APPENDIX A

Ecosystem Diagnosis & Treatment (EDT)

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Ecosystem Diagnosis and Treatment (EDT) is a system for rating the quality, quantity, and diversity of stream habitat relative to the needs of a "focal" salmonid species. The methodology was designed to be a practical, science-based approach for watershed planning. It gives resource managers a scientific tool to link habitat characteristics to salmon performance and provides a basis for prioritizing protection and restoration activities, evaluating progress, and refining restoration strategies.

EDT was developed by Mobrand Biometrics, Inc. (MBI) in the 1990s with input from state, federal, and tribal agency scientists. A partial list of articles and other documents containing more information about EDT appears at the end of this appendix. To date, EDT has been used in most anadromous watersheds in Puget Sound and in the Columbia River Basin. It is the most widely used analytical tool for watershed planning targeting salmonids. In 2001-2002, MBI worked with the Northwest Power and Conservation Council to bring EDT into the web environment to make the methodology available to the public.

EDT is a methodology that includes a conceptual framework for decision making and modeling tools that organize environmental information in a centralized database. It is a "scientific expert" system that translates watershed and population information into population performance parameters (abundance, productivity, and diversity) for salmonids. In effect, EDT provides a description of the way in which the focal species would rate conditions in a stream, based on scientific understanding of their needs.

This system allows users to predict how stream habitat might change in response to future conditions such as watershed restoration and development. These types of predictions provide a basis for adaptive management of stream restoration.

Application of the EDT methodology results in a scientifically based assessment of environmental conditions, identification of restoration and protection needs, prioritization of restoration actions to maximize potential benefits to salmonids, and formulation of long-term restoration plans for watersheds based on adaptive management principles.

An EDT analysis begins with a description of the stream environment. The stream is divided into segments, or "reaches." Each reach is described quantitatively in terms of the Stream Unit Type, such as riffles, pools, and so on. The Stream Unit Types used in EDT are:

- Backwater pools
- Beaver ponds
- Large cobble/boulder riffles
- Primary pools
- Pool tailouts
- Glides
- Off-channel areas
- Small cobble riffles

Each reach is then described qualitatively in terms of Environmental Attributes, such as temperature, flows, sediment, and so on. The Environmental Attributes used in EDT are:

- Alkalinity
- Artificial confinement
- Bed scour
- Benthos community richness
- Diel flow pattern
- Dissolved oxygen
- Embeddedness
- Fine sediment
- Fish community richness
- Fish pathogens
- Fish species introductions
- Gradient
- Harassment
- Hatchery outplants
- Icing
- Metals in soil
- Metals in water
- Natural confinement
- Natural flow regime
- Nutrient enrichment
- Obstructions
- Pollutants in water
- Predation
- Regulated flow regime
- Riparian function
- Salmon carcasses
- Temperature maximum
- Temperature minimum
- Temperature spatial variation
- Turbidity
- Water withdrawals
- Within year high flow
- Within year low flow
- Wood

The quantitative and qualitative descriptions, combined with some general geographic descriptors, e.g., subbasin, stream, and reach names; channel width and length, form the basic habitat inputs to EDT.

The next step in EDT is to define the species being analyzed, i.e., the "focal" species. Spawning reaches and times and harvest patterns are defined. Life history patterns (profiles) are created for both juveniles and adults within the defined population.

Once the environment has been described and the focal species defined, the next step is to rate the quality and quantity of habitat with respect to the needs of the species. The measure of habitat value is the biological productivity and carrying capacity of the stream for the selected focal species under the habitat conditions described. In EDT, habitat quality is rated using a set of "rules" that relates conditions, such as water temperature, to the survival of a particular life stage of the focal species. The rules are developed by consulting with scientific experts on the habitat needs of the focal species and by examining scientific literature.

