Sound Watershed Consulting

Creating Functional Water Environments

Riparian Ecology & Functions in Forested Landscapes

May 1, 2013

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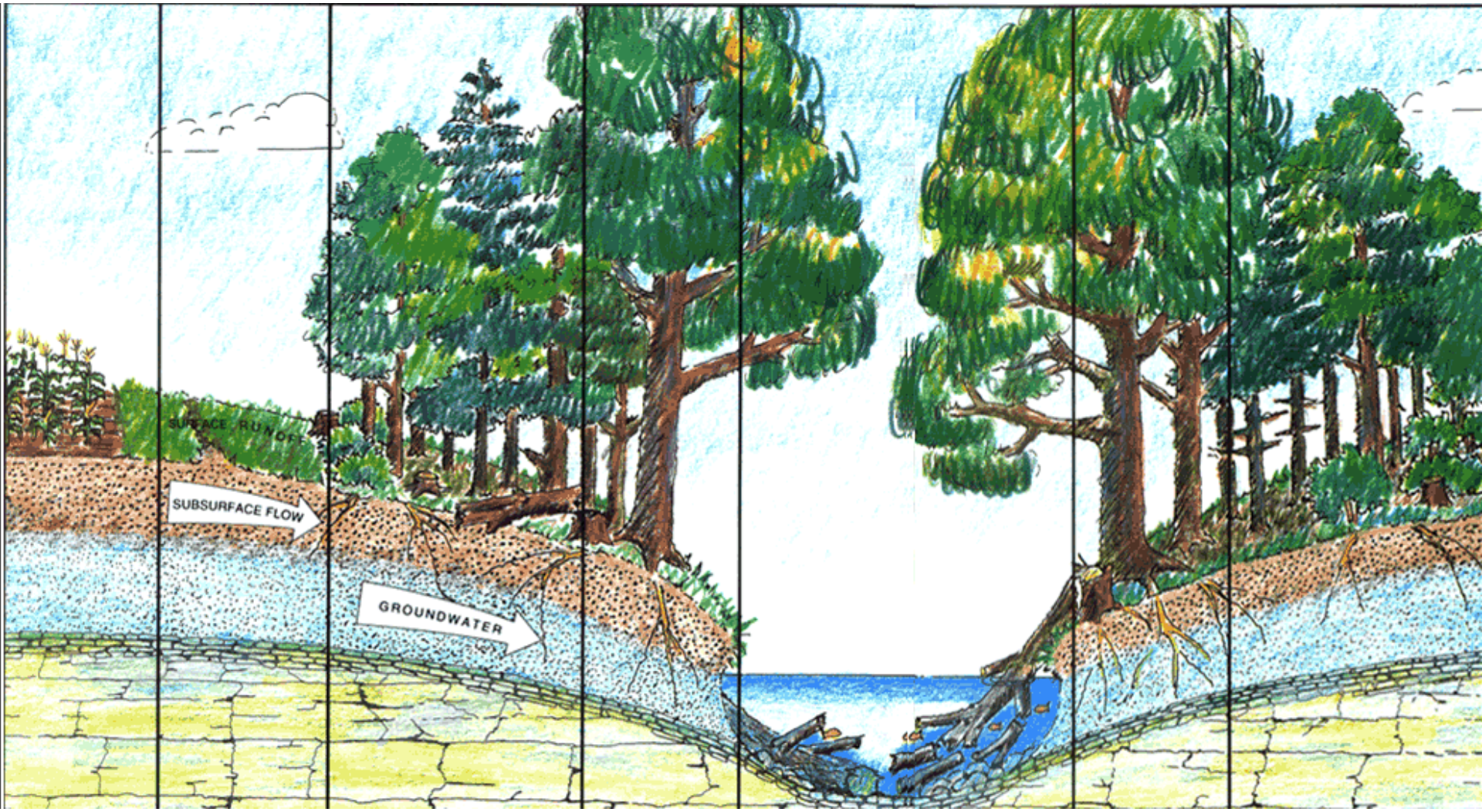
Principal, Sound Watershed

www.soundwatershed.com

Stream Buffers



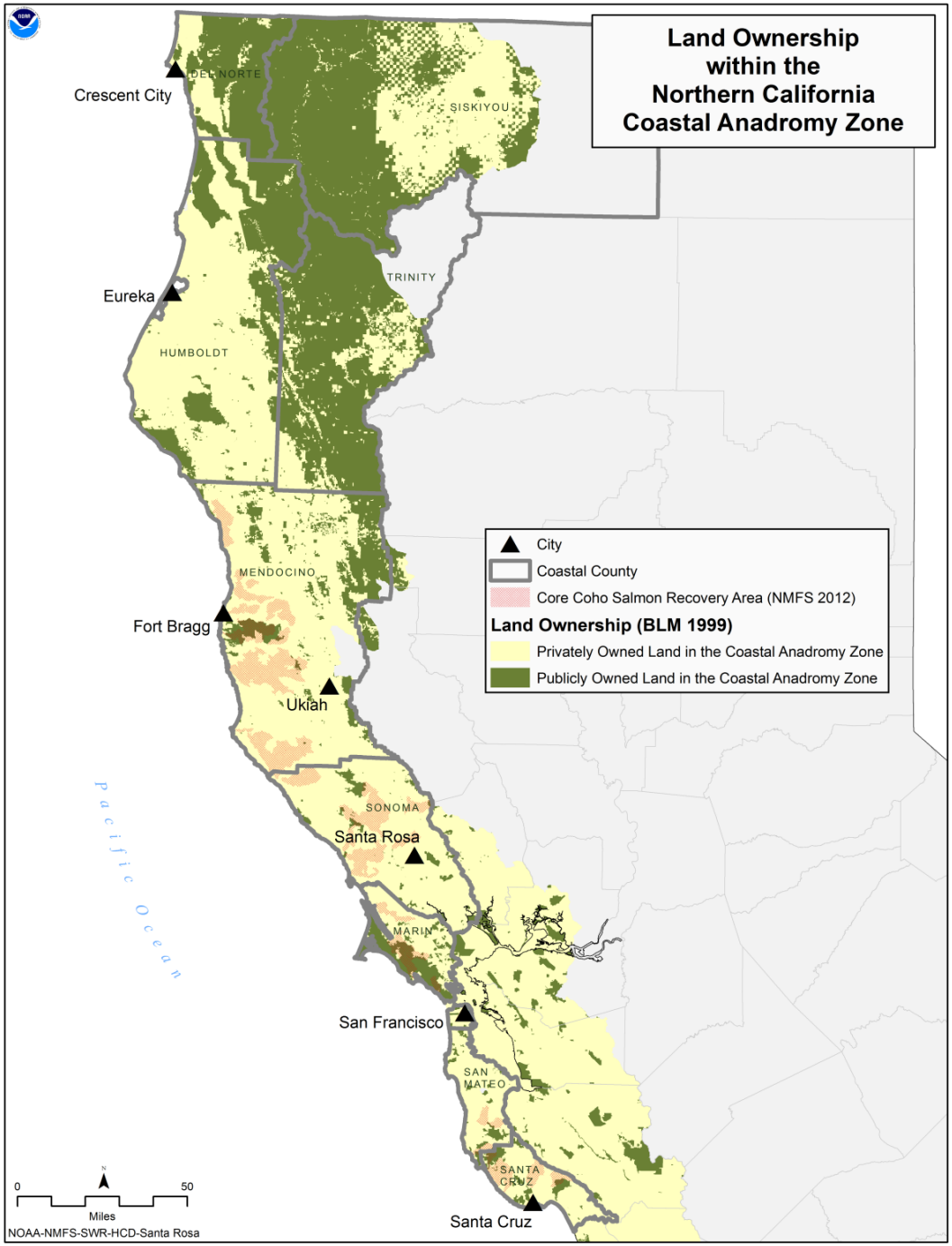
California Forestry Facts

- ~101 M acres
- 16.6 M ac of public and privately owned commercial timberland
- 9.3 M ac public ownerships
- 7.3 M ac privately-owned timberland
- 5.4 M ac private lands zoned for timber production

