subbasin Plan, which is currently available on the internet as a draft document (http://www.nwppc.org/fw/subbasinplanning/bigwhitesalmon/).

During the subbasin planning process, the EDT program was accessible largely because of funding by the NPCC. Prior to this, MBI required a fee for each model run, and the model was not available on the internet. However, subbasin planning support has ended and MBI now requires an annual fee to maintain the dataset on their website. As of this writing, the “BigWhite Removal4_21_04” dataset is registered on the MBI website and any changes to the model have to go through the watershed administrator (Dan Rawding, WDFW). Access to the model for updating attributes or evaluating scenarios is restricted until funding to MBI for support, backup, and upkeep of the model is available (~ $3000/year).

Because access to the model has been restricted and the model is not available for updating, USGS-CRRL was not able to correct typographical errors (all of those detected were minor), was not able to update the model (attribute-specific suggestions are included in Appendix A), was not able to conduct initial diagnostic model runs, and was not able to conduct additional alternative scenario runs. This situation limited our ability to collaboratively interpret output with technical staff at Yakama Nation's Fisheries Department, and did not allow conducting model runs to provide information on sensitivity of the output and potential alternative management scenarios. However, some initial diagnostic model runs and additional alternative scenario runs were done by WDFW for the subbasin planning process. A discussion of these results is available in this document and in the Big White Salmon River Subbasin Plan (NPCC 2004).

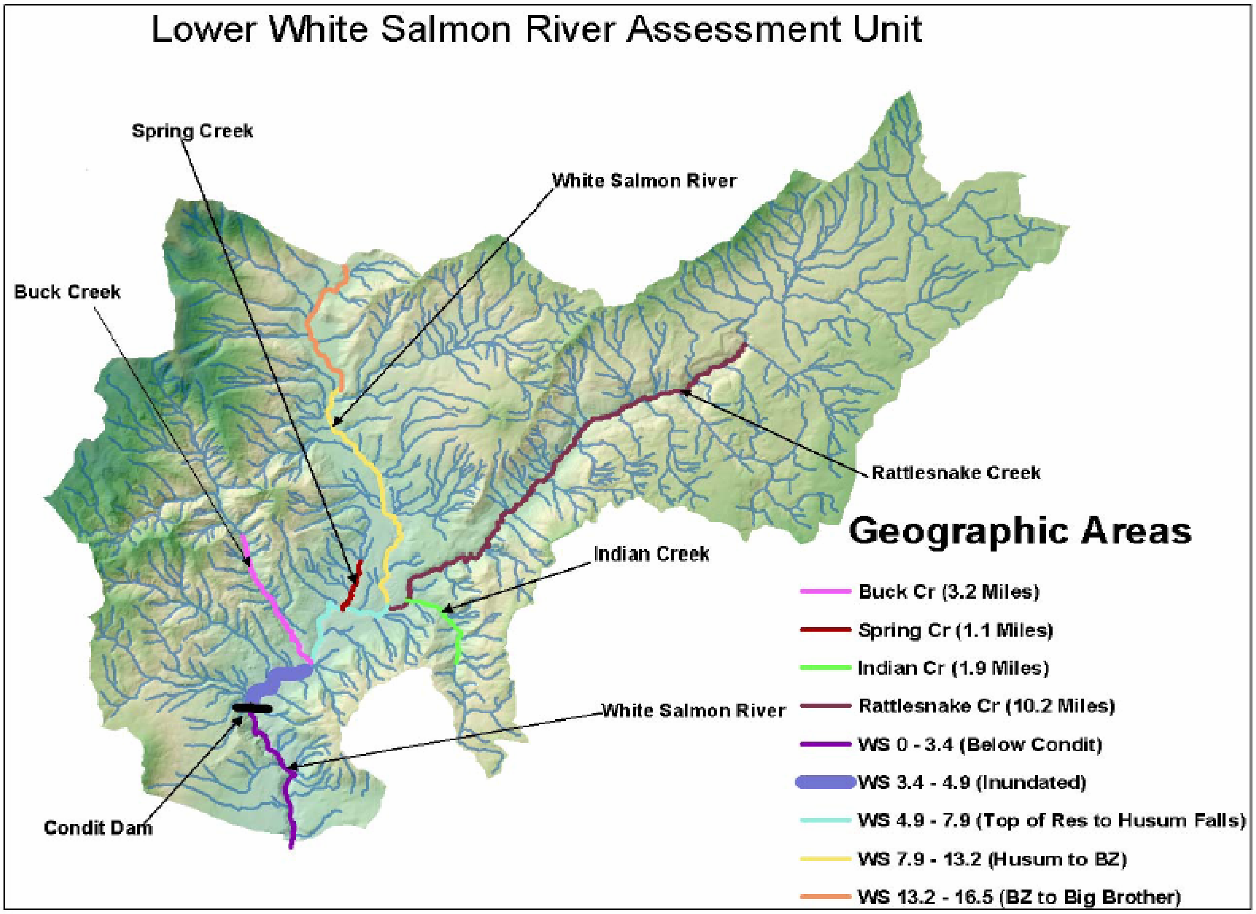


Figure 1. Map of geographic areas used in the EDT analysis of the White Salmon River, WA. From the White Salmon River Subbasin Plan (NPCC 2004).

Table 3. White Salmon River EDT reach breaks, descriptions, and lengths.

Reach name	Description	River miles	Length (mi)	Geographic area (river miles)
B1	Buck Creek mouth to diversion intake	(0.0 – 2.0)	2.0	Buck Creek
B2	Diversion intake to Buck Creek Falls 1	(2.0 - 3.2)	1.2	(0.0 - 3.2)
B3	Buck Creek Falls 1 to Buck Creek Falls 2	(3.2 – 4.0)	0.9	
B4	Buck Creek Falls 2 to end of anadromous distribution	(4.0 - 4.2)	0.2	
I1	Indian Creek mouth to Indian Creek culvert 1	(0.0 - 0.1)	0.1	Indian Creek
I2	Indian Creek culvert 1 to Indian Creek culvert 2	(0.1 - 0.8)	0.8	(0.0 - 1.9)
I3	Indian Creek culvert 2 to Indian Creek culvert 3	(0.8 - 1.1)	0.3	
I4	Indian Creek culvert 3 to Indian Creek culvert 4	(1.1 - 1.2)	0.1	
I5	Indian Creek culvert 4 to end of anadromous distribution	(1.2 - 1.9)	0.8	
LB1	Historic Little Buck Creek mouth to top of reservoir	(0.0 - 0.1)	0.1	Little Buck Creek
LB2	Top of reservoir to reach break	(0.1 – 1.0)	0.8	(0.0-2.2)
LB3	Reach break to end of anadromous distribution	(1.0 - 2.2)	1.2	
M1	Historic Mill Creek mouth to top of reservoir	(0.0 - 0.2)	0.2	Mill Creek
M2	Top of reservoir to Mill Creek culvert 1	(0.2 - 0.4)	0.2	(0.0-1.9)
M3	Mill Creek culvert 1to Mill Creek culvert 2	(0.4 - 1.1)	0.7	
M4	Mill Creek culvert 2 to end of anadromous distribution	(1.1 - 1.9)	0.9	
R1	Rattlesnake Creek mouth to Indian Creek confluence	(0.0 - 0.5)	0.5	Rattlesnake Creek
R2	Indian Creek confluence to Rattlesnake Creek Falls 1	(0.5 - 1.6)	1.2	(0-10.2)
R3	Rattlesnake Creek Falls 1 to end of confinement	(1.6 - 3.3)	1.6	
R4	End of confinement to upper confinement	(3.3 - 6.6)	3.3	
R5	Upper confinement to Rattlesnake Creek Falls 2	(6.6 - 10.2)	3.6	
R6	Rattlesnake Creek Falls 2 to end of anadromous distribution	(10.2 - 10.5)	0.4	
S1	Spring Creek mouth to dam	(0.0 - 0.7)	0.7	Spring Creek
S2	Pond behind Spring Creek dam	(0.7 - 0.8)	0.1	(0-1.1)
S3	Top of Spring Creek Pond to forks	(0.8 - 1.1)	0.3	
WS1	Mouth to first riffle-end of Bonneville Dam pool influence	(0.0 - 1.2)	1.2	Below Condit Dam
WS2	End of Bonneville Dam pool influence to Condit Powerhouse	(1.2 - 2.1)	0.9	(0 - 3.4)
WS3	Condit Powerhouse to Steelhead Falls	(2.1 - 2.7)	0.6	
WS4	Steelhead Falls to Condit Dam	(2.7 - 3.4)	0.7	
WS5	Condit Dam to Little Buck Ck.	(3.4 - 3.6)	0.2	Inundated
WS6	Little Buck Creek to Mill Creek	(3.6 - 4.1)	0.5	(3.4 - 4.9)
WS7	Mill Creek to end of deep reservoir	(4.1 - 4.9)	0.8	
WS8	End of deep reservoir to Buck Creek	(4.9 - 5.1)	0.2	Top of Reservoir
WS9	Buck Creek to Sandy Beach (first riffle)	(5.1 - 5.6)	0.5	to Husum Falls
WS10	Sandy Beach (first riffle) to Spring Creek	(5.6 - 6.8)	1.2	(4.9 - 7.9)
WS11	Spring Creek to Deadman's Corner	(6.8 - 7.5)	0.7	
WS12	Deadman's Corner to Rattlesnake Creek	(7.5 - 7.8)	0.3	
WS13	Rattlesnake Creek to Husum Falls	(7.8 - 7.9)	0.2	
WS14	Husum Falls to Sunshine (Big) Eddy	(7.9 - 9.9)	2.0	Husum to BZ
WS15	Sunshine (Big) Eddy to Diversion Hole	(9.9 - 10.3)	0.4	(7.9 - 13.2)
WS16	Diversion Hole to BZ Falls	(10.3 - 13.2)	2.9	
WS17	BZ Falls to Double Drop Falls	(13.2 - 14.4)	1.2	BZ to Big Brother
WS18	Double Drop Falls to Big Brother Falls	(14.4 - 16.5)	2.1	(13.2 - 16.5)

Representative outputs

A description of representative outputs are presented and explained below. For a complete set of outputs, the reader can download the full output report from http://www.mobrand.com/edt/home.jsp?subbasinID=2. For additional discussion of the results of the EDT modeling process and additional discussion of the diagnostic fish species used in the model the reader can refer to Big White Salmon Subbasin Plan (NPCC2004).

Baseline Outputs

After the reaches for the White Salmon Subbasin had been established and portrayed in terms of Level 2 attributes, preliminary model runs of each dataset were made. These runs were made for each scenario and diagnostic fish species. There were several reports (i.e., outputs) generated from a model run. One of the coarse scale or baseline outputs, termed "report 1", generates results for both smolts and adults. The "report 1" output displays population performance parameters, which were described in the introduction (productivity, capacity, equilibrium abundance, and life history diversity). Separate outputs were generated for the "patient", and the "template" conditions of the scenario describing the watershed.

Outputs in "report 1" were generated for adult coho, fall Chinook, spring Chinook, and steelhead (Figure 2). The historic potential ("template") condition and the "patient" conditions were titled "current without harvest" (Condit Dam in place, without accounting for harvest of any of the species), "dam removal" scenario, and "dam removal with PFC" scenario, which are described above. Essentially, the population performance parameters improved as the modeled conditions changed from the "current without harvest", to "dam removal", to "dam removal with PFC", and then to "historic potential".

The anomalous model results indicating that fall Chinook would have higher abundance with any of the other conditions compared to the "historic potential" condition can be attributed to several factors. As described in Appendix A, the model did not allow spring and fall Chinook to have overlapping spawning distributions. For the historic condition, the uppermost spawning reach of fall Chinook was set at WS5, which is 0.2 miles upstream of Condit Dam at the confluence with Little Buck Creek. Therefore, the historic and dam-removal scenarios only add 0.2 miles more potential spawning habitat than the "current without harvest" condition. In reality the spawning distribution of the two races of Chinook would likely overlap, with fall Chinook most likely spawning up to Husum Falls (an additional 4.4 miles of mainstem habitat). This additional spawning area would increase the fall Chinook abundance for the “dam removal” and “dam removal with PFC” scenarios.

In all but the “historic potential” scenario, Bonneville Dam inundates the lowest reaches of the White Salmon River, creating a pool that adds additional juvenile rearing habitat when compared with historic conditions. With Condit dam in place, the rating for bed scour was reduced in the bypass reaches (WS3 and WS4) where fall Chinook could spawn (NPCC 2004). The modeling suggests that these factors combine to increase fall Chinook abundance when Bonneville Dam and Condit Dam were in place compared to the historic condition. However, the model may not have adequately accounted for the reduced amount of appropriate spawning substrate in the reaches below Condit Dam, therefore over estimating the “current without harvest” condition.

