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

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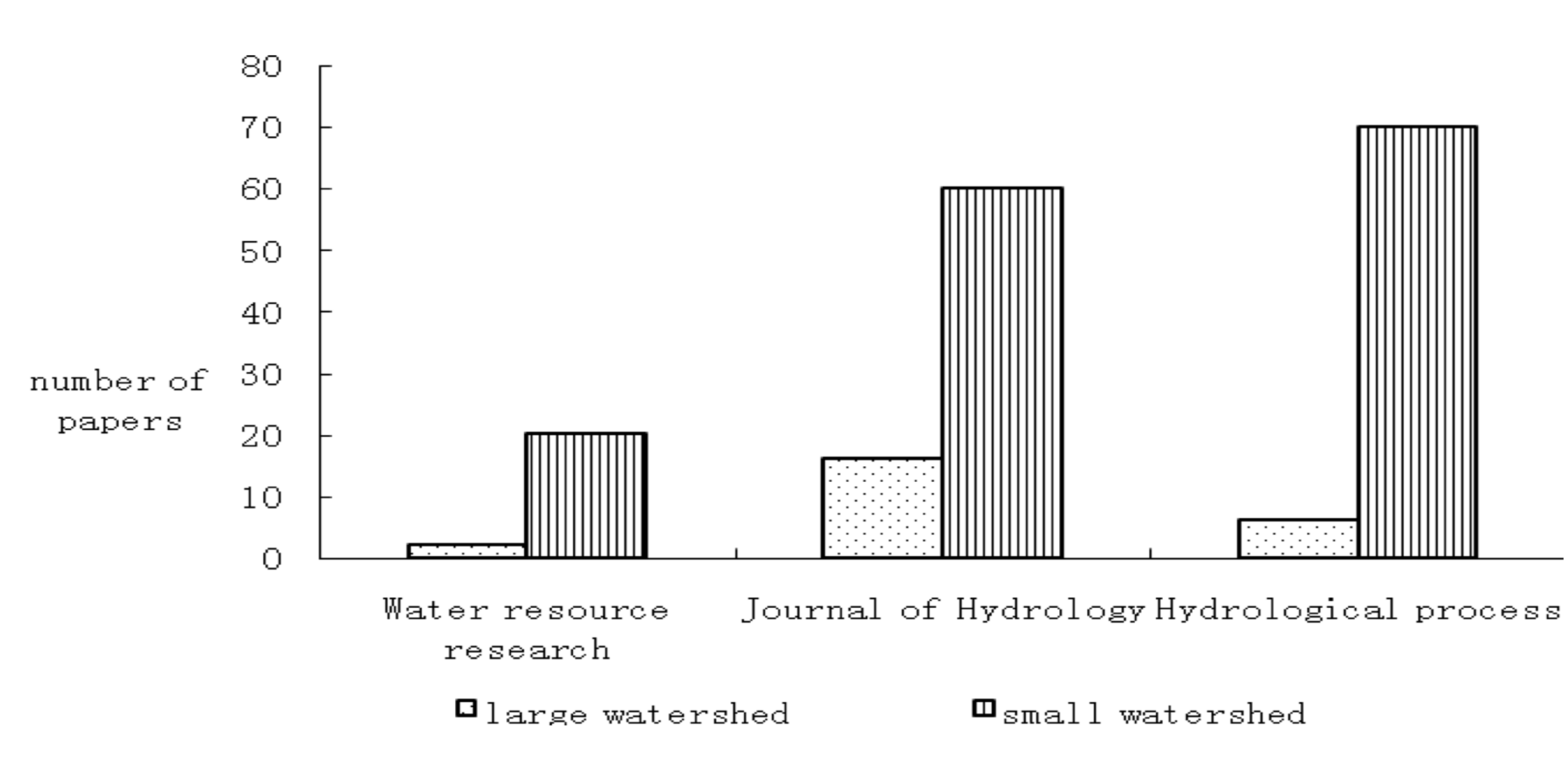
Outline

