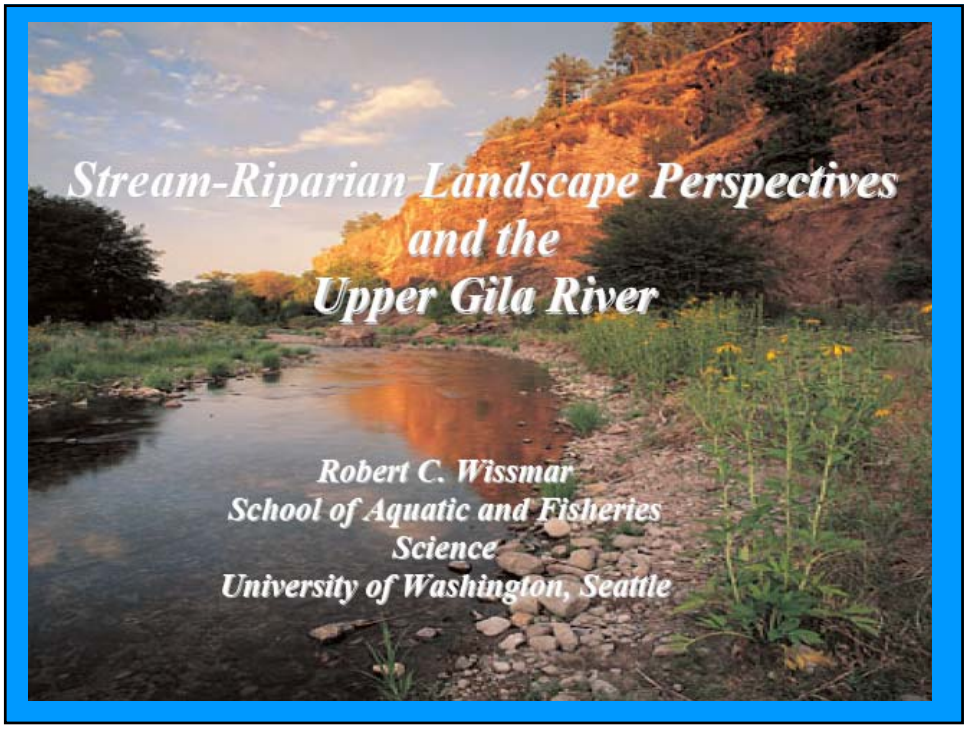
Stream-Riparian Landscape Perspectives
and the
Upper Gila River
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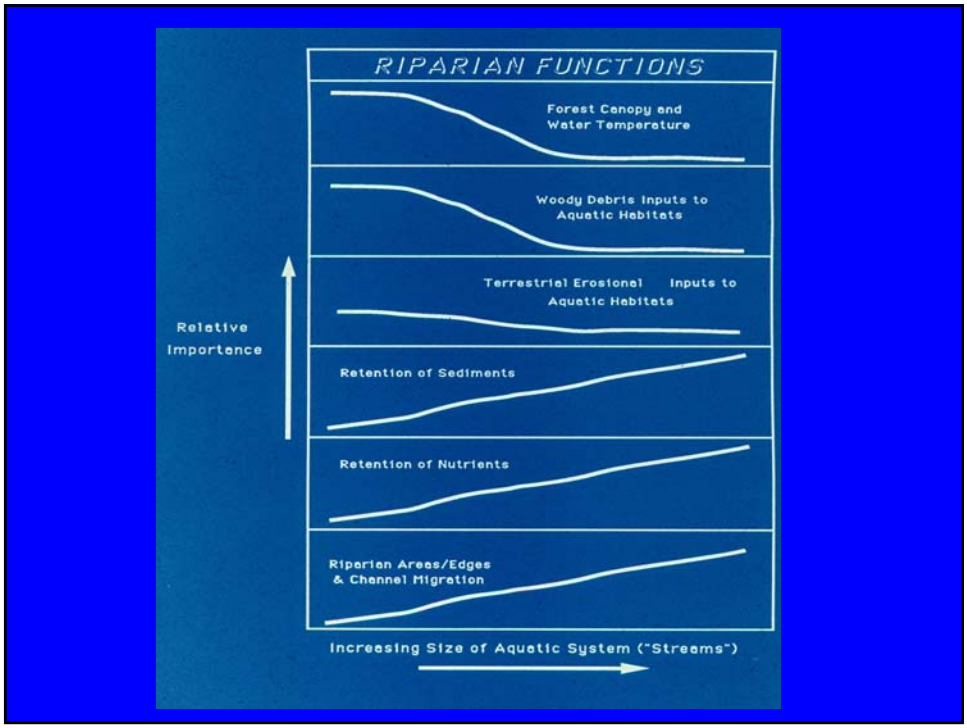
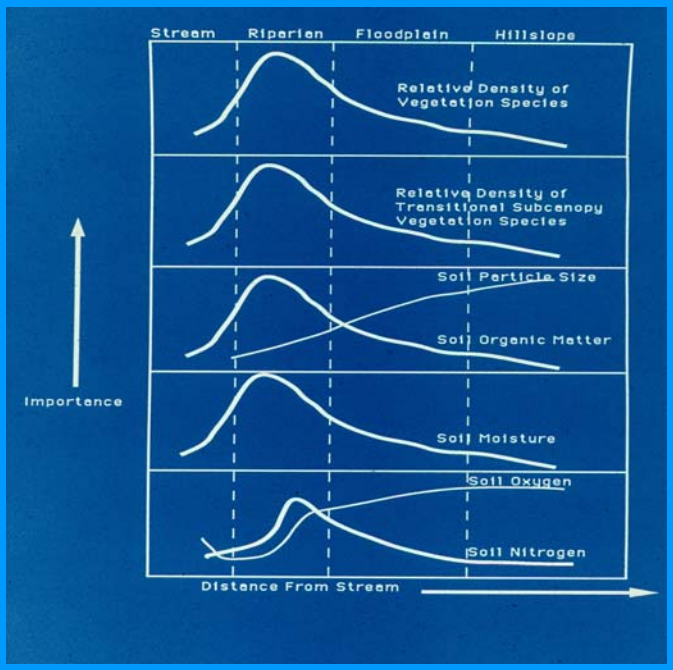
School of Aquatic and Fisheries
Science
University of Washington, Seattle


