Identifying sediment sources in the Minnesota River Basin
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Minnesota River Turbidity
Stakeholder Committee
New Ulm Library, August 27, 2009
Context
Sediment Sources
Research Goals
Methods for evaluating sediment sources
Findings
MN R Basin
Subwatersheds
Location within subwatersheds
Local source & mechanism
Sediment storage along the MN R
An Integrated Sediment Budget for the Le Sueur River Basin, Minnesota

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St. Croix Watershed Research Station

Minnesota River Basin Data Center

Minnesota Pollution Control Agency
Identifying sediment sources in the Minnesota River Basin

Minnesota River Sediment Colloquium
June 30, 2009

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11.5 ka: 70 m baselevel fall
Rapid Holocene Incision in lower 40 km

Holocene average
knick migration rate = 3 m/yr
vertical incision rate = 5 mm/yr
A grand geomorphic experiment
Minnesota River TMDL
Pre-settlement: 81% Mn R
Present: 88% Mn R

Engstrom & Allmendinger, 1997
Kelley & Nater, 2000
Sources
Fields
Ravines
Bluffs
Streambanks
Sources

**Fields**  Smaller erosion rates *per area* — big area

**Ravines**  Bigger erosion rates *per area* — small area

**Bluffs**  Bigger erosion rates *per area* — small area

**Streambanks**  Must balance erosion, deposition
Methods
Stream gaging
Fingerprinting
Source measurement & sediment budgeting
Geochemical Fingerprinting

Different sediment sources have unique “fingerprints” of tracers:
- Fields = high amounts of atmospherically-deposited tracers: $^7\text{Be}$, $^{210}\text{Pb}$, $^{137}\text{Cs}$
- Streambanks, minimal atmospheric exposure, negligible concentration
- Riverine suspended sediment is a mixture of sources.
- Apportion contribution to suspended sediment with a mixing model.

Source Fingerprints
- **Be-7**
- **Pb-210**

**St. Croix Watershed Research Station**

Dan Engstrom, and Shawn Schottler. Dylan Bloomentritt
Sediment Budgets

Adding it up provides context for evaluating magnitude of individual sources description of uncertainty
Findings

Minnesota River Basin
Subwatersheds
Location with subwatersheds
Erosion mechanism & local source
Changes in Minnesota River sediment storage
Pre-settlement: 81% Mn R
Present: 88% Mn R
Engstrom & Allmendinger, 1997
Kelley & Nater, 2000
If we are going to address the problem of eutrophication and turbidity in the receiving waters, we have to be specific about mechanism and location of sediment sources.
Maple - Air Photo. Median = 0.045, N = 121
Le Sueur - Ground LiDAR. Median = 0.084, N = 8
Blue Earth - Ground Survey. Median = 0.078, N = 7

92% of Maple values are < 0.10 t/m²/yr
### 41,300 t/yr at Lower Gage

<table>
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<th>Source</th>
<th>Rate</th>
<th>Unit</th>
<th>Extent</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field</td>
<td>0 – 50</td>
<td>t/km²</td>
<td>moderate</td>
<td>km²</td>
</tr>
<tr>
<td>Ravine</td>
<td>0 – 0.002</td>
<td>t/m²</td>
<td>small</td>
<td>m²</td>
</tr>
<tr>
<td>Bluff</td>
<td>0 - 0.4</td>
<td>t/m²</td>
<td>small</td>
<td>m²</td>
</tr>
<tr>
<td>Streambank</td>
<td>0.035</td>
<td>t/m</td>
<td>big</td>
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</table>

### 7,800 t/yr at Upper Gage

<table>
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<tr>
<td>Field</td>
<td>0 – 50</td>
<td>t/km²</td>
<td>big</td>
<td>km²</td>
</tr>
<tr>
<td>Ravine</td>
<td>0 – 0.002</td>
<td>t/m²</td>
<td>v little</td>
<td>m²</td>
</tr>
<tr>
<td>Bluff</td>
<td>0 - 0.4</td>
<td>t/m²</td>
<td>v little</td>
<td>m²</td>
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<tr>
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<td>0.035</td>
<td>t/m</td>
<td>small</td>
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</tr>
</tbody>
</table>
Can balance the budget with
(i) relatively large sediment supply from fields, ravines, & bluffs
but gives non-field percentage larger than shown by fingerprinting
(ii) smaller sediment supply from fields, giving consistent fingerprinting percentages
but extremely large supplies from ravines and bluffs

Next steps:
collect more gaging information
evaluate fingerprinting at co-located samples
evaluate potential for very high field yield near incised valleys
evaluate potential for exceptionally large, rare, localized supplies from fields and ravines
greater spatial detail from sediment routing model
Sediment routing model

- Tributaries
- Overland flow
- Erosion of bluffs and terraces
- Incision of ravines

Layers:
- Main floodplain
- Basal floodplain
- Substrate

- Overbank deposition
- Newly deposited point bar
- Sediment exchanged between the layers as the channel migrates in the floodplain
- Sediment eroded from the floodplain for channel migration

From Enrica Viparelli

collaboration with Gary Parker, Enrica Viparelli and Wes Lauer
Annual TSS Supply to Minnesota River Between Judson and Ft Snelling (Mg)

Annual TSS Balance (Mg)

Input - Output @ Ft Snelling

100% stored
25% stored
50% stored

25% stored
50% stored
100% stored
Ongoing and proposed work

i. Stream gauging: TSS loads from
   principal tributaries and mainstem stations
   upstream/downstream paired gauges.

ii. Complete sediment budget for the Le Sueur watershed.

iii. Use sediment budgeting to reconcile erosion estimates from different methods.

iv. Inventory of ravines and bluffs for incised portion of Minnesota River Basin.

v. Develop basis for extrapolating sediment budgets from one watershed to another.

vi. Develop a sediment budget for the Minnesota River mainstem.

vii. Evaluate relative roles of changing climate, land use, & land management.

vii. Evaluate tile and ditch drainage in changing stream flow and erosion potential.

x. Link sediment budget models with decision analysis methods to
   prioritize management and monitoring actions.