- 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

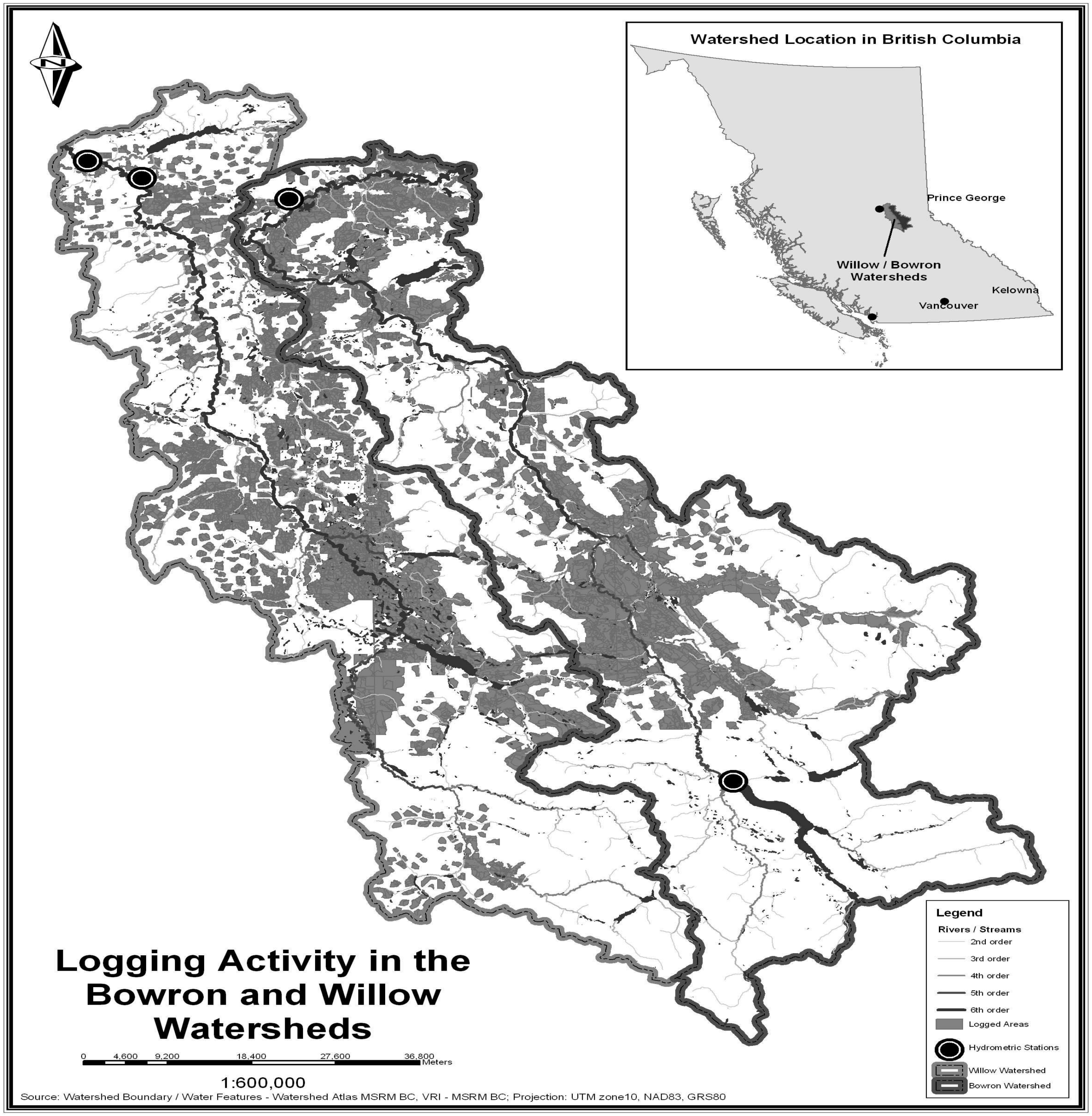
- Both watersheds have similar size (3000 km^2), climate and vegetation
- Excellent data availability
  - Streamflow data (>50 years)
  - Digital disturbance historical data (>50 years)
  - Climate data (3-4 long-term stations)

