Appendix F1

Upper Columbia Salmon Recovery Plan

Analysis of Habitat Actions Using EDT

F.1 Wenatchee EDT Diagnosis

F.1.1. Background

This section of Appendix F represents the "diagnosis" portion of EDT for the Wenatchee subbasin. The diagnosis portion of EDT was completed during subbasin planning in the Methow and Okanogan subbasins, but only a qualitative assessment had been completed in the Wenatchee (NPPC 2004). Both the diagnosis and treatment portions of EDT were completed in the Entiat (for spring and summer Chinook) as part of the watershed planning process (CCCD 2004). Therefore, the first step in using EDT as a habitat assessment tool for recovery planning in the Upper Columbia ESU was to complete the baseline environmental attribute ratings for the Wenatchee subbasin.

F.1.2 Methods

The Wenatchee Subbasin habitat was assessed using the Ecosystem Diagnosis and Treatment (EDT) method; EDT is an analytical model relating habitat features and biological performance to support conservation and recovery planning for salmonids (Lichatowich et al. 1995; Lestelle et al. 1996; Lestelle et al. 2004). EDT acts as an analytical framework that brings together information from empirical observation, local experts, and other models and analyses.

The Information Structure and associated data categories were defined at three levels of organization. Together, these can be thought of as an information pyramid in which each level builds on information from the lower level (**Figure F1**). As information in EDT moved up through the three levels, it took an increasingly organism-centered view of the ecosystem. Levels 1 and 2 together characterized the environment, or ecosystem, as it can be described by different types of data. This provides the characterization of the environment needed to analyze biological performance for a species. The Level 3 category is a characterization of that same environment from a different perspective: "through the eyes of the focal species" (Lestelle et al. 1996). This category describes biological performance in relation to the state of the ecosystem described by the Level 2 ecological attributes.

The organization and flow of information begins with a wide range of environmental data (Level 1 data) that describe a watershed, including all of the various types of empirically based data available. These data include reports and unpublished data. Level 1 data exist in a variety of forms and pedigrees. The Level 1 information is then summarized or synthesized into a standardized set of attributes (Level 2 ecological attributes) that refine the basic description of the watershed. The Level 2 attributes are descriptors that specify physical and biological characteristics about the environment relevant to the derivation of the survival and habitat capacity factors for the specific species in Level 3. Definitions for Level 2 and Level 3 attributes can be found along with a matrix showing associations between the two levels and various life stages (Lestelle et al. 2004).

The Level 2 attributes represent conclusions that characterize conditions in the watershed at specific locations, during a particular time of year (season or month), and for an

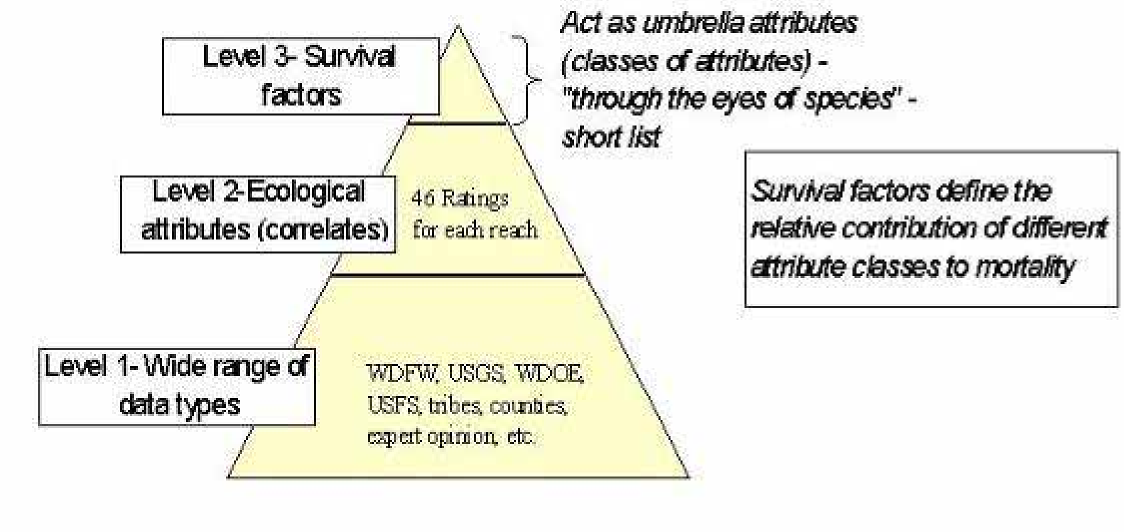


Figure F1. Data/information pyramid—information derived from supporting levels for use in the Ecosystem Diagnosis and Treatment model (Figure taken from Lestelle et al. 2004)

associated management scenario. Hence an attribute value is an assumed conclusion by site, time of year, and scenario. These assumptions become operating hypotheses for these attributes under specific scenarios. Where Level 1 data are sufficient, these Level 2 conclusions can be derived through simple rules. However, in many cases, experts were needed to provide knowledge about geographic areas and attributes where Level 1 data are incomplete. Regardless of the means whereby Level 2 information is obtained, the characterization it provides can be ground-truthed and monitored over time through an adaptive process.

The EDT model measured salmon/steelhead performance using 3 indicators; abundance, productivity, and life history diversity. Abundance (adults and smolts) was the equilibrium abundance based on the capacity of the watershed that was a measure of the habitat quantity. Productivity, or density-independent reproductive rate (returning adults per spawner), was a measure of the habitat quality. Life history diversity was the range of distributions and pathways that can be used successfully by a population. The life history diversity index in EDT output was reported as a percent of current life history trajectories that were successful, relative to the template potential (For more detail on EDT output parameters see documentation at www.mobrand.com).

EDT Model Input

To perform the assessment we first structured the entirety of the relevant geographic areas, including marine waters, into distinct habitat reaches. The Wenatchee drainage was subdivided into 119 stream segments (reaches) and 23 obstructions within the estimated historic range of each focal species. A stream reach was a segment of river in which environmental, anthropogenic, and biological attributes affecting the focal species were relatively constant. We identified reaches on the basis of similarity of habitat features, drainage connectivity, and land use patterns; some of the primary factors that influenced reach breaks included mainstem inundation, focal species bearing tributaries, obstructions to passage, changes in confinement (valley width), gradient, hydraulic roughness, dewatering reaches, thermal gradients, gross changes in riparian condition or channel form, urban-rural interface, and hatchery release points. Such a detailed reach structure, however, was counterproductive for displaying results and implementing a management plan. Therefore the reaches and obstructions were grouped into 18 larger geographic areas or assessment units (**Table F1**). In most cases, the assessment units corresponded to subwatersheds but were occasionally split into upper and lower portions of a watershed so that an AU strategy and plan could be easily described and implemented based on common problems and common solutions (**Table F1**). A set of standard habitat attributes and reach breaks developed by MBI were used for the mainstem Columbia River, estuarine, nearshore, and deep-water marine areas (www.mobrand.com). We then assembled baseline information on habitat and human-use factors and fish life history patterns for the watersheds of interest. This task required that all reaches be completely characterized by rating the 46 level 2 environmental attributes.

An obstruction was a structure (or multiple structures) that prevented fish passage in one or both directions (upstream or downstream). Obstruction complexes were designated when multiple culverts, diversions, or other barriers were in close proximity to avoid having excessive reach breaks in the model (**Table F2**). By lumping multiple barriers into complexes we were able to apply environmental attribute data at the appropriate scale and still capture the cumulative effects of the multiple barriers. Ten of the 23 obstructions were complexes with 2-28 barriers in each complex. The cumulative effect of the complex was applied at the lowest (downstream) obstruction.

Table F1 Reaches for EDT modeling based on historic (WDFW salmonscape) distribution of Wenatchee River steelhead and spring Chinook

Assessment Unit	Reach Codes	Location/Description
Lower Wenatchee Mainstem	Wen1-13	From Confluence with Columbia to Tumwater Canyon (RM 27)
Mission Ck	Miss1-7, Bren1-2, Sand1-3,LCam1-2, EFMiss1-2	Mission Creek to RM 16.3; Brender Ck to RM 2.8; Sand Ck to RM 3.1; Little Camas Creek to RM 1.7; East Fork of Mission Ck to RM 4.35
Lower Peshastin Ck	Pesh1-5, Mill1-2,Hans1	Peshastin Ck to RM 9.6; Mill Ck to RM 2.3; Hansel Ck to RM 0.25
Upper Peshastin Ck	Pesh6-9; Inga1-3;Ruby 1; Negro1; Tron1	Peshastin Ck to RM 9.6-16.3; Ingals Ck to RM 9.8; Ruby Ck to RM 1.5; Negro Ck to RM 2.9; Tronsen Ck to RM 1
Derby Ck	Derby1-2	Derby Ck to RM 3.2
Chumstick Ck	Chum1-3; Eagle1	Chumstick Ck to RM 5.9; Eagle Ck to RM 1
Lower Icicle Creek	Icic1-4	Icicle Creek to RM 5.6 (the boulder field)
Upper Icicle Creek	Icic5-11; Eightmile1, Jack1, French1	Icicle Ck from RM 5.6-24; Eightmile Creek to RM 0.39; Jack Ck to RM 1.2; French Ck to RM 0.66

Assessment Unit	Reach Codes	Location/Description
Tumwater Canyon	Wen14-16	Wenatchee River from the downstream end of Tumwater Canyon to the mouth of Chiwaukum Ck (RM 36)
Chiwaukum/Skinney Ck	Chiwaukum1-3; Skin1-2	Chiwaukum Creek to RM 4.3; Skinney Ck to RM 1.3
Upper Wenatchee Mainstem	Wen17-19	Wenatchee River from Chiwaukum Ck to Lake Wenatchee (RM 36-54)
Beaver Ck	Beav1-2	Beaver Ck to RM 2.5
Chiwawa River	Chiwawa1-9; Clear1-2; Bmeadow1; Twin1; Chik1; Rock1; Phel1	Chiwawa River to RM 35; Clear Ck to RM 1; Big Meadow Creek to RM 1.5; Twin Ck to RM 0.7; Chikamin Ck to RM 1; Rock Ck to RM 1.2; Phelps Ck to RM 0.5
Lower Nason Ck	Nas1-2; Coult1-3; Roar1	Nason Creek to Gaynor Falls (RM 17); Coulter Ck to RM 1.1; Roaring Ck to RM 0.75
Upper Nason Ck	Nas3-7	Gaynor Falls to Bygone Byway Falls (RM 17-21)
Lake Wenatchee	Wen20	Lake Wenatchee
Little Wenatchee	LitWen1-4	Little Wenatchee River to Falls at RM 7.8
White River	White1-4; Napee1, Panther1	White River to falls at RM 14.3; Napeequa River falls at RM 2.2; Panther Ck to RM 0.7

Table F2 Obstruction reaches for EDT modeling of Wenatchee steelhead and spring Chinook. Passage was estimated for each species and lifestage for both upstream and downstream orientation

Assessment Unit	Obstruction Codes	Location/Description
Lower Wenatchee Mainstem	None	None
Mission Ck	Bren1a	Obstruction Complex (18 structures) beginning with culvert at Kimber Rd. (rm 0.2)
	Miss3a	Miller Diversion Dam
	Miss4a	Triple Culvert just below Sand ck
	Sand1a	USFS culvert barriers at RM 1 and 1.29
	LCam1a	USFS barrier @ 0.8 mi
	EFMiss1a	7 culvert complex
Lower Peshastin Ck	Pesh1a	PID diversion @ RM 2.4
	Pesh2a	Tandy diversion
	Mill1a	Barrier complex including 2 diversion dams and 2 culverts
Upper Peshastin Ck	Ruby 1a	Culvert complex (3 culverts at rm 0.04, 0.64, and 1.48)
Derby Ck	Derby1a	Barrier complex (7 private fish blocking culverts then 4 USFS culverts)
Chumstick Ck	Chum1a	North Rd culvert
	Chum2a	Barrier complex (28 structures, culverts and diversions)

Assessment Unit	Obstruction Codes	Location/Description
Lower Icicle Creek	Icic1a	Leavenworth National Fish Hatchery
	Icic3a	Hatchery and Cascade Orchards Irr. Dist. Diversion
	Icic4a	Boulder field
	Icic4b	Icicle/Peshastin Irrigation diversion
Upper Icicle Creek	None	None
Tumwater Canyon	Wen14a	Tumwater Dam
Chiwaukum/Skinney Ck	Skin1a	Obstruction complex, beginning with FS Rd 7908 culvert (2 culverts and a mill pond)
Upper Wenatchee Mainstem	None	None
Beaver Ck	Beav1a	Barrier complex (6 culverts, starting at RM 0.3)
Chiwawa River	Clear1a	Culvert at RM 0.6
Lower Nason Ck	Coult1a	Complex: 2 obstructions at the mouth and 2 culverts at Rm 0.04
	Nas2a	Gaynor Falls at Rm 16.8
Upper Nason Ck	None	None
Lake Wenatchee	None	None
Little Wenatchee	None	None
White River	None	None

A habitat work group (Habitat Coordinating Committee; HCC) rated the Level 2 habitat attributes for the freshwater stream reaches within the Wenatchee subbasin and consisted of biologists from WDFW, USFWS, USFS, Yakama Nation, Chelan County, and several environmental consulting firms (Habitat Coordinating Committee). The work group drew upon published and unpublished data and information for the basin to complete the task. Expert knowledge about habitat identification, habitat processes, hydrology, water quality, and fish biology was incorporated into the process where data was not available. Protocol for rating attributes was taken from "Attribute Ratings Guidelines" (January 2003 revision) and "Attribute ratings Definitions" (January 2003); written and distributed by MBI (www.mobrand.com). In addition, MBI personnel were available for consultation and assistance with rating some attributes when local resources were not sufficient. The patient/current condition attribute ratings represent a variety of sources and levels of proof . Levels of proof (or confidence levels) assigned to ratings are directly from developed rating methods by MBI specifically for the EDT process. The attributes assigned to each reach are assigned a numerical value from 1 to 5 where: 1 is empirical observation; 2 is expansion of empirical observation; 3 is derived information; 4 is expert opinion; 5 is hypothetical. A brief description of the methods and the distribution of the confidence levels assigned to attributes are presented in **Table F3**. The template (reference) conditions were either a default, where level of proof was not applicable, or they were determined by expert opinion from within the HCC or other contributors to the EDT process that were solicited for participation by the HCC.

The estimate of template conditions represent an approximation of historic conditions that was intended to calibrate the model to the range of conditions that could naturally occur in the Wenatchee basin given the prevailing climatic, geologic, geographic, hydrologic, and biological characteristics. The objective of the diagnosis then became identifying the relative contributions of environmental factors to the reduction of focal species performance. The comparison of these scenarios (current and template) formed the basis for diagnostic conclusions about how the Wenatchee watershed and associated salmonid performance have been altered by human development. To accomplish this, we performed two types of analyses, the first to identify environmental attributes that were limiting the diversity, productivity and abundance of each species and the second to rank and prioritize the assessment units based on their importance for protection or restoration.

The final step in setting up the model was to define the life history characteristics of each population. Once the reaches and their habitat conditions were defined we needed to inform the model about the how, when, and where to move fish through the environment. The information that was used to accomplish this can be found in Tables F4 and F5.

Table F3 Environmental attributes, percent frequency in each Level of Proof category for 119 reaches, and a description of the data sources and abbreviated methods for EDT in the Wenatchee subbasin

Environmental Attribute	Level of Proof	Data Sources and Comments
Alkalinity	1) 3% 2) 26% 3) 71%	Data from WDOE watershed monitoring sites were used and extrapolated to reaches within a sub-watershed and the average was applied to other sub-watersheds without monitoring data and classified as derived.
Bed Scour	3) 100%	No empirical data existed for bed scour in the Wenatchee basin. EDT values for bed scour were derived using a multiple regression equation developed in the Yakima basin. Variables included gradient, hydroconfinement, LWD, % pools, fine sediment, high flow, and flow flashy with an r^2 of 0.77. Bed scour estimates were then adjusted to an index value of 2 in known core spawning areas of steelhead and spring Chinook and this correction factor was applied to all other bed scour estimates. Finally, bed scour was given an index score of 4 in all areas over 8% gradient.
Benthic Community Richness	1) 0% 2) 0% 3) 0% 4) 0% 5) 100%	Although WDOE collects the data that could provide B-IBI scores it was not available for inclusion in the model. We assumed that there was some impairment from nutrient reductions from small salmon runs and increased sediment. Benthic community richness was considered a critical data gap that needs more monitoring and research.
Channel Length	1) 100%	Channel length was measured in Terrain Navigator Pro and was considered empirical data for all reaches.
Channel Width Maximum	1) 76% 2) 5% 3) 0% 4) 18%	USFS habitat surveys on federal lands and WDFW surveys of mainstem Wenatchee River.

Environmental Attribute	Level of Proof	Data Sources and Comments
Channel Width Minimum	1) 74% 2) 4% 3) 0% 4) 21%	USFS habitat surveys on federal lands and WDFW surveys of mainstem Wenatchee River.
Confinement Man-Caused	3) 100%	Road encroachment on the floodplain was measured in Archview using the PBI road and transportation corridor layer and the riparian zone layer. Encroachment was measured in linear distance along the stream channel and this ratio was used to determine % hydroconfinement. We did not account for rip-rap and dikes, but those structures should be fairly well correlated with roads in the riparian corridor. In several relatively undisturbed watersheds (upper Icicle, Upper Nason, Chiwawa, White, and Little Wenatchee) we reduced the impact of road encroachment by 75% because road placement generally does not effect channel migration. However, the LFA (2000) report identified channelization and agriculture as contributing to loss of floodplain in the lower reaches of the White and Little Wenatchee Rivers. This report did not provide quantified estimates so we assumed that 50 % of the stream channel was confined.
Confinement Natural	1) 12% 2) 0% 3) 88%	Evaluated valley width using Terrain Navigator Pro and the Channel Migration Zone study for the mainstem and lower Nason Creek
Dissolved Oxygen	1) 4% 2) 25% 3) 0% 4) 71% 5) 0%	Used data from 5 WDOE watershed monitoring stations and USGS gauging stations. The data from these sites was expanded to other reaches within a subwatershed . We assumed that there was no DO problems in other areas since the subwatersheds with no monitoring are at higher elevations and generally contain cool clean water.
Embedded-ness	3) 100%	Used information from the USFS SMART database and summaries of USFS data reported in the LFA (2000).
% Fines	1) 6% 2) 5% 3) 4% 4) 85%	Used USFS SMART database for areas that had been surveyed and the LFA 2000 report that summarized some information at the sub-watershed scale. Information was generally lacking and not organized or presented in a way that would allow for much confidence in applying it to EDT. Given the effect of sediment on spawning and incubation this is a critical data gap that needs further analysis across the subbasin.
Fish Community Richness	3) 100%	Rated by local biologists and sources of information were not well documented. Future efforts should refine this attribute rating using USFS, USFWS, and WDFW fisheries survey data.
Pathogens	1) 0% 2) 4% 3) 66% 4) 30%	No studies exist for ambient pathogen levels. Derived via WDFW pathology reports, proximity to hatcheries, acclimation ponds, and release sites. Assumed historic stocking occurred in all drainages.
Fish Species Exotic	2) 100%	Rated by local biologists and sources of information were not well documented. Future efforts should refine this attribute rating using USFS, USFWS, and WDFW fisheries survey data.

Environmental Attribute	Level of Proof	Data Sources and Comments
Flow High	3) 100%	Gauging station data showed no trends, no high flow measurements are available for pre-development so we used road density (USFS data base) as an indicator to scale the EDT score between a 2 and 3. Confirmed with USFS hydrologists that this was the appropriate scale that road density would change runoff patterns.
Flow Low	1) 0% 2) 0% 3) 98% 4) 0%	Wenatchee Watershed Assessment, 2003. Some data derived from using acres of irrigated lands in relation to crop irrigation requirements.
Flow Diel Variation	1) 100%	Rock Island Pool effect in inundated reach. No other hydroelectric projects so this attribute is not applicable to the rest of the basin.
Flow Flashy	3) 100%	Gauging station data showed no trends, no high flow measurements are available for pre-development so we used road density (USFS data base) as an indicator to scale the EDT score between a 2 and 3. Confirmed with USFS hydrologists that this was the appropriate scale that road density would change flashy runoff patterns.
Gradient	1) 100%	Measured in Terrain Navigator Pro.
Habitat: Backwater-Pools; Large Cobble Riffles; Pool- Tailouts; Small Cobble-Riffles; Glides; Beaver Ponds; Primary-Pools;	1) 17% 2) 0% 3) 60% 4) 13% 5) 11%	**Wenatchee mainstem**: measurements for each habitat type (stream segment) were recorded with a laser rangefinder while floating the river on a raft. This method did not follow a standard protocol, however, no protocols were known for non-wadeable rivers. **Tributaries:** Pool and riffle data were generally available throughout much of the basin from USFS surveys in the last 10 years (SMART database). Survey data for pools and riffles were split into the 8 habitat categories based on Neiman classification available for all reaches from GIS layers from a classification analysis (PBI 2005). This transformation included assumptions about the composition of habitat segments in each Neiman class (see appendix X for details). In general, pools were split up into primary pools and pool tailouts in either (75:25) or (90:10) ratios. Likewise, riffles were split into small cobble/gravel riffles (0-40%), large cobble/boulder riffles (50-100%), glides (0-5%), and backwater pools (0-5%) based on Neiman classification and additional substrate information from USFS SMART database and Mullen et al. (1992).
Offchannel Habitat	3) 100%	Empirical assessments of offchannel habitat (oxbows, back swamps, riverine ponds, and connectivity channels) were not available for most areas in the Wenatchee basin. Therefore, we derived the proportion of offchannel habitat for current and historic conditions by applying a matrix of percentages of offchannel habitat that depended on the gradient and natural confinement within each.
Harassment	3) 100%	Used Terrain Navigator Pro to evaluate proximity to towns and roads.
Hatchery Fish Outplants	1) 70% 2) 0% 3) 0% 4) 30% 5) 0%	Stocking records and locations provided by WDFW, Yakama Nation, and USFWS
Hydrologic Regime Natural	1) 0% 2) 0% 3) 100%	In consultation with USFS hydrologist, reviewed the USFS subsection classification maps and the Hydrolic properties and responses map. Also evaluated flow patterns from USGS gauging stations.

Environmental Attribute	Level of Proof	Data Sources and Comments
Hydrologic Regime Regulated	1) 100%	This attribute was only applicable in reach Met1 (Rock Island Pool effect).
Icing	5) 100%	No data exists; we assumed that a min temp score < 3 = icing score of 1; Min temp 3-3.5 = Icing score 2; and Min temp score > 3.5 = icing score of 3. Winter temperatures, flows, and icing are an important data gap so we wanted to stress our uncertainty by categorizing the level of proof as "hypothetical" instead of "expert opinion".
Metals in Water Column	1) 0% 2) 0% 3) 100%	Derived or extrapolated from the WDOE website data or data collected by the CCCD.
Metals in Soils/ Sediment	4) 100%	Derived or extrapolated from the WDOE website data or data collected by the CCCD
Miscellaneous Toxins	1) 5% 2) 19% 3) 37% 4) 39%	Derived or extrapolated from the WDOE website data or data collected by the CCCD
Nutrients	3) 100%	Derived or extrapolated from the WDOE website data or data collected by the CCCD
Obstructions	NA	Obstructions were assessed individually and level of proof was not evaluated as it was for other attributes in standard reaches. Most of the obstructions had been surveyed but uncertainties still existed for some species/lifestages.
Predation Risk	3) 100%	Rated by local biologists and sources of information were not well documented. Future efforts should refine this attribute rating using USFS, USFWS, and WDFW fisheries survey data.
Riparian Function	3) 100%	Derived based on altered and unaltered riparian zone habitat types from PBI data layer 2004; see separate worksheet for details. C. Baldwin & M.Cookson. This method needs reviewed and cross referenced with recent studies (CMZ) and USFS stream surveys and biological assessments;
Salmon Carcasses	1) 0% 2) 56% 3) 44%	Wenatchee Hatchery Evaluation data, used average of 02 & 03 Used Mullen et al. (1992) for historic run re-creation. Some of the estimates did not make sense with very low numbers of carcasses, even historically. This attribute should be re-evaluated in conjunction with updating the benthic macro-invertebrate attribute with B-IBI scores. Then LOP scores for surveyed areas should be updated to 1 (empirical).
Temperature Maximum	1) 29% 2) 37% 3) 6% 4) 20% 5) 8%	USGS gauging stations (n=7); USFS temperature loggers (n=12); WDFW thermisters (n=5); expansions were made to adjacent reaches within a subwatershed and opinion was used to apply temperature patterns to other subwatersheds that were not monitored.
Temperature Minimum	1) 5% 2) 24% 3) 5% 4) 66% 5) 0%	USGS gauging stations (n=1), WDFW Thermisters n=5. These data were extrapolated to other reaches in the mainstem and within the subwatersheds. Most WDOE and USGS data sets were not helpful because they were not continuously logged.

Environmental Attribute	Level of Proof	Data Sources and Comments
Temperature Spatial Variation	1) 39% 2) 0% 3) 34% 4) 24% 5) 3%	FLIR analysis for the Wenatchee Mainstem, Chiwawa and Nason Ck. Other areas were estimated based on geomorphic change, IFIM video, and DNR aerial photos.
Turbidity	1) 0% 2) 33% 3) 0% 4) 67% 5) 0%	Used USGS gauging stations and WDOE monitoring sites to estimate the SEV and expanded to other subwatersheds based on opinion.
Withdrawals	3) 100%	WDOE GWIS data (2003). Not considered empirical because a comprehensive gravity and pump diversion inventory and assessment has not been completed. Most reaches were rated as a 1 or 2 (see attribute rating guidelines) but the results showed little or no effects.
Woody Debris	1) 0% 2) 0% 3) 83% 4) 17% 5) 0%	USFS habitat surveys (interpreted from the SMART database); WDFW surveys (mainstem). Although we had empirical estimates of pieces per mile in 83% of the reaches this information is not directly transferable into an EDT score. Also, high wood counts can be misleading if its small or isolated pieces that are not important to channel form or function or fish use. We had to generate categories of functioning conditions for wood in the Wenatchee based on wood levels in highly functional areas.

