Implementation and validation of large wood analysis for wood budgeting in a semi-alluvial river

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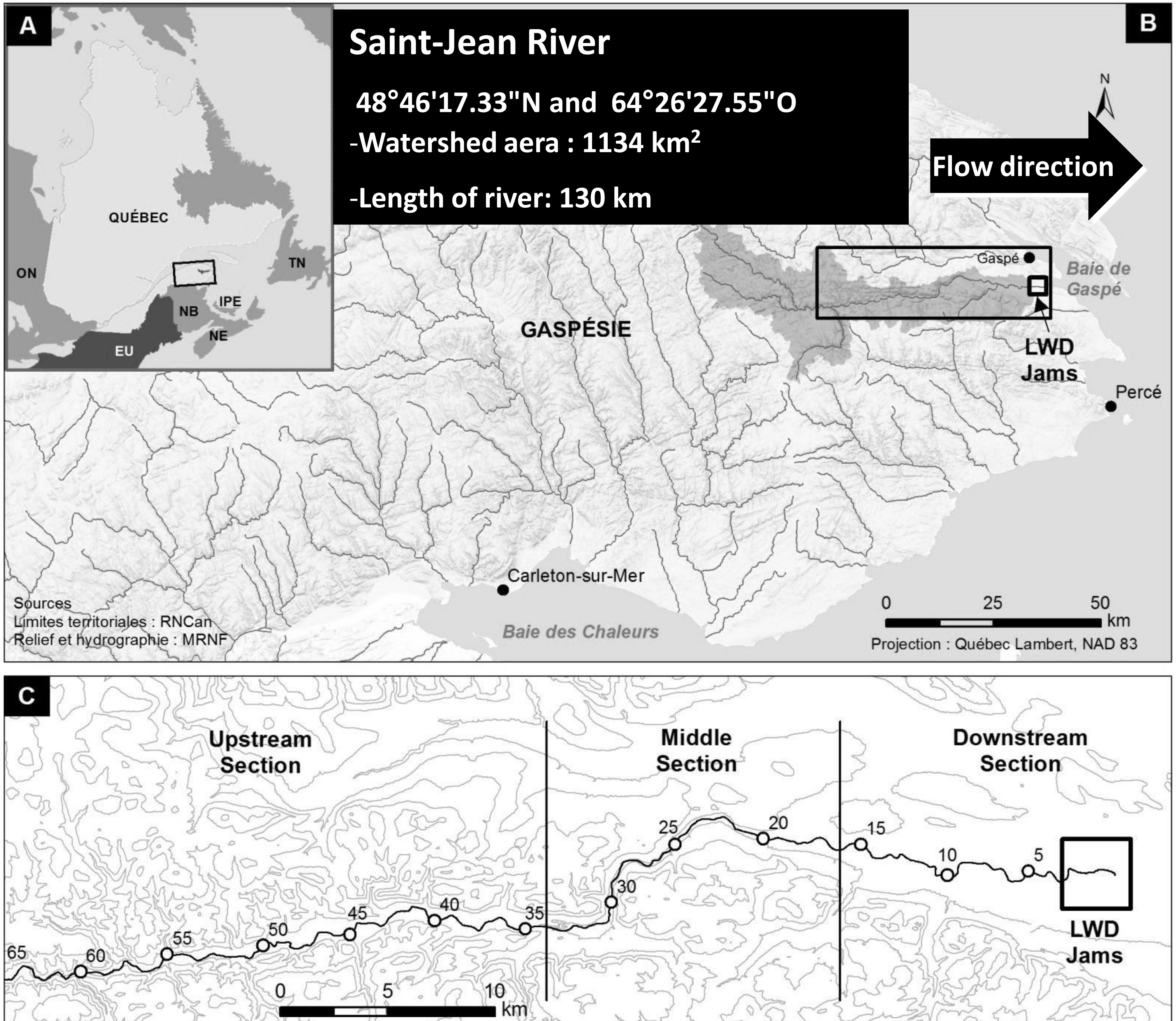
Case of the St-Jean River, Gaspé, Québec



Case of the St-Jean River, Gaspé, Québec

→ Majestic river : 1000$ / day for salmon fishing;

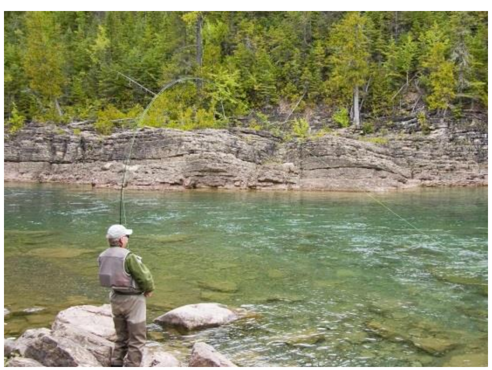
→ 4 million $ in economic benefits for the region;

→ Study site river for salmon and eel habitat;

→ 1960 : emerging of large wood rafts in the delta;

→ 2015 : 3 gigantic rafts;

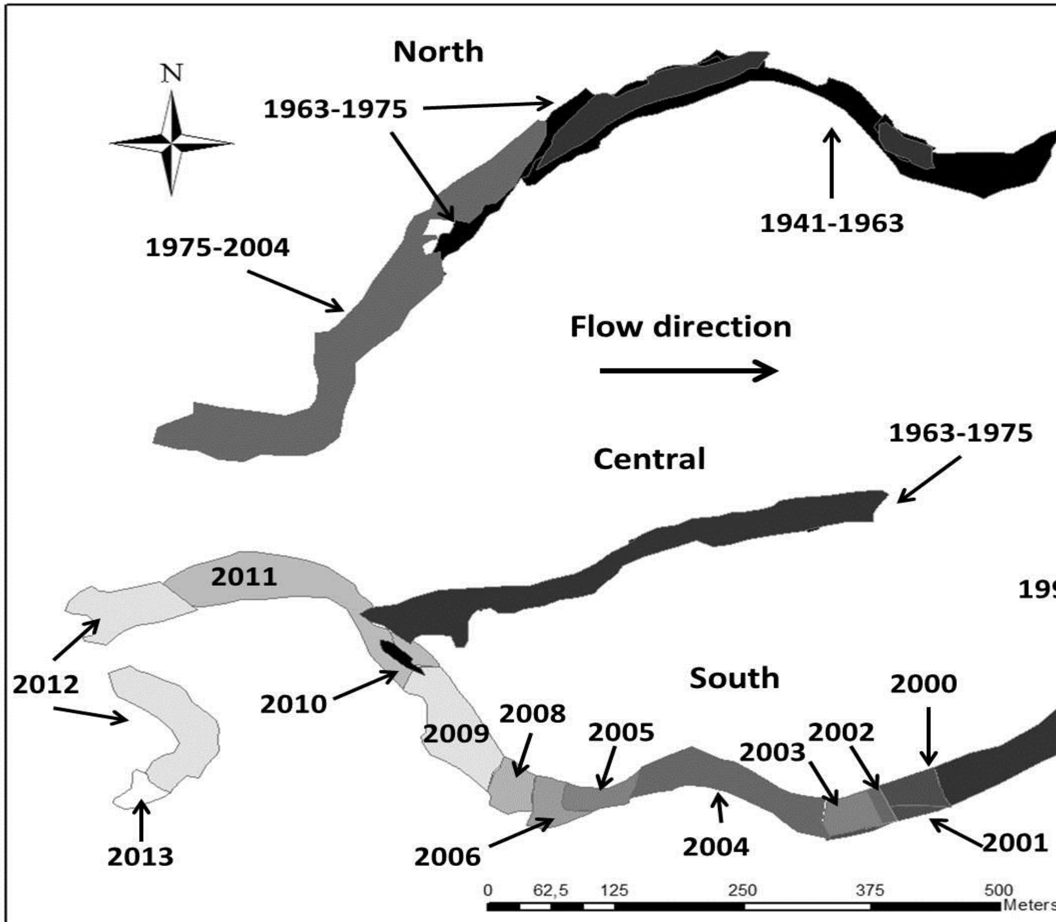
→ The Rafts has an exceptional amount of wood, unusual but natural; (Boivin et al. 2015, Geomorphology)



