Gravel-bed river morphodynamics and large wood dynamics

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1 Context and stakes

- Clear need to develop management tools and strategies to deal with large wood in medium to large rivers (Kasprak et al., 2012) and in rivers of cold regions (Piégay *et al.* 2015, Boivin *et al.* 2015).
- An issue with gravel-bed rivers of the Gaspé Peninsula, Québec (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.

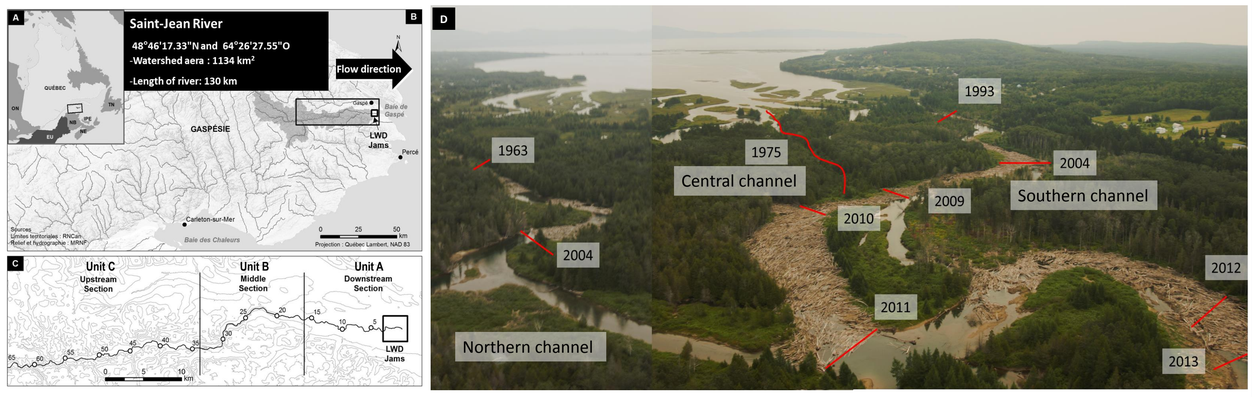

Fig. 1. (A) Large-scale map showing the general location of the Saint-Jean River, Canada. (B) Location of the Saint-Jean River on the Gaspé Peninsula. (C) Detailed map showing the studied river corridor with distance from river mouth in km. (D) Aerial photography (drone) in July 2014 and drawing showing the evolution of the large wood raft surfaces in three channels of the Saint-Jean River delta between 1963 and 2013.

2 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) Internannual wood mobility according to discharge conditions;

B) Methodology

1) Historical analysis of
   A. Channel forms, channel shifting and wood recruited volumes from a set of aerial photos and satellite imagery (1963 to 2013);
   B. 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.

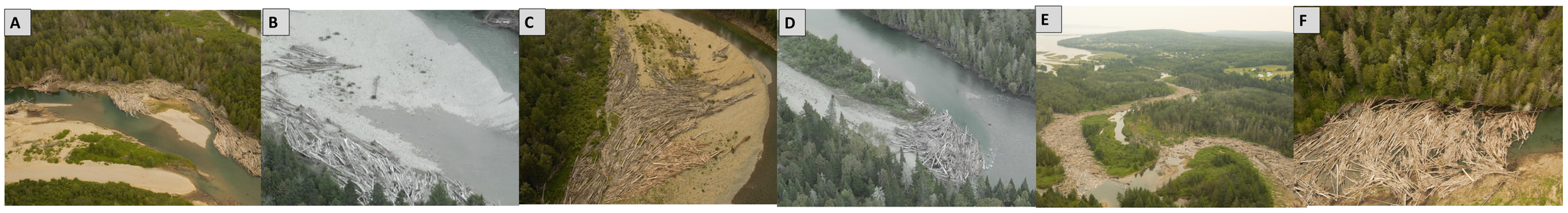

Fig. 2. Five examples of large wood accumulations in the fluvial corridor of Saint-Jean River. (A) meander jams; (B) secondary channel jams; (C) bank deposits jams; (D) bar apex jams and; (E-F) large jams raft.

3 Results

A) Biomorphological trajectory

- Analysis of the biomorphological trajectory between 1963 and 2013 reveal:
  - 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.