Table F4 Life history assumptions used to model spring Chinook in the Wenatchee River.

Stock Name:	Wenatchee River Spring Chinook
Race:	Spring
Geographic Area (spawning reaches):	Mission Ck (historic; RM 0-12); Peshastin Ck (RM 0-16); Ingals Ck; Icicle Ck (historic; RM 0-5); Chiwaukum Ck; Wenatchee R mainstem (RM 35-54), Chiwawa R. (RM 0-35), Nason Ck (0-17), Little Wenatchee River (RM 3-8), White River (RM 7-14).
River Entry Timing (Columbia R): Fish passage center	Bonneville Dam: March 1 – June 30 April 8: 10% April 24: 50% May 19: 90% Rock Island Dam: April 1 – July 15 April 30: 10% May 14: 50% June 2: 90%
River Entry Timing (Wenatchee): Tumwater Dam Video counts (1999-2003)	Tumwater Dam: May 9- August 22 June 23: 10% July 19: 50% August 14: 90%
Spawn Timing:	August 1- September 15 (peak August 31)

Stock Name:	Wenatchee River Spring Chinook	
Emergence Timing (dates):	February 15 to March 30	
Juvenile Life History:	Ocean type:	0%
	Stream type: Resident rearing: *Transient Rearing	100% 70% 30%
Stock Genetic Fitness:	85%	
Harvest (in basin):	0%	
Age Structure: (From scale analysis of carcass recoveries) WDFW data base	Age 3 (1.1) = 1.7% Age 4 (1.2) = 68.8% Age 5 (1.3) = 29.5%	
Fecundity:	Average = 4608 eggs/female	

*Transients move to the mainstem Wenatchee as subyearlings, residents remain in tributaries and migrate as yearlings. Subyearling fall migrants averaged 39% from the Chiwawa River (1993-2002; WDFW unpublished data). However, no data exists for other tributaries so to be conservative we modeled 30%.

Table F5 Life history assumptions used to model summer steelhead in the Wenatchee River.

Stock Name:	Wenatchee River summer steelhead
Geographic Area : (reaches with current and historic spawning):	Mission Ck (and tribs), Peshastin Ck. (and tribs), Derby Ck., Chumstick Ck, Eagle Ck, Icicle Ck (and tribs), Chiwaukum Ck (and Skinney Ck), Wenatchee R mainstem (RM 35-54), Beaver Ck, Chiwawa R (and tribs), Nason Ck. (including Coulter and Roaring), Little Wenatchee R., White R. (and tribs).
River Entry Timing (Columbia R.) : (Fish Passage Center website; however, we cannot use their numbers directly because they do not sample 100 % of the run timing)	Bonneville Dam: March-December June 30: 10% Aug. 15: 50% (peak, 40% of total pass in August) Oct. 1: 90% Rock Island Dam: April-February July 15: 10% Sept. 15: 50% (peak, 40% of total pass in September) Nov. 1: 90%
River Entry Timing (Wenatchee): (PUD radio telemetry; Tumwater Dam; Dryden Dam)	July to March; (peak October 15) 90% by November 30
Adult Holding: (PUD radio telemetry;	Columbia River: 50% Wenatchee R.: 50%
Spawn Timing:	Feb 15-June 15 (peak April 18)

Stock Name:	**Wenatchee River summer steelhead**	
Spawner Ages: Wild fish collected at Dryden and Tumwater Dams (1998-2003)	1-salt = 50.8% 2-salt = 48.8% 3-salt = 0.4%	
Emergence Timing :	May 28-August 6; mean July 2	
Smolt Ages: Wild fish collected at Dryden and Tumwater Dams (1998-2003)	age-1 = 3.8% age-2 = 69.5% age-3+ = 26.7%	
Juvenile Overwintering: No data exists	Columbia River:	25%
	Wenatchee Basin:	75%
Stock Genetic Fitness:	85%	
In-Basin Harvest:	0%	
Mean Fecundity: WDFW Broodstock	5913 eggs / female	

Analysis of Model Output

The first analysis considered conditions within individual stream reaches and identified the most important factors contributing to a loss in performance at specific life stages (1-12) corresponding to each reach. This analysis, called the Stream Reach Analysis, identified the survival factors (classes of Level 2 environmental attributes) that, if appropriately moderated or corrected, would produce the most significant improvements in overall fish population performance. The stream reach analysis identified the factors that should be considered in planning habitat restoration projects. Reach analysis tables (EDT consumer reports tables) were used to determine primary and secondary limiting factors within each Assessment Unit; this detailed information, specific to the Wenatchee basin analysis can be found at (www.mobrand.com/edt/NWPCC/index.htm).

We relied on the strategic priority summary, which was provided by the EDT software and integrated across the reaches and life stages within each AU to summarize limiting factors at the larger scale.

The second analysis was conducted across geographic areas (assessment units) relevant to populations, where each geographic area typically encompassed many reaches. This analysis, called the *Assessment Unit Analysis*, identified the relative importance of each area for either restoration or protection actions. In this case, we analyzed the effect of either restoring or further degrading of environmental conditions on population performance. These results were available in unscaled output. The unscaled output estimated the total potential for increase or decrease (due to restoration or protection actions) within an assessment unit, regardless of its length relative to other assessment units. Unscaled output showed us the critical areas for restoration and protection, regardless of size or efficiency of applying restoration action.

Priority Assessment Units

We evaluated the restoration and protection priorities separately for each species by categorizing the EDT output into 3 prioritization categories (Primary, Secondary, Tertiary). Although EDT provides quantitative output and ranks each assessment unit, we believed there was too much uncertainty in this first draft EDT assessment to rely on the absolute prioritization provided by the model. To establish the categories, we evaluated the fish performance increases (with restoration) or potential decreases (without protection) in two ways, 1) summing the percent increase or decrease across all three performance measures, 2) averaging the percent increase or decrease across all three performance measures and 3) averaging the ranks across all 3 performance measures. We presented and used all three summary methods because we did not believe that we had enough justification at this time to conclude that one method was the "right way" to analyze the results.

F.1.2. Results

Stream Reach Analysis

Wenatchee Spring Chinook.—When reach and life stage specific limiting factors were summed within the AU's, Habitat Diversity, Obstructions, Sediment Load, Temperature, Flow, and Key Habitat Quantity were primary limiting factors in one or more AU's (**Figure F2**). Secondary factors included competition with hatchery fish, channel stability, harassment, food, and predation. In several assessment units the interpretation was that there were no "primary" limiting factors because the habitat was in good condition and EDT confirmed that the degradations that were present were not having a "high" impact to fish survival. These assessment units included Tumwater Canyon, Upper Wenatchee Mainstem, Chiwaukum Ck, Chiwawa River, White River, and Little Wenatchee River (**Figure F2**). For a complete interpretation of the primary limiting factors and causal mechanism within each subwatershed refer to the recovery matrix (**Table 5.7**). A reach level assessment of each survival factors influence on 12 specific life stages can be downloaded from www.mobrand.com. An example of one of the 119 reach reports is shown in **Figure F3**. The first Peshastin Creek reach was selected to illustrate why flow (water quantity) was selected as a primary limiting factor even though it did not get a "high" rating on the strategic priority summary. The strategic summary report (**Figure F2**) indicated "low" impacts to spring Chinook in the lower Peshastin Creek assessment unit, however the reach report indicated that key habitat quantity was a limiting factor to 10 of the 12 life stages and that temperature was a limiting factor for spawning. Reduced key habitat quantity was caused by reduced flow decreasing minimum widths and artificial confinement simplifying the channel. Additionally, reduced flow was assumed to be a contributing factor to increased temperatures. Therefore, we concluded that water quantity in the Lower Peshastin Creek assessment unit should be classified was a primary limiting factor (**Table 5.7**).

Wenatchee steelhead.— When reach and life stage specific limiting factors were summed within the AU's, Flow, Habitat Diversity, Obstructions, Sediment Load, and Key Habitat Quantity were primary limiting factors in one or more AU's (**Figure F4**). Secondary factors included channel stability, competition with hatchery fish, food, harassment, predation, and temperature. In several assessment units the interpretation was that there were no "primary" limiting factors because the habitat was in good condition and EDT confirmed that the degradations that were present were not having a "high" impact to fish survival. These assessment units included Tumwater Canyon, Upper Wenatchee Mainstem, Chiwaukum Ck, Chiwawa River, White River, and Little Wenatchee River (**Figure F2**). For a complete interpretation of the primary limiting factors and causal mechanism within each subwatershed refer to the recovery matrix (**Table 5.7**). A reach level assessment of each survival factors influence on 12 specific life stages can be downloaded from www.mobrand.com.

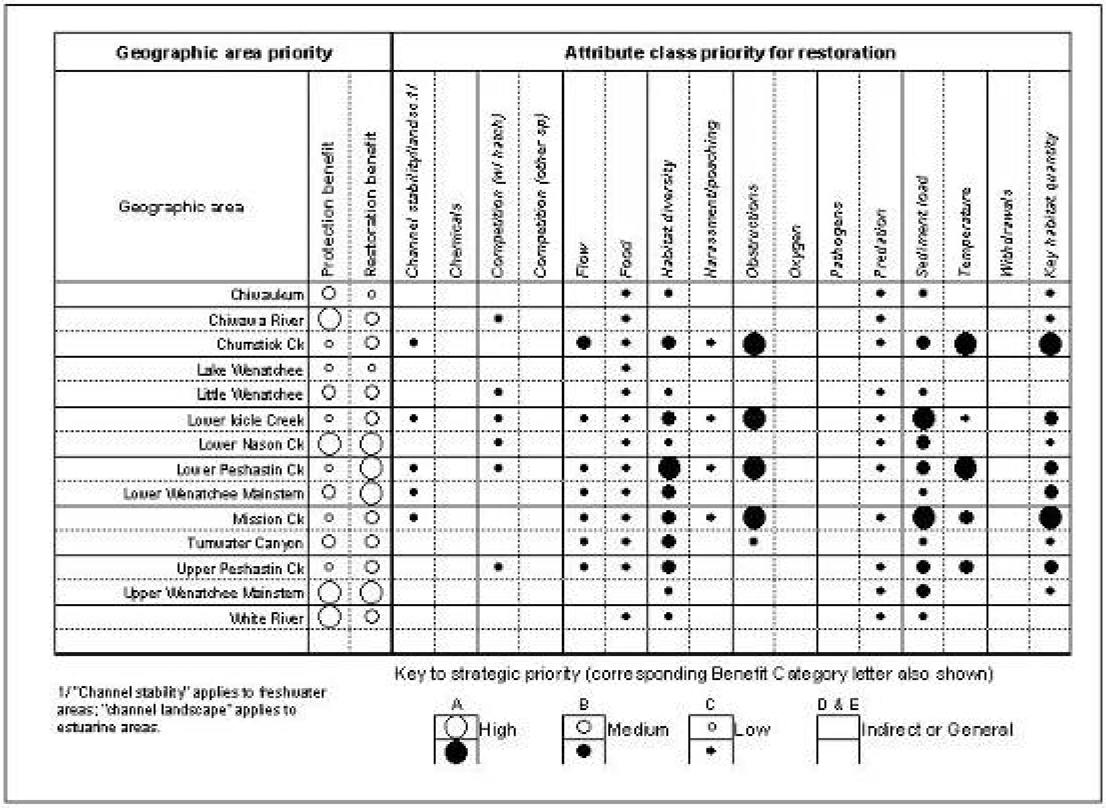


Figure F.2. EDT strategic priority summary for Wenatchee spring Chinook.

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

Wenatchee Spring Chinook May 2005 - Spring Chinook

Geographic Area:	Lower Peshastin Ck	Stream:	Peshastin Ck
Reach:	Peshastin Ck. Confluence to PID diversion @ RM 2.4	Reach Length (mi):	2.40
		Reach Code:	Pesh1

Restoration Benefit Category: 1/	A	Productivity Rank: 1/	9	Potential % change in productivity: 2/	0.0%
Overall Restoration Potential Rank: 1/	3	Average Abundance (Neq) Rank: 1/	3	Potential % change in Neq: 2/	17.0%
(lowest rank possible - with ties) 1/	11	Life History Diversity Rank: 1/	1	Potential % change in diversity: 2/	20.7%
Preservation Benefit Category: 1/	C	Productivity Rank: 1/	12	loss in productivity with degradation: 2/	0.0%
Overall Preservation Rank: 1/	9	Average Abundance (Neq) Rank: 1/	12	% loss in Neq with degradation: 2/	-1.7%
(lowest rank possible - with ties) 1/	10	Life History Diversity Rank: 1/	10	% loss in diversity with degradation: 2/	-0.5%

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
					Change in attribute impact on survival															
Spawning	Sep	1.5%	-47.4%	3							⬤	●			•	⬤		⬤		⬤
Egg incubation	Sep-Apr	1.5%	-43.9%	5	●												⬤			⬤
Fry colonization	Mar-May	4.6%	-19.6%	2	●			•	●	●	⬤					•	•			⬤
0-age active rearing	Mar-Oct	6.2%	-12.7%	4	•		●			•	●				•	•		•		⬤
0-age migrant	Oct-Nov	2.4%	-2.5%	7							●					•				⬤
0-age inactive	Oct-Mar	0.5%	-30.6%	6	●				•	●	⬤						●	•		⬤
1-age active rearing	Mar-May	0.5%	-6.3%	8			•		•	•	●									⬤
1-age migrant	Mar-Jun	3.4%	-0.3%	9							●					•				⬤
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Apr-Aug	12.6%	-0.1%	10							●	•								⬤
Prespawning holding	May-Sep	1.5%	-65.0%	1					●		⬤	•				●		●		⬤
All Stages Combined		12.6%																		

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 F.3. Reach report for one of the reaches (Pesh1) in the Lower Peshastin Creek assessment unit. For details and descriptions of the life stages and survival factors go to www.mobrand.com.

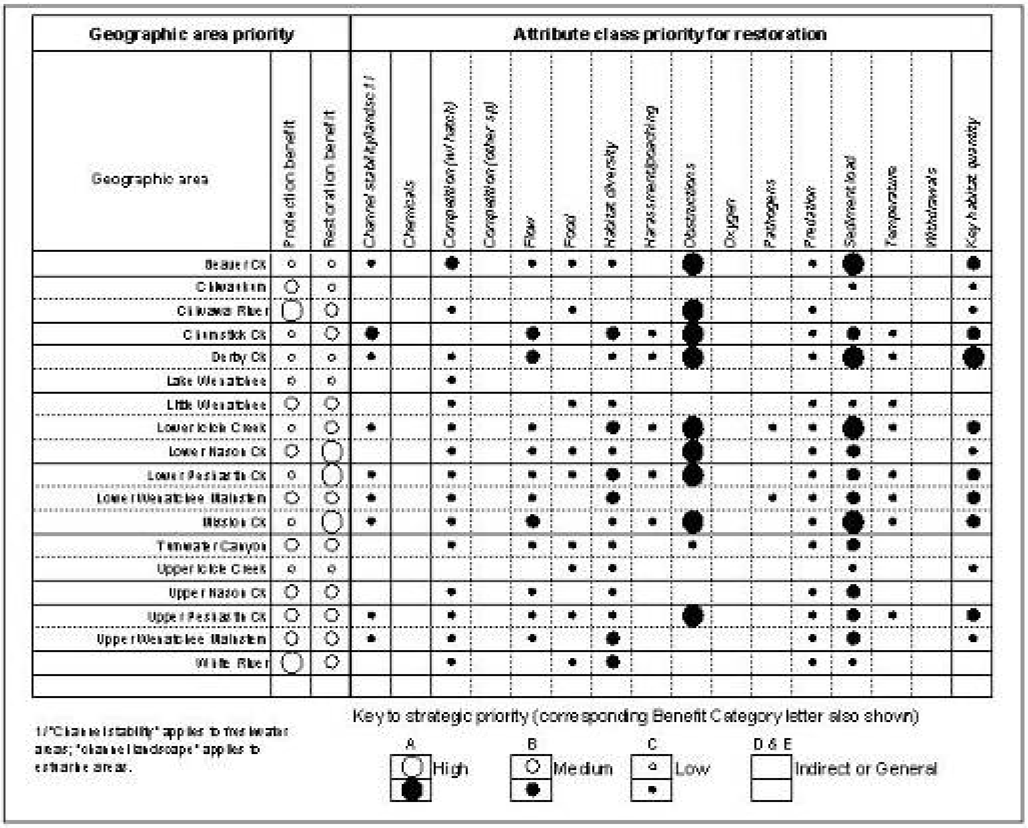


Figure F.4. EDT strategic priority summary for Wenatchee steelhead.

Priority Assessment Units

Spring Chinook.— The top assessment units for restoration benefits to spring Chinook were the Upper Wenatchee Mainstem, Lower Nason Creek, Lower Peshastin Creek, and the Lower Wenatchee Mainstem based on average rank and the sum of the restoration potential across the 3 performance measures (diversity index, productivity, and abundance)(**Table F6**). The high priority of the mainstem Wenatchee River AU's was primarily due to their contribution to abundance. We modeled a 50:50 resident:transient life history strategy which meant that 50% of the fry and parr left their natal streams and reared to smolt stages in the mainstem Wenatchee. This was consistent with empirical data that showed an average of 39% (range 17-74 %; 1993-2002) of the Chiwawa River smolts left the Chiwawa River as subyearling migrants (WDFW unpublished data). The inclusion of the Upper Wenatchee mainstem as a top restoration priority was somewhat unexpected since the strategic priority summary did not identify any primary limiting factors in this AU. We concluded that the quantity of habitat in this AU was so large compared to other AU's that the small restoration potential in individual environmental attributes was adding up to relatively large potential increases in performance. Similarly, the Chiwawa and White Rivers ranked relatively high for restoration benefit to productivity, even though they are thought to be in relatively pristine conditions. Again, we concluded that the small degradations to individual environmental attributes was adding up to relatively large potential increases because these areas had large quantities of critical spawning and rearing habitat. These conclusions were supported by the protection priorities because the Chiwawa and White Rivers and the Upper

Wenatchee Mainstem were 3 of the top 4 assessment units for protection (**Table F7**). Lower Nason Creek was also in the top benefit category for protection, in addition to being a high priority restoration AU. Other important AU's for protection included Tumwater Canyon, the Little Wenatchee River, and the Lower Wenatchee Mainstem.

Steelhead.— The top assessment units for restoration benefits to steelhead were Lower Peshastin Creek and Mission Creek, based on average rank and the sum of the restoration potential across the 3 performance measures (diversity index, productivity, and abundance)(**Table F.8**). However, 7 other assessment units were included in the benefit category A, based on summed restoration potentials over 40% (**Table F8**). It was unclear why the Upper Wenatchee Mainstem offered so much restoration potential for the diversity index (27%) and why the White River had so much restoration potential for productivity (19%). Both the White and Little Wenatchee Rivers were important for protection and restoration, though recent spawning ground surveys have revealed very little current steelhead use. No data existed to inform the model on when steelhead recruit to Lake Wenatchee, how long they stay in the lake, or what the mortality rates should be in the lake. All results and rankings relevant to the White and Little Wenatchee should be viewed tentatively until we know more about how steelhead are or should be dealt with in that lentic environment. Similar to spring Chinook, important AU's for protection for steelhead included the Chiwawa and White Rivers and Nason Creek (**Table F.9**).

Table F6. EDT model output for the assessment unit summary for Wenatchee spring Chinook. The restoration potential was the percent increase in each of the performance measures (diversity index, productivity, and abundance) by improving all environmental attributes in that assessment unit to template conditions. Benefit categories were derived by evaluating the mean rank and by finding breakpoints in the sum of the restoration benefits.

		Diversity Index		Productivity		Abundance				
Reach	Benefit Category	Rank	Restoration Potential	Rank	Restoration Potential	Rank	Restoration Potential	Mean Rank	Mean % Restoration Potential	Sum of % Restoration Potential
Upper Wenatchee Mainstem	A	4	9%	4	6%	2	23%	3	12%	37%
Lower Nason Ck	A	7	4%	1	23%	4	15%	4	14%	42%
Lower Peshastin Ck	A	1	21%	9	0%	3	17%	4	13%	38%
Lower Wenatchee Mainstem	A	6	5%	6	3%	1	29%	4	12%	37%
Lower Icicle Creek	B	3	9%	9	0%	6	8%	6	6%	17%
Chiwawa River	B	13	0%	2	20%	5	13%	7	11%	34%
Mission Ck	B	2	15%	9	0%	9	7%	7	7%	21%
White River	B	12	0%	3	19%	7	8%	7	9%	28%
Tumwater Canyon	B	8	3%	7	2%	8	7%	8	4%	12%
Chumstick Ck	B	5	6%	9	0%	11	3%	8	3%	9%
Little Wenatchee	B	10	1%	5	6%	10	4%	8	3%	10%
Upper Peshastin Ck	B	9	3%	9	0%	12	1%	10	1%	4%
Chiwaukum	C	11	1%	9	0%	13	0%	11	0%	1%
Lake Wenatchee	C	13	0%	8	0%	14	0%	12	0%	1%

Table F7. EDT model output for the assessment unit summary for Wenatchee spring Chinook. The potential loss from degradation was the percent decrease in each of the performance measures (diversity index, productivity, and abundance) by moving all environmental attributes in that assessment unit to a set of default extremely degraded conditions. Benefit categories were derived by evaluating the mean rank and by finding breakpoints in the sum of the losses from degradation.

		Diversity Index		Productivity		Abundance				
Reach	Benefit Category	Rank	Potential Loss From Degradation	Rank	Potential Loss From Degradation	Rank	Potential Loss From Degradation	Mean Rank	Mean Potential Loss From Degradation	Sum of Potential Loss From Degradation
Chiwawa River	A	1	-51%	1	-56%	1	-53%	1	-54%	-161%
White River	A	3	-14%	2	-23%	3	-19%	3	-19%	-57%
Lower Nason Ck	A	2	-17%	4	-9%	4	-19%	3	-15%	-45%
Upper Wenatchee Mainstem	A	5	-9%	3	-14%	2	-38%	3	-21%	-62%
Tumwater Canyon	B	4	-14%	5	-8%	6	-9%	5	-11%	-32%
Little Wenatchee	B	7	-6%	6	-8%	7	-8%	7	-7%	-22%
Lower Wenatchee Mainstem	B	8	-3%	7	-4%	5	-11%	7	-6%	-18%
Chiwaukum	C	6	-7%	9	-2%	8	-3%	8	-4%	-12%
Upper Peshastin Ck	C	9	-1%	10	0%	9	-2%	9	-1%	-3%
Lake Wenatchee	C	11	0%	8	-2%	11	-2%	10	-1%	-4%
Lower Icicle Creek	C	12	0%	12	0%	10	-2%	11	-1%	-2%
Lower Peshastin Ck	C	10	-1%	12	0%	12	-2%	11	-1%	-2%
Chumstick Ck	C	12	0%	11	0%	14	0%	12	0%	0%
Mission Ck	C	12	0%	12	0%	13	0%	12	0%	0%

Table F8. EDT model output for the assessment unit summary for Wenatchee steelhead. The restoration potential was the percent increase in each of the performance measures (diversity index, productivity, and abundance) by improving all environmental attributes in that assessment unit to template conditions. Benefit categories were derived by evaluating the mean rank and by finding breakpoints in the sum of the restoration benefits.

		Diversity Index		Productivity		Abundance				
Reach	**Benefit Category**	**Rank**	**Restoration Potential**	**Rank**	**Restoration Potential**	**Rank**	**Restoration Potential**	**Mean Rank**	**Mean % Restoration Potential**	**Sum of % Restoration Potential**
Lower Peshastin Ck	A	2	35%	3	20%	1	49%	2	35%	104%
Mission Ck	A	1	50%	6	13%	3	23%	3	29%	87%
Lower Nason Ck	A	7	12%	2	25%	4	20%	4	19%	58%
Lower Wenatchee Mainstem	A	5	20%	8	11%	5	19%	6	16%	49%
Upper Wenatchee Mainstem	A	3	27%	7	13%	10	10%	7	17%	51%
Chiwawa River	A	10	5%	5	16%	6	18%	7	13%	40%
Upper Nason Ck	A	13	3%	1	26%	7	17%	7	15%	45%
Lower Icicle Creek	A	4	22%	16	0%	2	28%	7	16%	49%
Tumwater Canyon	B	8	11%	10	2%	9	12%	9	9%	26%
White River	B	15	2%	4	19%	8	15%	9	12%	36%
Chumstick Ck	B	9	10%	11	1%	12	3%	11	5%	14%
Little Wenatchee	B	16	1%	9	9%	11	7%	12	5%	16%
Upper Peshastin Ck	B	6	19%	16	0%	14	1%	12	7%	20%
Beaver Ck	C	11	5%	13	1%	15	1%	13	2%	7%
Chiwaukum	C	14	2%	12	1%	13	2%	13	1%	4%
Derby Ck	C	12	4%	14	1%	16	1%	14	2%	6%
Lake Wenatchee	C	17	0%	15	0%	17	0%	16	0%	0%

		Diversity Index		Productivity		Abundance				
Reach	**Benefit Category**	**Rank**	**Restoration Potential**	**Rank**	**Restoration Potential**	**Rank**	**Restoration Potential**	**Mean Rank**	**Mean % Restoration Potential**	**Sum of % Restoration Potential**
Upper Icicle Creek	C	17	0%	16	0%	18	0%	17	0%	0%

Table F9. EDT model output for the assessment unit summary for Wenatchee steelhead. The potential loss from degradation was the percent decrease in each of the performance measures (diversity index, productivity, and abundance) by moving all environmental attributes in that assessment unit to a set of default extremely degraded conditions. Benefit categories were derived by evaluating the mean rank and by finding breakpoints in the sum of the losses from degradation

		Diversity Index		Productivity		Abundance				
Reach	**Benefit Category**	**Rank**	**Potential Loss From Degradation**	**Rank**	**Potential Loss From Degradation**	**Rank**	**Potential Loss From Degradation**	**Mean Rank**	**Mean Potential Loss From Degradation**	**Sum of Potential Loss From Degradation**
Chiwawa River	A	1	-39%	1	-38%	1	-51%	1	-43%	-128%
White River	A	3	-14%	2	-28%	2	-30%	2	-24%	-72%
Lower Nason Ck	A	2	-20%	4	-8%	4	-13%	3	-14%	-41%
Upper Nason Ck	A	4	-13%	3	-12%	3	-16%	3	-14%	-41%
Upper Wenatchee Mainstem	B	5	-11%	7	-5%	6	-10%	6	-9%	-26%
Chiwaukum	B	6	-7%	6	-6%	8	-8%	7	-7%	-21%
Tumwater Canyon	B	8	-6%	8	-4%	5	-13%	7	-8%	-23%
Little Wenatchee	B	7	-6%	5	-7%	10	-6%	7	-6%	-19%
Lower Wenatchee Mainstem	B	9	-3%	9	-3%	7	-9%	8	-5%	-15%
Upper Peshastin Ck	B	10	-1%	10	-1%	9	-7%	10	-3%	-9%
Lower Peshastin Ck	C	11	0%	12	0%	11	-2%	11	-1%	-2%
Mission Ck	C	12	0%	13	0%	12	-2%	12	-1%	-2%
Lake Wenatchee	C	12	0%	11	0%	15	0%	13	0%	-1%
Lower Icicle Creek	C	12	0%	15	0%	13	-1%	13	0%	-1%
Chumstick Ck	C	12	0%	15	0%	14	-1%	14	0%	-1%
Beaver Ck	C	12	0%	14	0%	17	0%	14	0%	0%

			Diversity Index			Productivity			Abundance					
Reach	Benefit Category		Rank	Potential Loss From Degradation		Rank	Potential Loss From Degradation		Rank	Potential Loss From Degradation		Mean Rank	Mean Potential Loss From Degradation	Sum of Potential Loss From Degradation
Derby Ck	C		12	0%		15	0%		16	0%		14	0%	0%
Upper Icicle Creek	C		12	0%		15	0%		18	0%		15	0%	0%

F.1.3 Data Availability and Quality

In general, adequate data sources were available to aid the habitat work group in rating the 46 environmental attributes for EDT. We evaluated 4641 current attribute rating levels of proof to determine the percent frequency of each level of proof (LOP) category (**Table F3**). Category one was used for attributes where data was available in a specific reach and was direct measure of the environmental attribute. Category two was used to expand empirical information to adjacent reaches, or to other reaches within the same sub-watershed, if appropriate. Category three was used when data was available to deduce the EDT score, but it was indirectly related to the EDT attribute or expanded from another sub-watershed where applicability was suspect. Category four was for expert opinion and was used for attributes where no data was available, so they had to be rated qualitatively. Category five was hypothetical, and was also based on opinion, but with less confidence and was sometimes used to highlight critical data gaps. Obviously, the more empirical data the better for population the EDT model with environmental attribute information. However, in many cases, the attributes could be adequately defined with derived information or expert opinion. In other cases, the analysis could benefit from refinement of the model input.

