A Process-Based Approach for Stream Delineation and Characterization

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Introduction

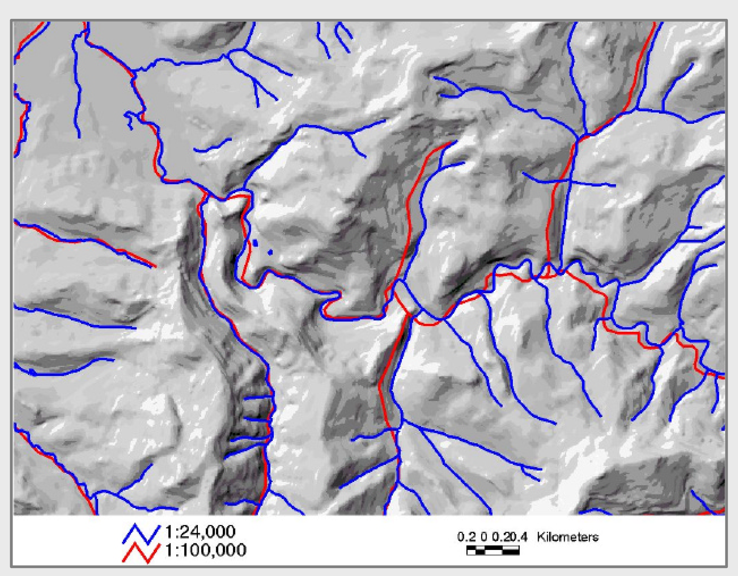
A digital stream network is essential for broad-scale aquatic analyses. Associated attributes enable robust spatial characterizations such as those needed to evaluate effects of forest policies on salmon and their habitats.

For use in CLAMS, the stream network should:

- Represent natural variation in drainage density;
- Represent the actual extent of the drainage network;
- Coincide with topographic features, such as valley bottoms or watershed outlets derived from Digital Elevation Models (DEMs);
- Have associated hydrologic and geomorphic attributes;
- Be compatible with outputs from landslide and debris flow routing models;
- Provide complete coverage for the study area.

Evaluate Existing Stream Data Sources

The available stream layers and the criteria they did not meet:

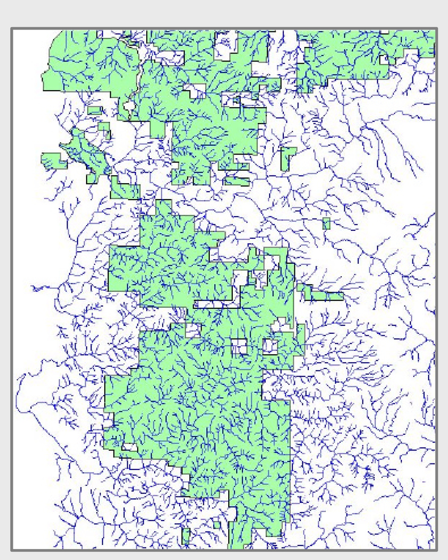


1:100,000-scale Digital Line Graph (DLG) hydrography

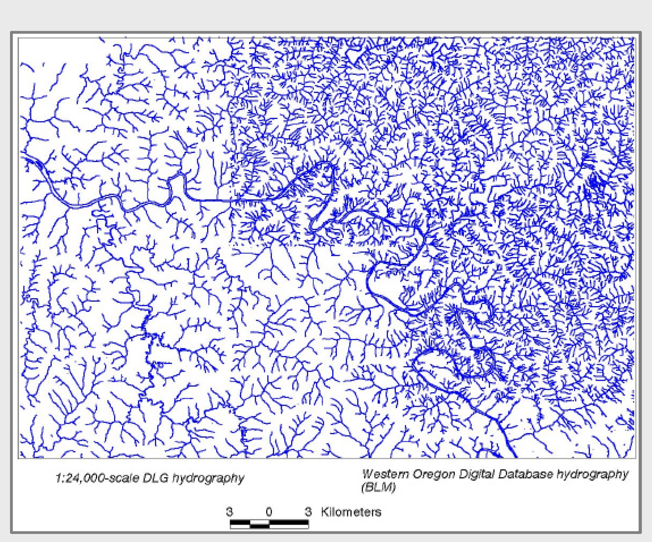
- Does not represent the actual extent of the drainage network
- Does not coincide with topographic features, such as valley bottoms or watershed outlets derived from DEMs
- Lacks associated hydrologic and geomorphic attributes
- Not compatible with outputs from landslide and debris flow routing models