While these estimates have some meaning, their main value was in troubleshooting by determining the reasonableness of the outcome and therefore appropriateness of the way the populations and their habitat have been described. It should be recognized that EDT outputs represent an equilibrium state, representing average habitat and climate conditions. The EDT productivity parameter is an estimated maximum productivity for average environmental conditions, therefore observed productivity may be notably less. This is also true for the capacity parameter. Therefore, abundance is the most appropriate performance parameter for assessing output accuracy, because it integrates productivity and capacity (Mobrand 2002). The lack of long-term assessment of anadromous salmonid abundance in the White Salmon River, and the lack of access for anadromous fish above Condit Dam makes it difficult to assess the “reasonableness” of the outcome. However, in other basins within the Lower Columbia River and the Columbia River Gorge Provinces, the EDT estimates of smolt and/or adult performance have been reasonably close to empirical estimates from WDFW population estimates (NPCC 2004). Since a similar approach was used in the White Salmon River, this suggests that the predicted performance of salmon and steelhead in the basin should be reasonable.

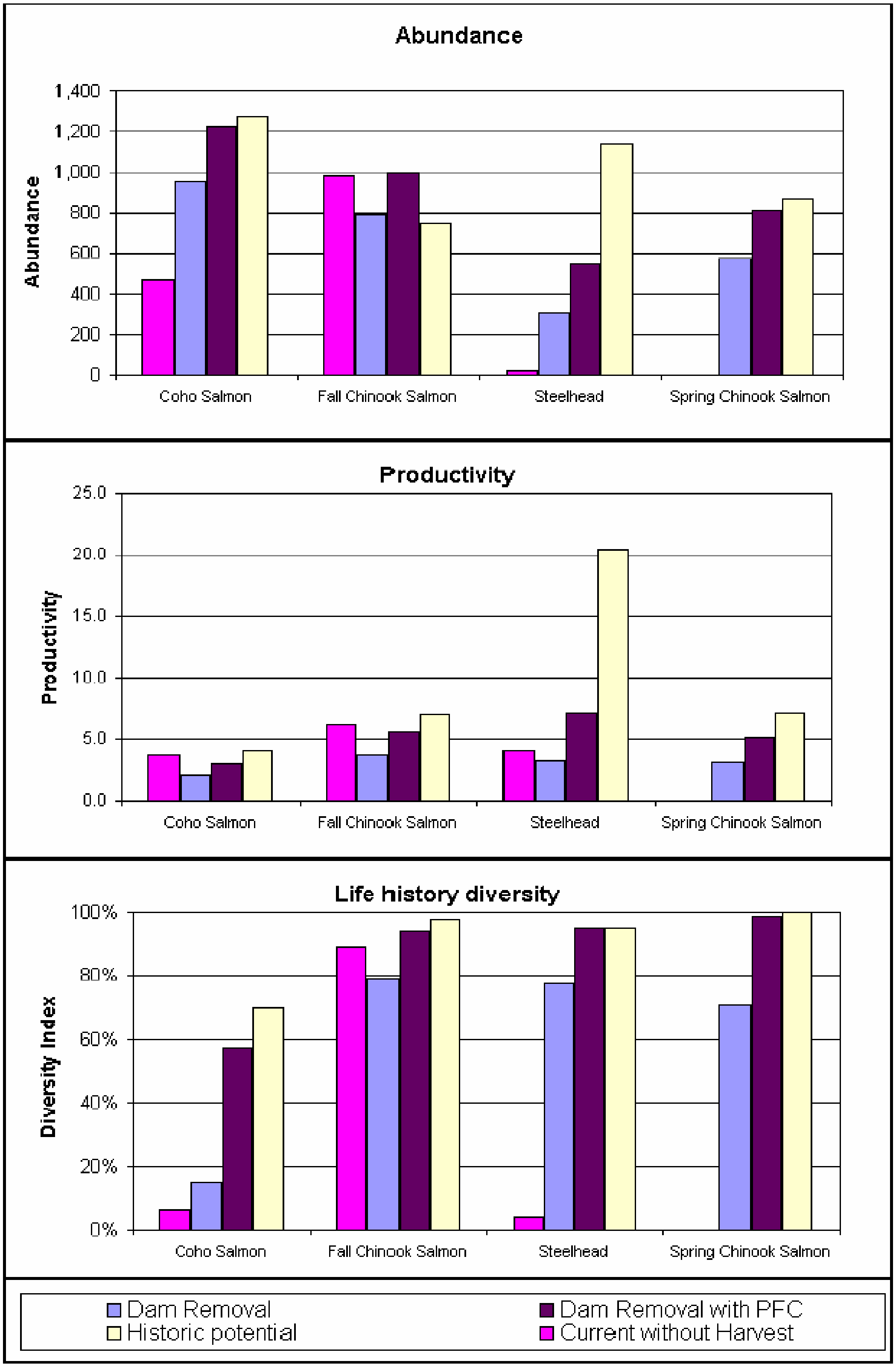


Figure 2. A summary of EDT performance parameters for each diagnostic species from report 1 outputs for historic potential, current conditions and possible future scenarios in the White Salmon River, WA. PFC = properly functioning condition. Figure from White Salmon River Subbasin Plan (NPCC 2004).

Diagnostic outputs

Geographic area priorities

An EDT model run produces outputs with information specific to each diagnostic fish species for each reach. These outputs are generated for the reach scale and/or geographic-area scale, and are labeled "report 2". The geographic-area scale essentially lumps individual reaches into a user-specified geographic area for ease of presentation. In the White Salmon River, each tributary was designated as a separate geographic area, and adjacent mainstem sections with similar characteristics were also separate geographic areas (Table 3, Figure 1, and Figure 3). Reach-scale analysis takes into account the same performance parameters for salmonid populations as the baseline output, but it provides a greater level of detail by identifying reaches based on their relative protection and restoration value. Because the habitat requirements are different for each fish species, the results of reach analyses are specific to each fish species.

One of the outputs from the "report 2" is called the "tornado" or "ladder" diagram (Figures 3-8). The tornado diagram lists reaches that can be prioritized by "protection benefit" and "restoration benefit". Protection benefit is the degree to which the performance parameters of a population are supported by a specific reach or geographic area. In other words, protection benefit indicates the estimated reduction in population performance if that reach or geographic area's habitat conditions were degraded. Restoration potential is the increase in performance a population would experience if a single reach or geographic area were restored to historical conditions (Mobrand 2004).

The model can sort the reaches in the tornado diagrams by ranking the reaches' importance to the diagnostic species averaged across all performance parameters (Figures 5-8). This report displays where protection and restoration efforts would benefit the diagnostic species the most. Some reaches can have high restoration and high preservation potential. Although this may seem contradictory, it actually indicates that these reaches are highly productive and have a larger effect on population performance than reaches with less restoration or preservation benefit. The diagrams shown in this report include reach length with the ranking, so consideration should be taken that longer reaches may inherently be ranked higher. Working with MBI, these results can be normalized by 1000 m of reach length (not currently available). It should also be noted that areas lower in the watershed have the most life history trajectories, and are therefore inherently ranked higher for both restoration and preservation benefit.

With the exception of the dam on Spring Creek (Sdam) between reaches S1 and S2, the culverts, falls, diversions, and dams were shown to have no restoration or protection benefit in the ladder diagrams. This was an artifact of the modeling effort for several reasons. One was because the model considers culverts and other possible barriers to be reaches with no length. Another reason was that the level of blockage at the potential fish barriers was unknown; so they were rated as 100% passable by all species and life stages. The exception was the Sdam reach, which was rated as 100% impassable. In Figures 4, 5, and 8 the S2 and S3 reaches also are shown to have no protection or restoration benefit. This was because the Sdam barrier was rated as not passable, so coho or steelhead can not inhabit those reaches. This gave those reaches no protection or restoration benefit for the fish that could potentially inhabit them. Obtaining and entering barrier passage information into the model would increase the accuracy of these outputs. Until then, the ranking of culverts and barriers, and reaches upstream of impassable culverts and barriers, should be viewed with caution.

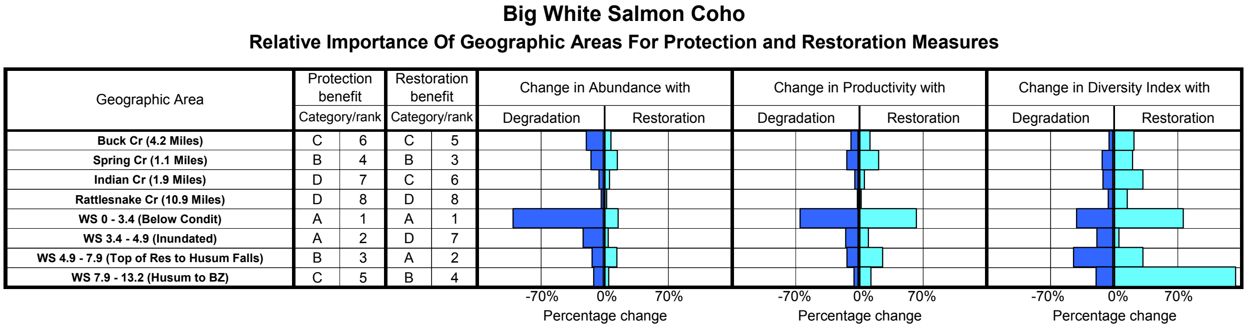
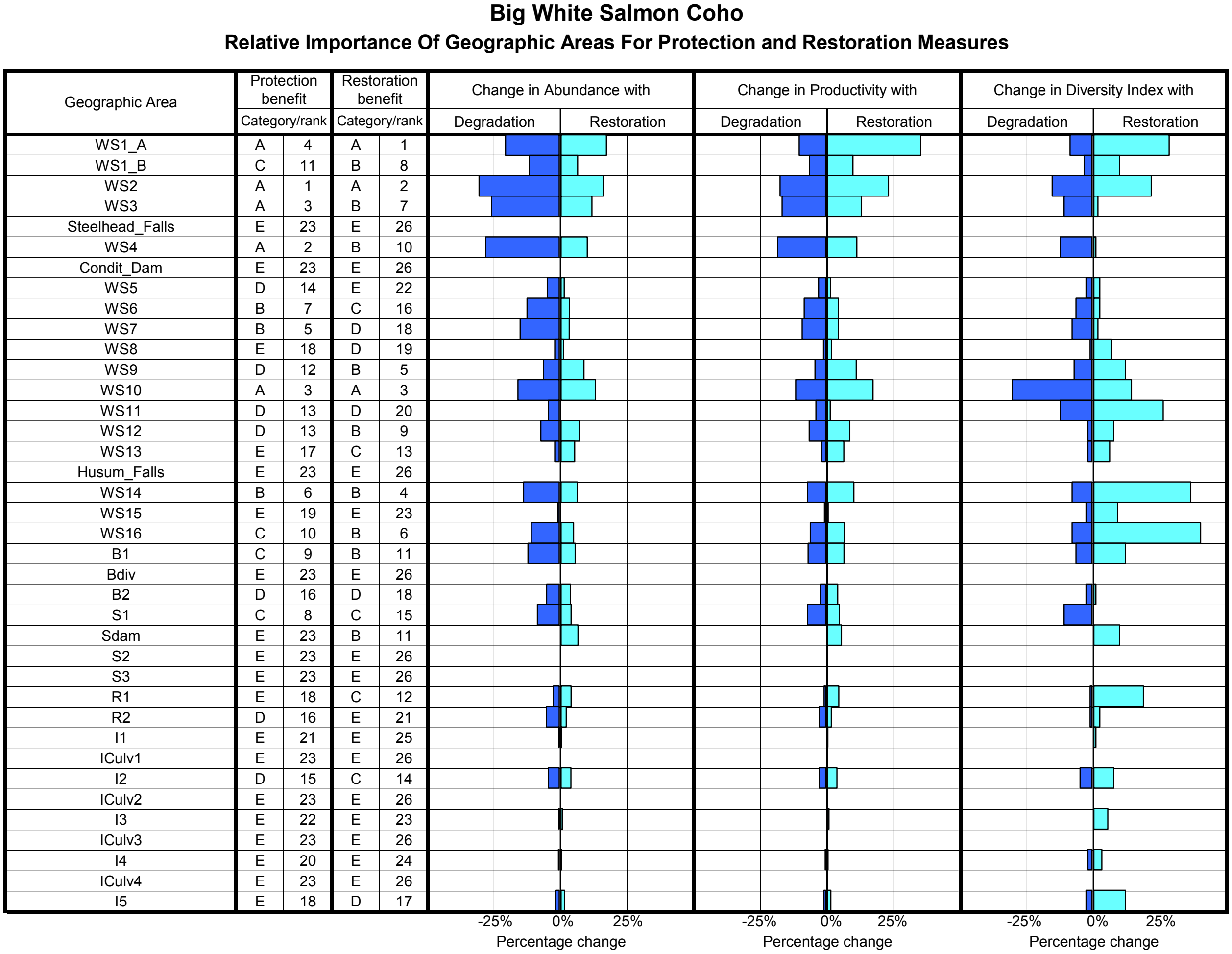


Figure 3. The relative restoration and preservation value of geographic areas in the White Salmon River subbasin based on EDT population performance parameters for coho salmon. The registered dataset (BigWhite Removal4_21_04) was used to generate this output. All culverts and barriers were rated with 100% passage, except for the dam on Spring Creek between reaches S1 and S2.