Overall, 76% of the data that populated the model for the Wenatchee Basin was empirical (21%), expanded from empirical (9%), or derived (46%) (**Figure F5**). Several of the attributes were designed to be rated qualitatively, according to the EDT attribute rating guidelines. For example, the attribute “harassment”, is a relative measure of the proximity to population centers and the potential for disturbance and poaching on a fish population. Empirical data did not exist and will never exist for this attribute as it was defined in the attribute rating guidelines. It was included in EDT for watersheds that might have issues related to major population centers such as in the Puget Sound area. These attributes probably could have been categorized as expert opinion but we had some links to data that warranted a slightly better level of proof rating. Several other attributes that were rated qualitatively using derived information included pathogens and predation.

Several of the derived attributes need improvement and future efforts to use EDT should first focus on reviewing and improving critical model input.

Some key attributes with the majority of their LOP in the derived category that need to be revisited include artificial hydroconfinement, bed scour, salmon carcasses, and benthic macroinvertebrates. The cumulative effect of artificial confinement from all sources needs to be identified in each reach. We used the road and transportation layer generated by PBI then made some assumptions about what % of the confined linear distance actually severs the channel from its floodplain (**Table F3**). These assumptions need groundtruthed by field and aerial photo observations. Bed scour is the primary modifier for the survival factor “channel stability” that was rated as secondary or not a limiting factor for many of the assessment units, thereby decreasing the models sensitivity to this environmental attribute. Given the importance of bed scour related to egg incubation and productivity, we were not satisfied with the multiple regression using other attribute ratings to come up with EDT scores for bed scour.

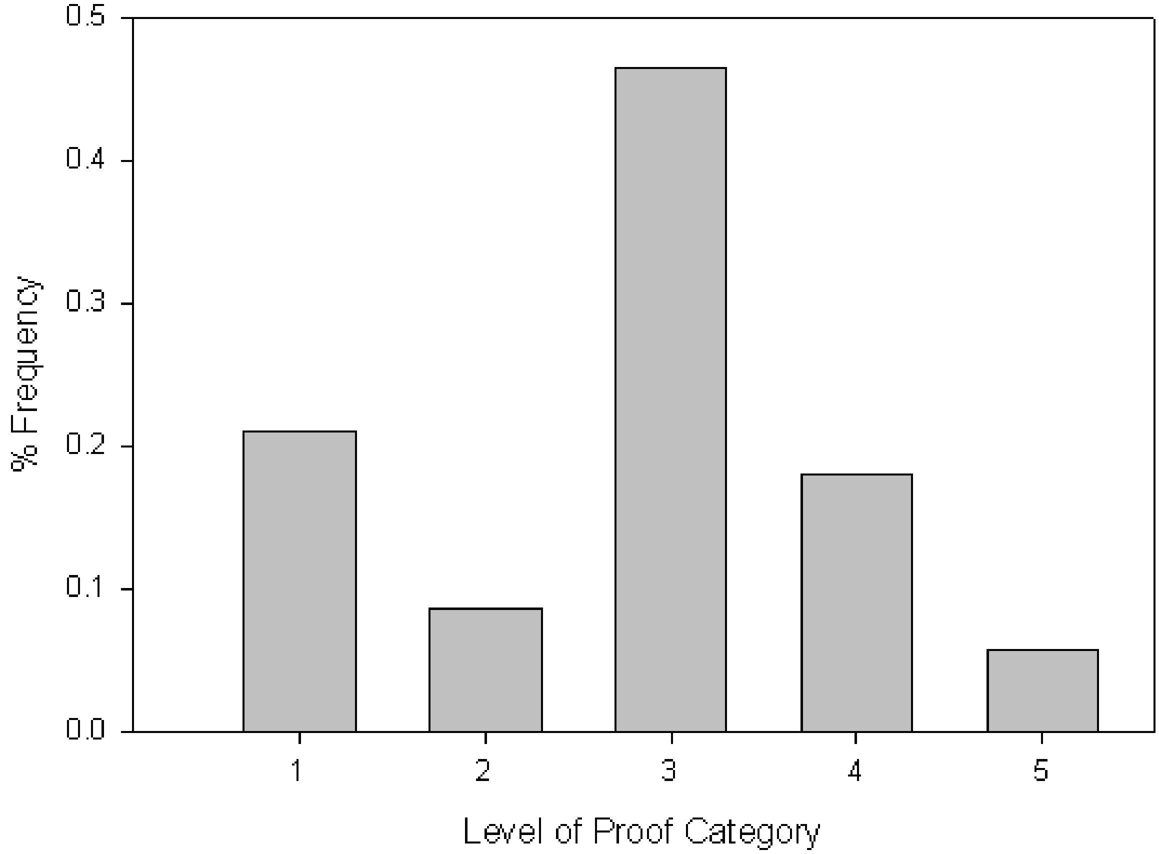


Figure F.5. Frequency distribution of each category of level of proof for the Wenatchee basin Ecosystem Diagnosis and Treatment model. Category 1= empirical data, 2=expansion of empirical data, 3=derived from relevant empirical information, 4=expert opinion, 5 = hypothetical.

Bed scour ratings generally came up very close to template conditions. However, until bed scour is measured using empirical studies at multiple locations throughout the watershed, we will have to rely on our initial indirect estimate. Salmon carcasses and benthic macroinvertebrates contributed to the limiting factor “food”. There were relatively high average T-C ratings for both of these attribute, although the survival factor appeared to be a secondary limiting factor when examining the strategic priority summary. The need to re-visit these attributes was increased when the sensitivity analysis showed such a large potential to increase to improve abundance and productivity by addressing the survival factor “food” (section F.6). A result that seemed to conflict with our initial diagnosis that food was a secondary limiting factor. Since B-IBI data has been collected it should be relatively easy to update this metric, but those scores were not available when we were initially populating EDT with attribute scores.

Additional information regarding population performance and scenario modeling can be found in the subsequent sections of this appendix.

F.2 Model Setup for Scenarios

EDT was used to analyze the potential increases in salmon performance based on improved habitat conditions. A scenario consisted of multiple action classes that were targeted at addressing limiting factors identified in the recovery matrix (Tables 5.7-5.10). Action classes were groups or categories of restoration activities that could be implemented in a watershed to change the stream environment toward the normative or historical condition, such as removing passage barriers, restoring riparian condition, or floodplain connectivity (see **Table 5.6**). Action classes were grouped into scenarios to represent a coordinated approach to habitat restoration.

Scenarios resulted in a change in the environment from a set of combined actions. The total amount of change resulting from a scenario was bounded by the current condition and the normative or template condition. In other words, an attribute could not be improved beyond what was defined as its intrinsic condition in the template condition. The distance between the current and the template condition defined the ***restoration potential*** for each attribute. Construction of scenarios involved determining a percent change in the restoration potential for attributes as a result of the component actions (habitat action classes; see **Table 5.6**). Benefits of actions were not applied as absolute increases, but as a percent change to the difference between the current and template condition of a particular environmental attribute by the following formula:

$$N_i = C_i + [(T_i - C_i)*(E*I)]$$

Where N_i was the new score for a particular environmental attribute in a specific reach, T_i was the template value of the attribute in that reach, C_i was the current value for that attribute score for that reach, E was the effectiveness of the action at changing that attribute and I was the intensity of the action class application.

Its impossible to know the quantitative benefit to a species that will result from restoration scenarios because of the uncertainty regarding physical processes in streams, uncertainty in how fish may respond to environmental change and because of the compounding effect of many different factors inside and outside the subbasin that affect the abundance of salmon. For this reason, we created ***action class hypotheses*** that were the basis for analysis of the actions and scenarios in EDT. These hypotheses are based on scientific information and represent our best judgments regarding the effect of the scenarios. As hypotheses, they can and should be evaluated as they are implemented. Action class hypotheses were developed through a structured approach that incorporated published scientific knowledge and the judgments of local experts regarding the change in the environment that is likely to result from implementation of the actions (**Figure F6**). These action class hypotheses were grouped into scenarios that consisted of input changes to the EDT model. EDT was then re-run and the effect of the scenario was measured as the change in fish performance between the scenario and the baseline run.

The process used for developing action hypotheses and scenarios for EDT is shown in **Figure F6**. An action hypothesis describes a specific measure taken to affect the stream—planting trees, adding large wood, reconnecting floodplains and so on. The hypothesis for each action consisted of two elements: the ***effectiveness*** of the type of action to change one or more EDT environmental attributes (for example, temperature, flow, sediment) and the ***intensity*** of application of the action along the stream. Effectiveness is independent of intensity and represents a scientific conclusion regarding how the different types of actions affect the environment. Planting trees along a stream, for example, has an effectiveness that relates to the ecological role of riparian forests on the stream environment. Intensity, on the other hand, might refer to the proposed width of the riparian planting and the number or species of trees to be planted. The result of the action hypothesis is a statement regarding the percent change in one or more attributes in one or more reaches of the stream as a result of implementing the action. The percent changes for each action are combined to create scenarios that are analyzed in EDT.

Model

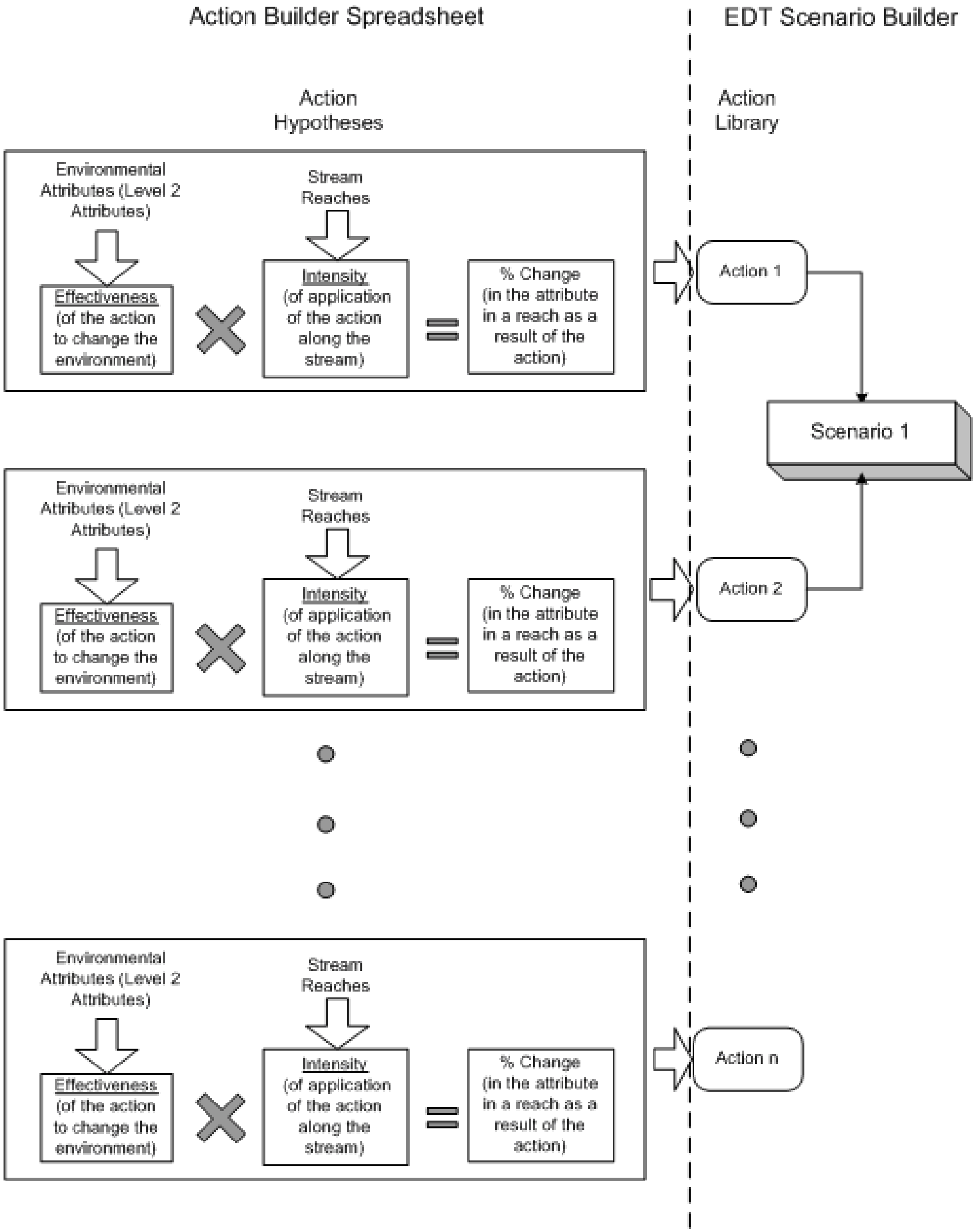


Figure F6. Development of scenarios for analysis within the Ecosystem Diagnosis and Treatment (EDT) model. An action builder spreadsheet was used to create an action hypothesis regarding the effectiveness of an action to change the environmental attributes and an intensity of application was selected to define the level of effort within each assessment unit. Actions were then brought together into a scenario that was evaluated

Scenarios were analyzed in two steps (**Figure F6**). First, recovery planners used an action builder spreadsheet to document assumptions regarding the effectiveness and intensity for each action class. This resulted in an estimate of the percent change in restoration potential that would result from the action class. Second, the estimated percent change in attributes in each affected reach was transferred to the EDT Scenario Builder where actions were combined into scenarios. Algorithms in the Scenario Builder combined the actions and ensured that the sum of all actions could not improve conditions beyond that described in the Template condition. Also in the scenario builder, the percent changes resulting from a scenario were applied to the EDT baseline environmental data set (developed in the Stream Reach Editor) to produce a modified environmental data set that was evaluated for its effectiveness at improving the status of salmon and steelhead performance measures including abundance, productivity, and life history diversity.

Effectiveness.— Effectiveness was used as a scientific hypothesis regarding how types of actions affect the environment, independent of the socioeconomic feasibility or intensity of application of a particular action. The intent of the effectiveness component was to develop a consistent scientific conclusion regarding each type of action that would be applied to address a limiting factor. The effectiveness hypotheses were developed by a group of scientists independently of the application of the action through the intensity multiplier. We estimated the effectiveness of each action class within 3 stream size categories (Strahler order) to capture the different levels of effectiveness in small (1-3 order) medium (4-5 order) and large (6^{th} order) stream sizes. The effectiveness hypothesis was created by considering how each type of action relates to one or more of the 46 physical and biological attributes in EDT. In most cases, there were one or more attributes for which the action had a primary impact and other secondary attributes that receive lesser benefits. Due to the uncertainty of how much an action class might change particular environmental attributes we formed 5 classes of effectiveness and then estimated the range and midpoint of each effectiveness rating (**Table F10**). We rarely assumed that an individual action class had a high capability of restoring normative conditions, but generally the sum of all action classes restored > 75% of normative conditions for most targeted attributes (**Table F11**). The gaps between the sum of the effectiveness and the template condition could be explained by other action classes that were not considered by recovery planners. For example, the action class "add large wood" was only rated to increase the large woody debris attribute by 0.3. We hypothesized that just adding wood to a dysfunctional stream channel would not be very effective at moving the attribute score towards the template condition (max = 0.30). However, when considered in combination with riparian restoration, floodplain reconnection, and road management the sum of the effectiveness to the large woody debris attribute was 1.05 (but if all actions were applied the model algorithms would cap the benefit at 1.0) indicating that template conditions could be achieved if all actions were implemented to their full intensity. As another example, the sum of effectiveness ratings for predation risk were only 0.15 for all stream sizes; however, we did not include specific actions to reduce predation, such as predator removal programs that would have moved the sum of the effectiveness towards 1.0. Additional discrepancies (variances from 1.0) could be explained by the uncertainty of the effectiveness assumptions and because we modeled the midpoints when the true value may have been closer to either end of the extremes.

Intensity.—Intensity described how much effort of each action class would be applied to specific assessment units of the subbasin. Because intensity directed specific actions at specific locations, managers referred to the EDT diagnosis and the recovery matrix (which included previous assessments as a guide to limiting factors). In determining the final effect of the action on the environmental attributes, intensity in each reach was multiplied by the effectiveness of the action (**Figure F6**). In the Action Builder Spreadsheet, intensity was set for each action in each assessment unit, so an intensity of 1.0 assumes that the action would be applied in every reach to its full effectiveness (limited to the midpoint of the effectiveness range). For example, we determined the effectiveness of adding large woody debris was 30% effective in medium and small streams so the overall effect with 1.0 intensity would be (1.0*0.3 = 0.3). Although this rating would take into account the biological and physical limitations of effectiveness of a particular action, it would not take into account social limitations or a cost benefit prioritization that would represent the feasibility of implementation. If an alternative scenario applied 0.33 intensity to the action class "add large woody debris" then the change to the attribute score would be (0.33*0.30 = 0.10). Again, this change (0.10) was not an absolute increase in the current score, rather it was applied to the difference between the current and template score. For example, if the attribute "large woody debris" was rated as a 3 for current and a 1 for historic (where a lower score means more wood; see attribute rating guidelines at www.mobrand.com) with an effectiveness of 0.3 and an intensity of 0.33 then, using the formula defined previously:

$$N_i = C_i + [(T_i - C_i)*(E*I)]$$

the new attribute score would be:

$$N_i = 3 + [(1-3)*(0.3*0.33)] = 2.8$$

Protection Action Classes.—A fundamental assumption of this plan was that existing high quality, functioning habitat needs to be protected. Much of the focus in the habitat section is on restoring or fixing impaired environmental function. That focus does not diminish the need to ensure that habitat remains functional or continues to recover from past land use/management practices where protection has already occurred. There were two forms of habitat protection considered in this plan, no-net-impact and passive restoration. First, in areas where development was likely to occur we applied no-net-impact protection that was designed to prevent degradation of riparian areas and stream channel function through mechanisms such as the Growth Management Act, Shorelines Management Act, Hydraulics Code and Clean Water Act. Second, in areas that were already protected by state and federal land ownership it is assumed that continued protection will occur and conditions will improve through passive restoration.

In the EDT modeling exercises, we assumed no-net-impact of development on the environmental attributes that affect fish survival in all assessment units. There are two ways to achieve this result. First, development will not be allowed in a manner that will impact the riparian area and stream channel. Second, if an impact does occur it must be mitigated by restoring and then protecting an area of the riparian and stream channel of "equal" value. This no-net-impact restoration will not be included with other restoration actions outlined to move the population towards recovery. It is simply compensating for new impacts and keeping conditions and species status from degrading. If species status is to improve then habitat conditions must improve and protection has to be applied to maintain functional conditions.

Within each watershed, areas already receiving some level of protection, primarily through state and federal ownership were noted (**Table F12**). These areas also generally represent the most pristine and functional habitats within each basin and it was assumed that continued protection of these habitats will lead to passive restoration, whereby conditions slowly improve without direct intervention. Our hypothesis was that habitat attributes associated with the riparian zone, stream channel, and water quality would improve through passive restoration at a rate of 0.25 over a 25 year time period. Additionally, we hypothesized that habitat attributes associated with or affected by roads would improve at a rate of 0.1 per 25 years. To see which of the 46 EDT environmental attributes these changes were applied to see (**Table F11**; action effectiveness table for hyperlink.xls). The improvement in habitat attribute scores were only applied to the difference between the current and template scores; therefore, no change occurred to a particular habitat attribute if it was rated the same for current and template. Passive restoration through protection was only applied in the relatively pristine sub-watersheds that were already in state and federal ownership, thereby leading to minor changes in attribute ratings and less sensitivity to our assumption that 0.25 and 0.10 were the correct rates for passive restoration. We also tested the models sensitivity to these passive restoration hypothesis by doubling and halving the multipliers (see section F.6 on model sensitivity).

The action class "add nutrients" (salmon carcasses or analogs) was also applied to the assessment units that were designated primarily for protection. Applying this action class makes sense when the majority of stream and riparian zone form and function are in place, but abundance and productivity are below carrying capacity. Although this action class was only applied at the generic scenario intensity levels, we believe that this action class should be prescribed on an annually, based on subwatershed level adult escapement objectives. This will ensure that nutrient levels are capable of supporting the juvenile production that is desired to achieve recovery levels.

Table F10. Effectiveness scores, ranges, and midpoints for modeling action classes in EDT and applied to the Upper Columbia salmon and steelhead populations in the Wenatchee, Methow and Okanogan. A score was assigned to each environmental attribute (1-46) and stream size category (small, medium, large) with the assumption that the true value was within the range of percentages. However, a single value was needed for modeling purposes so we chose to use the midpoint of the range as our hypothesis regarding how much each action class could effect the environment.

Score	Range	Mid Point (S1)
1	0-10%	5%
2	10%-20%	15%
3	20%-40%	30%
4	40%-80%	60%
5	80%-100%	90%

Table F11 Effectiveness assumptions for 3 size categories of streams in the Upper Columbia ESU. hyperlink file = action effectiveness table for hyperlink.xls)

Table F12 Assessment units in each subbasin where protection measures in at least some of the reaches were assumed to be adequate for passive restoration. Protection leading to passive restoration assumes that a greater level of protection is in place and habitat conditions will improve through time without the intervention of active restoration.

Subbasin	Assessment Unit	Protection leading to "passive restoration"
Wenatchee	Lower Wenatchee Mainstem	
Wenatchee	Mission Ck (upper reaches)	X
Wenatchee	Lower Peshastin Ck	
Wenatchee	Upper Peshastin Ck	X
Wenatchee	Derby Ck	
Wenatchee	Chumstick Ck	
Wenatchee	Lower Icicle Creek	
Wenatchee	Upper Icicle Creek	X
Wenatchee	Tumwater Canyon	X
Wenatchee	Chiwaukum	X
Wenatchee	Upper Wenatchee Mainstem	X
Wenatchee	Beaver Ck	
Wenatchee	Chiwawa River	X
Wenatchee	Lower Nason Ck	X
Wenatchee	Upper Nason Ck	X
Wenatchee	Lake Wenatchee	X
Wenatchee	Little Wenatchee	X
Wenatchee	White River	X
Methow	Lower Methow	
Methow	Middle Methow	
Methow	Upper Middle Methow	
Methow	Upper Methow/Early Winters/Lost River	X
Methow	Black Canyon/Squaw	

Subbasin	Assessment Unit	Protection leading to "passive restoration"
Methow	Libby/Gold	X
Methow	Beaver/Bear Creek	X
Methow	Lower Twisp	X
Methow	Upper Twisp	X
Methow	Lower Chewuch	X
Methow	Upper Chewuch	X
Methow	Goat Creek and Lower Boulder	X
Methow	Wolf Creek and Hancock Creek	X
Okanogan	Okanogan Lower	
Okanogan	Okanogan Middle	X
Okanogan	Okanogan Upper	X
Okanogan	Loup Loup Creek	
Okanogan	Lower Salmon	X
Okanogan	Upper Salmon	X
Okanogan	Omak Creek and Tributaries	X
Okanogan	Small Tributary Systems	
Okanogan	Similkameen	X
Okanogan	Osoyoos Lake South Central	
Okanogan	Osoyoos Lake North	
Okanogan	Inkaneep Creek	X
Okanogan	Canada Lower Mainstem	
Okanogan	Canada Middle Mainstem	
Okanogan	Vaseux-McIntire Creek	X
Okanogan	Vaseux Lake and Mainstem Reaches	
Okanogan	Skaha Lake	
Okanogan	Canadian Mainstem to Okanogan Lake	
Okanogan	Okanogan Lake	
Okanogan	Upper Okanogan Subbasin	
Entiat	Lower Entiat	
Entiat	Middle Entiat	X

Subbasin	Assessment Unit	Protection leading to "passive restoration"
Entiat	Upper Entiat	X
Entiat	Mad River	X

There were many assumptions that had to be made to conduct this predictive modeling exercise; however, we believe that the end result of the action effectiveness hypotheses were reasonable estimates of how the actions would change the environment. We used EDT because we could build on progress made during watershed planning and subbasin planning efforts and we knew of no other tool that would allow us to link restoration actions to habitat changes to fish performance changes in a quantitative assessment package. We evaluated 11 action classes for 3 stream size categories and 46 environmental attributes (that is 1518 decisions just for the effectiveness ratings). However, by laying out these decisions in a matrix format (**Table F11**) we could easily revise the model input to test alternative hypotheses. Eighty-five percent of the effectiveness ratings were "no effect" of the action on any of the environmental attributes. For the 232 times that we determined an action class would effect an attribute, we decided there would be very low (0.05) to low (0.15) effects on the environmental attribute 62% of the time (**Figure F7**). Again, those changes were for 100% intensity in the reach (or assessment unit) and they are only applied to the difference between current and template environmental attribute scores. Additionally, we did not model the downstream dispersal effect of action classes beyond the boundary of the assessment unit. However, we did capture the effect of upstream actions that benefit downstream AU's for actions such as road management that have downstream effects on survival factors such as sediment load. These assumptions should result in a fairly conservative model about how actions change the environment with respect to our scenarios, but we could not evaluate how the ratings were propagated through the EDT model and weather or not the results were likely an over or underestimate of salmon and steelhead performance. Assumptions and model sensitivity will be discussed further in section F.6.

