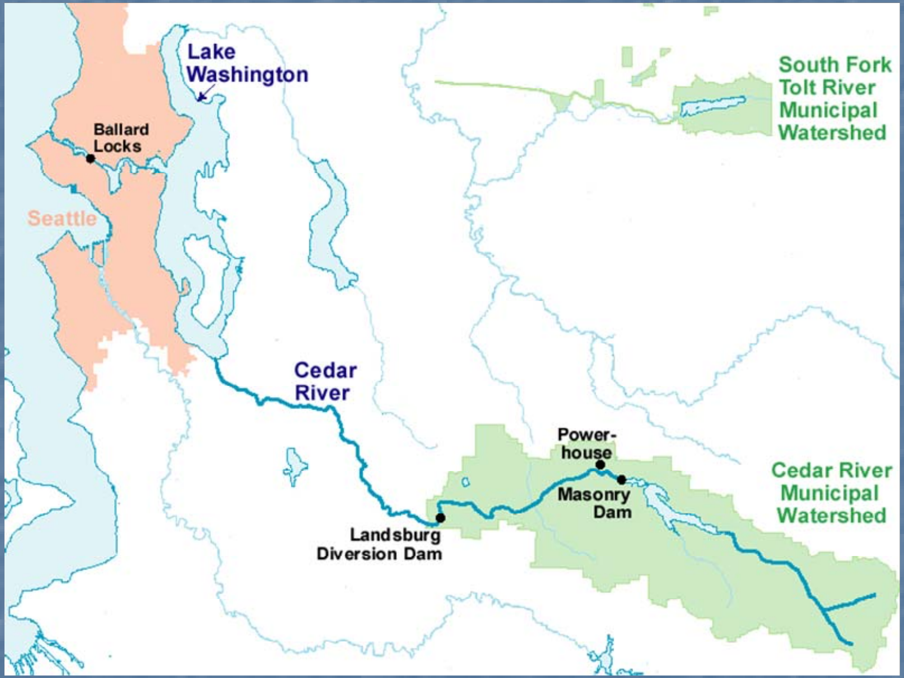
Challenges applying science to management and restoration in the Cedar River Municipal Watershed



Co-conspirator: Dave Beedle

Seattle Public Utilities
Watershed Management Division

Outline

- Present three challenges
- Current understanding
- Approaches
- Available tools, models and information needs
- Unknowns and on-going challenges

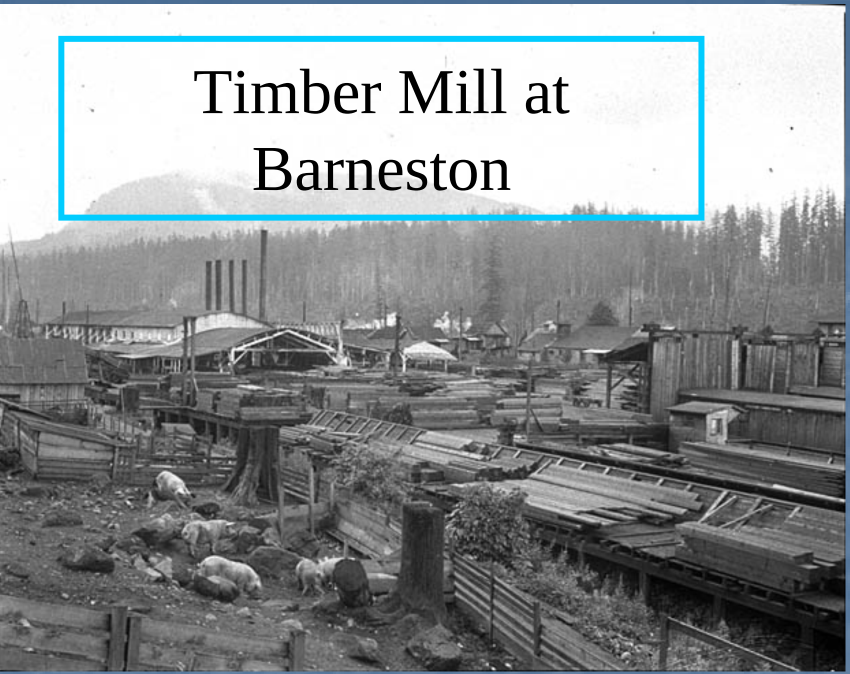
Interesting and challenging projects

- Road management: Quantifying road-generated surface erosion
- Assessing the Risk to the Landsburg Facility by Large Woody Debris
- Long term stream monitoring

Cedar River Municipal Watershed

- **92,000 acres**
- **550-5,500 ft elevation**
- **Owned by SPU**
- **Closed to uncontrolled public access**
- **Municipal water supply for 1.3 million people**
- **Hydroelectricity**
- **Long history of human use**

Historic Landuse



Timber Mill at Barneston

Logging Around Reservoir, Circa 1930

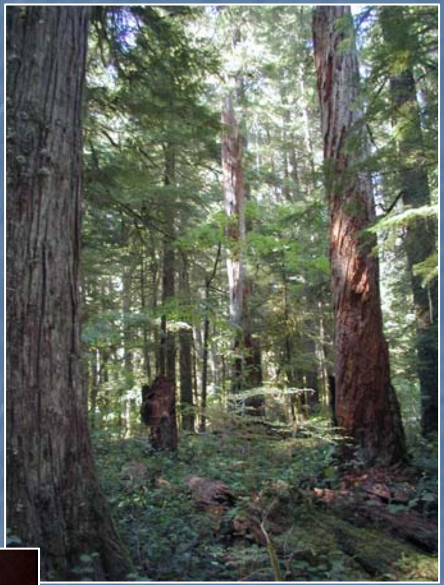
Habitat Conservation Plan (HCP): Agreement to conserve and restore CRMW while ensuring water supply

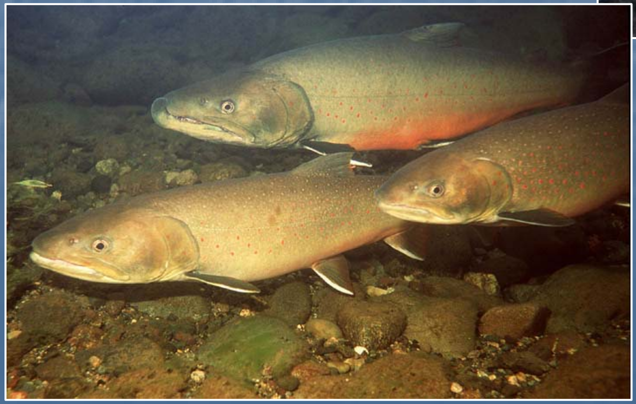
Relevant elements

- Long-term protection of CRMW
- Landsburg Dam mitigation (fish passage)
- Instream flow management

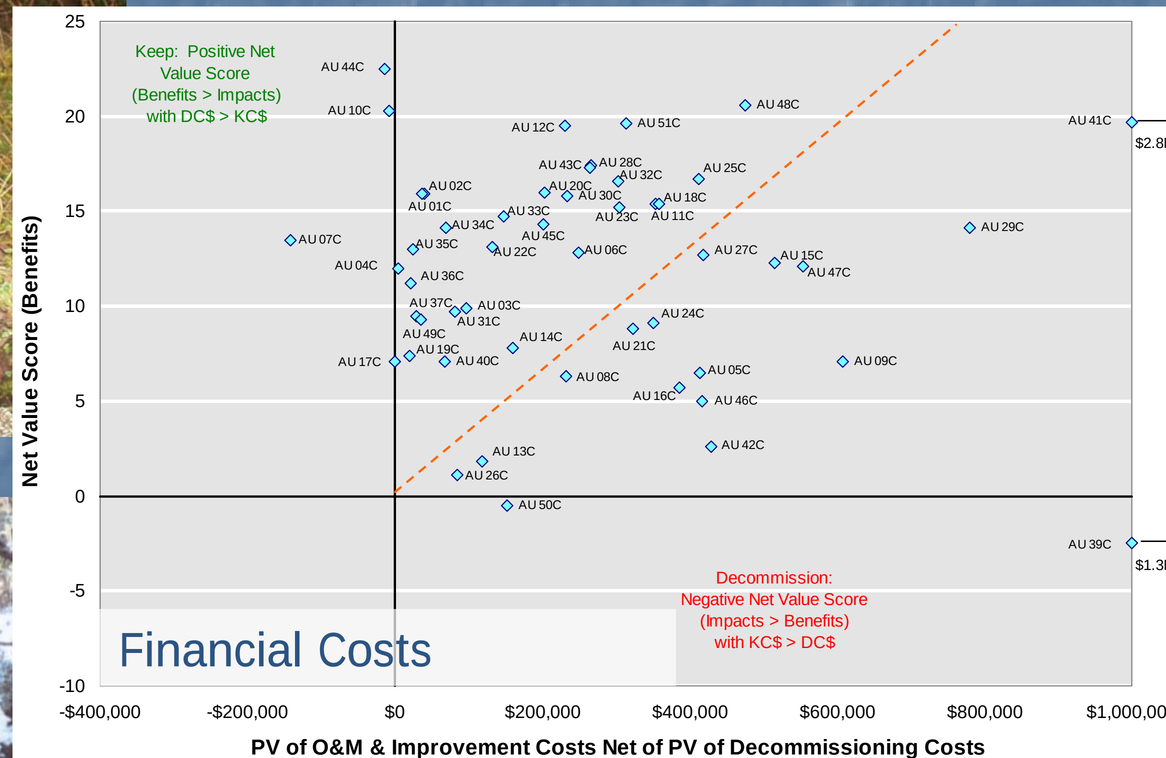
Key Resources in the Cedar River Watershed

- Clean water
- Old Growth Habitat
- Listed species:
  - Chinook salmon
  - Bull trout
  - Northern spotted owl
  - Marbled murrelet
  - Steelhead trout



