# Appendix B-1

## Level 2 Environmental Attributes

Level 2 Environmental Attributes are a standardized set of attributes for characterizing the environment, or ecosystem, as it affects the performance of various species. The attributes described here were selected to be applied to fish species, and in particular to salmonid species. Other attributes may need to be added to analyze performance for other aquatic species within freshwater.

This section provides a brief description for each of the 45 environmental attributes used to characterize the freshwater environment. Each of the 45 attributes is defined and described with regard to its ecological role, some of the factors affecting its condition, and its general importance to salmonid fishes of the Pacific Northwest. These descriptions should be helpful to individuals reviewing the Level 2 attribute values and in understanding the role of these attributes within the rules. Also, this section will be useful in the process of updating Level 2 information through the **Assessment Review** that the Northwest Power Planning Council is initiating in mid 2000.

The attributes are presented in alphabetical order.

# Alkalinity

## *Definition/Usage*

Alkalinity of water (at moderate flows)

## *Importance and Role*

Alkalinity is broadly correlated with the productive capacity of streams, with respect to both primary production and fish production. The correlation between alkalinity and fish production is believed to be due to the role alkalinity plays in the production of food organisms.

## *Categorical Conclusions*

| Index 0 | Index 1 | Index 2 | Index 3 | Index 4 |
|---|---|---|---|---|
| Very low (average value typically would be 0-5 mg/l) | Moderately low (average value typically would be 5-25 mg/l) | Moderately high (average value typically would be 25-50 mg/l) | High (average value typically would be 50-150 mg/l) | High (average value typically would be 150-250 mg/l) |

* *Where an index value is associated with a range, the integer value is assumed for modeling to be the midpoint. Index values can be identified as non-integers to represent the lower or upper ends of a range.*

## *Factors Affecting Attribute/Guidelines*

Because of the variability that can occur in alkalinity data and the incompleteness of available data for this data, a measure of alkalinity is sought for broad ecological regions only. Alkalinity is highly correlated with water yield in watersheds, being lowest in high runoff areas.

In general, alkalinity on the west side of the Cascades will fall into index levels 1 and 2. Therefore, Index 1 or 2 should be prevalent for the Westside unless evidence indicates otherwise. While alkalinity is generally higher on the east than the west side of the Cascades, it can vary widely in relation to runoff patterns, proximity to the Cascade crest, and local geology. In general, Index 3 and 4 should be prevalent in the mid and lower portions of subbasins on the east side of the Cascade crest but lower as the crest is approached.

## *Special Instructions for New Input or Updates*

In general, this attribute should be treated as a low priority. Default values premised on the pattern described above can be applied. When the attribute is explicitly addressed, all months should be rated the same. Conditions under moderate flows should be considered.

### *Effect on Level 3 Biological Metrics*

Alkalinity affects the Level 3 attributes Food and Competition (as a modifying attribute associated with food fish food production) and, in turn, affects 1) the maximum density that can be attained by the end of rearing life stages and 2) resultant species productivity.

### *References/Sources*

Importance and Role: Hynes (1970) and Ptolemy (1993).

Factors Affecting: Hynes (1970) and Ptolemy (1993).

# Bed Scour

## *Definition/Usage*

Average depth and frequency of scour on small-cobble/gravel riffles during high flow events. The term "frequent" indicates at least one event every 1-2 years. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1991): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 7 inch diameter), large cobble (7 to 11.9 inch diameter), boulder (>11.9 inch diameter).

## *Importance and Role*

The channel bed is a substrate used by aquatic organisms as a foothold, as a site to deposit or incubate eggs, and as a refuge from floods. The substrate can be extremely active biologically. The disruption of the particles comprising the upper layer of the substrate can therefore have a profound effect on survival and production of species that rely on this area of a stream. In particular, scour of bed materials during high flows can affect the survival of incubating salmonid eggs and overwintering juveniles located there. It can also affect the production of aquatic insects within streams.

## *Categorical Conclusions*

| Index 0 | Index 1 | Index 2 | Index 3 | Index 4 |
|---|---|---|---|---|
| Pool tailouts and riffles very stable, characteristic of conditions prevailing in largely spring fed streams. | Infrequent scour, averaging depths < 10 cm | Frequent scour, averaging depths < 10 cm | Frequent scour, averaging depths > 10 cm and < 25 cm | Frequent scour, averaging depths exceeding 25 cm |

**** Where an index value is associated with a range, the integer value is assumed for modeling to be the midpoint. Index values can be identified as non-integers to represent the lower or upper ends of a range.***

## *Factors Affecting Attribute/Guidelines*

Depth of bed scour in natural conditions is affected by discharge level and geomorphic conditions. Bed scour is generally assumed to occur when discharge reaches bankfull, which typically occurs every 1-2 years under pristine conditions. Some bed mobility occurs at stages below bankfull, but widespread bed mobility commonly occurs at a stage near bankfull. Steep and low-gradient channels, however, fundamentally differ in the extent of bed mobility and the depth of scour during typical bed-mobilizing events (Montgomery et al. 1999).

Bankfull flows generally mobilize the streambed across the entire channel. The average thickness of the layer in active transport is related to the bedload transport rate, which is determined by the magnitude and duration of the peak discharge.

Increased bedload transport rate in a stream reach may result from increases in peak flow or sediment supply—both of which may be caused by various land use activities. Channel straightening, diking, and closure of side channels can also increase bedload transport rate in a channel.

Bed scour within microhabitats of main channels may differ from surrounding areas due to localized conditions. For example, gravels impounded behind log jams may decrease local channel gradient enough to reduce bed scour. Elimination of such microhabitats may prevent spawning fish from spawning at sites relatively protected from significant bed scour. Side channels may also experience less bed scour than main channel areas.

Anadromous salmonids typically bury their eggs 15-20+ cm below the channel bed, whereas smaller resident and anadromous trout bury eggs at shallower depths, typically 5-10 cm (DeVries 1997; Montgomery et al. 1999). Larger females generally dig deeper redds than smaller fish do, and egg survival to emergence is inversely related to the depth of scour between time of spawning and fry emergence.

Montgomery et al. (1996) reported that chum salmon bury their eggs just below scour depths during bankfull flow. This suggests that the average depth of scour in many rivers of the Pacific Northwest prior to watershed development must have been less than this depth. It is likely that average scour depths have increased to greater than these levels in rivers where extensive watershed development has occurred.

In general, therefore, Index values 2-3 (<10 cm - ~17 cm scour depths) should be assumed for unconfined reaches of most streams within the region in pristine conditions during bankfull stage. For tightly confined reaches, Index values should be greater; values in the range 3-4 (~17 cm - >25 cm) are suggested.

## *Special Instructions for New Input or Updates*

This attribute is considered as a high priority for rating.

