L'effet des barrages de castors sur l'hydrologie et la morphologie des petits cours d'eau

Jan Nyssen, Jolien Pontzeele, Maarten De Visscher, Paolo Billi, Amaury Frankl

6ème rencontre des acteurs de la rivière - La cohabitation avec le castor en Wallonie. Lierneux, 6 Novembre 2012

Introduction

- Ingénieur écologique – zoogéomorphologie

(d'après Fichefet & Manet, 2001)

La Lienne

UNIVERSITEIT GENT

Introduction

- Barrages “imperméables”
- Rivière vs. chenal de drainage

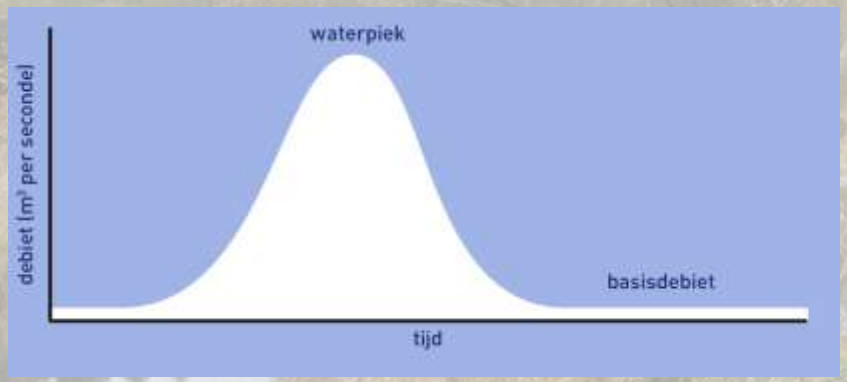

La Berwinne à Mouland

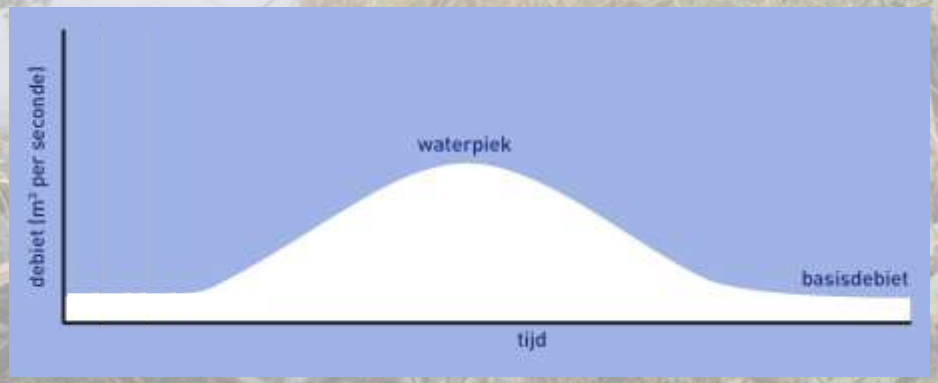

Grootbroek à Rode Ste Agathe

UNIVERSITEIT GENT

Introduction

- Littérature: sur le long terme
  - Régularisation des débits





Airborne Beavers Fight Floods

OUT in Idaho, the Department of Fish and Game is teaching eager beavers to yell "Geronimo!" These busy little creatures are being dropped by parachute to terrain where they can do their bit in the conservation battle.

Idaho state caretakers trap unwanted beavers which may be a nuisance in certain areas, round them up at central points and pack them in pairs in specially constructed wooden crates. After they are dropped, the boxes remain closed as long as there's some tension on the parachute shrouds but pull open as soon as the chute collapses on the ground. Then, out crawl Mama and Papa beaver, ready to start work.

After they're settled, the 40-pound, web-footed rodents multiply and become outpost agents of flood control and soil conservation. Fur supervisor John Smith reports that in carefully observed early operations, the beavers headed straight for water and started building a new dam with-

(USA, 1950)

Introduction

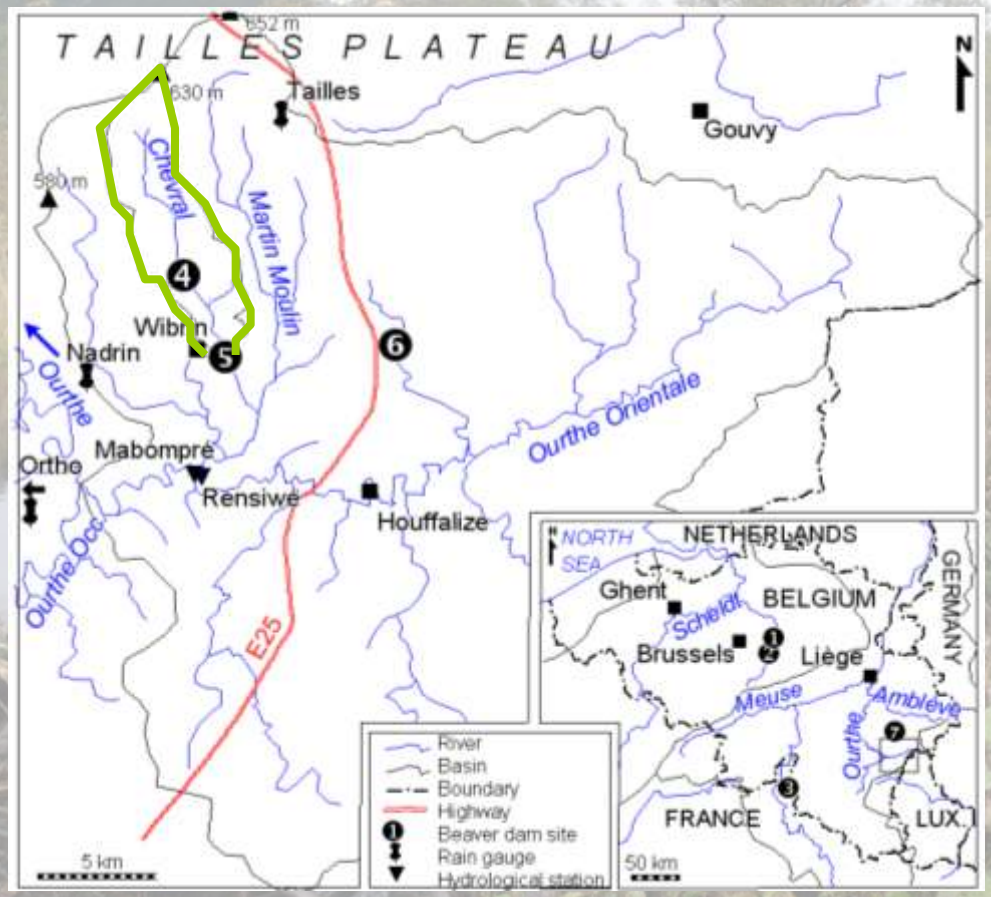
- Littérature: sur le long terme
  - Régularisation des débits
  - Aggradation – “beaver meadows” = “prés à castors”