F.3 Recovery Scenario Descriptions

Current without harvest.—This is the baseline EDT model run with current attribute ratings conducted during watershed planning for the Entiat (CCCD2004), subbasin planning for the Methow and Okanogan (NPPC 2004), and recovery planning for the Wenatchee (Section F.1 of this Appendix). The online EDT model only provided estimates without harvest; however, harvest was evaluated during integration of the four H's (section 5.6 of this plan) and the performance measures provided by EDT for each subsequent scenario were also without harvest so the results are compatible.

Scenario 1.—Recovery scenario 1 applied a full intensity of all restoration action classes to the limiting factors in each assessment unit, as identified in the recovery matrices (Tables 5.7-5.10). Scenario 1 was not grounded by the reality of socioeconomic feasibility. It was subject to the effectiveness limitations for each action class in each size category of stream (see effectiveness rating discussion above). It allowed us to evaluate how effective our action classes could be if applied to the in-basin limiting factors for each fish population. The cumulative change to each attribute from the implementation of all action classes in scenario 1 for the Wenatchee subbasin can be seen in **Table F13** (the same method and format was used in the Methow and Okanogan). The values in **Table F13** were obtained by summing the effectiveness ratings for action classes (**Table F11**) that addressed limiting factors in each assessment unit (Tables 5.7-5.10).

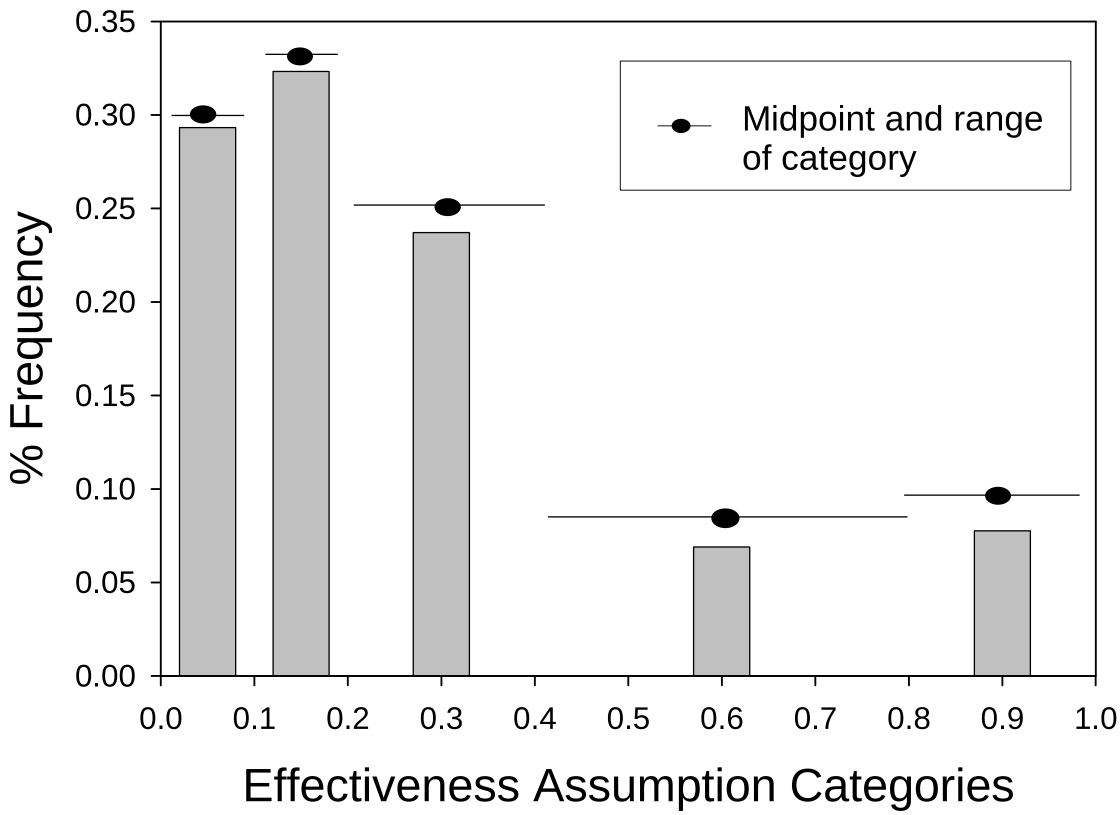


Figure F7. Distribution of effectiveness assumptions among the 5 categories of effectiveness for linking restoration actions to changes in habitat condition in EDT for the Upper Columbia ESU scenario modeling. This distribution only represents the actions and environmental attributes where a change to the current condition was applied and does not include the action-attribute combinations where "no effect" was assumed.

Table F13. The cumulative change to each EDT environmental attribute from the implementation of all action classes in scenario 1 for the Wenatchee subbasin. The values in were obtained by summing the effectiveness ratings for all recovery action classes that addressed limiting factors in each assessment unit

Environmental Attribute	Lower Wenatchee Mainstem	Mission Ck	Lower Peshastin Ck	Upper Peshastin Ck	Derby Ck	Chumstick Ck	Lower Icicle Creek	Upper Icicle Creek	Tumwater Canyon	Chiwaukum	Upper Wenatchee Mainstem	Beaver Ck	Chiwawa River	Lower Nason Ck	Upper Nason Ck	Lake Wenatchee	Little Wenatchee	White River
Flow High	0.45	0.90	0.60	1.00	0.90	0.90	0.60	0.10	0.10	1.00	0.10	0.90	0.10	0.60	0.10	0.10	0.10	0.10
Flow Low	0.90	0.90	0.90	1.00	0.90	0.90	0.90	0.10	0.10	1.00	0.10	0.90	0.10	0.90	0.10	0.10	0.10	0.10
Flow Diel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Flow Intra-Annual	0.15	0.60	0.30	0.70	0.60	0.60	0.30	0.10	0.10	0.70	0.10	0.60	0.10	0.30	0.10	0.10	0.10	0.10
Regime Natural	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Regime Regulated	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Channel Length	0.30	0.15	0.30	0.40	0.15	0.15	0.30	0.25	0.25	0.40	0.25	0.15	0.25	0.30	0.25	0.25	0.25	0.25
Width Max	0.00	0.15	0.15	0.40	0.15	0.15	0.15	0.25	0.25	0.40	0.25	0.15	0.25	0.15	0.25	0.25	0.25	0.25
Width Min	0.75	0.75	0.75	1.00	0.75	0.75	0.75	0.25	0.25	1.00	0.25	0.75	0.25	0.75	0.25	0.25	0.25	0.25
Gradient	0.05	0.05	0.05	0.30	0.05	0.05	0.05	0.25	0.25	0.30	0.25	0.05	0.25	0.05	0.25	0.25	0.25	0.25
Natural Confinement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Confinement-Hydro	0.70	0.95	0.80	1.05	0.95	0.95	0.80	0.10	0.10	1.05	0.10	0.95	0.10	0.80	0.10	0.10	0.10	0.10
Habitat-backwater pools	0.15	0.05	0.15	0.30	0.05	0.05	0.15	0.25	0.25	0.30	0.25	0.05	0.25	0.15	0.25	0.25	0.25	0.25
Habitat-beaver ponds	0.00	0.05	0.05	0.30	0.05	0.05	0.05	0.25	0.25	0.30	0.25	0.05	0.25	0.05	0.25	0.25	0.25	0.25

Environmental Attribute	Lower Wenatchee Mainstem	Mission Ck	Lower Peshastin Ck	Upper Peshastin Ck	Derby Ck	Chumstick Ck	Lower Icicle Creek	Upper Icicle Creek	Tumwater Canyon	Chiwaukum	Upper Wenatchee Mainstem	Beaver Ck	Chiwawa River	Lower Nason Ck	Upper Nason Ck	Lake Wenatchee	Little Wenatchee	White River
Habitat glides	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Habitat-Large cobble	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Habitat-Small cobble	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Habitat Pool Tailouts	0.10	0.60	0.35	0.85	0.60	0.60	0.35	0.25	0.25	0.85	0.25	0.60	0.25	0.35	0.25	0.25	0.25	0.25
Habitat-Pools	0.10	0.75	0.45	1.00	0.75	0.75	0.45	0.25	0.25	1.00	0.25	0.75	0.25	0.45	0.25	0.25	0.25	0.25
Habitat-Off channel Habitat	0.35	0.20	0.30	0.45	0.20	0.20	0.30	0.25	0.25	0.45	0.25	0.20	0.25	0.30	0.25	0.25	0.25	0.25
Obstructions	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.00	0.90	0.00	0.90	0.00	0.00	0.00	0.00
Water Withdrawal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bed Scour	0.75	1.15	0.90	1.40	1.15	1.15	0.90	0.25	0.25	1.40	0.25	1.15	0.25	0.90	0.25	0.25	0.25	0.25
Icing	0.00	0.05	0.00	0.30	0.05	0.05	0.00	0.25	0.25	0.30	0.25	0.05	0.25	0.00	0.25	0.25	0.25	0.25
Riparian Functions	0.65	0.95	0.95	1.20	0.95	0.95	0.95	0.25	0.25	1.20	0.25	0.95	0.25	0.95	0.25	0.25	0.25	0.25
Wood	0.65	1.05	1.05	1.30	1.05	1.05	1.05	0.25	0.25	1.30	0.25	1.05	0.25	1.05	0.25	0.25	0.25	0.25
Embeddedness	0.50	1.00	0.80	1.10	1.00	1.00	0.80	0.10	0.10	1.10	0.10	1.00	0.10	0.80	0.10	0.10	0.10	0.10
Fine sediment	0.50	1.00	0.80	1.10	1.00	1.00	0.80	0.10	0.10	1.10	0.10	1.00	0.10	0.80	0.10	0.10	0.10	0.10
Turbidity	0.15	0.60	0.30	0.70	0.60	0.60	0.30	0.10	0.10	0.70	0.10	0.60	0.10	0.30	0.10	0.10	0.10	0.10
Alkalinity	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25

Environmental Attribute	Lower Wenatchee Mainstem	Mission Ck	Lower Peshastin Ck	Upper Peshastin Ck	Derby Ck	Chumstick Ck	Lower Icicle Creek	Upper Icicle Creek	Tumwater Canyon	Chiwaukum	Upper Wenatchee Mainstem	Beaver Ck	Chiwawa River	Lower Nason Ck	Upper Nason Ck	Lake Wenatchee	Little Wenatchee	White River
Dissolved O2	0.65	0.15	0.05	0.40	0.15	0.15	0.05	0.25	0.25	0.40	0.25	0.15	0.25	0.05	0.25	0.25	0.25	0.25
Metals Water Column	0.90	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Metal sediment	0.90	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Misc Toxic pollutants	1.05	0.15	0.15	0.40	0.15	0.15	0.15	0.25	0.25	0.40	0.25	0.15	0.25	0.15	0.25	0.25	0.25	0.25
Nutrient Enrichment	0.90	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Temp Max	0.55	0.95	0.60	1.20	0.95	0.95	0.60	0.25	0.25	1.20	0.25	0.95	0.25	0.60	0.25	0.25	0.25	0.25
Temp Min	0.15	0.30	0.15	0.55	0.30	0.30	0.15	0.25	0.25	0.55	0.25	0.30	0.25	0.15	0.25	0.25	0.25	0.25
Temp Spatial Variation	0.25	0.70	0.50	0.95	0.70	0.70	0.50	0.25	0.25	0.95	0.25	0.70	0.25	0.50	0.25	0.25	0.25	0.25
Fish Community Richness	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Fish Pathogens	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Fish Species Intro	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Harassment	0.90	0.90	0.90	1.00	0.90	0.90	0.90	0.10	0.10	1.00	0.10	0.90	0.10	0.90	0.10	0.10	0.10	0.10
Hatchery outplants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Predation Risk	0.15	0.15	0.15	0.40	0.15	0.15	0.15	0.25	0.25	0.40	0.25	0.15	0.25	0.15	0.25	0.25	0.25	0.25
Salmon Carcass	0.15	0.05	0.05	0.90	0.05	0.05	0.05	0.55	0.40	0.90	0.40	0.05	0.55	0.35	0.85	0.25	0.55	0.55
Benthic Comm Rich	0.65	0.70	0.55	1.05	0.70	0.70	0.55	0.35	0.35	1.10	0.30	0.70	0.30	0.60	0.40	0.25	0.30	0.30

Protection strategies for scenario 1 included no-net-impact of development throughout all assessment units and passive restoration through protection on lands already in public ownership, such as USFS. No-net-impact assumes that protection will occur (at least) to the level where there is no loss to current habitat function or associated fish survival. Additional restoration actions (see above) were then assigned to these assessment units in order to improve their condition and function. Protection leading to passive restoration assumed that a greater level of protection was in place and habitat conditions would improve through time (without the intervention of active restoration). Finally, nutrient supplementation was applied to the assessment units where protection was the primary action class.

Scenario 2.—Scenario 2 was not available in time for modeling purposes. Our vision was for scenario 2 to be the chosen mix and match of action classes and intensities that were feasible in each assessment unit, based on detailed local input regarding feasibility. We left an un-modeled scenario 2 in the report to emphasize the need for subwatershed specific prescriptions of each action class. The HCC assumed that Scenario 2 would fall somewhere in between scenarios 1 and 3.

Scenario 3.—Scenario 3 was designed to provide perspective on “what if” we only applied 1/3 intensity for each of the action classes. It seemed logical that feasibility of certain action classes would be constrained due to social or economic factors. However, we did not have a final list of intensities for each action class and assessment unit. Therefore, 1/3 of full intensity was selected to provide an alternative level of reduced effort for the habitat action plan, without making judgments about exactly where higher and lower intensities were feasible. Scenario 3, though not grounded in reality, provides insight to species performance measures given an alternative application of the action classes that address limiting factors in each of the assessment units. The only exceptions to the 1/3 intensity application were regarding obstructions and protection. We assumed that all artificial fish migration obstructions would be fixed and maintained, and that the same protection strategies and intensities as Scenario 1 would occur with Scenario 3.

The cumulative change to each attribute from the implementation of all action classes in scenario 1 can be seen in **Table F14**. The values in **Table F14** were obtained by multiplying the effectiveness ratings by 0.33 then summing all action classes (**Table F11**) that addressed limiting factors in each assessment unit (Tables 5.7-5.10).

PFC.—EDT Scenario Builder is hard-wired to provide Properly Functioning Conditions (PFC), which was initially based on many of the targets listed in the “matrix of pathways and indicators” for functional habitat conditions (NMFS 1996). PFC for EDT was further developed and applied in the Puget Sound Recovery Planning process. We did not review and edit PFC specifically for the Upper Columbia watersheds, so we do not have confidence that the values represent reasonable objectives for the watersheds of the Upper Columbia. However, we included a PFC run in our model output to be consistent with the use of EDT in other areas in Washington State and because we were interested in comparing the results of our scenarios to PFC and possibly evaluating the similarities and differences in attribute objectives in the future.

Table F14. The cumulative change to each EDT environmental attribute from the implementation of all action classes in scenario 3 for the Wenatchee subbasin. The values in were obtained by multiplying the effectiveness ratings by 0.33 then summing all action classes that addressed limiting factors in each assessment unit

Environmental Attribute	Lower Wenatchee Mainstem	Mission Ck	Lower Peshastin Ck	Upper Peshastin Ck	Derby Ck	Chumstick Ck	Lower Icicle Creek	Upper Icicle Creek	Tumwater Canyon	Chiwaukum	Upper Wenatchee Mainstem	Beaver Ck	Chiwawa River	Lower Nason Ck	Upper Nason Ck	Lake Wenatchee	Little Wenatchee	White River
Flow High	0.15	0.30	0.20	0.40	0.30	0.30	0.20	0.10	0.10	0.40	0.10	0.30	0.10	0.20	0.10	0.10	0.10	0.10
Flow Low	0.30	0.30	0.30	0.20	0.30	0.30	0.30	0.10	0.10	0.40	0.10	0.30	0.10	0.30	0.10	0.10	0.10	0.10
Flow Diel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Flow Intra-Annual	0.05	0.20	0.10	0.30	0.20	0.20	0.10	0.10	0.10	0.30	0.10	0.20	0.10	0.10	0.10	0.10	0.10	0.10
Regime Natural	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Regime Regulated	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Channel Length	0.10	0.05	0.10	0.30	0.05	0.05	0.10	0.25	0.25	0.30	0.25	0.05	0.25	0.10	0.25	0.25	0.25	0.25
Width Max	0.00	0.05	0.05	0.30	0.05	0.05	0.05	0.25	0.25	0.30	0.25	0.05	0.25	0.05	0.25	0.25	0.25	0.25
Width Min	0.25	0.25	0.25	0.40	0.25	0.25	0.25	0.25	0.25	0.50	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Gradient	0.02	0.02	0.02	0.27	0.02	0.02	0.02	0.25	0.25	0.27	0.25	0.02	0.25	0.02	0.25	0.25	0.25	0.25
Natural Confinement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Confinement-Hydro	0.23	0.32	0.27	0.42	0.32	0.32	0.27	0.10	0.10	0.42	0.10	0.32	0.10	0.27	0.10	0.10	0.10	0.10
Habitat-backwater pools	0.05	0.02	0.05	0.27	0.02	0.02	0.05	0.25	0.25	0.27	0.25	0.02	0.25	0.05	0.25	0.25	0.25	0.25

Environmental Attribute	Lower Wenatchee Mainstem	Mission Ck	Lower Peshastin Ck	Upper Peshastin Ck	Derby Ck	Chumstick Ck	Lower Icicle Creek	Upper Icicle Creek	Tumwater Canyon	Chiwaukum	Upper Wenatchee Mainstem	Beaver Ck	Chiwawa River	Lower Nason Ck	Upper Nason Ck	Lake Wenatchee	Little Wenatchee	White River
Habitat-beaver ponds	0.00	0.02	0.02	0.27	0.02	0.02	0.02	0.25	0.25	0.27	0.25	0.02	0.25	0.02	0.25	0.25	0.25	0.25
Habitat glides	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Habitat-Large cobble	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Habitat-Small cobble	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Habitat Pool Tailouts	0.03	0.20	0.12	0.45	0.20	0.20	0.12	0.25	0.25	0.45	0.25	0.20	0.25	0.12	0.25	0.25	0.25	0.25
Habitat-Pools	0.03	0.25	0.15	0.50	0.25	0.25	0.15	0.25	0.25	0.50	0.25	0.25	0.25	0.15	0.25	0.25	0.25	0.25
Habitat-Off channel Habitat	0.12	0.07	0.10	0.32	0.07	0.07	0.10	0.25	0.25	0.32	0.25	0.07	0.25	0.10	0.25	0.25	0.25	0.25
Obstructions	0.90	0.90	0.90	1.15	0.90	0.90	0.90	1.15	1.15	1.15	1.15	0.90	1.15	0.90	1.15	1.15	1.15	1.15
Water Withdrawal	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Bed Scour	0.25	0.38	0.30	0.63	0.38	0.38	0.30	0.25	0.25	0.63	0.25	0.38	0.25	0.30	0.25	0.25	0.25	0.25
Icing	0.00	0.02	0.00	0.27	0.02	0.02	0.00	0.25	0.25	0.27	0.25	0.02	0.25	0.00	0.25	0.25	0.25	0.25
Riparian Functions	0.22	0.32	0.32	0.57	0.32	0.32	0.32	0.25	0.25	0.57	0.25	0.32	0.25	0.32	0.25	0.25	0.25	0.25
Wood	0.22	0.35	0.35	0.60	0.35	0.35	0.35	0.25	0.25	0.60	0.25	0.35	0.25	0.35	0.25	0.25	0.25	0.25
Embeddedness	0.17	0.33	0.27	0.43	0.33	0.33	0.27	0.10	0.10	0.43	0.10	0.33	0.10	0.27	0.10	0.10	0.10	0.10
Fine sediment	0.17	0.33	0.27	0.43	0.33	0.33	0.27	0.10	0.10	0.43	0.10	0.33	0.10	0.27	0.10	0.10	0.10	0.10

Environmental Attribute	Lower Wenatchee Mainstem	Mission Ck	Lower Peshastin Ck	Upper Peshastin Ck	Derby Ck	Chumstick Ck	Lower Icicle Creek	Upper Icicle Creek	Tumwater Canyon	Chiwaukum	Upper Wenatchee Mainstem	Beaver Ck	Chiwawa River	Lower Nason Ck	Upper Nason Ck	Lake Wenatchee	Little Wenatchee	White River
Turbidity	0.05	0.20	0.10	0.30	0.20	0.20	0.10	0.10	0.10	0.30	0.10	0.20	0.10	0.10	0.10	0.10	0.10	0.10
Alkalinity	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Dissolved O2	0.22	0.25	0.22	0.45	0.25	0.25	0.22	0.25	0.25	0.50	0.25	0.25	0.25	0.22	0.25	0.25	0.25	0.25
Metals Water Column	0.30	0.30	0.30	0.55	0.30	0.30	0.30	0.25	0.25	0.55	0.25	0.30	0.25	0.30	0.25	0.25	0.25	0.25
Metal sediment	0.30	0.30	0.30	0.55	0.30	0.30	0.30	0.25	0.25	0.55	0.25	0.30	0.25	0.30	0.25	0.25	0.25	0.25
Misc Toxic pollutants	0.35	0.35	0.35	0.60	0.35	0.35	0.35	0.25	0.25	0.60	0.25	0.35	0.25	0.35	0.25	0.25	0.25	0.25
Nutrient Enrichment	0.30	0.30	0.30	0.55	0.30	0.30	0.30	0.25	0.25	0.55	0.25	0.30	0.25	0.30	0.25	0.25	0.25	0.25
Temp Max	0.18	0.32	0.20	0.47	0.32	0.32	0.20	0.25	0.25	0.57	0.25	0.32	0.25	0.20	0.25	0.25	0.25	0.25
Temp Min	0.05	0.10	0.05	0.35	0.10	0.10	0.05	0.25	0.25	0.35	0.25	0.10	0.25	0.05	0.25	0.25	0.25	0.25
Temp Spatial Variation	0.08	0.23	0.17	0.48	0.23	0.23	0.17	0.25	0.25	0.48	0.25	0.23	0.25	0.17	0.25	0.25	0.25	0.25
Fish Community Richness	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Fish Pathogens	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Fish Species Intro	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Harassment	0.30	0.30	0.30	0.40	0.30	0.30	0.30	0.10	0.10	0.40	0.10	0.30	0.10	0.30	0.10	0.10	0.10	0.10
Hatchery outplants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Environmental Attribute	Lower Wenatchee Mainstem	Mission Ck	Lower Peshastin Ck	Upper Peshastin Ck	Derby Ck	Chumstick Ck	Lower Icicle Creek	Upper Icicle Creek	Tumwater Canyon	Chiwaukum	Upper Wenatchee Mainstem	Beaver Ck	Chiwawa River	Lower Nason Ck	Upper Nason Ck	Lake Wenatchee	Little Wenatchee	White River
Predation Risk	0.05	0.05	0.05	0.30	0.05	0.05	0.05	0.25	0.25	0.30	0.25	0.05	0.25	0.05	0.25	0.25	0.25	0.25
Salmon Carcass	0.05	0.02	0.02	0.47	0.02	0.02	0.02	0.35	0.30	0.47	0.30	0.02	0.35	0.02	0.45	0.30	0.35	0.35
Benthic Comm Rich	0.27	0.32	0.23	0.60	0.32	0.32	0.23	0.32	0.32	0.62	0.32	0.32	0.32	0.23	0.35	0.32	0.32	0.32

Habitat Template.—This model run is currently referred to as “historical” in the online EDT model, however, it only represents estimated historical habitat conditions (template) and current Columbia River mainstem conditions. This is fundamentally different than a true template, which estimates salmon performance with historic habitat and historic Columbia River mainstem conditions (i.e. no hydropower system). The habitat template allows us to evaluate fish performance relevant to what can be accomplished in the tributaries, because out-of-subbasin-effects (OOSE) generally dominate the mortality factors that effect capacity, abundance, and productivity of fish populations (Methow Subbasin Plan, NPPC 2004).

True Template.—A true template model run (historic habitat, historic mainstem) allowed us to evaluate the effectiveness of habitat actions relevant to “whole life cycle” mortality. In conjunction with other methods, it was helpful in integrating across various mortality sectors of each fish population.

F.4 Model Output Analysis Methods

We will only attempt to describe the methods that we used to analyze the results that EDT provided. There are a number of documents, available on-line, that explain the basics of how EDT works as well as all the formulas that derive the relationships between habitat conditions and fish life stage survival (www.mobrand.com).