It is necessary to rate only for the month when bed scour would likely be highest. Other months will be inferred using modeling techniques within the database by applying an appropriate flow pattern for the watershed of interest.

## *Effect on Leve1 3 Biological Metrics*

This attribute affects the Level 3 attribute Channel Stability and, in turn, affects resultant species productivity. The effects generally occur in the egg incubation and inactive life stages, though they can occur in the rearing life stages for certain species as well.

### *References/Sources*

Definition/Usage: Platts et al. (1983) and Gordon et al. (1992)

Importance and Role: DeVries (1997), Gordon et al. (1992), Montgomery et al. (1996), and Montgomery et al. (1999).

Factors Affecting: Gordon et al. (1992), Lisle (1989), Montgomery and Buffington (1993), Montgomery et al. (1996), and Montgomery et al. (1999).

# Benthos Diversity and Production

## *Definition/Usage*

Measure of the diversity and production of the benthic community.

## *Importance and Role*

Benthic organisms in flowing waters comprise an important component of the diet of many fish species, particularly of juvenile salmonids. Food supply in turn can affect the survival of rearing fishes, as well as the maximum densities that can be achieved by these species within key habitats.

## *Categorical Conclusions:*

| Index 0 | Index 1 | Index 2 | Index 3 | Index 4 |
|---|---|---|---|---|
| Macroinvertebrates abundant; multiple species of families Emphemeroptera, Plecoptera, and Trichoptera are present. | Intermediate | Macroinvertebrates common or abundant but 1-2 families among Emphemeroptera, Plecoptera, and Trichoptera are not present. | Intermediate | Macroinvertebrates are present only at extremely low densities and/or biomass. |

## *Factors Affecting Attribute/Guidelines*

The categorical conclusions employed for benthos diversity and production assume that biological impairment of the benthic community may be indicated by the absence of generally pollution-sensitive macroinvertebrate taxa such as Emphemeroptera, Plecoptera, and Tricoptera (EPT).

The EPT is highly sensitive to dissolved oxygen, resulting largely from the combination of temperature and nutrient loading. Benthos production and diversity will be at the lowest possible level under conditions of super enrichment and high temperature. Deleterious effects are assumed to drop sharply with reductions in enrichment levels. The EPT can generally be assumed to be highest possible under conditions of no nutrient loading because dissolved oxygen is normally at or near saturation in the absence of enrichment in the Pacific Northwest.

A suggested guideline is given below that corresponds closely with that for dissolved oxygen (see guideline for *Dissolved Oxygen*); both guidelines are based on water temperature and nutrient enrichment (see guideline for *Nutrient Enrichment*).

**Benthos Index Value Lookup Table**

| Nutrient enrichment index value | Mean monthly water temperature (°C) | | | | |
|---|---|---|---|---|---|
| | ≤10 | >10 and ≤12 | >10 and ≤12 | >10 and ≤12 | >20 |
| 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | |
|---|---|---|---|---|---|
| 1 | 0 | 0 | 1 | 1 | 1 |
| 2 | 0 | 0 | 2 | 2 | 2 |
| 3 | 2 | 2 | 2 | 3 | 3 |
| 4 | 2 | 2 | 3 | 3 | 4 |

Other attributes besides nutrient enrichment and water temperature are known to have significant effects on benthos production and diversity, such as fine sediment loading, riparian function, and toxic substances.

### *Special Instructions for New Input or Updates*

In general, this attribute should be treated as a low priority for rating. There is generally no need to rate this attribute for the region unless unusual conditions are present. Default values built from the temperature and oxygen attributes can be formulated within the database.

When the attribute is explicitly addressed, all months can be rated the same.

### *Effect on Leve1 3 Biological Metrics*

This attribute affects the Level 3 attribute Food, and in turn, affects 1) the maximum density that can be attained by the end of rearing life stages and 2) resultant species productivity.

### *References/Sources*

Importance and Role: Chapman (1966) and Hynes (1970).

Factors Affecting: Allan (1995), Hynes (1960), and Plafkin et al. (1989).

# Channel Width - Month Maximum Width (ft)

## *Definition/Usage*

Average width of the wetted channel during high flow month (average monthly conditions). If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels.

## *Importance and Role*

The wetted width of the channel helps define the quantity of wetted area available as habitat for riverine species.

## *Categorical Conclusions*

| Index 0 | Index 1 | Index 2 | Index 3 | Index 4 |
|---|---|---|---|---|
| < 15 ft | > 15 ft and < 60 ft | > 60 ft and < 100 ft | > 100 ft and 360 ft | > 360 ft |

** Where an index value is associated with a range, the integer value is assumed for modeling to be the midpoint. Index values can be identified as non-integers to represent the lower or upper ends of a range.*

## *Factors Affecting Attribute/Guidelines*

The width of the wetted channel, except in confined reaches, is normally related to discharge.

If width data are not available for the reach of interest, conclusions can be based on personal knowledge of the area. In some cases, a better characterization of flow may exist than channel width. Here, an estimate of width (in feet) can be obtained from flow (cfs) data using an equation formulated for streams in Western Washington from Johnson et al. (1988) as follows:

$$Width = a * CFS^b$$

Where $a$ = 4.58 and $b$ = 0.566

Similarly, a relationship can be applied to streams on the eastside of the Cascade crest using an equation given in Johnson et al. (1988) as follows:

$$Width = a * CFS^b$$

Where $a$ = 10.03 and $b$ = 0.435

The equation for the westside is based on data collected at 154 sites from a variety of rivers and tributaries in Western Washington. The eastside equation was developed with data from sites in the Wenatchee River system; this system contains a high degree of

semi- or fully confined reaches. Presumably, therefore the eastside equation should be applied to systems that contain a higher amount of confined reaches.

### *Special Instructions for New Input or Updates*

Channel width – month maximum width (ft) is to be rated for the month when average flow tends to be highest. This month will typically be during some part of March-June east of the Cascade crest and during December or January on the westside. A flow pattern can be applied to extrapolate from the high and low months to all remaining months.

In assigning values to this attribute, it is essential to recognize that channel width here is average wetted width during the month, *not bankfull width*. Individuals assigning widths to reaches are encouraged to be as specific as possible (i.e., assign width to the foot if possible). If only the categorical conclusion is designated (e.g., an index value of 2), then it will be assumed that the midpoint of the range is most applicable (though an index value will flag this assumption as being bounded by considerable uncertainty).

### *Effect on Leve1 3 Biological Metrics*

This attribute is used to estimate the wetted surface area of channel reaches in different months of the year. Percentages of key habitat for different life stages for the species of interest is then applied to wetted surface area to estimate quantities of key habitat at for each life stage.