Research Methods

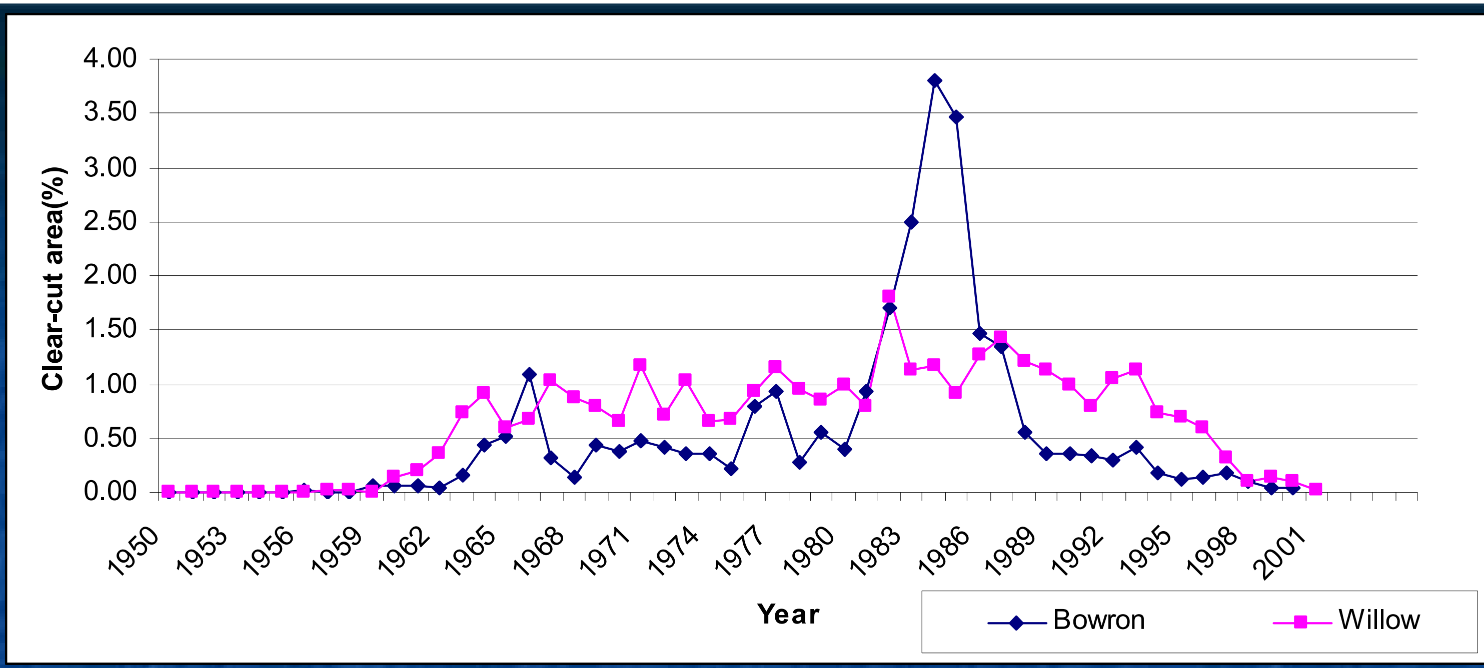
- Time series analysis
  - Cross-correlation
- Non-parametric tests
  - Spearman rho
  - Kendall tau correlations
- Where there is a significance, the magnitude of change is quantified by comparing comparable peak and mean flows