Stream-Riparian Landscape Perspectives
and the Upper Gila River
Outline
• "Natural" stream and riparian ecosystem functions
• Cumulative impacts
• Landscape, ecosystem and habitat based evaluations
– Erosion zones and riparian-stream conditions
– Assessing changes in land covers and impervious areas
– Identifying opportunities for habitat protection and restoration
– Assessing fish habitat preferences
• Developing strategies to restore and sustain ecological systems
• Management actions that promote the ecological sustainability


Flood plain
Hyporheic zone


RIPARIAN FUNCTIONS
Forest Canopy and Water Temperature
Woody Debris Inputs to Aquatic Habitats
Terrestrial Erosional Inputs to Aquatic Habitats
Relative Importance
Retention of Sediments
Retention of Nutrients
Riparian Areas/Edges & Channel Migration
Increasing Size of Aquatic System ("Streams")



Riparian Connectivity

Sustained by:

- *Interactions between terrestrial and aquatic systems*
- *Changes in riparian plant succession, biodiversity and spatial patterns*
- *Changes in animal community structures and functions in riparian corridors*
- *Influences of landscape features and disturbances (e.g., fires and floods)*

Riparian Connectivity

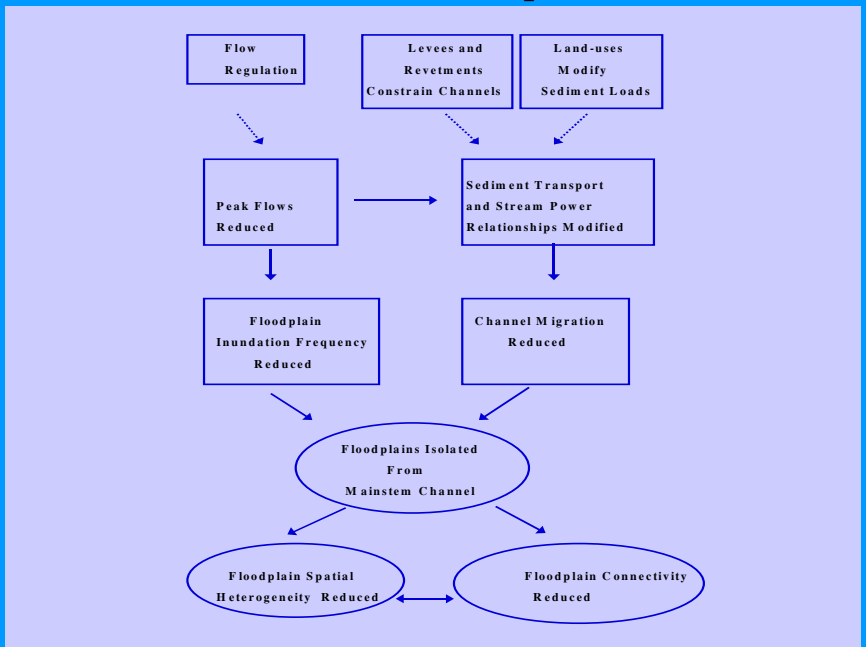
Terrestrial Factors

- *Geomorphic features (e.g., slope and aspect)*
- *Inputs of woody debris*
- *Exchanges of water (surface and subsurface) and nutrients*
- *Temperature regulation by canopy shade and exchanges of water*
- *Nutrient cycling (e.g., microbes, plants and animals)*
- *Erosion (e.g., landslides)*
- *Fires*

Aquatic Factors

- *Geomorphic features (e.g., channel width and gradient)*
- *Exchange of woody debris*
- *Exchanges of water (surface and subsurface) and nutrients*
- *Nutrient cycling (e.g., microbes, plants and animals)*
- *Erosion of channels and banks*
- *Flooding regimes*
  - *Frequency and magnitude*
  - *Inundation and storage times*

Cumulative Impacts



Landscape Disturbances that Alter Riparian and Stream Ecosystems

Natural Events

- *Fire*
- *Droughts*
- *Floods*
- *Earth quakes*

Human Induced

- *Forest (harvest, fire suppression)*
- *Agricultural (cultivation, livestock grazing)*
- *Urbanization*
- *Dams*
- *Irrigation*
- *Channel flood control*
- *Transportation (roads, railroads, canals)*
- *Recreation*

Cumulative Impacts




Responses in Altered Riparian and Stream Ecosystems

"Changes in Self-Sustaining Processes"

- *Habitat connectivity and composition*
  - *Fragmentation*
  - *Loss of live and dead wood*
  - *Channel confinement*
- *Plant and animal species diversity*
  - *Invasion by exotic species, loss of ecological diversity*
- *Sediment budget*
  - *Shifts in erosion and deposition phases*
  - *Compaction of soils*
- *Hydrology*
  - *Altered surface and subsurface flow paths*
- *Water quality*
  - *Enrichment of dissolved and particulate constituents*
- *Thermal regime*
  - *Elevated temperatures*

Hydrologic Responses

Modification of Surface and Subsurface Hydrology

- ***Decreased infiltration in soils***
- ***Increased impervious areas***
- ***Increased frequency of surface runoff events***

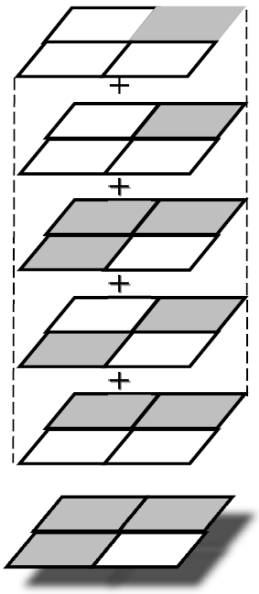
Landscape Approaches that Facilitate Self-Sustaining Natural Processes of Riparian and Aquatic Ecosystems

- *Define differences in sensitive areas within stream-riparian management corridors*
- *Prioritize habitats for protection and restoration*
  - *Intact areas needing protection*
  - *Damaged areas needing restoration*

Protection of Riparian Habitats in Erosion-prone Landscapes

- *Estimate erosion risk scores that indicate the absence and presence of different factors contributing to erosion hazards*
- *Assess the spatial distribution of erosion risks in watersheds*
- *Identify variable riparian buffer widths assigned to erosion risk scores*

"Erosion risk scores" define the absence and presence of land-cover types that could contribute to erosion- prone areas.