→ However, the rafts are a source of :

- conflicts between users and managers
- financial stress due to decreasing fishing trips

The Rafts: 1963-2013



Boivin *et al.* (2015)

1. Systematic interannual input in the delta since 1963;
2. Important variability in annual wood input in the delta;

There is a need to develop management tools and strategies to deal with large wood in medium to large rivers and in rivers of cold areas.

Objectives

The overall study aims to develop a LW budget from the analysis of the dynamics of large wood in a semi-alluvial river in a cold region.

Here, the analysis will focus on 3 keys questions pertaining to the wood budget:

1. Where and when does wood recruitment occur within the fluvial corridor for the period 1963-2013
2. Where and when does wood accumulation occur within the fluvial corridor in relation to geomorphic variables for the period 2010-2013;
3. What is the interannual variability of large wood transport in relation to hydrologic variables;

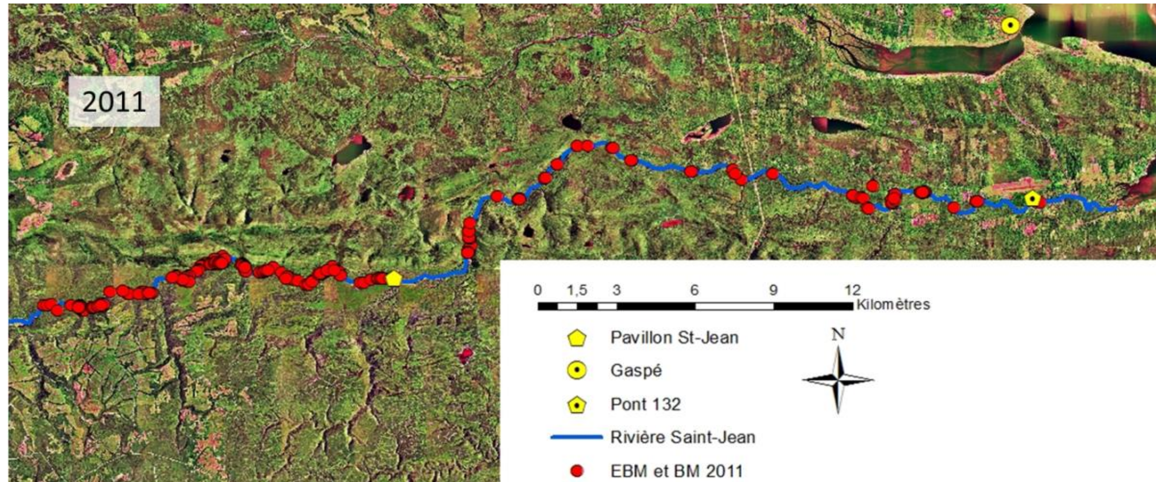
Methodology

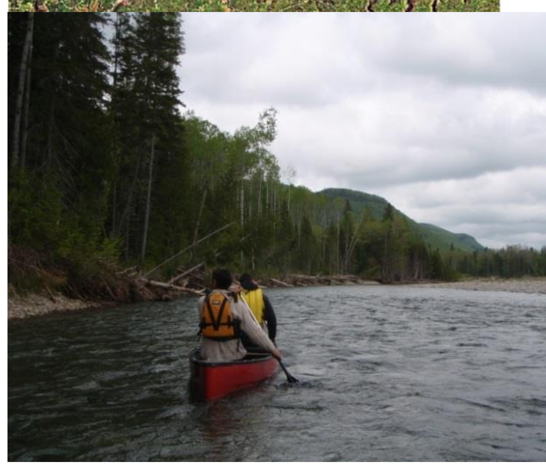
1) Wood in space and time

→ Aerial photos and satellite imagery *to infer wood recrutment and wood accumulation volumes*

→ Field campaigns *to locate and to quantify wood volume within the river*

→ In situ video cameras *to estimate wood discharges and wood transport dynamics*