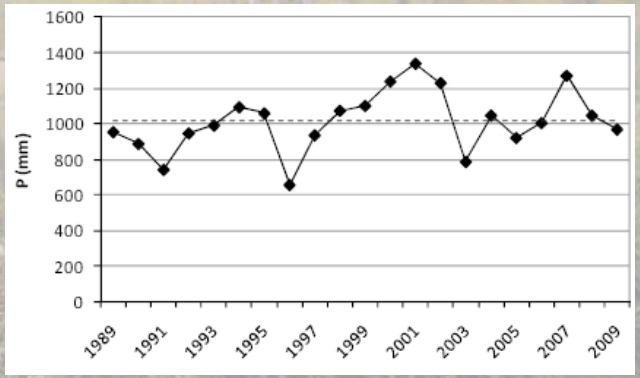
“Beaver Meadows”, Idaho, USA

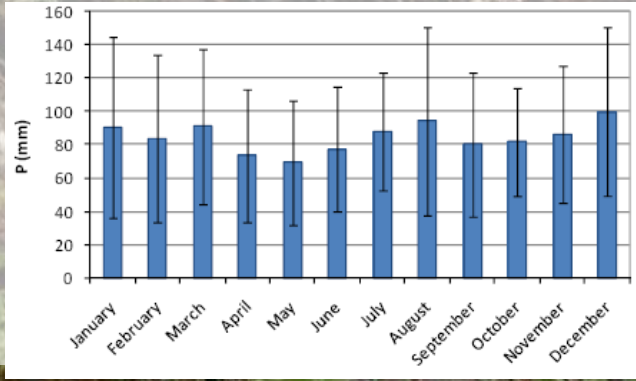
UNIVERSITEIT GENT

Méthodes de recherche

- Région étudiée



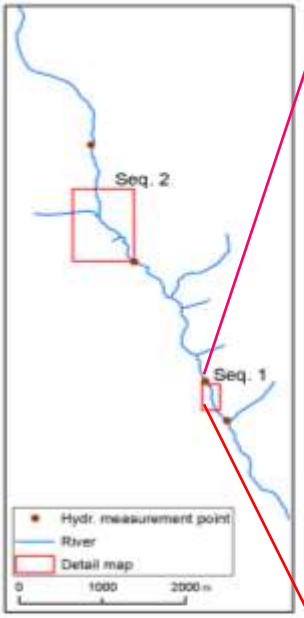


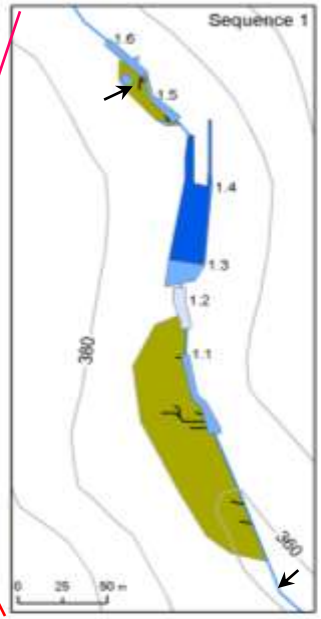


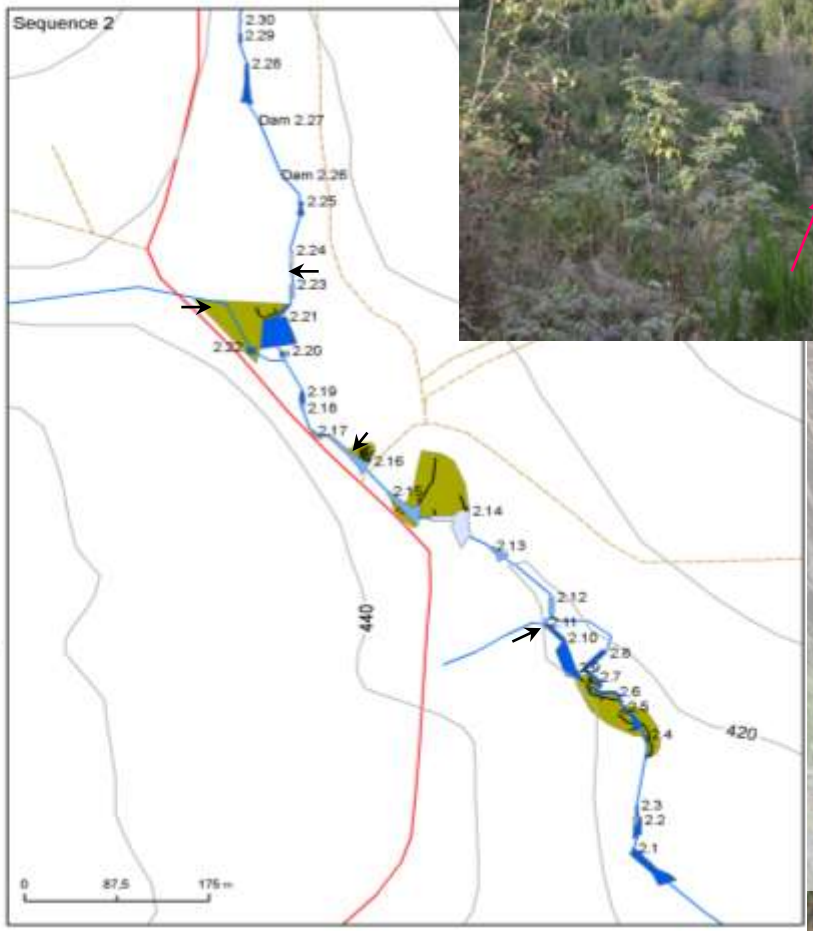
UNIVERSITEIT GENT

Méthodes de recherche

- Région étudiée







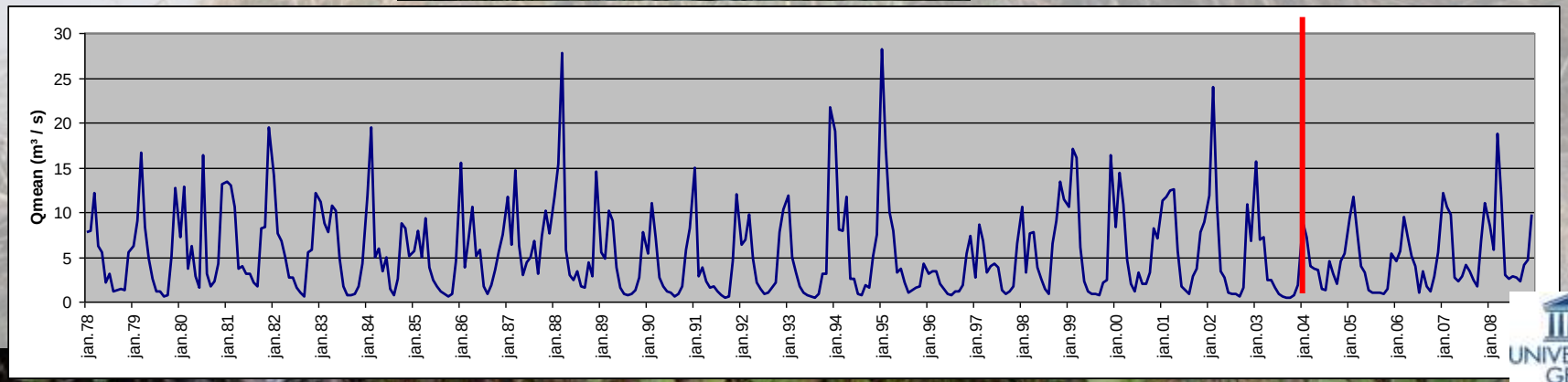