### *References/Sources*

Factors Affecting: Johnson et al. (1988).

# Channel Width - Month Minimum Width (ft)

## *Definition/Usage*

Average width of the wetted channel during low flow month (average monthly conditions). If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels.

## *Importance and Role*

The wetted width of the channel helps define the quantity of wetted area available to be used as habitat by riverine species.

## *Categorical Conclusions*

| Index 0 | Index 1 | Index 2 | Index 3 | Index 4 |
|---|---|---|---|---|
| < 15 ft | > 15 ft and < 60 ft | > 60 ft and < 100 ft | > 100 ft and 360 ft | > 360 ft |

** Where an index value is associated with a range, the integer value is assumed for modeling to be the midpoint. Index values can be identified as non-integers to represent the lower or upper ends of a range.*

## *Factors Affecting Attribute/Guidelines*

The width of the wetted channel, except in confined reaches, is normally related to discharge.

If width data are not available for the reach of interest, conclusions can be based on personal knowledge of the area. In some cases, a better characterization of flow may exist than channel width. Here, an estimate of width (in feet) can be obtained from flow (cfs) data using an equation formulated for streams in Western Washington from Johnson et al. (1988) as follows:

$$Width = a * CFS^b$$

Where $a$ = 4.58 and $b$ = 0.566

Similarly, a relationship can be applied to streams on the eastside of the Cascade crest using an equation given in Johnson et al. (1988) as follows:

$$Width = a * CFS^b$$

Where $a$ = 10.03 and $b$ = 0.435

The equation for the westside is based on data collected at 154 sites from a variety of rivers and tributaries in Western Washington. The eastside equation was developed with data from sites in the Wenatchee River system; this system contains a high degree of

semi- or fully confined reaches. Presumably, therefore the eastside equation should be applied to systems that contain a higher amount of confined reaches.

### *Special Instructions for New Input or Updates*

Channel width – month minimum width (ft) is to be rated for the month when average flow tends to be lowest. This month will typically be during late summer or early fall on both sides of the Cascade crest. A flow pattern can be applied to extrapolate from the high and low months to all remaining months.

Individuals assigning widths to reaches are encouraged to be as specific as possible (i.e., assign width to the foot if possible). If only the categorical conclusion is designated (e.g., an index value of 2), then it will be assumed that the midpoint of the range is most applicable (though an index value will flag this assumption as being bounded by considerable uncertainty).

### *Effect on Leve1 3 Biological Metrics*

This attribute is used to estimate the wetted surface area of channel reaches in different months of the year. Percentages of key habitat for different life stages for the species of interest is then applied to wetted surface area to estimate quantities of key habitat at for each life stage. This attribute is also used to group certain Biological Rules (Level 2 to Level 3 translation rules) by size of stream.

### *References/Sources*

Factors Affecting: Johnson et al. (1988).

# Confinement – Natural

## *Definition/Usage*

The extent that the valley floodplain of the reach is confined by natural features—determined as the ratio between the width of the valley floodplain and the bankfull channel width. *Note: this attribute addresses the natural (pristine) state of valley confinement only. The extent that reaches are confined by hydromodifications (e.g., diking) is addressed under a separate attribute.*

## *Importance and Role*

Channel confinement affects habitat-forming processes and, hence, the occurrence of different types of fish habitats within the stream network. Extent of confinement also affects water velocity and flood storage capacity of the floodplain, and, consequently it can strongly influence bed stability and potential for scour.

### *Categorical Conclusions*

| Index 0 | Index 1 | Index 2 | Index 3 | Index 4 |
|---|---|---|---|---|
| Reach mostly unconfined by natural features -- Average valley width > 4 channel widths. | Reach comprised approximately equally of unconfined and moderately confined sections. | Reach mostly moderately confined by natural features -- Average valley width 2 - 4 channel widths. | Reach comprised approximately equally of moderately confined and unconfined sections. | Reach mostly confined by natural features -- Average valley width < 2 channel widths. |

## *Factors Affecting Attribute/Guidelines*

Channel morphology and response to high flows are influenced by the degree of confinement by valley walls. Unconfined channels typically have relatively wide floodplains, relatively low gradients, and often are areas of alluvial aggradation. In this situation, sediment supply (of a wide range of sizes) exceeds transport capacity of the channel. Steep channels typically are confined by valley walls and shallow bedrock. These channels have relatively low sediment storage capacities and serve as transport reaches, with sediment loads being carried through the reach during high flow events.

Because confined channels have high transport capacities, their substrates containing small cobbles/gravel are typically subject to higher rates of bed scour than are unconfined reaches.

The extent of natural confinement can be determined from topography maps, though some ground truthing may be required. In Western Washington, natural confinement has been determined for many river systems as part of the Salmon and Steelhead Habitat Inventory and Assessment Project.

### *Special Instructions for New Input or Updates*

All months are rated the same for this attribute.

### *Effect on Leve1 3 Biological Metrics*

This attribute affects the Level 3 attributes Flow and Habitat Diversity, which, in turn, affect productivity of certain life stages of salmonids.

### *References/Sources*

Definition/Usage: Schuett-Hames et al. (1994)

Importance and Role: Montgomery and Buffington (1993)

Factors Affecting: Montgomery and Buffington (1993)

# Confinement – Hydromodifications

## *Definition/Usage*

The extent that man-made structures within or adjacent to the stream channel constrict flow (as at bridges) or restrict flow access to the stream's floodplain (due to streamside roads, revetments, diking or levees), or the extent that the channel has been ditched or channelized.

## *Importance and Role*

Stream channels are modified to protect adjacent property from streambank erosion and flooding. This is accomplished by eliminating and/or reducing meanders to increase velocity, construction of levees and dikes, and armoring streambanks. These alterations reduce or eliminate (often by blocking access) fish habitat and typically reduce the quality of remaining habitat.

## *Categorical Conclusions*

| Index 0 | Index 1 | Index 2 | Index 3 | Index 4 |
|---|---|---|---|---|
| The stream channel within the reach is essentially fully connected to its floodplain. Very minor structures may exist in the reach that do not result in flow constriction or restriction. Note: this describes both a natural condition within a naturally unconfined channel as well as the natural condition within a canyon. | Some portion of the stream channel, though less than 10%, is disconnected from its floodplain along one or both banks due to man-made structures or ditching. | More than 10% and less than 40% of the entire length of the stream channel within the reach is disconnected from its floodplain along one or both banks due to man-made structures or ditching. | More than 40% and less than 80% of the entire length of the stream channel within the reach is disconnected from its floodplain along one or both banks due to man-made structures or ditching. | Greater than 80% of the entire length of the stream channel within the reach is disconnected from its floodplain along one or both banks due to man-made structures or ditching. |

## *Factors Affecting Attribute/Guidelines*

The assignment of ratings to this attribute is subjective, to be based on a determination of the extent that hydromodifications to the channel within a reach have occurred. Such determination may be wholly or partially a *judgment* based on information available. Types of alterations to the channel corridor that should be considered are dikes, bank armoring, closure of flood relief channels, channel straightening, and channelization.