2) Hydrometeorological data

→ River discharge

→ Precipitation

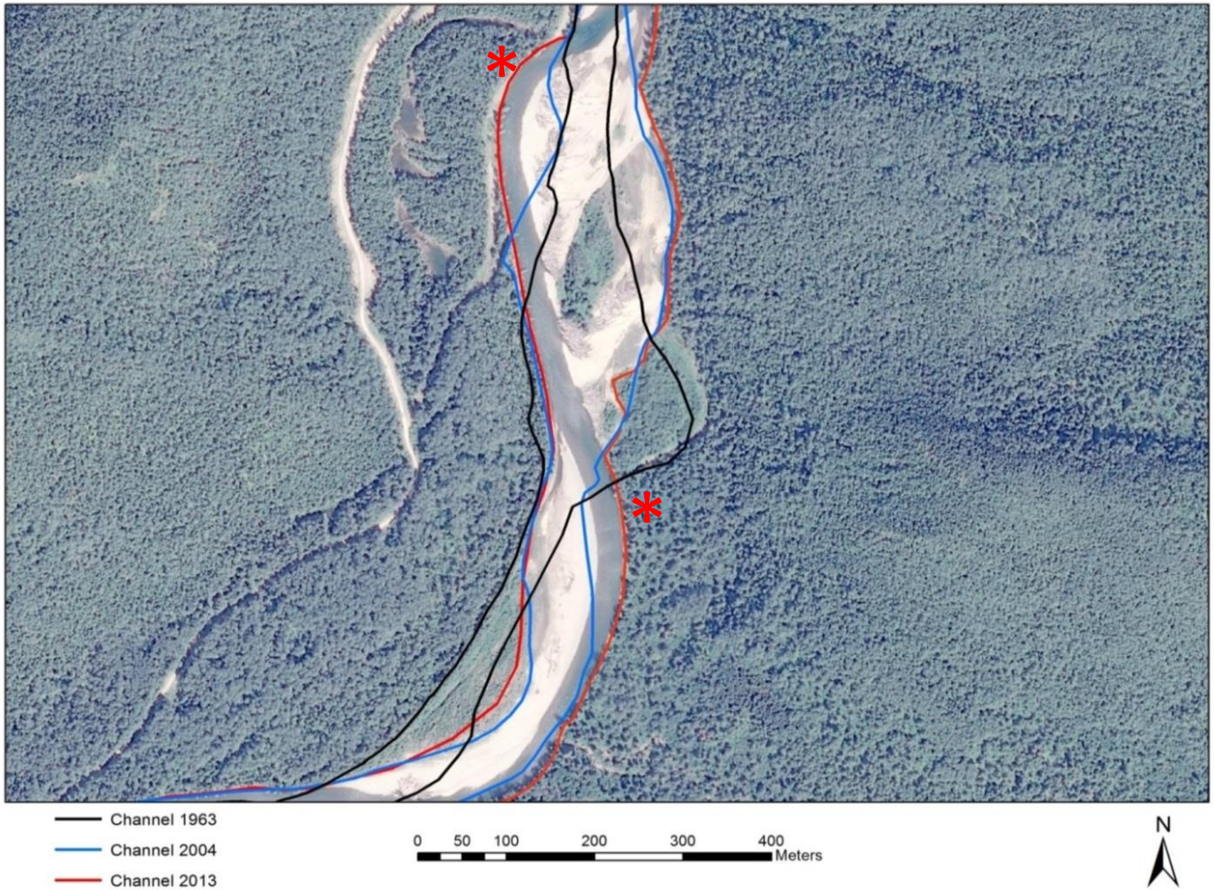
3) Hydrogeomorphological data

→ Aerial photos and satellite imagery *to characterise the geomorphological trajectory*

→ Field campaigns *to define river units and morhologies*

Results

1. Recruitment dynamics : 1963-2013

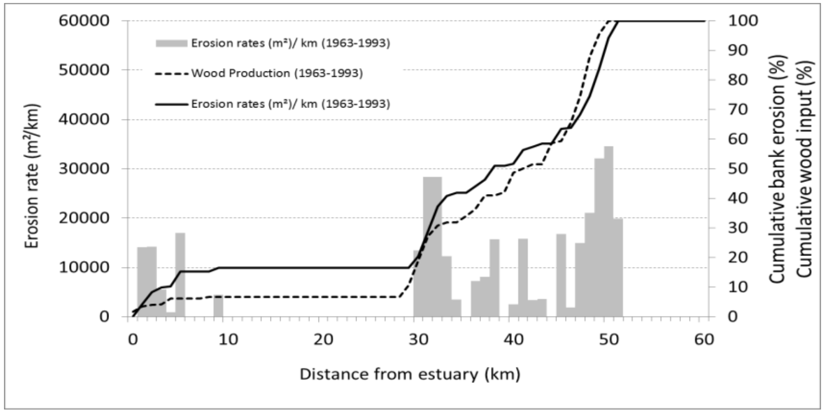


1) Lateral migration and avulsion processes are observed at many locations whereas landslide scars were not observed within the entire river corridor. As a result, wood recruitment results mostly from lateral migration and avulsion on the forested floodplain.

2) Standing wood volume on the floodplain was estimated at 25 locations (*) providing values ranging between 0,02m³ and 0,07m³ per m². The wood recruitment volumes were estimated from the product of wood density by the eroded surface of the floodplain.

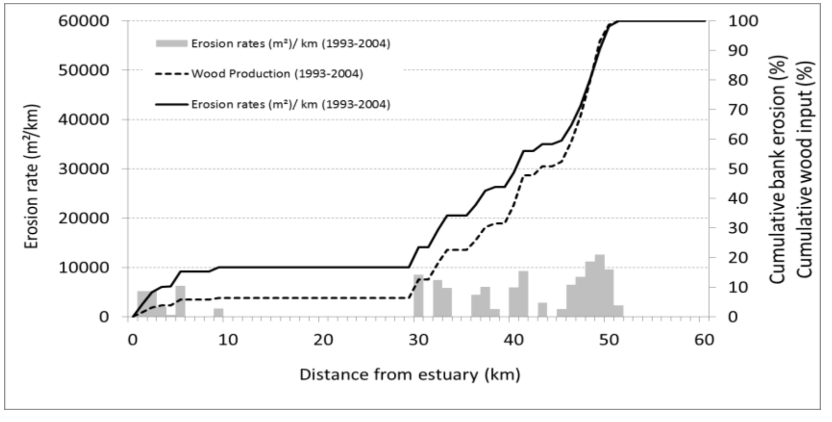
Results

1. Wood recruitment dynamics : 1963-2013



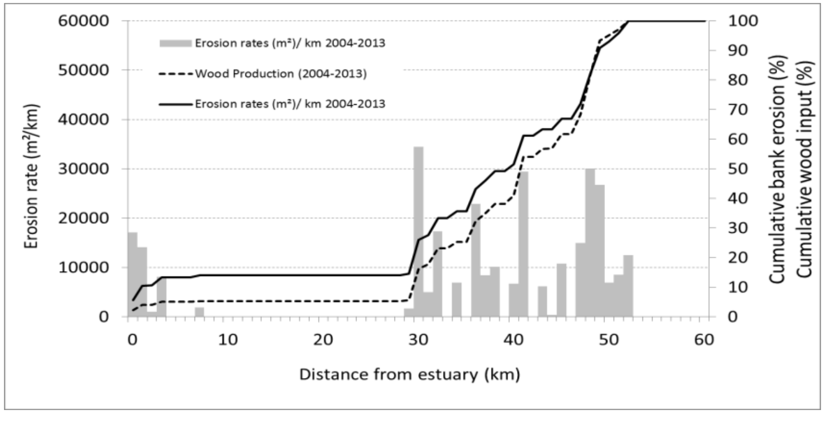
Wood delivery from floodplain (m^3)
1963-1993 : **17 700 m^3 ± 262m^3**

