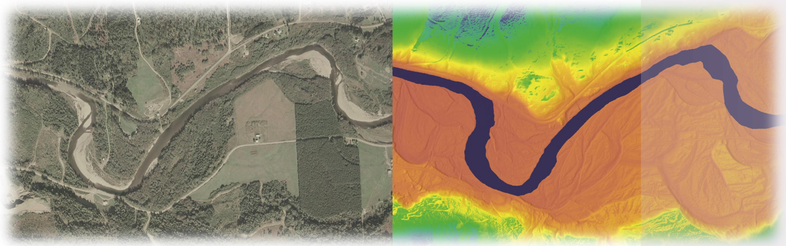

ASSESSING HUMAN AND NATURAL IMPACTS ON THE HYDRO-GEOMORPHOLOGICAL TRAJECTORY OF A NON-EQUILIBRIUM RIVER SYSTEM

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1. INTRODUCTION

Understanding the hydrogeomorphological trajectory of a river allows us to document the impact of environmental changes on the river (Ziliani and Surian, 2012). In the case of a non-equilibrium river system, it can also help determine sustainable management solutions. The hydrogeomorphological trajectory is obtained through the quantification of morphological and hydrological changes that have occurred in a river system over time. Although some of these changes are linked to natural processes (e.g. presence of bedrock outcrops, hydrological variability, river ice jams), many are associated with human activities.

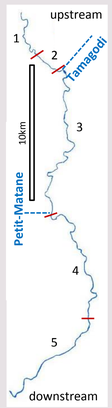
2. OBJECTIVE

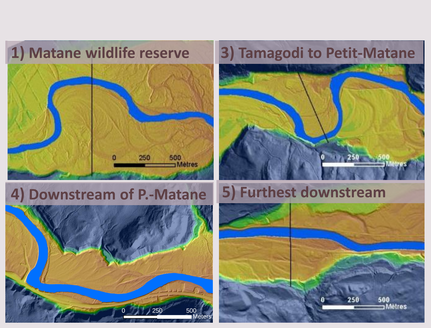
To document the hydrogeomorphological trajectory of the Matane River, a large gravel-bed river in Quebec (Canada) which has been highly impacted by wood rafting in the 19th century and early 20th century, and by bank stabilization structures in the downstream sections since the second half of the 20th century.

3. STUDY SITE AND METHODOLOGY

Matane River:

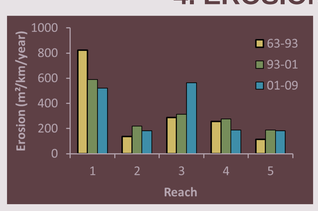
- 50-km study reach
- Partial LiDAR coverage (1m DEM)
- High-resolution imagery (0.21 m)
- Georeferenced aerial photos (1963 and 2009)
- Water surface profiles from 4292 DGPS points

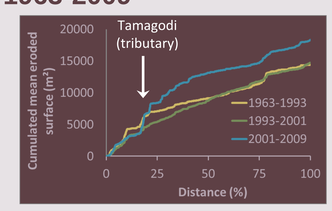




Matane River (A = 1690 km²)
Large gravel-bed, salmon river

4. EROSION 1963-2009



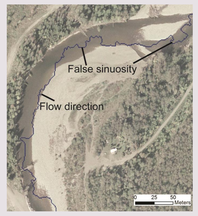


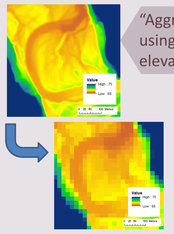
The trajectory of bank erosion with time is highly variable between the 5 reaches. Reach 1 is experiencing a decrease in erosion whereas reach 3 is showing the opposite trend. The cumulative erosion clearly reveals a sharp increase in erosion in reach 3 downstream from the confluence with the Tamagodi River.

Hydrogeomorphological tools developed in ArcGIS for LiDAR high-resolution DEMs.
River slope, channel width and discharge extracted to obtain unit stream power.

