Sediment Budget Model for Predicting Components of Sediment Yield

Russell Creek Sediment Budget Project

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Purpose: develop a sediment budget procedure to identify the relative contribution of different types of sediment source to the sediment load as measured at main stream gauge.

A sediment budget model was developed based on a set of equations that describe sediment production from gullies, landslides, road crossings:

- Based on area of source, rainfall, attributes of the feature
The sediment budget model was first developed in 1999-2000 from storm data collected in 1997-98.
- Funding from FRBC

Current study:
- Validate the model using new data
- Attempt to develop the model as an effectiveness evaluation tool for monitoring road deactivation.
- Funding from FIA.
Study Area

- Russell Creek: monitored since 1991
- Starting in 1994, we began developing a nested study to develop sediment budgets within sub-basins
  - continuous monitoring at 5 mainstem stream sites and 4 precipitation gauging sites.
  - manual storm-based sampling in gullies at road crossing sites.
  - All sediment sources are inventoried, thus their sediment yield can be forecast based on their type/attributes and rainfall variables.
Russell Creek

Suspended Sediment Concentration (mg/l)

Stream Discharge (m3/s)

Nov 12 1998

Nov 13 1998

Russell Creek
Streamflow (m³/s)

SSC (mg/l)

Flow
Sample
SSC Calc
Site 2 (Gully 61)

Peak = 2200 mg/l

Suspended Sediment Concentration (mg/l)

Stream Discharge (m³/s)

Nov 12 1998

Nov 13 1998

Peak = 2200 mg/l
Suspended Sediment Concentration (mg/l)

Site 12 (Gully 65)

Suspended Sediment Concentration (mg/l)

Stream Discharge (m^3/s)

Nov 12 1998
Nov 13 1998
Russell Confluence - South Slope
Site 27 (Gully B)

Suspended Sediment Concentration (mg/l)

Stream Discharge (m^3/s)

Nov 12 1998

Nov 13 1998
Site 34 (landslide scar)

Suspended Sediment Concentration (mg/l)
Stream Discharge (m³/s)

Nov 12 1998 to Nov 13 1998

Stream Discharge (m³/s)

Suspended Sediment Concentration (mg/l)
Suspended Sediment Concentration (mg/l)

Stream Discharge (m³/s)

Nov 12 1998

Nov 13 1998
A range of gully attributes were represented including:

- catchment area
- channel length
- stability of channel bed and banks
- presence of debris flow deposits
Various attributes were considered to model sediment yield during storms:
- Area of cut and fill slopes adjacent to the crossing
- Ditch length and area of ditch cut slopes
- Length of road sloping toward crossing
- Gully gradient
- Storm rainfall
Sediment yield at crossings is a function of storm rainfall and the area of cut and fill slopes.

Relationship accounts for “normal” sediment production but not episodic events or post-deactivation yield.
Yield due to ditch and road erosion

- There is a bias in the crossing yield model:
  - Ditch length and ditch cut slopes were not significant parameters in the model.
  - We know that road and ditch erosion contributes sediment to the gully and is included in crossing yield.
  - We can use the measured vs. modeled yield to derive the ditch/road surface contribution...
Road and Ditch Erosion

E = measured yield - (predicted yield + 1 s.e.)

- Yield (kg / metre of connected ditch):

<table>
<thead>
<tr>
<th>Storm Rainfall (mm)</th>
<th>Branch Ditch Erosion</th>
<th>Mainline Erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>38.0</td>
<td></td>
<td>0.00</td>
</tr>
<tr>
<td>44.0</td>
<td></td>
<td>2.39</td>
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<tr>
<td>48.9</td>
<td>0.06</td>
<td>2.17</td>
</tr>
<tr>
<td>60.3</td>
<td>0.16</td>
<td>7.08</td>
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<tr>
<td>192.2</td>
<td>0.91</td>
<td></td>
</tr>
</tbody>
</table>
There is a logarithmic relationship between ditch yield / metre of connected ditch and storm rainfall.
Valley flat buffers middle section of Russell Creek

- Sediment inputs from the confluence had to be scaled
  - grain size distribution of source sediments
  - ability of gully flows to transport coarse fractions - varies from 0 up to about 80%

Proportion of sediment from source types reflects this scaling
The sediment budget model was used to determine the relative contribution of road sources to the sediment load at Russell Creek main gauging site.

• Storms that are not supply limited
• A relationship between storm size and the proportion of sediment contributed by storms exists...
Testing of Sediment Budget Model

Note: the graph above is the result of applying the sediment budget model to storms that are not supply limited in terms of sediment transport. We chose to look at road contributions to the mainstem sediment budget, which goes with the current focus on applying the model to road deactivation effectiveness monitoring.
Cycles of Sediment Exhaustion

As in the last slide, there is a cycle of sediment supply exhaustion and renewal that the model did not capture. The model is based on data where the supply is unlimited, so exhaustion will be handled theoretically with the historic data and validated with new storm data.
Conclusion

- Ongoing
- Updated
- A long way to go
- Numerical Simulation?