± 590 m^3 ± 8,7m^3 / year



Wood delivery from floodplain (m^3)
1993-2004 : **6 900m^3 ± 102m^3**

630 m^3 ± 9,3m^3 / year



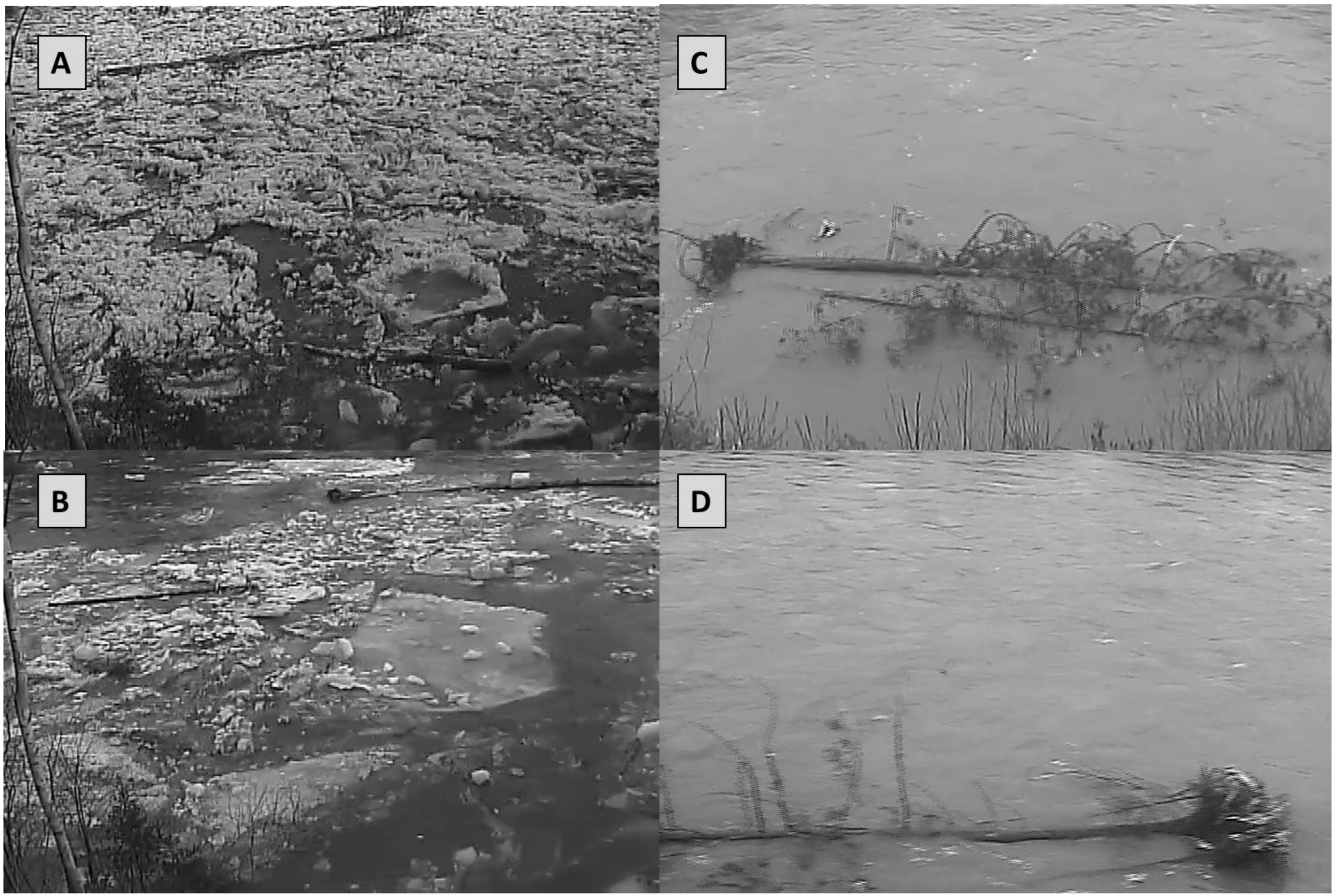
Wood delivery from floodplain (m^3)
2004-2013 : **17 000 m^3 ± 251m^3**

1860 m^3 ± 28m^3 / year

Results

2. Wood accumulation dynamics : 2010-2013

2 types of transport of large wood in northern environments



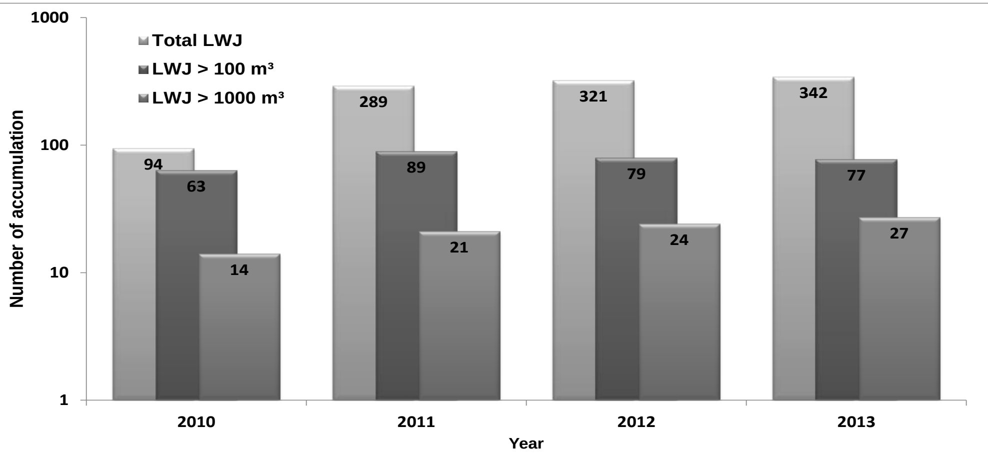
Major ice break up **Hydrometeorological events**

Results

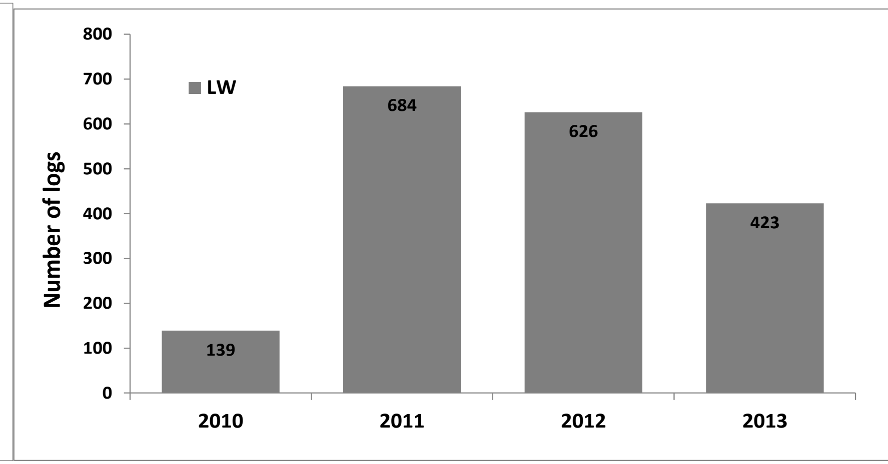
2. Wood accumulation dynamics : 2010-2013

