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

Co-conspirator: Dave Beedle
Outline

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

Masonry Pool

Chester Morse Lake

Masonry Dam
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...

Environmental Impacts

Legal Obligations
It all starts with the **Road Inventory**...

*completed in 2004 and updated annually*

**Key Attributes:**

- Identification of segments
- Delivery
- Surfacing
- Road configuration

[Diagram showing road segments with markers and labels]
Washington Road Surface Erosion Method (WARSEM) Results

Predicted Delivery of Road-Generated Fine Sediment

Legend
Predicted Annual Delivery of Road Sediment
Tons/year per Road Segment
- 0-0.1
- 0.1-5
- 5-15
- >15

Year of Road Decommissioning
- 1964 - 2003
- 2004 - 2007
**Question 1:** How accurate are road erosion estimates?

**Measured vs. Predicted Average Annual Sediment Yield**

Question 2: Do road maintenance and improvements result in measurable changes in road surface erosion?
Question 3: Sediment production from low traffic roads?

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

<table>
<thead>
<tr>
<th>Sampling Method</th>
<th>Number of plots</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Erosion Plots, no tipping bucket</td>
<td>25</td>
<td>$113,976</td>
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<td>Road Erosion Plots, with tipping bucket</td>
<td>25</td>
<td>$302,731</td>
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<tr>
<td>Silt fence plots</td>
<td>35</td>
<td>$43,505</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td><strong>50 + 35</strong></td>
<td><strong>$475,248</strong></td>
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#### Scenario 2. Does not address Question 7

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<th>Total</th>
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</thead>
<tbody>
<tr>
<td>Road Erosion Plots, no tipping bucket</td>
<td>32</td>
<td>$165,134</td>
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<tr>
<td>Road Erosion Plots, with tipping bucket</td>
<td>5</td>
<td>$60,546</td>
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<tr>
<td>Silt fence plots</td>
<td>35</td>
<td>$43,505</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>37 + 35</strong></td>
<td><strong>$269,185</strong></td>
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</table>

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

<table>
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<th>Sampling Method</th>
<th>Number of plots</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Erosion Plots, no tipping bucket</td>
<td>13</td>
<td>$50,798</td>
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<tr>
<td>Road Erosion Plots, with tipping bucket</td>
<td>3</td>
<td>$22,310</td>
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<tr>
<td>Silt fence plots</td>
<td>12</td>
<td>$11,616</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td><strong>16 + 12</strong></td>
<td><strong>$84,724</strong></td>
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</table>
# Site Selection

## Critical Questions 1, 4, and 6: Sediment Tank Sites

<table>
<thead>
<tr>
<th>Traffic</th>
<th>Surfacing</th>
<th>Gradient</th>
<th>Total No. of Sites</th>
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</thead>
<tbody>
<tr>
<td>Occasional</td>
<td>Borrow</td>
<td>5-7%</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Native blocky/coarse</td>
<td>5-7%</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Native Medium/fine</td>
<td>5-7%</td>
<td>3 (1 w/ tipping bucket)</td>
</tr>
<tr>
<td></td>
<td>Native fine</td>
<td>5-7% or 10-12%</td>
<td>0</td>
</tr>
<tr>
<td>Light</td>
<td>Borrow</td>
<td>5-7%</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Crushed</td>
<td>2-3%</td>
<td>2 (1 w/ Tipping bucket)</td>
</tr>
<tr>
<td></td>
<td>Blocky Medium</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Moderate</td>
<td>Borrow</td>
<td>2-3%</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Crushed</td>
<td>2-3%</td>
<td></td>
</tr>
</tbody>
</table>

## 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
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?

Calendar Year 2009
Cedar River Instream Flows Measured at USGS Stream Gage No. 12117600
All Data is Provisional and Subject to Revision

Last Update: 1/25/2009

- Normal Minimum Flows
- Normal Minimum Flows Plus Supplemental Flows
- Actual Flows
- Critical Minimum Flows

Non-Firm Flow Supplement 70% of days between February 11 and April 14.

Firm Block - 2500 Ac-Ft allocation for Steelhead Incubation between June 17 and August 4. This year's flow schedule to be determined.

Non-Firm block - up to 3500 Ac-Ft allocation for Steelhead Incubation between June 17 and August 4. This year's flow schedule to be determined.

Higher Normal Flows for sockeye and Chinook spawning between September 15 and September 30 if Temporary Flashboards on the Overflow Dike were in place throughout the period June 1 to September 30.

High Normal Flows for sockeye and Chinook spawning between October 8 and December 31. Implementation guided by provision in the Instream Flow Agreement.

Higher Normal Flows for sockeye and Chinook spawning between October 8 and December 31. Implementation guided by provision in the Instream Flow Agreement.

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
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?