The ladder diagrams for coho salmon indicate that protection and restoration of habitat, particularly in the mainstem reaches below Condit Dam, but also in the reaches from the top of the reservoir to Husum Falls, would have a high benefit to the species (Figures 3–5). This is most likely due to the large pools in these areas. All trajectories for coho life history pass through the reaches below Condit Dam, which increases the preservation benefit of those reaches. The protection and restoration of lower reaches of Buck and Spring creeks was also indicated to be a high priority to benefit the species. In general, the model output suggests that opportunities to enhance habitat quality (productivity) and life history trajectories through restoration are greater than opportunities for enhancing abundance through restoration.

The WS2 reach was found to have the highest protection and restoration benefit to fall Chinook (Figure 6). This reach was shown to have substantial opportunity for increased productivity through restoration. It is important to remember that we modeled the uppermost fall Chinook spawning distribution only up through WS5, because the model does not allow overlap between fall and spring Chinook. Most likely there would be overlap up to Husum Falls, therefore the reaches upstream of Condit Dam are likely more important than the model indicated.

The ladder diagrams for Spring Chinook showed that many of the mainstem reaches from the top of the reservoir up to BZ Falls have high protection values (Figure 7). The model indicated that tributaries tend to have more restoration benefit, with the lowermost reach in Buck Creek having the highest restoration benefit for the species. The results were similar for steelhead: the mainstem reaches below BZ Falls were shown to have high protection benefits, and the tributaries (particularly Rattlesnake Creek and lower Buck Creek) were shown to have high restoration benefits (Figure 8).

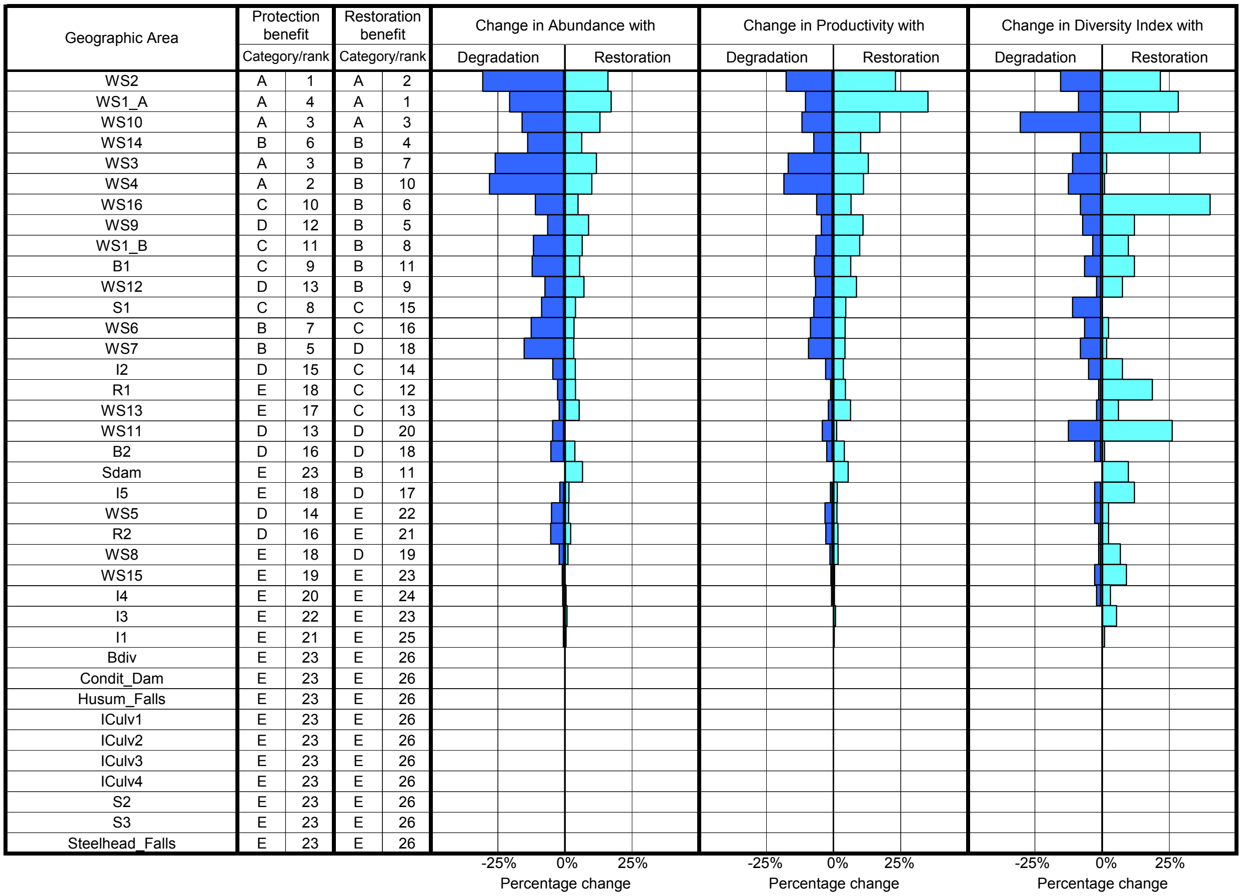


Geographic Area	Protection benefit Category/rank		Restoration benefit Category/rank	
WS1_A	A	4	A	1
WS1_B	C	11	B	8
WS2	A	1	A	2
WS3	A	3	B	7
Steelhead_Falls	E	23	E	26
WS4	A	2	B	10
Condit_Dam	E	23	E	26
WS5	D	14	E	22
WS6	B	7	C	16
WS7	B	5	D	18
WS8	E	18	D	19
WS9	D	12	B	5
WS10	A	3	A	3
WS11	D	13	D	20
WS12	D	13	B	9
WS13	E	17	C	13
Husum_Falls	E	23	E	26
WS14	B	6	B	4
WS15	E	19	E	23
WS16	C	10	B	6
B1	C	9	B	11
Bdiv	E	23	E	26
B2	D	16	D	18
S1	C	8	C	15
Sdam	E	23	B	11
S2	E	23	E	26
S3	E	23	E	26
R1	E	18	C	12
R2	D	16	E	21
I1	E	21	E	25
ICulv1	E	23	E	26
I2	D	15	C	14
ICulv2	E	23	E	26
I3	E	22	E	23
ICulv3	E	23	E	26
I4	E	20	E	24
ICulv4	E	23	E	26
I5	E	18	D	17

Figure 4. The relative restoration and preservation value of each reach in the White Salmon River subbasin based on EDT population performance parameters for coho salmon. The registered dataset (BigWhite Removal4_21_04) was used. All culverts and barriers were rated with 100% passage, with the exception of the dam on Spring Creek between reaches S1 and S2.

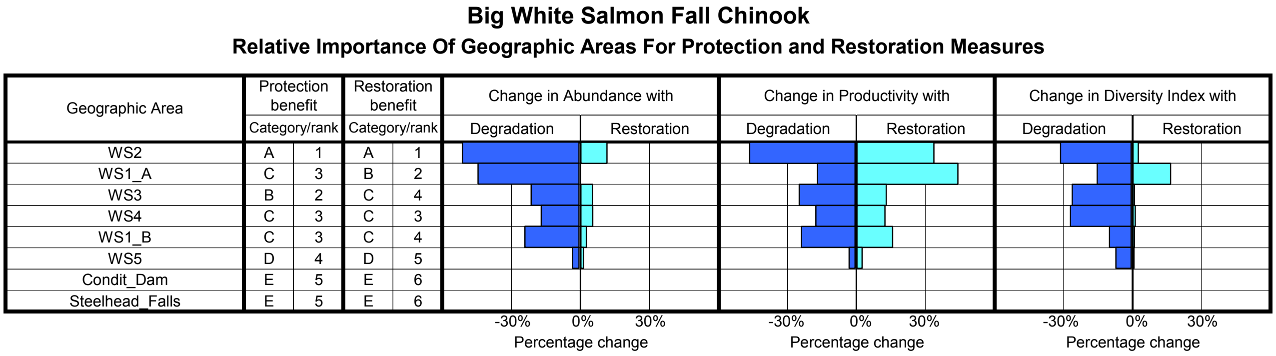
Big White Salmon Coho

Relative Importance Of Geographic Areas For Protection and Restoration Measures



Geographic Area	Protection benefit		Restoration benefit	
	Category/rank		Category/rank	
WS2	A	1	A	2
WS1_A	A	4	A	1
WS10	A	3	A	3
WS14	B	6	B	4
WS3	A	3	B	7
WS4	A	2	B	10
WS16	C	10	B	6
WS9	D	12	B	5
WS1_B	C	11	B	8
B1	C	9	B	11
WS12	D	13	B	9
S1	C	8	C	15
WS6	B	7	C	16
WS7	B	5	D	18
I2	D	15	C	14
R1	E	18	C	12
WS13	E	17	C	13
WS11	D	13	D	20
B2	D	16	D	18
Sdam	E	23	B	11
I5	E	18	D	17
WS5	D	14	E	22
R2	D	16	E	21
WS8	E	18	D	19
WS15	E	19	E	23
I4	E	20	E	24
I3	E	22	E	23
I1	E	21	E	25
Bdiv	E	23	E	26
Condit_Dam	E	23	E	26
Husum_Falls	E	23	E	26
ICulv1	E	23	E	26
ICulv2	E	23	E	26
ICulv3	E	23	E	26
ICulv4	E	23	E	26
S2	E	23	E	26
S3	E	23	E	26
Steelhead_Falls	E	23	E	26

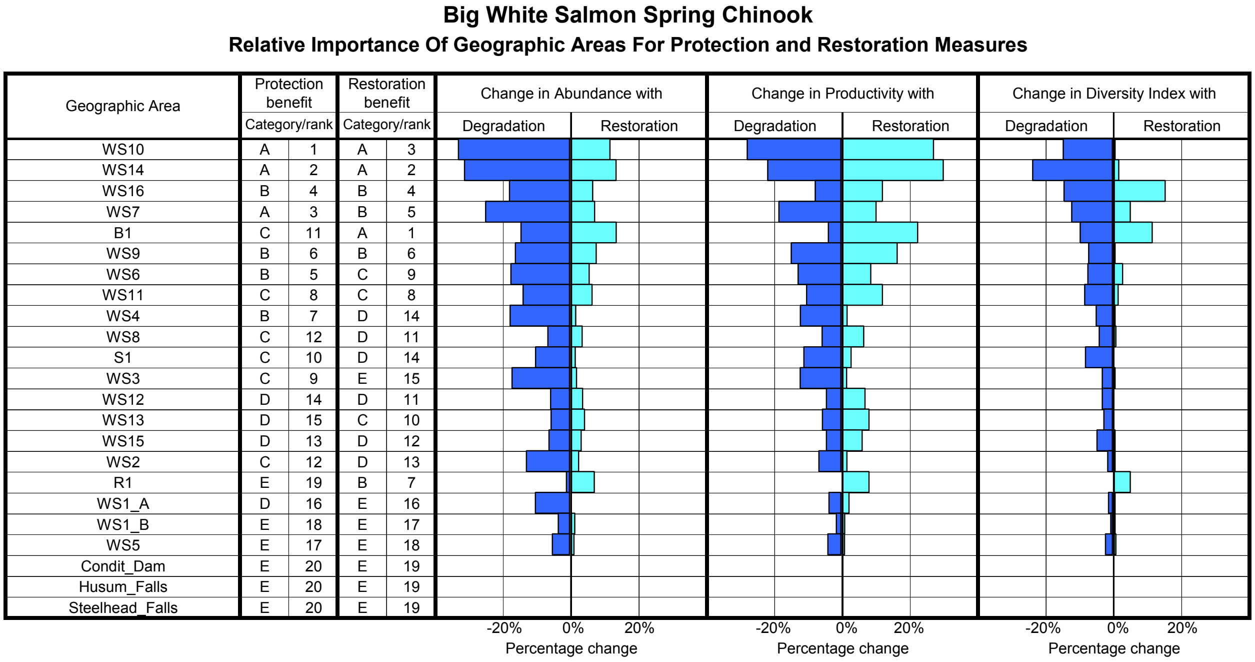
Figure 5. The relative restoration and preservation value of each reach, sorted by the average rank of the protection and restoration benefit combined, in the White Salmon River subbasin based on EDT population performance parameters for coho salmon. The registered dataset (BigWhite Removal4_21_04) was used. All culverts and barriers were rated with 100% passage, with the exception of 0% passage for the dam on Spring Creek between reaches S1 and S2.