5. GIS LIDAR TOOLS

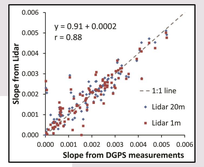
SLOPE: FLOW DIRECTION, RESAMPLING

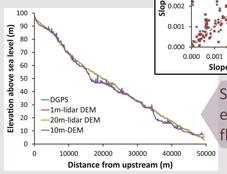




"Aggregate tool" using ***minimum*** elevation (20 m)

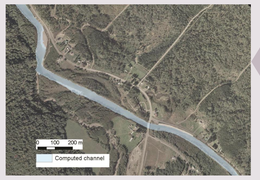
LiDAR vs DGPS





Script to extract elevation along flow direction only

WIDTH: FROM FLOW DIRECTION



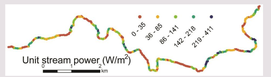
Width extracted using thresholds for elevation (0.5 m) and slope (12 °)

DISCHARGE: $Q = 0.46\ A^{0.92}$

Area (A) obtained from 10m-DEM of entire watershed

UNIT STREAM POWER (ω)

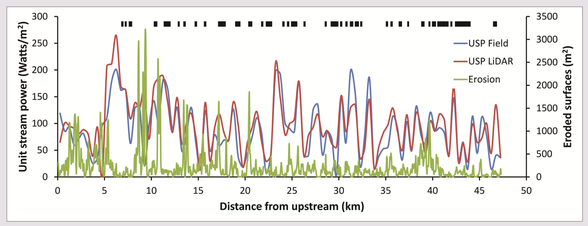
$$\omega = \frac{\rho\, g\, Q\, S}{w}$$



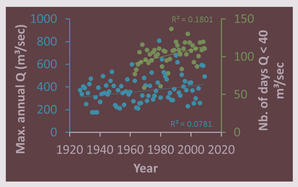
Biron et al. (in press)

No clear relationship between unit stream power and erosion.
Bar dynamics, bedrock outcrops and bank stabilization play a key role.

6. LINKS HYDRODYNAMIC - EROSION



The unit stream power (USP) automatically extracted from the LiDAR DEM shows very good agreement with field measurements. However, unlike in previous studies where high USP was associated with enhanced mobility of the channel (Bledsoe and Watson, 2001; Fonstad, 2005) the relationship between USP and eroded surface is very weak (R^2 = 0.006). Black bars represent bank stabilization.

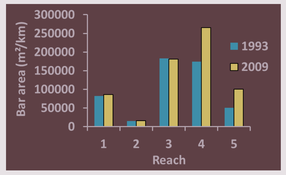


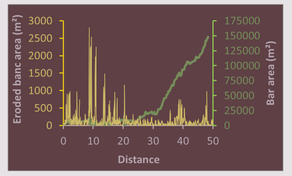
Since early in the 20th century, there is a significant increase ($p < 0.05$) in both the annual maximum discharge (blue) and the number of days with low flow discharge (green).

Bars area expanding in the downstream reaches where human impacts are largest.
Overall decrease in width with time, both in natural and stabilized reaches.

7. BARS, WIDTH AND HUMAN IMPACTS

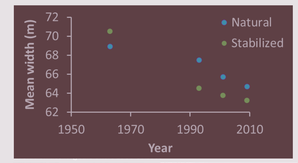
BARS





Bar area is stable in reaches 1 to 3 but it has increased markedly in the downstream reaches (4 and 5) which are less mobile

WIDTH AND HUMAN IMPACTS

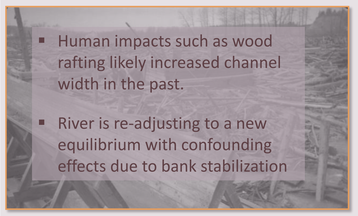


Evolution of width with time shows a progressive narrowing in all reaches between 1963 and 2009, with a narrower channel in human-impacted reaches

River was widened by human activities and is now re-adjusting differently in each reach.
Difficult to predict morphological trajectory based on hydrodynamics only.

8. DISCUSSION AND CONCLUSIONS

DISCUSSION



- Human impacts such as wood rafting likely increased channel width in the past.
- River is re-adjusting to a new equilibrium with confounding effects due to bank stabilization

Wood rafting on Matane River, early 20th century

- Areas of rapid erosion seem associated with deposition of sediments (mainly from Tamagodi tributary) where USP is not high enough to move load, forcing flow towards the opposite bank
- Bar dynamics may explain lack of link between high stream power and erosion (sequence high-low USP may favour sediment deposition and bank erosion)

CONCLUSIONS

- Understanding morphological trajectory per reach may be helpful for river management schemes.
- Unit stream power can now be automatically extracted from LiDAR DEM for long river reaches.
- However, more work is needed to understand links between USP and bank erosion. Understanding this relationship is very complicated in a non-equilibrium channel which is partly controlled by bedrock outcrops, by extreme hydrological events such as severe ice-jams, and where bank stabilization is frequently used to protect the road.

ACKNOWLEDGMENTS:

Thanks to François Morneau (Ministère de la Sécurité Publique du Québec) and Jean-Philippe Marchand, Pierre Simard, Claude-André Cloutier, Véronic Parent, Ariane Lelièvre, Valéry Hamel and Antonin Montané for their field assistance.

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