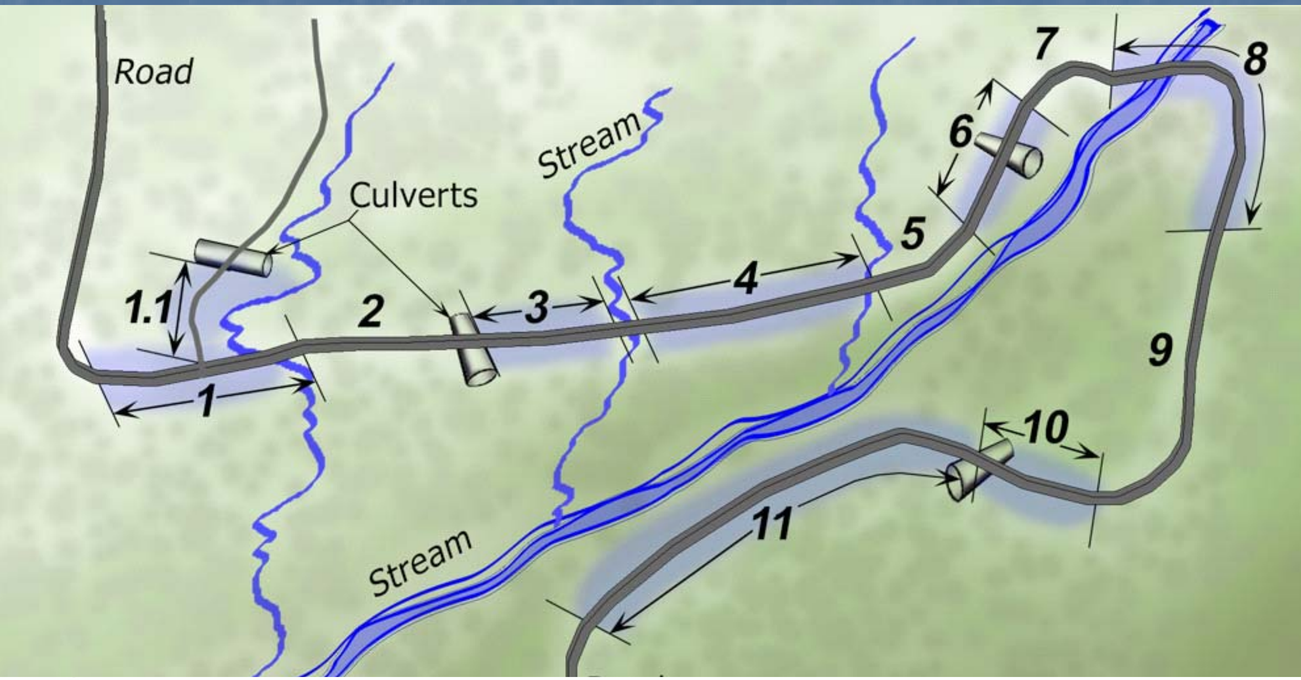


Road Management Concerns…



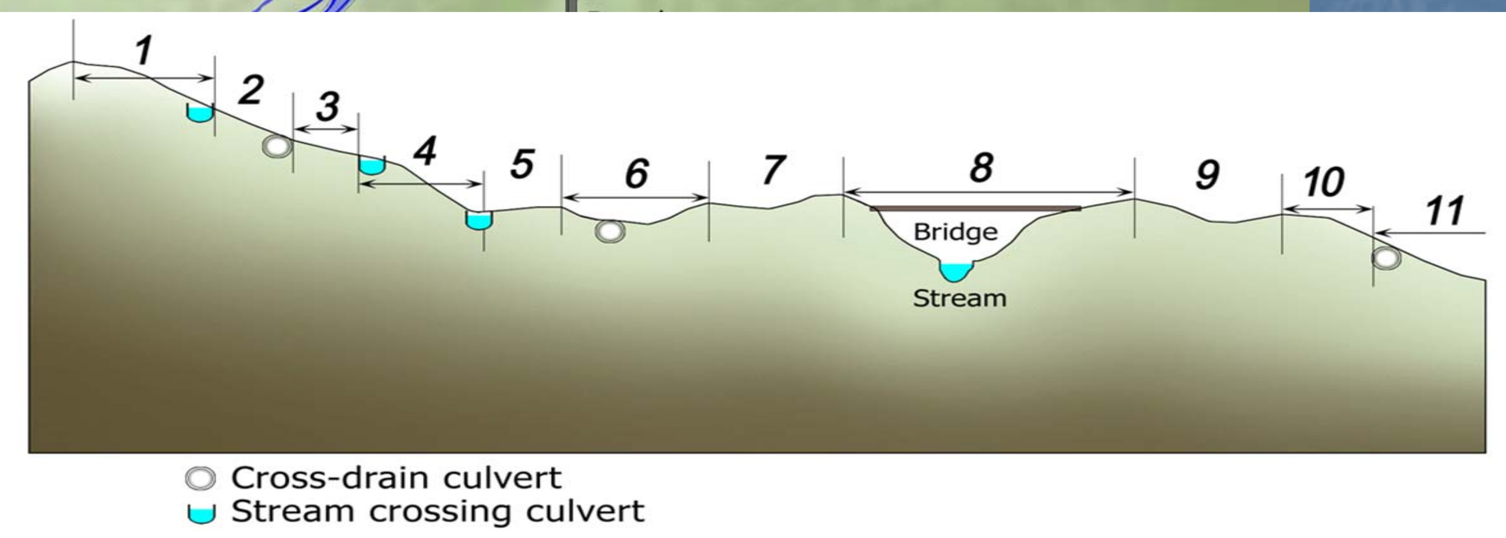
It all starts with the **Road Inventory…**

completed in 2004 and updated annually

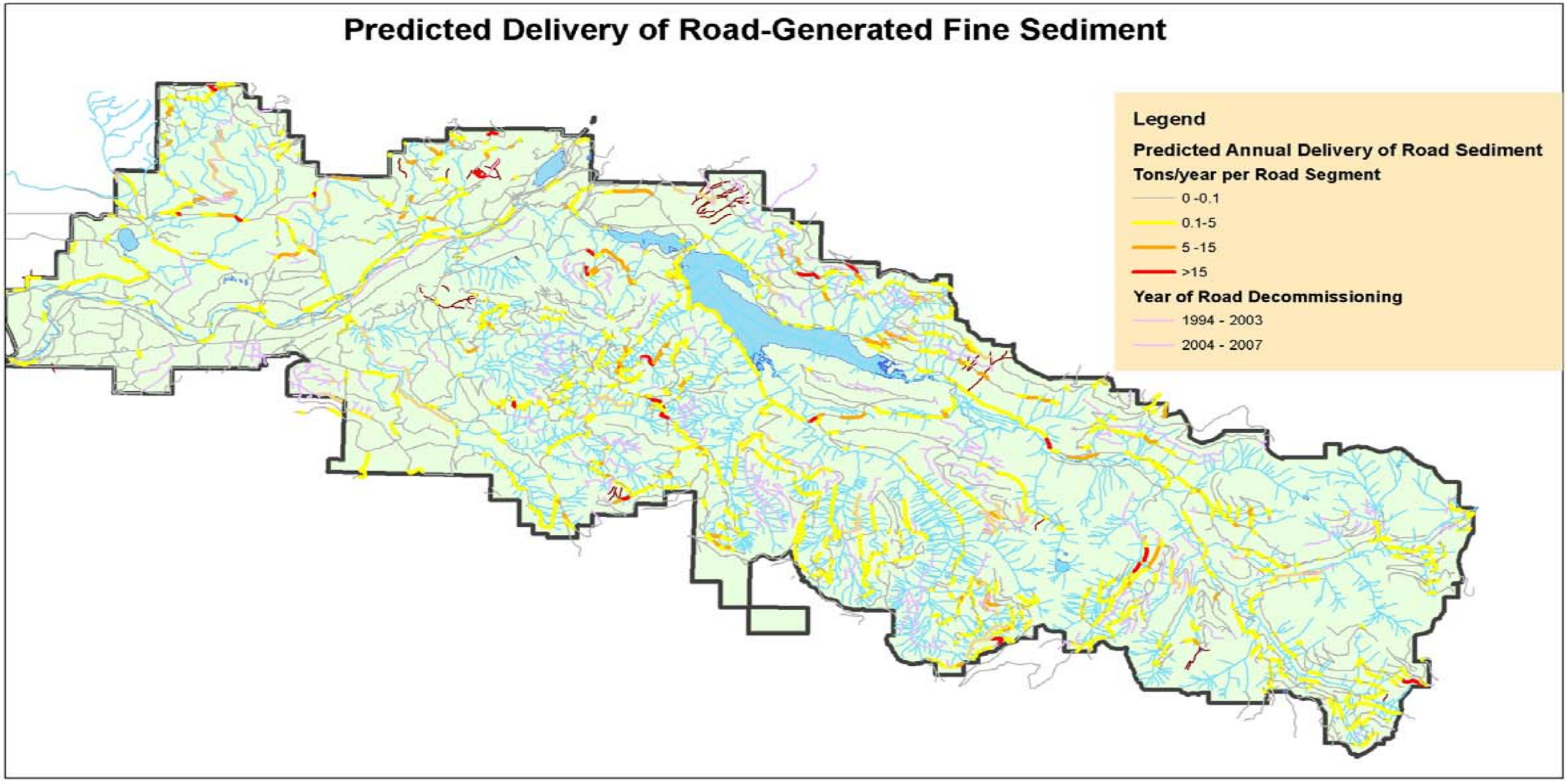


Key Attributes:

- Identification of segments
- Delivery
- Surfacing
- Road configuration

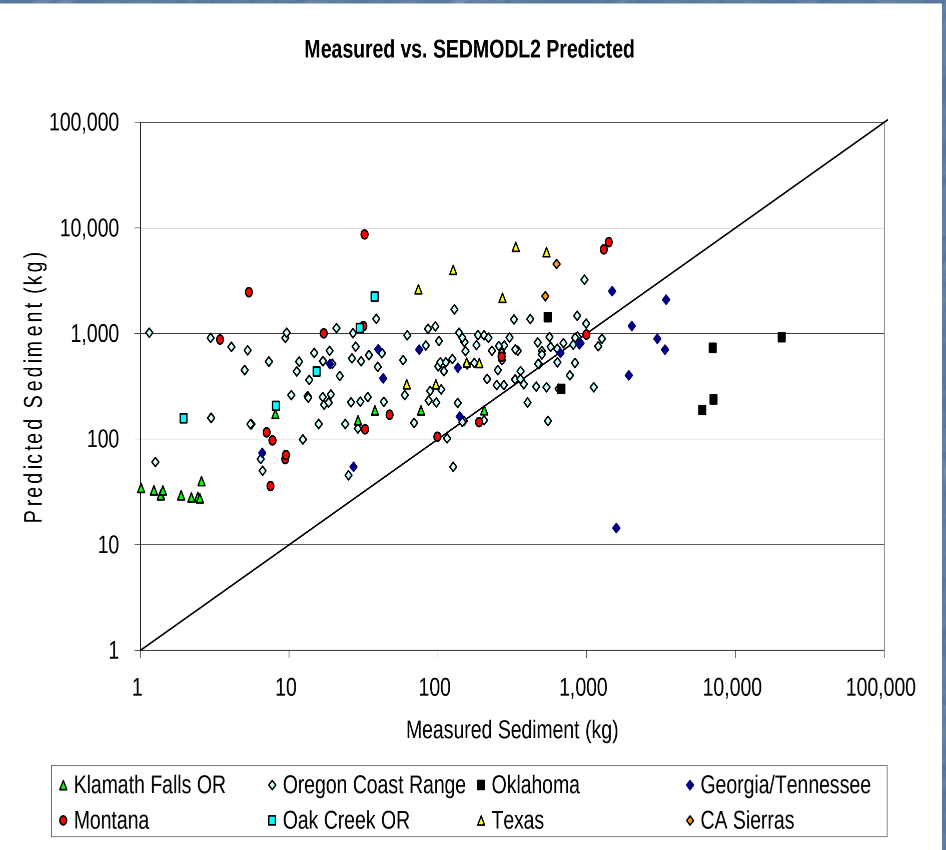


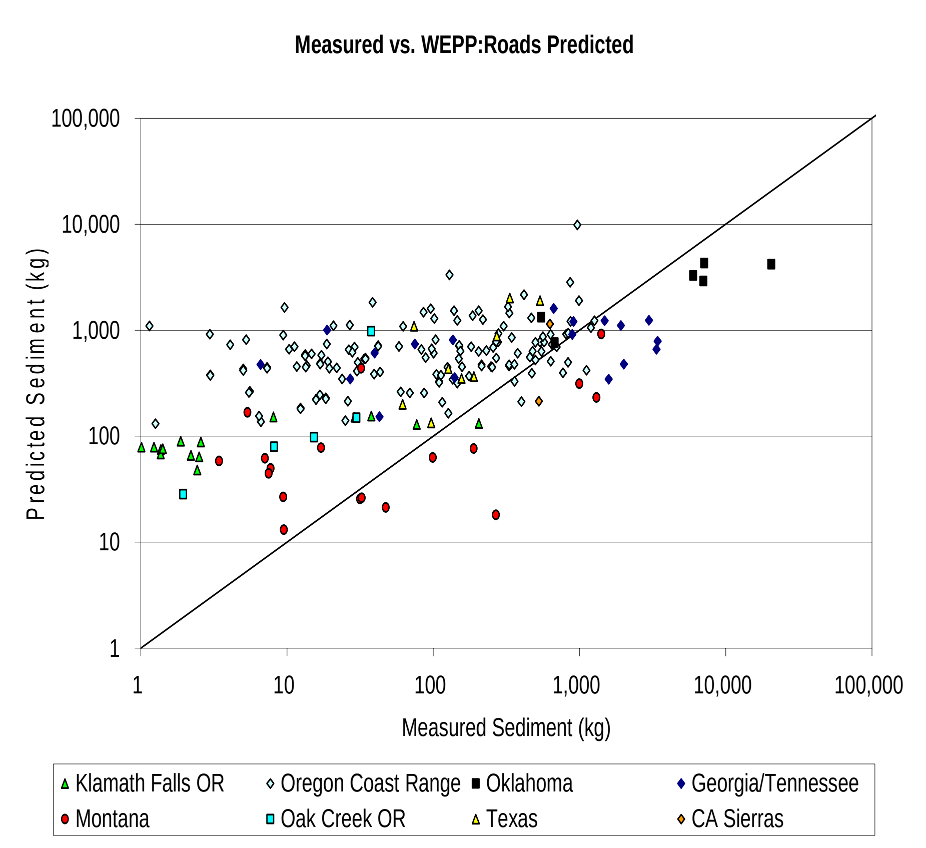
Washington Road Surface Erosion Method (WARSEM) Results



Question 1: How accurate are road erosion estimates?

Measured vs. Predicted Average Annual Sediment Yield





Dubé K., T. Black, C. Luce, and M. Riedel, In Press. Comparison of Road Surface Erosion Models with Measured Road Surface Erosion Rates. Report prepared for National Council for Air and Stream Improvement (NCASI).