## *Special Instructions for New Input or Updates*

All months are rated the same for confinement—hydromodifications.

### *Effect on Leve1 3 Biological Metrics*

Confinement—hydromodifications affects the Level 3 attributes Flow and Habitat Diversity, which, in turn, affects productivity of certain life stages of salmonid fishes.

### *References/Sources*

Importance and Role: Beechie et al. (1994), Federal Interagency Stream Restoration Working Group (1998).

Factors Affecting: Federal Interagency Stream Restoration Working Group (1998).

# Dissolved Oxygen

## *Definition/Usage*

Average dissolved oxygen within the water column for the specified time interval.

## *Importance and Role*

Dissolved oxygen (DO) is a basic requirement for a healthy aquatic ecosystem. Fish and aquatic insects require DO to survive and carry on life giving functions.

## *Categorical Conclusions*

| Index 0 | Index 1 | Index 2 | Index 3 | Index 4 |
|---|---|---|---|---|
| > 8 mg/L (allows for all biological functions for salmonids without impairment at temperatures ranging from 0-25 C) | > 6 mg/L and < 8 mg/L (causes initial stress symptoms for some salmonids at temperatures ranging from 0-25 C) | > 4 and < 6 mg/L (stress increased, biological function impaired) | > 3 and < 4 mg/L (growth, food conversion efficiency, swimming performance adversely affected) | < 3 mg/L |

** Where an index value is associated with a range, the integer value is assumed for modeling to be the midpoint. Index values can be identified as non-integers to represent the lower or upper ends of a range.*

## *Factors Affecting Attribute/Guidelines:*

DO in unpolluted streams and rivers is usually near saturation; and, under these circumstances, it poses no risk to biological function to species of concern. *Hence index values should be set to 0 when nutrient enrichment is nil for all temperature levels.*

DO can be severely depleted as a result of human activities that introduce nutrients into surface waters. This occurs, for example, when runoff is enriched with fertilizers and animal wastes or from municipal discharges. Nutrient enrichment, consisting of elevated concentrations of phosphates or nitrates, can lead to oxygen depletion when the stream flora increases in biomass followed by death and decomposition of plant material. These conditions are made worse when water temperature increases, due to corresponding increases in rates of plant growth and subsequent decay. Further, oxygen solubility decreases with increasing water temperature. *Index values for DO should be set at 4 when mean monthly water temperatures are high (>20°C) and super enrichment of nutrients occurs. Index values should be reduced corresponding to decreased temperatures or nutrient loading.*

A guideline for the dissolved oxygen index value is given in the Dissolved Oxygen Index Value Lookup Table based on mean monthly water temperature and the Level 2 nutrient enrichment index value (see guideline for *Nutrient Enrichment*).

**Dissolved Oxygen Index Value Lookup Table**

| Nutrient enrichment index value | Mean monthly water temperature (°C) | | | | |
|---|---|---|---|---|---|
| | ≤10 | >10 and ≤12 | >12 and ≤16 | >16 and ≤20 | >20 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 1 | 1 |
| 2 | 0 | 1 | 1 | 1 | 2 |
| 3 | 1 | 1 | 2 | 2 | 3 |
| 4 | 3 | 3 | 4 | 4 | 4 |

### *Special Instructions for New Input or Updates*

Rate the month when DO is likely to be lowest, i.e., the month when temperature is highest. Rate only one month. Other months will be inferred from an appropriate seasonal pattern based on temperature.

### *Effect on Leve1 3 Biological Metrics*

The attribute, Dissolved Oxygen, affects the Level 3 attribute, Oxygen, which, in turn, can affect the productivity of any life stage of stream dwelling fishes.

### *References/Sources*

Importance and Role: Hynes (1970).

Factors Affecting: Allan (1995), Federal Interagency Stream Restoration Working Group (1998), and Hynes (1960).

# Embeddedness

## *Definition/Usage*

The extent that larger cobbles or gravel are surrounded or covered by fine sediment.

## *Importance and Role*

Juvenile fish will hide in the interstitial spaces in stream substrates, particularly in winter, when the voids are accessible. When these spaces are filled by fine sediment (embedded), the quality of the substrate for hiding cover is diminished, and survival can be reduced. It can also diminish the flow of water into the substrate, thereby affecting oxygenation of incubating eggs buried there. Embeddedness also affects the production of aquatic insects.

## *Categorical Conclusions*

| Index 0 | Index 1 | Index 2 | Index 3 | Index 4 |
|---|---|---|---|---|
| < 10% of surface covered by fine sediment | > 10 and < 25 % covered by fine sediment | > 25 and < 50 % covered by fine sediment | > 50 and < 90 % covered by fine sediment | > 90% covered by fine sediment |

** Where an index value is associated with a range, the integer value is assumed for modeling to be the midpoint. Index values can be identified as non-integers to represent the lower or upper ends of a range.*

## *Factors Affecting Attribute/Guidelines*

Responses to increases in fine sediment load depend on the ability of the channel to transport material relative to sediment supply. Responses can include aggradation, channel widening, bed fining, pool filling, or braiding where the amount of introduced sediment overwhelms local sediment transport capacity. Increased supply of fine sediment to a plane-bed channel is expected to result in either fining of the bed surface or channel aggradation. Pool-riffle channels will undergo aggradation and fining in response to increased sediment load. Increased sediment supply can also result in expansion of the zone of active sediment transport. Although bed scour is expected to increase during high flow under this condition, the extent of embeddedness is expected to increase during lower flows. Hence, at the highest levels of sediment loading, reaches with the least transport capacity (typically lower gradient reaches with slowest water velocities) would result in the highest level of deposition and embeddedness.

## *Special Instructions for New Input or Updates*

All months are to be rated the same for embeddedness. In reality, the extent of embeddedness likely varies in response to scour and fill and times when sediment inputs are greatest. A temporal pattern may need to be applied in a future application.

### *Effect on Leve1 3 Biological Metrics*

Embeddedness affects the Level 3 attribute Sediment and, in turn, species survival of free-swimming fish when strongly associated with the streambed.

### *References/Sources*

Importance and Role: Bjornn et al. (1977), Bjornn and Reiser (1991), Chapman and Bjornn (1969), Cordone and Kelly (1961), and Platts et al. (1983).

Factors Affecting: Montgomery and Buffington (1993).