Big White Salmon Fall Chinook

Relative Importance Of Geographic Areas For Protection and Restoration Measures

Geographic Area	Protection benefit		Restoration benefit	
	Category/rank		Category/rank	
WS2	A	1	A	1
WS1_A	C	3	B	2
WS3	B	2	C	4
WS4	C	3	C	3
WS1_B	C	3	C	4
WS5	D	4	D	5
Condit_Dam	E	5	E	6
Steelhead_Falls	E	5	E	6

Figure 6. The relative restoration and preservation value of each reach, sorted by the average rank of the protection and restoration benefit combined, in the White Salmon River subbasin based on EDT population performance parameters for fall Chinook salmon. The registered dataset (BigWhite Removal4_21_04) was used. All culverts and barriers were rated with 100% passage.


Big White Salmon Spring Chinook

Relative Importance Of Geographic Areas For Protection and Restoration Measures

Geographic Area	Protection benefit		Restoration benefit	
	Category/rank		Category/rank	
WS10	A	1	A	3
WS14	A	2	A	2
WS16	B	4	B	4
WS7	A	3	B	5
B1	C	11	A	1
WS9	B	6	B	6
WS6	B	5	C	9
WS11	C	8	C	8
WS4	B	7	D	14
WS8	C	12	D	11
S1	C	10	D	14
WS3	C	9	E	15
WS12	D	14	D	11
WS13	D	15	C	10
WS15	D	13	D	12
WS2	C	12	D	13
R1	E	19	B	7
WS1_A	D	16	E	16
WS1_B	E	18	E	17
WS5	E	17	E	18
Condit_Dam	E	20	E	19
Husum_Falls	E	20	E	19
Steelhead_Falls	E	20	E	19

Figure 7. The relative restoration and preservation value of each reach, sorted by the average rank of the protection and restoration benefit combined, in the White Salmon River subbasin based on EDT population performance parameters for spring Chinook salmon. The registered dataset (BigWhite Removal4_21_04) was used. All culverts and barriers were rated with 100% passage.

Big White Salmon Steelhead

Relative Importance Of Geographic Areas For Protection and Restoration Measures

Geographic Area	Protection benefit		Restoration benefit	
	Category/rank		Category/rank	
WS16	A	2	A	4
B1	B	6	A	2
WS14	A	3	A	5
WS10	A	1	B	9
R5	C	11	A	1
WS7	B	4	B	8
R4	C	10	A	3
WS4	B	5	C	13
WS9	B	7	C	13
WS18	C	13	B	8
WS3	C	9	C	12
WS11	C	8	C	14
R3	D	17	B	6
WS17	C	12	C	11
R2	D	16	B	8
WS15	C	14	C	14
WS6	C	13	D	16
B2	E	23	B	7
WS2	C	15	D	16
WS1_A	D	22	C	10
R1	E	24	B	9
WS8	D	19	D	17
WS12	D	18	D	19
I2	E	25	D	15
WS5	D	21	D	21
S1	D	20	E	23
I5	E	26	D	18
WS13	E	25	D	20
WS1_B	E	28	D	20
I3	E	28	E	23
I1	E	27	E	25
Sdam	E	30	E	22
I4	E	29	E	24
Bdiv	E	30	E	26
BZFalls	E	30	E	26
Condit_Dam	E	30	E	26
Double_Drop	E	30	E	26
Husum_Falls	E	30	E	26
ICulv1	E	30	E	26
ICulv2	E	30	E	26
ICulv3	E	30	E	26
ICulv4	E	30	E	26
RFalls1	E	30	E	26
S2	E	30	E	26
S3	E	30	E	26
Steelhead_Falls	E	30	E	26

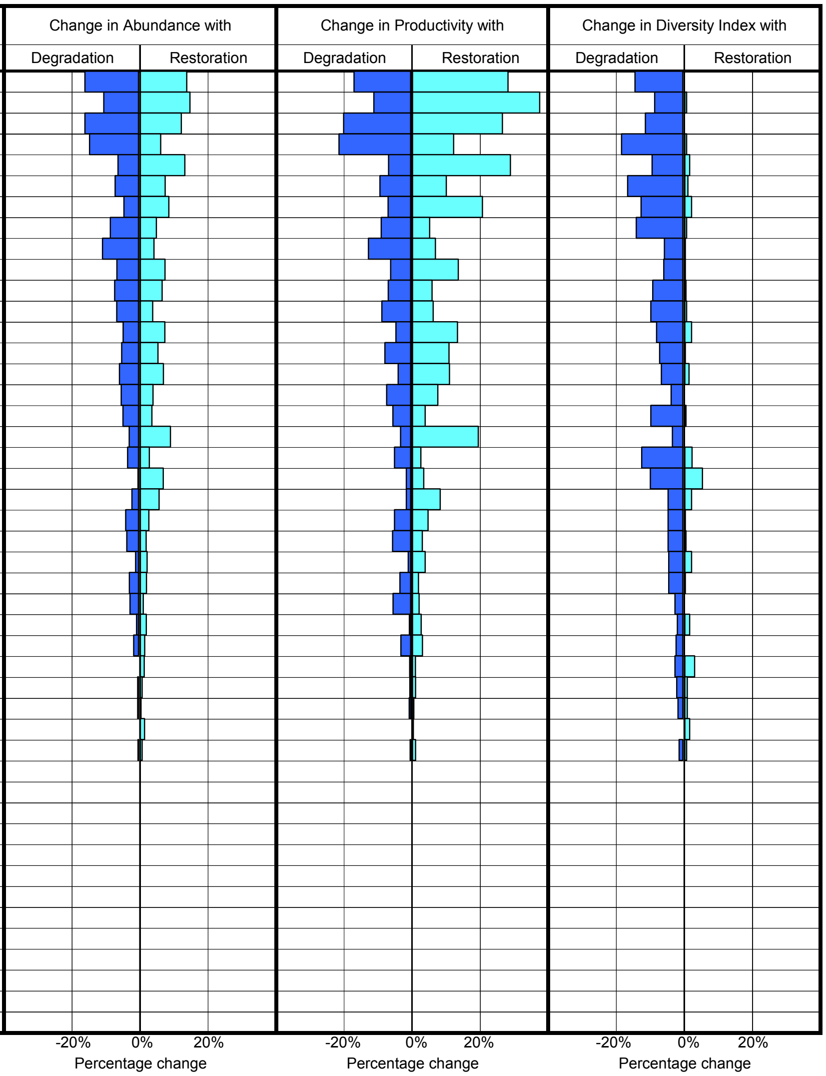


Figure 8. The relative restoration and preservation value of each reach, sorted by the average rank of the protection and restoration benefit combined, in the White Salmon River subbasin, based on EDT population performance parameters for steelhead. The registered dataset (BigWhite Removal4_21_04) was used. All culverts and barriers were rated with 100% passage, with the exception of 0% passage for the dam on Spring Creek between reaches S1 and S2.

Geographic area summary - Habitat factor analysis

The habitat factors or Level 3 survival factors that affect production potential are displayed in two types of "consumer report diagrams". The level 2 attributes that were used to rate the Level 3 survival factors are listed in Table 1, and Table 4 provides definitions for each survival factor. One report, titled "Protection and restoration strategic priority summary", shows the level of reduced productivity summarized by the habitat factors across the same set of reaches or geographic areas as the tornado diagrams presented above (Figure 9). This output condenses the most influential habitat factors across all life stages, and in the case of a geographic area analysis, across a number of reaches. This report is a display of the habitat factors that most reduce the diagnostic species population performance. Although often similar, the most important habitat factors may differ depending on the diagnostic species being analyzed.

The other type of consumer report diagram, titled "Reach analysis", shows more detail by describing the influence of Level 3 survival factors on the survival of each life stage for each diagnostic species, the relevant months for each life stage, percent of life history trajectories affected, the percent change in productivity, and several other statistics for each reach. For both styles of consumer report diagrams, increasing size of black dots indicates the relative magnitude of the negative impacts.

For the dam removal scenario, the habitat factor that was found to be the highest-ranked priority for restoration of coho salmon was habitat diversity (Figure 9). This was true for nearly every reach in the mainstem and tributaries. Other habitat factors that were shown to have affected potential productivity of coho salmon include reduced channel stability, increased sediment load, and flow. The model output suggested that an increase in harassment and poaching was a limiting factor in some of the reaches. Increased temperature was found to be a limiting habitat factor in the tributaries (Figure 9).

Because fall Chinook salmon leave the White Salmon River shortly after emergence, incubation is thought to be the most critical stage to their production. This explains why the most detrimental habitat factor was found to be the increased sediment load (Figure 10). Reduced key habitat quantity, reduced channel stability, and increased peak flow were also shown to be limiting factors for the productivity of fall Chinook salmon. In the lowermost reaches, increased harassment/poaching by anglers was found to limit productivity. The model output suggested that pathogens from fish stocking and straying, and predation from introduced species was also a factor in the downstream reaches (Figure 10).

The model output suggests that greatest potential limiting factors for spring Chinook salmon productivity were a loss of habitat diversity throughout the river, and increased sediment load in their spawning reaches (Figure 11). Decreased channel stability, increased peak flow, and reduced key habitat quantity were found to be limiting factors in many reaches. Higher than historic temperatures in the tributaries was also found to be a factor reducing productivity (Figure 11).

The potential steelhead productivity would likely be decreased due to the same factors listed for the other diagnostic species (Figure 12). The model output suggests that the most important limiting factors were a loss of key habitat quantity, decreased channel stability, increased sediment load, and increased peak flow, which decreases potential productivity in nearly all reaches. Harassment/poaching due to rafters and anglers was shown to be a limiting factor in the mainstem. Competition with hatchery fish, pathogens and predation were found to be habitat factors affecting productivity in the lowermost reaches. The model suggests that reduced summer low flows, increased temperatures, and susceptibility to pathogens due to increased temperatures, were concerns for steelhead production in Rattlesnake Creek (Figure 12).

Table 4. Definitions for the habitat factors also known as Level 3 survival factors (Lestelle et al. 2004).

Factor	Definition
Channel stability	The effect of stream channel stability (within reach) on the relative survival or performance of the focus species; the extent of channel stability is with respect to its streambed, banks, and its channel shape and location.
Chemicals	The effect of toxic substances or toxic conditions on the relative survival or performance of the focus species. Substances include chemicals and heavy metals. Toxic conditions include low pH.
Competition (with hatchery fish)	The effect of competition with hatchery produced animals on the relative survival or performance of the focus species; competition might be for food or space within the stream reach.
Competition (with other species)	The effect of competition with other species on the relative survival or performance of the focus species; competition might be for food or space.
Flow	The effect of the amount of stream flow, or the pattern and extent of flow fluctuations, within the stream reach on the relative survival or performance of the focus species. Effects of flow reductions or dewatering due to water withdrawals are to be included as part of this attribute.
Food	The effect of the amount, diversity, and availability of food that can support the focus species on the its relative survival or performance.
Habitat diversity	The effect of the extent of habitat complexity within a stream reach on the relative survival or performance of the focus species.
Harassment	The effect of harassment, poaching, or non-directed harvest (i.e., as can occur through hook and release) on the relative survival or performance of the focus species.
Key habitat	The relative quantity of the primary habitat type(s) utilized by the focus species during a life stage; quantity is expressed as percent of wetted surface area of the stream channel.
Obstructions	The effect of physical structures impeding movement of the focus species on its relative survival or performance within a stream reach; structures include dams and waterfalls.
Oxygen	The effect of the concentration of dissolved oxygen within the stream reach on the relative survival or performance of the focus species.
Pathogens	The effect of pathogens within the stream reach on the relative survival or performance of the focus species. The life stage when infection occurs is when this effect is accounted for.
Predation	The effect of the relative abundance of predator species on the relative survival or performance of the focus species.
Sediment load	The effect of the amount of the amount of fine sediment present in, or passing through, the stream reach on the relative survival or performance of the focus species.
Temperature	The effect of water temperature with the stream reach on the relative survival or performance of the focus species.
Withdrawals (or entrainment)	The effect of entrainment (or injury by screens) at water withdrawal structures within the stream reach on the relative survival or performance of the focus species. This effect does not include dewatering due to water withdrawals, which is covered by the flow attribute.