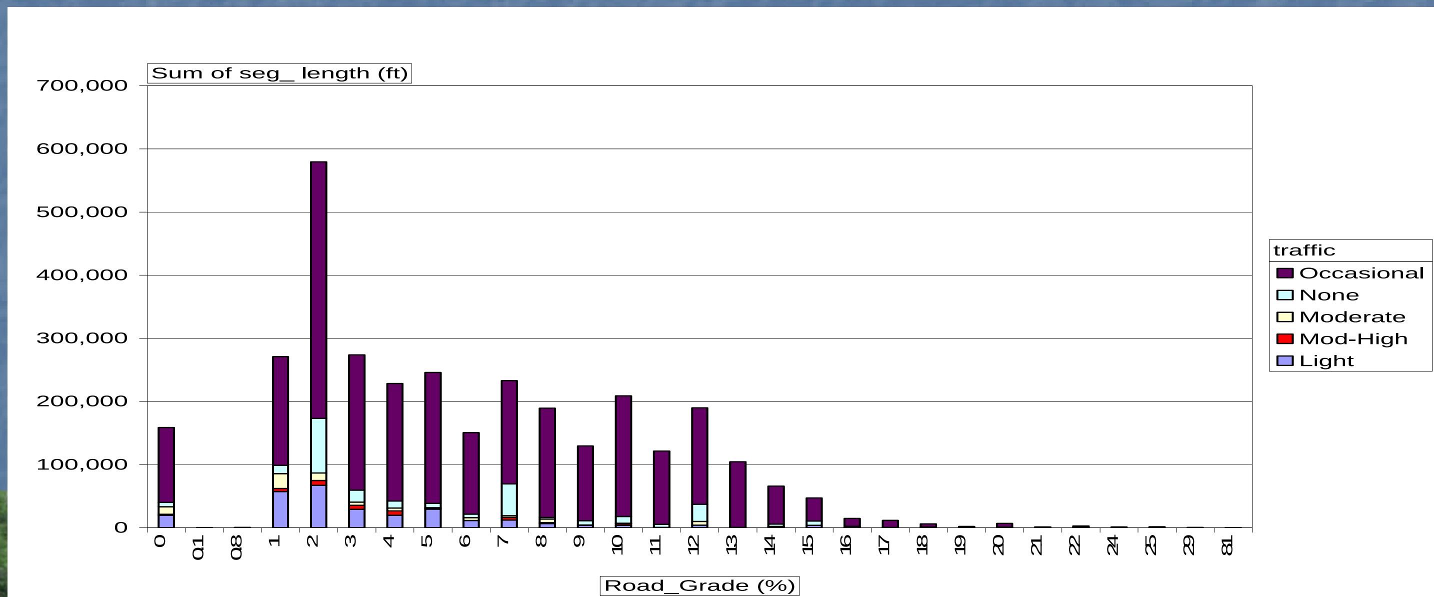
Question 2: Do road maintenance and improvements result in measureable changes in road surface erosion?

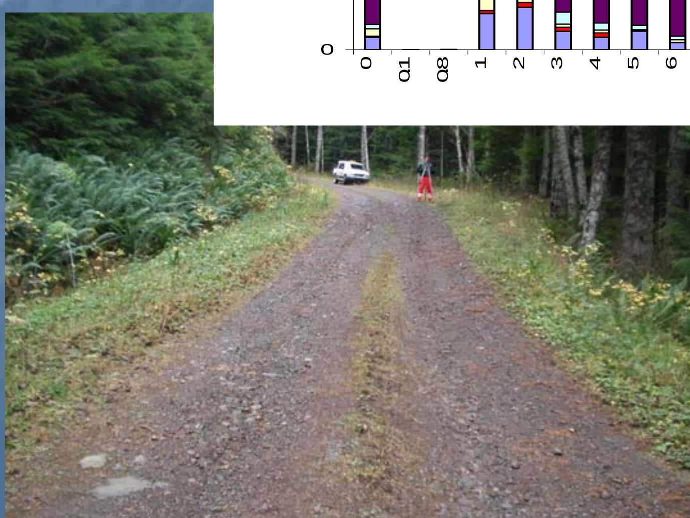
Road Decommissioning

Surfacing, Grading, Drainage

Question 3: Sediment production from low traffic roads?

Question 4: Sediment production from projects with brief but intense road use?





800 road – Occasional Use

50 road – Moderate Use

Question 5: How far does sediment travel across the forest floor?

WARSEM assumes 33% travels 100ft and 10% travels 200 ft across forest floor

Established silt fences at distances of 10, 25, 50 and 100 ft

Table 2. Estimated Sampling Costs

Scenario 1.

Sampling Method	Number of plots	Total
Road Erosion Plots, no tipping bucket	25	$113,976
Road Erosion Plots, with tipping bucket	25	$302,731
Silt fence plots	35	$ 43,505
TOTAL	**50 + 35**	**$ 475,248**

Scenario 2. *Does not address Question 7*

Sampling Method	Number of plots	Total
Road Erosion Plots, no tipping bucket	32	$ 165,134
Road Erosion Plots, with tipping bucket	5	$ 60,546
Silt fence plots	35	$ 43,505
TOTAL	**37 + 35**	**$ 269,185**

Scenario 3 (Actual Costs)*. Does not address questions 2 and 4*

Sampling Method	Number of plots	Total
Road Erosion Plots, no tipping bucket	13	$50,798
Road Erosion Plots, with tipping bucket	3	$22,310
Silt fence plots	12	$11,616
TOTAL	**16 + 12**	**$84,724**

Site Selection

Traffic	Surfacing	Gradient	Total No. of Sites
Critical Questions 1, 4, and 6: Sediment Tank Sites			
Occasional	Borrow	5-7%	3
	Native blocky/coarse	5-7%	2
	Native Medium/fine	5-7%	3 (1 w/ tipping bucket)
	Native fine	5-7% or 10-12%	0
Light	Borrow	5-7%	3
	Crushed	2-3%	2 (1 w/ Tipping bucket)
	Blocky Medium		1
Moderate	Borrow	2-3%	2
	Crushed	2-3%	
Critical Question 2: Delivery Distance			
Silt fences @ 10, 25, 50 and 100ft			12

Measuring Water and Sediment Discharge from a Bordered Road Plot using a Settling Basin and Tipping Bucket

Thomas A. Black and Charles H. Luce
Rocky Mountain Research Station. 322 East Front Street, Suite 401 Boise Idaho, 83702 USA

Figure 13.
Tipping bucket and flow splitter in operation. The 20 gpm (66 lpm) design is shown.

Study Details and Timeline

- Will install traffic counters to quantify road use on several roads
- Weigh sediment in tanks and silt fences annually
- Sample for 3-4 years
- Where BMP's are implemented (road improvements) or road use changes (for short duration projects), extend length of study if feasible
- Will install 3 tipping buckets to measure suspended sediment exiting tanks
- Project costs: $61,405 in 2008 Approx. $85-90k over 3 years

Challenges

- Storm frequencies and intensities
- Planned and unplanned road work
- Field support and dwindling budgets

Some of the many unknowns

- Differences in sediment production from different surface types within a traffic category
- Do the road segments WARSEM predicted to be the highest sediment producers actually produce large quantities of sediment?
- Effectiveness of road improvement?
- Production associated with elevated traffic?
- What amount of sediment poses a threat to which aquatic species?

Assessing the Risk to the Landsburg Facility by Large Woody Debris


1929

1929

2006

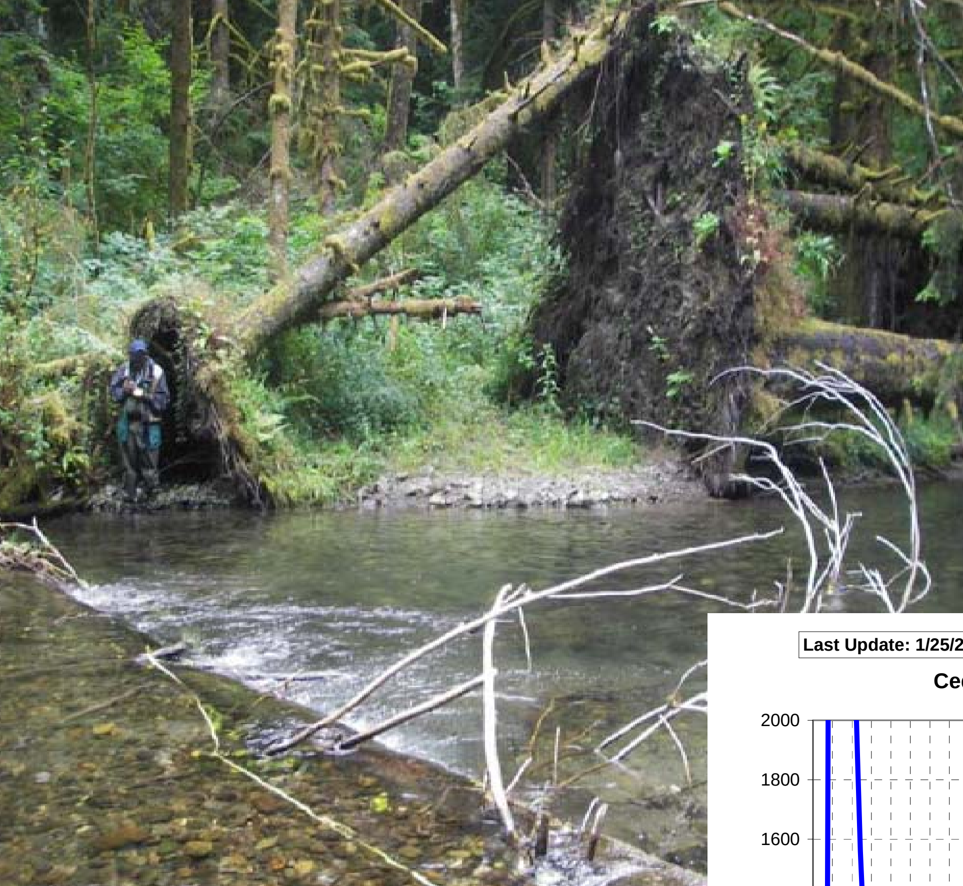
2006

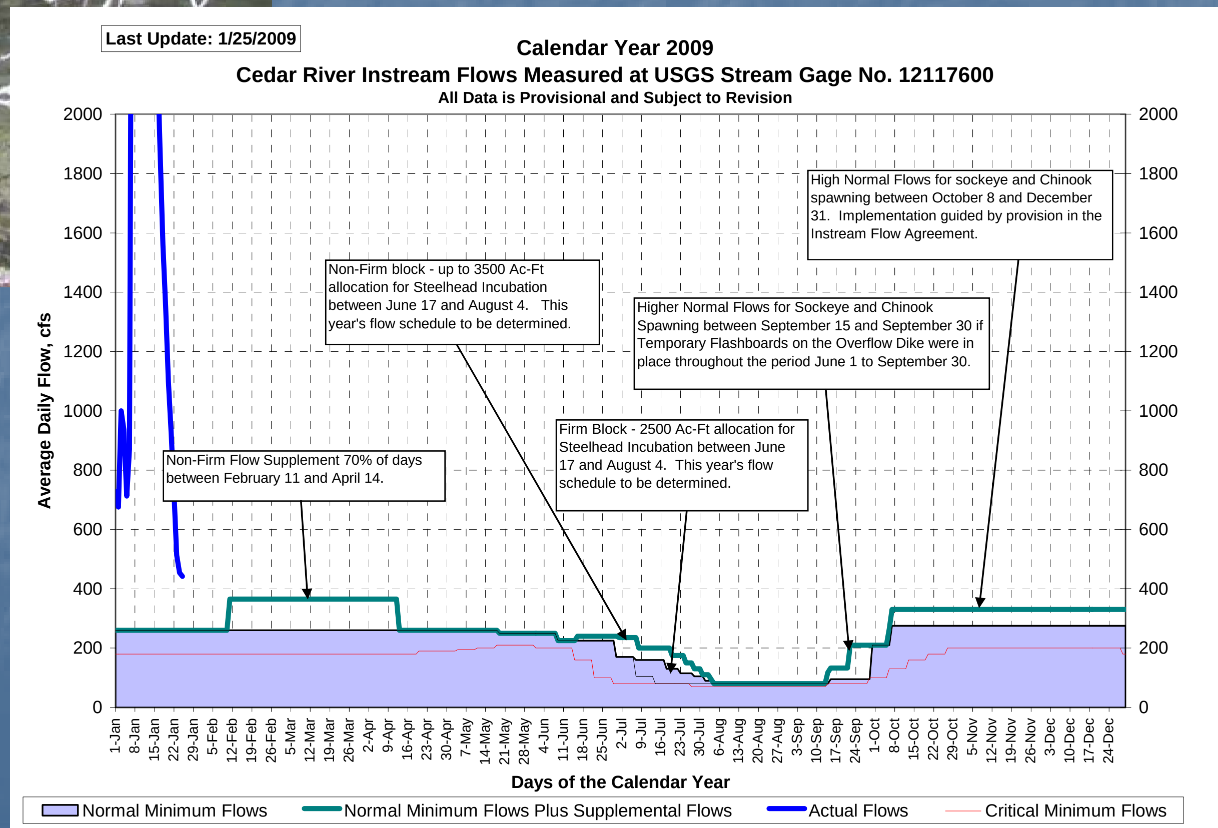
Has LWD been a problem in the past?