# Fine Sediment Load (intragravel)

## *Definition/Usage*

Percentage of fine sediment within pool-tailouts, glides, and riffles. Fine sediment in this definition refers to the percentage of the substrate composed of particles <0.85 mm in diameter.

## *Importance and Role*

Fine sediment particles within the substrate of pool-tailouts, glides, and riffles can affect the survival of incubating salmonid eggs and alevins by altering oxygen exchange across the organisms and by entombment. Fine sediment can also affect the benthos, both species diversity and production (benthos is rated directly as another attribute, however).

## *Categorical Conclusions*

| Index 0 | Index 1 | Index 2 | Index 3 | Index 4 |
|---|---|---|---|---|
| < 6% fines < 0.85 mm | > 6% and < 11% fines < 0.85 mm | > 11% and < 18% fines < 0.85 mm | > 18% and < 30% fines < 0.85 mm | > 30% fines < 0.85 mm |

** Where an index value is associated with a range, the integer value is assumed for modeling to be the midpoint. Index values can be identified as non-integers to represent the lower or upper ends of a range.*

## *Factors Affecting Attribute/Guidelines*

Levels of fine sediment in salmon spawning areas of unmanaged streams of the Pacific Northwest, British Columbia, and Alaska have been reported to generally range between 6% and 11% (summarized in Peterson et al. 1992). Basin geology and other geomorphic conditions (such as channel slope) can affect percent fines in unmanaged conditions. Some streams in such areas, however, do have fine sediment levels >11%, and, presumably, such situations occur in low slope areas or those with particularly erosive geologic conditions.

All measures of watershed disturbance can affect the amount of intragravel fine sediment. These disturbances can be associated with agriculture (includes grazing), forestry, mining, or urban related. Each of these land use practices contributes major quantities of sediment to streams.

In forested areas, the road system can be a primary contributor; in other cases, slope failures and stream bank erosion are most influential.

On the west side of the Olympic Peninsula, Rittmueller (1986) reported that percent fines ranged from 0.7% in an unlogged basin to 29% in a stream with the highest sediment input coming from heavily used logging roads. Rittmueller found that percent fines increased by 0.15% as percent of watershed clearcut increased by 1%. As road density increased by 1 $km/km^2$, intragravel fine sediment levels increased by 4.3%. In streams

where logging activity exists, road use and road building had ceased or been minimized in recent years, percent fines appeared to have returned to nearly background levels. *It should be noted that these streams would generally have channel slopes >0.5%, and many would have slopes >1%.*

In contrast to Rittmueller's findings, McHenry et al. (1994) suggested that recovery to pre-management levels would be slow for streams draining to the west side of the Strait of Juan de Fuca on the Olympic Peninsula even with road closure. Geology of the area is comprised of sandstones, siltstones and mudstones. Only one of eighteen streams studied was found with percent fines (<0.85 mm) <17%. All streams have been extensively logged over the past century.

The effect of changes in the fine sediment load carried by a stream on the amount of sediment entrained within the upper layer of substrate is related to the ability of the channel to transport material relative to sediment supply. In general, the response of a channel to changes in sediment load are known to depend on sediment transport capacity. Sediment transport capacities are high in high gradient channels, making channel types associated with high slopes more resilient to increased sediment loads. Sediment transport capacity in lower gradient channels (e.g., those <4%) are more easily overwhelmed by increased sediment supply, causing aggradation, channel widening, bed fining, pool filling, or braiding. Thus increased sediment loading should show a much greater response in intragravel fines in low slope than in higher slope reaches.

For many streams, the intragravel fine sediment level may be considered roughly constant over an annual cycle despite periods of scour and fill due to high flows.[1]

## *Special Instructions for New Input or Updates*

All months should be rated the same for fine sediment load (intragravel).[2]

## *Effect on Leve1 3 Biological Metrics*

This attribute affects the Level 3 attribute, Sediment Load and, in turn, affects resultant species productivity in life stages strongly associated with the substrate, particularly during egg incubation.

## *References/Sources*

Importance and Role: Everest et al. (1987), Bjornn and Reiser (1991), and Peterson et al. (1994).

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[1] Peterson et al. (1994) reported that fine sediment levels in spring, following winter high flows, approximated those in the fall prior to the advent of high flows in a salmon spawning stream.

[2] This does not necessarily mean that conditions with a salmon egg pocket would experience the same level of fine sediments, particularly over the entire period of incubation. Currently the Biological Rules assume that conditions remain constant in the redd over the entire period, but conditions may actually differ by hydrologic regime, particularly between streams in the high desert (e.g., the John Day subbasin) and those on the west side of the Cascade crest. This matter will be addressed in refining the rules.

Factors Affecting: Rittmueller (1986), Peterson et al. (1992), and Montgomery and Buffington (1993).

# Flow – Change in Inter-annual Variability in High Flows

## *Definition/Usage*

A measure of between-year variation in magnitude of high flow levels and/or the extent of change in overall high flow level during a month relative to an undisturbed watershed of comparable size, geology, and geography (or as would have existed in the pristine state).

## *Importance and Role*

Hydrologic patterns of ecologically healthy watersheds in the coastal ecoregion are strongly related to the timing and quantity of flow, characteristics of seasonal water storage, and dynamics of surface-subsurface exchanges.

Changes in the timing and quantity of flow, due to land uses and flow regulation, can affect responses of stream dwelling organisms like salmonids, leading to changes in overall performance of their populations.

Species adapted to disturbance events (such as floods) of intermediate intensity, as occurred in most pristine watersheds of the Pacific Northwest, can be negatively affected by increases in the frequency and magnitude of disturbance. Changes in flow runoff patterns associated with channelization, revetment, and timber harvest can increase both magnitude and frequency of high flow events resulting in increased intensity of disturbance.

Moreover, hydrologic regimes that have been shifted to more stable patterns (i.e., less variation and reduced high flows) can result in loss of habitat quality if channel/habitat forming events occur much less frequently.

## *Categorical Conclusions*

| Index 0 | Index 1 | Index 2 | Index 3 | Index 4 |
|---|---|---|---|---|
| Pronounced decreases in high flow levels and/or amount of between year variation in high flow levels relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest). | Some evidence of decreases in high flow levels and/or amount of between year variation in high flow levels relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest) | Typical high flow levels and amount of variation in high flows between years relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest). | Some evidence of increases in high flow levels and/or amount of between year variation in high flow levels relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest) | Pronounced increases in high flow levels and/or amount of between year variation in high flow levels relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest). |

### *Factors Affecting Attribute/Guidelines*

The attribute, Flow—Change in Inter-annual Variability in High Flows, operates in concert with the attribute Hydrologic Flow Regime—Natural. It defines the amount of change that has occurred in between-year variation in high flow or the extent of overall change in high flow as a result of watershed development.