Big White Salmon Coho
Protection and Restoration Strategic Priority Summary

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
WS1_A	◯	◯	•		•		•		⬤	•			•	•	⬤			
WS1_B	◦	○			•		•		⬤	●			•	•	●			●
WS2	◯	◯	●		•		•		⬤	•					●			●
WS3	◯	○	●				•		⬤						●			●
Steelhead_Falls																		
WS4	◯	○	●				•		⬤						●			●
Condit_Dam																		
WS5			●				•		⬤						●			
WS6	○	◦	●				•		⬤						●			
WS7	○		●				•		⬤						●			
WS8			●				•		⬤	•					●			
WS9		○	●				•		●	•					●			
WS10	◯	◯	●				•		●	•					●			
WS11			●				•		⬤	•					●			
WS12		○	●				•		⬤	•					●			
WS13		◦	●				•		⬤	•					●			
Husum_Falls																		
WS14	○	○	●				•		⬤	•					●			
WS15			●				•		⬤	•					●			
WS16	◦	○	●				•		⬤	•					●			•
B1	◦	○	•				•		⬤						●			●
Bdiv																		
B2			●				•		⬤						●			●
S1	◦	◦							●						•			•
Sdam		○									⬤							
S2									●						●			⬤
S3									•						•			●
R1		◦	●				•		⬤	•					●	●		⬤
R2			•				•		●						●	●		●
I1			•				•		●						●	●		●
ICulv1																		
I2		◦	•				•		●						●	●		●
ICulv2																		
I3			•				•		⬤						●	●		●
ICulv3																		
I4			•				•		●						●	●		●
ICulv4																		
I5			•				•		⬤						●	●		●

1/ "Channel stability" applies to freshwater areas only.

Key to strategic priority (corresponding Benefit Category letter also shown)

A		B		C		D & E	
◯	High	○	Medium	◦	Low		Indirect or General
⬤		●		•			

Figure 9. Habitat factor diagram for the White Salmon River averaged across all life stages of coho salmon. The registered dataset (BigWhite Removal4_21_04) was used. All culverts and barriers were rated with 100% passage, with the exception of 0% passage for the dam on Spring Creek between reaches S1 and S2.

Big White Salmon Fall Chinook
Protection and Restoration Strategic Priority Summary

Geographic area priority			Attribute class priority for restoration															
Geographic area	**Protection benefit**	**Restoration benefit**	***Channel stability***	***Chemicals***	***Competition (w/ hatch)***	***Competition (other sp)***	***Flow***	***Food***	***Habitat diversity***	***Harassment/poaching***	***Obstructions***	***Oxygen***	***Pathogens***	***Predation***	***Sediment load***	***Temperature***	***Withdrawals***	***Key habitat quantity***
WS1_A	∘	○	•				•		•	•			•	•	⬤			
WS1_B	∘	∘					•		•	●			•	•	●			●
WS2	◯	◯	•				•		●	•					●			●
WS3	○	∘	•				•		●						●			●
Steelhead_Falls																		
WS4	∘	∘	•				•		●						●			●
Condit_Dam																		
WS5			•				•		●	•					●			•

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.

A		B		C		D & E	
◯	High	○	Medium	∘	Low	☐	Indirect or General
⬤		●		•		☐	

Figure 10. Habitat factor diagram for the White Salmon River averaged across all life stages of fall Chinook salmon. The registered dataset (BigWhite Removal4_21_04) was used. All culverts and barriers were rated with 100% passage, with the exception of 0% passage for the dam on Spring Creek between reaches S1 and S2.

Big White Salmon Spring Chinook
Protection and Restoration Strategic Priority Summary

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
WS1_A			•				•		•					•				
WS1_B							•		•					•				●
WS2	∘		•				•		●									●
WS3	∘						•		●									
Steelhead_Falls																		
WS4	○		•				•		●									
Condit_Dam																		
WS5			•				•		●									
WS6	○	∘	•				•		●						●			•
WS7	◯	○	•				•		●						●			•
WS8	∘		•				•		●	•					●			•
WS9	○	○	•				•		•	•					●			
WS10	◯	◯	•				•		•	•					●			
WS11	∘	∘	•				•		●	•					●			•
WS12			•				•		•	•					●			
WS13		∘	•				•		●	•					●			●
Husum_Falls																		
WS14	◯	◯	•				•		●	•					●			•
WS15			•				•		●	•					●			
WS16	○	○	•				•		●	•					●			•
B1	∘	◯	•				•		●						●	●		●
S1	∘								●						•			•
R1		○	•				•		⬤	•					●	⬤		⬤

Key to strategic priority (corresponding Benefit Category letter also shown)

A	B	C	D & E
◯ ⬤ High	○ ● Medium	∘ • Low	Indirect or General

1/ "Channel stability" applies to freshwater areas only.

Figure 11. Habitat factor diagram for the White Salmon River averaged across all life stages of spring Chinook salmon. The registered dataset (BigWhite Removal4_21_04) was used. All culverts and barriers were rated with 100% passage, with the exception of 0% passage for the dam on Spring Creek between reaches S1 and S2.

Big White Salmon Steelhead
Protection and Restoration Strategic Priority Summary

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
WS1_A		◦			•		•		●	•			•	●	⬤	•		●
WS1_B					•		•		●	●			•	●	●			●
WS2	◦		•		•		•		●	•				•	●			●
WS3	◦	◦	•				•		•						●			●
Steelhead_Falls																		
WS4	○	◦	•				•		•						●			●
Condit_Dam																		
WS5			•				•		●	•					●			•
WS6	◦		•				•		●	•					●			•
WS7	○	○	•				•		●	•					●			•
WS8			•				•		•	●					●			
WS9	○	◦					•		•	•					●			
WS10	◯	○					•		•	•					●			
WS11	◦	◦	•				•		•	•					●			•
WS12			•				•		•	●					●			•
WS13			•				•		•	•					●			●
Husum_Falls																		
WS14	◯	◯					•		•	•					●			
WS15	◦	◦	•				•		•	●					●			
WS16	◯	◯	•				•		•	●					●			•
BZFalls																		
WS17	◦	◦	•				•		•						●			•
Double_Drop																		
WS18	◦	○	•				•		•						●			•
B1	○	◯					•		•						●	●		●
Bdiv																		
B2		○	•				•		•	•					●			●
S1									•						•			•
Sdam											⬤							
S2									⬤						●			⬤
S3									•						•			●
R1		○	•				•		•	•			•		●	●		⬤
R2		○					•		•				•		●	●		●
RFalls1																		
R3		○					•		•				•		●	●		●
R4	◦	◯					•		•				•		●	●		●
R5	◦	◯					•		•						●	●		●
I1							•		•				•		●	●		●
ICulv1																		
I2							•		•				•		●	●		●
ICulv2																		
I3							•		•				•		●	●		●
ICulv3																		
I4							•		•				•		●	●		●
ICulv4																		
I5							•		•				•		●	●		●

1/ "Channel stability" applies to freshwater areas only.

Key to strategic priority (corresponding Benefit Category letter also shown)

A	B	C	D & E
◯ ⬤ High	○ ● Medium	◦ • Low	Indirect or General

Figure 12. Habitat factor diagram for the White Salmon River averaged across all life stages of steelhead. The registered dataset (BigWhite Removal4_21_04) was used. All culverts and barriers were rated with 100% passage, with the exception of 0% passage for the dam on Spring Creek between reaches S1 and S2.

Reach analysis

The reach analysis level of detail is available for each diagnostic species in each reach and can be useful for specific recovery measures in specific reaches. This reach-specific "consumer report" output provides additional detail by quantifying the reduction in productivity of each life stage as affected by changes in habitat relative to historic conditions (Figure 13). In this output, the relevant times of year for the life stage, and percent of life history trajectories affected for each life stage is displayed, along with some overall reach statistics. As with the diagrams above, the size of the black dots in the reach analysis diagrams indicate the relative influence that the habitat attribute has on the survival of each life stage of the diagnostic species. Each life stage is also ranked, with "1" representing the most severe reduction in survival. Ranking is based on the percent of time a given life stage resides in the reach, as well as the degree to which survival is reduced relative to historical conditions. The definition for each life stage of coho salmon, Chinook salmon, and steelhead are presented in Tables 5, 6, and 7, respectively. Reach analysis diagrams of two mainstem reaches (WS2 and WS11, Table 3) and two tributary reaches (B1 and R1, Table 3) are presented for each diagnostic species (Figures 13-25). However, because the reach analysis diagrams were reach- and species-specific, they may be too detailed to compare habitat problems across the watershed. The Big White Salmon Subbasin Plan (NPCC 2004) provides additional species-specific discussion and conclusions regarding these outputs.

The model output suggests that the life stages of coho salmon most affected by changes in habitat were the egg incubation, age-0 active rearing, and age-0 inactive life stages (Figures 13-17). This was true in the tributaries and mainstem. Changes in sediment and channel stability were shown to have the greatest influence on the egg incubation life stage. Reductions in habitat diversity and key habitat quantity were found to be the main habitat factors reducing survival in the age-0 active rearing, and age-0 inactive life stages (Figures 13-16)

The most probable reaches for fall Chinook salmon spawning were modeled entirely in the lower mainstem of the White Salmon River. Therefore, for fall Chinook, only the WS2 reach analysis was presented (Figure 17). Compared to historic conditions, survival in the egg incubation and fry colonization life stages were found to be the most altered in this reach. Similar to the egg incubation life stage of coho salmon, the habitat factors implicated in reduced survival of that life stage are increased sediment load, decreased channel stability, and loss of key habitat quantity (Figure 17).

Spring Chinook salmon are not expected to spawn in the lower reaches of the White Salmon River, therefore only a few of the life stages would inhabit the WS 2 reach (Figure 18). The model output suggested that in the mainstem reach of WS11 and the lowermost reach in Buck Creek (B1), the egg incubation and fry colonization life stages were most affected by changes in habitat. The habitat factors that were found to be the most influential in those changes were increased sediment load, reduced channel stability and reduced key habitat quantity (Figures 19 and 20). In the lowest reaches of Buck and Rattlesnake creeks, increased temperatures also influenced some of the life stages (Figures 20 and 21). In Rattlesnake Creek, the greatest productivity change was shown to be in the spawning life stage, and reduced habitat diversity, reduced key habitat quantity, and increased summer temperatures were the habitat factors that influenced this change the most.

The model output suggests that the same habitat changes that altered survival of the other diagnostic species will likely also alter steelhead survival in the White Salmon River. The egg incubation stage was found to be one of the most affected life stages, with increased sediment load a primary habitat factor in this change in survival compared to historic conditions (Figures 22-25). Because steelhead spawn in the spring, and their eggs incubate into the early summer, increased temperature in the tributaries will affect steelhead egg incubation more than the other diagnostic fish species, which spawn in the fall (Figures 24 and 25). This is because the offspring from fish that spawn in the fall emerge in the spring when temperatures are lower, and the fry can out-migrate or find cold water refuge. Survival rates for the age-0 active rearing and age-0 inactive life stages have also changed substantially when compared to historic conditions. As with the other species, loss of habitat diversity, reduced channel stability, decreased flow in the tributaries in the summer, and increased peak flow associated with storm events were found to be some of the habitat factors that reduced survival by life stage.

Table 5. Description of coho salmon life stages within the freshwater environment. (Lestelle et al. 2004)

Life stage	**Description**
Spawning	Period of active spawning, beginning when fish move on to spawning beds and initiate redd digging and ending when gametes are released. Note: For computational purposes, the reproductive potential associated with a spawning female is incorporated at the beginning of this stage; this potential includes sex ratio (average females per total spawners) and average fecundity per female
Egg incubation	Egg incubation and alevin development; stage begins at the moment of the release of gametes by spawners and ends at fry emergence (losses to egg viability that occur in the instant prior to fertilization are included here).
Fry colonization	Fry emergence and initial dispersal; time period is typically very short, beginning at fry emergence and ending when fry begin active feeding associated with a key habitat.
0-age resident rearing	Rearing by age-0 fish that is largely associated with a small "home range"; these fish are generally territorial.
0-age migrant	Directional migration by age-0 fish that tends to be rapid and not strongly associated with feeding/rearing. This type of movement typically occurs when fish redistribute within the stream system prior to, or during, winter.
0-age inactive	Largely inactive or semi-dormant fish age fish; this behavior is associated with overwintering, when feeding is reduced; fish exhibiting this behavior need to be largely sustained by lipid reserves.
1-age resident rearing	Feeding/rearing by age-1 fish that is associated with a home range; these fish are often territorial.
1-age migrant	Directional migration by age-1 fish that tends to be rapid and not strongly associated with feeding/rearing. Such migrations will typically occur during either spring or fall/early winter by fish migrating seaward or as a redistribution to a different freshwater habitat (such as occurs following winter or in preparation for winter).
Migrant prespawner	Adult fish approaching sexual maturity that are migrating to their natal stream; in the ocean this stage occurs in the final year of marine life, in freshwater feeding has generally ceased.
Holding prespawner	Adult fish approaching sexual maturity that are largely stationary and holding, while en-route to their spawning grounds; distance to the spawning grounds from holding sites may be short or long.

