The Impacts of Large-Scale Forest Disturbance on Hydrology in Central British Columbia, Canada

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Outline

- Why large-scale studies?
- How to quantify large-scale forest disturbances?
- A case study on linking forest disturbance and hydrology
Why Large Scale Forest Hydrology?

Firstly, large-scale research is limited.
Why Large Scale Forest Hydrology?

Other reasons:

- Difficulty to extrapolate research results from small to large scales
- Large-scale forest disturbance becomes more frequent
- Many management issues are at large watershed or landscape scales
Large Scale Forest Disturbance

- Significant cumulative timber harvesting over a relatively short period
- Natural disturbance
  - Wildfire
  - Windstorm
  - Insects and diseases
  - Others
Cumulative Timber Harvesting
Okanagan mountain park forest fire in 2003
Storms
Large-scale mountain pine beetle damage in BC, Canada
In large-scale watersheds, different forest disturbances are cumulative over space and time. The challenge is how to use a quantitative indicator to represent them.
Concept of equivalent disturbance area (EDA): Area of disturbance with consideration of hydrological recovery.
Linking Forest Disturbance and Hydrology Using Two Neighbouring Watersheds: Bowron and Willow in BC

- Both watersheds have similar size (3000 km²), climate and vegetation

- Excellent data availability
  - Streamflow data (>50 years)
  - Digital disturbance historical data (>50 years)
  - Climate data (3-4 long-term stations)
Research Methods

- Time series analysis
  - Cross-correlation
- Non-parametric tests
  - Spearman rho
  - Kendall tau correlations
- Where there is a significance, the magnitude of change is quantified by comparing comparable peak and mean flows
Hydrological Variables Examined

- Selection of variables:
  - annual maximum daily flow
  - 7-days low flow
  - mean flow

- Separation of Hydrological Processes
  - P1: spring snow-melt (April--June)
  - P2: summer rain (July--Oct.)
  - P3: winter base flow (Nov.--March)
  - annual series
Annual logging area

EDA
## Sample Result: Cross-correlation Analysis Between EDA and Hydrology in Willow Watershed

<table>
<thead>
<tr>
<th>Series</th>
<th>ARIMA model</th>
<th>(P value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual mean</td>
<td>( \text{Ln}(1,0,3)(1,1,0)^{16} )</td>
<td>0.3513 (&lt;0.05)</td>
</tr>
<tr>
<td>Annual max</td>
<td>( \text{Ln}(1,1,3) )</td>
<td>0.4331 (&lt;0.05)</td>
</tr>
<tr>
<td>Annual low</td>
<td>((0,0,1)^1(0,1,1)^{12})</td>
<td></td>
</tr>
<tr>
<td>P1 mean</td>
<td>( \text{Ln}(3,0,0)(1,0,1)^9 )</td>
<td>0.3101 (0.014)</td>
</tr>
<tr>
<td>P1 max</td>
<td>( \text{Ln}(3,0,1)(1,0,0)^9 )</td>
<td>0.4287 (&lt;0.05)</td>
</tr>
<tr>
<td>P1 low</td>
<td>( \text{Ln}(1,0,0)^{15} )</td>
<td></td>
</tr>
<tr>
<td>P2 mean</td>
<td>( \text{Ln}(2,0,2) )</td>
<td></td>
</tr>
<tr>
<td><strong>P2 max</strong></td>
<td>((3,0,0)(1,0,0)^9)</td>
<td>0.3150 (&lt;0.05)</td>
</tr>
<tr>
<td>P2 low</td>
<td>( \text{Ln} )</td>
<td></td>
</tr>
<tr>
<td>P3 mean</td>
<td>( \text{Ln}(1,1,1)^1(0,0,1)^{12} )</td>
<td></td>
</tr>
<tr>
<td>P3 max</td>
<td>( \text{X}^0.5,(1,1,1) )</td>
<td></td>
</tr>
<tr>
<td>P3 low</td>
<td>((0,0,1)^1(0,1,1)^{12} )</td>
<td></td>
</tr>
</tbody>
</table>
Two Contrasted Results

- Forest harvesting in the Willow watershed significantly increased mean and peak flows for annual and spring snow-melt (April to June) periods.

- In contrast, the hydrological variables in the Bowron watershed showed either no significant responses to large-scale logging or were inconclusive.

- Why?
De-synchronization Effects in Bowron
Magnitude of Change in Mean Flows in Willow Watershed

Fig. 2 Cumulative disturbance effect on annual streamflow
Magnitude of Change in Peak Flows in Willow Watershed
General Conclusions

- Impacts of forest disturbances on hydrology must be defined in a watershed context.
- Statistical approach (i.e. time series analysis) is an useful approach for studying large-scale forest hydrology.
- Powerful software and GIS make the approach possible.
Thank you and welcome to visit Okanagan