Changes in vegetation cover and land use as a result of watershed development can alter the hydrograph shape, increasing inter-annual high flow variation and peak discharge. Because vegetation cover affects infiltration rates, its removal can cause direct runoff to increase and hydrographs to become more peaked. This is most strongly seen in urban areas, where total runoff and peak discharges are increased relative to the pristine conditions. Depending on the degree of watershed impervious cover, as occurs in urban areas, the annual volume of storm water runoff can increase by 2 to 16 times its predevelopment rate (Schueler 1995).

The index values for this attribute have been scaled to the pristine state, described by Index Value 2. Shifts toward more interannual variability or peak discharge are represented by Index Value 3 and 4, less variability or reduced peaks by values 0 and 1. The latter conditions would be characteristic of reaches subject to moderate or strong

### *Special Instructions for New Input or Updates*

Rate the month when high flow variability (between years) will be greatest. Rate only one month. Other months will be inferred from an appropriate flow pattern for the watershed of interest.

### *Effect on Leve1 3 Biological Metrics*

This attribute affects the Level 3 attributes Flow, which, in turn, affects productivity of certain life stages of salmonids.

### *References/Sources*

Importance and Role: Stanford and Ward (1992).

Factors Affecting: Federal Interagency Stream Restoration Working Group (1998), Gordon et al. (1993), Schueler (1995).

# Flow - Changes in Inter-annual Variability in Low Flows

## *Definition/Usage*

A measure of between-year variation in the severity of low flow discharge during a month. Variation in low flows as applied here is relative to an undisturbed watershed of comparable size, geology, and geography (or as would have existed in the pristine state).

## *Importance and Role*

Hydrologic patterns of ecologically healthy watersheds in the coastal ecoregion are strongly related to the timing and quantity of flow, characteristics of seasonal water storage, and dynamics of surface-subsurface exchanges.

Changes in the timing and quantity of flow due to land uses and flow regulation can affect responses of stream dwelling organisms like salmonids, leading to changes in overall performance of their populations.

This attribute defines how low flow (e.g., during late summer) has changed relative to the undisturbed state. Changes are considered in both overall level of flow and between-year variation. Increased variation in low flow or overall reduced low flow can result in survival reduction due to increased exposure or migration difficulties.

## *Categorical conclusions*

| Index 0 | Index 1 | Index 2 | Index 3 | Index 4 |
|---|---|---|---|---|
| Pronounced increases in low flow levels and between year stability in low flow levels relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest). This index level indicates a marked increase in both low flow and stability compared to pristine conditions. | Some evidence of increased low flow levels and between year stability in low flow levels relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest). This index level some evidence exists of an increase in both low flow and stability compared to pristine conditions. | Typical low flows and between-year variation in low flows relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest). | Some evidence of reduced low flows and/or between year variation in low flow levels relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest). | Pronounced reductions in low flows and/or between year variation in low flow levels relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest). |

## *Factors Affecting Attribute/Guidelines*

The attribute, Flow—Changes in Inter-annual Variability in Low Flows, operates in concert with the attribute Hydrologic Flow Regime—Natural. It defines the amount of

change that has occurred in between-year variation in low flow or the extent of overall change in low flow.

Changes in vegetation cover and land use as a result of watershed development can alter the hydrograph shape, increasing inter-annual low flow variation or decreasing the extreme low flow discharge. Changes in vegetation cover, reduction in the amounts of wetlands, and roads can alter the retention time and pattern of runoff in a watershed, resulting reduced low flows. Interannual variation in low flows may also be increased. Urbanization can result in dramatic reductions in low flows compared to the predevelopment condition. Impervious cover prevents infiltration into the soil, reducing ground water recharge. Consequently, during extended periods without rainfall, baseflow levels are often severely reduced (Simmons and Reynolds 1982).

The index values for this attribute have been scaled to the pristine state, described by Index Value 2. Shifts toward more interannual variability or lower low flow discharge are represented by Index Value 3 and 4, less variability or increased low flows by values 0 and 1.

Rate as 2 the pristine state for all stream reaches. This index value states that inter-annual variation is equal to what would have occurred in the watershed's natural state.

Rate as 3 or 4 the reaches affected by land uses that increase between-year variation in low flow or reduce low flows. Rate as 0 or 1 the reaches subject to flow regulation that act to stabilize low flow or increase them. The latter conditions can lead to increased survival of salmonids in some life stages, at least in the short-term. Over the long-term, habitat-forming disturbance events may be reduced in frequency, leading to degradation of some environmental attributes.

### *Special Instructions for New Input or Updates*

Rate the month when low flow variability (between years) will be greatest. Rate only one month. Other months will be inferred from an appropriate flow pattern for the watershed of interest.

### *Effect on Leve1 3 Biological Metrics*

This attribute affects the Level 3 attributes Flow and Predation[3], which, in turn, affect productivity of certain life stages of salmonids.

### *References/Sources*

Importance and Role: Stanford and Ward (1992)

Factors Affecting: Federal Interagency Stream Restoration Working Group (1998), Gordon et al. (1993), Simmons and Reynolds (1982)

# Flow - Intra Daily (diel) Variation

## *Definition/Usage*

Variability in flow level during a daily period. This attribute is informative mainly for regulated rivers or when flow patterns are influenced by storm water runoff.

## *Importance and Role*

Sudden changes in flow associated with flow regulation or storm runoff can result in displacement of rearing juveniles or, in the case of loss of flow, in stranding. Such rapid flow changes can also affect other environmental attributes, like streambank erosion and riparian habitat.

## *Categorical conclusions*

| Index 0 | Index 1 | Index 2 | Index 3 | Index 4 |
|---|---|---|---|---|
| Essentially no variation in discharge during a 24-hr period. During a month, this condition would characterize most flow patterns not associated with flow ramping by a hydro project or storm - water runoff. | Little variation, on average, in discharge during a 24-hr period--typical of natural runoff pattern during relatively small rainfall storm events. | Moderate variation, on average, in discharge during a 24-hr period--typical of low ramping rate associated with hydro facilities or natural change in discharge associated with an average to above average rainfed freshet. | Some evidence of increased variation in discharge during a 24-hr period compared to natural runoff pattern. This pattern typical of moderate ramping condition associated with flow regulation. | Extreme variation on average over a 24-hr period during month. This pattern typical of severe ramping condition associated with flow regulation or highly urbanized areas. |

## *Factors Affecting Attribute/Guidelines*

Most, if not all, pristine basins should be assigned a rating of 0. This rating indicates that the average daily fluctuation in flow over a month is slight. (Note: under pristine conditions, some streams could experience much more variation over a single day, but the average value over a month would be minimal.)

The rating should be applied in consideration of the average expected variation over a month.