F.4.1 Percent Increase Relative to Current

It is not possible, at this time, to thoroughly explain all the methods and assumptions used to populate the EDT model for the Upper Columbia subbasins because they are each comprised of tens of thousands of data points compiled from various sources of empirical data and expert opinion. Reviews of the level of proof and quality of information for environmental attribute ratings can be found in CCCD (2004) for the Entiat, NPPC (2004) for the Methow and Okanogan, and section F.1 (of this Appendix) for the Wenatchee. See section F.6 for a more detailed discussion of assumptions and model sensitivity.

Because of these uncertainties, we avoided using the EDT output as a predictor of absolute change, but rather an indicator of the potential for change based on relative increases over the current condition and the proportion of in-basin potential that could be realized under different scenarios. The relative change (percent) compared to the current condition were calculated for each EDT performance measure (Diversity Index, Productivity, Capacity, Abundance) by the equation:

$$R_x = \frac{S_x - S_c}{S_c}$$

where R_x was the relative change in the performance measure (x), S_x was the scenario being evaluated, and S_c was our scenario for current conditions.

F.4.2 Proportion of In-basin Potential

We used the proportion of in-basin potential to isolate how effective the restoration and protection scenarios were at capturing the potential for each performance measure (abundance, productivity, and diversity index) just within the subbasin habitat. The proportion of in-basin potential that was realized by each scenario was calculated by the equation:

$$P_x = \frac{S_x}{S_t}$$

where Px was the proportion of in-basin potential realized for each performance measure (x), S_x was the scenario being evaluated, and S_t was the scenario for the habitat template.

Unfortunately, there were no recovery criteria or standards to compare these results to and come to a conclusion regarding “how much is enough?”. We recognize that the future desired conditions, as a result of scenario implementation, will have to be compared to socioeconomic constraints to determine if the actions in the habitat have done all they could. For now, this measure should be viewed as general guidance regarding how effective the scenarios are at reaching the habitat’s potential.

F.4.3 Comparison of EDT to VSP

Abundance.—Abundance was the only parameter that could be directly compared to the VSP criteria from the ICTRT. However, due to uncertainty regarding the accuracy of changes to abundance predicted by EDT, we compared percent increase predicted by EDT to the percent increase needed to achieve the ICTRT minimum abundance threshold. We also qualitatively considered the relationship between the EDT estimate of abundance and the empirical estimate of abundance, but did not apply the restoration benefits to the empirical estimates. These estimates were generally close to one another and we believed the conclusions would have been the same, considering the variance of the empirical estimates and the uncertainty of the EDT predictions. Therefore, the results should be viewed as a likely trajectory and monitoring efforts in the future will have to determine the empirical abundance as a measure of recovery.

An important factor in considering the results of the scenarios was the smolt-to-adult survival rates (SAR) used in EDT. The SAR back to the spawning grounds in EDT has a huge effect on abundance, and changes or inaccuracies in SAR will skew the observed benefits from habitat restoration actions. The smolt to adult return rates (SAR) in EDT were developed during the subbasin planning process and we did not attempt to validate or alter them (www.nwppc.org). We reported the SAR with each model output so that fish performance measures could be put into perspective relative to the SAR used to generate it. The one case where we had an empirical estimate of SAR for a wild stock (Chiwawa spring Chinook) suggested that EDT overestimated the SAR and therefore the EDT projections of abundance relative the ICTRT minimum threshold would be overly optimistic or only representative of periods with relatively high ocean survival. Another perspective was that the EDT prediction represents a future condition where SAR’s have improved due to decreased mortality in the Columbia River Mainstem, Estuary, or Ocean.

Productivity.—The EDT performance measure “Productivity” could not be directly compared to productivity on the ICTRT viability curve because EDT reports the slope of the Beverton-Holt stock recruitment function at the y-intercept (theoretically = 2 spawners), whereas the ICTRT viability curve requires a prediction of the hockey stick stock recruitment function at generally low abundances (above the y-intercept). Therefore, we will only discuss the relative trends in productivity and qualitatively evaluate if the changes might be adequate to achieve VSP.

Additionally, it is useful to examine the relative changes observed between EDT scenarios and to evaluate how much additional improvement might be possible based on the proportion of in-basin potential.

Diversity Index.—The life history diversity index in EDT is not directly comparable to spatial structure and diversity in a VSP risk assessment. The EDT diversity index should correlate with several of the ICTRT metrics for evaluating spatial structure and diversity; however, it cannot be compared directly to any of them. EDT did not consider genetic variation and the possible genetic influences of hatchery fish on the spawning grounds. The EDT diversity index is a measure of the proportion of historic life history pathways that are available to the fish populations. Its generated by first testing all possible (productivity > 1.0) life history trajectories under template conditions. A trajectory is a life history pathway that starts in one of the spawning reaches and moves through time and space in the environment that was defined by the reach structure and environmental attribute ratings. Complete methods for how MBI created, rejected, and accepted trajectories were not available for the Upper Columbia watersheds.

We will only discuss general trends in the change to the EDT diversity index with the assumption that large changes in the index were indicators and high proportions of in-basin potential were indicators that the restoration actions were effective at providing an opportunity for spatial structure and diversity to be expressed. We recognize that empirical estimates of changes to distribution, genotype, phenotype, spawner composition, and selective pressures will have to be monitored to determine the effectiveness of the actions at improving spatial structure and diversity for a viable salmonid population.

F.5 EDT Scenario Results and Comparison to VSP

F.5.1 Wenatchee Spring Chinook

Abundance.—The accuracy of EDT for spring Chinook in the Wenatchee was difficult to evaluate. The model output for abundance was considerably higher (1604 adult spawners) than the 12-year geometric mean (444 adult spawners; 1992-2003; **Table 2.1**). Much of this difference was due to an SAR that was too high in the EDT model. EDT used an SAR (back to the spawning grounds) of 1.36%, whereas recent studies on the Chiwawa River have estimated an 8-year geometric mean of only (0.63%). This empirical estimate of SAR would have dropped the adult abundance in EDT to 741 fish. Additionally, the variance of the abundance estimate was high with a standard deviation of 1225 fish and a coefficient of variation of 2.76. Therefore, we concluded that the EDT estimate was within an acceptable error range to be used for planning purposes, when compared to recent abundance estimates. Additionally, there could be other factors, such as genetic fitness, that are not accounted for in the modeling estimates.

Scenarios 1 and 3 predicted 69% and 56% increases in abundance, respectively, suggesting that both scenarios would be effective at moving the population abundance in a positive direction (**Table F15**; **Figure F8**). Scenario 3 captured 59% of the proportion of in-basin potential, whereas Scenario 1 captured 64%. We conducted a series of additional model runs to test the EDT model's sensitivity to our assumptions and help explain the magnitude of the changes from current conditions to future conditions under each scenario. Additionally, we wanted to be able to explain why the model predicted relatively small differences between S1 and S3. See section F.6 for the results of these test model runs. In general, the small difference between S3 and S1 was because the large quantities of relatively pristine habitat in the Upper Wenatchee Mainstem, Tumwater Canyon, Chiwawa, White, and Little Wenatchee Rivers were mostly unaffected by the restoration action classes. Conversely, the habitat below Tumwater Canyon were smaller, shorter, and of lower quality so when a higher intensity of action class was applied, there was a relatively small improvement at the population scale.

Additionally, the same intensity of protection and obstruction action classes were applied to each scenario. Additional gains in abundance could be achieved by increasing the habitat quality in the lower and middle mainstem (below Tumwater Canyon) and by addressing secondary limiting factors (see section F.6 for details).

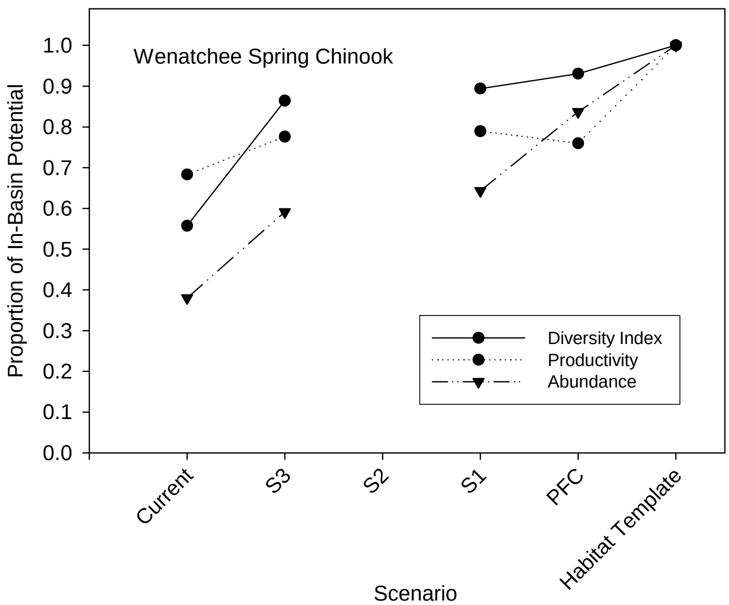
Table F15 Performance measures of Wenatchee spring Chinook based on EDT modeling scenarios using an SAR of 1.36% back to the spawning grounds. Scenario 1 (S1) applied the full effectiveness of the restoration action classes that addressed primary limiting factors within each assessment unit. Scenario 3 (S3) was 33% of the intensity of S1, with full effect of artificial barrier removal and protection. PFC was properly functioning conditions, the habitat template was historic pristine habitat with current mainstem conditions, and true template was historic habitat, historic mainstem conditions. Scenario 2 (S2) (assessment unit specific intensities based on feasibility) was not available for this analysis

		Adult Performance					Juvenile Performance		
Population	**Scenario**	**Diversity index**	**Productivity**	**Capacity**	**Abundance**	**Abundance with 0.63% SAR**	**Juvenile Productivity**	**Juvenile Capacity**	**Juvenile Abundance**
Wenatchee Spring Chinook	Current without harvest	48%	4.4	2071	1604	741	236	170,763	117,619
	Scenario 3	75%	5.0	3,114	2,496	1,085	271	231,024	172,176
	Scenario 2								
	Scenario 1	78%	5.1	3,372	2,714	1,209	288	254,307	191,831
	PFC	81%	4.9	4,432	3,534	1,620	287	344,491	257,222
	Habitat Template	87%	6.5	4,990	4,221	1,922	376	377,537	305,060
	True Template	97%	26.8	23,978	23,084				

		Increase relative to current					Increase relative to current		
Wenatchee Spring Chinook	Current without harvest	0%	0%	0%	0%	0%	0%	0%	0%
	Scenario 3	55%	14%	50%	56%	46%	15%	35%	46%

	Scenario 2								
	Scenario 1	60%	16%	63%	69%	63%	22%	49%	63%
	PFC	67%	11%	114%	120%	119%	22%	102%	119%
	Habitat Template	79%	46%	141%	163%	159%	60%	121%	159%
	True Template	100%	504%	1058%	1339%				

		Proportion of In-basin Potential					**Proportion of In-basin Potential**		
	Current without harvest	56%	68%	42%	38%	39%	63%	45%	39%
	Scenario 3	86%	78%	62%	59%	56%	72%	61%	56%
	Scenario 2								
Wenatchee Spring Chinook	Scenario 1	89%	79%	68%	64%	63%	76%	67%	63%
	PFC	93%	76%	89%	84%	84%	76%	91%	84%
	Habitat Template	100%	100%	100%	100%	100%	100%	100%	100%
	True Template								



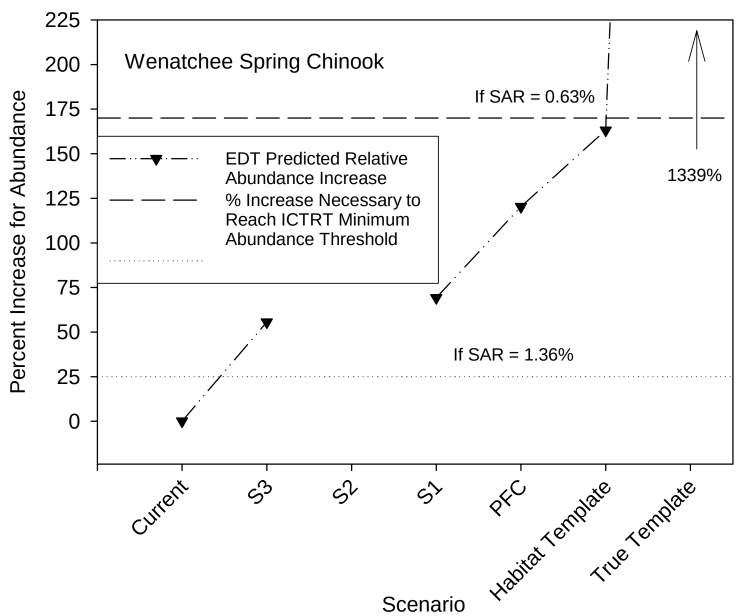


Figure F8. EDT model predictions for spring Chinook in the Wenatchee subbasin. Scenario 1 (S1) applied the full effectiveness of the restoration action classes that addressed primary limiting factors within each assessment unit. Scenario 3 (S3) was 33% of the intensity of S1, with full effect of artificial barrier removal and protection. PFC was properly functioning conditions, the habitat template was historic pristine habitat with current mainstem conditions, and true template was historic habitat and historic mainstem. Scenario 2 (S2) (assessment unit specific intensities based on feasibility) was not available at the time of this analysis. Alternative SAR values were based on those used in EDT (1.36%) and empirical estimates (0.63%).

The conclusions of our modeling scenarios stress the importance of protecting the intact habitat in the upper watershed, along with restoring the mainstem Wenatchee rearing areas for overwintering subyearling migrants. Although EDT predicted a relatively low benefit to abundance (and productivity) through restoration actions in the more degraded assessment units below Tumwater Canyon, these areas were determined to be important for spatial structure and diversity in the VSP risk assessment (particularly Peshastin Creek), so the value of restoring them should not be overlooked based on modeling results with respect to abundance.

The EDT model predicted that in-basin restoration and protection actions could achieve the ICTRT minimum threshold abundance (2000 spawners) for the Wenatchee spring Chinook population for scenarios 1 and 3 (**Figure F8**), assuming an SAR of 1.36%. However, with the empirically derived SAR from 1993-2000 (0.63%; WDFW unpublished data), both recovery scenarios and even the habitat template would not reach the minimum abundance threshold. Although the average of the five highest years SAR was 1.28% (1995-1999, 2001). These results stress the importance of integrating habitat-based productivity (smolts/redd) versus whole life cycle productivity (including SAR) to understand the mechanisms driving population performance related to recovery actions. Integration of the habitat actions identified in this plan with the other 3 H's will be necessary to achieve recovery abundance levels, especially when considered simultaneously with productivity using the viability curve.

Productivity.— The recovery actions increased the proportion of in-basin potential from 68% (Current) to 78% (S3) and 79% (S1). Additionally, the increase in productivity relevant to the current condition was 14% (S3) and 16% (S1), suggesting that both scenarios were effective at moving the population productivity in a positive direction but that neither had much room for improvement relevant to what is needed for recovery (**Table F15**). However, Wenatchee spring Chinook need to improve their productivity from 0.74 (12 yr geomean as of 1999) to 1.2 (viability curve minimum) which represents an increase of 62%. Therefore, we conclude that there is no combination of restoration and protection actions to habitat conditions, within the Wenatchee subbasin, that would be adequate to achieve a viable population of spring Chinook with respect to productivity. Integration of the habitat actions identified in this plan with the other 3 H's will be necessary to achieve recovery.

Increasing the restoration intensity (beyond S1) in the middle and lower mainstem did not improve productivity, as it did abundance. Additional gains in productivity were predicted with increased passive restoration in the upper watersheds and addressing secondary limiting factors such as competition, predation, and harassment (see section F.6).

Diversity Index.— The diversity index for spring Chinook in the Wenatchee basin improved from 48% to 75% for Scenario 3 and 78% for Scenario 1, indicating that the recovery scenarios effectively provided an opportunity for the expression of the majority of the life history pathways. All obstructions were made passable for both scenarios so the change in the diversity index from S3 to S1 was due to improved habitat quality in areas that affected survival of early or late migrating smolts or adults. Additional contributions to increased life history diversity came from increased survival of eggs and fry that were produced earlier or later than normal. See Appendix B to better understand the kinds of actions and improvements that would be needed to achieve low risk for spatial structure and diversity beyond the habitat related action classes that were modeled in EDT.

F.5.2 Entiat Spring Chinook

Action alternative 5 of the Entiat watershed plan represents Scenario 2 of this plan because it was the watershed group's mix and match of action classes and intensities. For consistency with the watershed plan, we will continue to refer to the recovery scenario for Entiat habitat as action alternative 5 (CCCD 2004). We could not analyze the Entiat with respect to the proportion of in-basin potential because there was not a habitat template model run in the watershed plan.

Abundance.—The EDT model predicted an abundance (138) of spring Chinook that was similar to empirical estimates (12-year geometric meant = 108 spawners; 1992-2003). Action alternative 5 increased the abundance of spring Chinook by 36% over current conditions but still fell short of the ICTRT minimum threshold by a considerable margin (262%).

Productivity.—The EDT model predicted a 5% increase in productivity for spring Chinook in the Entiat for scenario 5. To reach the ICTRT minimum abundance threshold the Entiat would need to improve its productivity from 0.76 to 1.4 (84%).

Diversity Index.—The EDT model predicted that the Entiat spring Chinook diversity index would increase from 35% (current) to 50% (action alternative 5).

F.5.3 Methow spring Chinook

Abundance.—The accuracy of EDT for spring Chinook in the Methow was difficult to evaluate due to the influence of hatchery fish. The EDT abundance (535) estimate was very close to the 12-year geometric mean abundance (480 spawners; 1988-1999). In recent years with higher abundance (2001 and 2002) there was 2200-8400 hatchery fish on the spawning grounds, making it impossible to determine if the natural population is responding to the capacity of the habitat.

Scenarios 1 and 3 predicted a 124% and 54% increase in abundance, respectively, suggesting that both scenarios were effective at moving the population abundance in a positive direction (**Table F16**; **Figure F9**). Scenario 3 only captured 36% of the in-basin potential, suggesting that there may be additional limiting factors that were not adequately addressed. This deficiency was probably not just a factor of intensity because Scenario 1 only utilized 53% of the in-basin potential with a relatively large gap between Scenario 1 and PFC (80%). Or, it could be that the effectiveness assumptions underestimated the effectiveness of the action classes. Future efforts should first determine the model input and processing mechanisms that lead to this discrepancy to determine if the difference makes sense with respect to ecological interactions or if the problem was with model application. To better understand the models sensitivity to our scenarios see the sensitivity analysis conducted on the Wenatchee populations.

The EDT model predicted that in-basin restoration and protection actions could not achieve the minimum threshold abundance (2000 spawners) for the Methow spring Chinook population under any scenario except Historic Template (**Figure F9**). This result was obtained with an SAR of 1.241% back to the spawning grounds, which was probably an overestimate because the 8-year (1993-2000) geometric mean SAR for wild Chiwawa River spring Chinook was only 0.63% and Chiwawa River fish have 2 fewer dams to negotiate. Therefore, we conclude that there is no combination of restoration and protection actions to habitat conditions, within the Methow subbasin, that would be adequate to achieve a viable population of spring Chinook with respect to abundance. Integration of the habitat actions identified in this plan with the other 3 H's will be necessary to achieve recovery.

Productivity.—The recovery actions increased the proportion of in-basin potential from 43% (Current) to 51% (S3) and 66% (S1). Additionally, the increase in productivity relevant to the current condition was 17% (S3) and 53% (S1), suggesting that both scenarios were effective at moving the population productivity in a positive direction (**Table F16**; **Figure F9**). However, Methow spring Chinook need to improve their productivity from 0.51 (12 yr geomean as of 1999) to 1.2 (viability curve minimum) which represents an increase of 135%. Therefore, we conclude that there is no combination of restoration and protection actions to habitat conditions, within the Methow subbasin, that would be adequate to achieve a viable population of spring Chinook with respect to productivity. Integration of the habitat actions identified in this plan with the other 3 H's will be necessary to achieve recovery.

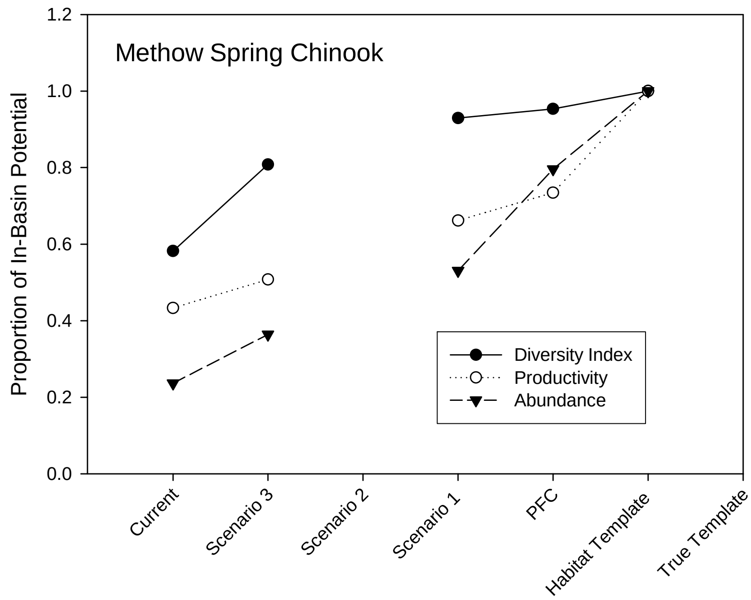
Diversity Index.—The diversity index for spring Chinook in the Methow improved from 58% to 77% for Scenario 3 and 89% for Scenario 1 indicating that the modeling scenarios were effective at provided an opportunity for the expression of the majority of the life history pathways (**Table F16**). All obstructions were made passable for both scenarios so the change in the diversity index from S3 to S1 was due to improved habitat quality in areas that affected survival of early or late migrating smolts or adults. Additional contributions to increased life history diversity came from increased survival of eggs and fry that were produced earlier or later than normal. See Appendix B to better understand the kinds of actions

Table F16 Performance measures of Methow spring Chinook based on EDT modeling scenarios that used an SAR of 1.24 %, back to the spawning grounds. Scenario 1 (S1) applied the full effectiveness of the restoration action classes that addressed primary limiting factors within each assessment unit. Scenario 3 (S3) was 33% of the intensity of S1, with full effect of artificial barrier removal and protection. PFC was properly functioning conditions, the habitat template was historic pristine habitat with current mainstem conditions, and true template was historic habitat, historic mainstem conditions. Scenario 2 (S2) (assessment unit specific intensities based on feasibility) was not available for this analysis

		Adult Performance				Juvenile Performance		
Population	Scenario	Diversity index	Productivity	Capacity	Abundance	Juvenile Productivity	Juvenile Capacity	Juvenile Abundance
	Current without harvest	56%	1.9	1,116	535	122	84,045	36,802
	Scenario 3	77%	2.3	1,482	823	139	96,584	52,432
	Scenario 2							
Methow Spring Chinook	Scenario 1	89%	2.9	1,821	1,200	173	110,642	72,158
	PFC	91%	3.3	2,600	1,801	186	151,438	104,213
	Habitat Template	96%	4.4	2,922	2,263	249	168,097	129,483
	True Template	100%	22.9	10,874	10,400			
		% Increase relative to current				% Increase relative to current		
Methow Spring Chinook	Current without harvest	0%	0%	0%	0%	0%	0%	0%
	Scenario 3	39%	17%	33%	54%	14%	15%	42%
	Scenario 2							
	Scenario 1	60%	53%	63%	124%	41%	32%	96%

	PFC	64%	69%	133%	237%	52%	80%	183%
	Habitat Template	72%	131%	162%	323%	104%	100%	252%
	True Template	80%	1092%	875%	1844%			

		Proportion of In-basin Potential				Proportion of In-basin Potential		
	Current without harvest	58%	43%	38%	24%	49%	50%	28%
	Scenario 3	81%	51%	51%	36%	56%	57%	40%
	Scenario 2	NR	NR	NR	NR	NR	NR	NR
Methow Spring Chinook	Scenario 1	93%	66%	62%	53%	69%	66%	56%
	PFC	95%	73%	89%	80%	74%	90%	80%
	Habitat Template	100%	100%	100%	100%	100%	100%	100%
	True Template	NA	NA	NA	NA	NA	NA	NA



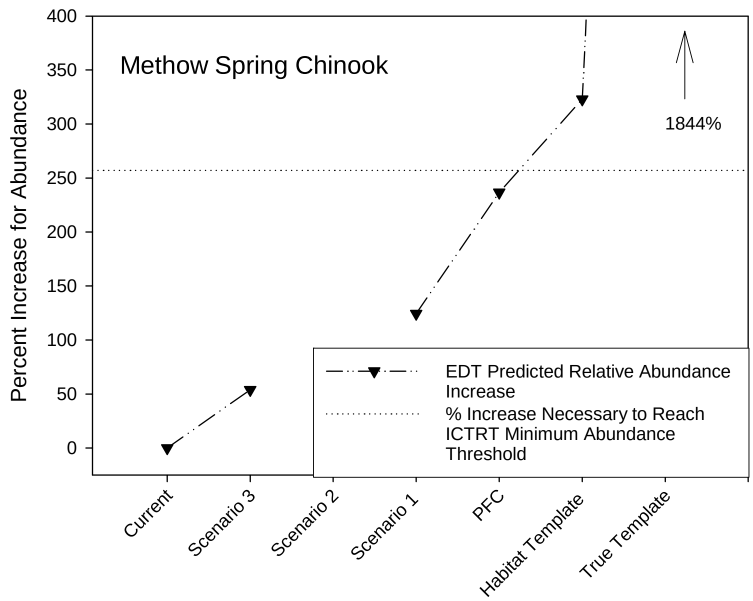


Figure F9. EDT model predictions for spring Chinook in the Methow subbasin, assuming an SAR of 1.24% back to the spawning grounds. Scenario 1 (S1) applied the full effectiveness of the restoration action classes that addressed primary limiting factors within each assessment unit. Scenario 3 (S3) was 33% of the intensity of S1, with full effect of artificial barrier removal and protection. PFC was properly functioning conditions, the habitat template was historic pristine habitat with current mainstem conditions, and true template was historic habitat and historic mainstem. Scenario 2 (S2) (assessment unit specific intensities based on feasibility) was not available at the time of this analysis.

and improvements that would be needed to achieve low risk for spatial structure and diversity beyond the habitat related action classes that were modeled in EDT.