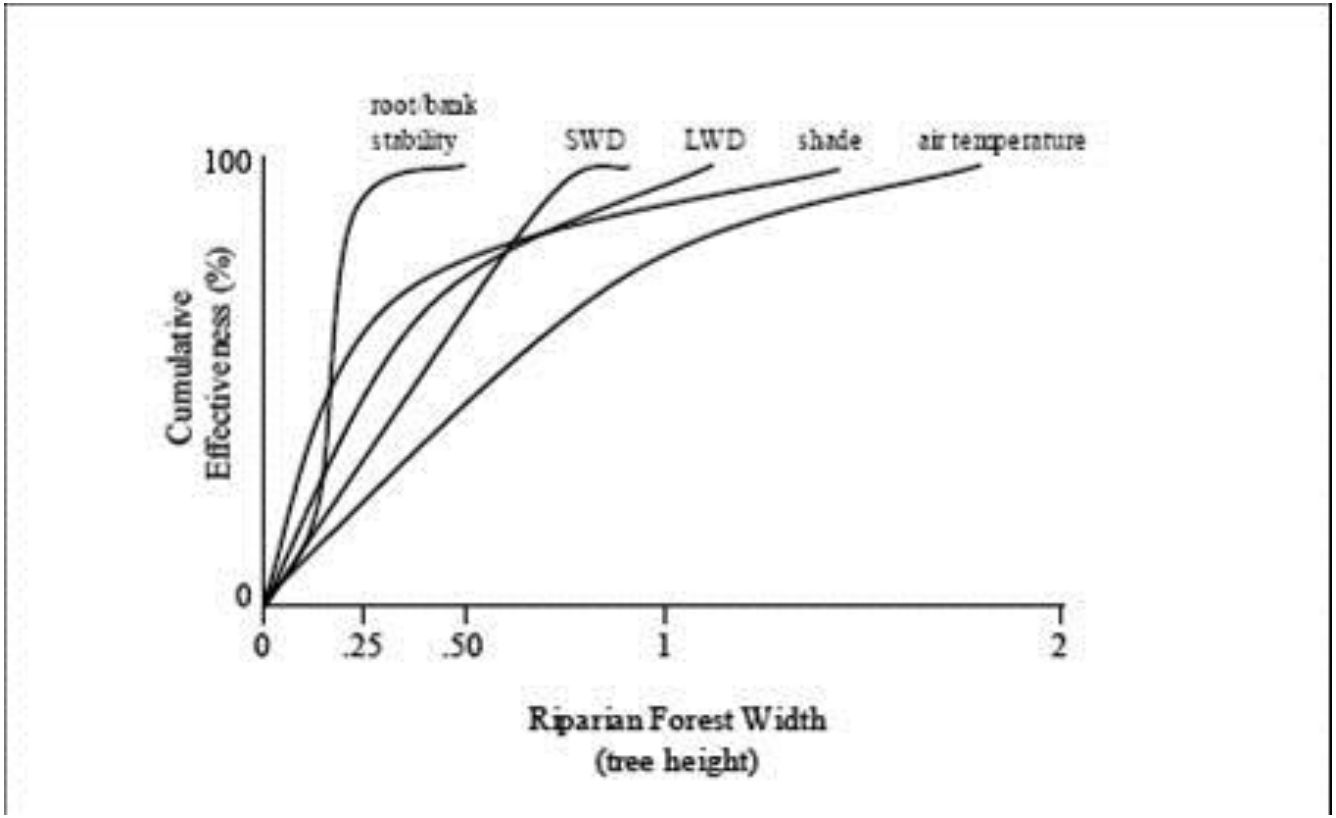
Image: CDF 2003

Private and Public Land Ownership within the Coastal Anadromy Zone

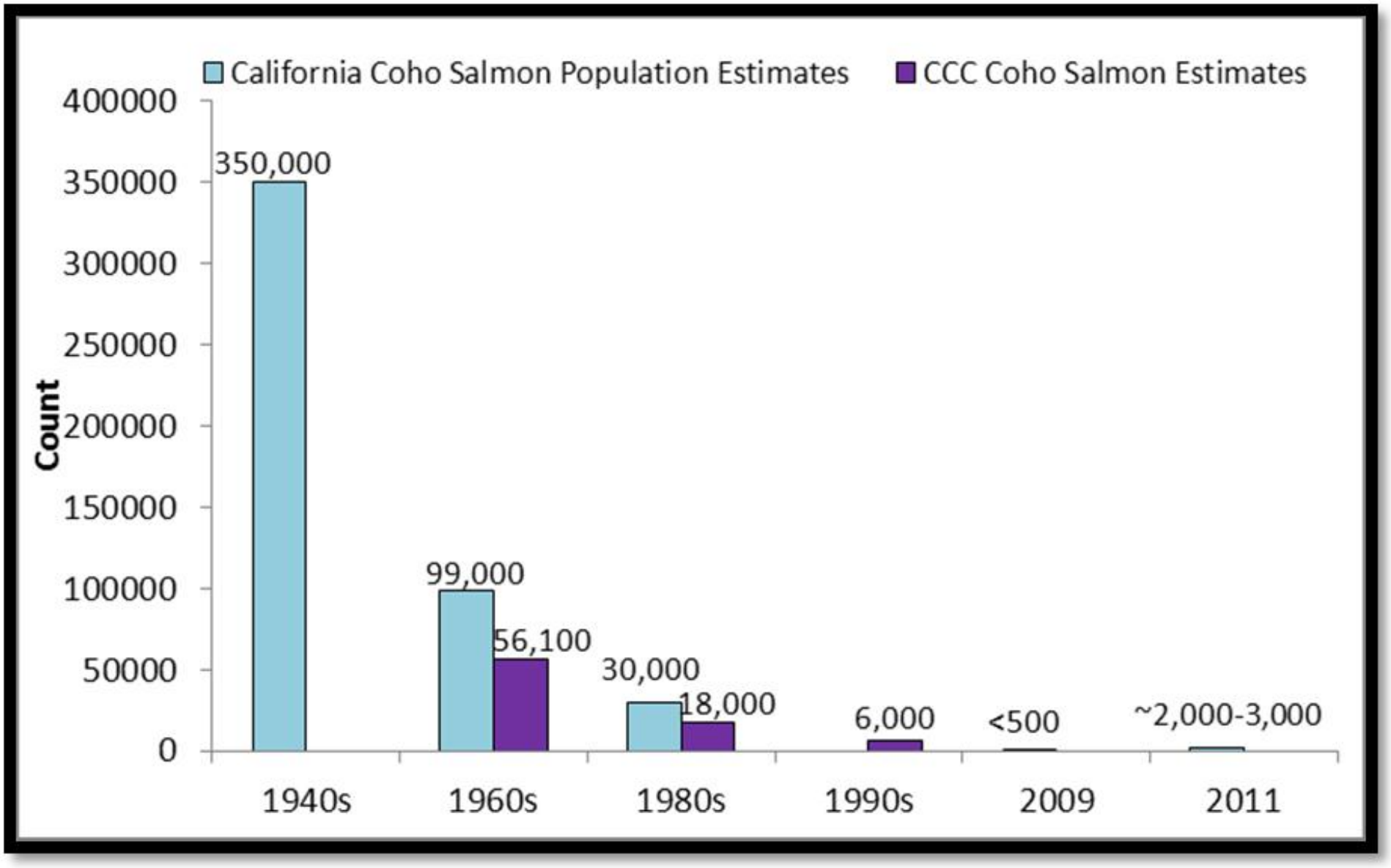
85-90% of remaining CCC coho salmon exist on private forestlands



- *The scientific basis for defining buffer widths in fish-bearing streams was source distance relationships*



Policy Drivers



Policy Drivers

90% of the waterbodies in California's North Coast Region are listed as "impaired"


2012 Ponderosa Fire Battle Creek
Digger Creek Riparian Zone
Photo: Mark Lathrop, SPI

2007 Angora Fire

"Dense stands of trees in the Angora SEZ likely contributed to the rapid [fire] spread upslope to Angora Ridge…"