Beaver pond - with changes (08/10 - 04/11)
- Intact
- Reduced
- Disappeared
- Periodically flooded zone
- Rivier
- Canal
- Paved Road
- Unpaved Road
- Contour lines (vertical interval 20 m)

UNIVERSITEIT GENT

Méthodes de recherche

- Analyse de la série hydrologique de l'Ourthe Orientale (station de Mabompré)

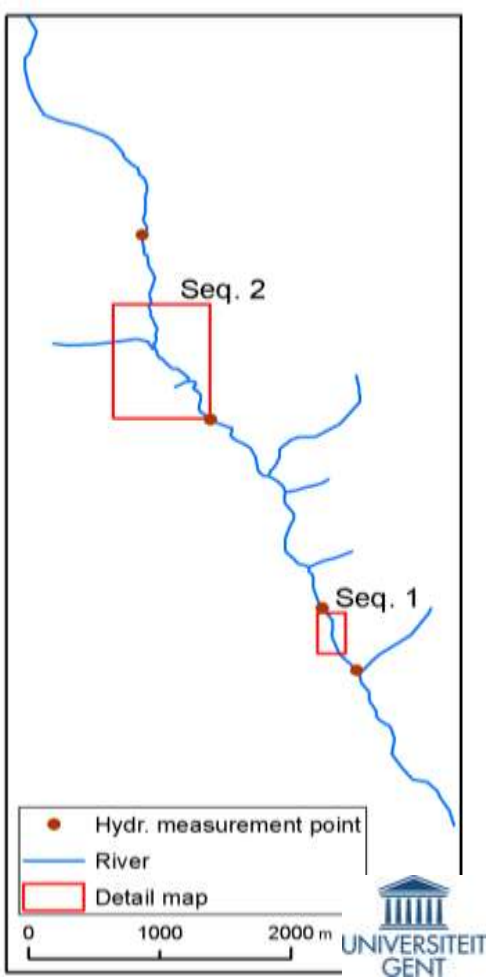
Ourthe Orientale à Mabompré (voies-hydrauliques.wallonie.be)



