SECTION I. INTRODUCTION TO WATERSHED FUNDAMENTALS

Overview outline notes from OWEB, 1999, Watershed Fundamentals Publication
https://people.wou.edu/~taylors/g473/1_OWEB_1999_watershed_fundamentals.pdf

I. Watershed Overview
   a. Watershed – area of land that drains downslope to a common outlet point (from headwaters and drainage divide to mouth)
      i. Gravity Driven Fluid Flow
      ii. Drainage network – a series of channel tributaries feeding downslope to a common outlet

Figure 1. Watershed is an area of land that drains downslope to the lowest point.

      iii. Hydrologic connections between channel runoff, atmospheric precipitation, groundwater infiltration + discharge, evapotranspiration
      iv. Hydrologic Units – nested scaling of channel networks, basins and sub-basins
         1. Hydrologic Unit Codes (HUC) – U.S. Geological Survey coding method for numerically identifying watersheds, basins and sub-basins in the U.S.
            a. 4th field HUC watersheds – large scale
            b. 5th field HUC sub-basins medium scale, avg. area ~60,000 ac in Oregon
            c. 6th field HUC sub-basins, smallest scale

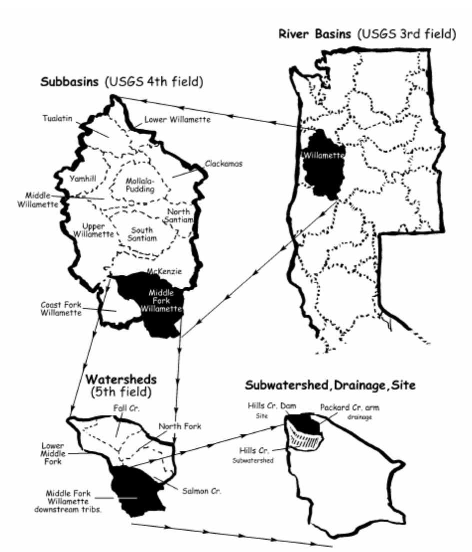


Figure 2. Suggested terminology for watershed descriptive terms based on USGS hydrologic "fields." These fields correspond to the following terms: river basin (3rd field), sub-basin (4th field), and watershed (5th field). In the figure, the Willamette River Basin is divided into sub-basins including the Middle Fork Willamette, which is divided into watersheds including the Middle Fork Willamette downstream tributaries. This watershed then includes a subwatershed, drainage, and site, as seen in the lower right of the figure.

II. Regional Controls on Watershed Conditions

a. Geology
   i. Tectonic Setting
   ii. Bedrock Geology of Substrate (lithology, stratigraphy, structure, alteration, geologic history)
   iii. Regolith + Soil Composition
b. Topography
   i. Hillslope vs. Valley Bottom Patterns
   ii. Elevation, Slope, Aspect, and Relief
   iii. Channel Network Drainage Patterns
c. Climate + Hydrology
   i. Seasonal + Annual Weather Patterns
   ii. Long-term Climate Trends
   iii. Precipitation, Air Temperature, Humidity
   iv. Streamflow Patterns, Flooding, Water Use
d. Vegetation
   i. Land Cover Type
   ii. Species Distribution
e. Antropogenic Activities
   i. Generally the most impacts from post-European Settlement in U.S. the last 150 – 300 years
   ii. Agriculture, Forestry, and Industrial Development
   iii. Urbanization
   iv. Hydrologic Alternation (dams, drain fields, diversions, flood control)

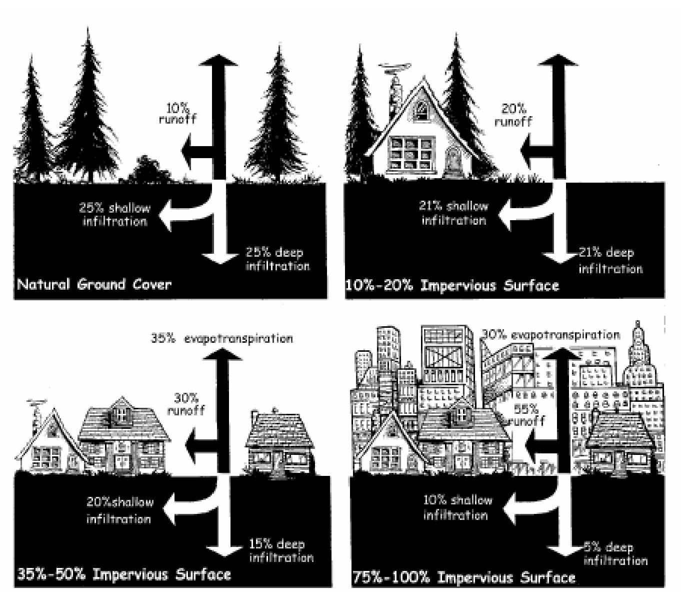


Figure 3. Human activities such as urbanization and road development can modify the routing of water. An increase in impervious surfaces causes a decrease in infiltration and an increase in runoff.