LAND-COVER TYPES

Rain on Snow elevations

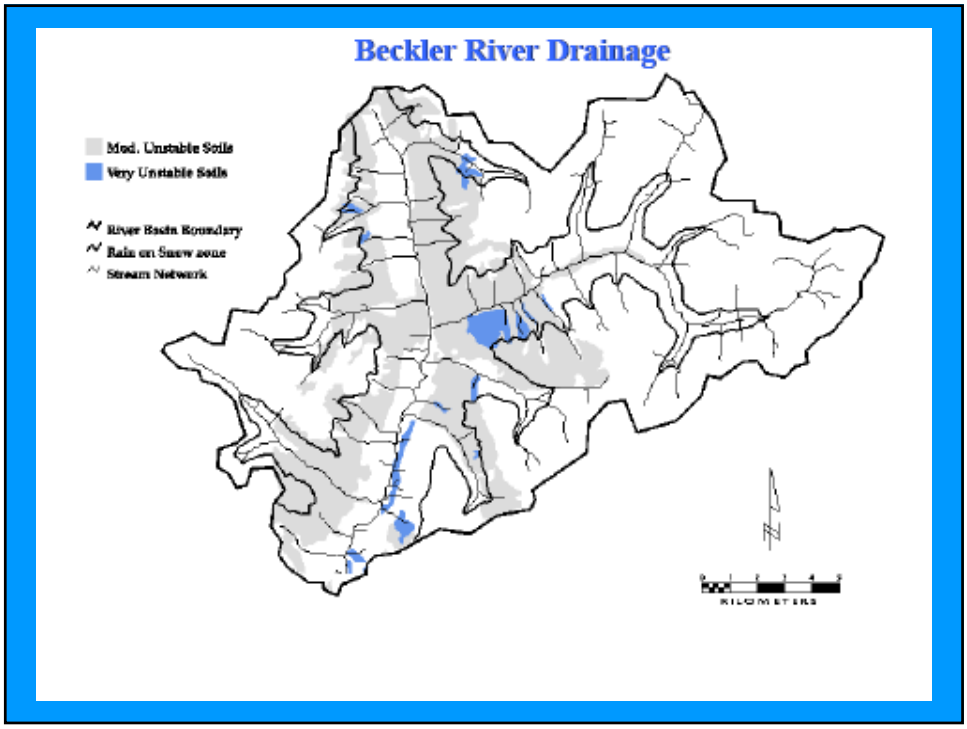
Unstable soils

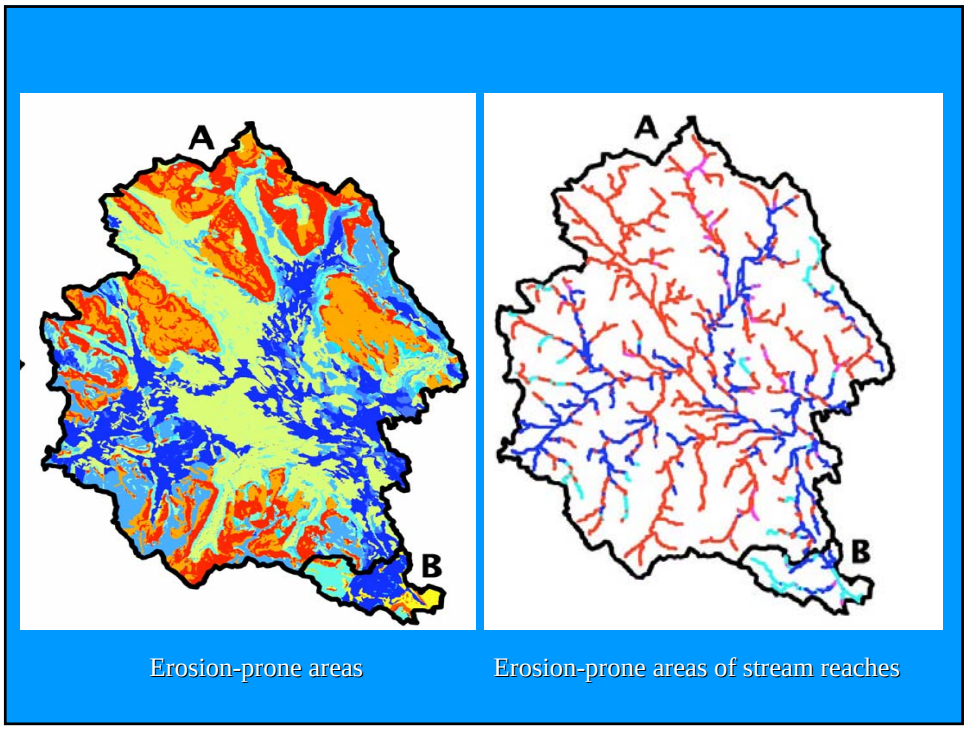
Immature forest stands

Roaded areas

Critical slopes

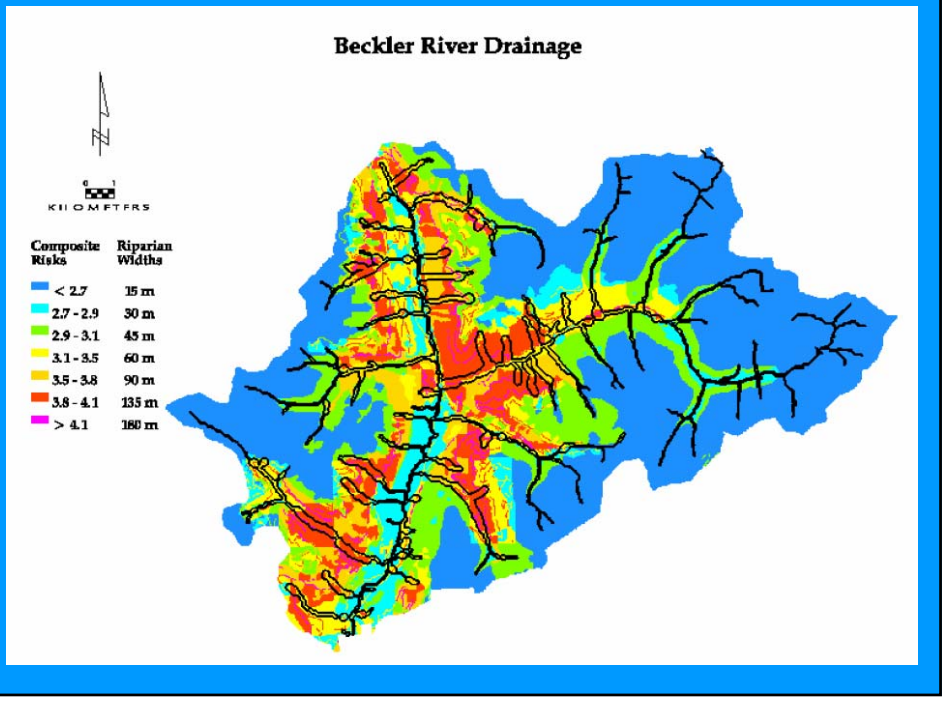
Erosion-Risk Score





Erosion-prone areas

Erosion-prone areas of stream reaches

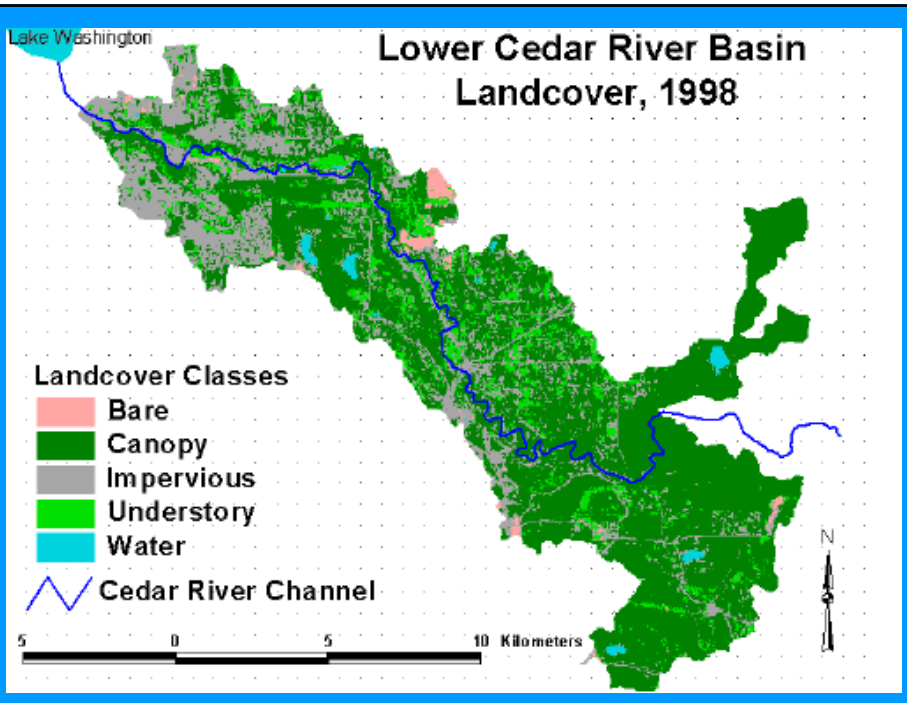


Applications: Facilitate self-sustaining natural processes of stream and riparian ecosystems

- *Define differences in sensitive areas within riparian-stream management corridors*
  - *Intact areas needing protection*
  - *Damaged areas needing restoration*
- *Determine actions that sustain the connectivity of different vegetative cover types and aquatic habitats*
  - *Link areas of passive protection and active restoration*
  - *Provide networks of refuge habitats that protect fish and wildlife and facilitate movements.*

Changes in Land-Cover and Hydrology

- *Evaluate changes in land covers (GIS coverages) in different tributary watersheds (urban and rural)*