Hydrological Variables Examined

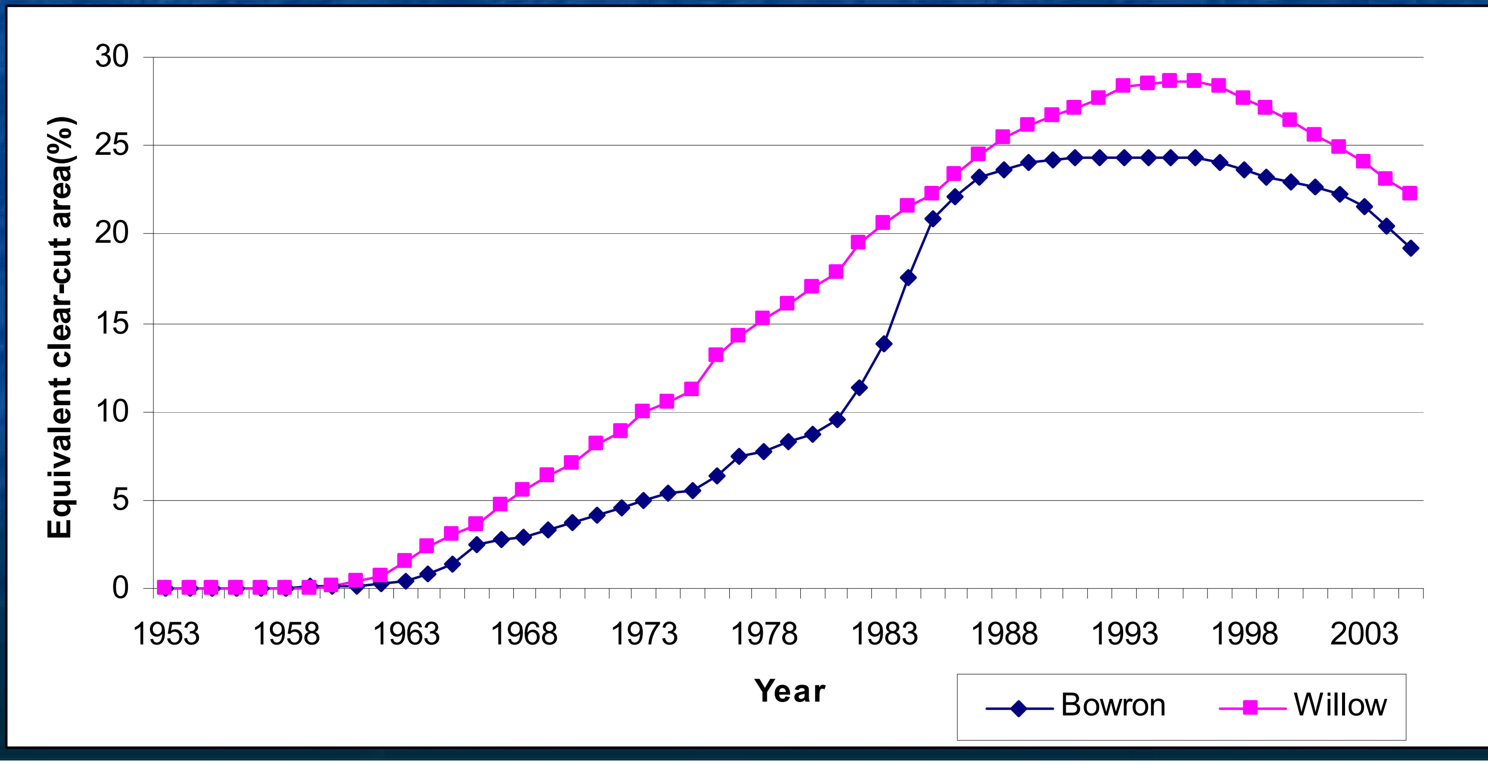
- Selection of variables:
  - annual maximum daily flow
  - 7-days low flow
  - mean flow
- Separation of Hydrological Processes
  - P1: spring snow-melt (April--June)
  - P2: summer rain (July--Oct.)
  - P3: winter base flow (Nov.--March)
  - annual series


Logging Activity in the Bowron and Willow Watersheds
Watershed Location in British Columbia
Prince George
Willow / Bowron Watersheds
Kelowna
Vancouver
N
0 4,600 9,200 18,400 27,600 36,800 Meters
1:600,000
Source: Watershed Boundary / Water Features - Watershed Atlas MSRM BC, VRI - MSRM BC; Projection: UTM zone10, NAD83, GRS80
Legend
Rivers / Streams
2nd order
3rd order
4th order
5th order
6th order
Logged Areas
Hydrometric Stations
Willow Watershed
Bowron Watershed