UNIVERSITEIT GENT

Méthodes de recherche

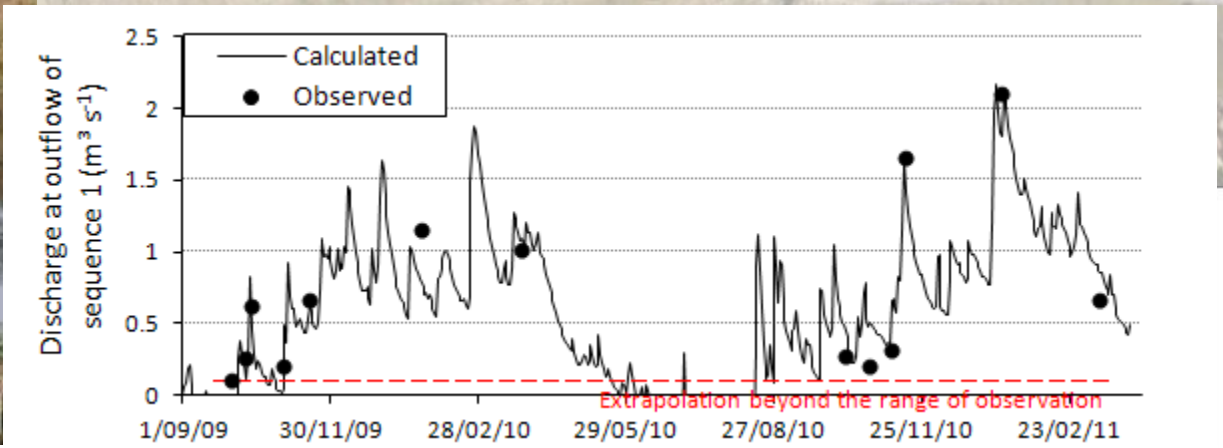
- Analyse de la série hydrologique de l'Ourthe Orientale
- Suivi de l'hydrologie du Chevral



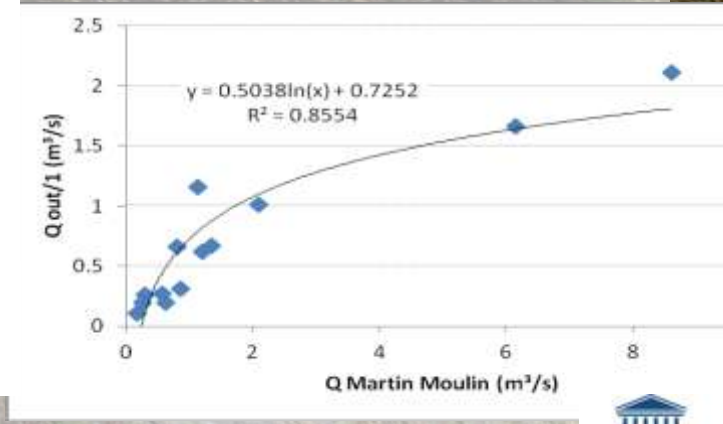
UNIVERSITEIT GENT

Méthodes de recherche

- Analyse de la série hydrologique de l'Ourthe Orientale
- Suivi de l'hydrologie du Chev



Observed and calculated outflow discharges at beaver pond sequence 1.



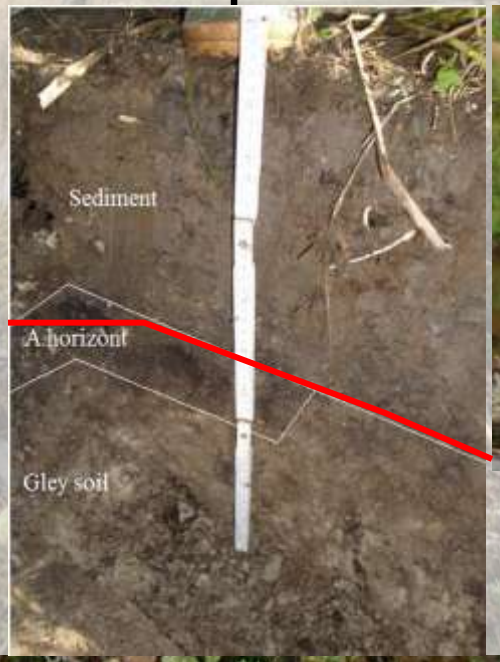
UNIVERSITEIT GENT

Méthodes de recherche

- Transport et dépôt de sédiments
  - Charge et transport de sédiments (Qs) à l’entrée et à la sortie des systèmes de barrages

Méthodes de recherche

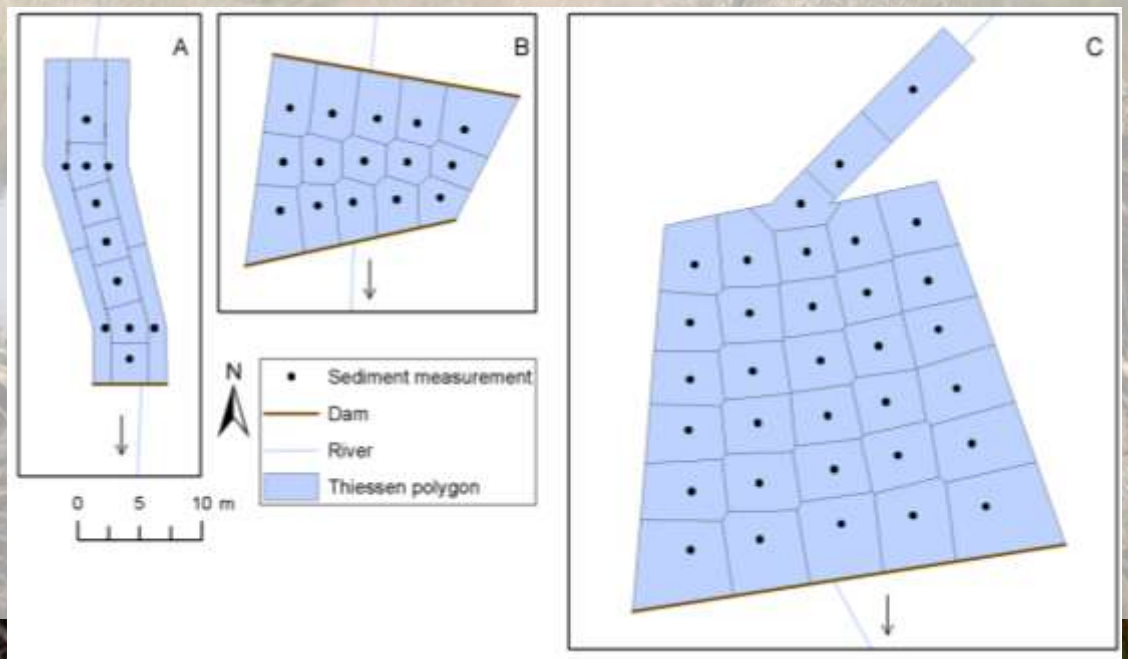
- Transport et dépôt de sédiments
  - Charge et transport de sédiments (Qs)
  - Volume et masse de sédiments déposés dans le chenal et dans la plaine alluvial inondée