- *Use fine-resolution spatial hydrological model to evaluate influences of land covers on changes in stream discharge in different tributary watersheds*
- *Evaluation periods*
  - *Historical ("full forest cover")*
  - *1991 ("developed")*
  - *1998 ("developed")*



Percent change in forest cover, impervious surfaces and annual flood discharges within urban and rural watersheds of the lower Cedar River, WA

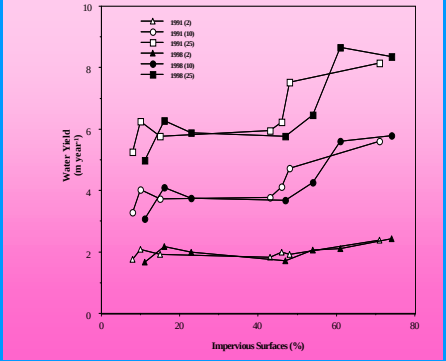
	Land-covers				Annual flood discharge*	
	Historical to 1991		1991 to 1998		Historical to 1991	1991 to 1998
Watershed	Forest (Δ%)	Impervious (Δ%)	Forest (Δ%)	Impervious (Δ%)	Discharge (Δ%)	
Ginger ø	-83	71	18	4	169	4
Maplewood ø	-63	48	-24	27	96	17
Fairwood ø	-63	46	-3	17	84	3
Madsen ø	-63	43	19	9	68	-2
Peterson	-34	15	11	53	16	2
Taylor	-28	10	-4	60	21	1
Rock	-29	8	14	38	7	-5

** Flood discharges are based on the 10-year recurrence interval.*

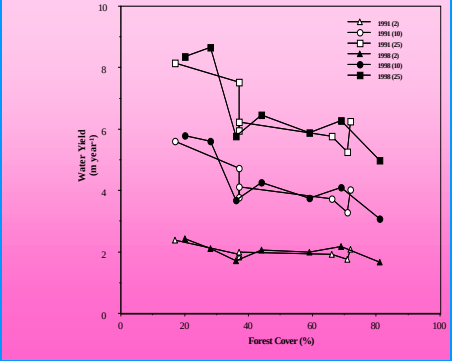
ø Urban watersheds

Change in forest cover, impervious surfaces and water yields within urban and rural watersheds of the lower Cedar River, WA.