## *Special Instructions for New Input or Updates*

Rate the month when diel variation will be greatest. Rate only one month. Other months will be inferred from an appropriate flow pattern for the watershed of interest. In this case, the month will likely occur during power peaking. Any unusual pattern should be noted in the comments.

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[3] The effect of Low Flow on predation is likely incorrect and will probably be adjusted.

### *Effect on Leve1 3 Biological Metrics*

This attribute affects the Level 3 attribute Flow, which , in turn, affects survival of free swimming fish (including emergent fry) or the survival of eggs due to stranding.

### *References/Sources*

Importance and Role: Federal Interagency Stream Restoration Working Group (1998), Gordon et al. (1993)

Factors Affecting: Federal Interagency Stream Restoration Working Group (1998), Gordon et al. (1993)

# Flow - Intra-Annual Flow Pattern

## *Definition/Usage*

The average extent of intra-annual flow variation during a month—a measure of a stream's *flashiness* during a season.

## *Importance and Role*

Frequent, significant changes in flow over a relatively short time-period like a month associated with flow regulation or storm runoff can result in displacement of rearing juveniles during high flows, or, in the case of loss of flow, in stranding.

## *Categorical conclusions*

| Index 0 | Index 1 | Index 2 | Index 3 | Index 4 |
|---|---|---|---|---|
| Pronounced decreases in variation in daily flow during a month (intra-annual) relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest). | Some evidence of decreased variation in daily flow during a month (intra-annual) relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest). | Typical variation in flow variation during a month (intra-annual) in an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest). | Some evidence of increased variation in daily flow during a month (intra-annual) relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest). | Pronounced increases in variation in daily flow during a month (intra-annual) relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest). |

## *Factors Affecting Attribute/Guidelines*

This attribute is similar to the one that describes diel variation in flow, only in acts on a slightly longer time scale. The extreme on the high end in this attribute would be seen in heavily urbanized watersheds. Less extreme conditions would be found in watersheds with a high amount of vegetation cover removed (e.g., high degree of clearcutting) or high road densities. In heavily urbanized streams, the annual volume of storm water runoff can increase by 2 to 16 times the predevelopment rate; essentially every rainfall event can produce a sharp spike in the hydrograph, resulting in a high degree of flashiness (Schueler 1995).

Rate as 2 the pristine state for all stream reaches. This index value states that within-year variation is equal to what would have occurred in the watershed’s natural state.

Rate as 3 or 4 the reaches affected by land uses that increase within-year variation daily flow. Rate as 0 or 1 the reaches that are subject to flow regulation that acts to reduce within-year variation.

### *Special Instructions for New Input or Updates*

Rate the month when intra-annual flow variation is greatest. It is assumed that this variation will be greatest during high runoff months. Rate only one month. Other months will be inferred from an appropriate flow pattern for the watershed of interest.

### *Effect on Leve1 3 Biological Metrics*

This attribute affects the Level 3 attribute Flow and, in turn, principally affects survival of fingerlings during overwintering. It can affect other free-swimming stages also. In addition, it can affect survival from egg to emergence due to redd stranding.

### *References/Sources:*

Importance and Role: Gordon et al. (1993).

Factors Affecting: Federal Interagency Stream Restoration Working Group (1998), Gordon et al. (1993), Schueler (1995)

# Predation Risk

## *Definition/Usage*

Level of predation risk on fish species due to presence of top-level carnivores or unusual concentrations of other fish-eating species. This is a classification of per-capita predation risk—in terms of the likelihood, magnitude, and frequency of exposure to potential predators (assuming other habitat factors are constant).

## *Importance and Role*

Human activities can affect concentrations of fish-eating predators relative to conditions that existed prior to Euro-American settlement. In some cases, predator risk has been reduced as some fish-eating species have declined sharply due to human activity. Other activities, such as construction of dams, have concentrated some fish-eating species, like northern pikeminnow, at critical fish passage sites in the Columbia River. These changes in relative concentrations (or effectiveness) may have altered predation risk on salmon species compared to historic levels in some areas.

## *Categorical Conclusions*

| Index 0 | Index 1 | Index 2 | Index 3 | Index 4 |
|---|---|---|---|---|
| Many or most native predators are depressed or rare, none are greatly increased over natural levels, and there may be some numerical survival advantage to fish as a result compared to historical predator abundance. | Intermediate | Diversity and per-capita abundance of predators exists so that predation risk is at near-natural level and distribution. | Intermediate | Excessive population density or concentrated population of predator species exists due to artifacts of human alteration of the environment (e.g., top-down food web effects, habitat manipulations). |

## *Factors Affecting Attribute/Guidelines*

This factor is meant to cover a fairly broad range of types of predation risk, though it largely addresses the *relative concentration or dispersal* of fish-eating predators compared to the pristine state associated with dispersed predators. Situations that are meant to be covered by this attribute are concentrations of birds or pisivores below dams or near juvenile migrant bypasses, and artificially enhanced, concentrations of fish eating species associated with the creation of new habitat (as on Rice Island in the Columbia River), or large concentrations of hatchery smolts at or near release sites. The natural concentrations of pisivores that occurs at the outlet of sockeye producing streams under pristine conditions would also be addressed here.

A rating of 2 is assumed to be the historic condition. In areas where human activity acts to concentrate fish-eating predators, or to increase their effectiveness at prey capture, ratings will increase to 3 or 4. A value of 4 would represent highly unusual conditions

likely to result in a dramatic per capita predation risk on salmon species, as might occur below fish bypass facilities associated with some dams.

In areas where human activity has dispersed fish-eating species abundance or reduced their overall population abundance (e.g., where bull trout or Dolly Varden are listed through the ESA), ratings will be reduced to values <2.

It is recognized that the per capita risk of some fish-eating species may be increased over historic levels, while risk associated with other species may be reduced. The assigned ratings should represent an average condition across all species.

### *Special Instructions for New Input or Updates*

*A rating of 2 is assumed to be the historic condition.* Rationale to be given for assigned ratings should note the fish-eating species that are assumed in the ratings. Consideration should be given to species that prey either on small or large fish (i.e., juvenile or adult salmon).

Rate the month when per capita predation risk is believed to be highest.

### *Effect on Leve1 3 Biological Metrics*

This attribute affects the Level 3 attribute, Predation, and, in turn, affects resultant species productivity.

### *References/Sources*

Importance and Role: Beamesderfer et al. (1996) and Roby et al. (1998)

Factors Affecting: Beamesderfer et al. (1996) and Roby et al. (1998)

# Riparian Function

## *Definition/Usage*

A measure of riparian function that has been altered within the reach.

## *Importance and Role*

The riparian zone is characterized by its vegetation—trees, brush, grass, and sedges. This zone and the stream channel are interdependent. The zone comprises those areas near the stream channel that affect the channel and are affected by it. Riparian areas constitute the interface between aquatic and terrestrial ecosystems.