Annual logging area



EDA



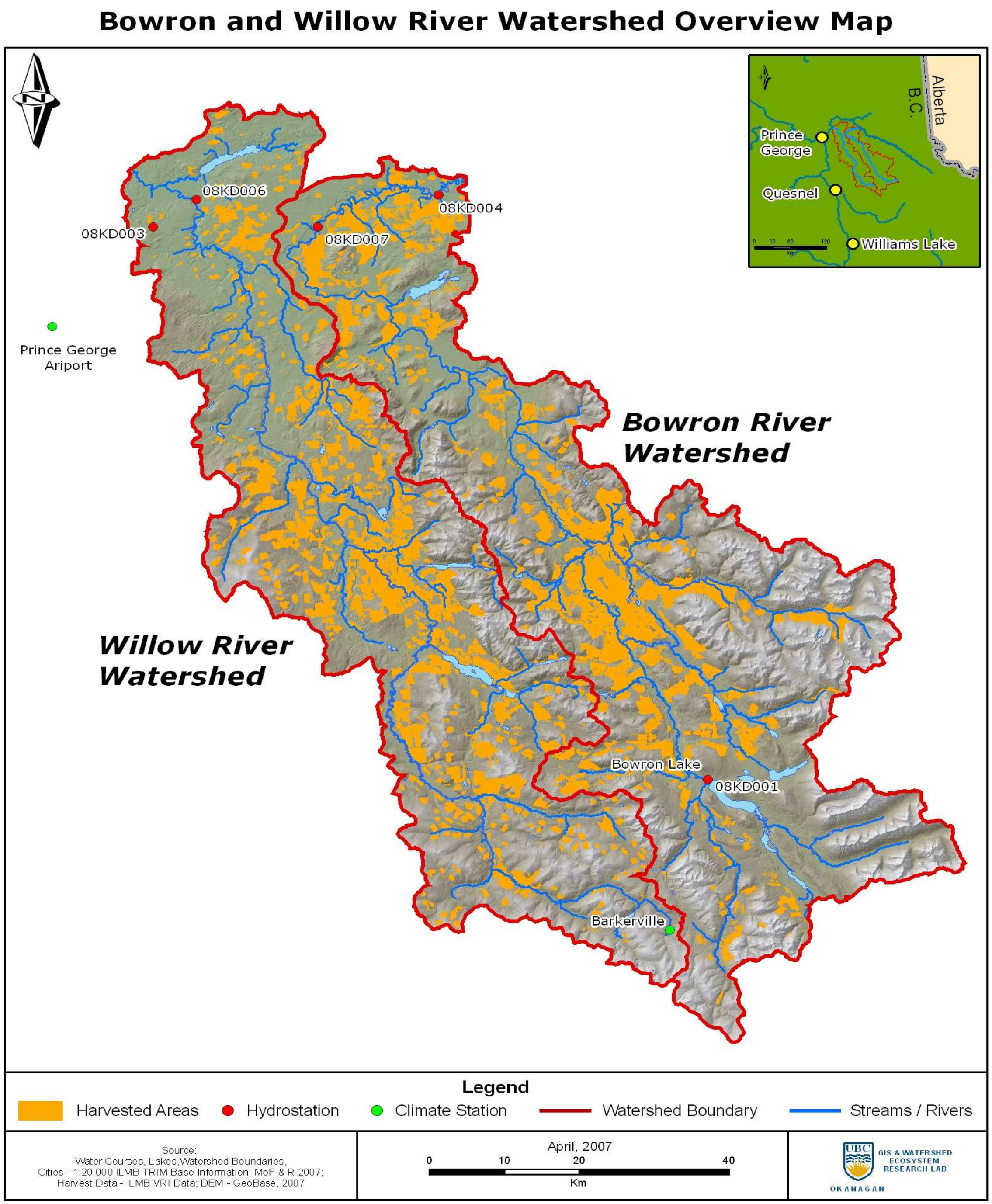
Sample Result: Cross-correlation Analysis Between EDA and Hydrology in Willow Watershed