Technical Basis for ASP Rules

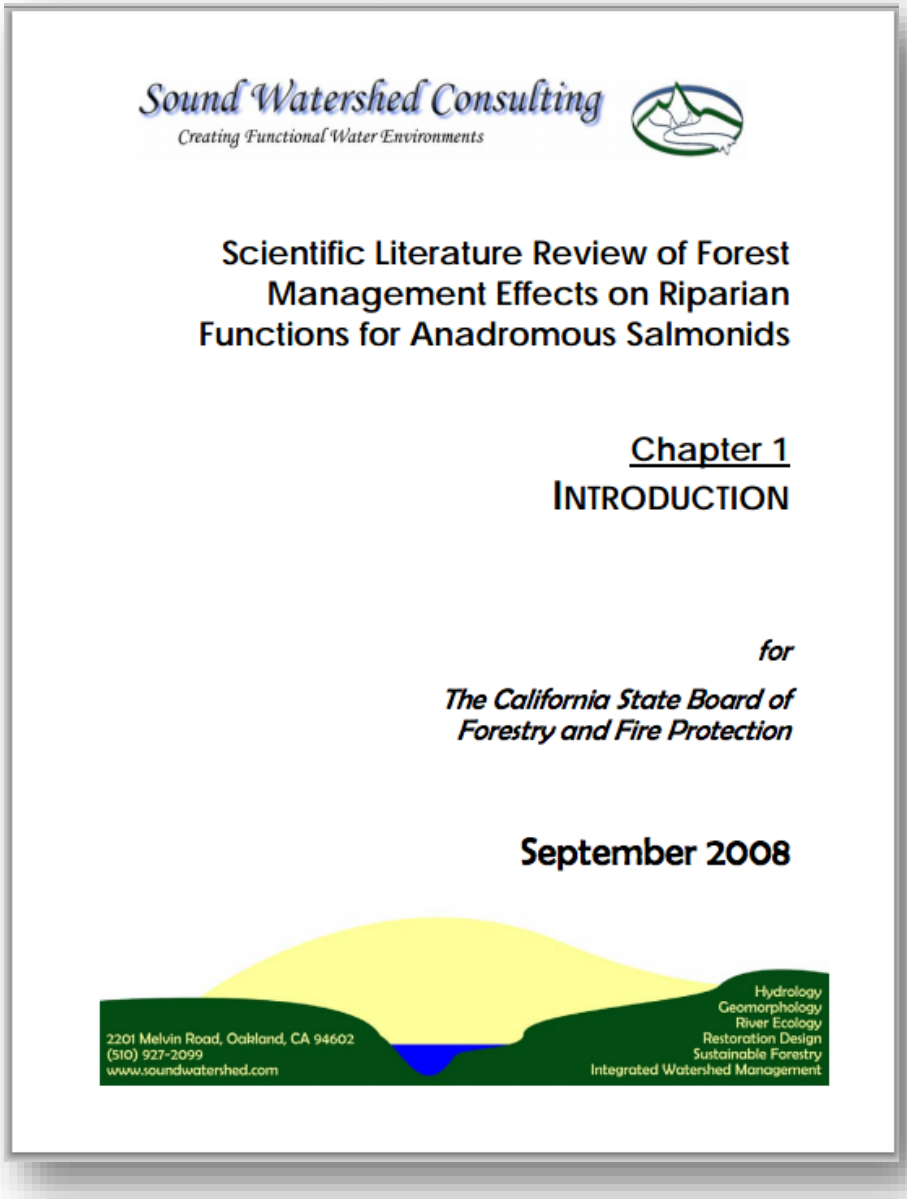
Mike Liquori

Doug Martin

Robert Coats

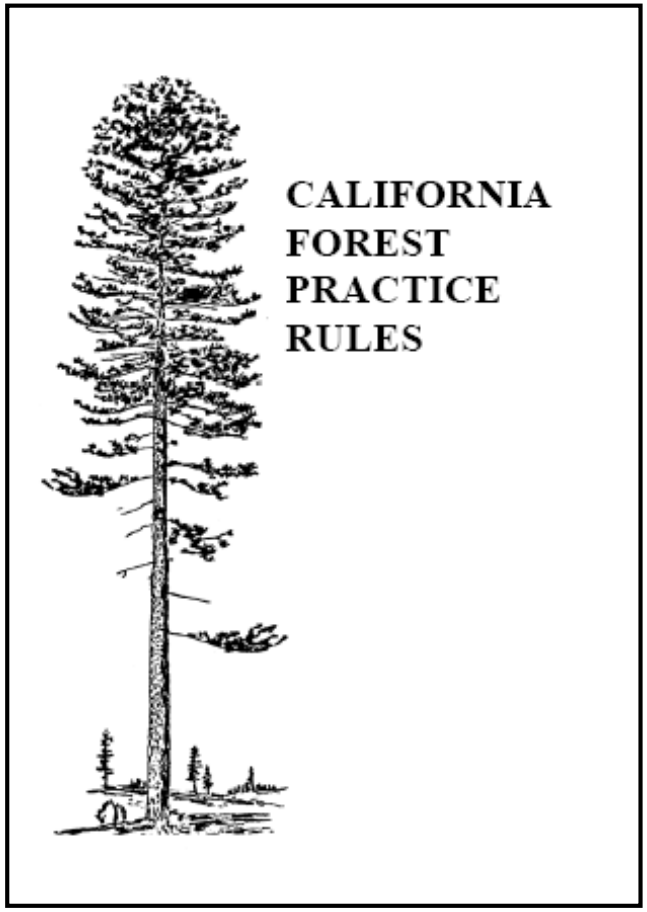
Lee Benda

David Ganz



ASP Rule Section V

- The 2009 Anadromous Salmonid Protection (ASP) Rules



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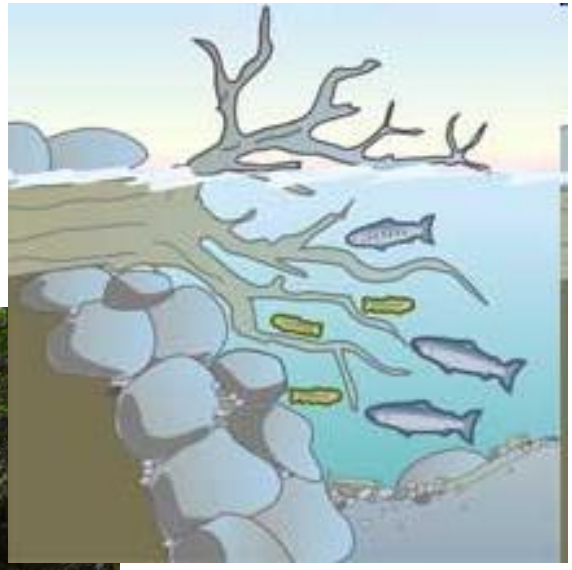
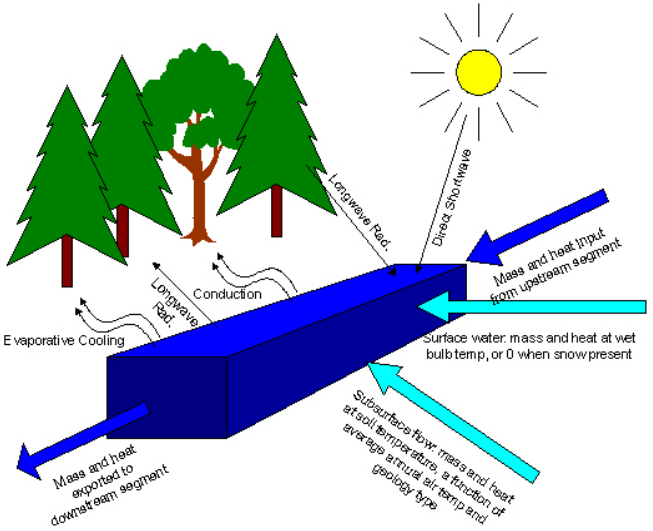
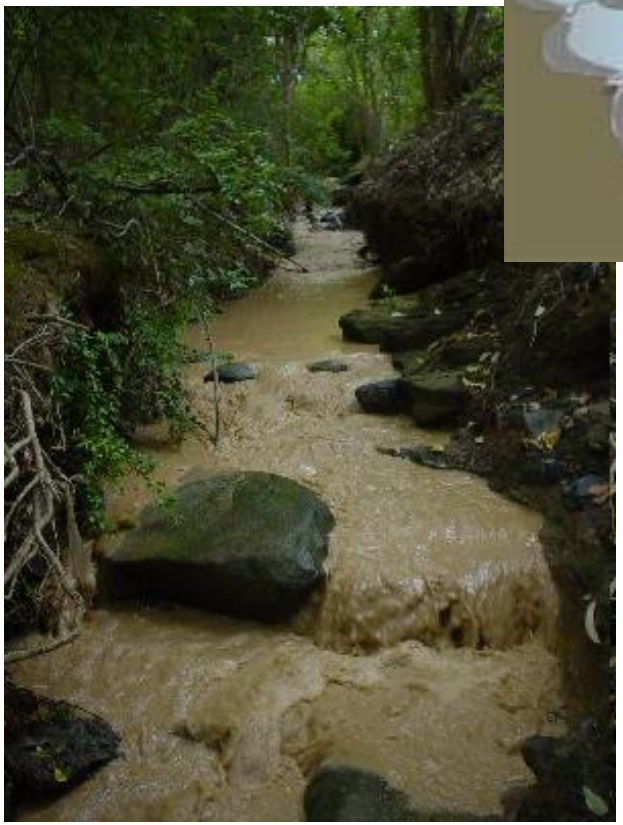
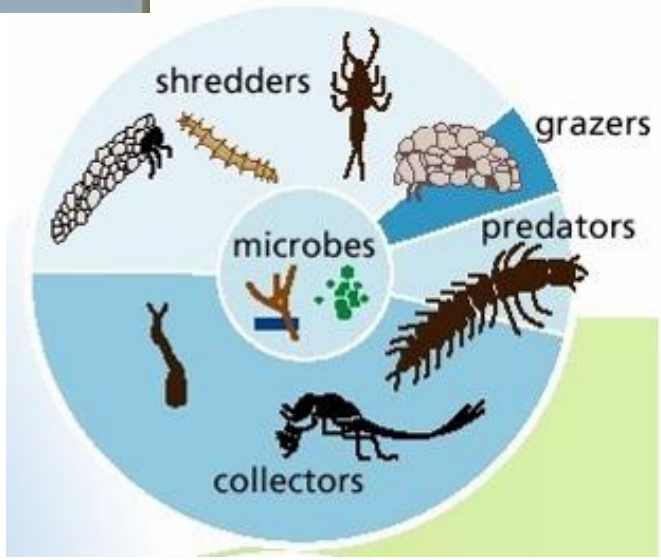
Riparian Functions

Functions




Longwave Rad.
Direct Shortwave
Mass and heat input from upstream segment
Conduction
Longwave Rad.
Evaporative Cooling
Surface water: mass and heat at wet bulb temp, or 0 when snow present
Subsurface flow: mass and heat at soil temperature, a function of average annual air temp and geology type
Mass and heat exported to downstream segment




shredders
grazers
microbes
predators
collectors

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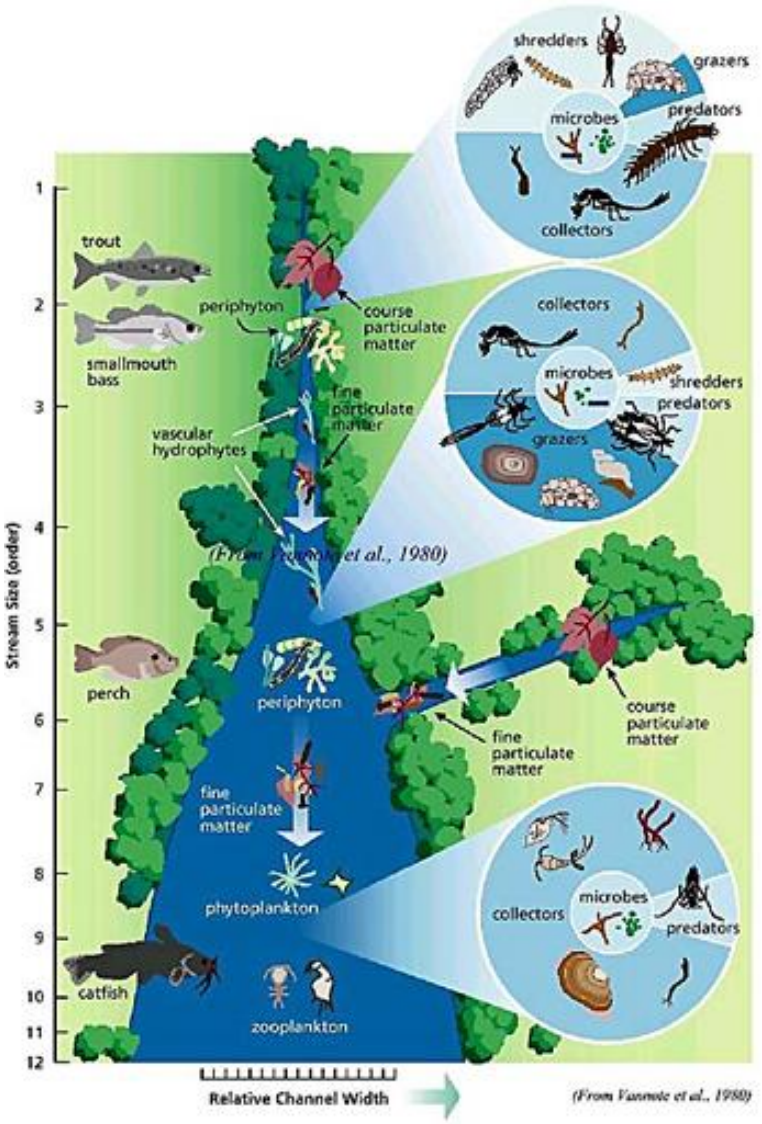
Biotic & Nutrient Exchange

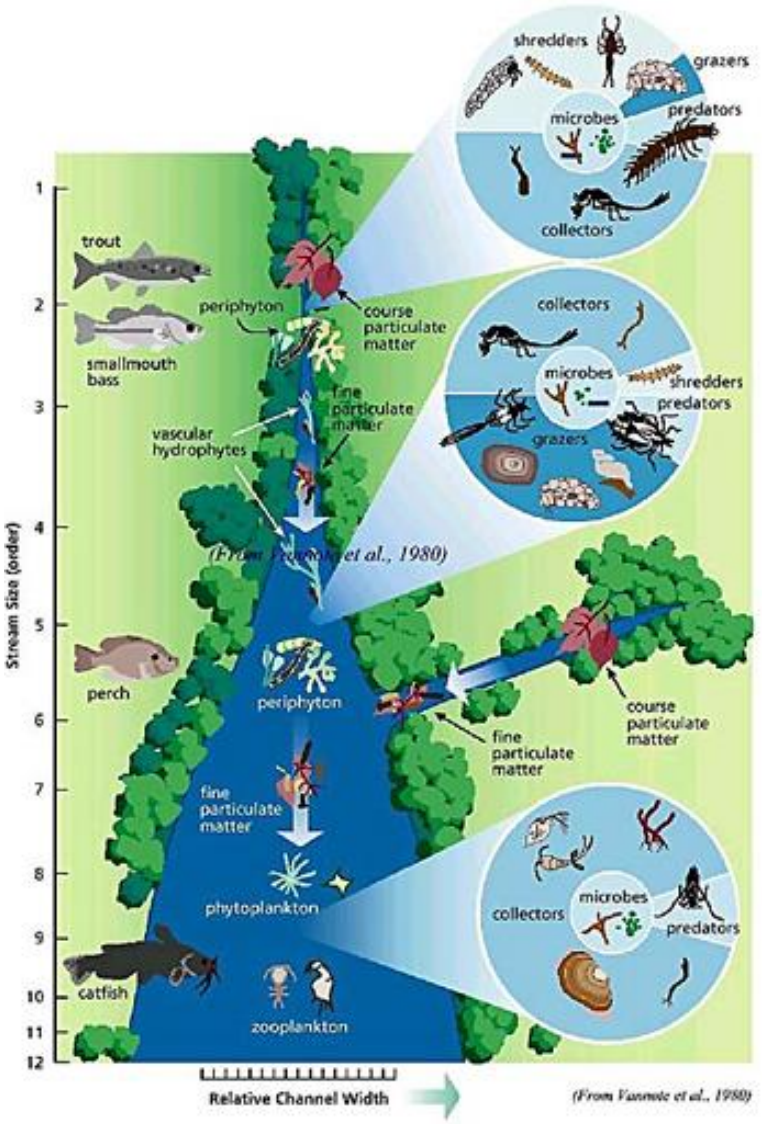
River Continuum

- Distribution of aquatic organisms change longitudinally
  - Driven by process changes

