Gravel-bed river morphodynamics and large wood dynamics

Maxime Boivin, Thomas Buffin-Bélanger, Hervé Piégay

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Context and stakes

- Clear need to develop management tools and strategies to deal with large wood in medium to large rivers (Kasprak et al., 2022) and in rivers of cold regions (Piégay et al., 2015; Boivin et al., 2015).
- An issue with gravel-bed rivers of the Gaspé Peninsula, Quebec (Canada)
  - Active channel shifting due to high-energy flows and non-cohesive banks
  - prone to recruit and transport vast quantities of large wood (LW) in river.
- Case of the delta of the Saint-Jean River
  - accumulated wood since 1960, forming a natural raft of more than 3 km long and leading to frequent avulsions over that time period.
  - Unique opportunity to better understand the interactions between river morphodynamics and large wood flux at the basin scale.

Objectives and methods

A) This study aims to determine:
1) Biomorphological trajectory of the reach over 1963-2014
2) The geomorphic controls on wood recruitment and deposits
3) Interannual wood mobility according to discharge conditions

B) Methodology
1) Historical analysis of
   - Channel forms, channel shifting and wood recruited volumes from a set of aerial photos and satellite imagery (1963 to 2012)
   - River discharge, precipitation and historical land-use from archived data
2) Annual surveys from 2010 to 2013 to locate and estimate wood deposits in-channel and standing wood volumes to define characteristics of evolving river morphologies; and to examine the expansion of the raft in the delta.

Results

A) Biomorphological trajectory
- Analysis of the biomorphological trajectory between 1963 and 2013 reveals:
  - An increase in the annual maximum discharge,
  - An increase for bar area
  - An increase for erosion and wood production,
  - And a relationship between wood mobility and discharge conditions.
- The most important changes are concentrated in units A and C.

B) Interrelations between large wood and morphology
- Units A and unit C are both recruiting and trapping wood
- Large wood volume is strongly related with sinuosity, bar surface area and low unit stream power
- Changes in fluvial dynamics can change dynamics of large wood in river:
  - More erosion = increase in wood recruitment
  - Increase in bar surface area = increase roughness and deposition area for LW and more wood available in the channel for transport during flood.
  - Discharge conditions = relationship with wood mobility.
- The morphological trajectory of the Saint-Jean River suggests an increase in fluvial dynamics leading to larger recruitment of wood and increasing wood volume trapped in the river corridor since 2004.
- A combined approach using morphological trajectory can identify keys variables (discharge, erosion rate, bar surface area, sinuosity and unit stream power) necessary for understanding LW dynamics and fluvial dynamics in gravel-bed river systems.
- Managers of the river have decided to dismantle 1.2 km long of the main raft (fig. 7).
- The results of our studies have helped to manage the operator’s position in the dismantling of the raft. The analysis of the biomorphological dynamics encourages managers to work preventively to avoid the return of the raft.

Discussion

- Changes in fluvial dynamics can change dynamics of large wood in river:
  - More erosion = increase in wood recruitment
  - Increase in bar surface area = increase roughness and deposition area for LW and more wood available in the channel for transport during flood.
  - Discharge conditions = relationship with wood mobility.
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