1991 to 1998



impervious surfaces

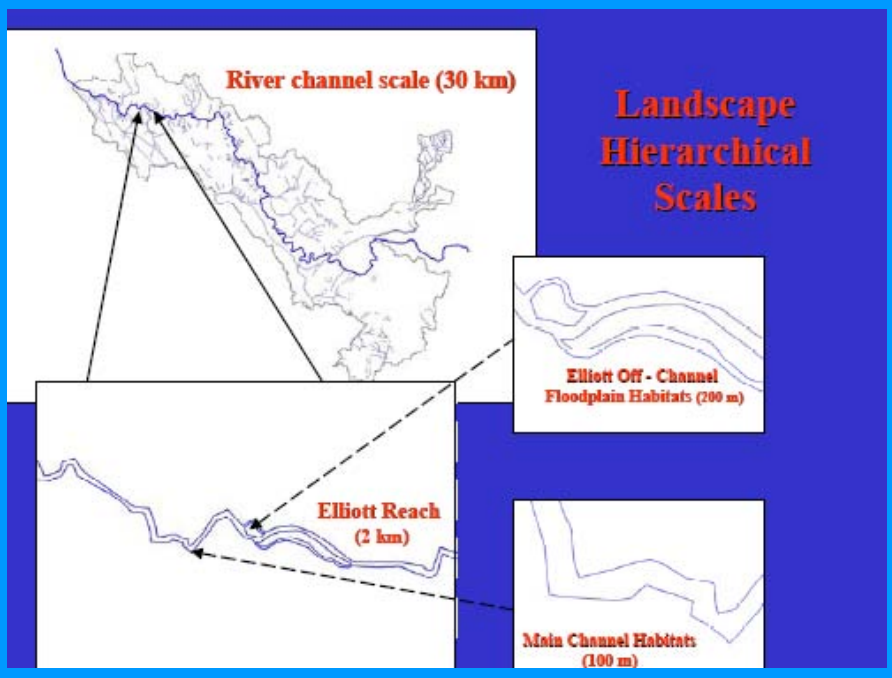


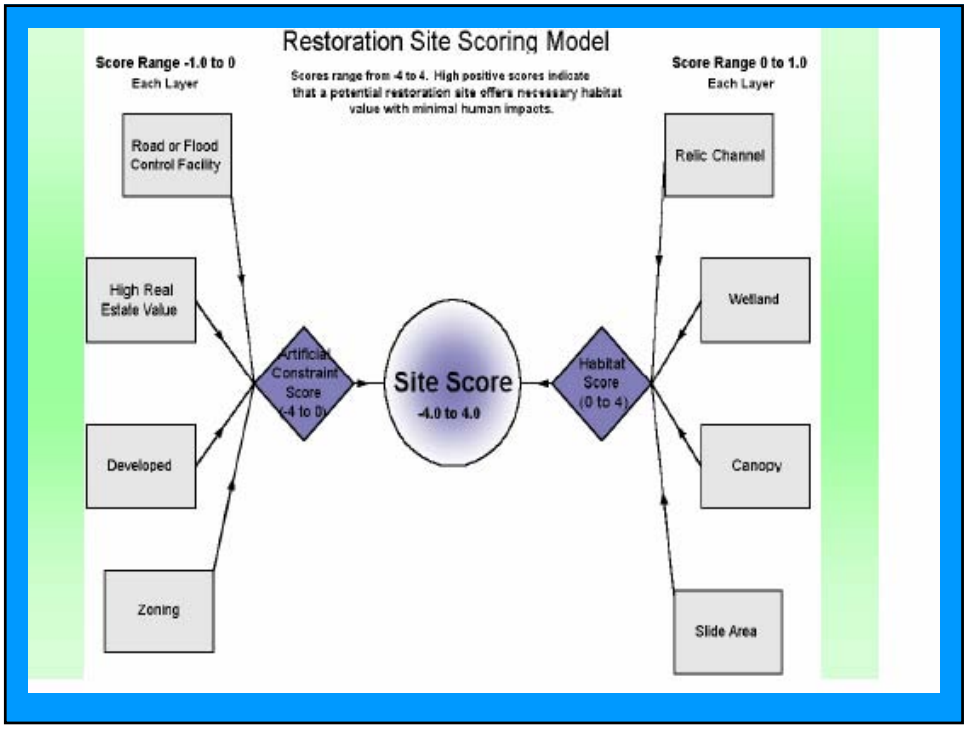
forest cover

Identifying opportunities for habitat Protection and Restoration

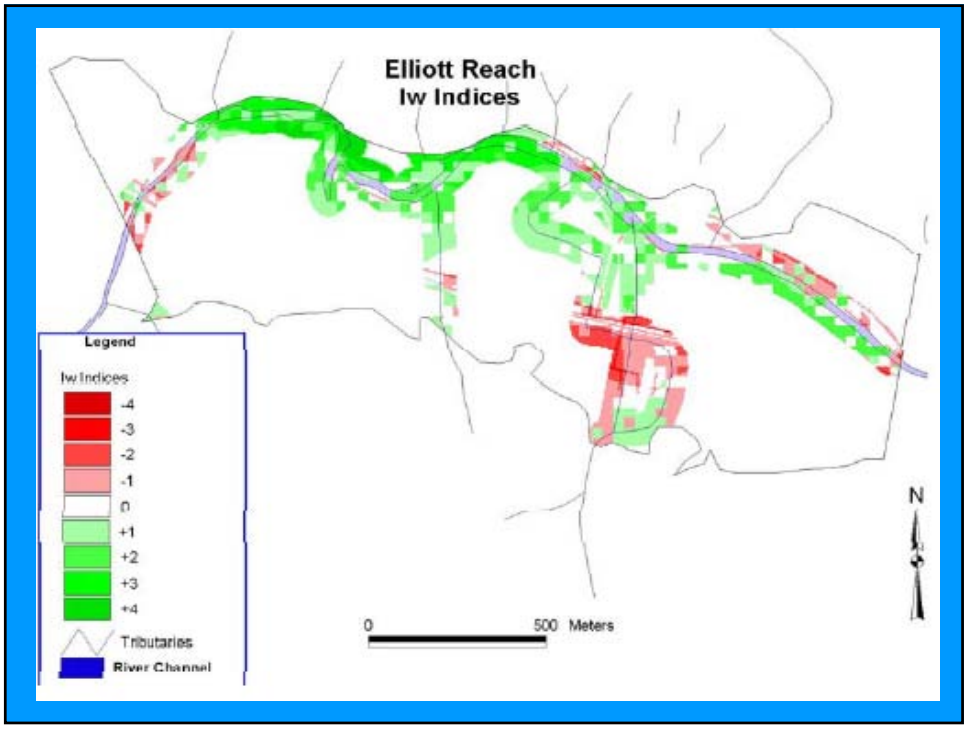
- *Can co-occurring, ecologically functional and anthropogenic land-covers be used to identify opportunities for habitat restoration within the floodplain?*