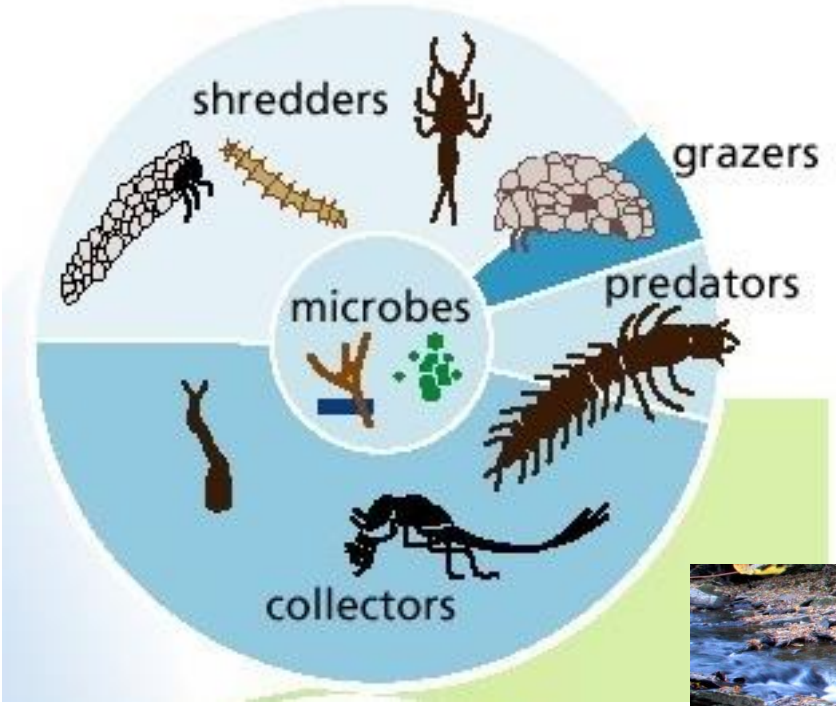


River Continuum

- Distribution of aquatic organisms change longitudinally
  - Driven by process changes
  - And source materials



- Riparian leaf litter is an important food source



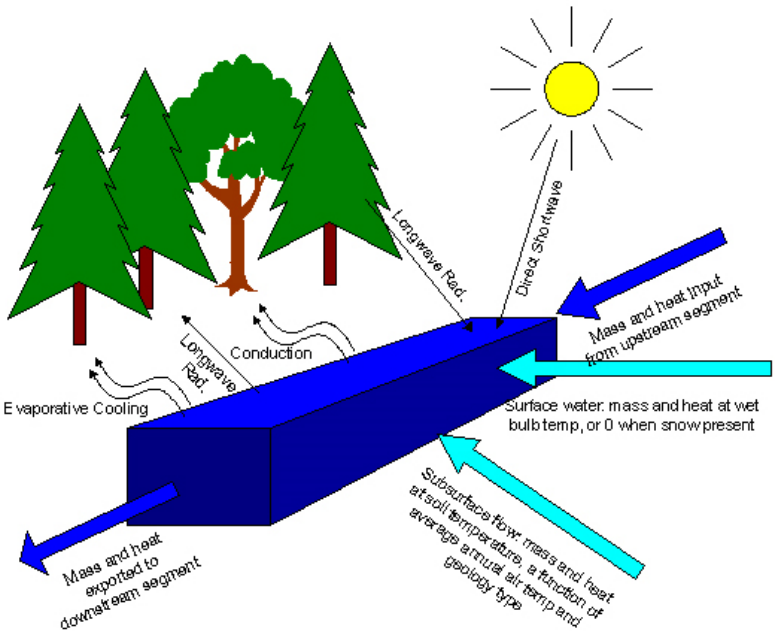
Highest Value

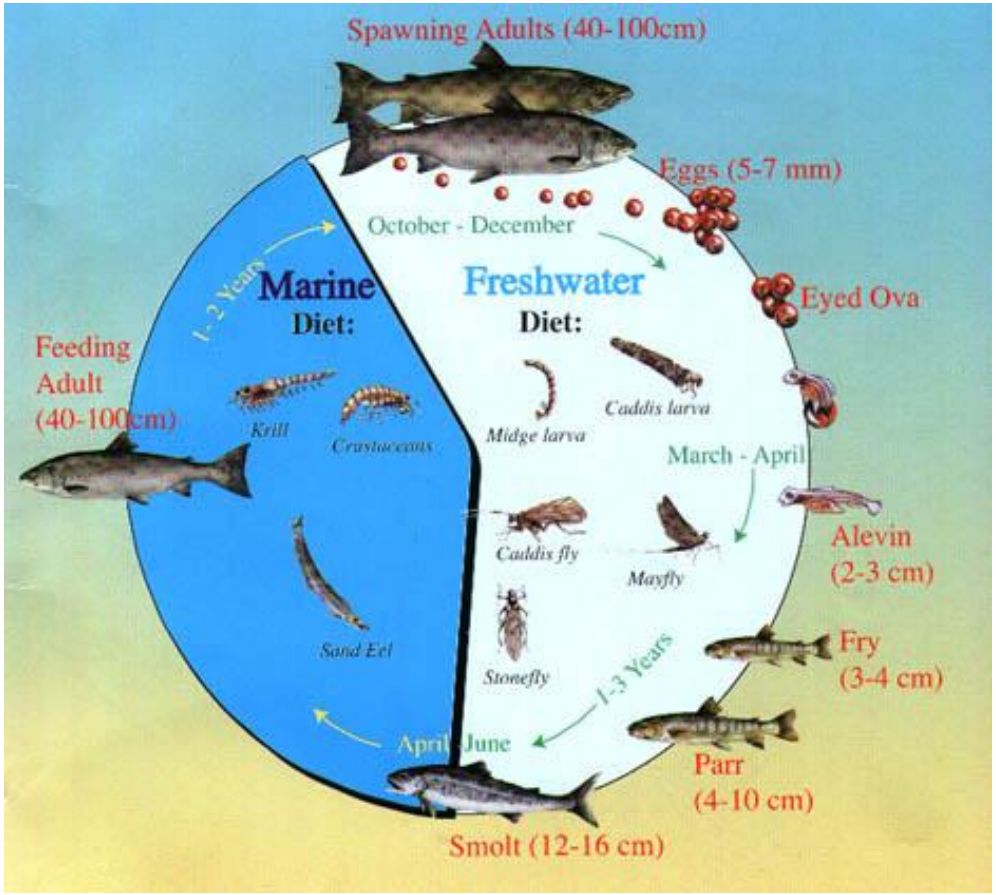
Moderate

Poor Quality

Key Findings – Biotic & Nutrient

- Tradeoffs between nutrient exchange and other functions
  - Heat regulation
  - Water – response to flooding
  - Wood recruitment potential




Spawning Adults (40-100cm)
Eggs (5-7 mm)
October - December
Freshwater
Diet:
Midge larva
Caddis larva
Eyed Ova
March - April
Caddis fly
Mayfly
Alevin
(2-3 cm)
Fry
(3-4 cm)
Stonefly
1-3 Years
April
June
Parr
(4-10 cm)
Smolt (12-16 cm)
1-2 Years
Marine
Diet:
Krill
Crustaceans
Sand Eel
Feeding
Adult
(40-100cm)

Key Findings – Biotic & Nutrient

- No-cut buffers may forego opportunities to:
  - increase fish growth rate and biomass
  - manage other functions

Key Findings – Biotic & Nutrient

A 100 foot wide no-cut buffer on both sides of a stream provides conditions similar to a “no harvest” level

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Heat Exchange Functions

Thermodynamics

$$\frac{dT_s}{dt} = \frac{Q}{V}T_{in} + \frac{J_{DS}}{\rho C_p H} + \frac{J_{AL}}{\rho C_p H} - \frac{Q}{V}T_{Out} - \frac{J_{WL}}{\rho C_p H} - \frac{J_{COND}}{\rho C_p H} - \frac{J_{EVAP}}{\rho C_p H}$$

Jds: Heat from direct solar radiation

Jal: Heat for atmospheric longwave radiation

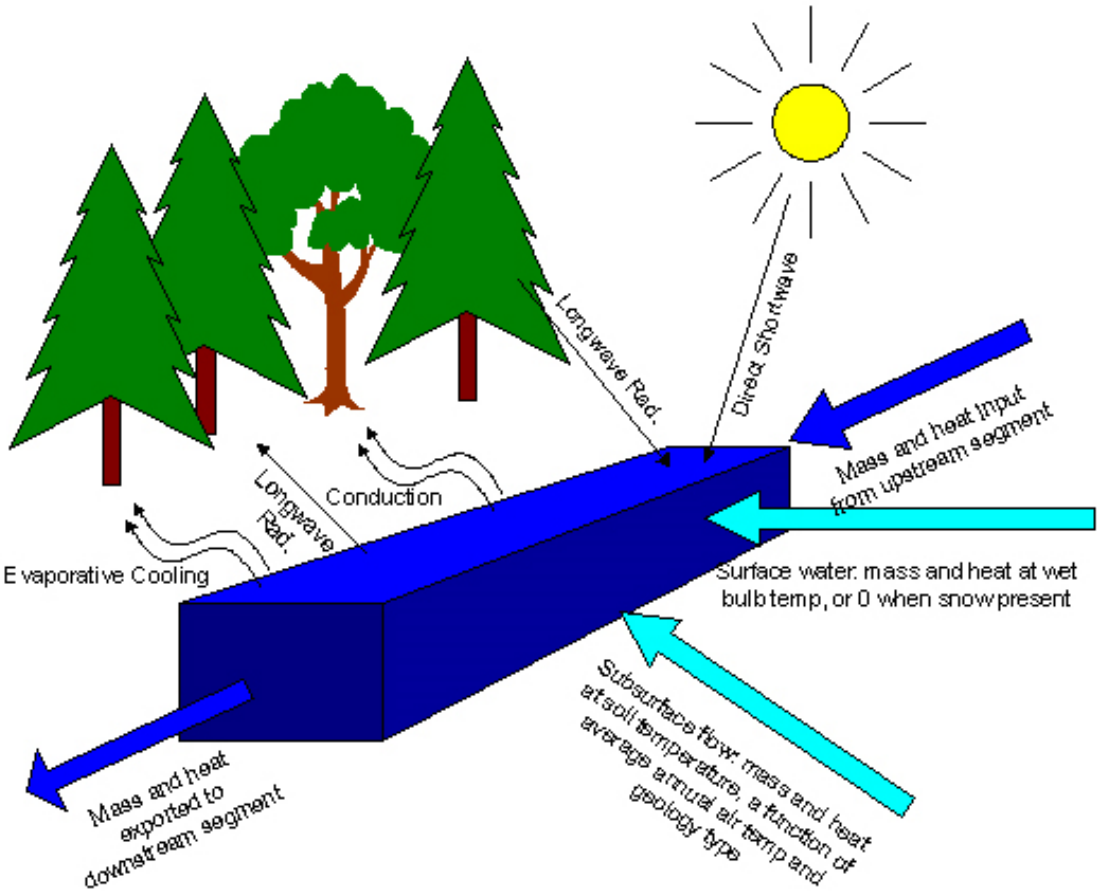
Jwl: Longwave re-emitted from water surface