Table 6. Description of Chinook salmon life stages within the freshwater environment (Lestelle et al. 2004).

Life stage	**Description**
Spawning	Period of active spawning, beginning when fish move on to spawning beds and initiate redd digging and ending when gametes are released. Note: For computational purposes, the reproductive potential associated with a spawning female is incorporated at the beginning of this stage; this potential includes sex ratio (average females per total spawners) and average fecundity per female.
Egg incubation	Egg incubation and alevin development; stage begins at the moment of the release of gametes by spawners and ends at fry emergence (losses to egg viability that occur in the instant prior to fertilization are included here).
Fry colonization	Fry emergence and initial dispersal; time period is typically very short, beginning at fry emergence and ending when fry begin active feeding associated with a key habitat.
0-age resident rearing	Rearing by age-0 fish that is largely associated with a small "home range"; these fish are generally territorial.
0-age transient rearing	Rearing by age-0 fish accompanied by directional movement (i.e., these fish do not have home ranges); these fish are non-territorial, though agonistic behavior may still be exhibited (note: this pattern typifies a 0-age fall Chinook rearing pattern).
0-age migrant	Directional migration by age- 0 fish that tends to be rapid and not strongly associated with feeding/rearing. This type of movement typically occurs when fish redistribute within the stream system prior to, or during, winter.
0-age inactive	Largely inactive or semi-dormant fish age fish; this behavior is associated with overwintering, when feeding is reduced; fish exhibiting this behavior need to be largely sustained by lipid reserves.
1-age resident rearing	Feeding/rearing by age-1 fish that is associated with a home range; these fish are often territorial.
1-age migrant	Directional migration by age-1 fish that tends to be rapid and not strongly associated with feeding/rearing. Such migrations will typically occur during either spring or fall/early winter by fish migrating seaward or as a redistribution to a different freshwater habitat(such as occurs following winter or in preparation for winter).
Migrant prespawner	Adult fish approaching sexual maturity that are migrating to their natal stream; in the ocean this stage occurs in the final year of marine life, in freshwater feeding has generally ceased.
Holding prespawner	Adult fish approaching sexual maturity that are largely stationary and holding, while en-route to their spawning grounds; distance to the spawning grounds from holding sites may be short or long.

Table 7. Description of steelhead life stages within the freshwater environment (Lestelle et al. 2004).

Life stage	**Description**
Spawning	Period of active spawning, beginning when fish move on to spawning beds and initiate redd digging and ending when gametes are released. Note: For computational purposes, the reproductive potential associated with a spawning female is incorporated at the beginning of this stage; this potential includes sex ratio (average females per total spawners) and average fecundity per female.
Egg incubation	Egg incubation and alevin development; stage begins at the moment of the release of gametes by spawners and ends at fry emergence (losses to egg viability that occur in the instant prior to fertilization are included here).
Fry colonization	Fry emergence and initial dispersal; time period is typically very short, beginning at fry emergence and ending when fry begin active feeding associated with a key habitat.
0-age resident rearing	Rearing by age-0 fish that is largely associated with a small "home range"; these fish are generally territorial.
0-age migrant	Directional migration by age-0 fish that tends to be rapid and not strongly associated with feeding/rearing. This type of movement typically occurs when fish redistribute within the stream system prior to, or during, winter.
0-age inactive	Largely inactive or semi-dormant age-0 fish; this behavior is associated with overwintering, when feeding is reduced; fish exhibiting this behavior need to be largely sustained by lipid reserves.
1-age resident rearing	Feeding/rearing by age-1 fish that is associated with a home range; these fish are often territorial.
1-age migrant	Directional migration by age-1 fish that tends to be rapid and not strongly associated with feeding/rearing. Such migrations will typically occur during either spring or fall/early winter by fish migrating seaward or as a redistribution to a different freshwater habitat (such as occurs following winter or in preparation for winter).
1-age inactive	Largely inactive or semi-dormant fish age-1fish; this behavior is associated with overwintering, when feeding is reduced; fish exhibiting this behavior need to be largely sustained by lipid reserves.
2+-age resident rearing	Feeding/rearing by age-2 and older fish that is associated with a home range; these fish are often territorial.
2+-age migrant	Directional migration by age-2 fish that tends to be rapid and not strongly associated with feeding/rearing. Such migrations will typically occur during either spring or fall/early winter by fish migrating seaward or as a redistribution to a different freshwater habitat (such as occurs following winter or in preparation for winter).
2+-age inactive	Largely inactive or semi-dormant fish age 2 and older fish; this behavior is associated with overwintering, when feeding is reduced; fish exhibiting this behavior need to be largely sustained by lipid reserves.
Migrant prespawner	Adult fish approaching sexual maturity that are migrating to their natal stream; in the ocean this stage occurs in the final year of marine life, in freshwater feeding has generally ceased.
Holding prespawner	Adult fish approaching sexual maturity that are largely stationary and holding, while en-route to their spawning grounds; distance to the spawning grounds from holding sites may be short or long.

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed
Reach Analysis - Coho

Geographic Area:	WS2	**Stream:**	Big White Salmon
Reach:	End of BON pool influence to Powerhouse	**Reach Length (mi):**	0.95
		Reach Code:	WS2

Restoration Benefit Category:1/	A	**Productivity Rank:1/**	2	**Potential % change in productivity:2/**	23.2%
Overall Restoration Potential Rank:1/	2	**Average Abundance (Neq) Rank:1/**	2	**Potential % change in Neq:2/**	16.0%
(lowest rank possible - with ties)1/	26	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	21.8%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	2	**loss in productivity with degradation:2/**	-17.2%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-30.3%
(lowest rank possible - with ties)1/	23	**Life History Diversity Rank:1/**	2	**% loss in diversity with degradation:2/**	-15.0%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	11.7%	-5.2%	8							●	●								●
Egg incubation	Oct-May	11.7%	-42.7%	3	⬤							•					⬤			●
Fry colonization	Mar-May	64.7%	-6.1%	4	●				●		⬤					•				●
0-age active rearing	Mar-Oct	10.1%	-37.7%	2	•		●				⬤				•	•				⬤
0-age migrant	Oct-Nov	12.7%	-2.9%	6							●					•				
0-age inactive	Oct-Mar	10.2%	-87.8%	1	•				●		⚫									⬤
1-age active rearing	Mar-May	10.2%	-16.5%	5	•		•		●		●				•	•				⬤
1-age migrant	Mar-Jun	30.0%	-0.3%	7							●					•				
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	87.1%	0.0%	10								•								
Prespawning holding	Oct-Dec	11.7%	-3.0%	9								●								⬤
All Stages Combined		87.1%																		

1/ Ranking based on effect over entire geographic area.
2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	∘
Moderate	●	○
High	⬤	◯
Extreme	⚫	⚪

Figure 13. A coho salmon "consumer reports diagram", for Reach WS2 (RM 1.2-2.1) of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with "1" representing the most severe impact relative to historical conditions.

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed
Reach Analysis - Coho

Geographic Area:	WS11	**Stream:**	Big White Salmon
Reach:	Spring Ck. to Deadman's Corner	**Reach Length (mi):**	0.70
		Reach Code:	WS11

Restoration Benefit Category:1/	D	**Productivity Rank:1/**	24	**Potential % change in productivity:2/**	1.0%
Overall Restoration Potential Rank:1/	20	**Average Abundance (Neq) Rank:1/**	28	**Potential % change in Neq:2/**	0.0%
(lowest rank possible - with ties)1/	26	**Life History Diversity Rank:1/**	4	**Potential % change in diversity:2/**	26.3%
Preservation Benefit Category:1/	D	**Productivity Rank:1/**	15	**loss in productivity with degradation:2/**	-3.6%
Overall Preservation Rank:1/	13	**Average Abundance (Neq) Rank:1/**	18	**% loss in Neq with degradation:2/**	-4.1%
(lowest rank possible - with ties)1/	23	**Life History Diversity Rank:1/**	3	**% loss in diversity with degradation:2/**	-12.0%

					Change in attribute impact on survival																	
Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	2.3%	-4.4%	6							●	●								
Egg incubation	Oct-May	2.3%	-40.7%	3	⚫							•					⚫			
Fry colonization	Mar-May	21.0%	-5.2%	4	●				●		⚫									
0-age active rearing	Mar-Oct	3.0%	-37.9%	2	•						⚫									
0-age migrant	Oct-Nov	4.1%	-1.3%	8							●									
0-age inactive	Oct-Mar	2.7%	-89.6%	1	•				●		⬤									
1-age active rearing	Mar-May	2.7%	-14.1%	5	•				●		⚫									•
1-age migrant	Mar-Jun	9.9%	-0.2%	9							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	29.4%	0.0%	10								•								
Prespawning holding	Oct-Dec	2.3%	-3.1%	7								●								
All Stages Combined		29.4%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	◦
Moderate	●	○
High	⚫	◯
Extreme	⬤	◯

Figure 14. A coho salmon "consumer reports diagram" for Reach WS11 (RM 6.8-7.5) of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with 1 representing the most severe impact relative to historical conditions.

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed
Reach Analysis - Coho

Geographic Area:	B1	**Stream:**	Big White Salmon
Reach:	Buck Ck. mouth to diversion intake	**Reach Length (mi):**	2.01
		Reach Code:	B1

Restoration Benefit Category:1/	B	**Productivity Rank:1/**	11	**Potential % change in productivity:2/**	6.3%
Overall Restoration Potential Rank:1/	11	**Average Abundance (Neq) Rank:1/**	11	**Potential % change in Neq:2/**	5.4%
(lowest rank possible - with ties)1/	26	**Life History Diversity Rank:1/**	8	**Potential % change in diversity:2/**	12.0%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	10	**loss in productivity with degradation:2/**	-6.6%
Overall Preservation Rank:1/	9	**Average Abundance (Neq) Rank:1/**	9	**% loss in Neq with degradation:2/**	-11.8%
(lowest rank possible - with ties)1/	23	**Life History Diversity Rank:1/**	8	**% loss in diversity with degradation:2/**	-6.0%

					Change in attribute impact on survival															
Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	5.4%	-2.1%	6							●									●
Egg incubation	Oct-May	5.4%	-42.4%	1	●												⚫			●
Fry colonization	Mar-May	7.8%	-12.7%	4	●				●	•	⚫									⚫
0-age active rearing	Mar-Oct	0.3%	-41.6%	3	•				●		⚫							•		⚫
0-age migrant	Oct-Nov	0.3%	-3.0%	7							●									
0-age inactive	Oct-Mar	0.2%	-63.0%	2	•				●		⬤									⚫
1-age active rearing	Mar-May	0.2%	-17.6%	5	•				●		⚫									⚫
1-age migrant	Mar-Jun	0.2%	-0.7%	9							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	7.8%	0.0%	10							•									
Prespawning holding	Oct-Dec	5.4%	-1.2%	8							•									⚫
All Stages Combined		7.8%																		

1/ Ranking based on effect over entire geographic area.

2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	◦
Moderate	●	○
High	⚫	⚪
Extreme	⬤	◯

Figure 15. A coho salmon "consumer reports diagram" for reach B1 (RM 0.0-02.0) of Buck Creek, a tributary of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with 1 representing the most severe impact relative to historical conditions.

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed Reach Analysis - Coho

Geographic Area:	R1	**Stream:**	Big White Salmon
Reach:	Rattlesnake Ck. mouth to Indian Ck.	**Reach Length (mi):**	0.48
		Reach Code:	R1

Restoration Benefit Category:1/	C	**Productivity Rank:1/**	15	**Potential % change in productivity:2/**	4.3%
Overall Restoration Potential Rank:1/	12	**Average Abundance (Neq) Rank:1/**	14	**Potential % change in Neq:2/**	3.8%
(lowest rank possible - with ties)1/	26	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	18.8%
Preservation Benefit Category:1/	E	**Productivity Rank:1/**	23	**loss in productivity with degradation:2/**	-0.5%
Overall Preservation Rank:1/	18	**Average Abundance (Neq) Rank:1/**	20	**% loss in Neq with degradation:2/**	-2.2%
(lowest rank possible - with ties)1/	23	**Life History Diversity Rank:1/**	13	**% loss in diversity with degradation:2/**	-0.8%

					Change in attribute impact on survival															
Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	2.6%	-6.7%	6							⚫	●								⬤
Egg incubation	Oct-May	2.6%	-45.9%	3	⚫												⚫			⬤
Fry colonization	Mar-May	8.9%	-7.9%	4	●				●	•	⚫									⚫
0-age active rearing	Mar-Oct	2.1%	-72.4%	2	•		•		•	•	⚫							⚫		⚫
0-age migrant	Oct-Nov	2.3%	-4.4%	7							●									
0-age inactive	Oct-Mar	1.9%	-88.5%	1	●				●		⬤									●
1-age active rearing	Mar-May	1.9%	-20.7%	5	•				●		⚫									⚫
1-age migrant	Mar-Jun	2.8%	-0.4%	9							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	10.0%	0.0%	10							•	•								
Prespawning holding	Oct-Dec	2.6%	-4.5%	8							●	•								●
All Stages Combined		10.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	◦
Moderate	●	○
High	⚫	◯
Extreme	⬤	⭕

Figure 16. A coho salmon "consumer reports" diagram for reach R1 (RM 0.0-0.5) of Rattlesnake Creek, a tributary of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with 1 representing the most severe impact relative to historical conditions.