The Habitat Attributes used in EDT are:

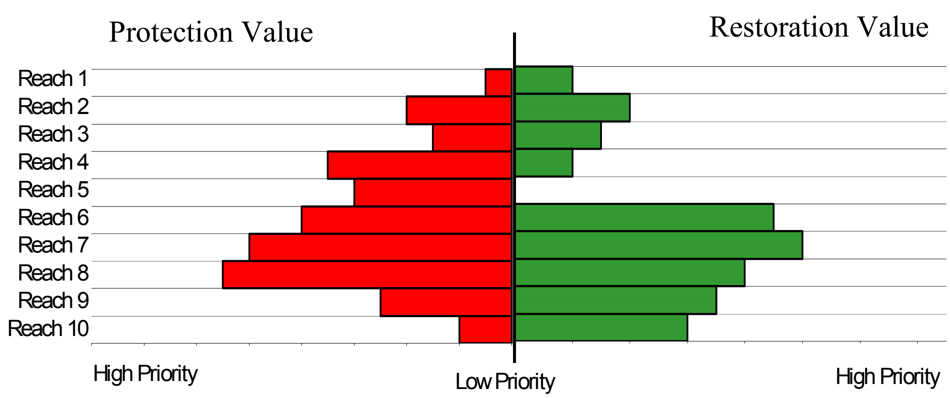
- Channel stability
- Chemicals
- Competition
- Flow
- Food
- Habitat diversity
- Harassment
- Key habitat
- Obstructions
- Oxygen
- Pathogens
- Predation
- Salinity
- Sediment load
- Temperature
- Water withdrawals

Combining the Environmental Quality Attributes into Habitat Attributes allows the quality of the habitat to be related to the survival of one or more life stages of the focal species. For example, the Habitat Attribute "habitat diversity" is formed by combining survival relationships for a particular life stage, such as juvenile rearing over the summer, with Environmental Quality Attributes such as stream gradient, natural and artificial channel confinement, riparian function, and presence of woody debris. The result is that the survival of the juvenile summer rearing life stage can be related to habitat diversity as a function of gradient, channel confinement, riparian function, and woody debris.

The quantity of habitat is rated by summing the amount (total area) of different stream unit types in a stream reach and weighting them according to their potential value for a given life stage. For example, small cobble riffles are more important (weighted heavily) for spawning whereas primary pools are not important for this life stage and receive a weight of zero.

By rating the quantity and quality of habitat as seen "through the eyes" of the focal species reach by reach and performing an EDT analysis based on these inputs, it is possible to identify those areas where conditions are particularly good or bad for the fish. Actions that could be taken in "bad" areas to fix them and in "good" areas to preserve them can also be identified. The EDT output identifies the restoration and protection value for each reach as shown in Figure A-1.

Figure A-1 Example of a plot of restoration and protection priorities along a stream



Baseline reports from EDT describe population performance potential (under specified habitat conditions) in terms of capacity, productivity, and diversity. Factors limiting each life stage are identified.

Restoration actions based on the population performance potential and limiting factors may then be developed and combined into scenarios. Scenarios demonstrate how a salmonid population's performance can be expected to change as a result of future actions. Different actions or combinations of actions may be compared in terms of their biological effectiveness. Comparison may also be made to the original stream reach data. These comparisons allow planners and managers to choose actions that will yield the greatest benefit for the least cost.

The EDT output report referred to as a "reach analysis" is presented using a "Consumer Reports" format with different sized dots representing different sized impacts (the larger the dot, the more severe the impact) on survival for each focal species at a given life stage.

The EDT Online Web site was developed by MBI in cooperation with government agencies and organizations in the Pacific Northwest. The site is designed to allow planners and technical teams to assess habitat conditions in their areas and to analyze the benefits and risks of recovery actions. More information about becoming an EDT Online user is available at www.mobrand.com/EDT. This Web site provides documentation and tools available for download; the Mobrand Website (www.mobrand.com) provides most of the general EDT reports and literature, as well as the documentation available on the EDT Online Web site.

Additional Information

American Fisheries Society. 1994. Proceedings of the Northwest Pacific Chinook and Coho Salmon Workshop of the American Fisheries Society, November 1994, Eugene, Oregon.

Lestelle, L.C., L.E. Mobrand, J.A. Lichatowich, and T.S. Vogel. 1996. Applied ecosystem analysis – a primer, EDT: the ecosystem diagnosis and treatment method. Bonneville Power Administration. Project No. 9404600, Portland, Oregon.