III. Hydrologic Processes

a. Watershed + Sub-Basin Scale and Channel Network Configuration
   i. Channel Habitat Types – in-channel aquatic habitat conditions

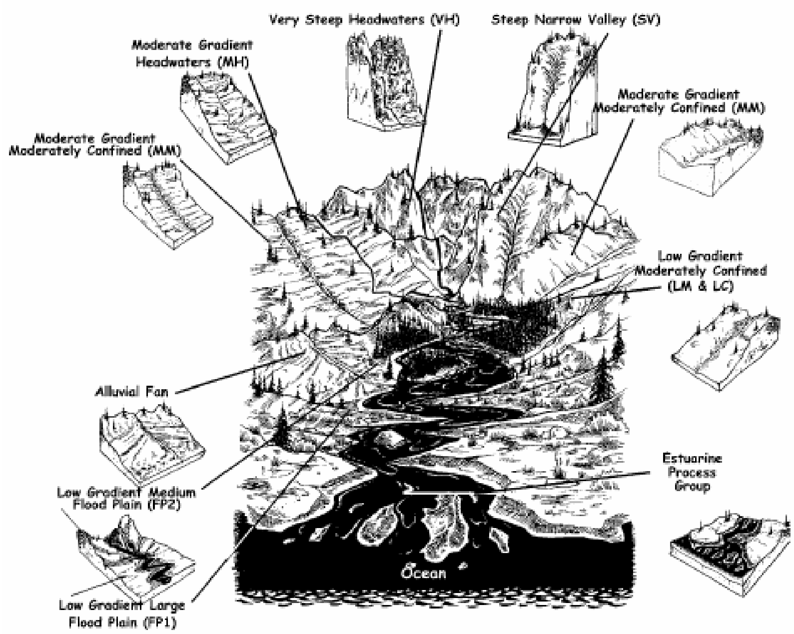


Figure 5. Typical distribution of CHTs in a mountainous watershed.

b. Hydrologic Cycle
    i. Defined: circulation of water on planet Earth, from ocean to atmosphere, and back again.
    ii. Reservoirs
        1. Oceans (98% of total volume)
        2. Ice
        3. Groundwater
        4. Rivers, Wetlands + Lakes
        5. Biologic Waters
c. Mass Transfer Functions
    i. Evaporation – Condensation – Precipitation – EvapoTranspiration
    ii. Gravity Transport: streamflow + infiltration

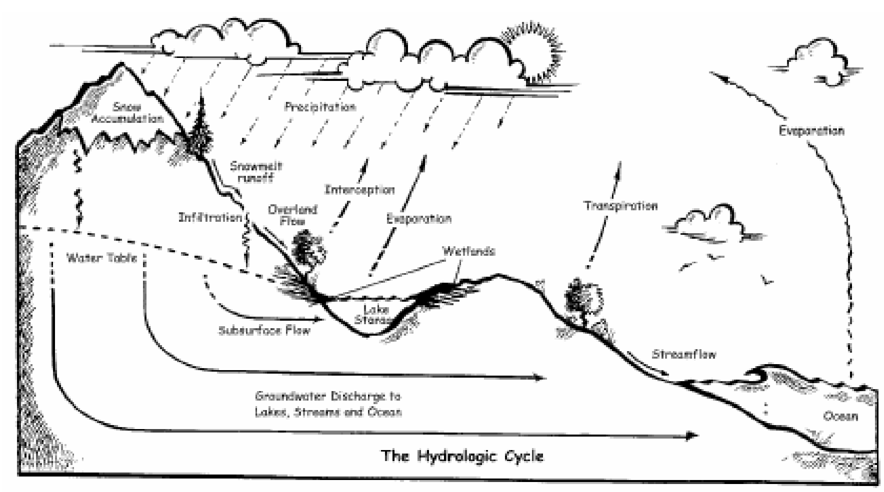


Figure 6. The hydrologic cycle describes the circulation of water around the earth, from ocean to atmosphere to the earth's surface and back to the ocean again.

d. Runoff and River Channel Flow Considerations for Ecosystem Services
   i. Seasonal Flow Volume (Discharge)-Rate-Water Depth (Stage)
      1. Storm Patterns
      2. Seasonal Snow Melt
   ii. Seasonal Water Quality and Quantity
   iii. Groundwater Exchange with Channel System (Inputs and Removals)
      1. Hyporheic Exchange
   iv. Anthropogenic Removals and Discharges
      1. Irrigation
      2. Water Resource Extraction
      3. Disposal / Discharges

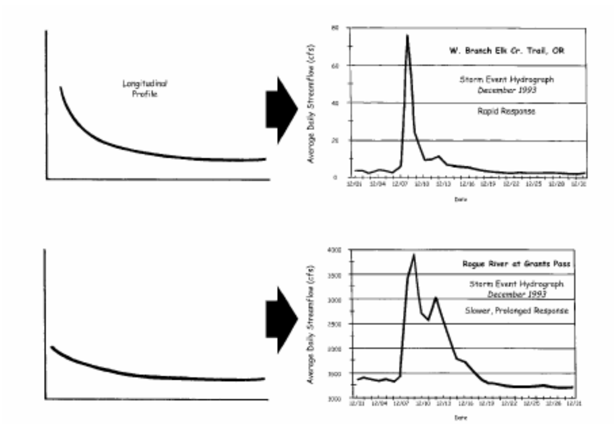


Figure 8. Hydrograph patterns showing the difference between watersheds with a steeper topography, which have a rapid runoff response (top), and watersheds with flatter topography, which have a slower, more prolonged runoff response (bottom).

e. Floodplain Configuration and Channel Connectivity
   i. Floodplain Sorption and Channel Exchanges
      1. Seasonal Flood Patterns
      2. Urbanization Effects
   ii. Off Channel Wetlands and Connectivity

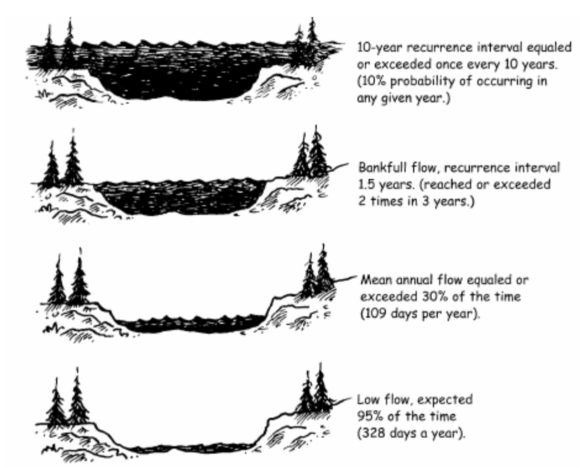


Figure 9. A recurrence interval is the average length of time between two events (rain, flooding) of the same size or larger. Recurrence intervals are associated with a probability, as illustrated in the figure for streamflow.