Model output can be imported to ArcGIS
Where, when and how much wood is likely to enter the river through time?
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

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>
<thead>
<tr>
<th>Key Ecological Attributes</th>
<th>Indicator</th>
<th>Relevant GACUs/ HGM Types</th>
<th>Technical Rationale</th>
<th>Data Source</th>
<th>Knowledge Gap (addressed in Table?)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LWD Recruitment process</td>
<td>Tree Species Composition, DBH, Tree Height, Tree Density</td>
<td></td>
<td>Addressed in Riparian Restoration Strategic Plan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency of large woody debris (LWD) per 100 m of channel length</td>
<td></td>
<td></td>
<td>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 (Namah and Sedell, 1979). As a result, LWD frequency represents an important measure of aquatic health, integrating 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 (Baechie &amp; Sibly, 1997).</td>
<td>Use Fox (2005) thesis to define Desired Future Conditions (DFCs).</td>
<td></td>
</tr>
<tr>
<td>Key Piece frequency per 100m of channel length</td>
<td></td>
<td></td>
<td>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 (&lt;25 m BFW) channels (Billby &amp; Ward, 1989). Others (Montgomery et al., 1995, and Baechie &amp; Sibly, 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 (Brodosick &amp; Grant, 2000)</td>
<td>Use Fox (2005) thesis to define DFC's. Will tentatively define interim targets using the 25th percentile distribution of Fox's (2003) data.</td>
<td></td>
</tr>
<tr>
<td>Bankfull width</td>
<td>5, 6, 8-15</td>
<td></td>
<td>Needed to interpret relationships between channel characteristics, woody debris abundance, and habitat characteristics (e.g., pool or gravel areas) (Baechie &amp; Sibly, 1997).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LWD function</td>
<td>Formation of habitat features – pools, steps, Habitat complexity</td>
<td></td>
<td></td>
<td>Montgomery (et al., 1997) for DFC. CW/Pool = 0.5-2, Baechie &amp; Sibly (1997) for interim objectives: For 0.2-2% channels: CW/Pool = - 0.5LWD(m) + 4.3 For 2.1-4.8% channels: CW/Pool = 14.3LWD(m) + 7.9</td>
<td>R1 and R3</td>
</tr>
<tr>
<td>Pool spacing</td>
<td>8-15, 15-18</td>
<td></td>
<td>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 juveniles rearing, particularly for coho and Chinook, pools also represent resting sites for migrating fish (large pools) (Ejnarson and Raiser, 1991). Pools associated with LWD are preferred habitats for juvenile coho salmon, cutthroat trout, and steelhead (Bisson et al.1988).</td>
<td></td>
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</tr>
<tr>
<td>Racial pool depth</td>
<td>8-15</td>
<td></td>
<td>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.</td>
<td>Likely define DFC's and natural range of variation using USFS stream inventory data from unmanaged streams.</td>
<td>R4</td>
</tr>
</tbody>
</table>
Where do we monitor?

Delineated 15 different channel types...
Or Geomorphic Map Units (GMU)
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

<table>
<thead>
<tr>
<th>Year</th>
<th>Panel 1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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<th>10</th>
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<td>X</td>
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<td>X X</td>
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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

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<th>Year</th>
<th>Panel 1</th>
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<th>4</th>
<th>5</th>
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<tr>
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<td>X X</td>
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<td></td>
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<tr>
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<td>X X</td>
<td>X X</td>
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<td>X X</td>
<td>X X</td>
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<td>4</td>
<td>X X</td>
<td>X X</td>
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<tr>
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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)

<table>
<thead>
<tr>
<th>Interannual SD</th>
<th>Positive Annual Trend 2%</th>
<th>Positive Annual Trend 4%</th>
<th>Negative Annual Trend 2%</th>
<th>Negative Annual Trend 4%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low—0.0005</td>
<td>0.426</td>
<td>0.836</td>
<td>0.456</td>
<td>0.820</td>
</tr>
<tr>
<td>High—0.0002</td>
<td>0.174</td>
<td>0.483</td>
<td>0.175</td>
<td>0.432</td>
</tr>
</tbody>
</table>
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?
How do current conditions compare with desired future conditions?

**Large Woody Debris Volume: Current vs Desired Future Conditions**

- **75th Percentile**
- **25th Percentile**
- **Current Condition**
- **Reach meeting Desired Future Conditions**

![Graph showing large woody debris volume comparison between current and desired future conditions.](image)
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

Sensitive Area: Fine Sediment
- High
- Moderate

Management Impact: Road Erosion
- High
- Moderate
Road Sediment Modeling

Washington Road Sediment Erosion Model

Predicted Annual Delivery of Road-Generated Sediment Since Implementation of Road Decommissioning Program

- Upper Watershed (Bull Trout Habitat)
- Lower Watershed (below Masonry Dam)

No data on roads decommissioned before 2004
But still so many questions...

- How far does sediment travel across the forest floor?
- How much sediment is actually eroding?
- So what? Is it a threat to aquatic species?
- How does it affect the aquatic ecosystem?
Average sensitivity ranking of WARSEM variables for all sites

- Road Age
- Traffic
- Precipitation
- Surfacing
- Geology
- Road Gradient
- Total Delivery
- Configuration
- Cut Cover
- Cut Height
Road Erosion

**Sediment Transport**
- Road Configuration
- Ditch Condition
- Road Slope (energy)

**Delivery to Streams**
- Soil Detachment
- Surfacing (cover)
- Geology
- Traffic
- Cutslope cover
- Rainfall

**Drainage Structure**
- Ditch Condition
- Ditch Delivery

Modified from Watershed Dynamics
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