Streams produced by federal agencies-USFS and BLM

- Inconsistent associated hydrologic and geomorphic attributes
- Not compatible with outputs from landslide and debris flow routing models
- Does not provide complete coverage for the study area



Siuslaw National Forest (SNF)
SNF Stream Data



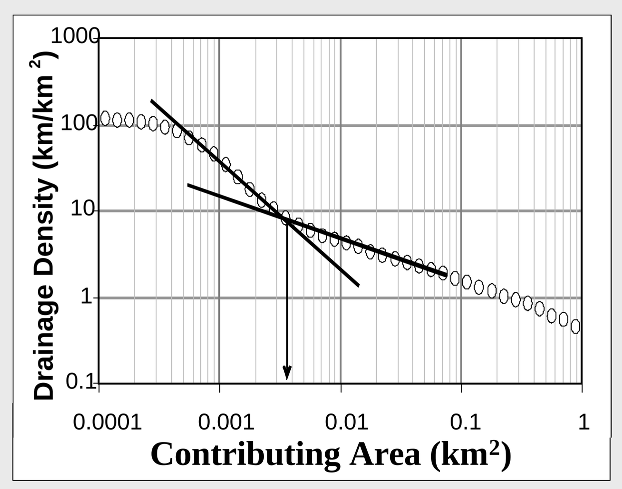
Pacific Northwest Hydrography Framework stream layer (1:24,000 and larger-scale)

- Inconsistent representation of the natural variation in drainage density
- Inconsistent representation of the actual extent of the drainage network
- Inconsistent associated hydrologic and geomorphic attributes
- Not compatible with outputs from landslide and debris flow routing models

Generate the Stream Network

To meet the stated criteria, we developed a process-based stream model using 10-m Drainage-Enforced (DE) DEMs. To generate streams the model:

- Allows flow dispersion over topographically divergent areas until a channel is initiated;
- Incorporates a parameter to determine the amount of topographic convergence allowed at channel heads;
- Uses a slope/drainage area relationship to initiate channels derived from fluvial processes;
- Uses a single drainage area to initiate channels derived from mass-wasting processes.

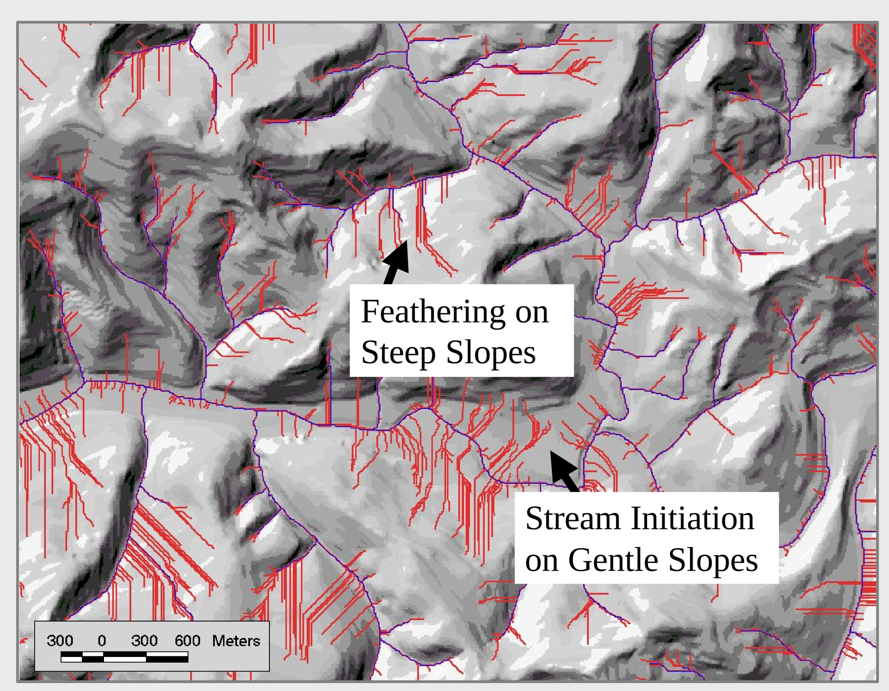


Channel Initiation in High-gradient Areas

The inflection point indicates the drainage area at which channel feathering begins (i.e. extension of the derived channel network onto unchannelized hillslopes) (*Montgomery and Foufoula-Georgiou, 1993*)

By examining plots from multiple basins in all ecoregions throughout the study area, a 0.75 ha channel initiation value was determined. The stream network generated with a 0.75 ha drainage area threshold compared favorably with streams mapped by USFS and BLM relative to drainage density and channel extent.