Questions

- What is the risk to Landsburg Dam from LWD
- How does the risk change with time
- How do we monitor conditions
- How can we manage the risk

What do we know about the issue?



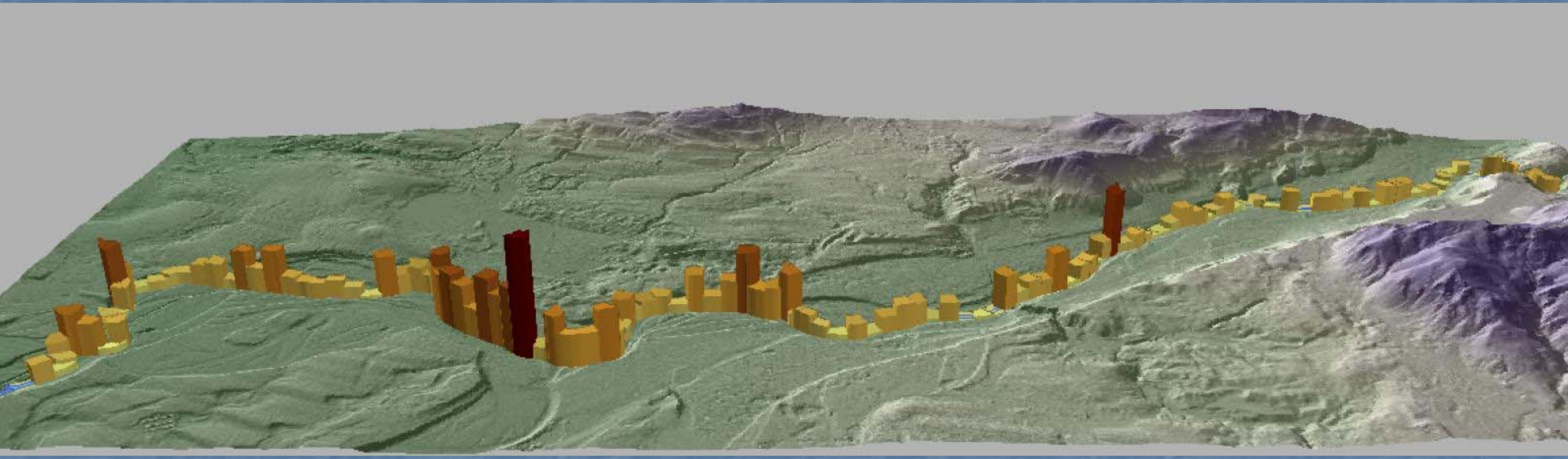


Cedar River Instream Flow Compliance Graph

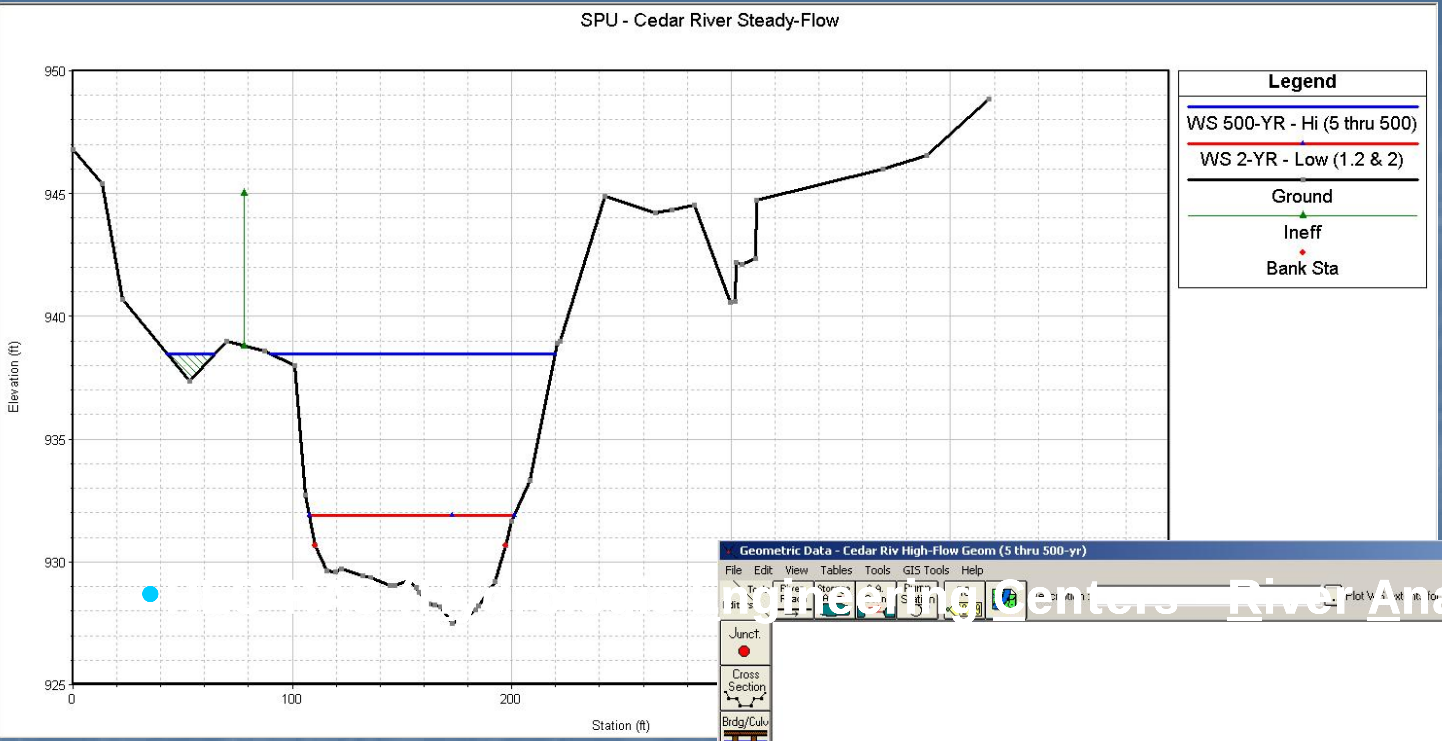
- Dimension Information
  - Length
  - Diameter
  - Rootwad width and height

- Stability Factors
  - Cabled
  - Rootwad
  - Pinned

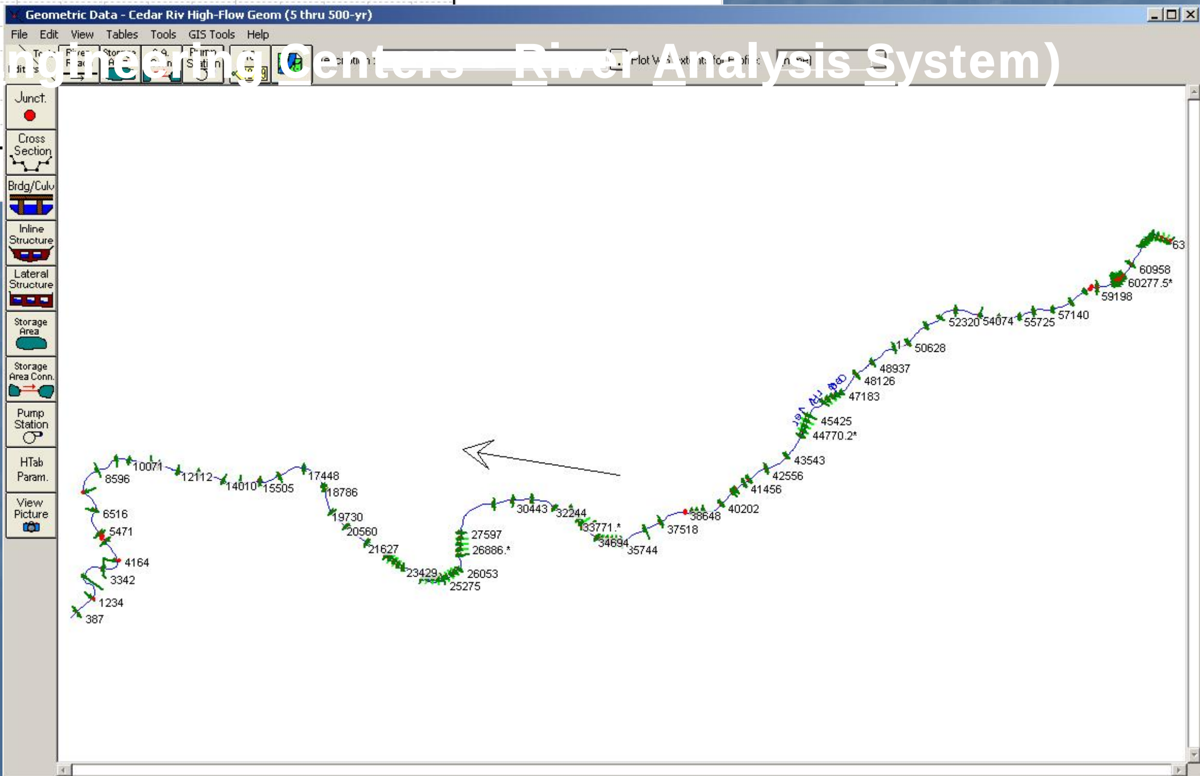
How is our LWD currently distributed?



Example of output from a **HEC-RAS (Hydrologic Engineering Centers - River Analysis System)** 1-dimensional flow model



Centers – River Analysis System)