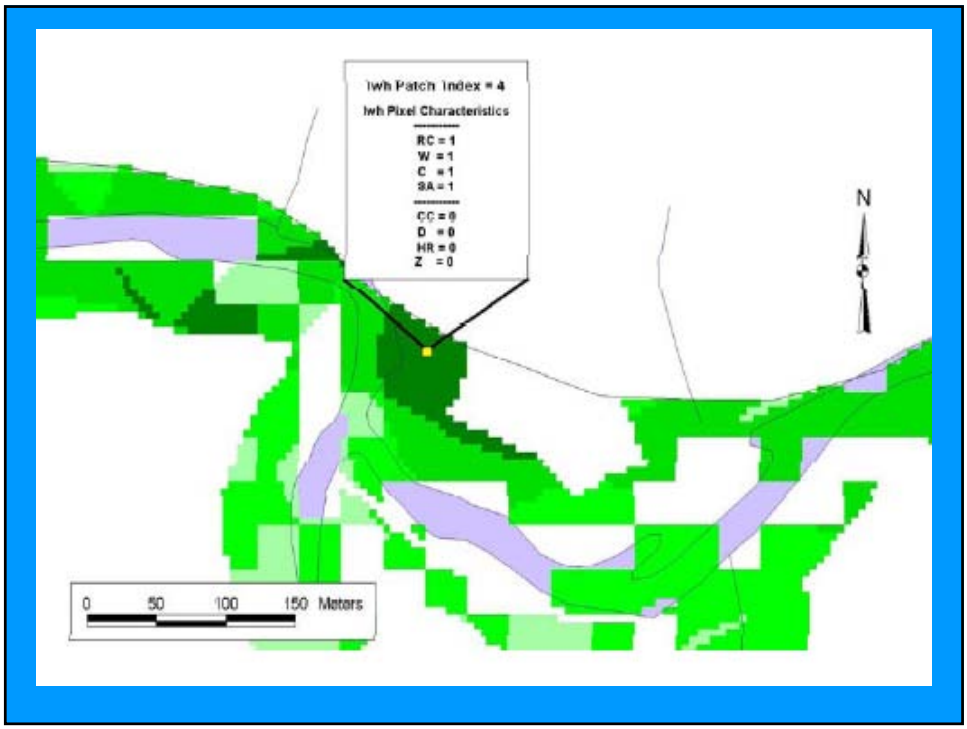
- *Can indices of patch characteristics of different land- covers be used at different landscape scales?*




Restoration Site Scoring Model
Score Range -1.0 to 0
Each Layer
Scores range from -4 to 4. High positive scores indicate that a potential restoration site offers necessary habitat value with minimal human impacts.
Score Range 0 to 1.0
Each Layer
Road or Flood Control Facility
High Real Estate Value
Developed
Zoning
Artificial Constraint Score (-4 to 0)
Site Score
-4.0 to 4.0
Habitat Score (0 to 4)
Relic Channel
Wetland
Canopy
Slide Area


2 28 2001


Elliott Reach
Iw Indices
Legend
Iw Indices
-4
-3
-2
-1
0
+1
+2
+3
+4
Tributaries
River Channel
0
500 Meters
N


Iwh Patch Index = 4
Iwh Pixel Characteristics
RC = 1
W = 1
C = 1
SA = 1
CC = 0
D = 0
HR = 0
Z = 0
N
0
50
100
150 Meters

Landscape procedures allow managers to:

- *use existing information to address problems common to spatially complex stream and riparian corridors*
- *define stream reaches and habitats requiring protection by variable riparian buffer widths*
- *use simple constructs for patterns and sizes of patch indices (ecological and anthropogenic factors) to identify opportunities for habitat restoration and protection*

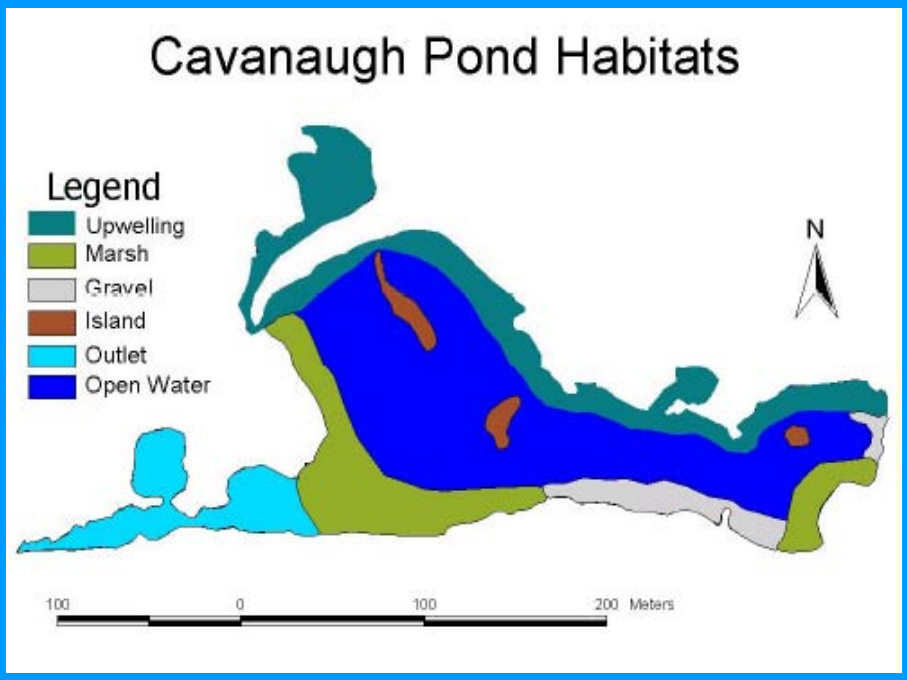
Sockeye Salmon Habitat Selection in Off-Channel Habitats

Habitat selection by salmonids

- *What habitat factors do spawning salmon prefer?*
- *What habitat factors do juvenile salmon prefer?*

Implications for habitat management

- *Can we incorporate fish habitat preferences into protection and restoration plans?*



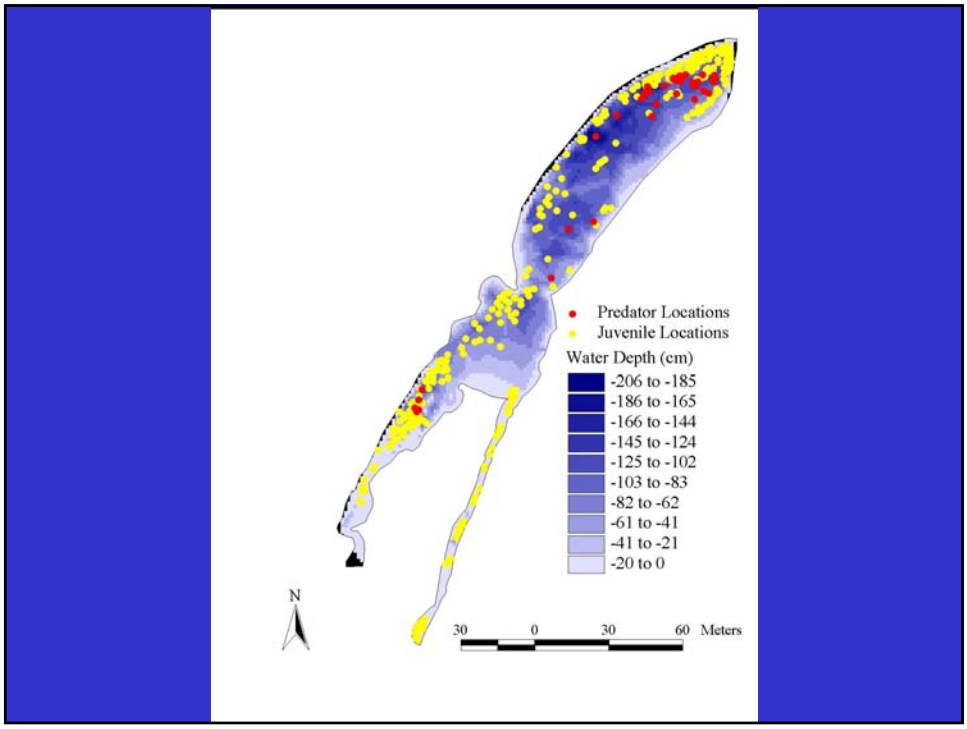
Spawning sockeye use of off-channel habitats. Conclusions