Species/Component:	Fall Chinook
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed
Reach Analysis - Fall Chinook

Geographic Area:	WS2	**Stream:**	Big White Salmon
Reach:	End of BON pool influence to Powerhouse	**Reach Length (mi):**	0.95
		Reach Code:	WS2

Restoration Benefit Category:1/	A	**Productivity Rank:1/**	2	**Potential % change in productivity:2/**	33.8%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	11.5%
(lowest rank possible - with ties)1/	6	**Life History Diversity Rank:1/**	2	**Potential % change in diversity:2/**	2.3%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-46.0%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-51.1%
(lowest rank possible - with ties)1/	5	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-30.7%

					Change in attribute impact on survival																	
Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Nov	23.6%	-6.2%	3							●	●								●
Egg incubation	Nov-May	23.6%	-32.6%	1	●							•					⬤			●
Fry colonization	Apr-May	50.7%	-4.9%	2	●				●		⬤					•				○
0-age active rearing	Mar-Oct	3.4%	-5.9%	5	•		•				●				•	•				⬤
0-age migrant																				
0-age inactive																				
1-age active rearing																				
1-age migrant																				
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Oct	50.9%	0.0%	6							•	•								
Prespawning holding	Oct-Nov	23.6%	-4.9%	4					•		●	•								⬤
All Stages Combined		50.9%																		

1/ Ranking based on effect over entire geographic area.

2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	∘
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Figure 17. A fall Chinook salmon "consumer reports diagram" for Reach WS2 (RM 1.2-2.1) of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with 1 representing the most severe impact relative to historical conditions.

Species/Component:	Spring Chinook
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed
Reach Analysis - Spring Chinook

Geographic Area:	WS2	**Stream:**	Big White Salmon
Reach:	End of BON pool influence to Powerhouse	**Reach Length (mi):**	0.95
		Reach Code:	WS2

Restoration Benefit Category:1/	D	**Productivity Rank:1/**	17	**Potential % change in productivity:2/**	1.2%
Overall Restoration Potential Rank:1/	13	**Average Abundance (Neq) Rank:1/**	14	**Potential % change in Neq:2/**	2.1%
(lowest rank possible - with ties)1/	19	**Life History Diversity Rank:1/**	8	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	11	**loss in productivity with degradation:2/**	-6.5%
Overall Preservation Rank:1/	12	**Average Abundance (Neq) Rank:1/**	11	**% loss in Neq with degradation:2/**	-12.8%
(lowest rank possible - with ties)1/	20	**Life History Diversity Rank:1/**	16	**% loss in diversity with degradation:2/**	-1.4%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning																				
Egg incubation																				
Fry colonization	Mar-May	19.1%	-2.3%	2	●				●		⬤					•				○
0-age active rearing	Mar-Oct	67.0%	-1.4%	1							•									⬤
0-age migrant																				
0-age inactive																				
1-age active rearing																				
1-age migrant	Mar-Jun	19.1%	-0.2%	3							●					•				
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Apr-Aug	100.0%	0.0%	4							•	•								
Prespawning holding																				
All Stages Combined		100.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	∘
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Figure 18. A spring Chinook salmon "consumer reports diagram" for Reach WS2 (RM 1.2-2.1) of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with 1 representing the most severe impact relative to historical conditions.

Species/Component:	Spring Chinook
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed
Reach Analysis - Spring Chinook

Geographic Area:	WS11	**Stream:**	Big White Salmon
Reach:	Spring Ck. to Deadman's Corner	**Reach Length (mi):**	0.70
		Reach Code:	WS11

Restoration Benefit Category:1/	C	**Productivity Rank:1/**	5	**Potential % change in productivity:2/**	11.8%
Overall Restoration Potential Rank:1/	8	**Average Abundance (Neq) Rank:1/**	8	**Potential % change in Neq:2/**	6.1%
(lowest rank possible - with ties)1/	19	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	1.1%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	9	**loss in productivity with degradation:2/**	-10.2%
Overall Preservation Rank:1/	8	**Average Abundance (Neq) Rank:1/**	10	**% loss in Neq with degradation:2/**	-13.8%
(lowest rank possible - with ties)1/	20	**Life History Diversity Rank:1/**	6	**% loss in diversity with degradation:2/**	-8.2%

					Change in attribute impact on survival																
Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Sep	6.3%	-5.3%	6							●	●					•			●
Egg incubation	Sep-Apr	6.3%	-42.5%	1	●							•					⬤			●
Fry colonization	Mar-May	23.8%	-5.8%	2	●				●		⬤									
0-age active rearing	Mar-Oct	21.6%	-2.9%	4							●									
0-age migrant	Oct-Nov	2.0%	-2.0%	8							●									
0-age inactive	Oct-Mar	2.0%	-28.0%	3	●				●		⬤									
1-age active rearing	Mar-May	2.0%	-3.3%	7					•		●									
1-age migrant	Mar-Jun	10.3%	-0.1%	9							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Apr-Aug	47.8%	0.0%	10							•	•								
Prespawning holding	May-Sep	6.3%	-5.4%	5					•		●	•								
All Stages Combined		47.8%																			

1/ Ranking based on effect over entire geographic area.
2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

KEY	Loss	Gain
None		
Small	•	∘
Moderate	●	○
High	⚫	⚪
Extreme	⬤	◯

Figure 19. A spring Chinook salmon "consumer reports diagram" for Reach WS11 (RM 6.8-7.5) of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with 1 representing the most severe impact relative to historical conditions.

Species/Component:	Spring Chinook
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed
Reach Analysis - Spring Chinook

Geographic Area:	B1	**Stream:**	Big White Salmon
Reach:	Buck Ck. mouth to diversion intake	**Reach Length (mi):**	2.01
		Reach Code:	B1

Restoration Benefit Category:1/	A	**Productivity Rank:1/**	3	**Potential % change in productivity:2/**	22.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	13.4%
(lowest rank possible - with ties)1/	19	**Life History Diversity Rank:1/**	2	**Potential % change in diversity:2/**	11.3%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	17	**loss in productivity with degradation:2/**	-3.7%
Overall Preservation Rank:1/	11	**Average Abundance (Neq) Rank:1/**	9	**% loss in Neq with degradation:2/**	-14.5%
(lowest rank possible - with ties)1/	20	**Life History Diversity Rank:1/**	5	**% loss in diversity with degradation:2/**	-9.5%

					Change in attribute impact on survival															
Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Sep	13.0%	-17.9%	3							●	•						⚫		●
Egg incubation	Sep-Apr	13.0%	-52.0%	1	●												⚫	●		●
Fry colonization	Mar-May	13.0%	-20.9%	2	●				●	•	⚫									●
0-age active rearing	Mar-Oct	3.8%	-18.2%	6					●		●							•		⚫
0-age migrant	Oct-Nov	2.1%	-3.0%	8							●									
0-age inactive	Oct-Mar	2.1%	-38.0%	4	•				●		⚫									⚫
1-age active rearing	Mar-May	2.1%	-3.7%	7					•		•									⚫
1-age migrant	Mar-Jun	2.1%	-0.4%	9							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Apr-Aug	13.0%	-0.2%	10					●		•							•		
Prespawning holding	May-Sep	13.0%	-15.6%	5					●		●							●		⚫
All Stages Combined		13.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	∘
Moderate	●	○
High	⚫	◯
Extreme	⬤	⭘

Figure 20. A spring Chinook salmon "consumer reports diagram" for reach B1 (RM 0.0-02.0) of Buck Creek, a tributary of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with 1 representing the most severe impact relative to historical conditions.

Species/Component:	Spring Chinook
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed
Reach Analysis - Spring Chinook

Geographic Area:	R1	**Stream:**	Big White Salmon
Reach:	Rattlesnake Ck. mouth to Indian Ck.	**Reach Length (mi):**	0.48
		Reach Code:	R1

Restoration Benefit Category:1/	B	**Productivity Rank:1/**	9	**Potential % change in productivity:2/**	7.8%
Overall Restoration Potential Rank:1/	7	**Average Abundance (Neq) Rank:1/**	6	**Potential % change in Neq:2/**	6.8%
(lowest rank possible - with ties)1/	19	**Life History Diversity Rank:1/**	3	**Potential % change in diversity:2/**	4.8%
Preservation Benefit Category:1/	E	**Productivity Rank:1/**	20	**loss in productivity with degradation:2/**	0.0%
Overall Preservation Rank:1/	19	**Average Abundance (Neq) Rank:1/**	20	**% loss in Neq with degradation:2/**	-0.9%
(lowest rank possible - with ties)1/	20	**Life History Diversity Rank:1/**	19	**% loss in diversity with degradation:2/**	0.0%

					Change in attribute impact on survival															
Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Sep	4.0%	-76.5%	1							⚫	●					•	⬤		⬤
Egg incubation	Sep-Apr	4.0%	-68.1%	2	●												⚫	⚫		⬤
Fry colonization	Mar-May	4.0%	-22.9%	5	●				●	•	⚫									●
0-age active rearing	Mar-Oct	1.1%	-42.5%	4	•		•		•		●				•			⚫		●
0-age migrant	Oct-Nov	0.7%	-5.1%	8							●									
0-age inactive	Oct-Mar	0.7%	-42.3%	6	●				●		⚫									●
1-age active rearing	Mar-May	0.7%	-6.2%	7					•		●									●
1-age migrant	Mar-Jun	0.7%	-0.2%	10							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Apr-Aug	4.0%	-0.3%	9					•		●	•						⚫		
Prespawning holding	May-Sep	4.0%	-59.3%	3					●		⚫	•					•	⚫		●
All Stages Combined		4.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	∘
Moderate	●	○
High	⚫	◯
Extreme	⬤	⭘

Figure 21. A spring Chinook salmon "consumer reports diagram" for reach R1 (RM 0.0-0.5) of Rattlesnake Creek, a tributary of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with 1 representing the most severe impact relative to historical conditions.

Species/Component:	Winter Steelhead
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed
Reach Analysis - Steelhead

Geographic Area:	WS2	**Stream:**	Big White Salmon
Reach:	End of BON pool influence to Powerhouse	**Reach Length (mi):**	0.95
		Reach Code:	WS2

Restoration Benefit Category:1/	D	**Productivity Rank:1/**	26	**Potential % change in productivity:2/**	2.4%
Overall Restoration Potential Rank:1/	16	**Average Abundance (Neq) Rank:1/**	21	**Potential % change in Neq:2/**	2.6%
(lowest rank possible - with ties)1/	26	**Life History Diversity Rank:1/**	3	**Potential % change in diversity:2/**	2.2%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	19	**loss in productivity with degradation:2/**	-4.8%
Overall Preservation Rank:1/	15	**Average Abundance (Neq) Rank:1/**	20	**% loss in Neq with degradation:2/**	-3.2%
(lowest rank possible - with ties)1/	30	**Life History Diversity Rank:1/**	6	**% loss in diversity with degradation:2/**	-12.1%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**																
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Mar-Jun	0.9%	-5.8%	9							⬤	●								●
Egg incubation	Mar-Jul	0.9%	-31.5%	4	●							•					⬤			●
Fry colonization	May-Jul	2.1%	-8.4%	6	•				●		⬤				•	●				
0-age active rearing	May-Jul	2.0%	-21.4%	5			●				●				•	•				
0,1-age inactive	Oct-Mar	6.3%	-23.2%	2	•				●		●									
1-age migrant	Mar-Jun	35.5%	-0.7%	8							●					•				
1-age active rearing	Mar-Oct	6.7%	-15.5%	1			●		•		●				•	•				
2+-age active rearing	Mar-Oct	3.6%	-6.3%	7			•		•		●									
2+-age migrant	Mar-Jun	64.1%	-0.1%	13							●					•				
2+-age transient rearing																				
Prespawning migrant	Nov-Apr	99.0%	-0.1%	12								•								
Prespawning holding	Dec-May	0.9%	-1.0%	14								•								⬤
All Stages Combined		99.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	∘
Moderate	●	○
High	⬤	◯
Extreme	⚫	⚪

Figure 22. A steelhead "consumer reports diagram" for Reach WS2 (RM 1.2-2.1) of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with 1 representing the most severe impact relative to historical conditions.