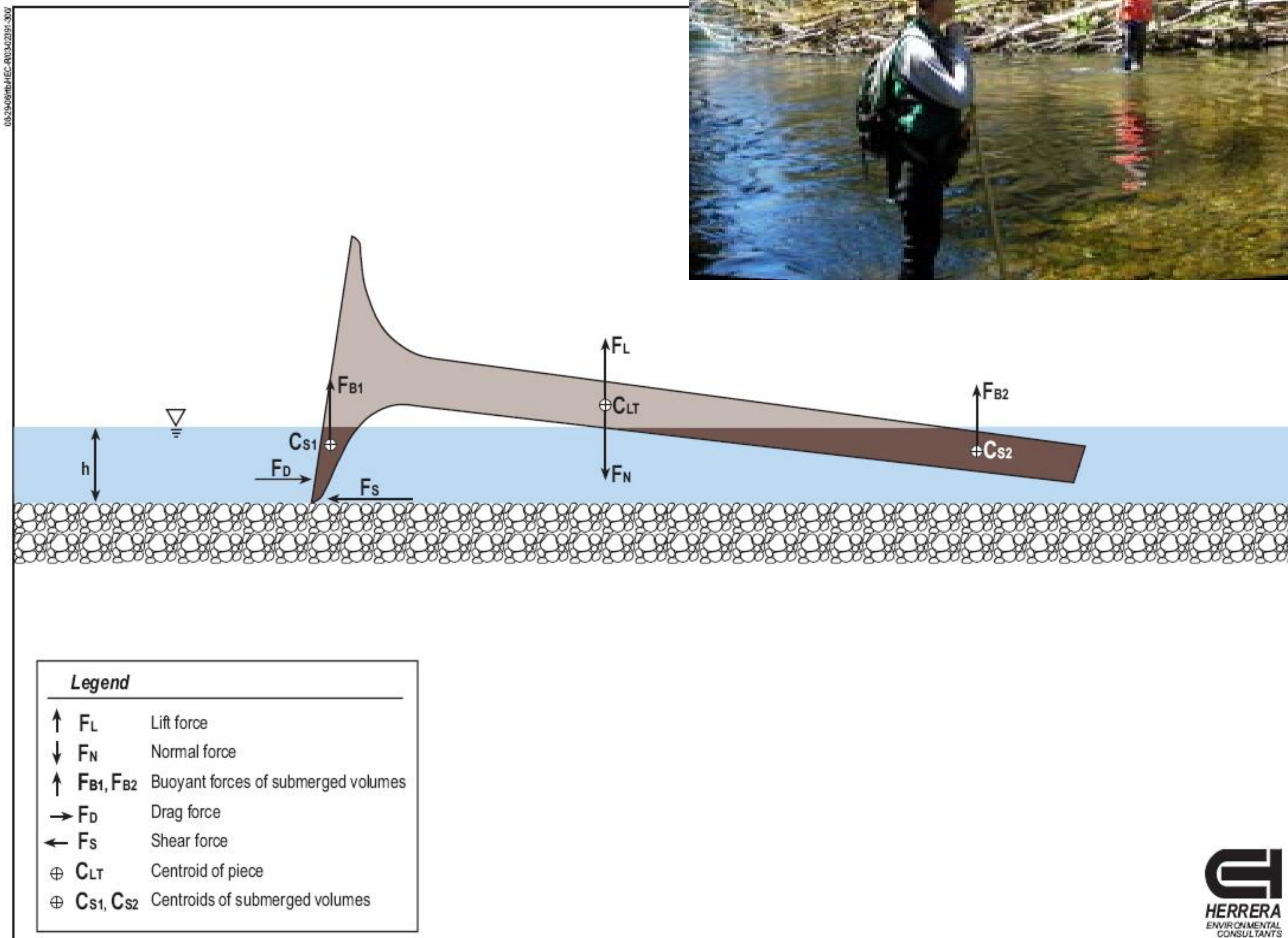
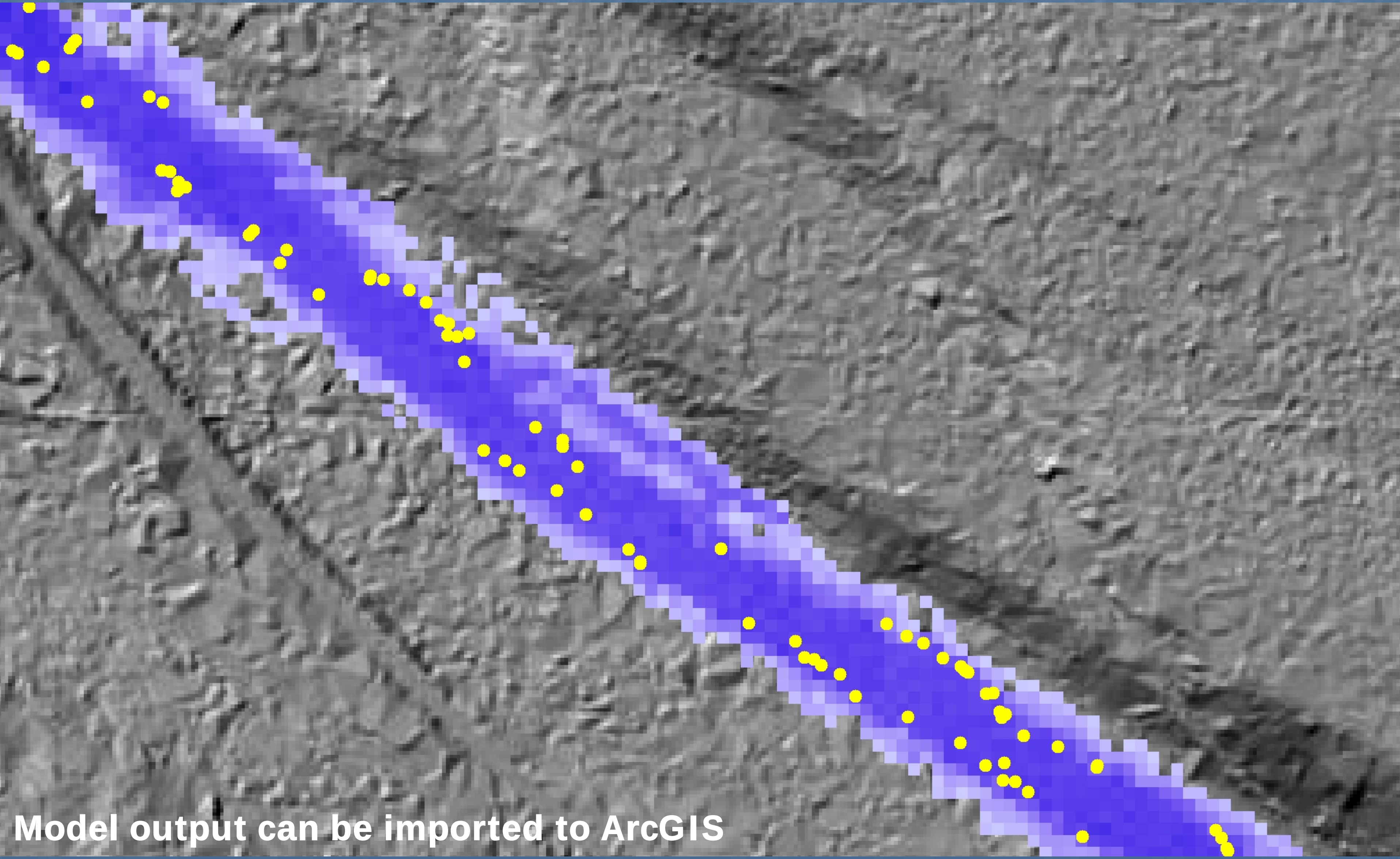


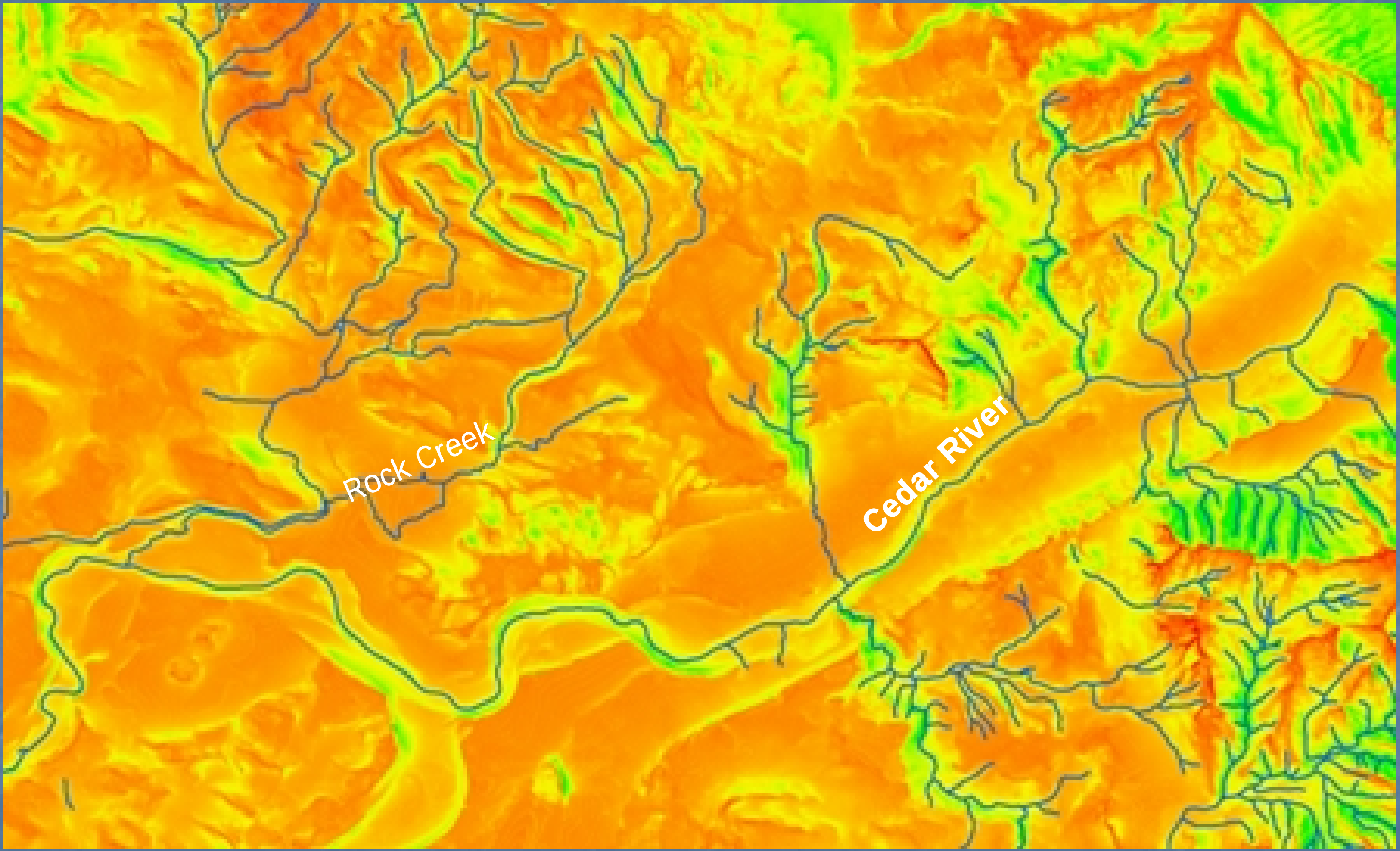
Figure E-1. Free-body diagram of driving and resisting forces on a log with a rootwad.

Under what flow conditions is LWD inundated?

Flow depths at each piece?



Where, when and how much wood is likely to enter the river through time?



Red/Orange depict high wind velocities

TOPAX – Topographic Exposure Model

What we still won't know...

Long term stream monitoring

- Monitor stream health for the duration of the HCP
- Document recovery from past water supply and land management operations

Bernhardt, et al. 2005. Restoring Rivers One Reach at a Time: Results from a survey of U.S. River Restoration Practitioners, Restoration Ecology, Vol.15, No. 3

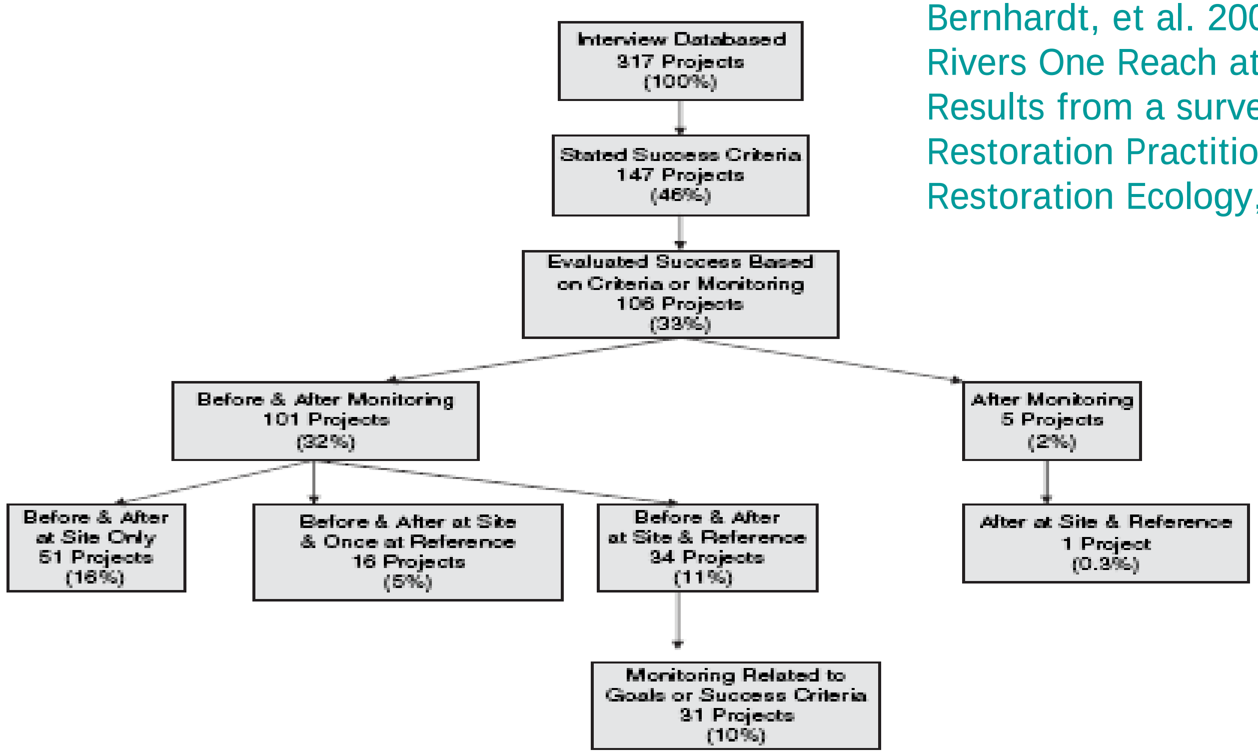


Figure 2. The idealized restoration process showing the proportion of projects within the NRRSS Interview Database that met increasing levels of rigor in their design and evaluation.

What impacts are we concerned about?

Given these land uses, what processes have most likely been altered?