IV. Soil Erosion and Stream Sedimentation
- a. Water Quality and Channel Substrate
  - i. Sediment Supply and Transport Influences Aquatic Habitat and Water Quality
  - ii. River Transport: suspended load, dissolved load, bedload
- b. Natural Sediment Sources
  - i. Channel Erosion Processes
    1. Rilling, gullying, sheetwash, rainsplash erosion
    2. Channel Erosion, channel migration
  - ii. Mass Wasting Processes: hillslope delivery of sediment to valley bottom
    1. Shallow vs. Deep Seated Landslides
    2. Debris Flow
    3. Soil Creep and Earth Flow

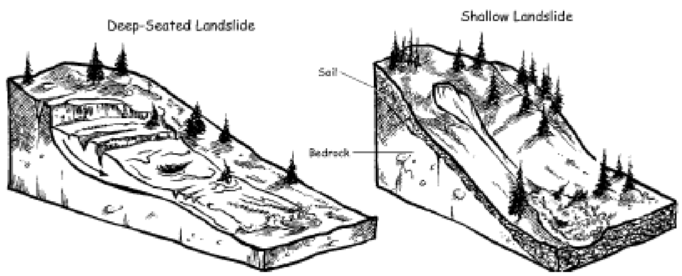


Figure 10. Deep-seated landslides often originate from shallow depressions, but can also involve a broader area of a hillslope. When shallow landslides move into a channel they can trigger *debris flows*—a rapid movement of soil down a steep channel.

  - iii. Anthropogenic Erosion
    1. Road Construction and Maintenance
    2. Agricultural Runoff
    3. Forest / Range Land Runoff
    4. Urban Runoff

V. Vegetation Controls
- a. Vegetation strongly influences watershed hydrology, stream temperatures, solar energy flux, and water quality
  - i. Vegetative Cover Patterns
    1. Seasonal Changes: deciduous vs. coniferous
    2. Forestry / Agriculture / Landuse
    3. Natural Disturbances
       - a. Mass Wasting
       - b. Fire
  - ii. Role Upland Vegetation
    1. Root strength and slope stability
    2. Organic sediment inputs
    3. Wood Recruitment to Stream Channels
    4. Snowmelt – Runoff Cycles
  - iii. Role of Riparian Vegetation – areas adjacent to streams, along floodplains
    1. Water quality + filtration
    2. Root Strength + Channel bank stabilization
    3. Habitat Cover
    4. Channel Shading + stream temperature reduction
    5. Large Wood Recruitment to channel areas
       - a. Nutrient inputs, channel habitat complexity

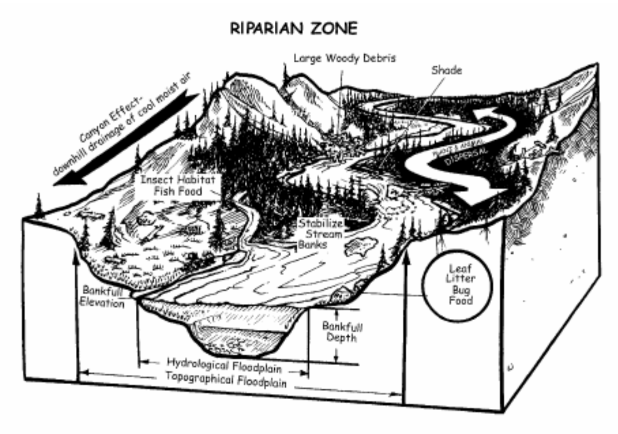


Figure 12. The riparian zone provides a number of functions, as illustrated.

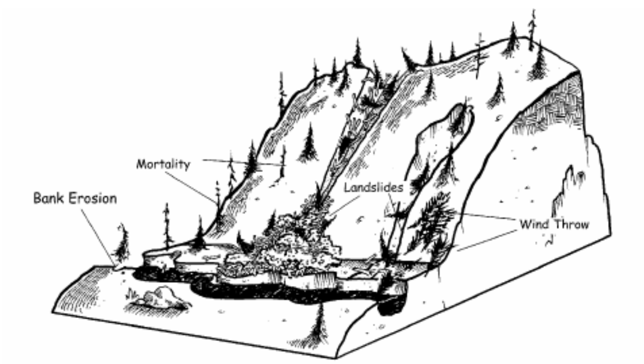


Figure 13. Large woody debris is recruited to the stream by bank erosion, mortality (disease or fire), or wind throw.