F.5.4 Wenatchee Steelhead

Abundance.— The accuracy of EDT and comparisons to empirical estimates for steelhead in the Wenatchee were difficult to evaluate due to the influence of hatchery fish and the uncertainty of actual spawners because redd counts were not available for a long enough time series. Regardless, the EDT abundance estimate (528) was fairly close to the 12-year geometric mean abundance of wild fish on the spawning grounds (716 spawners; 1992-2003; **Table 2.4**). Statistical tests would not be valid when comparing modeling results with unknown error bounds to empirical estimates; however, the empirical estimate has a standard deviation of 742 fish (not reported in **Table 2.4**). Therefore, given the high variance of the empirical estimate we assumed that the EDT model was an adequate representation of Wenatchee steelhead.

Scenarios 1 and 3 predicted a 102% and 89% increase in abundance, respectively, suggesting that both scenarios were effective at moving the population abundance in a positive direction (**Table F17**; **Figure F10**). A sensitivity model run revealed that the majority of the benefit to steelhead came from the obstruction removal (48%) and protection measures (11%)(section F.6). This would partially explain the relatively small difference between S1 and S3. S1 and S3 captured 66% and 62% of the in-basin potential, respectively, suggesting that there may be additional limiting factors that were not adequately addressed by the action classes that were applied to the limiting factors from the recovery matrix. See section F.5 for additional analysis of EDT attributes and model sensitivity for Wenatchee steelhead scenarios.

The EDT model predicted that in-basin restoration and protection actions would just barely achieve the minimum threshold abundance (1000 spawners) for the Wenatchee steelhead population for S3 and S1 (**Table F17**; **Figure F10**). This result was obtained with an SAR of 1.257% back to the spawning grounds, which was probably an overestimate of actual SAR (if the comparison of Chiwawa River spring Chinook SAR to EDT SAR correlates with steelhead). However, there are no data for empirical estimates of SAR for wild Wenatchee steelhead. Additionally, the model predicted changes that would not put abundance far enough past the minimum abundance threshold to achieve recovery with any certainty, particularly when incorporating the error bounds around the empirical estimate. Therefore, we conclude that the habitat recovery actions are not likely to achieve the VSP minimum abundance threshold suggested by the ICTRT and integration with the other 3 H’s will be necessary to achieve recovery.

Productivity.—The recovery actions increased the proportion of in-basin potential from 65% (Current) to 70% (S3) and 72% (S1). We believe that achieving over 70% of the in-basin potential represents a very good level of achievement in the habitat, particularly considering that the PFC scenario resulted in 75% the in-basin potential and the PFC

Table F17 Performance measures of Wenatchee steelhead based on EDT modeling scenarios that used an SAR of 1.26%, back to the spawning grounds. Scenario 1 (S1) applied the full effectiveness of the restoration action classes that addressed primary limiting factors within each assessment unit. Scenario 3 (S3) was 33% of the intensity of S1, with full effect of artificial barrier removal and protection. PFC was properly functioning conditions, the habitat template was historic pristine habitat with current mainstem conditions, and true template was historic habitat, historic mainstem conditions. Scenario 2 (S2) (assessment unit specific intensities based on feasibility) was not available for this analysis

		Adult Performance				Juvenile Performance		
Population	**Scenario**	**Diversity index**	**Productivity**	**Capacity**	**Abundance**	**Juvenile Productivity**	**Juvenile Capacity**	**Juvenile Abundance**
Wenatchee Steelhead	Current without harvest	25%	2.5	883	528	166	80,948	42,117
	Scenario 3	65%	2.7	1,590	1,000	171	119,590	70,344
	Scenario 2							
	Scenario 1	72%	2.8	1,668	1,068	176	124,419	74,812
	PFC	78%	2.9	2,021	1,321	182	149,971	92,397
	Habitat Template	85%	3.8	2,200	1,626	242	162,348	114,935
	True Template	91%	11.3	6,457	5,884			
		Increase relative to current				**Increase relative to current**		
Wenatchee Steelhead	Current without harvest	0%	0%	0%	0%	0%	0%	0%
	Scenario 3	164%	8%	80%	89%	3%	48%	67%
	Scenario 2							

	Scenario 1	192%	12%	89%	102%	6%	54%	78%
	PFC	218%	16%	129%	150%	10%	85%	119%
	Habitat Template	245%	54%	149%	208%	46%	101%	173%
	True Template	270%	354%	631%	1014%			

		Proportion of In-basin Potential				**Proportion of In-basin Potential**		
Wenatchee Steelhead	Current without harvest	29%	65%	40%	32%	69%	50%	37%
	Scenario 3	77%	70%	72%	62%	71%	74%	61%
	Scenario 2							
	Scenario 1	85%	72%	76%	66%	73%	77%	65%
	PFC	92%	75%	92%	81%	75%	92%	80%
	Habitat Template	100%	100%	100%	100%	100%	100%	100%

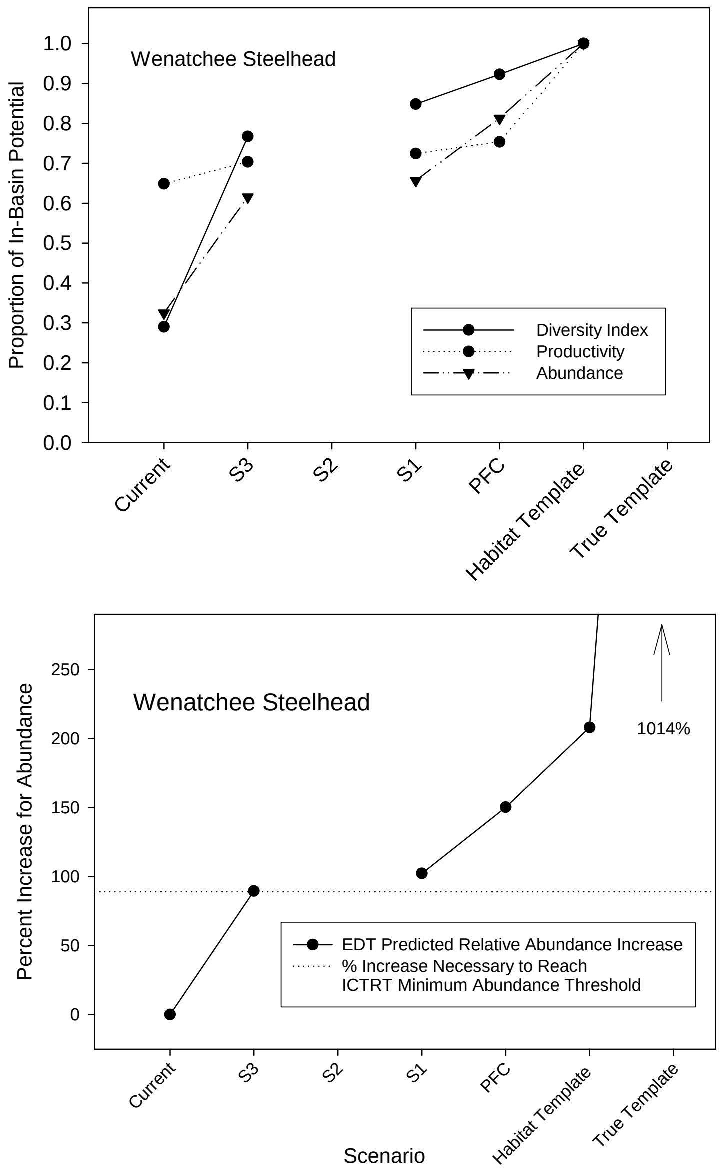


Figure F10. EDT model predictions for steelhead in the Wenatchee subbasin, assuming an SAR of 1.26% back to the spawning grounds. Scenario 1 (S1) applied the full effectiveness of the restoration action classes that addressed primary limiting factors within each assessment unit. Scenario 3 (S3) was 33% of the intensity of S1, with full effect of artificial barrier removal and protection. PFC was properly functioning conditions, the habitat template was historic pristine habitat with current mainstem conditions, and true template was historic habitat and historic mainstem. Scenario 2 (S2) (assessment unit specific intensities based on feasibility) was not available at the time of this analysis. Alternative SAR values were based on those used in EDT (1.36%) and empirical estimates (0.63%).

attribute ratings were generally considered unrealistic based on societal constraints. The increase in productivity relevant to the current condition was 8% (S3) and 12% (S1), suggesting that both scenarios were effective at moving the population productivity in a positive direction (**Table F17**; **Figure F10**). However, Wenatchee steelhead need to improve their productivity from between 0.25 and 0.81 (depending on hatchery fish contribution (12 yr geomean as of 1999) to 1.2 (viability curve minimum threshold assuming adequate abundance) which represents an increase of between 48% and 380%. Therefore, we conclude that there is no combination of restoration and protection actions to habitat conditions, within the Wenatchee subbasin, that would be adequate to achieve a viable population of steelhead with respect to productivity. Therefore, integration of the habitat actions identified in this plan with the other 3 H's will be necessary to achieve recovery.

Diversity Index.—The diversity index for steelhead in the Wenatchee improved from 25% (current) to 65% for Scenario 3 and 72% for Scenario 1 indicating that the recovery scenarios effectively provided an opportunity for the expression of the majority of the life history pathways. All obstructions were made passable for both scenarios so the small change in the diversity index from S3 to S1 was due to improved habitat quality in areas that affected survival of early or late migrating smolts or adults. Additional contributions to increased life history diversity came from increased survival of eggs and fry that were produced earlier or later than normal. See Appendix B to better understand the kinds of actions and improvements that would be needed to achieve low risk for spatial structure and diversity beyond the habitat related action classes that were modeled in EDT.

F.5.5 Entiat Steelhead

Steelhead were not modeled in EDT as part of any previous planning process, although the 2514 watershed planning group did expand the Chinook reaches to cover areas accessible to steelhead. They also rated the environmental attributes in those reaches. We completed the life history assumptions and conducted baseline model runs for current, PFC, habitat template, and true template scenarios. However, we did not model the recovery scenarios (S1, S3) or the watershed plans action alternative 5. In general, we assume that the model would predict similar increases for steelhead as it did for spring Chinook, based on similar relative performance increases in the other Upper Columbia populations. We present a brief description of the results for the baseline and PFC model runs to serve as an indicator regarding the likelihood of achieving recovery by implementing restoration and protection actions in the habitat. This information is not published but is available online (www.mobrand.com)

The EDT model failed to produce enough viable trajectories to sustain a population of steelhead in the Entiat with a productivity greater than 1.0. Therefore, a current abundance estimate could not be generated. EDT predicted an abundance of 244 adult spawners using the default PFC habitat conditions and 321 fish with the habitat template conditions. These results were considered generally consistent with the observation that current abundance was less than 100 fish, based on the 12-year geometric mean and recent redd counts.

Therefore, based on the observation that our recovery scenarios always result in fewer fish than the PFC and habitat template conditions; we conclude that there is no combination of restoration and protection actions to habitat conditions, within the Entiat subbasin, that would be adequate to achieve a viable population of steelhead with respect to abundance or productivity. Integration of the habitat actions identified in this plan with the other 3 H's will be necessary to achieve recovery.

F.5.6 Methow Steelhead

Abundance.— The accuracy of EDT and comparisons to empirical estimates for steelhead in the Methow were difficult to evaluate due to the influence of hatchery fish and the uncertainty of actual spawners because comprehensive redd counts were unavailable for a long time series. The EDT abundance estimate (724) was considerably higher than the 12-year geometric mean abundance (202 spawners; 1991-2002; **Table 2.4**). However, the EDT model used an SAR (back to the spawning grounds) of 1.032% which may have been an overestimate of actual SAR. Unfortunately, no empirical data exists for SAR of wild steelhead in the Methow. However, for Wenatchee spring Chinook the SAR used in EDT was more than twice that observed for wild fish. If the SAR in the model had been reduced in half (0.52%) then the current EDT abundance estimate would have been 363 fish. Therefore, considering the unknown influence of hatchery fish affecting capacity and productivity and the uncertainty of the correct SAR we assumed that the EDT model was an adequate representation of Methow steelhead.

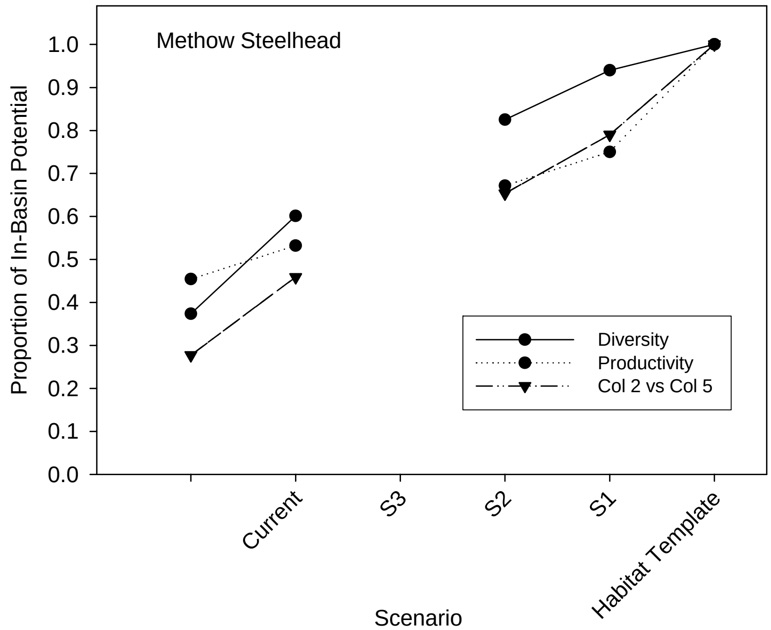
Scenarios 1 and 3 predicted a 136% and 65% increase in abundance, respectively, suggesting that both scenarios were effective at moving the population abundance in a positive direction (**Table F18**; **Figure F11**). Scenario modeling predicted the population would move from 28% (current) of the in-basin potential to 46% (S1) and 65% (S1) of the in-basin potential, respectively. Although this is a considerable change, the gap between S1 and PFC suggests that there may be additional limiting factors that were not adequately addressed by the restoration action classes used in this modeling effort. Or, it could be that the effectiveness assumptions underestimated the effectiveness of the action classes. Future efforts should first determine the model input and processing mechanisms that lead to this discrepancy to determine if the difference makes sense with respect to ecological interactions, or if the problem was with model application. To better understand the models sensitivity to our scenarios see the sensitivity analysis conducted on the Wenatchee populations (section F.6).

The EDT model predicted that in-basin restoration and protection actions could achieve the minimum threshold abundance (1000 spawners) for the Methow steelhead population for both Scenario 1 and Scenario 3, assuming the average SAR (back to the spawning grounds was at least 1.03% (**Figure F11**). However, S3 only exceeded the ICTRT minimum threshold by 12% and coefficient of variation (using 1 standard deviation) of the empirical estimate was 91%. This suggests that a restoration action plan with an intensity near or greater than S1 might be necessary to achieve an abundance that has a high probability of achieving the ICTRT minimum abundance threshold. Therefore,

Table F18. Performance measures of Methow steelhead based on EDT modeling scenarios that used an SAR of 1.03%, back to the spawning grounds. Scenario 1 (S1) applied the full effectiveness of the restoration action classes that addressed primary limiting factors within each assessment unit. Scenario 3 (S3) was 33% of the intensity of S1, with full effect of artificial barrier removal and protection. PFC was properly functioning conditions, the habitat template was historic pristine habitat with current mainstem conditions, and true template was historic habitat, historic mainstem conditions. Scenario 2 (S2) (assessment unit specific intensities based on feasibility) was not available for this analysis

		Adult Performance				Juvenile Performance		
Population	**Scenario**	**Diversity index**	**Productivity**	**Capacity**	**Abundance**	**Juvenile Productivity**	**Juvenile Capacity**	**Juvenile Abundance**
	Current without harvest	33%	1.4	2,407	724	131	270,926	70,316
	Scenario 3	54%	1.7	2,971	1,198	150	303,973	112,886
	Scenario 2							
Methow Steelhead	Scenario 1	74%	2.1	3,236	1,706	187	326,336	161,326
	PFC	84%	2.4	3,578	2,060	205	356,010	192,991
	Habitat Template	89%	3.1	3,827	2,612	269	376,265	245,092
	True Template	94%	11.3	13630	12422	NR	NR	NR
		% Increase relative to current				**% Increase relative to current**		
Methow Steelhead	Current without harvest	0%	0%	0%	0%	0%	0%	0%
	Scenario 3	61%	17%	23%	65%	14%	12%	61%

	Scenario 2							
	Scenario 1	121%	48%	34%	136%	43%	20%	129%
	PFC	151%	65%	49%	185%	56%	31%	174%
	Habitat Template	168%	120%	59%	261%	105%	39%	249%
	True Template	181%	690%	466%	1615%	NR	NR	NR
		Proportion of In-basin Potential				**Proportion of In-basin Potential**		
	Current without harvest	37%	45%	63%	28%	49%	72%	29%
	Scenario 3	60%	53%	78%	46%	56%	81%	46%
	Scenario 2							
Methow Steelhead	Scenario 1	83%	67%	85%	65%	69%	87%	66%
	PFC	94%	75%	93%	79%	76%	95%	79%
	Habitat Template	100%	100%	100%	100%	100%	100%	100%



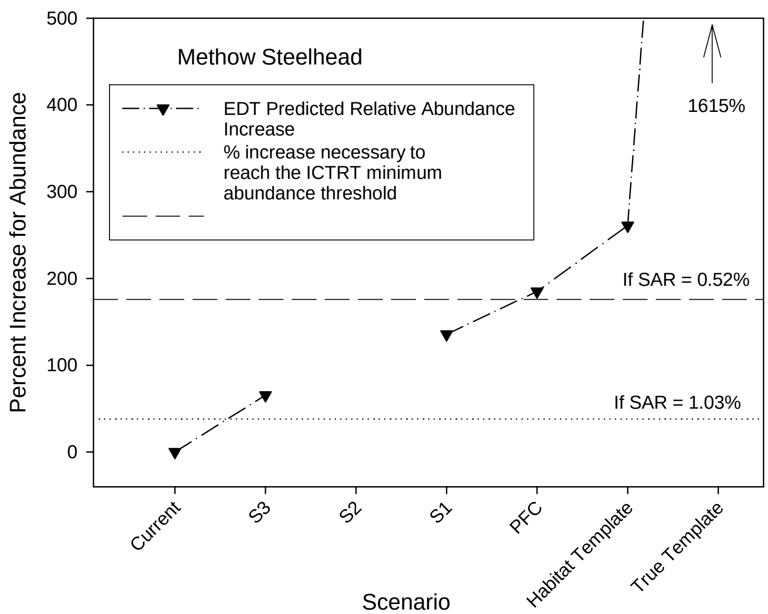


Figure F11. EDT model predictions for steelhead in the Methow subbasin, assuming 2 different SAR values. Scenario 1 (S1) applied the full effectiveness of the restoration action classes that addressed primary limiting factors within each assessment unit. Scenario 3 (S3) was 33% of the intensity of S1, with full effect of artificial barrier removal and protection. PFC was properly functioning conditions, the habitat template was historic pristine habitat with current mainstem conditions, and true template was historic habitat and historic mainstem. Scenario 2 (S2) (assessment unit specific intensities based on feasibility) was not available at the time of this analysis.

considering the variance of the empirical estimate and the uncertainty of the actual SAR for wild Methow steelhead we believe that integration of the habitat actions identified in this plan with the other 3 H's will be necessary to achieve recovery.

Productivity.—The recovery actions increased the proportion of in-basin potential from 45% (current) to 53% (S3) and 67% (S1). We believe that achieving over 60% of the in-basin potential represents a very good level of achievement in the habitat, particularly considering that the PFC scenario resulted in 75% the in-basin potential and the PFC attribute ratings were generally considered unrealistic based on societal constraints. The increase in productivity relevant to the current condition was 17% (S3) and 48% (S1), suggesting that both scenarios were effective at moving the population productivity in a positive direction (**Table F18**; **Figure F11**). However, Methow steelhead need to improve their productivity from between 0.09 and 0.84 (depending on hatchery fish contribution (12 yr geomean as of 1996; **Table 2.6**) to 1.2 (viability curve minimum threshold for a basic population, assuming adequate abundance) which represents an increase of between 43% and 1233%. Therefore, we conclude that there is no combination of restoration and protection actions to habitat conditions, within the Methow subbasin, that would be adequate to achieve a viable population of steelhead with respect to productivity. Therefore, integration of the habitat actions identified in this plan with the other 3 H's will be necessary to achieve recovery.

Diversity Index. — The diversity index for steelhead in the Methow improved from 33% to 54% for Scenario 3 and 74% for Scenario 1 indicating that the recovery scenarios effectively provided an opportunity for the expression of the majority of the life history pathways. All obstructions were made passable for both scenarios so the change in the diversity index from S3 to S1 was due to improved habitat quality in areas that affected survival of early or late migrating smolts or adults. Additional contributions to increased life history diversity came from increased survival of eggs and fry that were produced earlier or later than normal. See Appendix B to better understand the kinds of actions and improvements that would be needed to achieve low risk for spatial structure and diversity beyond the habitat related action classes that were modeled in EDT.

Okanogan steelhead

Abundance.— The accuracy of EDT and comparisons to empirical estimates for steelhead in the Okanogan were difficult to evaluate due to the influence of hatchery fish and the uncertainty of actual spawners because redd counts were unavailable. Regardless, the EDT abundance estimate (61) was very close to the 12-year geometric mean abundance (53 spawners; 1991-2002; **Table 2.4**). Therefore, we assumed that the EDT model was an adequate representation of Okanogan steelhead.

Scenarios 1 and 3 predicted a 377% and 281% increase in abundance, respectively, suggesting that both scenarios were effective at moving the population abundance in a positive direction (**Table F19**; **Figure F12**). Scenario modeling predicted the population would move from 15% (current) of the in-basin potential to 72% (S1) and 57% (S3) of the in-basin potential. Although no test model runs were conducted, it is assumed that the vast majority of the increase in abundance was due to providing access to the blocked habitat in Salmon and Omak Creeks (based on 100% barrier removal with the S3 scenario).

The EDT model predicted that in-basin restoration and protection actions in the US portion of the Okanogan steelhead population would not achieve the minimum threshold abundance (500 spawners for US portion) (**Table F19**; **Figure F12**). This result was obtained with an SAR of 0.915% back to the spawning grounds, which was probably an overestimate of actual SAR (if the comparison of Chiwawa River spring Chinook SAR to EDT SAR correlates with Okanogan steelhead). However, there are no data for empirical estimates of SAR for wild Okanogan steelhead.

Productivity.**—**The recovery actions increased the proportion of in-basin potential from 46% (current) to 68% (S3) and 76% (S1). We believe that achieving over 60% of the in-basin potential represents a very good level of achievement in the habitat, particularly considering that the PFC scenario resulted in 75% the in-basin potential and the PFC attribute ratings were generally considered unrealistic based on societal constraints. The increase in productivity relevant to the current condition was 49% (S3) and 66% (S1), suggesting that both scenarios were effective at moving the population productivity in a positive direction (**Table F19**; **Figure F12**). However, Okanogan steelhead need to improve their productivity from between 0.09 and 0.84 (depending on hatchery fish contribution (12 yr geomean as of 1996; **Table 2.6**) to 1.4 (viability curve minimum threshold for a basic population, assuming adequate abundance) which represents an increase of between 67% and 1400%. Therefore, we conclude that there is no combination of restoration and protection actions to habitat conditions, within the Okanogan subbasin, that would be adequate to achieve a viable population of steelhead with respect to productivity. Therefore, integration of the habitat actions identified in this plan with the other 3 H's will be necessary to achieve recovery.

Diversity Index. —The diversity index for steelhead in the Okanogan improved from 1% (current) to 29% for Scenario 3 and 49% for Scenario 1 indicating that there was still considerable impediments to life history pathways for Okanogan steelhead, even under the improved habitat conditions. However, the improved habitat conditions represented 50% (S3) to 85% (S1) of the in-basin potential, indicating that out-of-subbasin factors were a strong driver in achieving a high diversity index score in EDT.