A. Interannual characteristics of large wood (2010-2013)

Large wood jams (LWJ)



Individual large wood (LW)



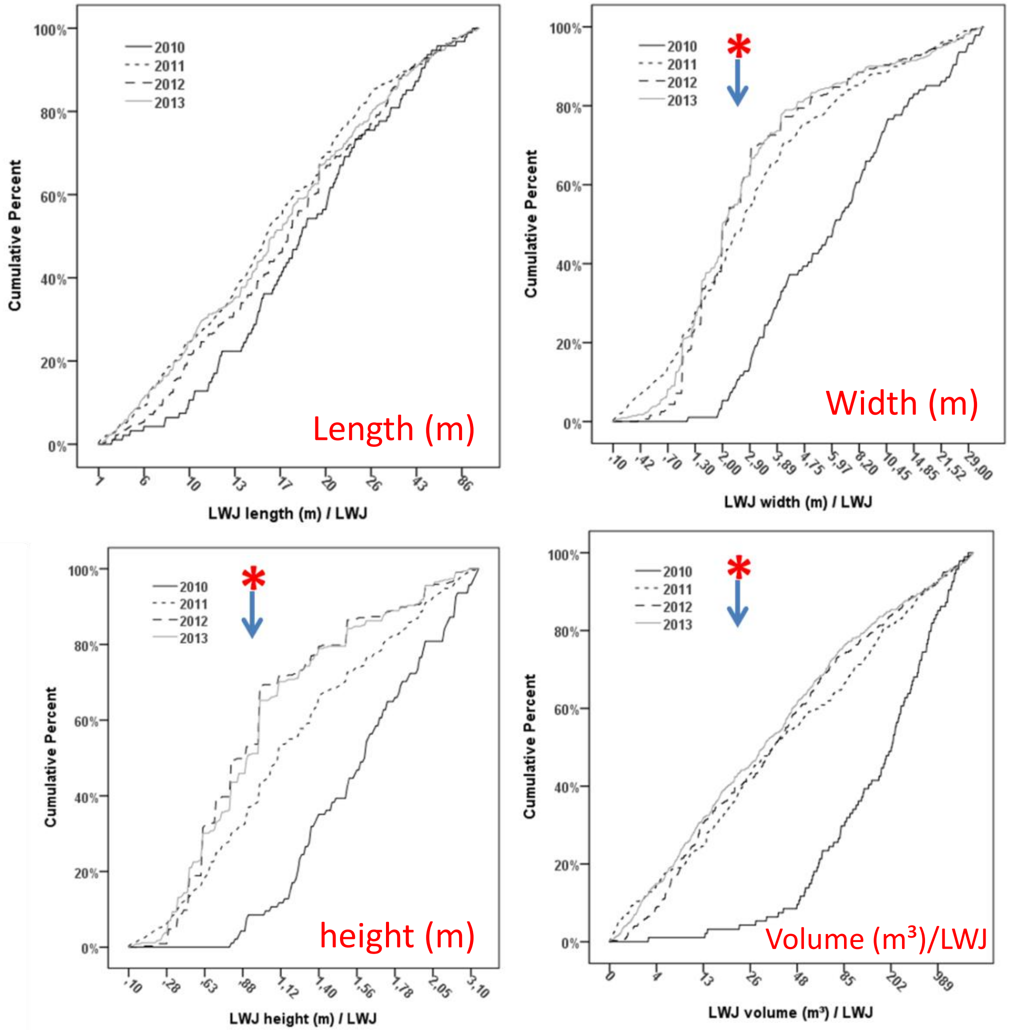
- Increase in the overall wood volume between 2010 and 2013 : ↑ **225%**
- Significantly increasing between 2010 and 2011 : ↑ **207%**
- Significantly increasing LWJ larger than $100 m^3$ and for LWJ larger than $1,000\ m^3$;

- Significant increase of LW between 2010 and 2011 : ↑ **392%**
- Slow decrease until 2013

Results

2. Wood accumulation dynamics : 2010-2013

B. Interannual characteristics of large wood (2010-2013)



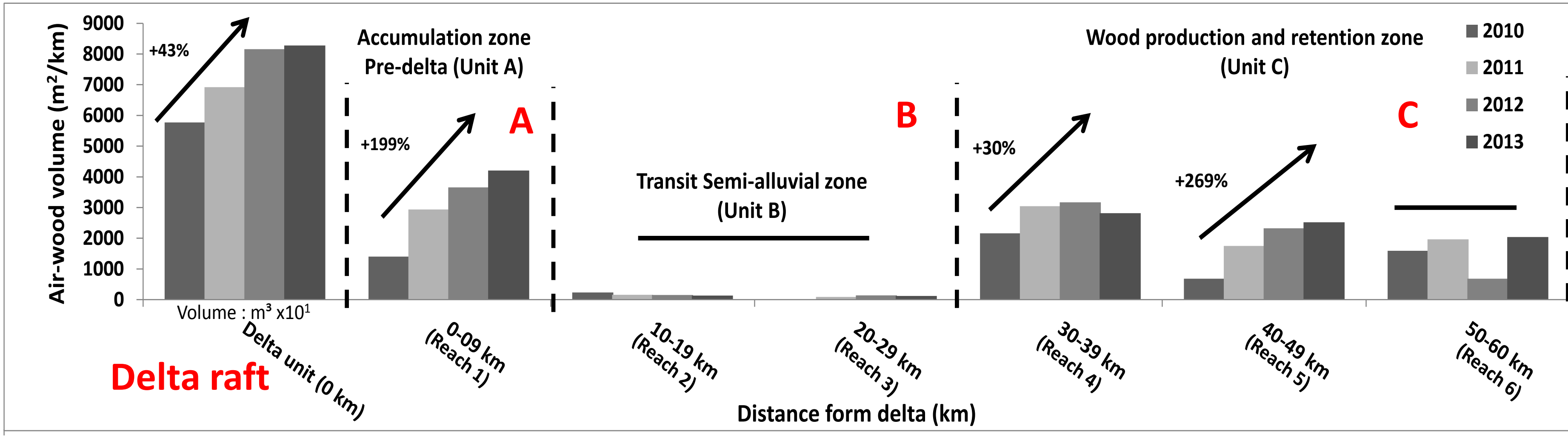
Asterisk (*) shows the variables with a significant change and the arrow shows the direction of change.

- Width, height, wood volume/LWJ, surface area/LWJ and density index have changed significantly between 2010 and 2011-2012-2013; (Anova and Scheffe's test : ***P* < 0.01 (n: 1040)**)
- Characteristics are substantially similar between 2011, 2012 and 2013.