Jcond: Conduction heat exchange with atmosphere

Jevap = Heat excange from evaporation (function of windspeed)

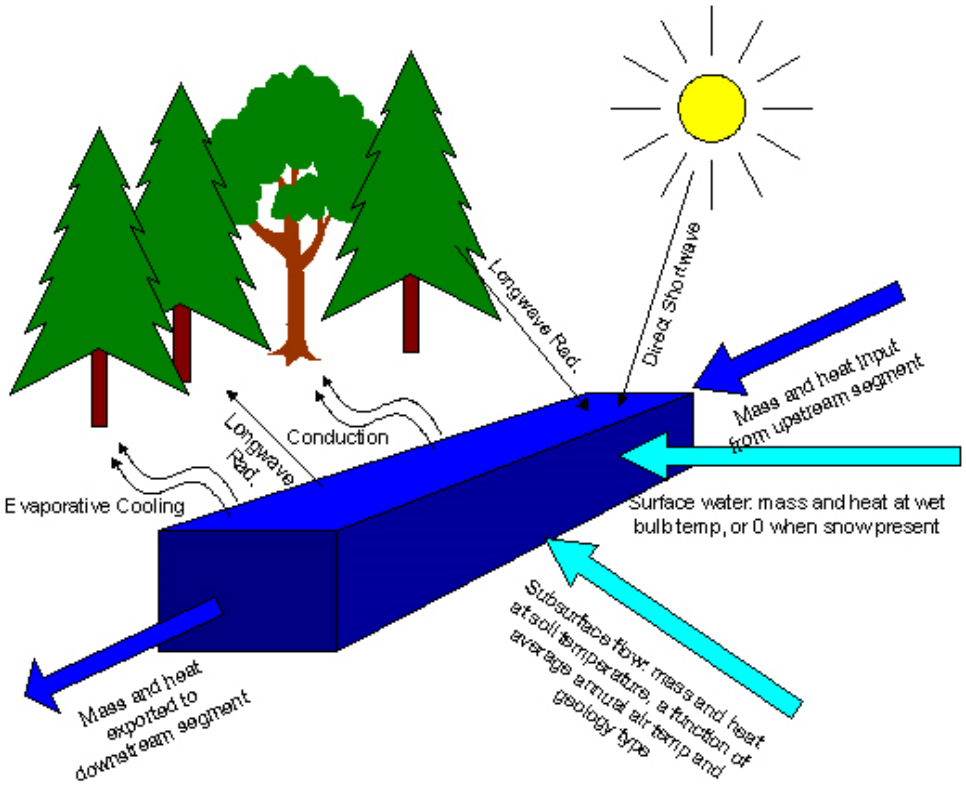
QT/V: Heat conveyed by mass flow into and out of segment.

From: Chapra, S.C., Surface Water Quality Modeling. 1997, McGraw-Hill.



Key Findings – Heat

- Riparian shade helps to control heat input to streams
- Other factors important too



Factors Affecting Temperature

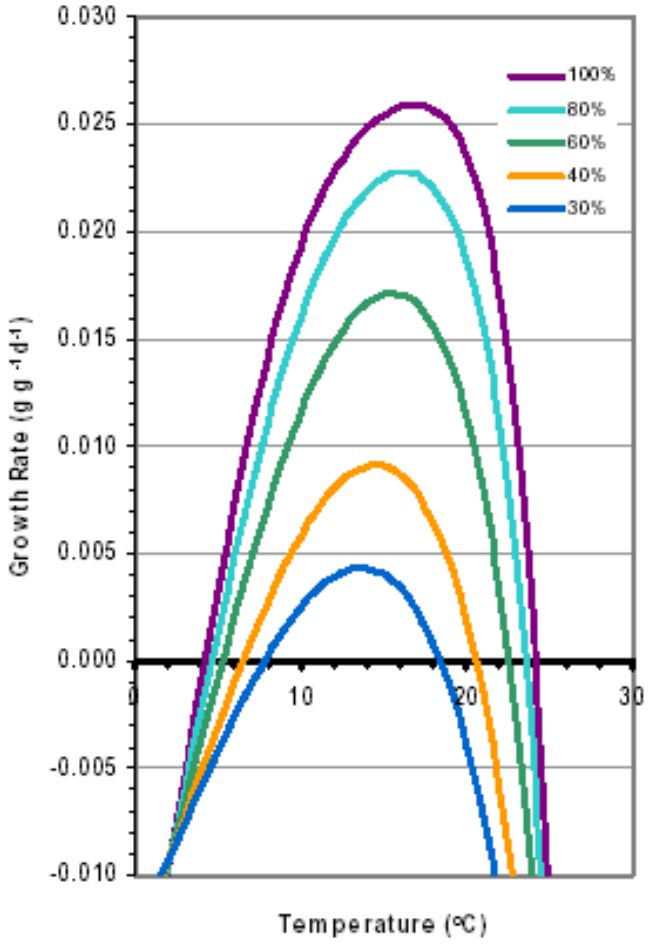
Table 2. Stream structures that influence insulating and buffering characteristics

Component and characteristic	Determined by	Ecological influence over
Channel		
Slope	catchment topography	flow rate
Substrate	flow regime, sediment sources, stream power	resistance to groundwater flux; channel roughness and therefore flow rate and thermal stratification
Width	flow regime, sediment sources, stream power, bank stability	surface area for convective heat exchange
Streambed topography	flow regime, sediment sources, stream power, bank stability, large roughness elements (e.g., large woody debris)	gradients that drive hyporheic flux
Pattern	flow regime, sediment sources, stream power, bank stability, large roughness elements, valley shape	gradients that drive hyporheic flux; potential shade from riparian vegetation
Riparian zone		
Vegetation	flow regime, vegetation height, density, growth form, rooting pattern	shade to reduce solar radiation; windspeed, advective heat transfer, conductive heat transfer; bank stability
Width	(same as channel pattern)	potential for hyporheic flux; potential for shade
Alluvial aquifer		
Sediment particle size	(same as channel substrate)	potential for hyporheic flux
Sediment particle sorting	(same as channel substrate)	diversity of subsurface temperature patterns by determining stratigraphy; extent of hyporheic flux
Aquifer depth	(same as channel pattern)	extent of hyporheic flux

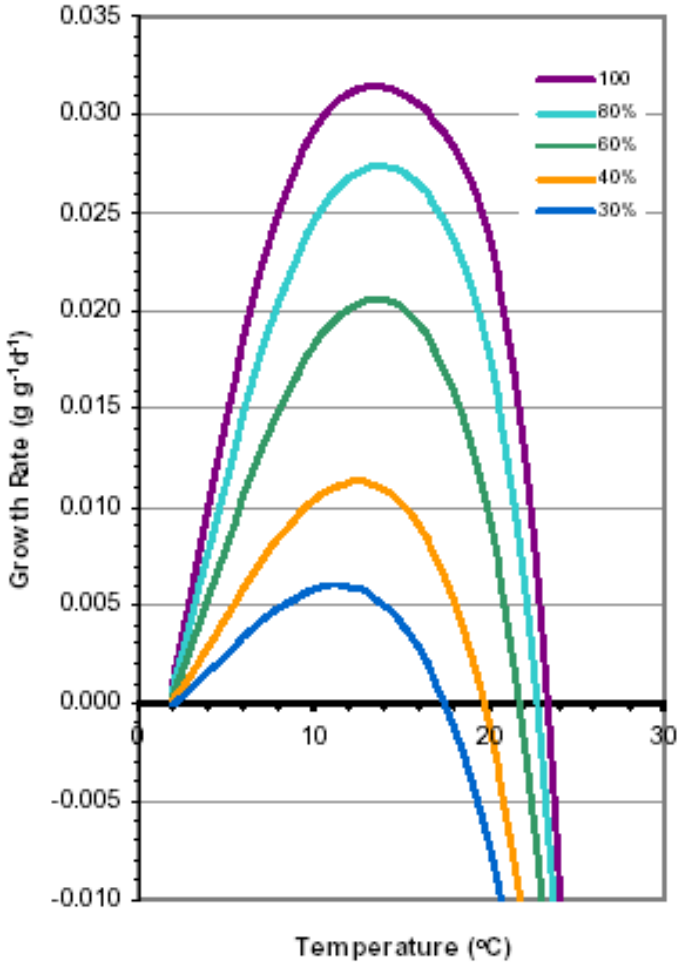
Poole & Berman 2001

Thermal Growth Curves

Coho

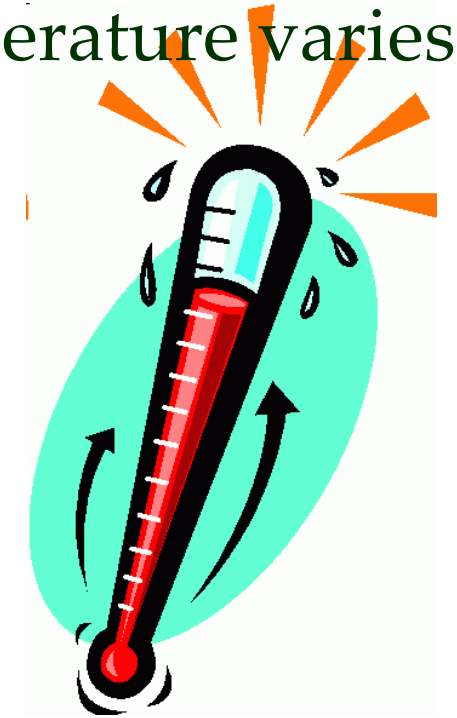


Steelhead



Key Findings – Heat

- The relative importance and sensitivity of riparian vegetation to influence stream temperature varies by:
  - Geographic province
  - At least 11 site specific factors