Table F19 Performance measures of Okanogan steelhead based on EDT modeling scenarios that used an SAR of 1.03%, back to the spawning grounds. Scenario 1 (S1) applied the full effectiveness of the restoration action classes that addressed primary limiting factors within each assessment unit. Scenario 3 (S3) was 33% of the intensity of S1, with full effect of artificial barrier removal and protection. PFC was properly functioning conditions, the habitat template was historic pristine habitat with current mainstem conditions, and true template was historic habitat, historic mainstem conditions. Scenario 2 (S2) (assessment unit specific intensities based on feasibility) was not available for this analysis

		Adult Performance				Juvenile Performance		
Population	**Scenario**	**Diversity index**	**Productivity**	**Capacity**	**Abundance**	**Juvenile Productivity**	**Juvenile Capacity**	**Juvenile Abundance**
Okanogan Steelhead US and Canada	Current without harvest	1%	1.9	127	61	178	17,323	6,650
	Scenario 3	29%	2.9	355	231	247	38,124	22,851
	Scenario 2							
	Scenario 1	49%	3.2	422	290	277	44,740	28,717
	PFC	55%	3.1	492	335	272	51,375	32,846
	Habitat Template	58%	4.2	531	405	361	54,940	39,914
	True Template	60%	15.1	2,469	2,305			

		% Increase relative to current				**% Increase relative to current**		
Okanogan Steelhead US and Canada	Current without harvest	0%	0%	0%	0%	0%	0%	0%
	Scenario 3	3144%	49%	181%	281%	39%	120%	244%
	Scenario 2							

	Scenario 1	5379%	66%	234%	377%	56%	158%	332%
	PFC	6030%	64%	289%	453%	53%	197%	394%
	Habitat Template	6333%	118%	320%	567%	103%	217%	500%
	True Template	6570%	686%	1851%	3698%			

		Proportion of In-basin Potential				Proportion of In-basin Potential		
	Current without harvest	2%	46%	24%	15%	49%	32%	17%
	Scenario 3	50%	68%	67%	57%	68%	69%	57%
	Scenario 2							
Okanogan Steelhead US and Canada	Scenario 1	85%	76%	80%	72%	77%	81%	72%
	PFC	95%	75%	93%	83%	75%	94%	82%
	Habitat Template	100%	100%	100%	100%	100%	100%	100%
	True Template							

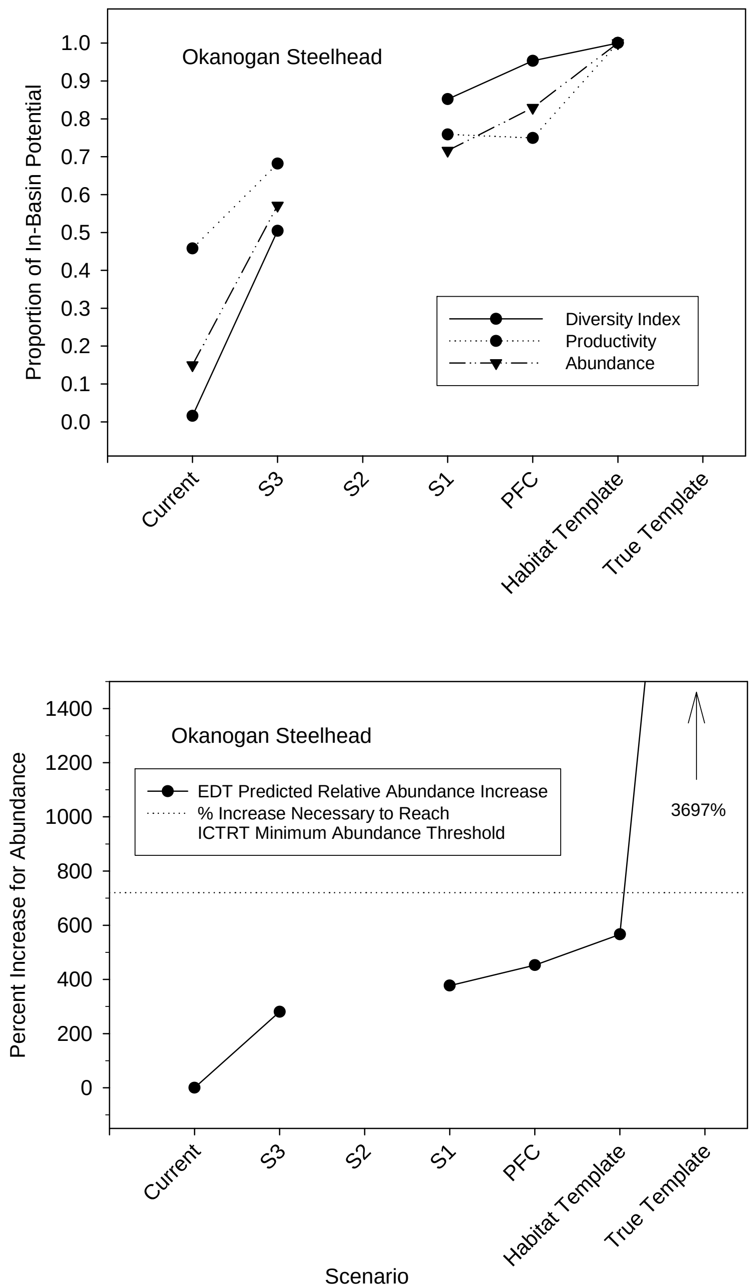


Figure F12. EDT model predictions for steelhead in the Okanogan subbasin, assuming an SAR of 0.92%, back to the spawning grounds. Scenario 1 (S1) applied the full effectiveness of the restoration action classes that addressed primary limiting factors within each assessment unit. Scenario 3 (S3) was 33% of the intensity of S1, with full effect of artificial barrier removal and protection. PFC was properly functioning conditions, the habitat template was historic pristine habitat with current mainstem conditions, and true template was historic habitat and historic mainstem. Scenario 2 (S2) (assessment unit specific intensities based on feasibility) was not available at the time of this analysis.

F.6 EDT Model Sensitivity in the Wenatchee Subbasin

We evaluated several aspects of model sensitivity in the Wenatchee Subbasin in relation to performance predictions for spring Chinook and steelhead. We did not attempt to test general EDT model sensitivity or validate the algorithms in EDT that link habitat conditions to life stage specific survival. The algorithms that link fish performance to habitat conditions can be found at www.mobrand.com. Our goal was to better understand what EDT did with the information we provided. Additionally, we did not attempt any statistical analysis so our conclusions are purely descriptive and to provide the opportunity for review, understanding, and improvement. We could only focus this analysis on one subbasin (2 populations) due to time constraints. Although it was possible that some of the general conclusions from this analysis would apply to the other subbasins, we highly recommend that each individual population has its own sensitivity analysis. This will provide local biologists, stakeholders, and planners the understanding of the strengths, weaknesses, and limitations of EDT as it applies to each watershed and population. We recognize that the information in this section is incomplete and we suggest that the entire Columbia Basin needs to establish a set of standardized analysis protocols and sensitivity tests for watershed level population modeling efforts for EDT and/or any other model that is used to predict changes in fish performance from implementation of actions in the habitat.

Our specific objectives were to evaluate…

1. Contributions of select environmental attributes to fish performance
2. Interactions of environmental attribute ratings and action effectiveness
3. Action class effects to scenario results

F.6.1 Contributions of Select Environmental Attributes to Fish Performance

We evaluated the contributions of select environmental attributes to fish performance to understand why the information we put into EDT led to the model results for the diagnosis portion of the assessment (section F.1 of this Appendix). We interpreted the output and categorized survival factors (groups of environmental attributes) as primary, secondary, or not limiting factors. This assessment was then considered in concert with other assessments (Subbasin Plan, Biological Strategy) to identify the limiting factors for each assessment unit in the Recovery Matrix (**Table 5.7**).

We first examined the attribute ratings that contributed to limiting factors in one or more assessment units. To do this we calculated the average difference between template and current (T-C) ratings for each attribute. This provided insight to how attributes were rated and how much change there was from template conditions. This assessment was conducted across all reaches, however, we recognize that conditions were generally degraded (or pristine) in certain subwatersheds so there was a pattern of T-C variance that we did not account for. Additionally, a change of 0.5, 1 or 2 is not the same for every attribute because each of differences in units and because the survival curves are not linear (**Table F15**).

The average T-C value was 0.58, however, this included many attributes that were not relevant for this analysis (natural hydrologic regime, natural confinement, gradient) or were considered not applicable in the Wenatchee (hydrologic regime-regulated) (**Table F20**). A subset of attributes that were generally thought to contribute to limiting factors averaged 0.76, indicating that an average change in the EDT score less than 1 could still have notable impacts to population performance (**Table F20**). Because the data for these results were non-normal, we also plotted the distribution of the average T-C variance for a subgroup of attributes (**Figure F13**). This simply points out that the majority of reaches were rated very similar (< 0.5) between current and template, with select reaches (or assessment units) where larger deviations from the template were applied. Finally, several attributes had an average T-C variance greater than 1, but were not generally considered a limiting factor. Defining all the relationships between attribute ratings, performance measures and the Strategic Priority Summary (consumer reports, big dot-little dot graphics) provided in the diagnosis were beyond the time and financial scope of this analysis.

Therefore, we conducted individual model runs on select attributes and changed the attribute score from current to template value in every reach. For each model run, all other attributes were left at their respective score for current conditions. The model was then re-run and the change to each performance measure was documented. This method did not identify the correlated and synergistic relationships between attributes that are part of the hard-wired model relationships; therefore, the sum of the individual performance increases could be greater than 100%. These results indicated that many of the attributes thought to be primary limiting factors from the diagnosis did result in larger opportunities for improvement of the 3 performance measures (**Table F21**). However, several attributes that were identified as limiting factors in certain assessment units showed negligible change at the population level. For example, temperature increases in Mission, Peshastin, and Chumstick Creeks were identified as limiting factors for these assessment units, but simply changing the temperature to template conditions (for the whole subbasin) did not improve performance of either species by more than 0.32% for any performance measure (**Table F21**). Conversely, several attributes that appeared to be secondary limiting factors in the Strategic Priority Summary (consumer reports, big dot-little dot graphics) had the potential to change the performance of the performance measures by greater than or equal to many of the primary limiting factors. For example, the attributes benthic diversity and production and salmon carcasses were rated relatively poorly (T-C > 1) but were considered secondary limiting factors because there were no "big hits" on the Strategic Priority Summary for the survival factor "food". Additionally, nutrient limitations were not identified as a recommended management action in the Biological Strategy (RTT 2003). However, increasing benthic productivity and salmon carcasses to template conditions in all reaches resulted in the largest increases in population performance for abundance of both species and for productivity of spring Chinook. The final factor that must be taken into consideration is the certainty of the inputs for these environmental attributes. The level of proof analysis/description revealed that the majority of reaches were rated with derived information or expert opinion for both benthic macroinvertebrates and salmon carcasses, rather than empirical data (section F.1). Therefore, the coarse of action for addressing nutrient limitations depends on the risks associated with implementation based on a "false positive". Finally, some attributes had a relatively high T-C variance but had little or no effect in individual assessment units or at the population scale. An example of this situation was the attribute "water withdrawals". The average T-C variance (1.44) was among the highest of the 46 attributes but it had virtually no effect at the assessment unit or population scale. This result was a function of the EDT model not being sensitive to the attribute ratings in the range that we used, regardless of the magnitude of change between current and historic.

Table F20. The average difference between template (estimated historic) and current conditions for the 46 EDT environmental attributes from 119 reaches in the Wenatchee River subbasin. Habitat types and channel widths and lengths were not included in the averages because they were entered in % and ft, respectively, rather than a transformed EDT score. Definitions for EDT attribute scores can be found at www.mobrand.com)

Attribute #	EDT Environmental Attribute Name		Average (T-C)	Max (T-C)
1	Alkalinity		0.00	0.0
2	Bed scour	*	0.05	1.1
3	Benthos diversity and production	**	3.00	3.0
4	Channel length		0.0	0.0
5	Channel width - month maximum width (ft)		-1.2	-51.9
6	Channel width - month minimum width (ft)		2.2	25.0
7	Confinement – Hydromodifications	*	1.93	4.0
8	Confinement - natural		0.00	0.0
9	Dissolved oxygen		0.00	0.0
10	Embeddedness		0.90	1.5
11	Fine sediment	*	0.87	3.0
12	Fish community richness		0.02	1.0
13	Fish pathogens		0.62	2.0
14	Fish species introductions	**	1.02	2.0
15	Flow - change in average annual peak flow		0.26	0.6
16	Flow - change in average annual low flow	*	0.28	1.5

17	Flow - Intra daily (diel) variation		0.03	3.0
18	Flow - intra-annual flow pattern		0.26	0.6
19	Gradient		0.00	0.0
20	Habitat type - backwater pools		1%	5%
21	Habitat type - beaver ponds		1%	10%
22	Habitat type - glide		3%	-33%
23	Habitat type - large cobble/boulder riffles		15%	-48%
24	Habitat type - off-channel habitat factor		3%	25%
25	Habitat type - pool tailouts.		1%	6%
26	Habitat type - primary pools		10%	43%
27	Habitat type - small cobble/gravel riffles		5%	26%
28	Harassment	**	1.79	3.0
29	Hatchery fish outplants	**	1.77	4.0
30	Hydrologic regime - natural		0.00	0.0
31	Hydrologic regime - regulated		0.00	0.0
32	Icing		0.01	1.0
33	Metals - in water column		0.10	1.0
34	Metals/Pollutants - in sediments/soils		0.13	1.0
35	Miscellaneous toxic pollutants - water column		0.21	2.0
36	Nutrient enrichment		0.32	2.5
37	Obstructions to fish migration		NA	
38	Predation risk		0.55	2.0

39	Riparian function	*	0.89	3.5
40	Salmon Carcasses	**	1.01	3.0
41	Temperature - daily maximum (by month)	*	0.04	0.2
42	Temperature - daily minimum (by month)		0.11	2.0
43	Temperature - spatial variation	*	0.45	2.0
44	Turbidity		0.18	1.0
45	Water withdrawals	**	1.44	2.0
46	Wood	*	1.56	4.0
		Grand Mean =	0.58	
	*Attributes generally associated with limiting factors; mean =		0.76	

**Other attributes generally not classified as “primary" but with anaverage T-C > 1

Table F21. Percent change in population performance for three performance measures for spring Chinook and Steelhead in the Wenatchee River subbasin EDT model. Each attribute's (or attribute group) EDT score was increased to template conditions (estimate of historic/pristine) and the model was re-run with current conditions for all other attributes

		% Increase under Template Conditions					
		Wenatchee Spring Chinook			Wenatchee Steelhead		
	Attribute(s) name	Diversity Index	Productivity	Abundance	Diversity Index	Productivity	Abundance
Common EDT Attributes Contributing (or thought to contribute) to Primary Limiting Factors	Fine sediment & Embeddedness	14.9%	8.9%	9.0%	40.3%	8.9%	4.5%
	Obstructions to fish migration	9.5%	0.0%	10.4%	30.8%	-4.1%	41.4%
	Confinement – Hydromodifications	6.0%	7.0%	19.0%	23.0%	2.0%	7.0%
	Riparian function	5.0%	5.0%	18.0%	21.0%	2.0%	11.0%
	Wood	9.9%	3.8%	15.5%	19.6%	2.8%	7.9%
	Habitat type - primary pools	0.0%	-0.6%	8.7%	0.3%	0.1%	-0.2%
	Key habitat types (all 7 habitat types)	0.0%	-0.7%	7.7%	0.3%	0.1%	1.1%
	Temperature - spatial variation	0.00%	0.03%	0.26%	0.16%	-0.05%	0.18%
	Bed scour	0.00%	0.01%	0.02%	0.16%	0.01%	0.04%
	Low Flow	0.00%	0.00%	0.11%	0.08%	0.00%	0.08%
	Temperature - daily maximum (by month)	0.00%	0.00%	0.32%	0.08%	0.01%	0.15%

	Benthos diversity and production & Salmon Carcasses	1.7%	12.1%	22.8%	11.9%	8.6%	30.5%
	Hatchery Fish Outplants	1.5%	5.1%	4.7%	12.8%	3.3%	2.5%
	Predation risk	1.0%	2.5%	2.6%	2.3%	1.0%	1.1%
	Fish Species Introductions (exotics)	0.6%	1.6%	2.1%	4.6%	1.5%	1.2%
Select "other" EDT Attributes	Harassment	0.1%	0.2%	0.5%	1.3%	0.9%	2.5%
	Habitat type - pool tailouts.	0.00%	0.02%	0.01%	0.00%	0.00%	0.24%
	Minimum Width	0.0%	0.0%	2.1%	0.1%	-0.1%	3.5%
	Flow - change in average annual peak flow & Flashy Flow	0.00%	-0.02%	0.04%	0.24%	0.12%	0.12%
	Habitat type - off-channel habitat factor	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Water withdrawals (entrainment impingement)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

*19 additional environmental attributes were not tested for sensitivity due to time constraints and because they were perceived as not being as important as the 27 attributes shown here. For a complete list go to www.mobrand.com.

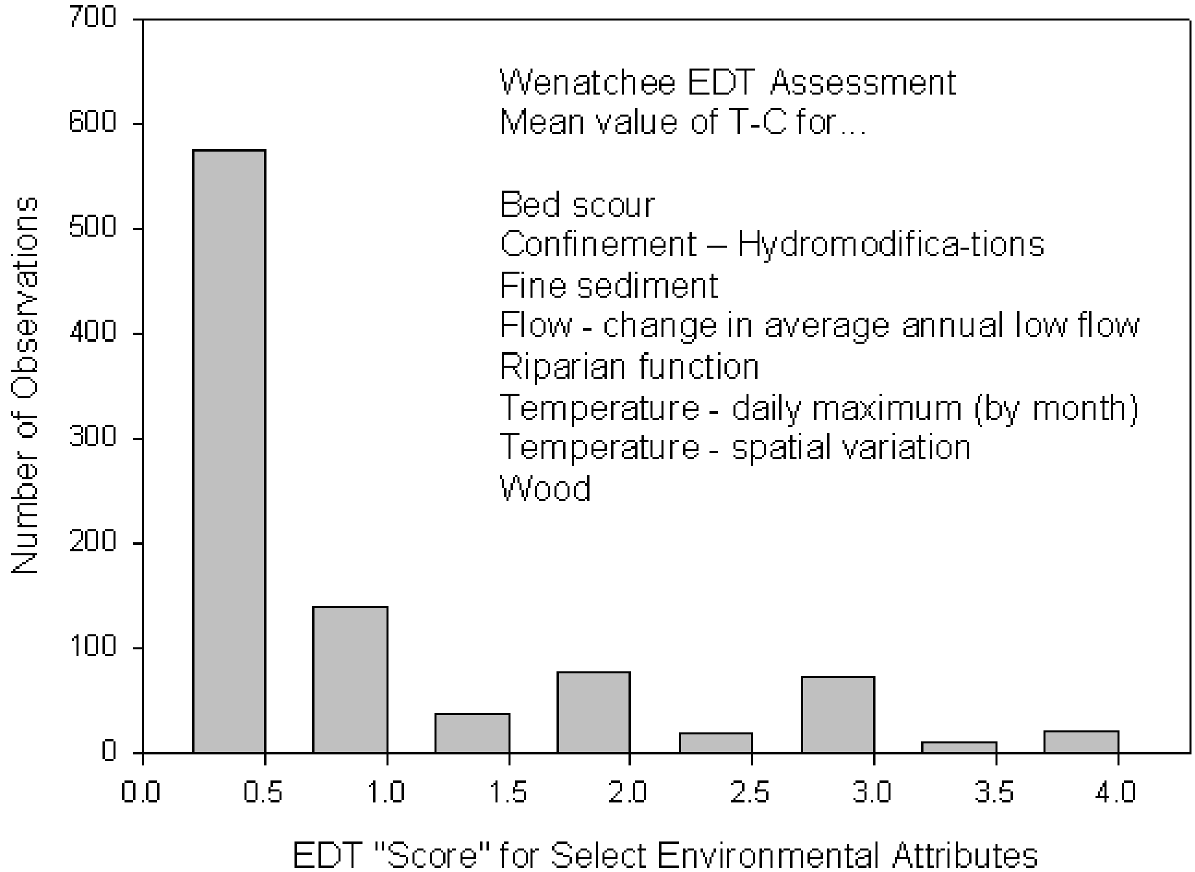


Figure F13. The difference between template (T) and current (C) attribute scores for select environmental attributes that contributed to habitat limiting factors during the "diagnosis" phase of Ecosystem Diagnosis and Treatment

F.6.2 Interactions of Environmental Attribute Ratings and Action Effectiveness

In section F.2 we described the process of defining effectiveness, using an intensity multiplier, and changing the current attribute score within the constraints of the template conditions. Sections F.3 and F.4 defined the scenarios that were modeled and the methods used to analyze and interpret the results of the model output. Finally, section F.5 provided the population specific results for the scenario modeling in all the Upper Columbia populations. In those results, there was a relatively small difference between the S1 and S3 scenarios, despite the fact that S3 had been defined as 33% of the intensity of S1. In this section we will describe how effectiveness and intensity are interacting with the restoration potential (T-C) for particular attributes in our EDT scenarios.

The greatest change to an attribute score occurs when;

1. The restoration (T-C) potential for the environmental attribute is high
2. The effectiveness of the action is high
3. The intensity of the application is high

Using the formula defined previously;

$$N_i = C_i + [(T_i - C_i)*(E*I)]$$

It is only possible to obtain a new attribute value (N_i) equal to the template score when both effectiveness and intensity are 1.0. Therefore, the greater the difference between template and current the greater the magnitude of change to the attribute score (**Table F22**). Likewise, when the intensity was held constant, then increasing effectiveness would increase the magnitude of change between current and template (**Figure F14**). Relatively small differences occurred to the attribute score when the effectiveness was less than 0.3 and when the restoration potential was low.

In the Wenatchee EDT analysis, the average T-C value was 0.56 indicating that the restoration potential was generally small. Additionally, the majority (85%) of action effectiveness designations were $\leq$ 30% (**Figure F7**). Therefore, absolute change between S1 (100% intensity) and S3 (33% intensity) was usually very small (**Figure F14**). However, in some assessment units where conditions were degraded, the difference between S1 and S3 was quite large (**Table F23**). The algorithms used in EDT to link habitat conditions with fish performance were not linear, so relatively large gains in survival could be obtained from small improvements in habitat conditions and vice versa (**Figure F15**; www.mobrand.com).

Table F22 A hypothetical example of changes to environmental attribute scores when various intensities of actions (S1 = 100%; S3 = 33%) were applied to current and template scores, assuming constant action effectiveness

		EDT Attribute "score"			
Environmental Attributes	**Action Effectiveness**	**Current**	**Template**	**S1**	**S3**
Bed Scour	30%	0	0	0.0	0.0
Riparian Function	30%	1	0	0.7	0.9
Wood	30%	2	0	1.4	1.8
Embeddedness	30%	3	0	2.1	2.7
Fine Sediment	30%	4	0	2.8	3.6

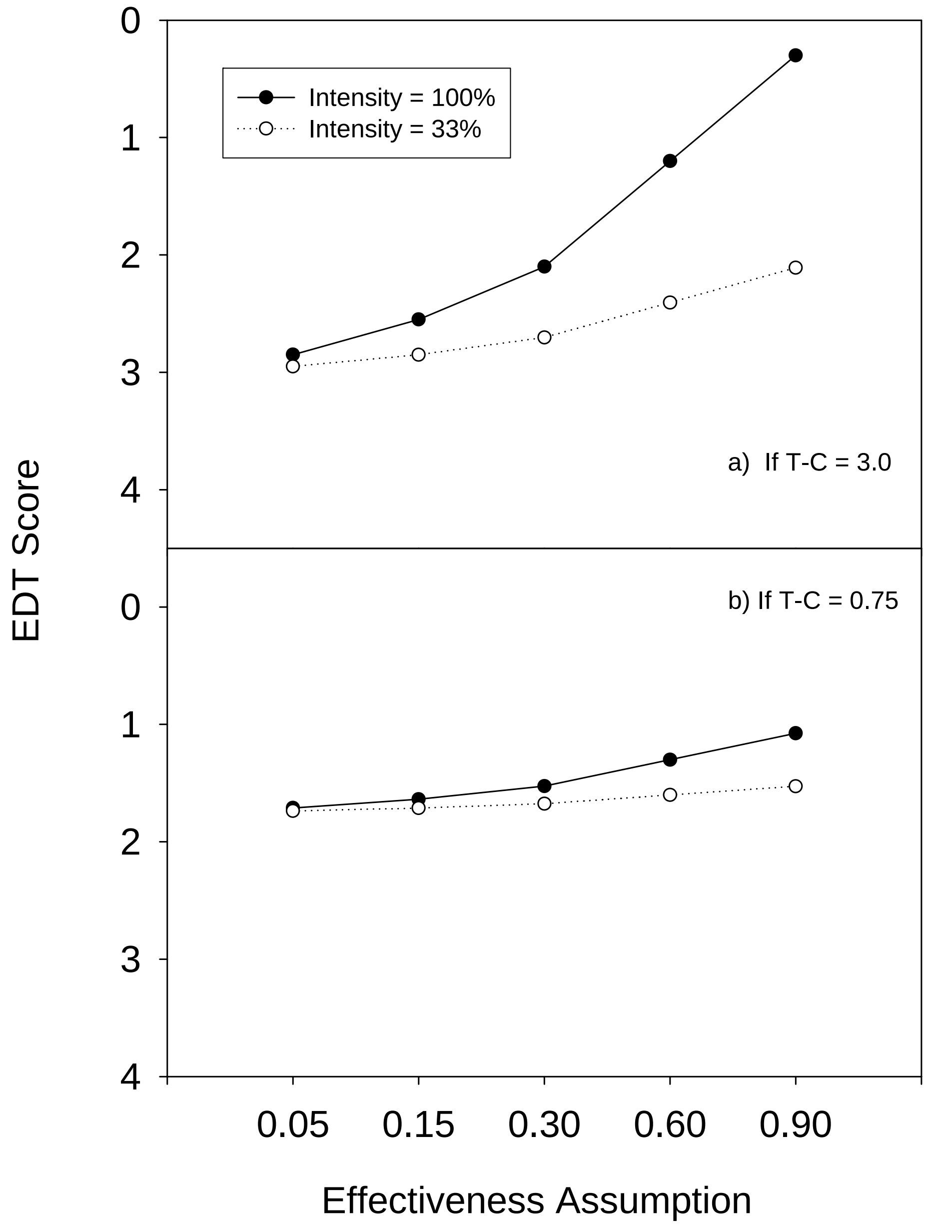


Figure F14. Change in EDT environmental attribute scores at two intensities and two restoration potentials using the effectiveness assumptions used for restoration action classes in the Upper Columbia. Graph a) represents a highly degraded attribute where the difference between template (T) and current (C) was 3.0 and graph b) represents a low level of degradation (T-C = 0.5).