	W79	*CAV*
Areas with high amounts of detritus were not used	✓	
Upwelling areas were highly selected	✓	✓
Redd depths were within expected ranges	✓	✓
Fish chose areas with gravel and cobble substrates	✓	✓
Temperatures were within suitable spawning and incubation ranges	✓	✓
When many sockeye were present, the range of habitat types used expanded:		
-Substrate	✓	✓
-Detritus depth	✓	
-Depth		✓
There was substantial use of the newly constructed side-channel habitats	✓	

W79 = Wetland 79, CAV = Cavanaugh Pond

Juvenile salmon use of off-channel habitats. Conclusions

- **Juvenile habitat use influenced by the threat of predation**
  - **-moved to deeper areas to avoid predation from birds**
  - **-formed larger schools as protection from aquatic predators**
  - **-majority of fish used cover**
  - **-preferred complex woody debris**
- ***Fish avoided warmer temperatures and low dissolved oxygen levels***
- ***Juvenile fish did not select for other habitat factors***


Predator Locations
Juvenile Locations
Water Depth (cm)
-206 to -185
-186 to -165
-166 to -144
-145 to -124
-125 to -102
-103 to -83
-82 to -62
-61 to -41
-41 to -21
-20 to 0
N
30 0 30 60 Meters

Habitat Rehabilitation Considerations

- *Define habitat limiting factors.*
  - *Damage to riparian plants and soils*
  - *Lack of wood and habitats in channels*
  - *Lack of hydrologic connectivity*
- *Define at landscape scales (km^2) sensitive areas within river and riparian management corridors.*
- *Develop strategies that prioritize intact and damaged habitats needing protection and restoration*
- *Determine actions that sustain and restore the connectivity of different vegetative cover types and aquatic habitats*
  - *Link areas of passive protection and active restoration*
  - *Provide networks of refuge habitats that protect fish and wildlife and facilitate movements.*

Developing Strategies to Restore and Sustain Riparian and Fish Habitats

- *Define objectives of restoration projects and desired future conditions.*
- *Use retrospective analyses to define natural and unnatural disturbance regimes (flood frequencies, fires, land-uses).*
- *Identify modified areas (dams, water diversions, roads, agricultural, urban).*
- *Identify high risk areas (landslides, unstable soils, steep slopes, unstable channels).*
- *Summarize stream flow characteristics for channel reaches near restoration sites (flooding regimes, low flow periods).*

Retrospective Analyses

Cumulative impacts in riparian-stream areas:
Little Naches River, WA

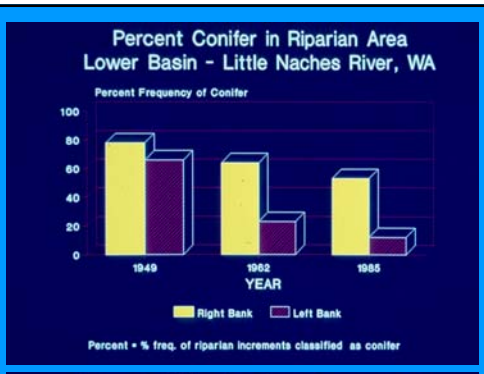
Causes

- *Confinement of the river channel*
  - *– road construction*
  - *– riprap for control of bank erosion*
- *Timber harvest*
- *Increased recreational use*
- *Legacy of poor grazing management*

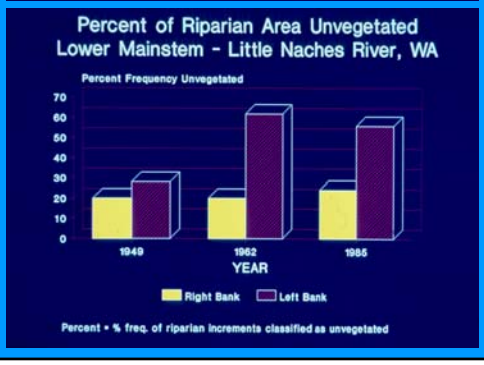
Responses

- *Down cutting (erosion) or incision in channels*
- *Fragmentation of forest communities*
- *Low recruitment of woody debris to channels*
- *Creation of un-vegetated lands*
  - *– Invasion of noxious weeds*
  - *– Compaction of soils*
- *Modification of surface and subsurface hydrology*

Conifers Lost

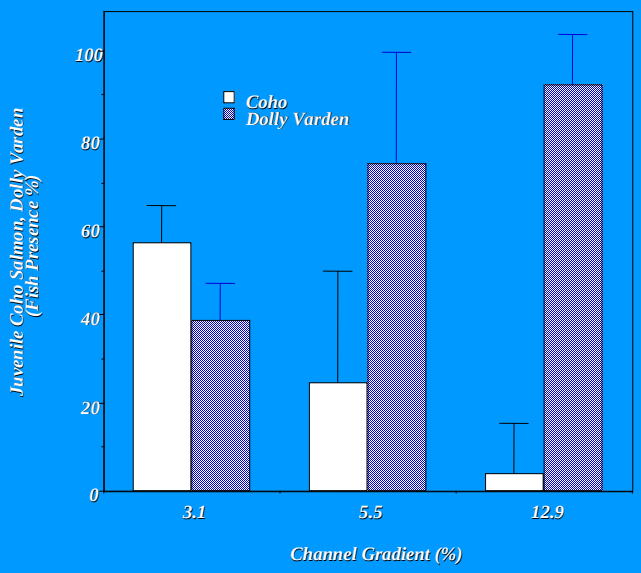


Bare Areas Increase



Developing Strategies to Restore and Sustain Riparian and Fish Habitats

- *Survey reaches, riparian - aquatic habitats, and reference systems (plan views, channel profiles, channel cross sections)*
- *Compare fish densities, habitats, and distributions to historic (spawning adults, juvenile densities, habitat distributions)*
- *Summarize fishes preferred habitat and instream flow needs. (discharge, velocity, substrate, temp., refuge from predators)*
- *Identify conditions indicating recovery*