Results

2. Wood accumulation dynamics : 2010-2013

C. Mobility and retention of large wood (2010-2013)



<u>Four large units and six reaches</u> are observed in the river corridor, upstream from the delta :

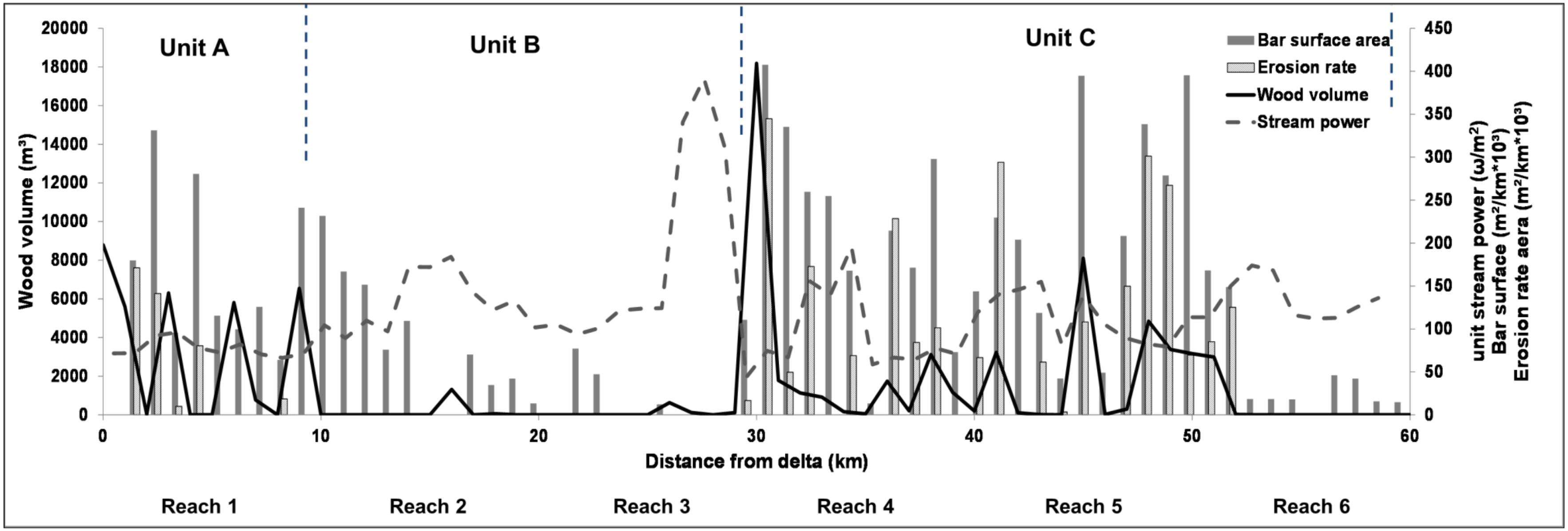
A. The semi-alluvial and alluvial units are the **zones with large accumulation** of LW (0-9km);

B. The semi-alluvial units (10-29km), have lower accumulation and are **the transit zone**;

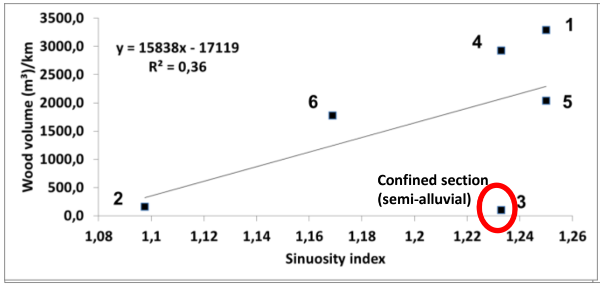
C. The upstream alluvial unit (30-60 km), shows the maximum **retention and production** of LW

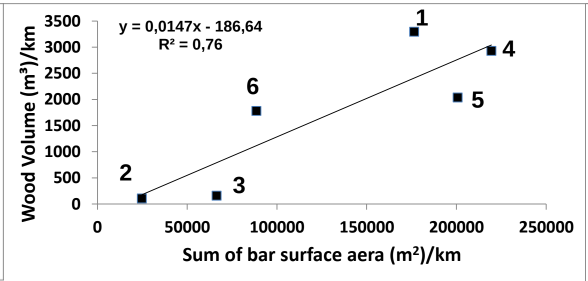
3. Hydro-geomorphological analysis : 1963-2013

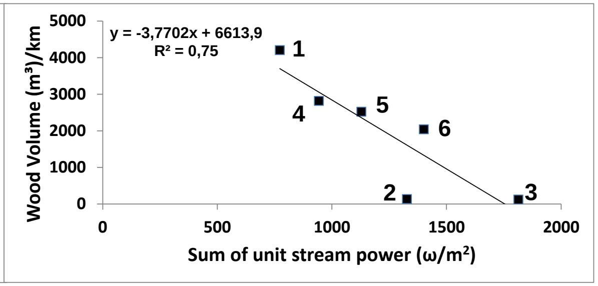
A. Longitudinal distribution of large wood and geomorphology characteristics



- Two sections have the highest contributions to wood recruitment via bank erosion and avulsion (Unit A and Unit C). These sections play a key role in the temporary storage of wood in transit and a large amount remains temporarily stored on bars.