Streams Derived From:
Process-Based Approach
Single Initiation Value Approach

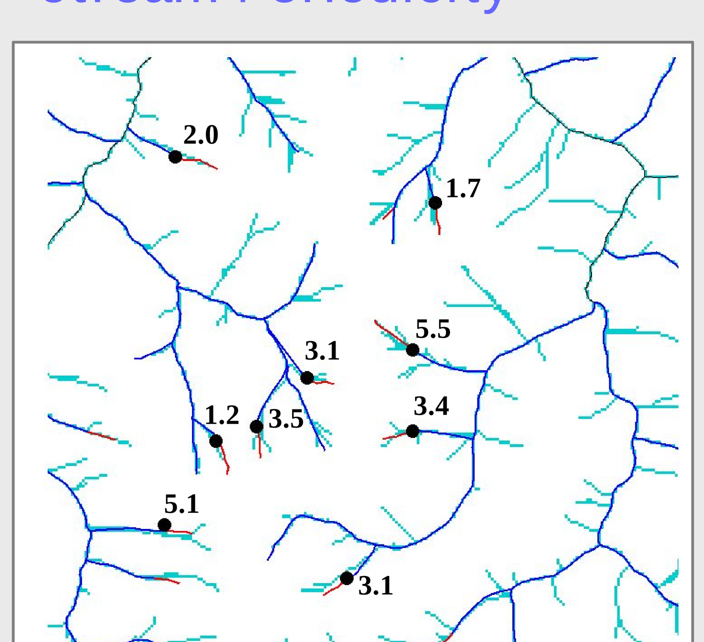


Model parameters control drainage extent and reduce obvious errors in channel initiation.

Attribute the Stream Network

The channel network is subdivided into reaches. Reach endpoints occur at tributary junctions and create relatively uniform length segments of similar channel slope and valley width. Hydrologic and geomorphic attributes (i.e. periodicity, drainage area, gradient, valley floor width, and valley floor width index) are derived for each reach. Stream periodicity is used to create a perennial stream layer of consistent density.