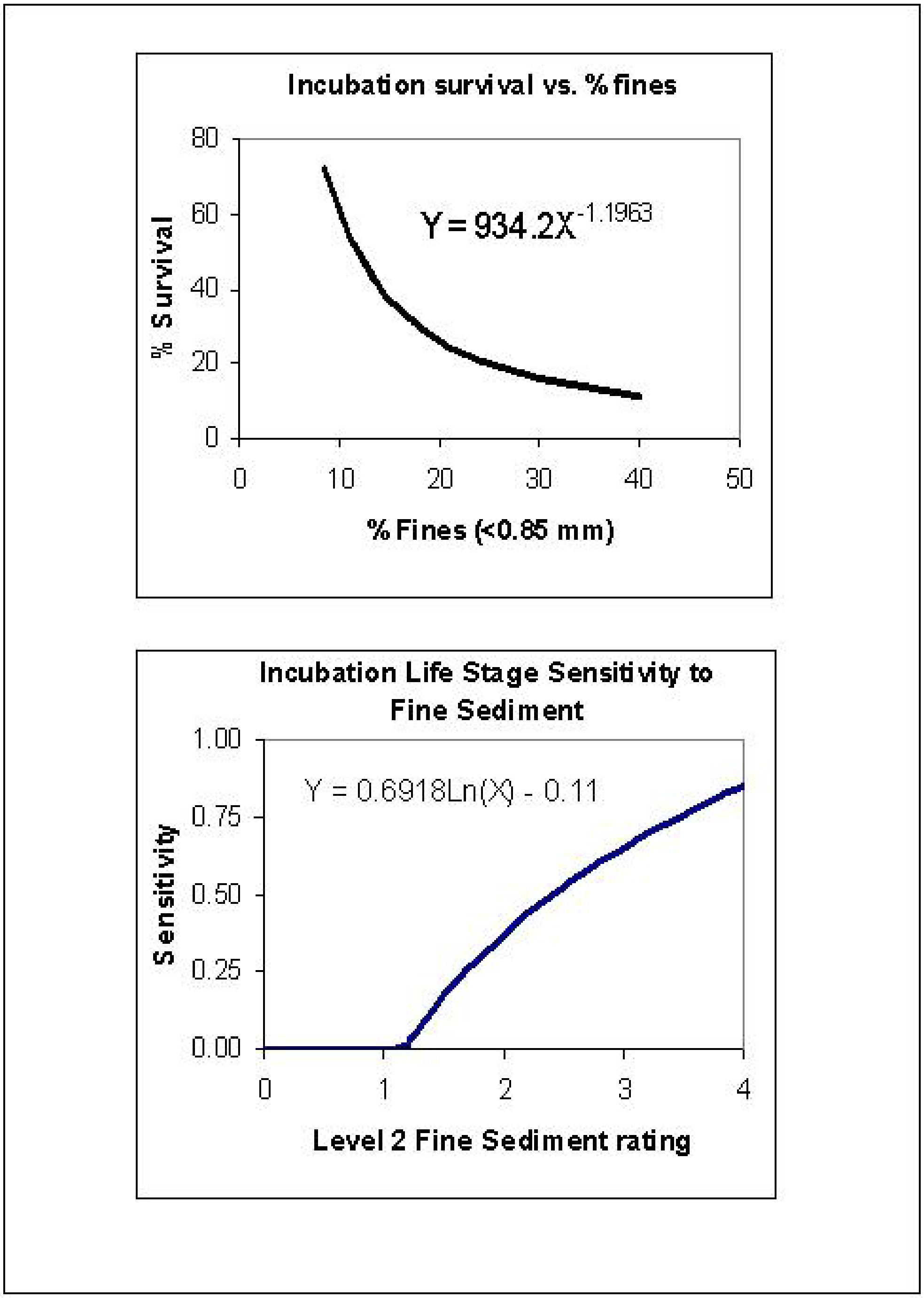


Figure F15. Relationship between percent fines and survival from egg deposition to emergence for coho salmon, adapted from Tagart (1984), and the relationship between ratings for Level 2 Fine Sediment and sensitivity of eggs in the EDT model (figure taken from Mobrand (2002).

Table F23. Ecosystem Diagnosis and Treatment (EDT) attribute scores and empirical data equivalents for large woody debris in the Wenatchee subbasin. Each number represents the average value of the reaches within each assessment unit. Lower EDT attribute score mean more wood was present.

	EDT Attribute Score				Empirical data equivalent (Pieces per mile)			
Assessment Unit	Current	S3	S1	Template	Current	S3	S1	Template
Beaver	3.0	2.0	0.0	0.0	13	36	75	75
Chiwaukum/Skinney	0.8	0.7	0.6	0.6	106	107	111	111
Chiwawa	0.9	0.8	0.8	0.5	100	106	106	113
Chumstick	3.0	2.0	0.0	0.0	13	36	75	75
Derby	3.0	2.0	0.0	0.0	13	36	75	75
Little Wenatchee	1.0	0.8	0.8	0.0	100	106	106	125
Lower Icicle	3.5	2.5	0.8	0.8	11	25	106	106
Lower Nason	2.0	1.5	0.7	0.7	51	76	109	109
Lower Peshastin	3.1	2.2	0.5	0.5	17	40	113	113
Lower Wenatchee	3.5	3.0	1.9	1.1	11	18	55	95
Mission	2.8	1.8	0.0	0.0	16	42	75	75
Tumwater Canyon	2.0	2.0	2.0	2.0	51	51	51	51
Upper Icicle	1.0	1.0	1.0	0.8	100	103	103	106
Upper Nason	2.6	2.4	2.4	1.8	24	30	30	60
Upper Peshastin	2.4	1.5	0.9	0.9	25	51	64	103
Upper Wenatchee	2.0	1.7	1.7	0.7	51	65	65	109
White River	1.5	1.3	1.3	0.5	76	85	85	113

F.6.3 Action Class Effects to Scenario Results

We conducted a series of additional model runs to better understand what factors were driving the results presented in section F.4 and F.5. Due to time and budget constraints, we were only able to do this assessment for Wenatchee spring Chinook. Although the concepts should be generally applicable to the other populations, we believe that these (and other) model sensitivity tests should be conducted for each population in order to understand what the model did with the information that was put into it.

Our objectives were to;

1. Understand the difference between S1 and S3.

2. Evaluate sensitivity to protection assumptions (i.e. the rate of passive restoration).

3. Understand the difference between S1 and Habitat Template.

To address the objectives we first examined the assessment unit specific restoration potential from the diagnosis phase of EDT, then conducted a series of additional model runs.

The model runs designed to meet objectives 1-3 were as follows:

1. Current (without harvest): See description in section F.3.

2. Protection (passive restoration): Applied only the protection measures outlined in section F.2. The goal was to understand what proportion of the improvements in performance measures were due to the passive restoration assumptions.

3. Protection and Obstructions: Applied the protection measures outlined in section x.1 and assumed that all obstructions would be made 100% passable. The goal was to assess the two actions that were applied with equal intensity to both scenarios 1 and 3. The remaining benefit could then be attributed to intensity of application of the restoration actions.

4. Scenario 3: See description in section F.3.

5. Scenario 2: See description in section F.3.

6. Scenario 1: See description in section F.3.

7. Scenario 1 (half protection): This scenario used all the same actions and intensities as S1, but used ½ the rate of passive restoration. Specifically, 12.5% improvement of environmental attributes related to the stream channel and riparian zone and 5% for attributes related to roads (see **Table F11** for details of which of the 46 attributes fall into each category). The goal of this model run was to determine how sensitive our results were to the rates of passive restoration.

8. Scenario 1 (double protection): This scenario used all the same actions and intensities as S1, but used double the rate of passive restoration. Specifically, 50% improvement of environmental attributes related to the stream channel and riparian zone and 20 % for attributes related to roads (see **Table F11** for details of which of the 46 attributes fall into each category). The goal of this model run was to determine how sensitive our results were to the rates of passive restoration.

9. Scenario 1 with template lower Wenatchee: This scenario used all the same actions as Scenario 1 then improved conditions in the Lower Wenatchee mainstem to template for all 46 environmental attributes. The goal of this model run was to see how much additional performance improvement potential remained in the lower mainstem after implementation of Scenario 1.

10. PFC: See description in section F.3.

11. Habitat Template: See description in section F.3.

12. True Template: See description in section F.3.

Modeling additional scenarios to evaluate assumptions revealed that the protection assumptions were particularly effective for increasing spring Chinook abundance and productivity but only very small gains could be made for productivity under any other scenario, except doubling the passive restoration assumption (**Table F24**, **Figure F16**). Similar gains were obtained for abundance under all of the test scenarios, indicating that one aspect of the model input was not driving the results for abundance. Conversely, the habitat quality improvements in S3 made a relatively large difference to the life history diversity index (**Figure F16**). This was somewhat contrary to our initial assumption that the life history diversity index was primarily driven by accessing formerly occupied habitat through obstruction removal. It emphasized the importance of restoring habitat quality in conjunction with removing obstructions because just providing more degraded habitat will not increase productivity and therefore will not increase the proportion of viable life history trajectories (diversity index). Further evidence of this was provided in the individual attribute sensitivity tests when productivity was reduced by removing obstructions without improving habitat behind the obstructions (**Table F21**). The scenario modeling results were not substantially altered by the magnitude of the passive restoration assumption (represented by error bars to S1 in **Figure F16**) because the assessment units where it was applied were in good condition so the restoration potential was relatively low. This was not particularly surprising for the diversity index and productivity because these performance measures were already very close to the maximum in-basin potential (**Figure F16**). Abundance, on the other hand, was still 15% below PFC and 31% from the habitat template indicating that additional improvements outside the major production areas still had potential to contribute to increased abundance. We hypothesized that the remaining abundance potential was in the mainstem Wenatchee River below Tumwater Canyon where degraded habitat conditions where effecting survival of sub-yearling parr that left the tributaries above Tumwater Canyon. To test this hypothesis we conducted an additional model run that used S1 conditions in all assessment units but improved middle and lower mainstem Wenatchee River conditions to the habitat template condition. This scenario increased the proportion of in-basin potential for abundance by an additional nine percent when compared to S1, but added nothing to productivity and very little to the diversity index. This scenario emphasized the importance of the lower Wenatchee mainstem for capacity through providing additional habitat quantity for transient rearing juvenile life stages (i.e. subyearling fall migrants that overwinter in the mainstem Wenatchee). It also highlights the kinds of improvements that could be made through addressing secondary limiting factors. The remaining difference between the scenarios and the habitat template were due to secondary limiting factors throughout the watershed.

Table F24 Ecosystem Diagnosis and Treatment model predictions of Diversity Index, Productivity, Capacity, and Abundance under various scenarios for Wenatchee spring Chinook.

		Adult Performance					Juvenile Performance		
Population	Scenario	Diversity index	Productivity	Capacity	Abundance	Abundance with 0.63% SAR	Juvenile Productivity	Juvenile Capacity	Juvenile Abundance
Wenatchee Spring Chinook	Current without harvest	48%	4.4	2,071	1604	741	236	170,763	117,619
	Protection (passive restoration)	50%	4.9	2,337	1859	830	257	181,892	131,674
	Protection and Obstr	55%	4.9	2,563	2,039	895	255	195,520	142,084
	Scenario 3	75%	5.0	3,114	2,496	1,085	271	231,024	172,176
	Scenario 2								
	S1 (half protection)	77%	5.0	3,253	2,600	1,176	282	250,279	186,675
	Scenario 1	78%	5.1	3,372	2,714	1,209	288	254,307	191,831
	S1 (double protection)	79%	5.4	3,563	2,904	1,272	299	263,211	201,908
	S1 w/ template lower Wen	79%	5.2	3,838	3,094	1,408	297	295,144	223,470
	PFC	81%	4.9	4,432	3,534	1,620	287	344,491	257,222
	Habitat Template	87%	6.5	4,990	4,221	1,922	376	377,537	305,060
	True Template	97%	26.8	23,978	23,084				

		Increase relative to current					Increase relative to current		
Wenatchee Spring Chinook	Current without harvest	0%	0%	0%	0%	0%	0%	0%	0%
	Protection (passive restoration)	4%	10%	13%	16%	12%	9%	7%	12%
	Protection and Obstr	14%	10%	24%	27%	21%	8%	14%	21%
	Scenario 3	55%	14%	50%	56%	46%	15%	35%	46%
	Scenario 2								
	S1 (half protection)	59%	12%	57%	62%	59%	20%	47%	59%
	Scenario 1	60%	16%	63%	69%	63%	22%	49%	63%
	S1 (double protection)	64%	22%	72%	81%	72%	27%	54%	72%
	S1 w/ template lower Wen	63%	16%	85%	93%	90%	26%	73%	90%
	PFC	67%	11%	114%	120%	119%	22%	102%	119%
	Habitat Template	79%	46%	141%	163%	159%	60%	121%	159%
	True Template	100%	504%	1058%	1339%				

		Proportion of In-basin Potential					Proportion of In-basin Potential		
Wenatchee Spring	Current without harvest	56%	68%	42%	38%	39%	63%	45%	39%

Chinook	Protection (passive restoration)	58%	75%	47%	44%	43%	68%	48%	43%
	Protection and Obstr	64%	75%	51%	48%	47%	68%	52%	47%
	Scenario 3	86%	78%	62%	59%	56%	72%	61%	56%
	Scenario 2								
	S1 (half protection)	88%	77%	65%	62%	61%	75%	66%	61%
	Scenario 1	89%	79%	68%	64%	63%	76%	67%	63%
	S1 (double protection)	91%	83%	71%	69%	66%	79%	70%	66%
	S1 w/ template lower Wen	91%	79%	77%	73%	73%	79%	78%	73%
	PFC	93%	76%	89%	84%	84%	76%	91%	84%
	Habitat Template	100%	100%	100%	100%	100%	100%	100%	100%
	True Template								

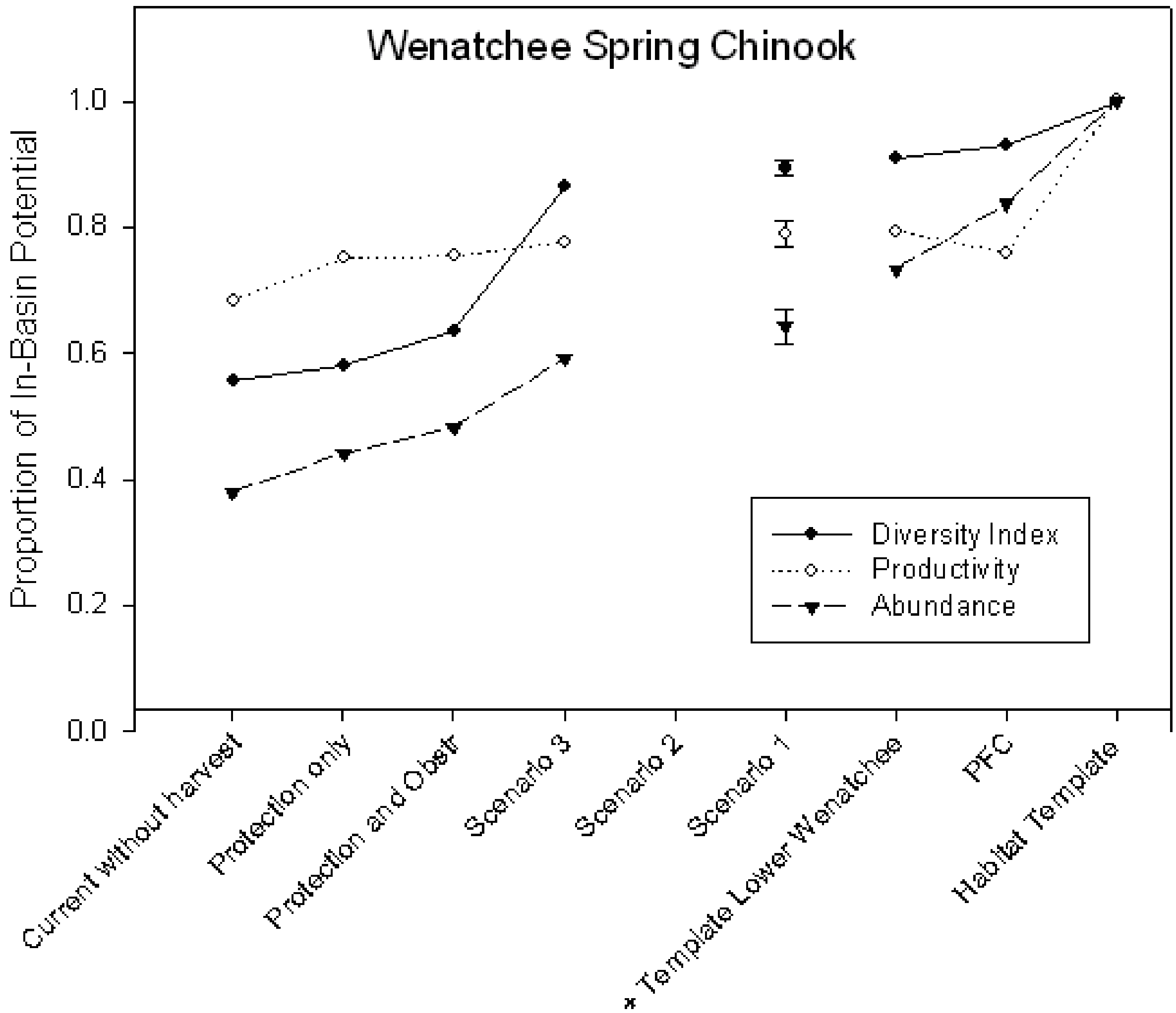


Figure F16. The proportion of in-basin potential predicted by EDT for Wenatchee spring Chinook under various modeling scenarios

Evaluation of the restoration potential from the diagnosis suggested that the assessment units where limiting factors were addressed with restoration actions were not necessarily the most important areas for increasing all the performance measures for both species. To evaluate this effect we summed the restoration potential from groups of subwatersheds above and below Tumwater Canyon from the "diagnosis" portion of the EDT analysis (section F.1). We hypothesized that high intensity restoration efforts in the small but more degraded subwatersheds below Tumwater Canyon (Mission, Peshastin, Chumstick, and Icicle Creeks) were not affecting population level performance as much as small degradations to large important production areas (Chiwawa, White, Little Wenatchee Rivers, and Nason Creek).

For spring Chinook, the model predicted no restoration potential for productivity in subwatersheds below Tumwater Canyon, similar potential above and below Tumwater Canyon for abundance, and much higher potential to improve diversity below Tumwater Canyon (**Figure F17**). The large improvement in the diversity index was not surprising considering that spring Chinook do not currently occupy this habitat but it represents a different range of elevations, temperatures, ecoregions, geologic, and hydrologic conditions than the spawning areas above Tumwater Canyon. Except for Lower Nason Creek, our scenarios only applied protection (and the resulting passive restoration) to the areas above Tumwater Canyon. In general, the passive restoration rates were applied to very small restoration potentials for individual environmental attributes (see LWD example; **Table F23**), but when summed over the large quantities of habitat in the upper watersheds the results indicated that considerable gains in performance could still be obtained from these areas **Table F25**). These results were not scaled to stream length or area, so general application of restoration efforts would probably not be very efficient. A reach level diagnosis within each subwatershed needs to be conducted to identify specific opportunities to improve habitat conditions.

For steelhead, there was relatively more potential benefit from restoration actions in the subwatersheds below Tumwater Canyon for all three performance measures (**Figure F17**).

Table F25 Restoration potential (% increase in each performance measure) from EDT for a subset of assessment units for Wenatchee spring Chinook and steelhead.

		Diversity Index	Productivity	Abundance
Population and Area	Assessment Unit	Restoration Potential	Restoration Potential	Restoration Potential
	Chiwawa River	0%	20%	13%
Spring Chinook	Lower Nason Ck	4%	23%	15%
(above Tumwater Canyon)	White River	0%	19%	8%
	Little Wenatchee	1%	6%	4%
	Subtotal	5%	68%	41%
	Mission Ck	15%	0%	7%
Spring Chinook	Lower Peshastin Ck	21%	0%	17%
(below Tumwater Canyon)	Chumstick Ck	6%	0%	3%
	Lower Icicle Creek	9%	0%	8%

	Subtotal	50%	0%	35%
Steelhead	Chiwawa River	5%	16%	18%
(above Tumwater Canyon)	Lower Nason Ck	12%	25%	20%
	White River	2%	19%	15%
	Little Wenatchee	1%	9%	7%
	Subtotal	20%	70%	60%
	Mission Ck	50%	13%	23%
Steelhead	Lower Peshastin Ck	35%	20%	49%
(below Tumwater Canyon)	Chumstick Ck	10%	1%	3%
	Lower Icicle Creek	22%	0%	28%
	Subtotal	116%	34%	103%

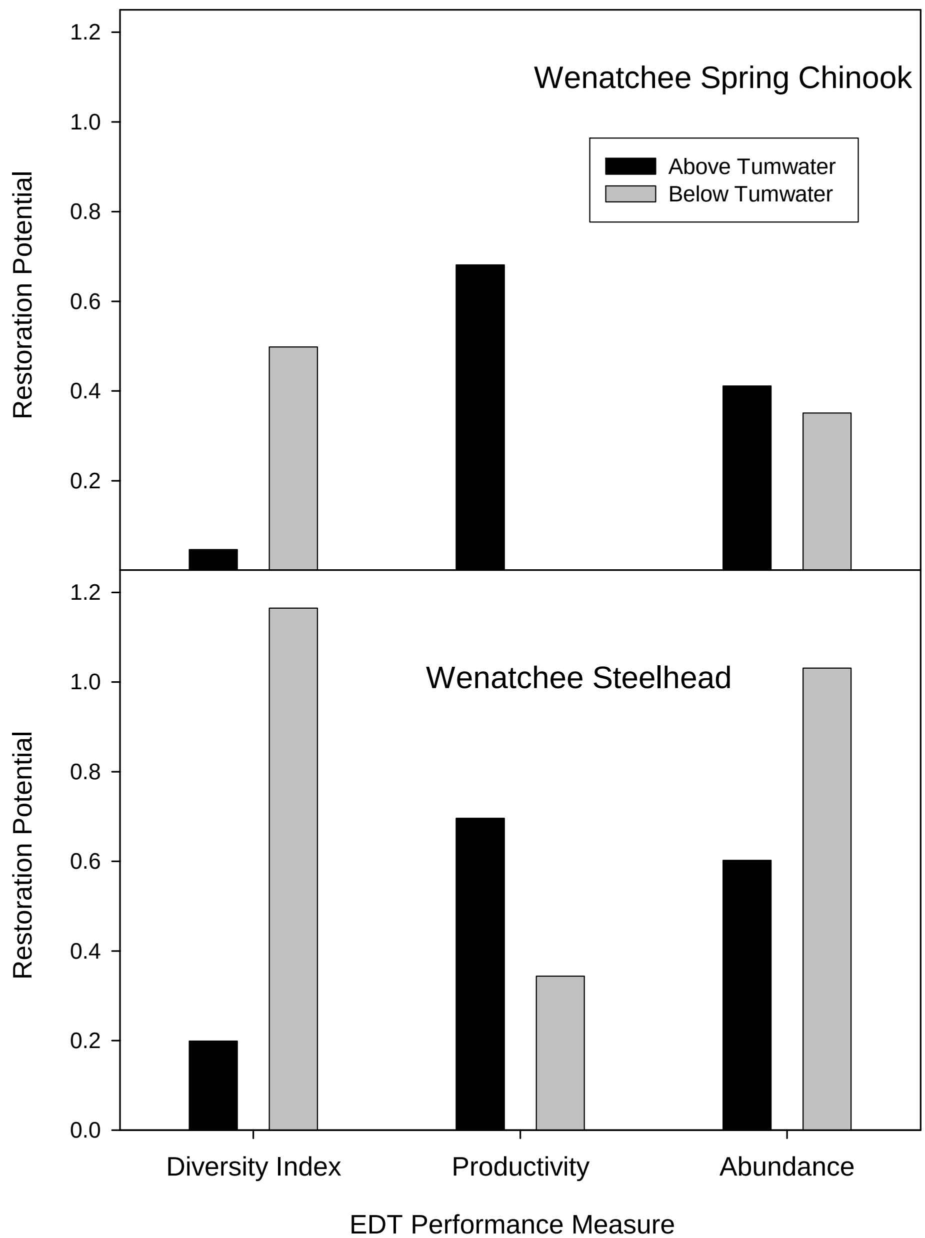


Figure F17 The sum of the restoration potential (% increase in each performance measure) from EDT for Wenatchee spring Chinook and steelhead. Above Tumwater Canyon assessment units included Chiwawa, Nason, White, and Little Wenatchee whereas the below Tumwater Canyon assessment units included Mission, Peshastin, Chumstick, and Icicle Creek.

We concluded that the relatively small difference in performance measures between scenarios 1 and 3 was a result of 4 factors;

1. The same protection and barrier removal action classes and intensities were applied to both scenarios.

2. Protection was the only action applied to most of the large important production areas (particularly for spring Chinook).

3. Restoration actions were generally applied to smaller subwatersheds with less inherent potential (stream area and intrinsic habitat quality) to contribute to abundance and productivity, or to large lower mainstem reaches where they were relatively less effective (due to limitations in applying actions to large systems and because fewer life stages use the lower mainstem.

4. The absolute change to individual environmental attributes was generally small (regardless of intensity of application) due to low restoration potential (small difference between current and template conditions).

References

Andonaegui, C. 2001. Salmon, steelhead, and bull trout habitat limiting factors for the Wenatchee Subbasin (water resource inventory area 45) and portions of WRIA 40 within Chelan County (Squilchuck, Stemilt, and Colockum drainages). Washington State Conservation Commission. Olympia, Washington.

CCCD 2004. CCCD (Chelan County Conservation District). 2004. Entiat water resource inventory area (WRIA) 46 management plan. Prepared for the Entiat WRIA Planning Unit. Chelan County Conservation District, Wenatchee, WA.

Lestelle, L. C., L. E. Mobrand, J. A. Lichatowich, and T. S. Vogel. 1996. Ecosystem Diagnosis and Treatment (EDT) applied ecosystem analysis – A Primer, Report to Bonneville Power Administration. Project No. 199404600, Contract No. 1994AM33243. BPA report DOE/BP-33243-2. Portland, Oregon.

Lestelle, L., L. E. Mobrand, and W. E. McConnaha. 2004. Information Structure of Ecosystem Diagnosis and Treatment (EDT) and habitat rating rules for spring Chinook, coho, and steelhead trout. Mobrand Biometrics Inc. www.mobrand.com. Vashon, Washington.

Lichatowich, J., L. Mobrand, L. Lestelle, and T. Vogel. 1995. An approach to the diagnosis and treatment of depleted Pacific salmon populations in freshwater ecosystems. Fisheries (Bethesda) 20(l):10-18.

Mullen, J. W., K. R. Williams, G. Rhodus, T. W. Hillman, and J. D. McIntyre. 1992. Production and habitat of salmonids in mid-Columbia River tributary streams. US Fish and Wildlife Service Monograph 1. Leavenworth, Washington.

NMFS 1996. Making Endangered Species Act determinations of effect for individual or group actions at the watershed scale. National Marine Services Division. Environmental and Technical Services Division. Habitat Conservation Branch. “Matrix of Pathways and Indicators”. http://www.nmfs.noaa.gov.

NPPC 2004. Methow Subbasin Plan. http://www.nwppc.org/fw/subbasinplanning

Tagart, J.V. 1984. Coho salmon survival from egg deposition to fry emergence. In J.M. Walton and D.B. Houston, (eds.), Proceedings of the Olympic wild fish conference. Peninsula Coll. Fish. Technol. Prog., Port Angeles, WA.