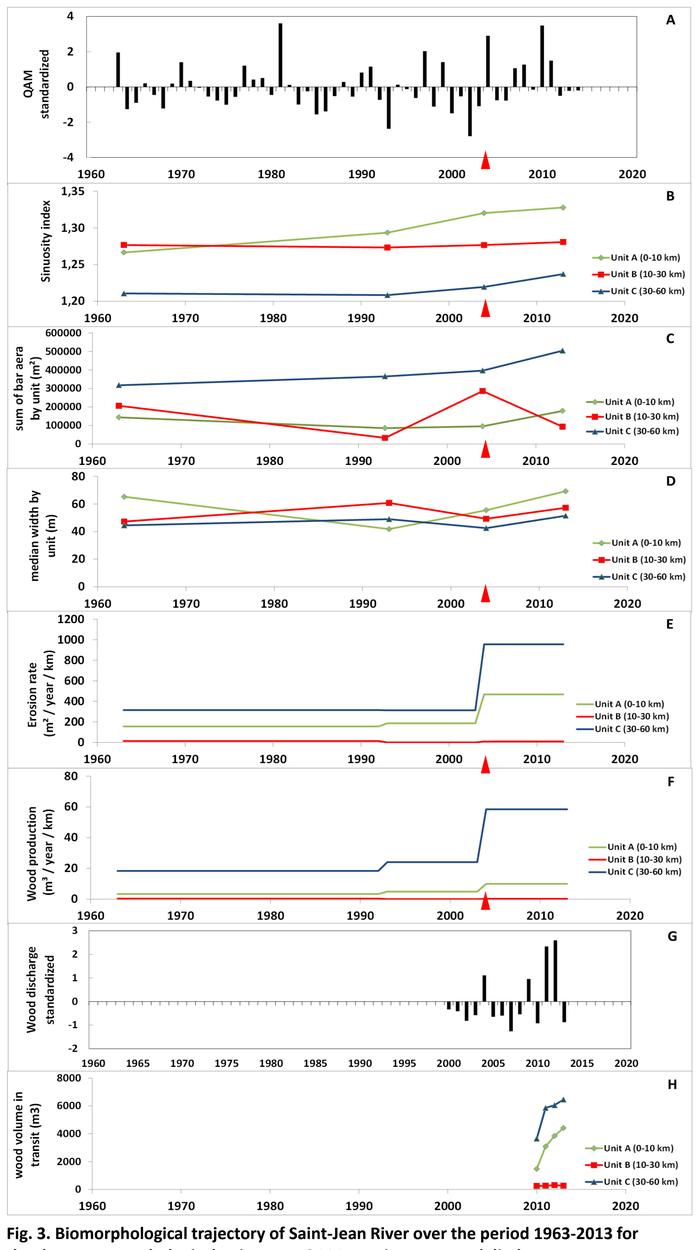

Fig. 3. Biomorphological trajectory of Saint-Jean River over the period 1963-2013 for the three geomorphological units area. QAM: maximum annual discharge.

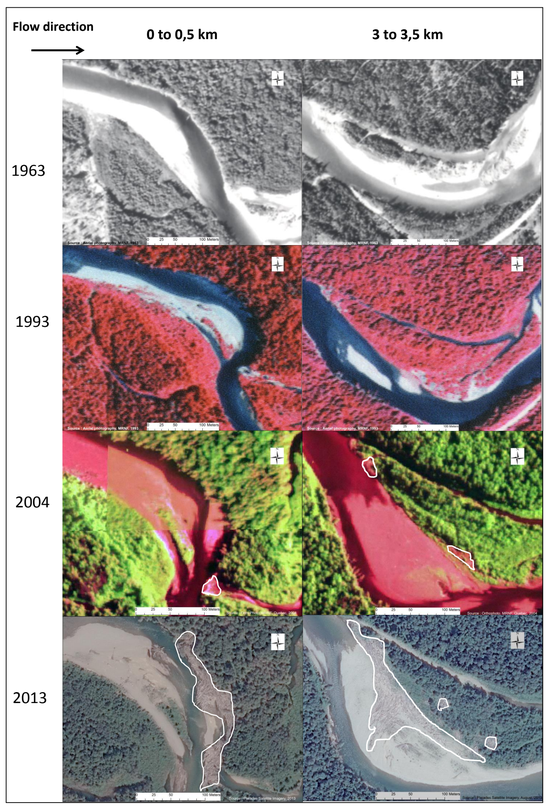

Fig. 4. Two examples of change in the trajectory of channel biomorphology. White line indicate the wood surface.