VI. Water Quality
   a. Nutrients
   b. Bacteria
   c. Temperature and Dissolved Oxygen
      i. 64 F = standard for salmonid maximum average
   d. Anthropogenic Contaminants

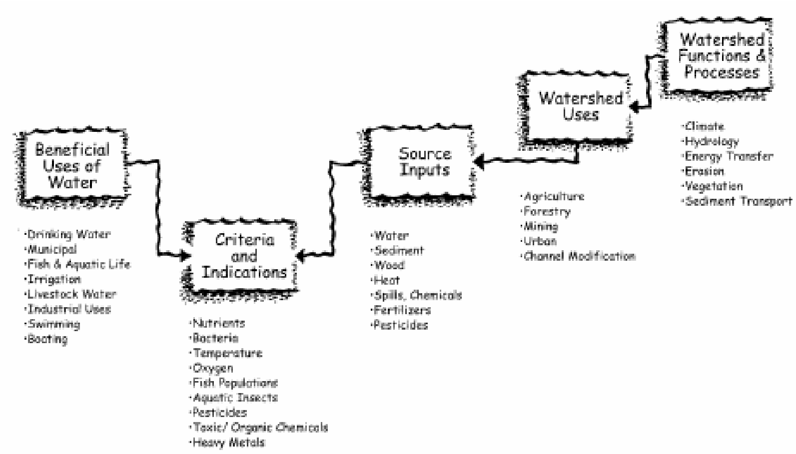


Figure15. Measures of water quality—the criteria or indicators—provide the connection between the beneficial uses of water and the natural and human sources of watershed inputs. These relationships provide the context for water quality and fisheries assessments.

VII. Fisheries Resources

a. Pacific Northwest Salmonid Fisheries (salmon, steelhead, trout)

i. Anadromous – salmonid rearing in upstream fresh water, life cycle in marine oceans

1. Migratory spawning cycles

ii. Resident – salmonid in residence for duration of life cycle in upstream fresh water

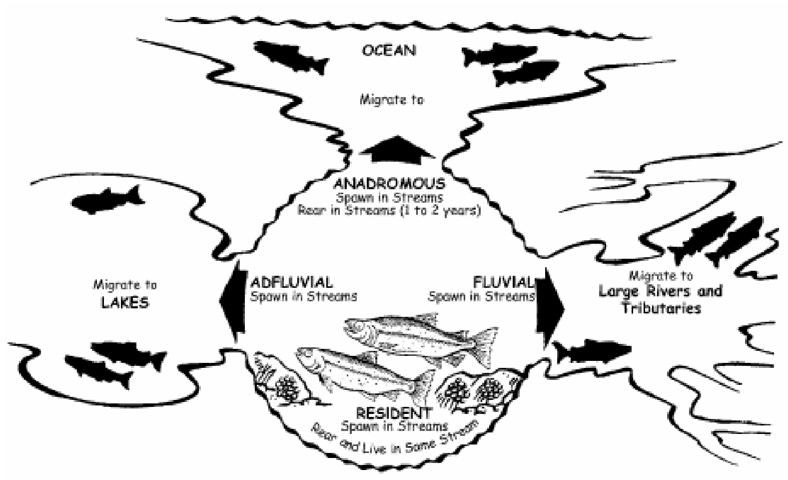
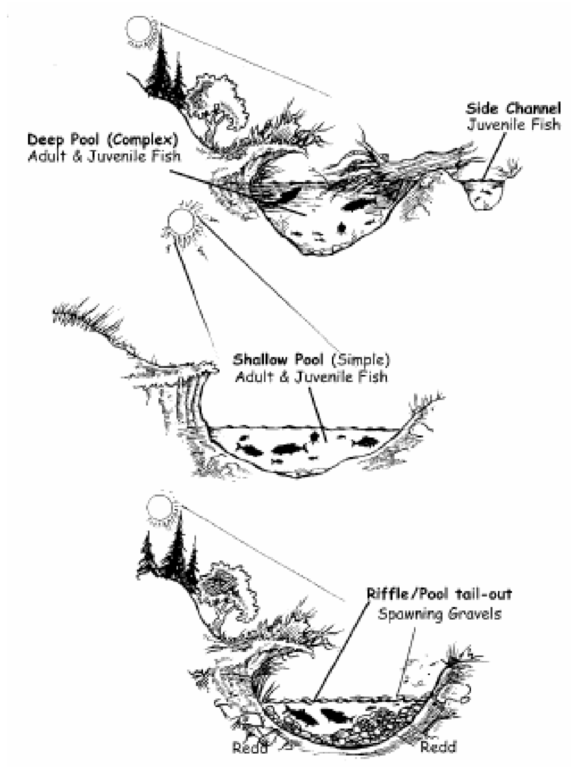


Figure 16. Salmon and trout have three distinct life history patterns: (1) "anadromous," spending some portion of their life history in the ocean and returning to freshwater streams to spawn; (2) "resident," spending their entire lives in the stream network; or (3) fluvial or adfluvial, moving between large river systems or reservoirs and the stream network where they were born.

Table 1. Generalized life history patterns of anadromous salmon, steelhead, and trout in the Pacific Northwest.[1]