Series	ARIMA model	(P value)
Annual mean	Ln,(1,0,3)(1,1,0)^{16}	0.3513 (<0.05)
Annual max	Ln,(1,1,3)	0.4331 (<0.05)
Annual low	(0,0,1)^{1}(0,1,1)^{12}	
P1 mean	Ln,(3,0,0)1(1,0,1)^{9}	0.3101 (0.014)
P1 max	Ln,(3,0,1)(1,0,0)^{9}	0.4287 (<0.05)
P1 low	Ln,(1,0,0)^{15}	
P2 mean	Ln,(2,0,2)	
P2 max	(3,0,0)(1,0,0)^{9}	0.3150 (<0.05)
P2 low	ln	
P3 mean	Ln(1,1,1)^{1}(0,0,1)^{12}	
P3 max	X^0.5,(1,1,1)	
P3 low	(0,0,1)^{1}(0,1,1)^{12}	

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

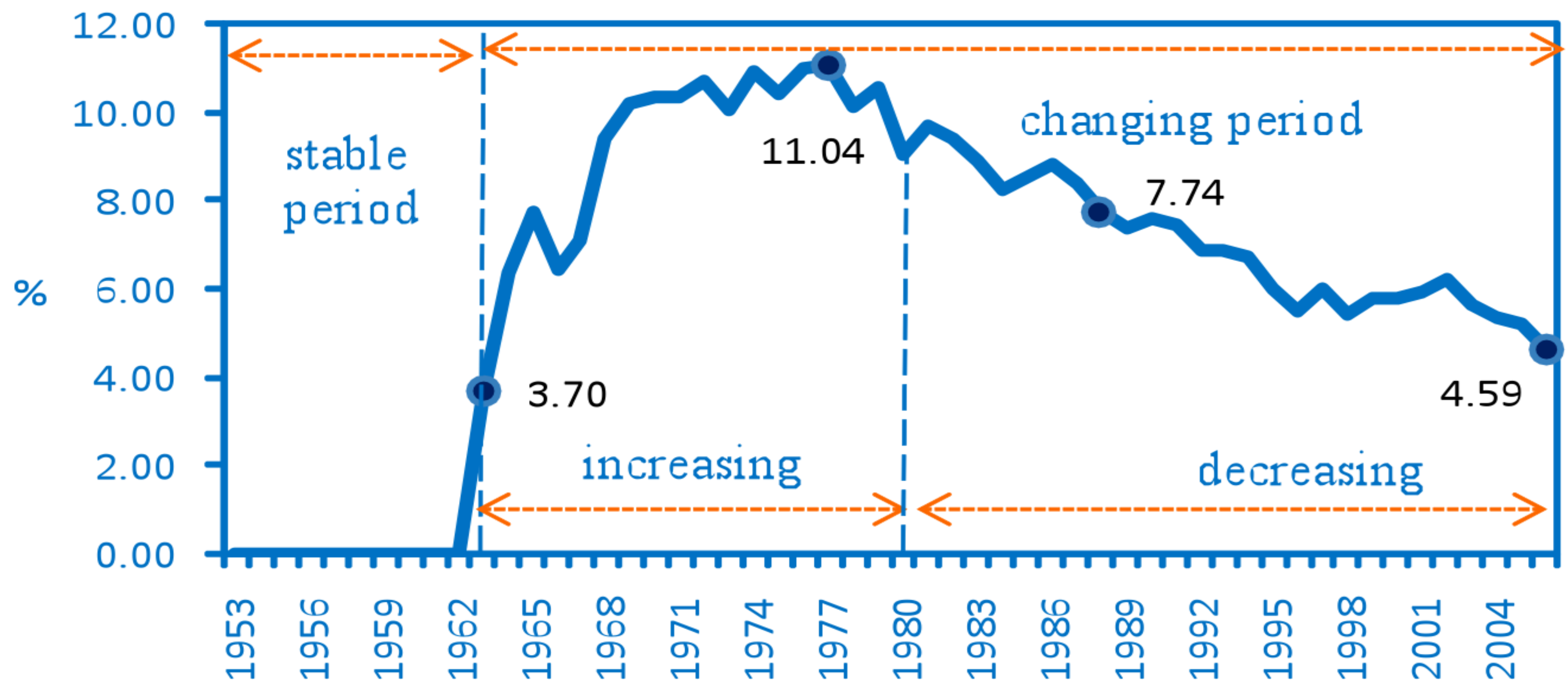
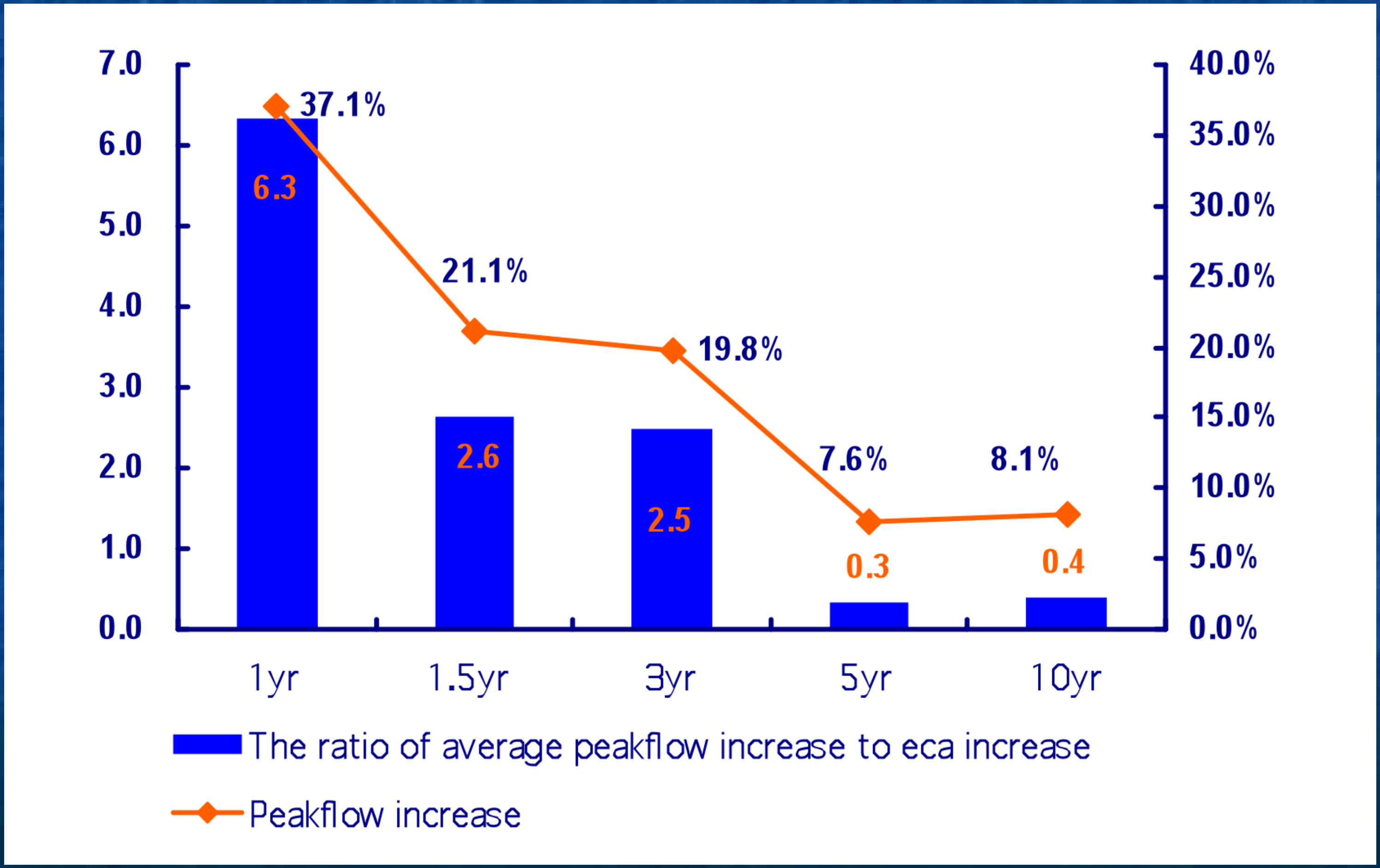


Fig. 2 Cumulative disturbance effect on annual streamflow

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