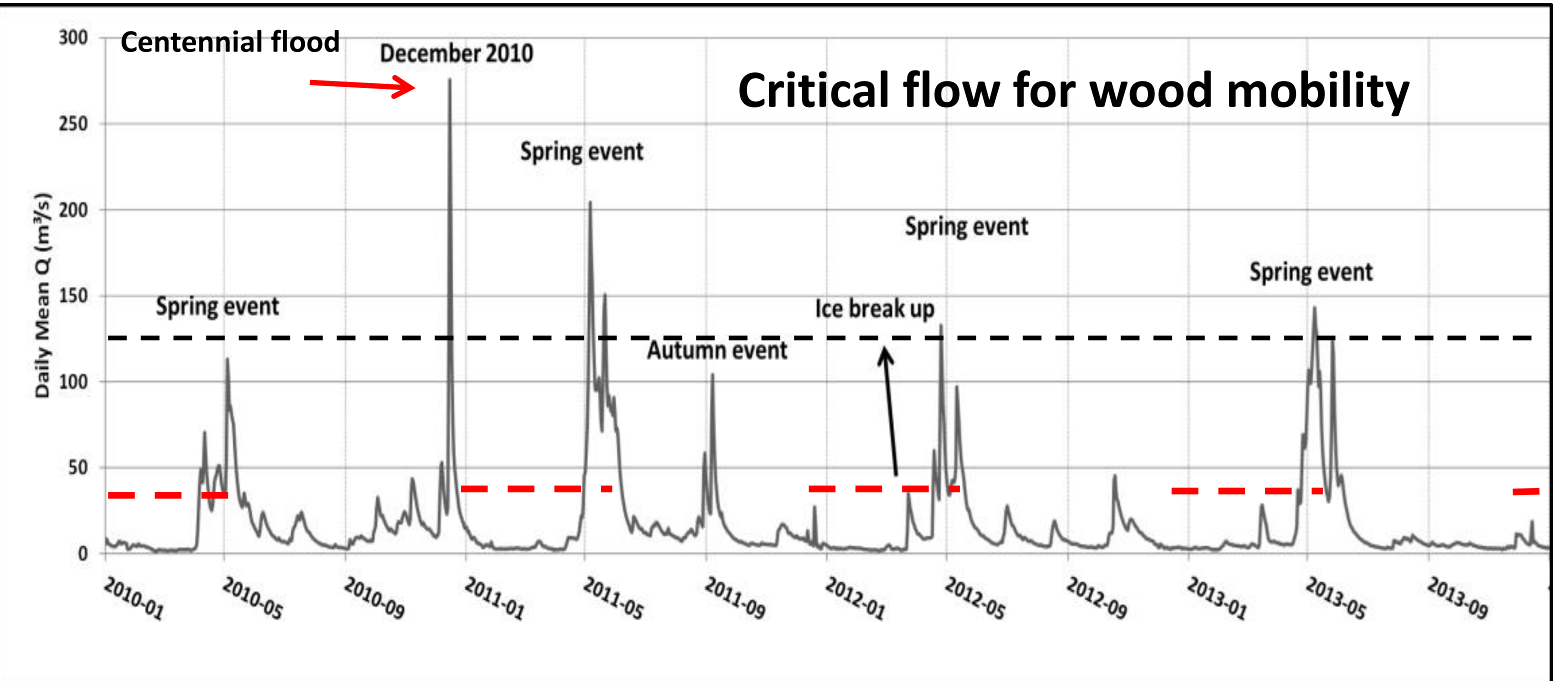




- Relationships is strong between sinuosity, bar surface area and decrease with unit stream power.

3. Hydro-geomorphological analysis : 1963-2013

B. Extreme event and ice cover dynamics



Large wood transport threshold without ice ± 130 m³/s

Large wood transport threshold with ice break-up during winter ± 40 m³/s

centennial flood in 2010

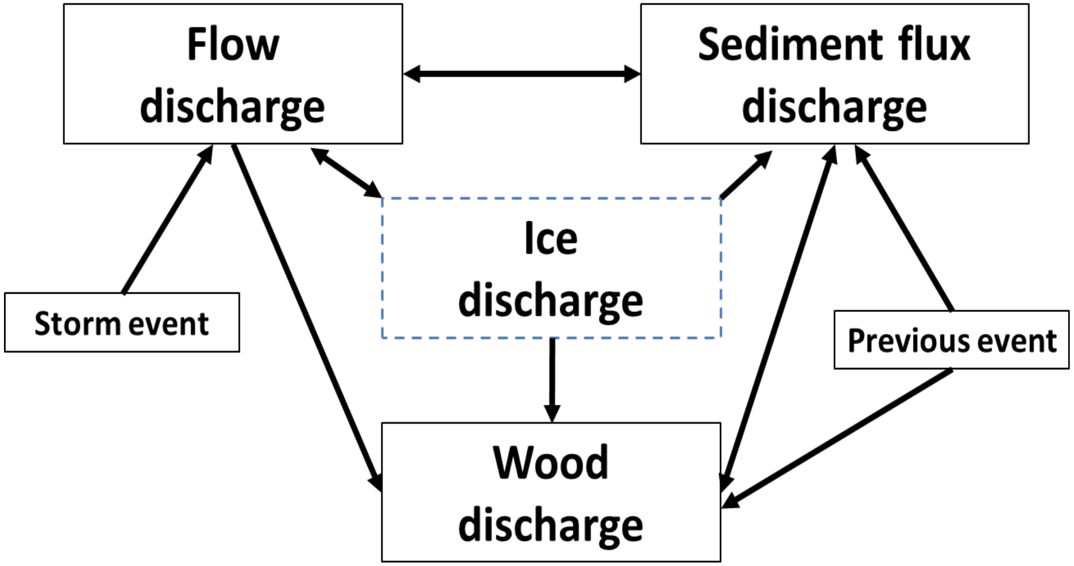
Major ice break-up in 2012

Discussion

What are the links and interelations between flow, sediments and wood discharges?

1) Changes in hydro-geomorphological characteristics influence wood recruitments

- **Extreme hydrometeorological events in december 2010 and major ice break up in March 2012 are the cause for large production and retention of LW.**
- **Wood discharge is not simply linked to flood intensity in cold rivers due to LW transport during ice breakup;**
- **Wood discharge is influenced by previous events (where is the wood in active channel and availability of LW)**
- **Wood production due to channel migration is increasing in period 2004-2013 compare with period 1963-1993 and 1993-2004 .**
- **Extreme events in Eastern Canada are increasing with the number of Post-tropical storms**