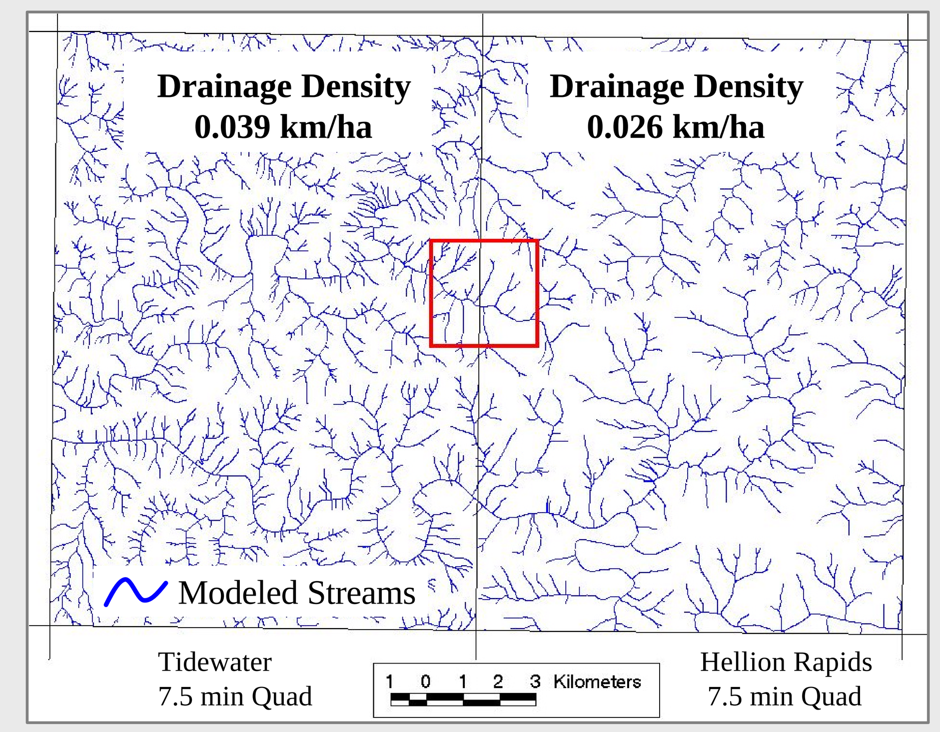
Stream Periodicity

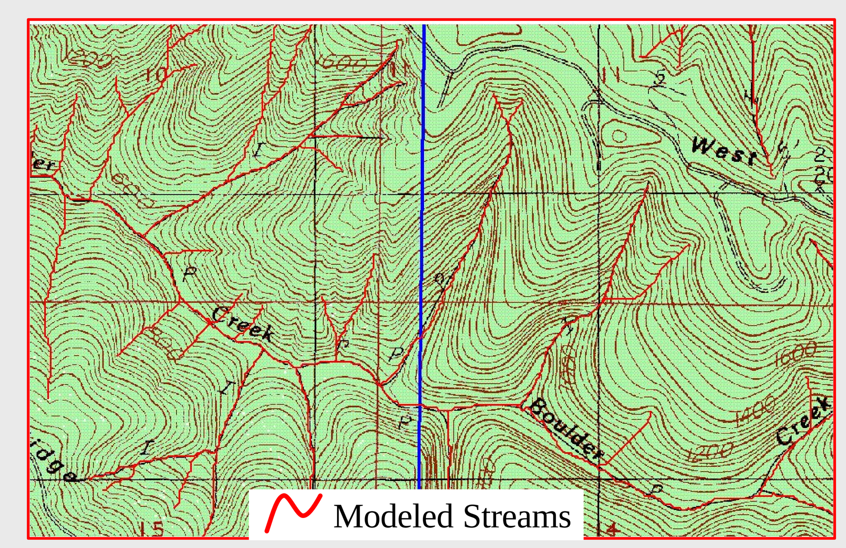


Intermittent and perennial streams were distinguished by determining the flow accumulation at which this transition occurred on a sample from the Siuslaw National Forest's (SNF) stream layer. Flow accumulation values from both basaltic and sedimentary rock types were averaged to obtain an approximate threshold of 5 ha.

Flow accumulation grid
SNF Perennial stream
SNF Intermittent stream
Flow accumulation value (ha)

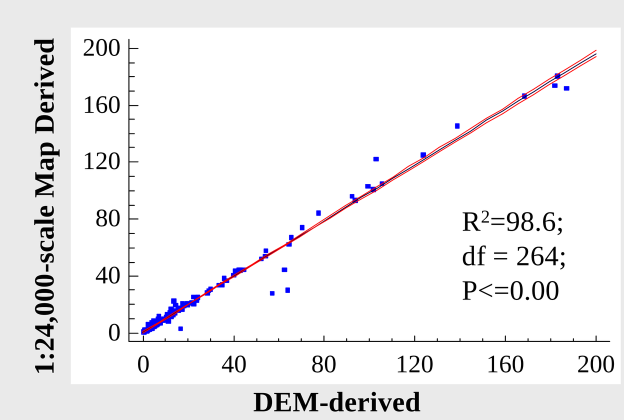
Differences in the degree to which contour crenulations were preserved on 1:24,000-scale USGS topographic quadrangles used to produce the 10-m DE-DEMs resulted in inconsistent drainage density and extent across quadrangle boundaries. Two steps will be taken to mitigate the problem: 1) perennial streams will be used for most analyses over the study extent, and 2) to determine the impact of this decision, results from analyses using only perennial streams will be compared with those using the full stream network for a subset of the study area