UNIVERSITEIT GENT

Méthodes de recherche

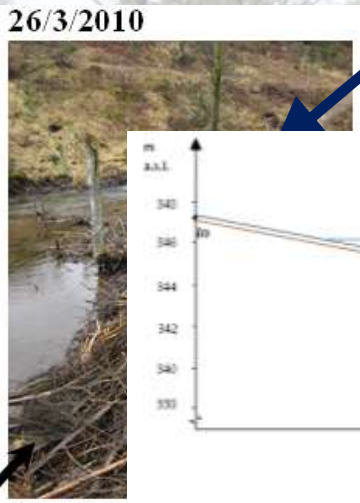
- Transport et dépôt de sédiments
  - Charge et transport de sédiments (Qs)
  - Volume et masse de sédiments déposés dans le chenal et dans la plaine alluvial inondée

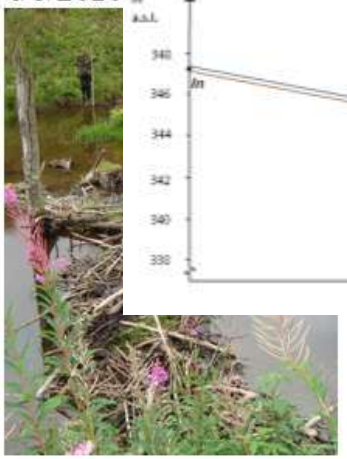


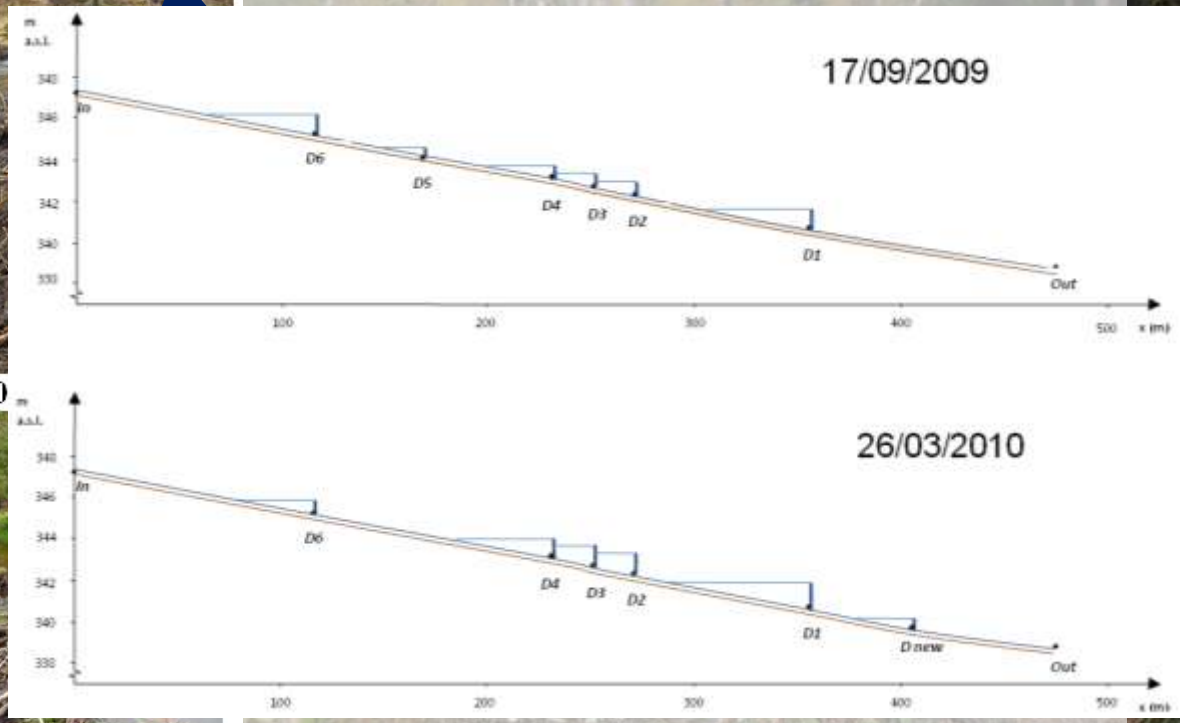
UNIVERSITEIT GENT

Un système dynamique

- Modifications continues







Un système dynamique

- Modifications continues
- Brèches et colmatages

UNIVERSITEIT GENT

Un système dynamique


Berwinne à Mauhin

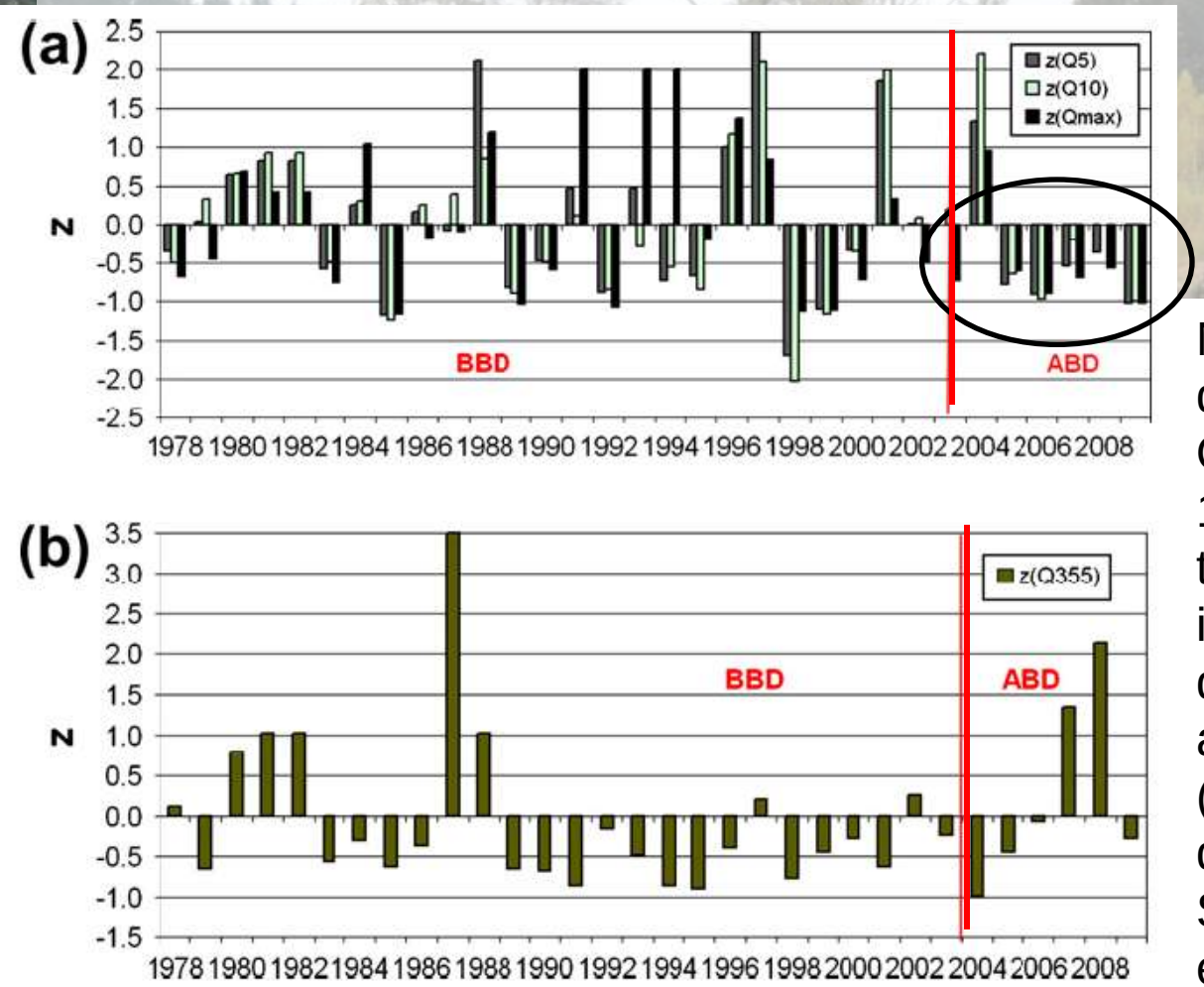
- Modifications continues
- Brèches et colmatages
- Barrages “de circonstanc sèches


Berwinne à Mouland le 28.11.2011


Berwinne à Mouland le 27.12.2011

UNIVERSITEIT GENT

Hydrologie de l'Ourthe Orientale avant et après l'installation des barrages



Normalised (z) values of yearly discharges of the Ourthe Orientale at Mabompré since 1978, with vertical line indicating the installation of beaver dams in the basin: (a) maximal discharges (Qmax, Q5, Q10), and (b) minimal discharges (Q355). (BBD: before beaver dams; ABD: after beaver dams). Source: own processing of existing dataset (SETHY, 2