- Wood recruitment processes
- Wood functions
- Flow regime
- Sediment supply and movement
- Connectivity of AQ habitat
- Biotic community composition

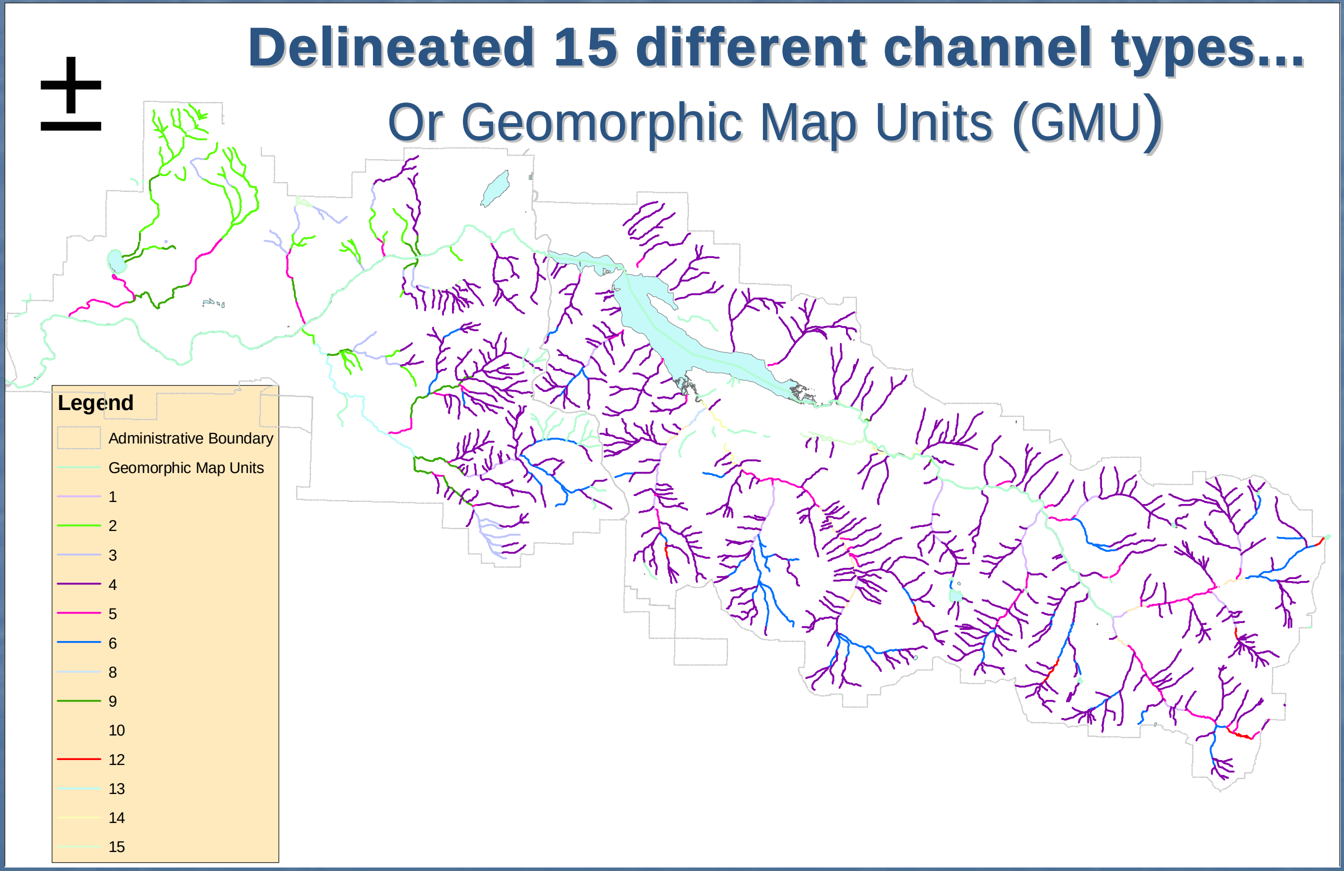


Which "processes" or attributes do you measure and how?

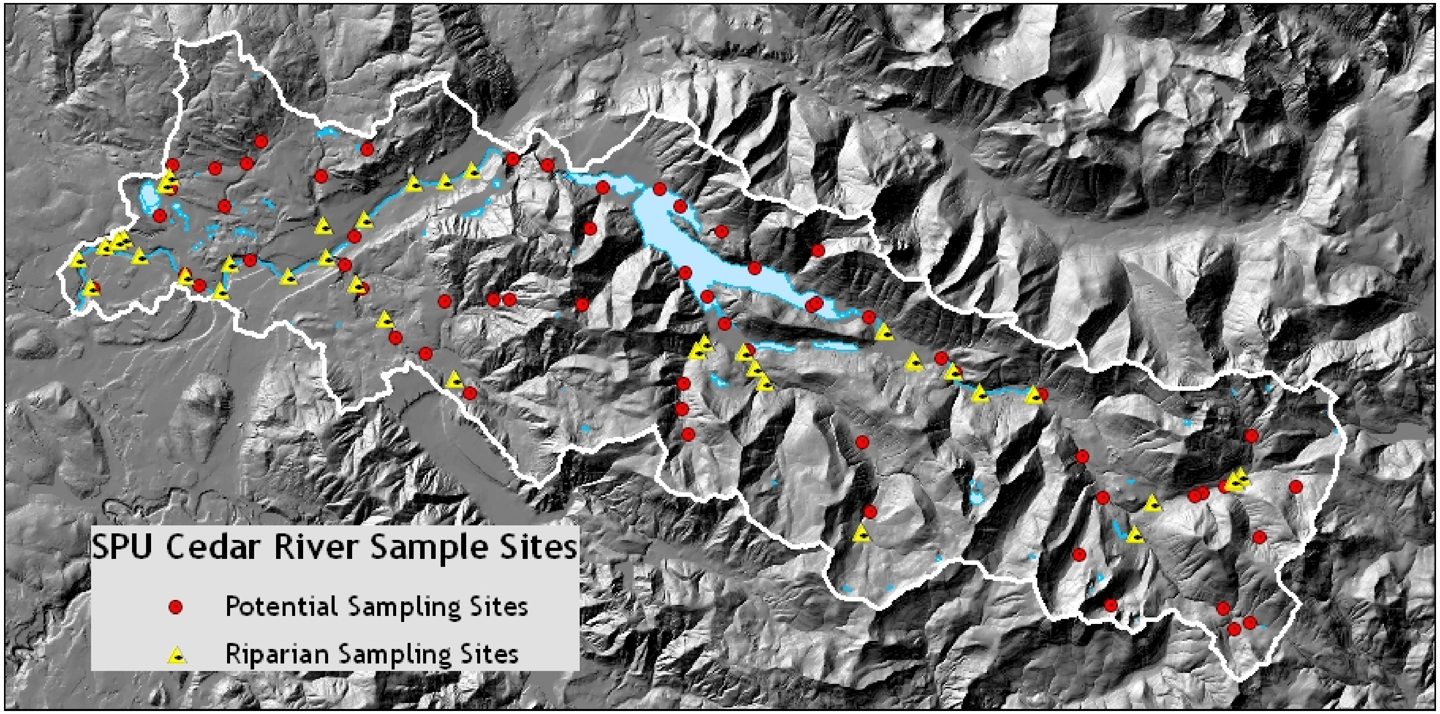
Table 3: Technical rationale, source of data and status of knowledge gaps for aquatic ecosystem indicators within the Cedar River Municipal Watershed.

Key Ecological Attributes	Indicator	Relevant GMUs/ HGM Types	Technical Rationale	Data Source	Knowledge Gap *(addressed in Table 7)*
LWD Recruitment process	Tree Species Composition, DBH, Tree Height, Tree Density		Addressed in Riparian Restoration Strategic Plan		
	Frequency of large woody debris (LWD) per 100 m of channel length	8-15	Individual pieces and LWD jams play an important role in controlling channel morphology as well as storage and transport processes of sediment and organic matter (Bisson et al., 1987). In addition to these important physical functions, LWD represents an important source of nutrients and insects to the aquatic system (Naiman and Sedell, 1979). As a result, LWD frequency represents an important measure of aquatic health, integrating of an array of important aquatic processes and conditions that are well established in the literature. Well established relationships exist between LWD frequency and fish habitat characteristics (Beechie & Sibley, 1997).	Use Fox (2003) thesis to define Desired Future Conditions (DFCs).	
	Key Piece frequency per 100m of channel length	8-15	Sizes of stable LWD, defined as being independently stable within the bankfull channel (i.e., not held or trapped by other material) and retaining or having the ability to retain other LWD (WFPB 1997), increase with channel width in small (<25m BFW) channels (Bilby & Ward, 1989). Others (Montgomery et al., 1995, and Beechie & Sibley, 1997) have found this relationship particularly true for pool creation and maintenance. Successful in-stream LWD restoration that provides habitat is also likely to be based on stability of pieces (Braudrick & Grant, 2000).	Use Fox (2003) thesis to define DFCs. Will tentatively define interim targets using the 25th percentile distribution of Fox's (2003) data.	
	Bankfull width	5, 6, 8-15	Needed to interpret relationships between channel characteristics, woody debris abundance, and habitat characteristics (e.g., pool or gravel areas)(Beechie & Sibley, 1997).		
LWD function • Formation of habitat features – pools, steps • Habitat complexity	Pool spacing	8-13, 15-18	Pools, including those formed by LWD, represent one of the most important habitat elements for salmon (Keller and Swanson 1979). In addition to providing low velocity areas for juvenile rearing, particularly for coho and Chinook, pools also represent resting sites for migrating fish (large pools) (Bjornn and Reiser, 1991). Pools associated with LWD are preferred habitats for juvenile coho salmon, cutthroat trout, and steelhead (Bisson et al., 1988).	Montgomery (et al. 1995) for DFC. CW/Pool of 1; range of 0.5-2. Beechie & Sibley (1997) for interim objectives: For 0.2-2% channels: CW/Pool = -6.2(LWD/m)+4.3 For 2.1-4.8% channels: CW/Pool = -14.7(LWD/m)+7.9	R1 and R3
	Residual pool depth	8-15	Where pools depths or volumes have decreased, species or age groups of salmonids requiring deep pools may be eliminated or reduced (Sullivan et al., 1987). In small streams, including GMUs 8, 9, 12, 13, and 15, deep pools provide important summer holding habitat during low flow periods.	Likely define DFCs and natural range of variation using USFS stream inventory data from unmanaged streams.	R4

Where do we monitor?



Site selection...



Hypotheses

Pools

- *Residual pool depth*
- *Numbers of pools*
- *No. Pools formed by wood*

Woody Debris

- *Woody debris pieces*
- *Woody debris volumes*
- *Position in channel*

When?

Connected Panel Design

Design 3

N = 35 sites

5 sites/panel; visit 10 sites per year

	Year														
Panel	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1	X	X						X	X						X
2		X	X						X	X					
3			X	X						X	X				
4				X	X						X	X			
5					X	X						X	X		
6						X	X						X	X	
7	X						X	X						X	X

not included in the analysis

Calculate power after 15 years, based on 4 points

Design 4

N = 25 sites

5 sites/panel; visit 10 sites per year

	Year														
Panel	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**				
1	X	X				X	X				X				
2		X	X				X	X							
3			X	X				X	X						
4				X	X				X	X					
5	X				X	X				X	X				

not included in the analysis

Calculate power after 11 years, based on 4 points

How it's going? Installed 20 sites. Repeat sampling of 10

- Many rejected sites – Had to change from Panel Design 3 to 4
- Result- slightly less power
- Significant channel-altering flows in 2006 and 2009
- Personnel changes

Power Estimates for Design 4 (under 2 and 4% change in residual pool depth)

	Positive Annual Trend		Negative Annual Trend	
	2%	4%	2%	4%
Interannual SD	Year 11	Year 11	Year 11	Year 11
0.0001	0.426	0.839	0.456	0.820
Low--0.0005	0.833	0.976	0.837	0.987
High--0.0002	0.174	0.483	0.175	0.432