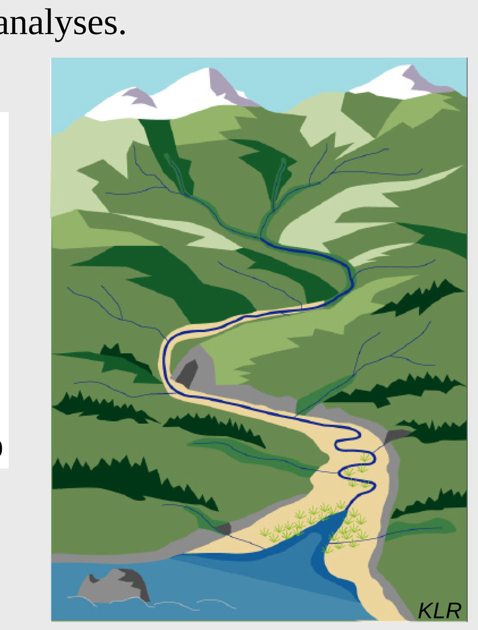




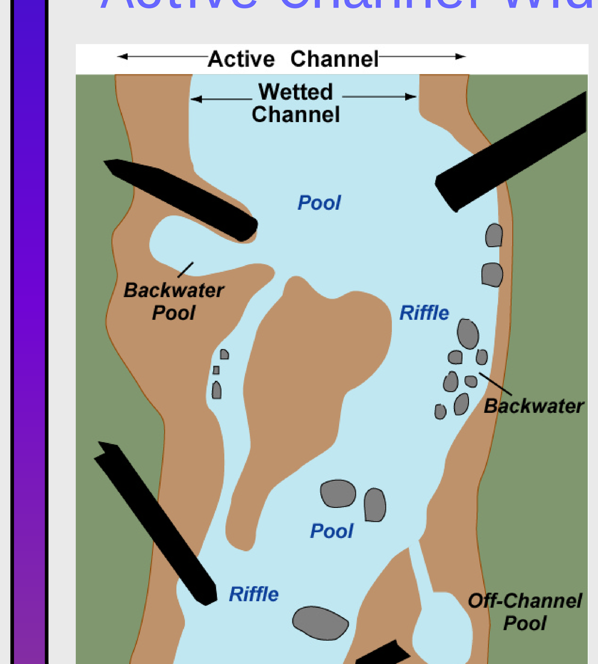
Drainage Area

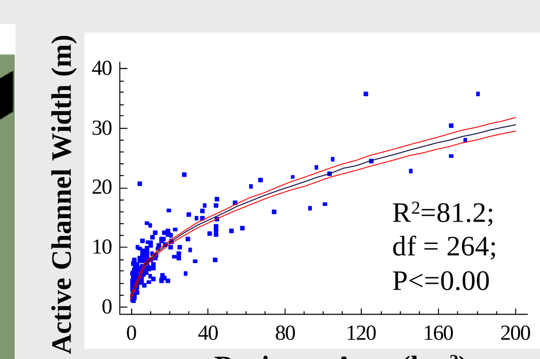
Drainage area is obtained from DEM-derived flow accumulation. DEM-derived drainage area was evaluated relative to drainage area derived from Oregon Plan stream habitat survey data. This is a basic attribute that will be used in variety of analyses.





Active Channel Width



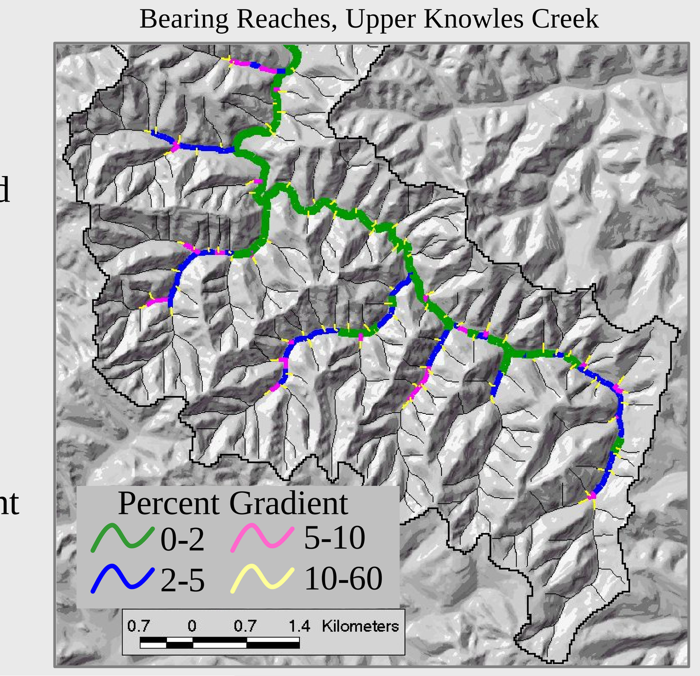


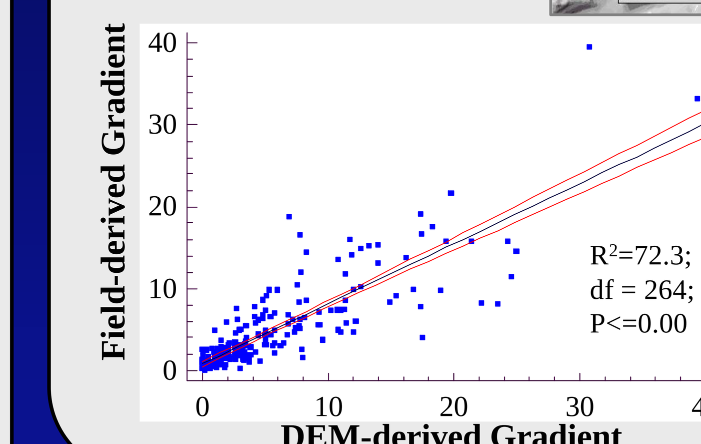
Active channel width (ACW) cannot be determined directly from the 10-m DE-DEMs. Thus, ACW was predicted from Oregon Plan stream habitat survey data.