Lichatowich, J.A. and L.E. Mobrand. 1996. Chinook salmon (*Oncorhynchus tschawytscha*) in the Columbia River: the components of decline. Mobrand Biometrics, Inc., compiler. Report 5 of 8 in Applied Ecosystem Analysis – background, EDT: the ecosystem diagnosis and treatment method. Bonneville Power Administration, Portland, Oregon.

Lichatowich, J., L.E. Mobrand, L. Lestelle, and T. Vogel. 1995. An approach to the diagnosis and treatment of depleted Pacific salmon populations in freshwater ecosystems. Fisheries 20(1): 10-18.

Mobrand, L.E., L. Lestelle, and L. Gilbertson. 1995. An approach to planning ecosystem restoration with specific reference to the Grande Ronde Watershed, Oregon. In: M.L. Keefe (ed.) Salmon Ecosystem Restoration: Myth and Reality, Proceedings of the 1994

Mobrand, L.E., L.C. Lestelle, J.A. Lichatowich, and T.S. Vogel. 1997. An approach to describing ecosystem performance "through the eyes of salmon". Canadian Journal of Fisheries and Aquatic Sciences 54: 2964-2973.

Available on the Mobrand website (http://www.mobrand.com):

EDT Information Structure for Chinook, Coho, and Steelhead (.pdf 579 kb).

Guidelines for Rating Level 2 Environmental Attributes in Ecosystem Diagnosis and Treatment (EDT) (.pdf 810 kb).

Species-Habitat Rules for Bull Trout in EDT (.pdf 1362 kb).

DRAFT - STREAM REACH ANALYSIS SUMMARY FOR SANDY RIVER CHINOOK SALMON (REVISIONS EXPECTED!)

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

Stream(s) / Water(s):	Sandy River	**Sub-Watershed:**	
Reach:	Sandy1 extends from confluence with Columbia River upstream 5.4 miles (near Dabney Park)	**Reach Length (mi):**	5.4
		Reach Code:	Sandy1

Restoration Benefit Category:	A	**Life History Diversity Rank:**	4	**Potential % change in diversity:1/**	5.6%
Combined Performance Rank:	2	**Productivity Rank:**	9	**Potential % change in productivity:1/**	7.6%
% of Total Life History Trajectories Affected:	100%	**Average Abundance (Neq) Rank:**	2	**Potential % change in Neq:1/**	28.2%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival** Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Habitat diversity	Harvest	Nutrient load	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	% Key habitat (quantity)
Spawning	Sep	2.6%	-89.9%	3							•							⬤		
Egg incubation	Sep-Apr	2.6%	-100.0%	1													⬤	⬤		
Fry colonization	Mar-May	5.3%	-7.3%	10						●										
0-age resident rearing	Mar-Oct	12.9%	-10.7%	5					•	●					●	●		●		
0-age transient rearing	Mar-Aug	14.8%	-2.2%	11						●										
0-age migrant	Oct-Nov	13.8%	-3.2%	9						•					•	●				
0,1-age inactive	Oct-Mar	6.4%	-35.4%	4, 2	●				●	●					•	●	⬤			
1-age migrant	Mar-Jun	68.9%	-0.7%	8						●						●				
1-age resident rearing	Mar-May	6.4%	-3.7%	12						•										
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Apr-Aug	100.0%	-0.9%	6						●	●							●		
Prespawning holding	May-Sep	2.6%	-24.3%	7					•	●	•							●		

1/ 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).

<HP> indicates highest priority given due to fragmentation of habitat by dam or reservoir.

KEY

NA = Not applicable

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

Table Heading Descriptions

Species/Component – Identifies the species to which the reach analysis applies. In this case, the species being examined is spring Chinook.

Restoration Potential – Identifies the comparison being used to determine the restoration potential of the reach. For the Sandy River, current habitat conditions are being compared to historic (Template) conditions.

Restoration Emphasis – Identifies the emphasis of the restoration approach. Typical restoration approaches could include increasing salmon productivity, re-establishing lost life-history patterns, or improving habitat quality through active restoration.