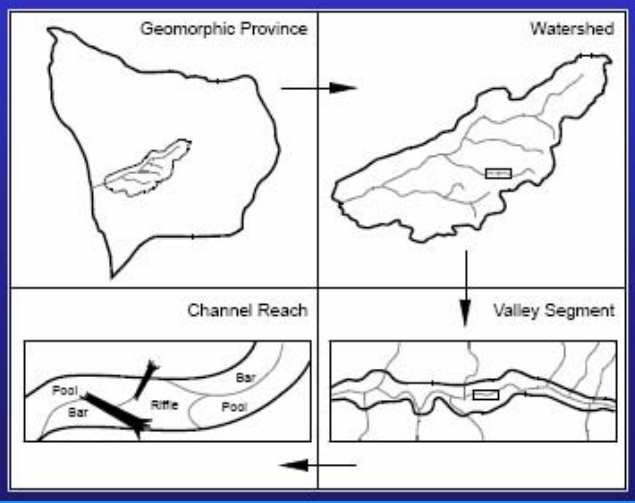
What Conditions Indicate Recovery in Riparian and Stream Habitat Ecosystems?

- *Plants and roots protect and stabilize banks*
- *Canopy cover improves shading*
- *Elevated saturated zone increases storage of water*
- *Increased summer flow*
- *Cooler water in summer*
- *Reduced ice effects in winter*
- *Improved habitats for plants, fish and wildlife*

Developing Strategies to Restore and Sustain Riparian and Fish Habitats

- *Establish monitoring sites to assess implementation and management.*
- *Use monitoring data to evaluate if objectives are being achieved.*
- *Use adaptive management to maintain and improve restoration projects.*

Facilitate a basin-wide hierarchical monitoring program



Management actions that promote the sustainability of watershed and stream systems

Actions	***References***
Increase connectivity between stream and riparian ecosystems and habitats	*Bednarek 2001; Pitlick and Wilcock 2001; Richards, et al. 2002; Amoros and Bornette 2002*
Sustain habitat functions, aquatic and riparian species diversity and distributions	*Hankin and Reeves 1988; Jones et al. 1999; Dunham et al. 2001*
Reduce bare ground, compacted and eroded soils, density of grazing livestock	*Grant 1988; Smith 1993; Kauffman et al. 2000; Wissmar et al. 2004*

Rehabilitate Off-Channel Habitats

Management actions that promote the sustainability of watershed and stream systems

Actions	*References*
Re-establish riparian habitat functions and plants (protect, restore and maintain connectivity, heterogeneity, species composition)	*Harris and Olson 1997; Russell et al. 1997; Timm et al. 2004; Lindenmayer et al. 2000*
Decrease widths of riparian canopy openings (m), increase shade (low light intensity)	*Grant, 1988; Smith, 1993; MacDonald et al. 1991*
Develop strategies for applying variable riparian buffer widths	*Wissmar et al. 2004*
Increase riparian habitats for wildlife species (connectivity of habitats, species composition, food webs)	*Polis et al. 1997; Sisk et al. 1997; Sieving et al. 2000; Johnson 2002*

Management actions that promote the sustainability of watershed and stream systems

Actions	*References*
Maintain "normal" water tables, elemental cycles temperature regimes	*Gurnell 1995; Olson 1995; Dwire et al. 2000; Olson and Wissmar 2000*
Maintain aquatic food webs (forage, species)	*Tait et al. 1994; Bunn et al. 2003*
Maintain "normal" thermal regimes and cold water refuge habitats	*Berman and Quinn, 1991; Ebersole et al. 2001*
Maintain "normal" peak flow frequency (years) to re-establish channel and riparian habitats	*Scott et al. 1997; Galat et al. 1998; Chapin et al. 2000; Kauffmann et al. 2000; Richter and Richter 2000, Sommer et al. 2001*

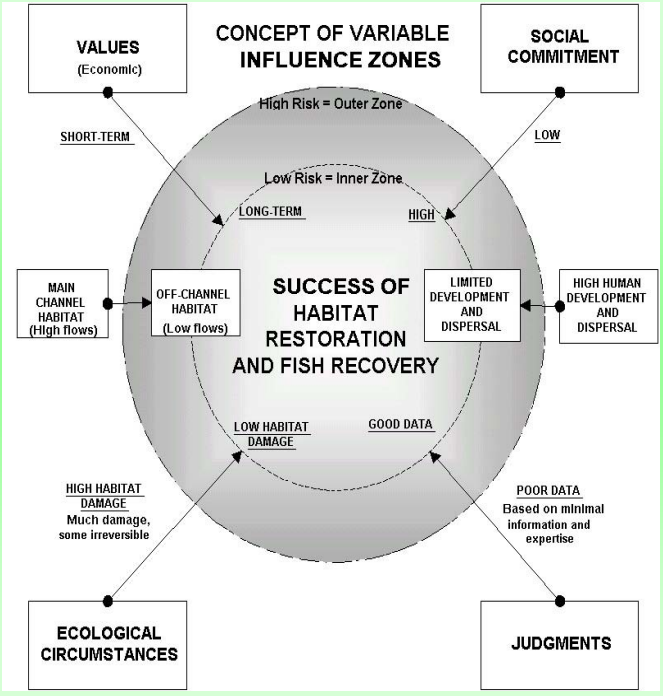
"Peak flows and large woody debris interact to form pool habitats"

"Normal peak flow frequency and habitats"

Management actions that promote the sustainability of watershed and stream systems

Actions	*References*
Increase recruitment of woody debris in riparian and stream ecosystems (number, size)	*Gregory et al. 2003*
Re-establish erosion resistant plants (species)	*Elmore and Beschta 1987*
Reduce exotic species (number, species)	*Jacobs 1999; Sher et al. 2000*

Reduce exotic species (number, species)




Acknowledgements
•U.S. EPA Grant # R827149-01-0
•King County
•City of Renton
•City of Seattle
•U.S. Forest Service
•U.S. Army Corps of Engineers
•Washington Dept. of Fish & Wildlife