Gradient

Channel gradient is calculated for each pixel and averaged over the reach to produce a mean, standard deviation, minimum, and maximum channel gradient. A maximum downstream gradient is produced to identify downstream gradient barriers to fish movement.

Modeled Stream Gradient for Anadromous Fish-Bearing Reaches, Upper Knowles Creek

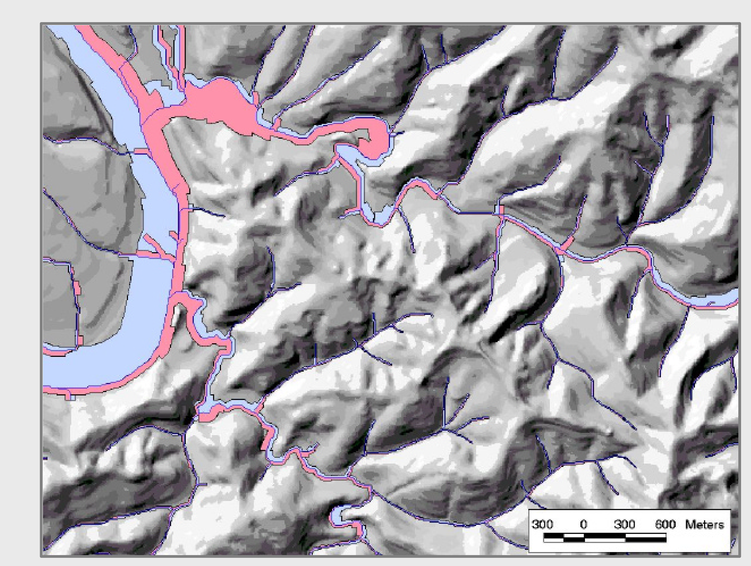




DEM-derived mean reach gradient was evaluated relative to gradient from the Oregon Plan stream habitat survey data, which was measured in the field with a clinometer.

Valley Floor Width

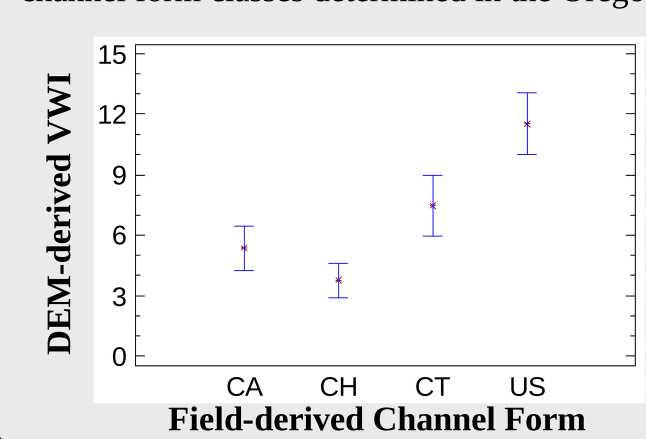
Valley floor width was estimated for the left and right side of each stream reach. It was calculated as the length of a transect that intersects the valley walls at a specified height above the channel. Valley floor width is used to delineate geomorphic-based riparian areas.



Right valley floor
Left valley floor

Valley Floor Width Index

Valley floor width index (VWI) was calculated as the ratio of valley floor width to the ACW. A general linear statistical model was used to relate VWI to the channel form classes determined in the Oregon Plan stream habitat survey data.



Means and 95% Fisher's Least Significant Difference Intervals

Channel-form classes
CA – Alternating Constrained
CH – Hillslope Constrained
CT – Terrace Constrained
US – Unconstrained

Other attributes calculated by the model are tributary junction angle, stream order, mean annual precipitation volume, mean annual streamflow, probability of debris flow deposition and scour, and volume estimates of debris flow deposited material.

Summary

This stream layer represents a major improvement over existing data. CLAMS is using it to generate parcels, indices of wildlife habitat suitability, and watershed condition; and to predict instream habitat structure for anadromous salmonids from upslope and streamside attributes. The resultant data and the modeling process is used by other agencies and groups.