Species	Adult Return	Spawning Location	Eggs in Gravel[2]	Young in Stream	Freshwater Habitat	Young Migrate Downstream	Time in Estuary	Time in Ocean	Adult Weight (average)
COHO	Oct-Jan	coastal streams, shallow tributaries	Oct-May	1+yrs	tributaries, main-stem, slack water	Mar-Jul (2^{nd} yr)	few days	2 yrs	5-20 lb (8)
CHUM	Sept-Jan	coastal rivers and streams lower reaches	Sep-Mar	days-weeks	little time in fresh water	shortly after leaving gravel	4-14 days	2.5-3 yrs	8-12 lb (10)
CHINOOK		main-stem large and small rivers			main-stem-large and small rivers		days-months	2-5 yrs	
spring	Jan-Jul		Jul-Jan	1+yrs		Mar-Jul (2^{nd} yr)			10-20 lb (15)
summer	Jun-Aug		Sep-Nov	1+yrs		spring (2^{nd} yr)			10-30 lb (14)
fall	Aug-Mar		Sep-Mar	3-7 months		Apr-Jun (2^{nd} yr)			10-40 lb
STEELHEAD[3]		tributaries, streams, & rivers			tributaries		less than a month	1-4 yrs	
winter	Nov-Jun	Nov-Jun	Feb-Jul	1-3 yrs		Mar-Jun (2^{nd}-5^{th} yr)			5-28 l b(8)
spring	Feb-Jun	Feb-Jun	Dec-May	1-2 yrs		spring & summer (3rd-4^{th} yr)			5-20 lb
summer (Col. R.)	Jun-Oct	Jun-Oct	Feb-Jun	1-3 yrs		Mar-Jun (3rd-5th yr)			5-30 lb (8)
summer (coastal)	Apr-Nov	Apr-Nov	Feb-Jul	1-2 yrs		Mar-Jun (of 2nd-5^{th} yr)			5-30 lb (8)
Inland Columbia STEELHEAD/ REDBAND	Jun-Oct	tributaries	spring	1-3 yrs or resident		1-3^{rd} yr	less than a month	1-4 yrs	
Oregon Basin REDBAND	resident spring		spring	resident		resident	na	na	
Coastal-Sea Run CUTTHROAT	Jul-Dec	tiny tributaries of coastal streams	Dec-Jul	1-3 yrs (2 avg.)	tributaries	Mar-Jun (2^{nd}-4^{th} yr)	less than a month	0.5-1 yrs	0.5-4 lb (1)
Lahontan CUTTHROAT	resident		spring	resident	tributaries, lakes	resident	na	na	
Westslope CUTTHROAT	resident Mar-Jul	small tributaries	Apr-Aug	resident	tributaries	resident	na	na	
BULL TROUT	Jul-Oct	cold headwaters, spring-fed streams	Sep-Apr	1-3 yrs (2 avg.)	prefer water < 15°C	spring, summer, fall (1^{st}-3^{rd} yr)	na	na	0.5-20 lb (varies with form)

Figure 18. Elements of in-stream fish habitat that affect salmonid production in fresh water include depth and water velocity, cover, spawning gravels, and temperature ranges.



These conditions are dependent on such physical characteristics as pools and side channels, substrate, and riparian vegetation.

b. Historic Anthropogenic Habitat Degradation of Salmonid Fisheries

Table 2. Summary of potential stream impacts from human activities.

Human Activity	Potential Disturbances	Potential Habitat/Watershed Process Responses
Timber harvest	• removal of riparian zone canopy cover • soil disturbance, increased erosion of fine sediments • alteration of total basin vegetation cover	• increased summer water temperatures • reduced woody debris recruitment potential • decrease in interstitial spaces and pools (spawning and rearing habitat) • alteration of timing and magnitude of peak flows (hydrology) • change in timing and characteristics of landslides
Transportation (road development, rail, bridges, etc.)	• surface erosion, increased fine-sediment inputs • destabilization of upslope areas increased coarse- and fine-sediment inputs • blockage of migratory corridors (culverts) • loss of riparian vegetation • chemical spills, toxics, nutrient runoff	• decrease in interstitial spaces and pools (spawning and rearing habitat) • major channel disruption & catastrophic loss of habitat with major events • loss of migratory population component • increased summer water temperatures • reduced woody debris recruitment potential • chemical contamination • changes in peak flows
Agriculture/livestock grazing	• bank damage • soil compaction • in-channel stream bed disruption • removal of bank vegetation • changes in vegetation species & distribution	• decreased bank stability & direct inputs of fine sediments • reduced water infiltration, changes in peak flows, reduced baseflows • loss or disruption of summer rearing habitat • loss of cover, increased summer water temperatures & formation of anchor ice • increased stream nutrients
Agriculture/crops	• soil compaction • surface erosion, increased fine-sediment inputs • removal of bank vegetation • chemical, nutrient runoff	• decreased bank stability & direct inputs of fine sediments • reduced water infiltration, changes in peak flows, reduced baseflows • loss of cover, increased summer water temperatures & formation of anchor ice • increased stream nutrients, contamination
Mining	• streambed disturbance • fine-sediment inputs • chemical runoff or seepage to groundwater	• loss or disruption of spawning & summer rearing habitat • creation of chemical barriers &/or direct fish mortality, groundwater contamination
Dams (hydroelectric development, water supply, irrigation diversions)	• blockage of migratory corridors • changes in temperature, sediment delivery, flow regime due to dam regulation • increased temperatures, fine sediments, chemicals and nutrients with wastewater returns • channel dewatering	• loss of migratory/anadromous population component • overall decrease in habitat condition • direct mortality loss of one or more year-classes, reduction of redds, loss of available habitat • loss of anadromous prey base/nutrients • loss or disruption of spawning & summer rearing habitat