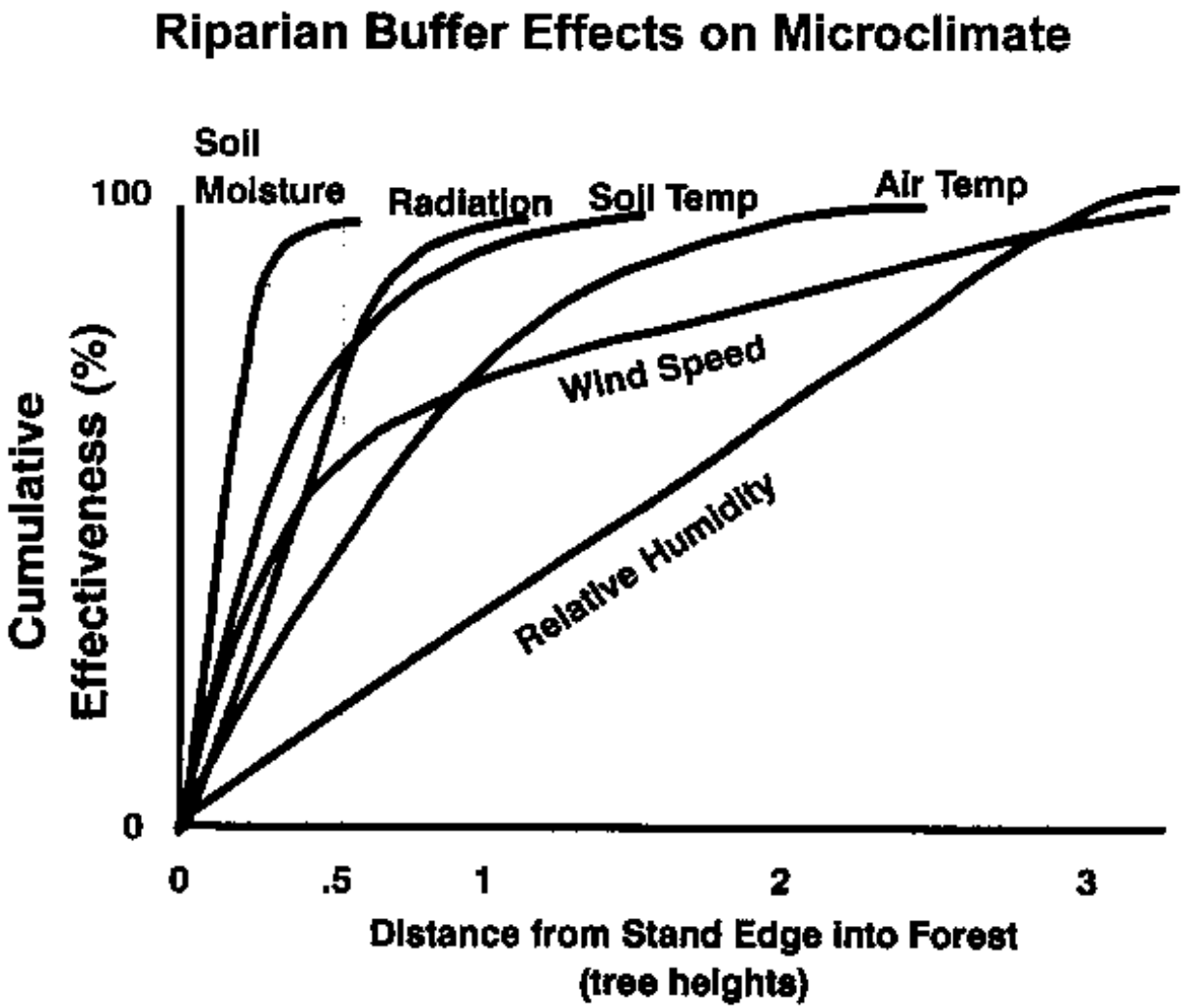


- Stream temperature targets can be helpful in managing to desired shade conditions

Key Findings – Heat

- No single, fixed-width buffer or canopy closure prescription can regulate heat objectives for salmon in all cases.
- Effective shading can be provided by:
  - **Lateral**: buffer widths ranging from 30 to 100 ft
  - **Longitudinal**: generally within 500 to 650 ft upstream

Microclimate



Key Findings – Heat

- Timber harvest in or adjacent to riparian areas can influence microclimate,

HOWEVER

- microclimate changes have not been demonstrated to translate to changes in water temperature.

Key Findings – Heat

- Shade conditions inversely influence biotic and nutrient exchange functions.

- Similarly, the canopy that provides shade also influences:

  - Water exchange functions

  - Wood exchange functions

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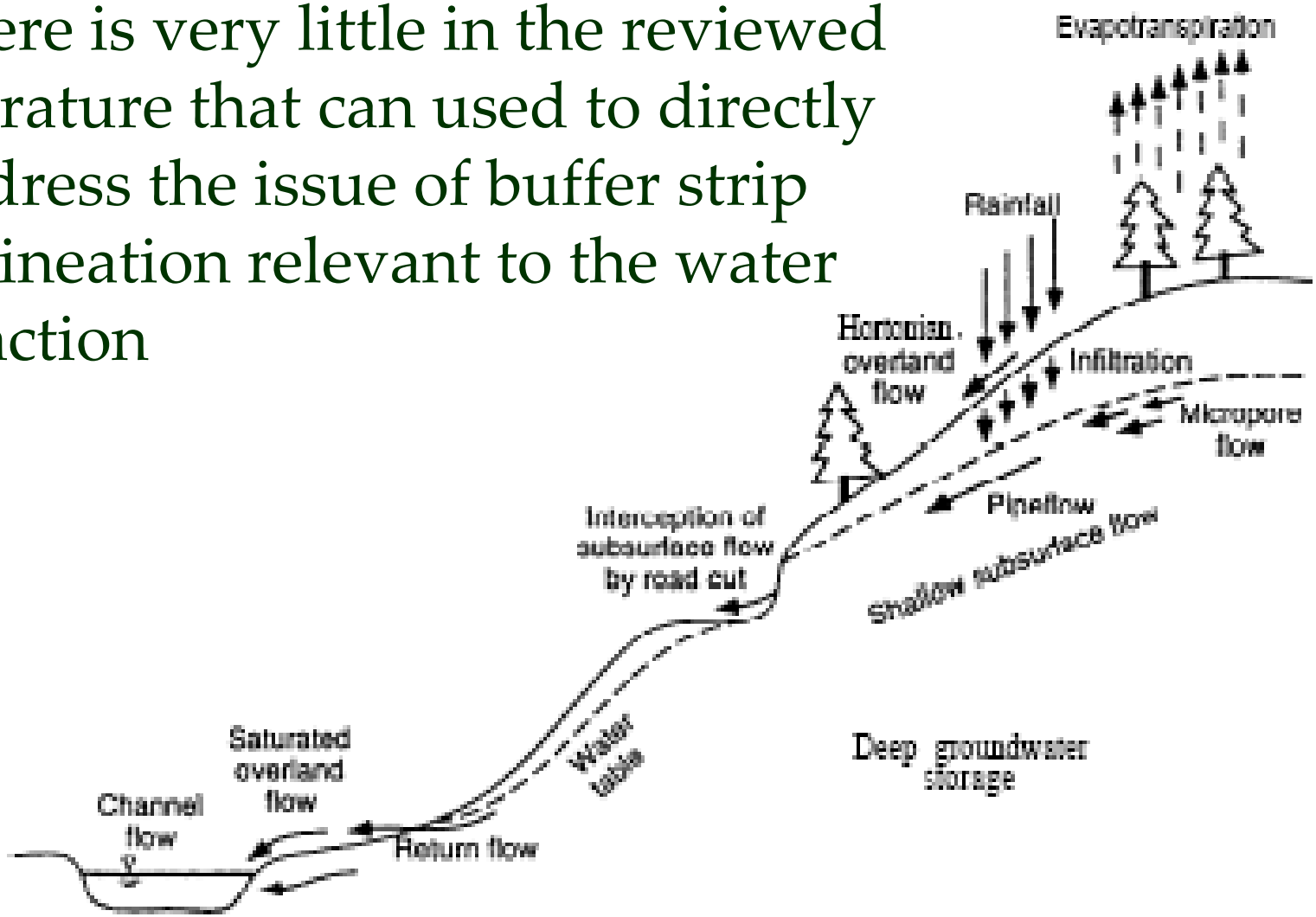
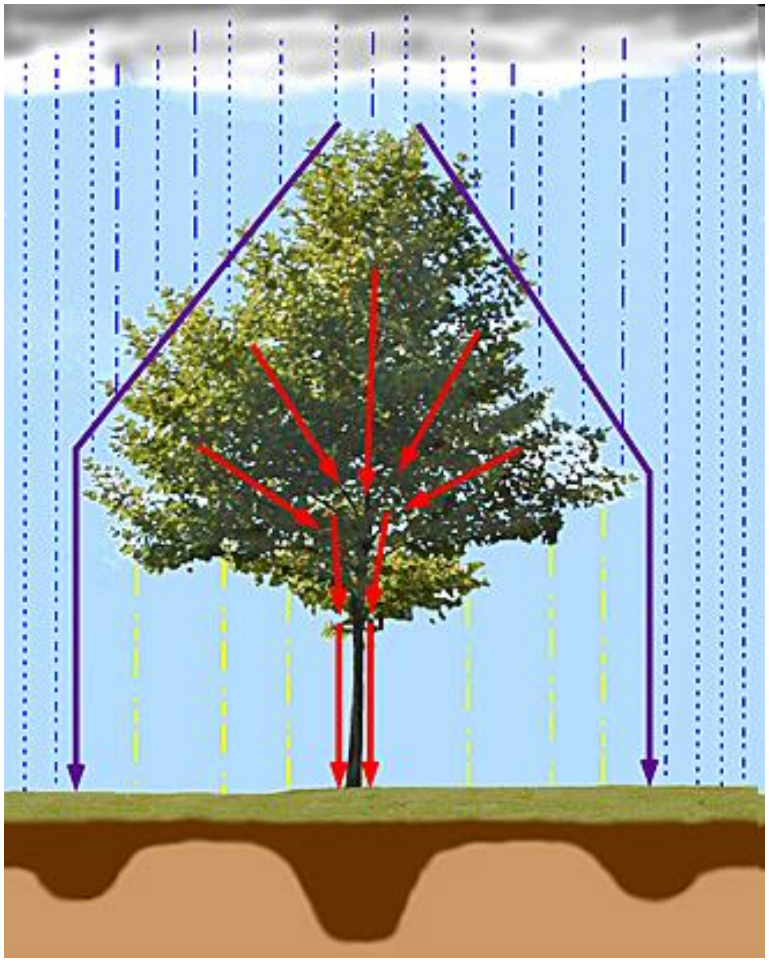
Water Exchange Functions

Key Findings – Water

There is very little in the reviewed literature that can used to directly address the issue of buffer strip delineation relevant to the water function



- Management affects the riparian canopy
  - canopy interception
  - evapotranspiration



Key Findings – Water

- Forest management activities in riparian areas might affect stream functions
  - effect is likely to be small
  - highly variable
  - strongly influenced by the watershed context
  - impacts are mixed

