Modeling the Impact of Wildfire on Reservoir Capacity

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Objectives

1. Research parameter inputs for a pre-existing capacity model and analyze outputs in comparison to survey data.

2. Adjust the model to simulate yearly fire frequency via modified sedimentation rates.
Tributaries upstream of Ruth Lake

Fire-Flood Regime

• Fire impact
  • Hydrophobic soils = lowers soil infiltration
  • Sudden loss of vegetation = increases sediment availability

• Precipitation
  • Cannot infiltrate soil, thus contributes to surface runoff
  • Carries available sediment down stream

“Event-based surface runoff to rainfall ratios approached 0.45 during the first year post wildfire, compared to reported values <0.01…”


Methods Overview

I. Review capacity modeling done by Minear and Kondolf.

II. Data collection of Ruth Lake and research of various parameter values.

III. Addition to previous model of varying sedimentation rate to reflect fire events.

IV. Capacity estimation comparisons between:
   A. Minear’s original spreadsheet model
   B. Survey data of Ruth Lake
   C. Modified (for fire regime) spreadsheet model
I. Summary of Reservoir Capacity Model by Minear & Kondolf

Objectives

1. Apply the median sedimentation yield of surveyed reservoirs in a geomorphic region to un-surveyed reservoirs of the same region.

2. Predict future yearly reservoir capacities in reservoirs based on region.

Sedimentation relationships modeled by Minear and Kondolf

Trap efficiency (%)\[ T_e = 1 - \frac{1}{1 + 0.1 \times \left( \frac{K_{t-1}}{1233.482} \right) \times \frac{W}{2.59}} \]

Reservoir sedimentation (m$^3$)\[ R = T_e \times W \times Y \]

Reservoir capacity (m$^3$)\[ K = K_{t-1} - R \]

\( W = \) Watershed area (km$^2$)
\( K_{t-1} = \) Previous year’s capacity (m$^3$)
\( Y = \) Regional median sedimentation rate (m$^3$/km$^2$/yr)

## II. Data collection of Ruth Lake

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Minear &amp; Kondolf</th>
<th>Alternative inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Capacity (m³)</td>
<td>63,894,368</td>
<td>59,244,044 (Ruth Lake Community District Services, 2014)</td>
</tr>
<tr>
<td>Watershed Area, W (km²)</td>
<td>310.8</td>
<td>313.389 (USGS, 2016)</td>
</tr>
<tr>
<td>Regional (Coastal) sedimentation rate, Y (m³/km²/year)</td>
<td>261.83</td>
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</tr>
<tr>
<td>Trap efficiency</td>
<td>0.9774</td>
<td>0.9754</td>
</tr>
<tr>
<td>Reservoir 2016 capacity (m³)</td>
<td>59,523,337</td>
<td>54,845,930</td>
</tr>
</tbody>
</table>


III. Adjustments to Minear’s spreadsheet

Fire frequencies

- Each year was assigned as a “fire year” or “non-fire year”
- Evaluated every 40, 30, 20, 10, and 5 years

Sedimentation, Y, for fire years was estimated using RUSLE

Sedimentation, Y, for non-fire years was evaluated at three different values based on various input parameters

<table>
<thead>
<tr>
<th>Source</th>
<th>Y (m³/km²/year)</th>
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<tr>
<td>Minear &amp; Kondolf regional median</td>
<td>261.83</td>
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<tr>
<td>RUSLE 2007</td>
<td>82.14</td>
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<tr>
<td>Observations (Matthews, 2007)</td>
<td>147.25</td>
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## IV. Capacity estimation comparisons

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<tr>
<th>Model Scenario</th>
<th>Sedimentation input unburned (m³/km²/year)</th>
<th>Sedimentation input fire (m³/km²/year)</th>
<th>2016 Capacity (m³) W=310.8 km² K=63,894,368 m³</th>
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<td>Modified fire frequency to every 10 years</td>
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Implications & Suggestions for Further Development

• Survey data could overestimate volume of Ruth Lake, even though capacity seems low compared to other projections
  • Survey capacity = 49,741,375 m$^3$
  • Conducted after 2015 fire, but before a major precipitation event

• Fire frequency does not have a drastic impact on reservoir capacity in this simplified model adjustment
  • Not to say fire events do not have an impact at all
  • ‘On/Off’ pattern does not encompass ecological complexities such as climate, vegetation, soil factors, and precipitation.

• Specify sediment yields to reflect rainfall after wildfire
  • Simulate various precipitation events: Intensity-Duration-Frequency curve
Intensity-Duration-Frequency curve

Thank you

Questions?
References