Human Activity	Potential Disturbances	Potential Habitat/Watershed Process Responses
Urbanization, channelization, diking, levees, recreation, & other	• reduction / removal of riparian vegetation • direct streambed modification • dewatering • stormwater runoff, reduced infiltration to soils	• increased summer water temperatures & formation of anchor ice • habitat simplification • reduced channel stability, channel incision • chemical, nutrient, bacterial inputs • increased magnitude and frequency of peak flows • reduced baseflows
UTILIZATION/HARVEST		
Fishing harvest	• direct mortality	• reduced recruitment & loss of nutrients to the stream
SPECIES INTERACTIONS		
Exotic species introductions, hatchery production	• competition • hybridization • predation • disease • water pollution	• displacement from most favorable habitats • sterile or less fit hybrids • direct mortality • weakness • nutrient, dissolved oxygen, and chemical contamination
HISTORICAL HUMAN USES (modifications that may not be apparent without historical research)		
Splash damming & log drives, yarding up stream channels, channel dredging, harvest of stream-bank trees, agriculture	• channel scour • streambed damage • removal of riparian vegetation • bank destabilization	• long-term loss or disruption of spawning & summer rearing habitat • increased summer water temperatures & formation of anchor ice • reduced woody debris recruitment potential • decrease in interstitial spaces and pools (spawning and rearing habitat)
Water withdrawals/ channel dewatering	• dry channel	• migration barriers, loss of one or more year-classes of fish
Stream cleaning to remove wood	• reduced sediment retention • increased channel scour • reduced channel complexity	• loss or disruption of spawning, summer & winter rearing habitat
Placer (hydraulic) mining or gravel quarries	• streambed disturbance • substrate removal	• loss or disruption of spawning & summer rearing habitat
Beaver eradication	• dam deterioration, removal • loss of pond/wetland areas	• loss of rearing habitat • alteration of water retention/floodplain function • temperature increases
Tailings deposits	• fine-sediment inputs • toxic contaminants	• loss or disruption of spawning & summer rearing habitat • creation of chemical barriers &/or direct fish mortality

SECTION II. OVERVIEW OF RIVER RESTORATION IN THE PACIFIC NORTHWEST

(Overview outline notes from Roni et al., 2002, A Review of Stream Restoration Techniques in the Pacific Northwest)

https://people.wou.edu/~taylors/g473/3_Roni_etal_%202002_restoration_techniques_review_PNW.pdf

I. River Restoration Defined
  a. "assisting the establishment of improved hydrologic, geomorphic, and ecological processes in a degraded watershed system and replacing lost, damaged, or compromised elements of the natural system"
  b. Criteria for Successful River Restoration
    i. Established Goal for a Restoration Standard: what are the desired elements of the restoration initiative?
    ii. Ecosystem Improvements and Reparation
    iii. Increased Resilience of the Ecosystem: create systems with flexible response mechanisms
    iv. Do No Harm: don't worsen the damage
    v. Availability of Pre- and Post- Project Assessment Data: were the goals achieved?

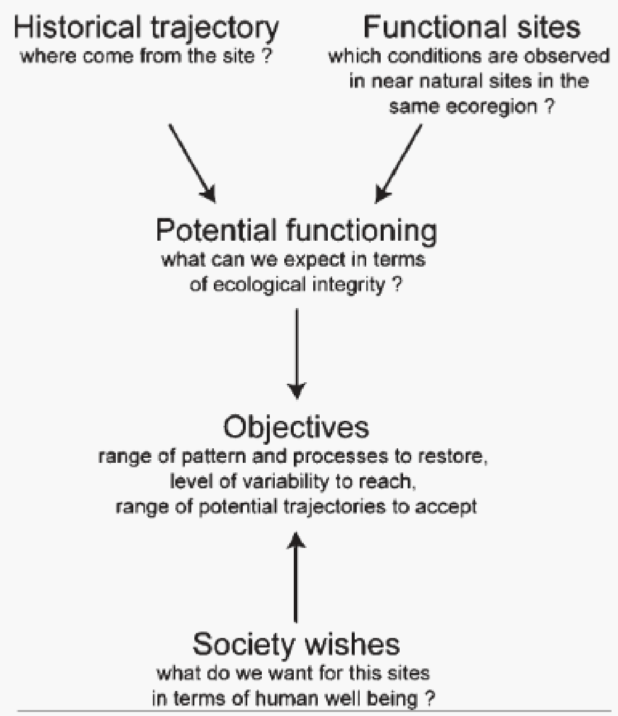


Figure 5. A framework to define objectives for river restoration projects

  c. River Restoration in Pacific Northwest:
    i. 10's of millions of dollars spent annually
    ii. Goal of PNW restoration = increase salmonid populations
    iii. Focus: restoring natural processes that create and maintain habitat to increase fish populations

II. River Restoration Planning and Design
  a. Process-Based Restoration at the local channel reach and sub-basin scale
    i. Biological Habitat Assessment
    ii. Abiotic Hydrogeologic and Gemophorphologic Assessment
  b. Restoring Natural Watershed Processes
    i. Improve Watershed Health
    ii. Improve Water Quality
    iii. Improve Fish Habitat

c. Outcomes Assessment
   i. Decadal Scale Monitoring of Salmonid Populations

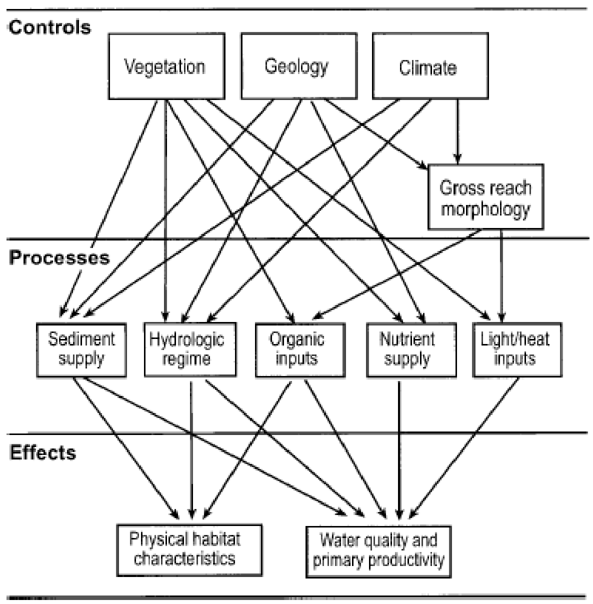


FIGURE 1.—Schematic diagram of linkages between landscape controls on habitat-forming processes and between habitat-forming processes and effects on habitat conditions.

d. Watershed Assessment - Steps in Identifying Restoration Needs
   i. Identify types and rates of habitat forming processes
   ii. Determine which processes are altered and where, identify sources of problems
   iii. Determine Restoration Strategy and Mitigation Approach

TABLE 1.—Examples of watershed processes and watershed assessment methods used to determine effects different processes have on stream morphology, instream habitat, and water quality.