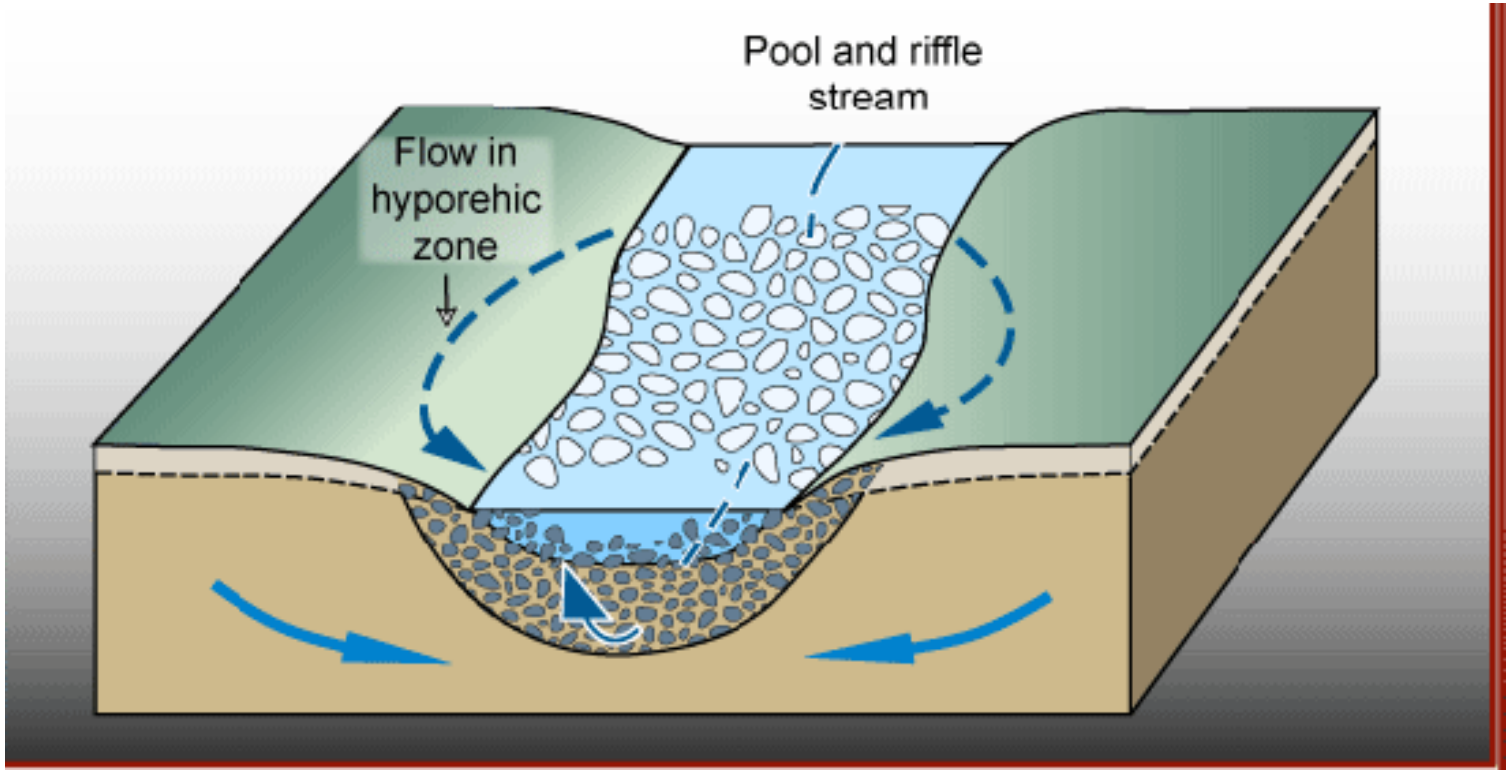
Key Findings – Water

- There is little direct evidence of riparian effects:
  - studied for entire watersheds
  - riparian zones alone have not been studied
- The most sensitive hydrologic areas may be steep, zero-order basins (hollows)
  - This was not a focus of this review

Key Findings – Water

- Soil compaction in riparian areas can negatively affect hydrologic processes.
  - Suggests limits for heavy equipment near streams

- Hyporheic flows are important ecologically
  - forest management effects are unclear



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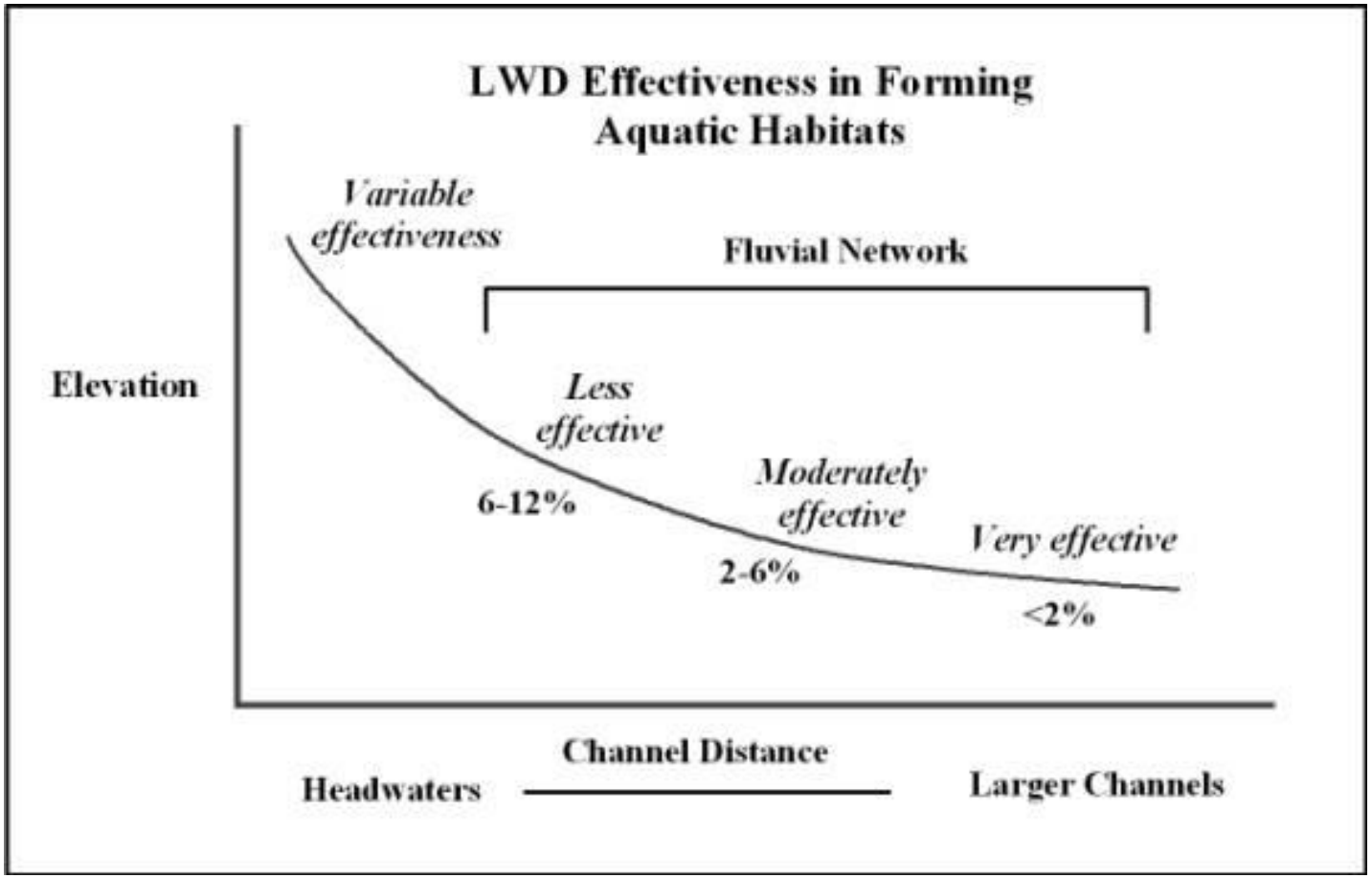
Wood Exchange Functions

- Wood functions vary by stream type and geomorphic context



LWD Sources

Type	Proportion of Supply	Source Distance
Bank Erosion	40-60%	< 30 ft
Landslides	~30%	100-200 ft
Treefall (mortality)	~10-30%	< 100 ft
Treefall (windthrow)		Up to 130 ft

Key Findings – Wood

- The major factors that are reported to influence wood recruitment conditions include:
  - Existing Stand Density, Composition And Structure
  - Stream Type, Order and Watershed Context
  - Vegetation Type and Soil/ Site Index
  - Regional Context
  - Disturbance Context

Key Findings – Wood

- Instream wood can move downstream through:
  - Flood: in larger streams

Debris-flow: in steep, low-order streams

Key Findings – Wood

- Wood recruitment potential depends upon:
  - Existing stand conditions
  - Successional pathway
  - Disturbance Regime

Key Findings – Wood

- Forest management appears to influence natural disturbance regimes by affecting
  - How often disturbances occur
  - How large the disturbances are
  - Which type of disturbances are likely

Key Findings – Wood

- Active forest management can manipulate riparian stand structure in ways that:
  - a) affect the growth and mortality dynamics for the stand and
  - b) influence the types, qualities and risks of disturbances
- and thus influence wood functions