Hydrologie de l'Ourthe Orientale avant et après l'installation des barrages

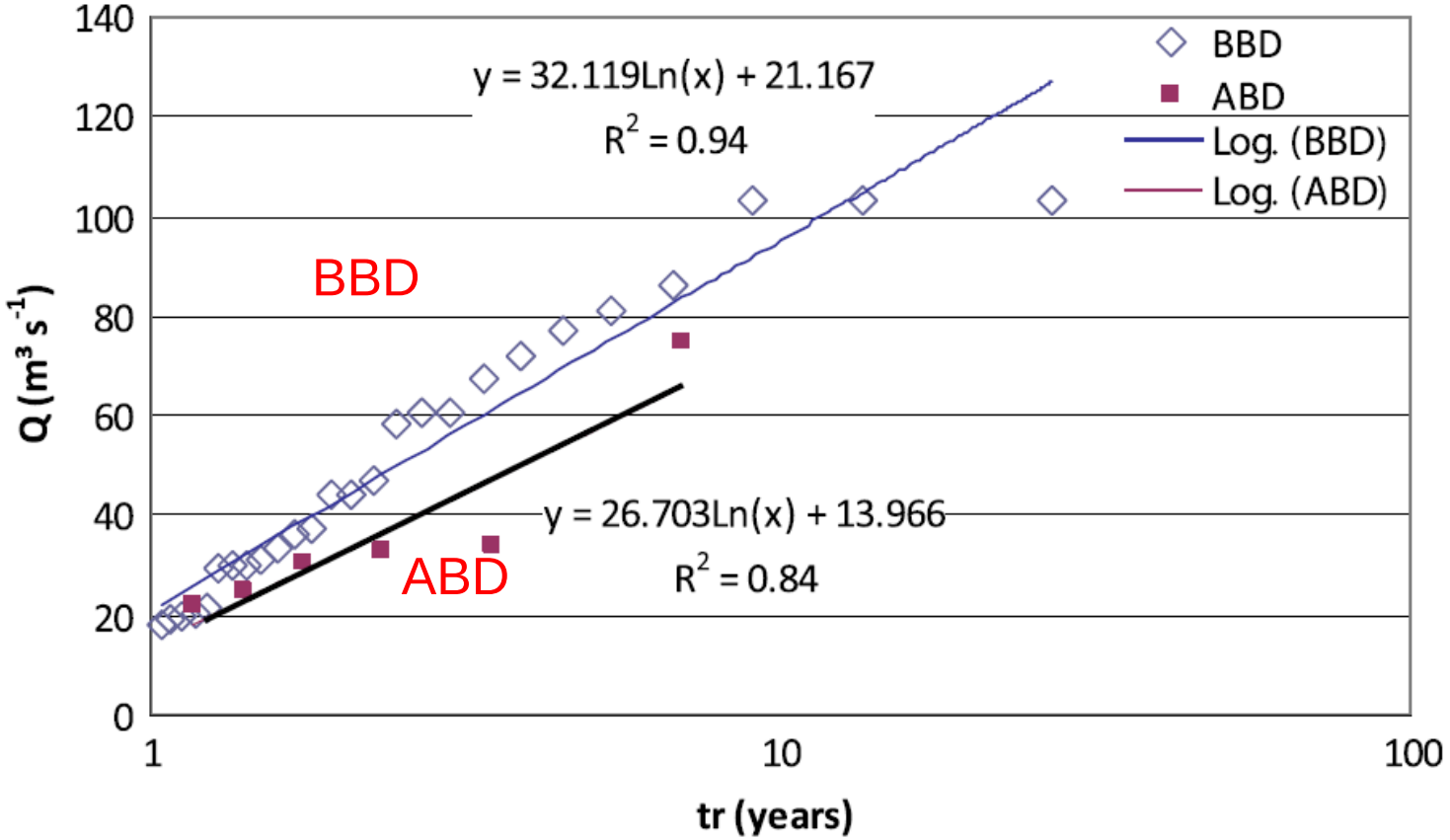


Fig. 7. Flood frequency curves of the Ourthe Orientale at Mabompré as a function of recurrence interval (*tr*) for the periods before (BBD; 1978–2003) and after beaver dam installation (ABD; 2004–2009). *Source*: own processing of existing dataset (SETHY, 2010).