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

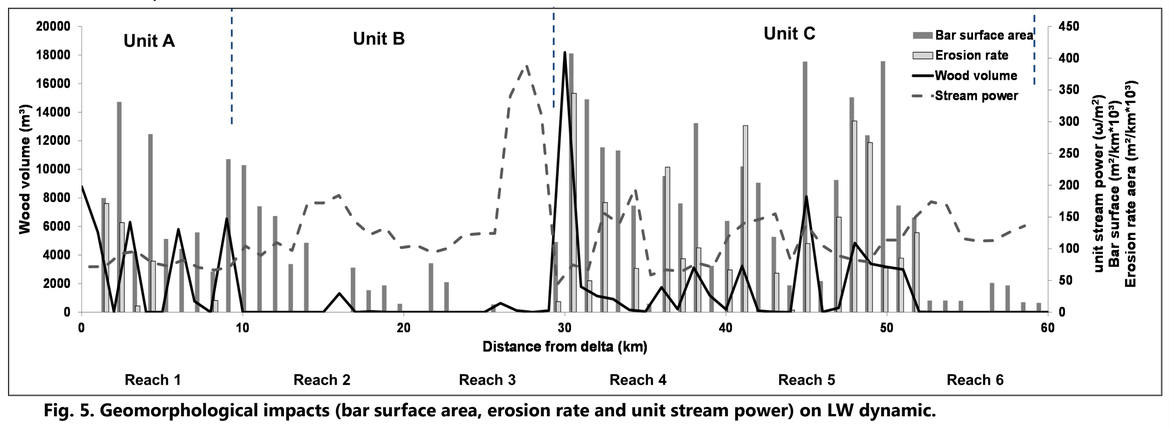

Fig. 5. Geomorphological impacts (bar surface area, erosion rate and unit stream power) on LW dynamic.

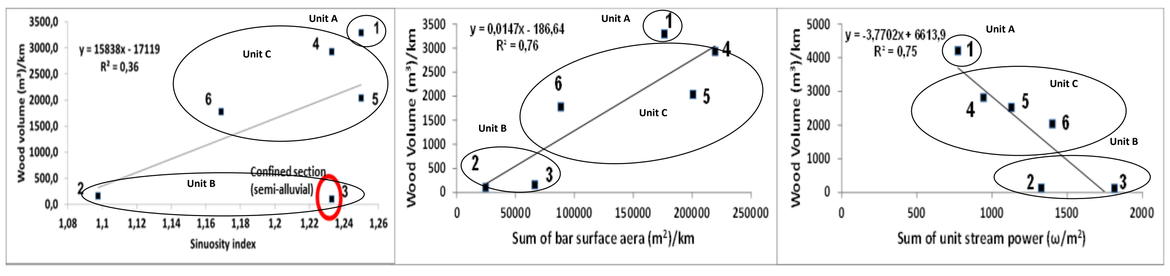

Fig. 6. Geomorphological relation between sinuosity, bar surface area and unit stream power on LW dynamic for the six different reaches . Number (1) indicate the reach in fluvial corridor (Fig.5) and circle indicate the unit.

4 Discussion

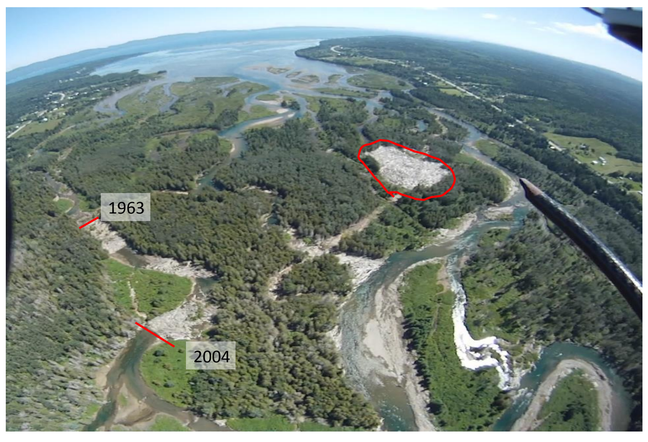

Fig. 7. Aerial view of the Saint-Jean delta in July 2015, after dismantling of the main large raft in the south channel. *The red circle represents the deposition area of the removed wood of the raft in winter 2015.

- Changes in fluvial dynamics can change dynamics of large wood in river;
  - More erosion =» increase in wood recruitment
  - Increase in bar surface area =» increasing 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 consolidate the manager'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.

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