Species/Component:	Winter Steelhead
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed
Reach Analysis - Steelhead

Geographic Area:	WS11	**Stream:**	Big White Salmon
Reach:	Spring Ck. to Deadman's Corner	**Reach Length (mi):**	0.70
		Reach Code:	WS11

Restoration Benefit Category:1/	C	**Productivity Rank:1/**	16	**Potential % change in productivity:2/**	6.1%
Overall Restoration Potential Rank:1/	14	**Average Abundance (Neq) Rank:1/**	19	**Potential % change in Neq:2/**	3.7%
(lowest rank possible - with ties)1/	26	**Life History Diversity Rank:1/**	9	**Potential % change in diversity:2/**	0.5%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	8	**loss in productivity with degradation:2/**	-8.5%
Overall Preservation Rank:1/	8	**Average Abundance (Neq) Rank:1/**	9	**% loss in Neq with degradation:2/**	-6.5%
(lowest rank possible - with ties)1/	30	**Life History Diversity Rank:1/**	9	**% loss in diversity with degradation:2/**	-9.4%

					Change in attribute impact on survival															
Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Mar-Jun	1.9%	-5.2%	7							●	●								●
Egg incubation	Mar-Jul	1.9%	-31.6%	1	●							•					⬤			●
Fry colonization	May-Jul	6.5%	-4.8%	5	•				●		●									
0-age active rearing	May-Jul	3.8%	-11.5%	3							●									
0,1-age inactive	Oct-Mar	4.5%	-19.3%	3	•				●		●									
1-age migrant	Mar-Jun	24.6%	-0.4%	9							•									
1-age active rearing	Mar-Oct	4.7%	-9.1%	4					•		●									
2+-age active rearing	Mar-Oct	1.6%	-4.1%	10					•		●									
2+-age migrant	Mar-Jun	27.5%	0.0%	14							•									
2+-age transient rearing																				
Prespawning migrant	Nov-Apr	63.7%	-0.1%	12								•								
Prespawning holding	Dec-May	1.9%	-1.8%	11								•								
All Stages Combined		63.7%																		

1/ Ranking based on effect over entire geographic area.

2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	∘
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Figure 23. A steelhead "consumer reports diagram" for Reach WS11 (RM 6.8-7.5) of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with 1 representing the most severe impact relative to historical conditions.

Species/Component:	Winter Steelhead
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed
Reach Analysis - Steelhead

Geographic Area:	B1	**Stream:**	Big White Salmon
Reach:	Buck Ck. mouth to diversion intake	**Reach Length (mi):**	2.01
		Reach Code:	B1

Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	37.9%
Overall Restoration Potential Rank:1/	2	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	14.7%
(lowest rank possible - with ties)1/	26	**Life History Diversity Rank:1/**	9	**Potential % change in diversity:2/**	0.5%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	5	**loss in productivity with degradation:2/**	-10.9%
Overall Preservation Rank:1/	6	**Average Abundance (Neq) Rank:1/**	5	**% loss in Neq with degradation:2/**	-10.3%
(lowest rank possible - with ties)1/	30	**Life History Diversity Rank:1/**	12	**% loss in diversity with degradation:2/**	-8.3%

					Change in attribute impact on survival															
Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Mar-Jun	8.0%	-1.5%	7							●	•								●
Egg incubation	Mar-Jul	8.0%	-44.2%	1	•				•								⬤	⬤		●
Fry colonization	May-Jul	9.4%	-6.9%	4	•				●		●							●		
0-age active rearing	May-Jul	7.4%	-20.0%	2					●		●							•		
0,1-age inactive	Oct-Mar	10.0%	-12.6%	4	•				●		●									
1-age migrant	Mar-Jun	3.4%	-0.3%	11							•									
1-age active rearing	Mar-Oct	6.7%	-7.8%	5					●		•									
2+-age active rearing	Mar-Oct	3.3%	-2.3%	9					•		•									
2+-age migrant	Mar-Jun	5.0%	0.0%	13							•									
2+-age transient rearing																				
Prespawning migrant	Nov-Apr	12.3%	0.0%	12							•									
Prespawning holding	Dec-May	8.0%	-0.5%	10							•									⬤
All Stages Combined		12.3%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	∘
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Figure 24. A steelhead "consumer reports diagram" for reach B1 (RM 0.0-02.0) of Buck Creek, a tributary of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with 1 representing the most severe impact relative to historical conditions.

Species/Component:	Winter Steelhead
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed Reach Analysis - Steelhead

Geographic Area:	R1	**Stream:**	Big White Salmon
Reach:	Rattlesnake Ck. mouth to Indian Ck.	**Reach Length (mi):**	0.48
		Reach Code:	R1

Restoration Benefit Category:1/	B	**Productivity Rank:1/**	13	**Potential % change in productivity:2/**	8.2%
Overall Restoration Potential Rank:1/	9	**Average Abundance (Neq) Rank:1/**	14	**Potential % change in Neq:2/**	5.6%
(lowest rank possible - with ties)1/	26	**Life History Diversity Rank:1/**	4	**Potential % change in diversity:2/**	2.0%
Preservation Benefit Category:1/	E	**Productivity Rank:1/**	26	**loss in productivity with degradation:2/**	-1.3%
Overall Preservation Rank:1/	24	**Average Abundance (Neq) Rank:1/**	24	**% loss in Neq with degradation:2/**	-1.9%
(lowest rank possible - with ties)1/	30	**Life History Diversity Rank:1/**	18	**% loss in diversity with degradation:2/**	-4.3%

					Change in attribute impact on survival															
Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Mar-Jun	1.0%	-5.6%	8							●	●						•		⬤
Egg incubation	Mar-Jul	1.0%	-49.1%	5	●												⚫	⚫		⬤
Fry colonization	May-Jul	5.0%	-15.3%	2	•				●	•	●					•		⚫		
0-age active rearing	May-Jul	2.9%	-40.1%	1	•		•		●		●				●			⚫		
0,1-age inactive	Oct-Mar	6.1%	-20.1%	5	●				●		●									
1-age migrant	Mar-Jun	11.1%	-0.5%	10							●									
1-age active rearing	Mar-Oct	4.9%	-18.5%	3	•		•		●		●							●		
2+-age active rearing	Mar-Oct	1.8%	-4.0%	9					•		•									
2+-age migrant	Mar-Jun	10.3%	0.0%	13							●									
2+-age transient rearing																				
Prespawning migrant	Nov-Apr	28.4%	0.0%	12							•	•								
Prespawning holding	Dec-May	1.0%	-2.6%	11							•	•								●
All Stages Combined		28.4%																		

1/ Ranking based on effect over entire geographic area.   2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	◦
Moderate	●	○
High	⚫	⚪
Extreme	⬤	◯

Figure 25. A steelhead "consumer reports diagram" for reach R1 (RM 0.0-0.5) of Rattlesnake Creek, a tributary of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with 1 representing the most severe impact relative to historical conditions.

Discussion

Applying the EDT model to the White Salmon River has been successful in organizing the available information and identifying data gaps. Stream reaches were designated for the model and they have been identified and reviewed (Appendix A). The best available information has been used to rate each attribute in each reach, and this information has been reviewed (Appendix A). The model has been run, along with scenarios describing potential future conditions. These EDT results were used to aid identification of key limiting factors (their type and location). The results of these scenarios have been used to guide the White Salmon River Subbasin Plan assessment and management plan (NPCC 2004). In the Subbasin Plan, the EDT results were used to help identify and prioritize restoration actions most likely to achieve specified biological objectives for a target population. The limiting factors described in this document, were also discussed in the White Salmon River Subbasin Plan, and were specifically linked to restoration actions that would help address these limiting factors.

As additional information is collected and evaluated, the model inputs may be refined, which may alter the outputs. As a tool, the model will need to be continually adapted to represent the more current understanding of the watershed and the relationship of the diagnostic fish species to the attributes of interest. Because the model and our understanding of the watershed are continually evolving and because access to the model is restricted until funding for its upkeep is arranged, no diagnostic model run should be considered as final.

There have been several suggested modifications to the dataset that have been described in this text and by attribute in Appendix A. In addition to these suggestions, another useful product might be a summary of the rationales for changes made by WDFW to the dataset titled “BigWhite Removal4_21_04” with a table detailing which reaches were changed and which attributes were changed. Lastly, when funding is secured for additional model runs, an output that is normalized for reach length may prove useful.

The White Salmon River above Condit Dam is currently capable of supporting all the diagnostic species (steelhead trout, spring and fall Chinook salmon, and coho salmon). In general, many of the habitat factors in the White Salmon River and its tributaries are healthy, with adequate food and oxygen throughout the system, essentially no detrimental chemicals or competition, few unscreened water diversions, and little concern for pathogens. The mainstem habitat was in better shape than the tributaries, with maximum temperatures, minimum temperatures, and dissolved oxygen remaining at optimum levels. However, our modeling effort indicated that there is potential for increasing the population performance of the diagnostic species in both the mainstem and tributaries. The environmental attributes with the most significant impact on population performance include: habitat diversity, key habitat quantity, sedimentation, channel stability, flow, and harassment/poaching. Some of the main differences in habitat condition, between the mainstem and tributary habitats, were an increase in maximum water temperatures, decrease in summer low flow, and more degraded riparian conditions in the tributaries. There was a lack of large woody debris and altered riparian conditions in both the mainstem and tributaries, which offer opportunities for restoration.

One must be mindful that the model describes the symptoms but not causes. So when restoration is recommended in certain reaches, often the way to restore those reaches is by doing improvements to the watershed upstream. Restoration measures designed to benefit one species will generally benefit the other diagnostic species.

As stated in Appendix F of the White Salmon River Subbasin Plan (NPPC 2004); validity of current EDT estimates can be assessed when long-term estimates of wild spawners, hatchery spawners, reproductive success of hatchery spawners, and smolts are available. The available information for the White Salmon River was insufficient for this type of analysis. However, in other basins within the Lower Columbia River and the Columbia River Gorge Provinces, the EDT-predicted estimates of smolt and adult performance are reasonably close to empirical estimates from WDFW population estimates (NPCC 2004). Since a similar approach was used in the White Salmon River, we believe the predicted performance of salmon and steelhead in the basin was reasonable.

Acknowledgements

The USGS portion of this work was funded by the Salmon Recovery Funding Board, Bonneville Power Administration and the Yakama Nation (YN). We would like to thank YN staff (Jeff Spencer, Bill Sharp, Greg Morris, Will Conley, Joe Zendt, Chris Fredrickson), WDFW staff (Dan Rawding, Steve Vanderploeg, Lee Van Tussenbrook, Carl Dugger, John Weinheimer, and Steve Manlow), USGS-CRRL staff (Sally Sauter, Brien Rose), Klickitat County Staff (Dave McClure, Domoni Glass, John Runyon, and Karen Kuzis), Tony Grover (NPPC), Robert McDonald (Normandeau Associates), Dick Nason, Klickitat Lead Entity Citizens Review Committee, and others who attended White Salmon River EDT workshops, and who provided data and rationale for this dataset. The staff at Mobrand Biometrics (Rick Paquette, Jen Garrow, Kevin Malone, and Greg Blair) provided assistance with running the EDT model.

References

Connolly, P. J., editor. 2003. Assess current and potential salmonid production in Rattlesnake Creek associated with restoration efforts. U. S. Geological Survey, Columbia River Research Laboratory report provided to Bonneville Power Administration, Portland Oregon. Project No. 200102500, (BPA Report DOE/BP-00005068-1).

Lestelle, L. C., L. E. Mobrand and W. E. McConnaha 2004. Information structure of ecosystem diagnosis and treatment (EDT) and habitat rating rules for Chinook salmon, coho salmon, and steelhead trout. Mobrand Biometrics, Inc. Vashon, WA. Available: http://www.mobrand.com/MBI/pdfs/EDT%20InfoStructure_ChinCohoStlhd_June2004.pdf (February 2005).

Mobrand L. E. 2002. Subbasin planning with EDT- A primer. Mobrand Biometrics, Inc. Vashon, WA. Available: http://www.mobrand.com/MBI/pdfs/Subbasin_planning.pdf (February 2005).

NPCC (Northwest Power and Conservation Council) 2004. White Salmon River subbasin plan. Portland, OR. Available: http://www.nwppc.org/fw/subbasinplanning/bigwhitesalmon/ (February 2005).

Prichard D., and nine others. 1998. Riparian area management: A user guide to assessing proper functioning condition and the supporting science for lotic areas. TR-1737-15. Bureau of Land Management. BLM/RS/ST-98/001+1737. National Applied Resource Sciences Center, Denver, CO.