UNIVERSITEIT GENT

Hydrologie de l'Ourthe Orientale avant et après l'installation des barrages

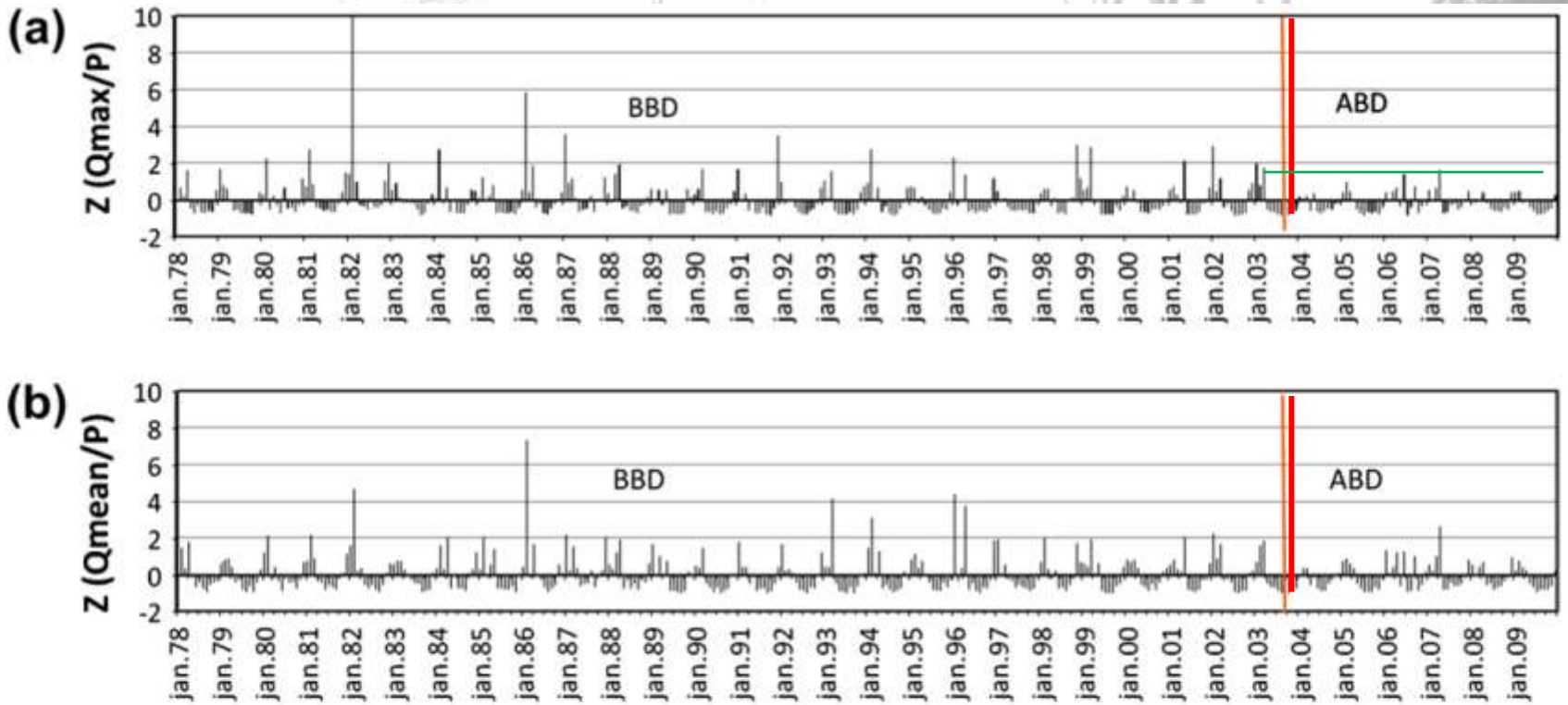


Figure 8. z-values for the ratio of discharge (Q in mm, Mabompré station on the Ourthe Orientale) to total rainfall (P in mm, Nadrin station) of the same month, before (BBD) and after beaver dam construction (ABD): (a) for monthly maximum of average daily discharges (Qmax), and (b) for average discharges (Qmean). Source: own processing of existing datasets (RMI, 2010; SETHY, 2010).

UNIVERSITEIT GENT

Hydrologie des systèmes de barrages sur le Chevral

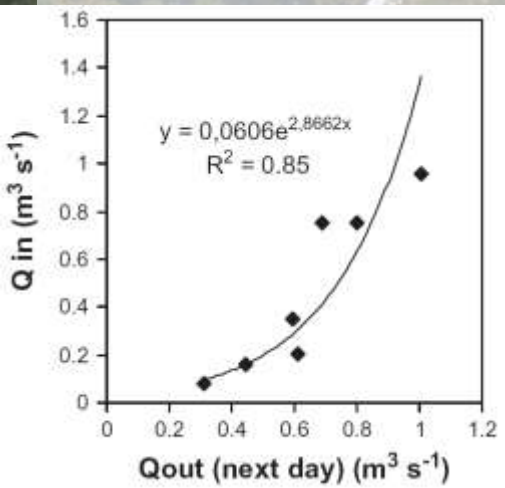
Results of hydrological measurements at the lower Chevral beaver dam system.

Date	Discharge into the beaver system Q_{in} ($m^3\ s^{-1}$)	Discharge out of the beaver dam system Q_{out} ($m^3\ s^{-1}$)	$Q_{in}-Q_{out}$ ($m^3\ s^{-1}$)	Water volume stored in the beaver ponds[a] V (m^3)
30/9/2009	0.08	0.11	−0.03	0
9/10/2009	0.16	0.26	−0.10	43
12/10/2009	0.35	0.62	−0.27	202
1/11/2009	0.20	0.20	0.00	75
17/11/2009	0.76	0.66	0.09	310
24/1/2010	0.75	1.16	−0.41	163
26/3/2010	0.96	1.01	−0.05	59