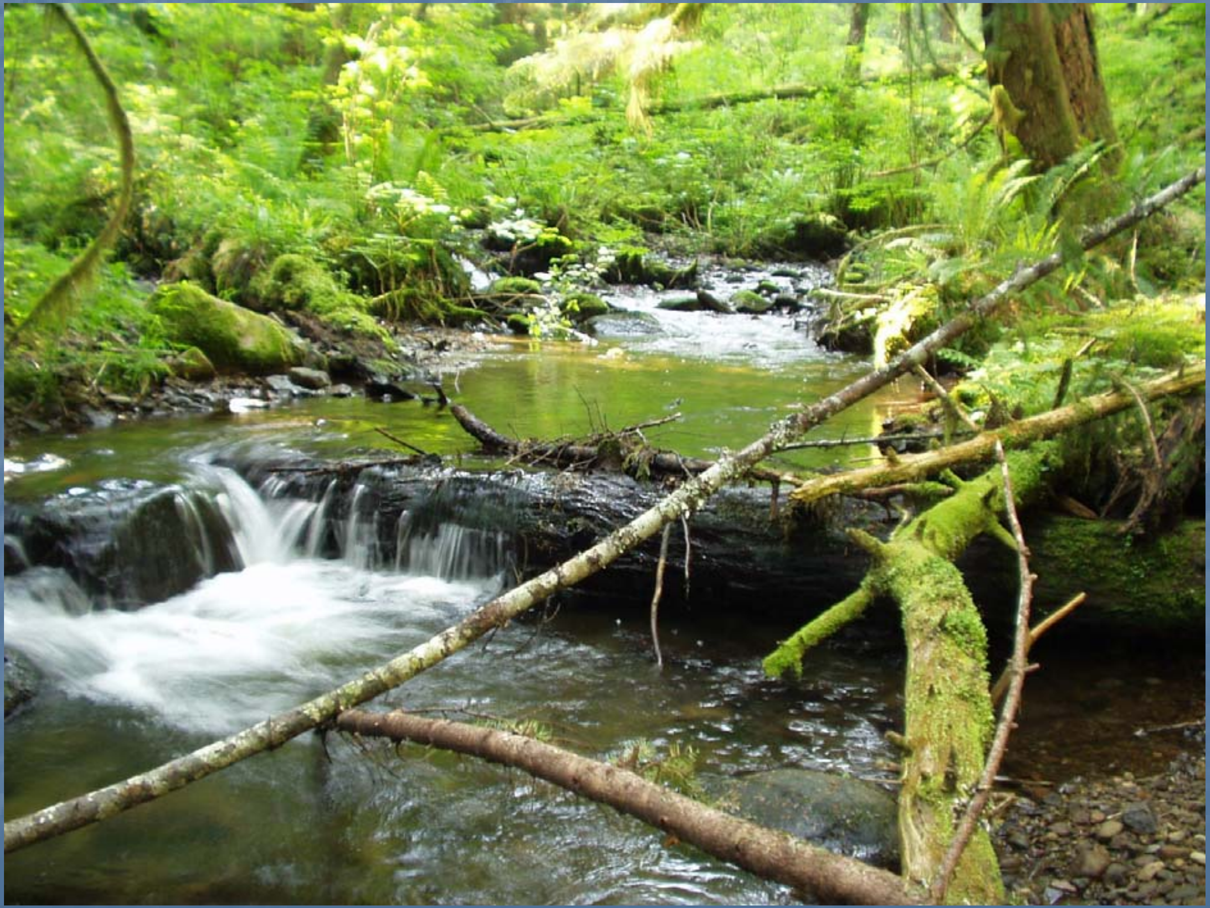
What we’ve learned

- Always keep focused on hypotheses
- Know the precision of the data to be collected
- Attempts to assess power of different panel designs specious without data from one or more endpoints/variables for 2 or more years
- Review and, if needed, update protocols annually
- Continuity in staff is immensely beneficial

Remaining Challenges and Unknowns

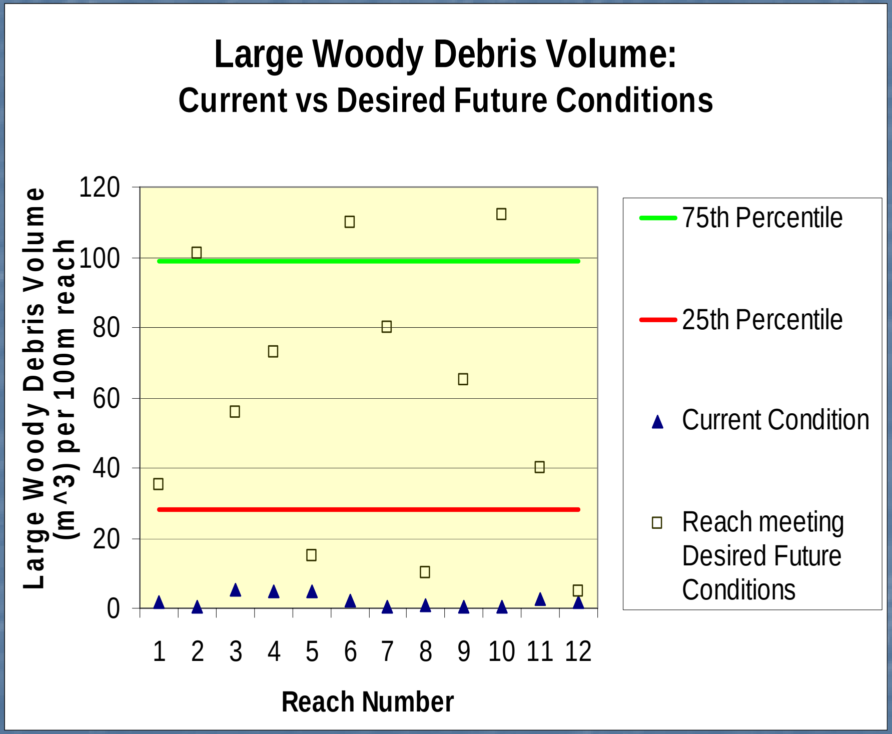
- Staying on top of data checking and data management
- Recent flood frequencies impact on assessment of between year variation in data... not to mention detection of long term trends

Questions?



Extras

How do current conditions compare with desired future conditions?



Competing Restoration Objectives

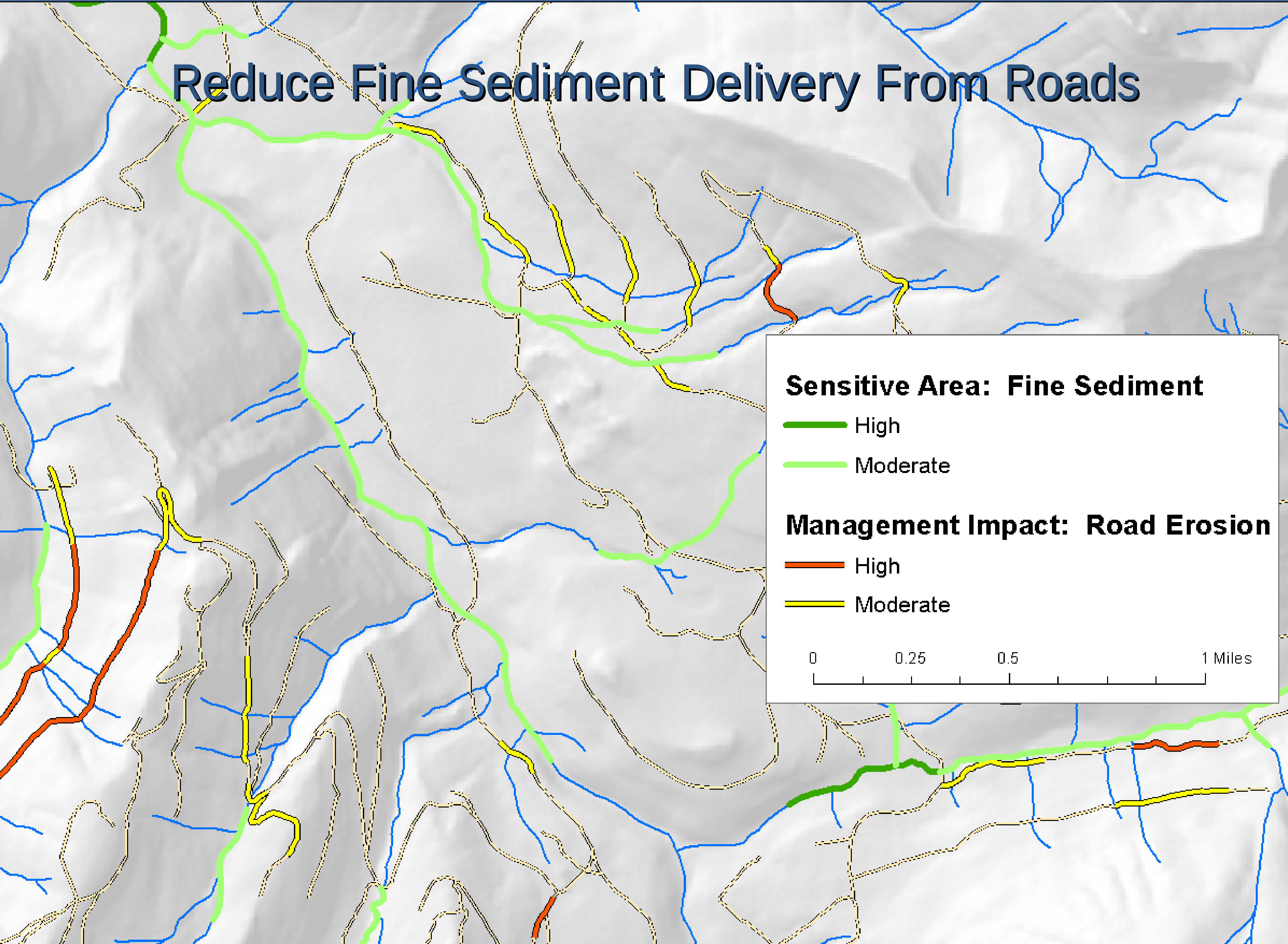
Two key questions:

- Which resources are most sensitive to road management or use?
- Which roads have the greatest potential impact on these sensitive areas?

Important Questions for Road Management

- Where are our sensitive environments?
- Where are our biggest road problems?
- Where do we go first?

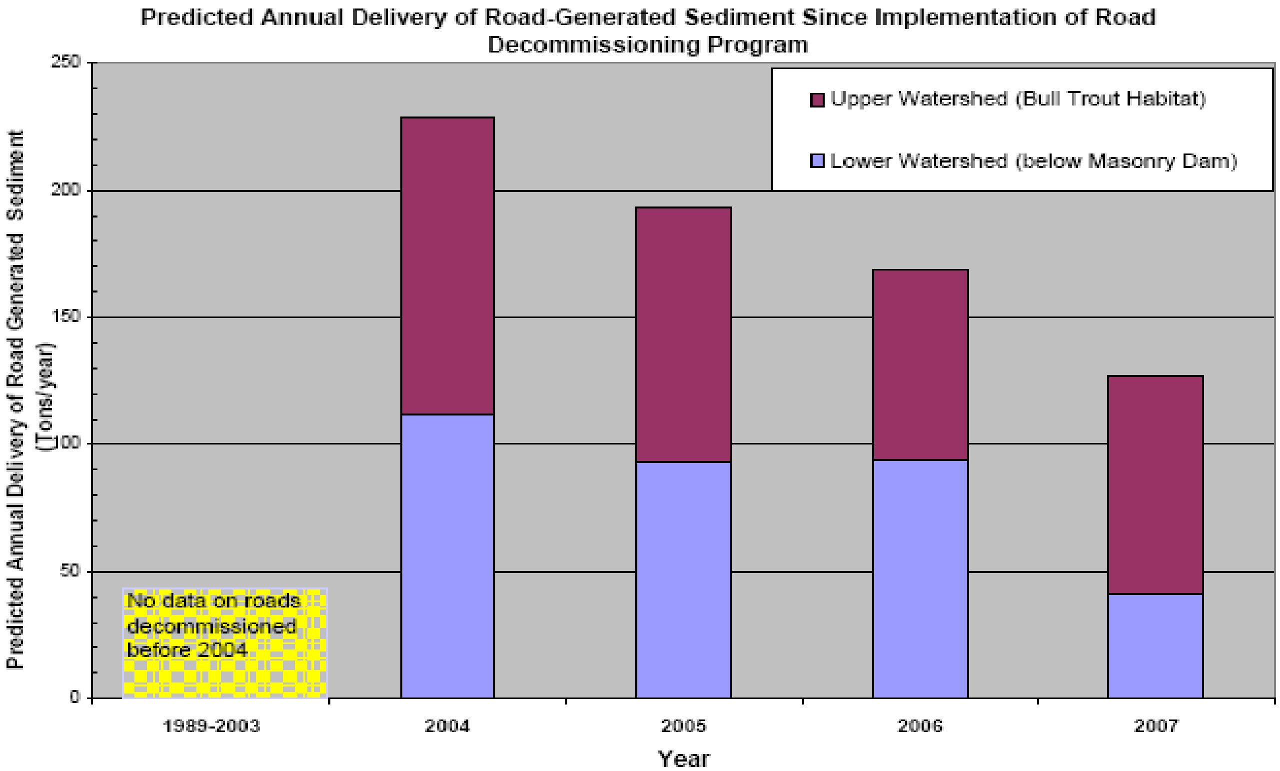
Reduce Fine Sediment Delivery From Roads