Watershed process[a]	Examples of assessment methods
Sediment supply and erosion	Inventory landslides and calculate sediment budgets
	Inventory roads for landslide hazard; list sites requiring restoration work
	Map surface erosion hazards (road surfaces and soils)
Hydrology	Assess changes in hydrologic regime due to increased impervious surface areas
	Assess changes in peak flows resulting from rain-on-snow and extension of drainage networks by road ditches
	Assess connectivity of wetlands, sloughs, and stream channels
Riparian and organic inputs	Map riparian forest conditions to locate areas of low woody debris availability
	Assess historical riparian vegetation including land use and fire history to understand changes in woody debris and organic matter inputs
Nutrients	Assess inorganic nutrient inputs based on geologic mapping
	Assess current and historical salmon escapement to examine changes in marine-derived nutrients
Light and heat inputs	Assess current and historical shading to estimate changes in stream temperature

III. Restoration Techniques

a. General Categories

i. Habitat Reconnection – re-connecting channels, tributaries, wetlands and floodplains to ocean; reducing occurrence of disconnected and isolated habitats

ii. Road Improvement – fish passage in river conduits via bridges and culverts; reduced sedimentation

iii. Riparian Restoration – vegetative restoration

iv. Instream Channel Habitat Restoration – promotion of favorable channel habitats for spawning and migration

v. Nutrient Enrichment – food chain improvements

b. Habitat Reconnection

i. Off Channel Restoration

1. Reconnecting wetlands, swales and side channels to main stem flow
   a. Increasing habitat area + increasing salmonid migration pathways
   b. Sequencing seasonal high-water and low-water conditions with salmonid migration patterns
2. Culverts and Fish Passage Barriers
   a. Culvert redesign, increase diameter, roughness design for improved fish migration
   b. Large Culvert design to facilitate large woody debris and sediment transport
3. Bridge Structures and Fish Passage

TABLE 2.—Summary of various stream crossing structures and whether (Y = yes; N = no) they allow for juvenile and adult salmonids fish passage and the transport of sediment and large woody debris (LWD) or impact stream morphology by constraining the channel.

Stream crossing type	Provides fish passage for		Transports		Constrains channel[a]
	Adult	Juvenile	Sediment	LWD	
Bridge	Y	Y	Y	Y	N
Culverts					
Bottomless pipe arch	Y	Y	Y	N	Y
Squash pipe or countersunk	Y	Y	Y	N	Y
Round corregated, baffled	Y	Y	N	N	Y
Round corregated, no baffles	Y or N[b]	Y or N[b]	N	N	Y
Smooth (round or box)	N[b]	N[b]	N	N	Y

[a] Constrainment depends upon size of culvert or bridge relative to channel and floodplain width.
[b] Fish passage depends upon culvert slope and length.

ii. Estuarine Habitats – tidally influenced, marginal marine fluvial zones

1. Degraded Habitats
   a. Dewatering and Dike Construction
   b. Reduced marsh habitat from development
2. Marsh and Tidal Flat Restoration + Habitat improvements

c. Road Improvement

i. Degraded Conditions

1. Roads as sediment sources
   a. Find sediment production, channel siltation and turbidity
   b. Drainage Ditches
2. Stream Crossing impediments, fish passage barriers
3. Road Runoff and Water Quality Degradation

TABLE 3.—Processes restored (×) by various road improvement techniques.

Road improvement technique	Hydrology	Sediment delivery	
		Fine	Coarse
Removal of roads	×	×	×
Culvert or stream crossing upgrades (correct unstable crossings)		×	×
Sidecast removal or reduction		×	×
Reduce road drainage to stream[a]	×	×	
Increase surface material thickness or hardness with crushed rock or paving		×	
Traffic reduction (unpaved roads)		×	

[a] Drainage reduced through increased crossings and by diverting water onto forest floor.

d. Riparian Restoration
   i. Riparian Silviculture – Timber Harvest Degradation
      1. Loss of habitat, shading and root strength
      2. Riparian reforestation conversion – historic conifer plantations
      3. Reduced Woody Debris Recruitment
      4. Tree Planting and Native Plant Restoration Initiatives
   ii. Grazing and Fencing Strategies
      1. Livestock grazing in riparian zones, habitat disruption, increase sedimentation
      2. Water quality degradation
      3. Fencing and Grazing Exclusion Zone Initiatives
e. Instream Habitat Restoration
   i. Discharge + Flow Restoration
   ii. Coarse Gravel Sediment Retention
   iii. Large Wood Placement / Wood Structures – increase channel complexity and salmonid habitat
f. Nutrient Enrichment and Carcass Placement
   i. Nutrient deficiencies in altered rivers systems: Nitrogen and Phosphorous balance
   ii. Addition of fish carcass to river system, nutrient improvements for food chain

TABLE 6.—Typical response time, duration (plus sign means it could extend beyond the indicated duration), variability in success, and probability of success (low = L, moderate = M, high = H) of common restoration techniques.