Many of the functional and structural attributes of stream habitat are created and maintained through interaction with the riparian vegetation. Healthy riparian areas dissipate flood energy, moderate drought, store surface waters, recharge groundwater supplies, moderate water temperatures by providing shade, regulate energy inputs, and reduce erosion. These areas also provide large-sized wood structure, which is critical in creating structural diversity and habitat complexity in streams.[4]

## *Categorical Conclusions:*

| Index 0 | Index 1 | Index 2 | Index 3 | Index 4 |
|---|---|---|---|---|
| Strong linkages with no anthropogenic influences. | >75-90% of functional attributes present (overbank flows, vegetated streambanks, groundwater interactions typically present). | 50-75% functional attribute rating- significant loss of riparian functioning- minor channel incision, diminished riparian vegetation structure and inputs etc. | 25-50% similarity to natural conditions in functional attributes- many linkages between the stream and its floodplain are severed. | < 25% functional attribute rating: complete severing of floodplain-stream linkages |

** Where an index value is associated with a range, the integer value is assumed for modeling to be the midpoint. Index values can be identified as non-integers to represent the lower or upper ends of a range.*

## *Factors Affecting Attribute/Guidelines*

Valley form and channel confinement, including the extent that the channel has been artificially modified, strongly affect the extent and maintenance of the riparian zone. Unconfined channels tend to flood relatively frequently, promoting riparian development. Tightly confined channels, particularly within canyons, have much less opportunity for such development and support much smaller riparian zones.

[4] Historically large wood was not available in all streams east of the Cascade crest, particularly in the high desert. In those streams, other types of vegetation served some of the same purposes as those afforded by large wood, see text under "Factors Affecting Attribute/Guidelines."

Riparian wetlands are an important component of riparian zones. A wetland is a system that depends on recurrent or constant inundation or saturation at or near the surface of the substrate. Besides providing habitat for fish and wildlife, wetlands provide water storage, sediment trapping, flood damage reduction, water quality improvement/pollution control, and ground water recharge.

Drawing from the Bureau of Land Managment's (BLM) use of the concept, Proper Functioning Condition (PFC), the riparian-wetland area is considered to be proper functioning when adequate vegetation, landform, or large woody debris is present to:

- dissipate stream energy associated with high waterflow, thereby reducing erosion and improving water quality;
- filter sediment, capture bedload, and aid floodplain development;
- improve flood-water retention and ground-water recharge;
- develop root masses that stabilize streambanks against cutting action;
- develop diverse ponding and channel characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses;
- support greater biodiversity.

The reason the definition of proper function here includes "adequate vegetation, landform, *or* large woody debris" is that not all riparian-wetland areas are created equally. For example, in many areas west of the Cascade crest, large wood must be present to dissipate energy, capture bedload, and aid floodplain development. However, many streams in the high desert do not have the potential or require large wood to dissipate stream energy associated with high streamflows. These streams can dissipate energy through the presence of vegetation such as willows, sedges, and rushes (Prichard 1998).

The BLM's definition of function emphasizes the aspect of stream stability. Other elements of function are also worth noting, however, including: shading and inputs and regulation of energy sources (e.g., litter input) (Spence et al. 1996).

The assignment of ratings to this attribute is subjective, to be based on a *judgment* of the extent that the elements defined above have been diminished by land use. Conclusions are to be based on personal knowledge of the reaches or inferences based on land use. Riparian function within urban areas and agricultural valleys will typically be extremely modified. Grazing practices are also known to severely impair riparian function. Forestry operations, especially using current standards, can result in impaired function, though usually not to the level seen with the other land uses.

### *Special Instructions for New Input or Updates*

All months are rated the same for Riparian Function.

### *Effect on Leve1 3 Biological Metrics*

Riparian Function can affect the Level 3 attributes channel stability, habitat diversity, flow, and harassment, which in turn affects species productivity at certain life stages. Riparian function also affects other environmental conditions like temperature or habitat types. In these cases, however, the linkage is already accounted for in assessing the condition of the Level 3 attribute (here, temperature and key habitat).

### *References/Sources*

Importance and Role: Cederholm et al. (2000), Federal Interagency Stream Restoration Working Group (1998), Leopold (1997), and Spence et al. (1996)

Factors Affecting: Federal Interagency Stream Restoration Working Group (1998), Prichard (1998), and Spence et al. (1996)

# Salmon Carcasses

## *Definition/Usage*

Relative abundance of anadromous salmonid carcasses within watershed (e.g., HUC 5 level) that can serve as nutrient sources for many wildlife and fish species.

## *Importance and Role*

Salmon act as an ecological process vector, important in the transport of energy and nutrients between the ocean, estuaries, and freshwater environments. Salmon serve to cycle nutrients between these environments, most notably from the ocean to freshwater, where the carcasses can be the source of large amounts of nutrients to the riparian-stream system. The carcasses provide food to numerous wildlife species, macroinvertebrates, and fish species, including juvenile salmonids.

## *Categorical Conclusions*

| Index 0 | Index 1 | Index 2 | Index 3 | Index 4 |
|---|---|---|---|---|
| Super abundant -- an average number of carcasses per total miles of main channel habitat >800. | Very abundant -- an average number of carcasses per total miles of main channel habitat >400 and < 800. | Moderately abundant -- an average number of carcasses per total miles of main channel habitat >200 and < 400. | Not abundant -- an average number of carcasses per total miles of main channel habitat >25 and <200. | Very few or none -- an average number of carcasses per total miles of main channel habitat <25. |

** Where an index value is associated with a range, the integer value is assumed for modeling to be the midpoint. Index values can be identified as non-integers to represent the lower or upper ends of a range.*

## *Factors Affecting Attribute/Guidelines*

The attribute, Salmon Carcasses, is intended to describe the relative number of salmon carcasses available for nutrient input. It is meant only to be a very rough approximation of an average annual number of carcasses that becomes available to the system. All species of salmon that spawn naturally (including those of hatchery origin) in the system should be considered. The density of carcasses is to represent potential availability only to the sytem.[5]

## *Special Instructions for New Input or Updates*

All months are to be rated the same for Salmon Carcasses.

[5] The effectiveness that carcasses can be utilized as food is likely related to channel structure (e.g., as provided by wood), flow patterns, and riparian condition. These may need to be incorporated in the biological rules that translate the Salmon Carcass attribute into the Level 3 attribute Food.

### *Effect on Leve1 3 Biological Metrics*

The attribute, Salmon Carcasses, affectd the Level 3 attributes Food and Competition.

### *References/Sources*

Importance and Role: Cederholm et al. (2000)

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