Modeling the Evolution of Catskill Stream Channels - Preliminary Results

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• Introduction
• CONCEPTS - model
• Model setup for Stony Clove
• Preliminary results
• Conclusions and future work
In North America, damage due to soil erosion and fluvial sediment ($20-$50 billion/year) (Pimental et al., 1995; Osterkamp, 2004; Larsen et al., 2012)

- Damage – physical, chemical, biological
- Limited understanding – sources and fluxes
- Regionally consistent approach needed (Larsen et al., 2012)
Erosion – in the U.S.

• Significant success with reducing erosion on the farmers’ fields (USDA-NRCS, 2010)
• Elevated sediment concentration remains a problem in many streams in the U.S.
• Whole system approach required – land and stream components (CAST, 2012)
Sediment and Water Quality

Where does it come from?

How can we reduce it?

Ashokan Reservoir of NYC water supply; September 1, 2011 following Tropical Storm Irene flooding

Stony Clove Creek near Phoenicia, Oct 1, 2010
Sedimentation Process

(Hillslope (Agricultural e.g., crop fields, pastures etc. and Non-Agricultural e.g., unpaved roads, construction sites etc.)

Surface erosion → Gully erosion → Mass erosion → Bank/Bed erosion → Hillslope storage

Channel transport

Hillslope storage

Channel storage

Watershed sediment yield

Production

Storage and transport

Yield

(Modified from USEPA, 1999)
### NYC Water Supply Watersheds

<table>
<thead>
<tr>
<th>Catskill system</th>
<th>Delaware system</th>
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</thead>
<tbody>
<tr>
<td>Less Agriculture</td>
<td>More Agriculture</td>
</tr>
<tr>
<td>More glacial clay</td>
<td>Less glacial clay</td>
</tr>
<tr>
<td><strong>Dominant source of stream sediment- glacial clay from stream channels</strong> <em>(NYCDEP, 2008)</em></td>
<td><strong>Dominant source of stream sediment- upland/agricultural source</strong> <em>(Nagle et al., 2007)</em></td>
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</tbody>
</table>
Climate Change and Stream Turbidity

- Regional climate change (Burns et al., 2007)
  - increase @ 0.5-2.0°C/50 years
  - increase @ 8-26 cm/50 years
  - shift in spring runoff - 1-2 weeks earlier in the year
- Impact on stream turbidity?
  - Current assessment use flow based turbidity rating curves
  - Need for physically based models

Mukundan et al. (In review)
Channel Evolution Model

Modified from Simon and Hupp (1989)
CONCEPTS - Model

CONservational Channel Evolution and Pollutant Transport System

- Part of USEPA’s “toolbox” of approved models
- Developed at the USDA- National Sedimentation Lab Oxford, Mississippi (Langendoen, 2000)
- 1-dimensional numerical model
- Simulates
  - Sediment transport by size classes
  - Channel erosion processes
- Successfully used in incised stream systems
CONCEPTS - Model

• Model inputs
  – Channel dimensions
  – Hydraulic resistance
    • (particle size, erodibility, critical shear stress etc.)
  – Shear strength
    • (bulk density, pore-water pressure, root biomass etc.)
  – Inflows
    • (water and fine sediment from upstream)
Model Setup – Stony Clove

- Tributary of Esopus Creek
- 4.28 Km reach
- 10 cross-sections
  (01-19-2012)
- Distance between cross sections (231-592 m)

Stony Clove at Phoenicia, Oct 1, 2010
• SCENARIOS
  – Runoff events of different return periods
  – Discharge (Q) estimated from regional curves based on drainage area (USGS, 2006)

- Q2
- Q5
- Q10
- Q25
- Q50
Results – change in bed elevation

[Graph showing bed elevation change in meters along model kilometers with data points for Q2, Q5, Q10, Q25, Q50.

Arrow indicating downstream direction.]
Results - XS3 geometry
Results - XS3 geometry

channel constriction
Results - XS2 geometry

Is this too much?
Results – Sediment Yield
Results – Sediment Yield
Warner Creek confluence with Stony Clove Creek – Pre and Post Hurricane Irene

Photos: Danny Davis
• A preliminary test of CONCEPTS model in a mountain setting

• This is work in progress!

• Model capable of simulating sediment deposition, degradation and transport by size classes

• Model results highly sensitive to input data
  • Channel geometry
  • Bed material composition

• Realistic simulation in the study region requires model changes

• A potential tool for developing scenarios?
  • Management
  • Climate change
Future work

• Better characterization of stream bed
  • Include stream bed sediment size classes observed in the Catskills (Large cobbles & Boulders!)
  • Needs model modification

• Collect site specific data
  • Resistance to erosion properties
  • Representative channel geometry

• Compare model runs with monitoring data
  • Channel geometry over time/ historical
  • Water quality (fine sediment)

• Develop scenarios
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