Specific action	Years to achieve response	Longevity of action (years)	Variability of success among projects	Probability of success
Reconnect habitats				
Culverts	1–5	10–50+	L	H
Off-channel	1–5	10–50+	L	H
Estuarine	5–20	10–50+	M	M–H
Road improvement				
Removal	5–20	decades to centuries	L	H
Alteration	5–20	decades to centuries	M	M–H
Riparian vegetation				
Fencing	5–20	10–50+	L	M–H
Riparian replanting	5–20	10–50+	L	M–H
Rest-rotation or grazing strategy	5–20	10–50+	M	M
Conifer conversion	10–100	Centuries	H	L–M
Instream habitat restoration				
Artificial log structures	1–5	5–20	H	M[a]
Natural LWD[b] placement	1–5	5–20	H	M[a]
Artificial log jams	1–5	10–50+	M	M[a]
Boulder placement	1–5	5–20	M	M[a]
Gabions	1–5	10	M	M[a]
Nutrient enhancement				
Carcass placement	1–5	Unknown	L	M–H
Stream fertilization	1–5	Unknown	M	M–H
Habitat creation				
Off-channel	1–5	10–50+	H	M
Estuarine	5–10	10–50+	H	L
Instream	(See various instream restoration techniques above)			

[a] Low to high; depends upon species and project design.
[b] LWD = large woody debris.

IV. Prioritizing Stream Restoration Activities

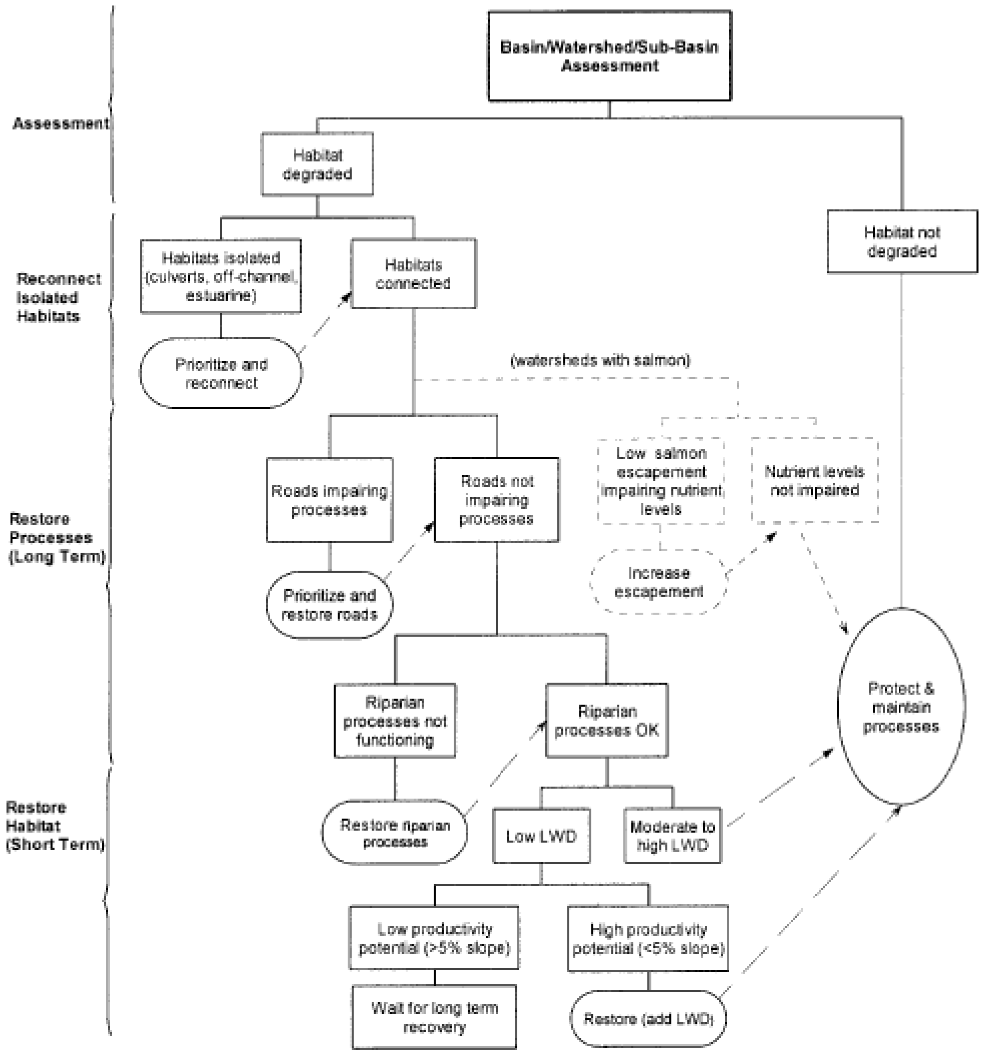


FIGURE 2.—Flow chart depicting hierarchical strategy for prioritizing specific restoration activities. Ovals indicate where restoration actions should take place. Addition of salmon carcasses or nutrients (small dashed lines) may be appropriate at various stages following reconnection of isolated habitats.

a. Key Question: given the widespread scaling and scope of riverine habitat alteration in the Pacific Northwest, and limited amounts of funding for restoration initiatives, how do policy makers and decision makers prioritize the most effective "bang for the buck"?

   i. Step 1: conduct watershed assessment and keen understanding of natural processes that promote high quality salmonid habitat.
   ii. Step 2: do no harm – protect, promote and prioritize existing high-quality habitats that are currently not degraded.
   iii. Step 3: Use stepwise, science-based approach with known methodologies that promote best possible outcomes
      1. Reconnectivity of Habitats (barrier removal, off channel reconnection)
      2. Restoration of natural hydrologic, sedimentation and riparian processes
      3. Instream habitat improvements, engineered structures
      4. Monitoring, Outcomes-Based Assessment, Adaptive Management over time