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Sediment Exchange Functions

Key Findings – Sediment

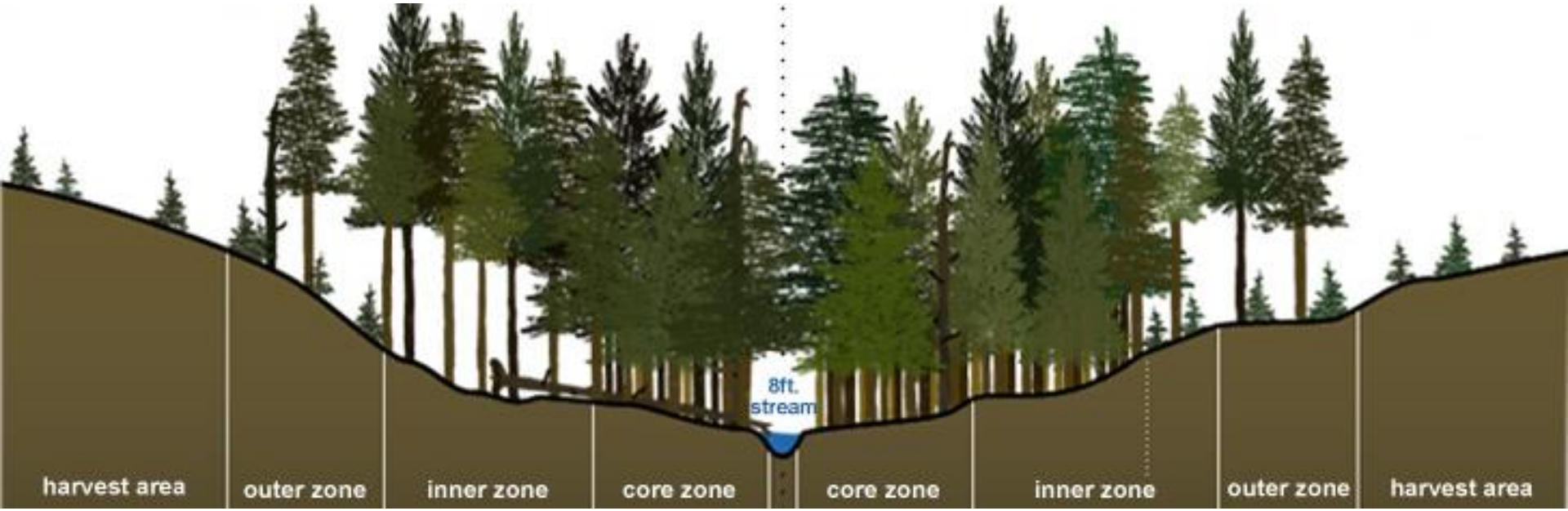
- Sediment sources from forest management include:
  - surface erosion processes (rills and sheetwash)
  - skid trails
  - yarding ruts
  - gullies
  - soil piping
  - roads
  - fire
  - mass wasting processes
  - bank erosion
  - windthrow
  - legacy forest management practices

Key Findings – Sediment

- Sediment Best Management Practices (BMPs) typically address sediment in three general ways:
  - **Source controls**
  - **Runoff Controls**
  - **Treatment Controls**

Key Findings – Sediment

- Riparian buffers are mostly effective at limiting sediment delivery



Key Findings – Sediment

- Riparian buffers are mostly effective at limiting sediment delivery

- In the absence of buffers, ground disturbances that are near streams have the potential to deliver sediment

Key Findings – Sediment

- Selective forest management within buffers does not appear to substantially increase sediment production or delivery

- The extent that riparian buffers along headwater streams are necessary to prevent sediment delivery is not clear from the reviewed literature.

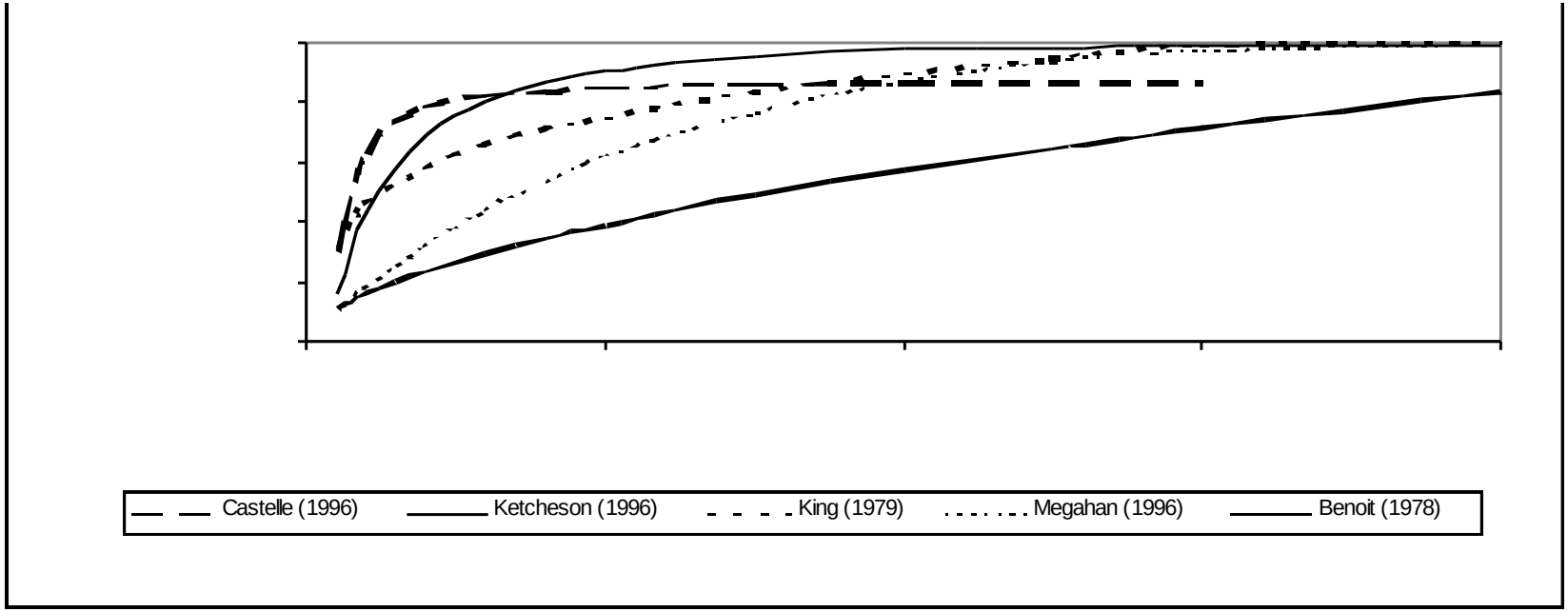
Key Findings – Sediment

- Despite the lack of evidence for direct sediment delivery, instream sediment yields tend to increase following logging

  - Sources of such sediment are not clear

Key Findings – Sediment

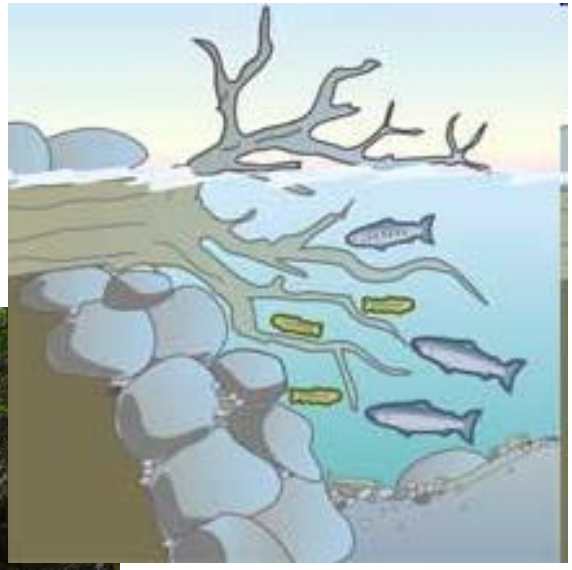
- Source distance relationships for sediment also appear to vary with the dominant processes and site conditions

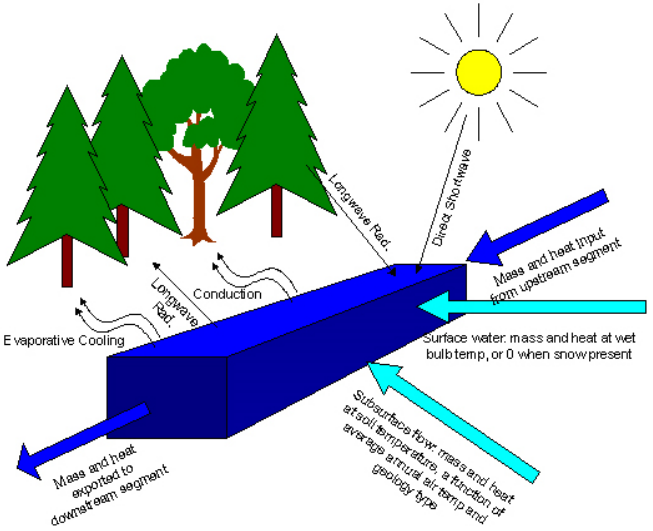


Key Findings – Sediment

- Riparian sediment management objectives include mitigating for:
  - **Harvest-Related Sediment**
  - **Hydrologic Link to Sediment Delivery**
  - **Road Sediment**
  - **Mass Wasting Impacts**

Functions

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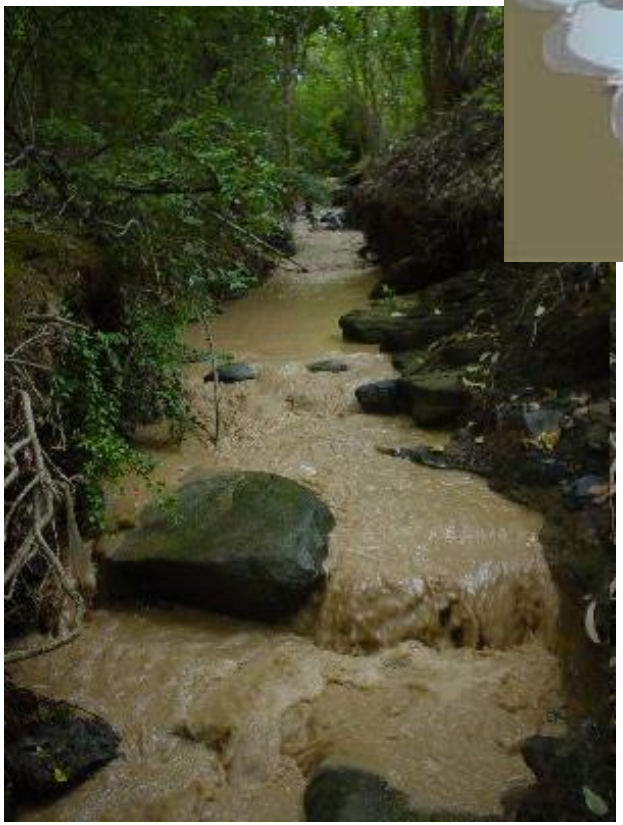

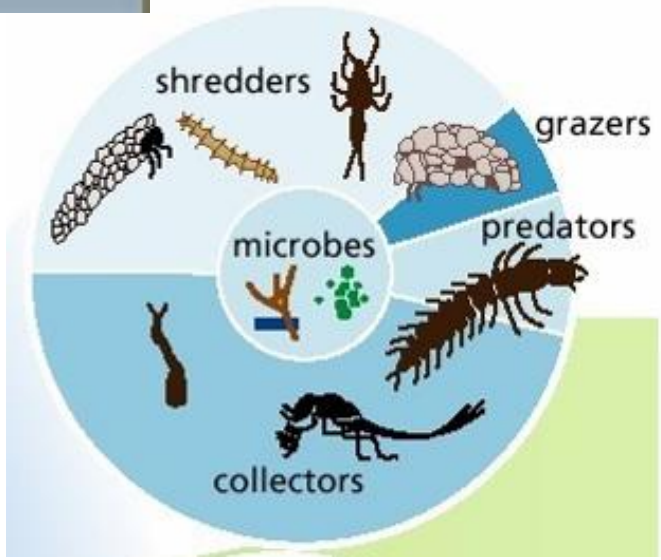
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