Road Sediment Modeling

Washington Road Sediment Erosion Model

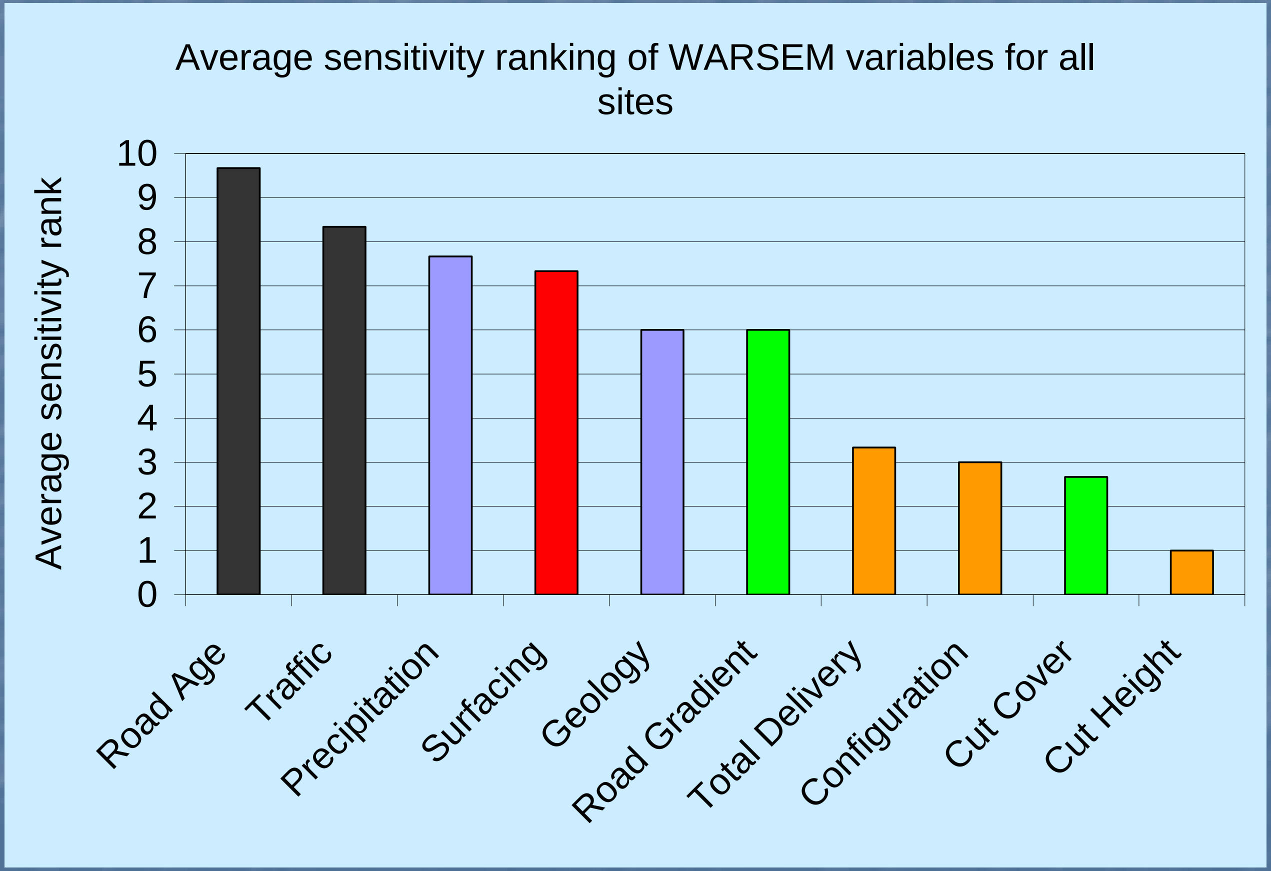


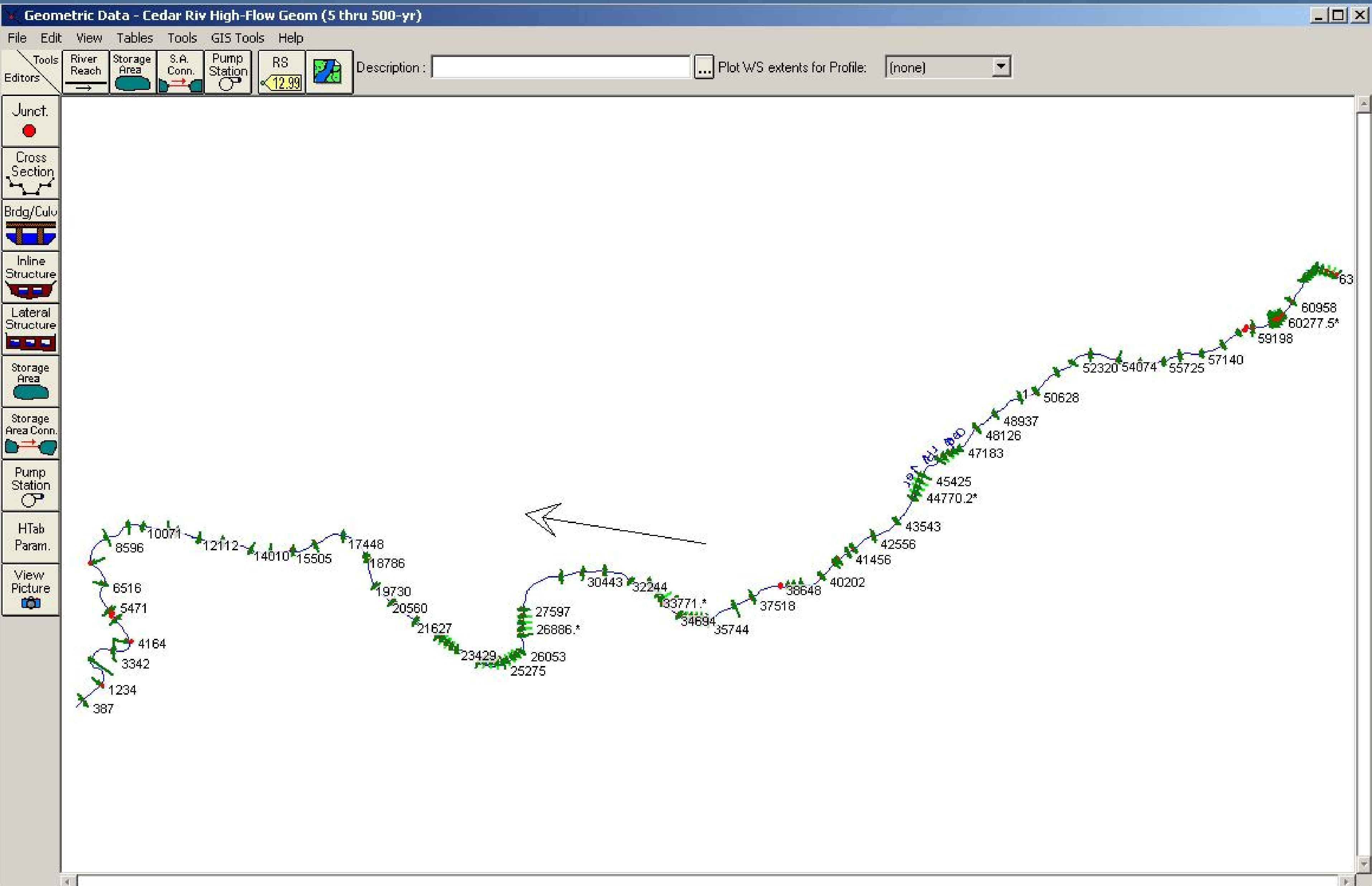
But still so many questions...

- How much sediment is actually eroding?

- How far does sediment travel across the forest floor?

- So what? Is it a threat to aquatic species?


Average sensitivity ranking of WARSEM variables for all sites
Average sensitivity rank
0
1
2
3
4
5
6
7
8
9
10
Road Age
Traffic
Precipitation
Surfacing
Geology
Road Gradient
Total Delivery
Configuration
Cut Cover
Cut Height


Geometric Data - Cedar Riv High-Flow Geom (5 thru 500-yr)
File Edit View Tables Tools GIS Tools Help
Tools
Editors
River Reach
Storage Area
S.A. Conn.
Pump Station
RS
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Description :
Plot WS extents for Profile:
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Cross Section
Brdg/Culv
Inline Structure
Lateral Structure
Storage Area
Storage Area Conn.
Pump Station
HTab Param.
View Picture
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60958
60277.5*
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52320
54074
55725
50628
48937
48126
47183
45425
44770.2*
43543
42556
41456
40202
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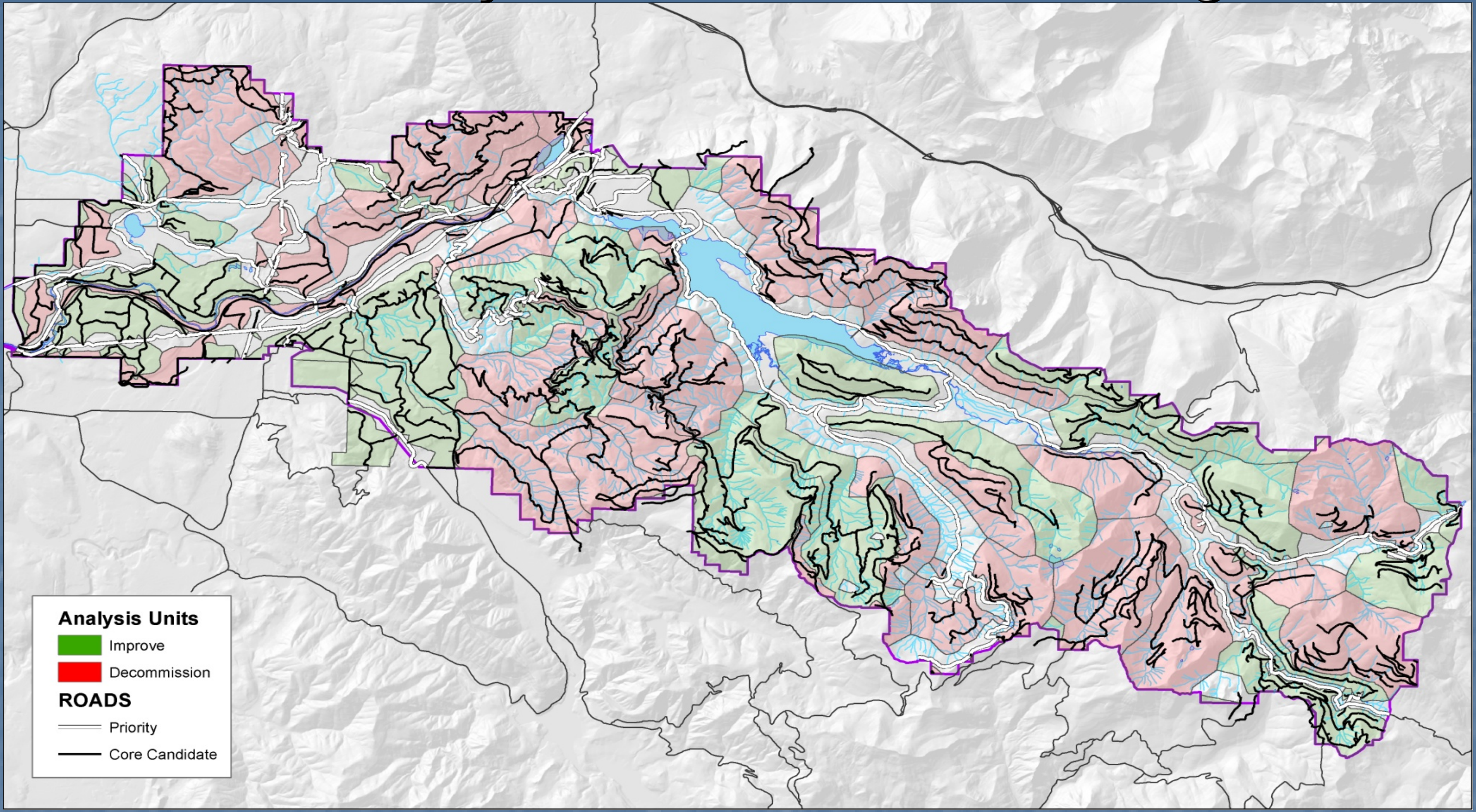
387

Road Erosion

Goals and Objectives for Road Management



- Consistent with Policies and Regulations
- Protect Stream and Riparian Ecosystems
- Reduce Road Network
- Minimize Sediment Delivery to Streams
- Improve Drainage Patterns
- Reestablish Fish Passage