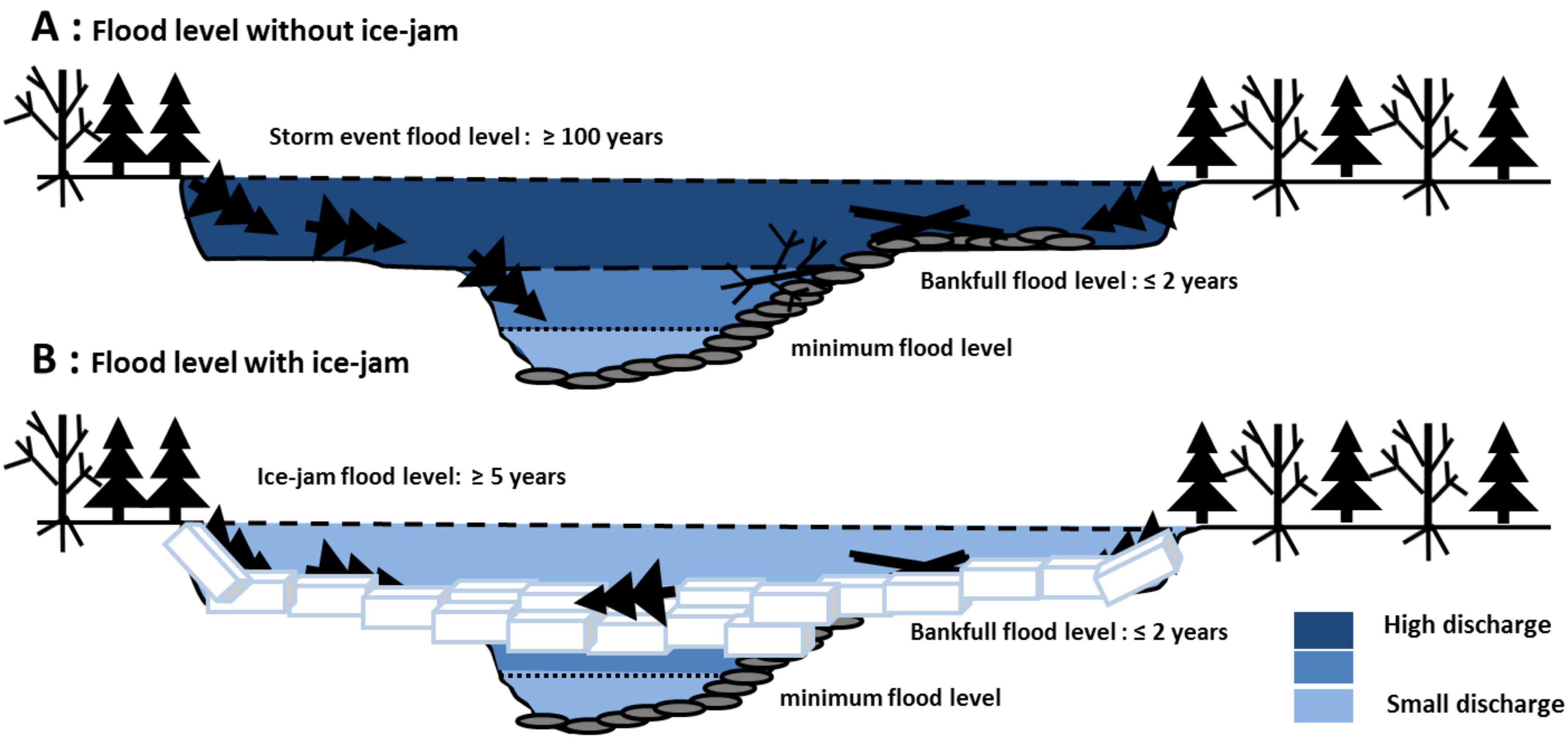


= Increasing wood discharge

Discussion

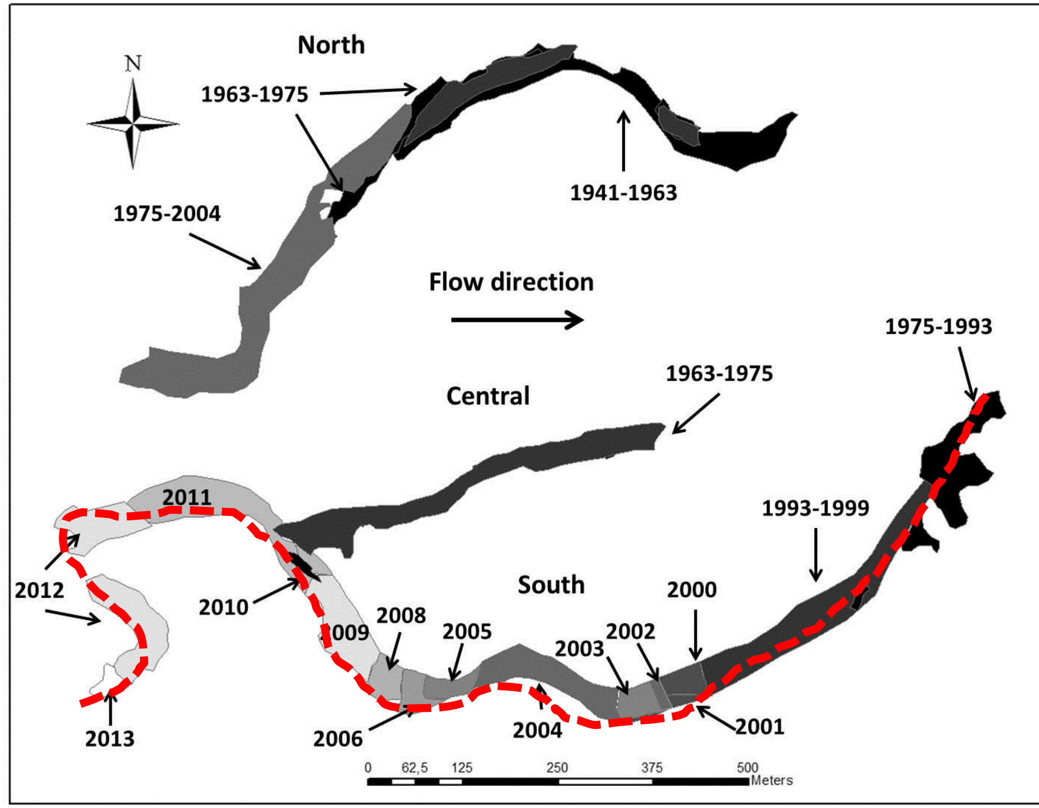
Influence of ice cover in wood discharge.

2) **Presence of recurrent Ice-jams and major Ice Break-up influence wood accumulation dynamics and interannual variability of transport**



Discussion

Management decision : research opportunity



Managers of the river have removed more than 1200 meters of the large raft in the south channel during 2015 winter.

Residence time by dendrochronology : ± 400 samples on 1500 meter Large raft long

Conclusion

- **Regional conditions in semi-alluvial river and in northern environment play a key role;**
- **Actually, the volumes available in the watershed are enormous**
- **The majority of the wood is produced by the natural lateral migration**
- **High capacity on wood retention in semi-alluvial river in Quebec**
- **Ice cover dynamics play key role;**
  - **Critical flow for wood transport without ice: 130m³ / s**
  - **Critical flow for wood transport with ice : 40 m³ / s**
- **More retention of wood in river corridor**
- **More lateral erosion = more wood in transit**
- **Significant increase between 2004 and 2013**
- **Flood flow is not the only one factor to explain volume of large wood in cold river.**

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Thank you for your attention!

Fonds de recherche sur la nature et les technologies Québec

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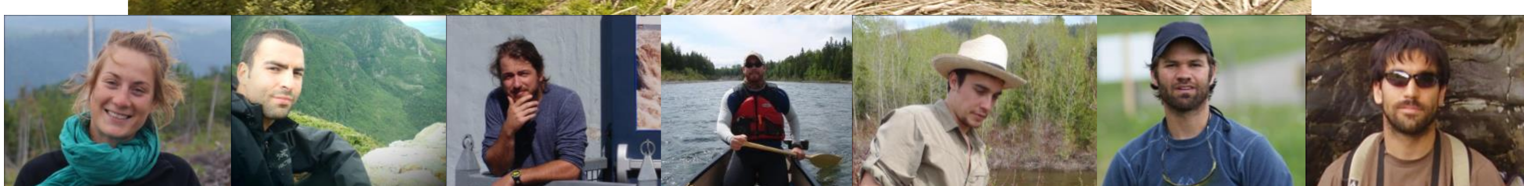

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Discussion

Missing data for large wood budget

Residence time by dendrochronology : ± 400 samples on 1500 meter Large raft long

To be continued