Stream(s) Water(s) – Used to identify basin, major river, ocean reach, etc.

Reach – Provides a brief description of the reach location.

Sub-watershed – Line provided to allow modelers to break the basin into subbasins for analysis purposes.

Reach Length – The length of the reach in either miles or kilometers.

Reach Code – Identifies the specific reach the data in the table applies to and its EDT modeling designation.

Restoration Benefit Category – The reach category is an arbitrary grouping of reaches based on a visual examination of the change in diversity index, productivity, and abundance for the reach if the reach were fully restored to the historic condition (Template). In this example, Sandy1 was assigned to the "A" category as its restoration has great potential for improving spring Chinook diversity, productivity, and abundance.

Life History Diversity, Productivity and Average Abundance (NEQ) Rank – Shows the ranking of the reach relative to all others for these performance measures. For this example, Sandy1 was the 4th best candidate reach for improving spring Chinook life history diversity, 9th for productivity, and 2nd for increasing abundance.

% of Total Life History Trajectories Affected – Calculates the percent of all modeled fish trajectories that this reach impacts. Sandy1 affects 100% of the trajectories, as it is the first reach in the basin. In general, the further upstream the each, the fewer trajectories the reach affects.

Combined Performance Rank – Combined reach ranking is the average rank among the three performance ranks in comparison to all reaches in the basin. In other words, the three ranks are averaged for each reach, the average scores for the reaches are then sorted lowest to highest, the lowest score is then converted to a 1 (reach with highest restoration potential) other reaches assigned ranks based on ascending order. In this example, Sandy1 was rated "2"; therefore, there is only 1 reach with a higher restoration benefit.

Potential % Change in Productivity, Abundance, and Diversity – These are the basic parameters for comparing the benefit category and reach ranking. They show the potential for improvement in overall population performance if this reach were fully restored to historic conditions. The restoration of Sandy1 would result in a 5.6%, 7.6%, and 28.2% increase in spring Chinook diversity, productivity, and abundance (NEQ), respectively.

Life Stage – This column shows the life stages examined in the model (may vary by species).

Relevant Months – The months, or target month, when the life stage occurs.

% of Life History Trajectories Affected By Life Stage – This column shows how the reach is used by the entire spring Chinook population. Trajectories are computer-generated pathways through the landscape. Trajectories originate with spawning and end with pre-spawning holding, i.e., closed life history. It should be noted that:

1. The percent of the life history trajectories affected for pre-spawning, egg incubation, and spawning are reach specific. For example, note that the % of life history trajectories is the same for all of these life stages (2.6%).

2. Note that the values for other life stages vary considerably as fish from different reaches in the basin use this reach differently. For example, 68.9% of the 1-age migrant trajectories pass through this reach, but only 5.3% of the fry colonization trajectories use the reach. The fry

trajectories are made up of fry produced in the reach and those migrating downstream from the next reach or two upstream.

Productivity change (%) – This is the change in life stage specific productivity resulting from the change in the attributes shown across the row (black dots). For Sandy1, the reach analysis shows that spawning productivity has decreased by 89.9% due primarily to a change in temperature in this reach in comparison to Template conditions.

Life Stage Rank – Rank is a combination of productivity loss and relative use of the reach by a particular life stage. A reach that is heavily used for a particular life stage and that has experienced a large loss will rank high. A reach may have experienced a large change in productivity for a life stage but if the reach is not used heavily by that life stage it will rank lower. In this example, egg incubation (1) was the life stage most heavily affected by the change in the attributes, followed by 1-age inactive (2) and spawning (3).

Change in attribute impact on survival – A Consumer Report style format is used to show the change in each attribute in comparison to the Template condition. Larger black circles indicate greater effect on survival as the result of a decrease in habitat quality. Circles are scaled in comparison to all other circles presented for the reach. Note that a lot of small black circles spread across multiple attributes could equal or exceed the effect of a single large circle. Thus, both the life stage rank and the size of the circles must be examined to discern the conclusions presented in this table. Clear circles show where conditions have improved for a life stage. For example, the addition of a reservoir would increase pool habitat which in turn would result in an increase in key habitat for juvenile rearing.