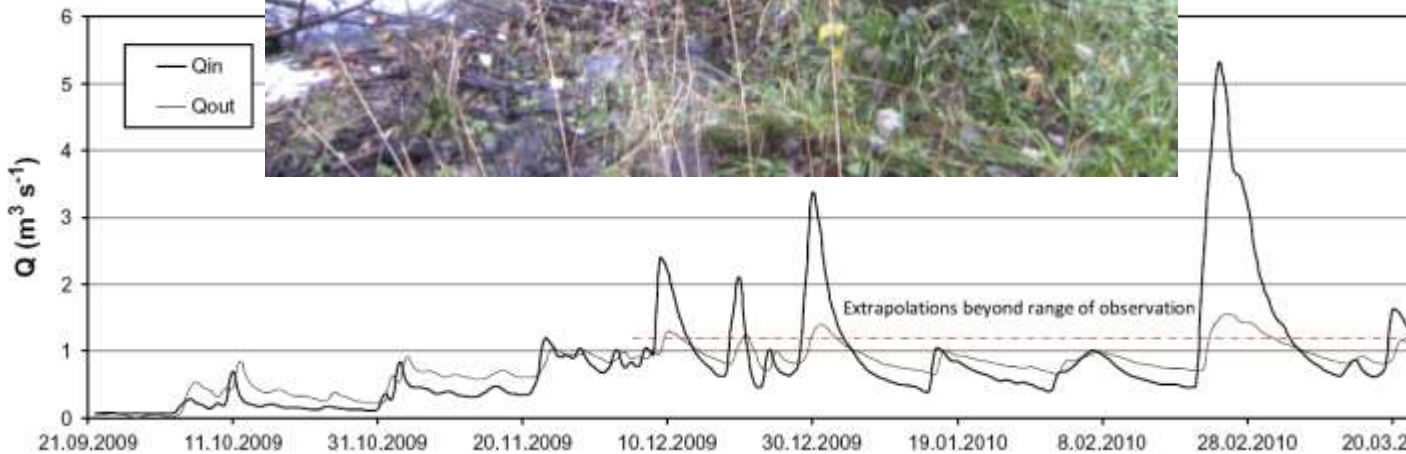
[a] As compared to the volume on 30/9/2009, date with lowest water level.

UNIVERSITEIT GENT

Hydrologie des systèmes de barrages sur le Chevral



Measured inflow in the Chevral beaver dam system (Qin) vs. calculated outflow (Qout) of the next day



Comparison over time of the calculated curves for inflow (Qin) and outflow (Qout) in the Chevral beaver dam system. The Qout curve is flattened and delayed as compared to the Qin curve. The dotted horizontal line indicates discharge of 1.2 m³ s-1, the upper end of the range of our measurements.

UNIVERSITEIT GENT

Hydrologie des systèmes de barrages sur le Chevral

Risque de “flow surge” & effet domino?

Failure of beaver dam 2.17 in January 2011; the wood debris (middle) are rests of dam material removed from the stream bed by municipal workers (recent traces of machinery) to protect a road (behind the photographer) from flood. The dam was destroyed at high water level, probably the maximum of the flood, as can be observed from the extent of the snow-free area and from humidity on standing trees.

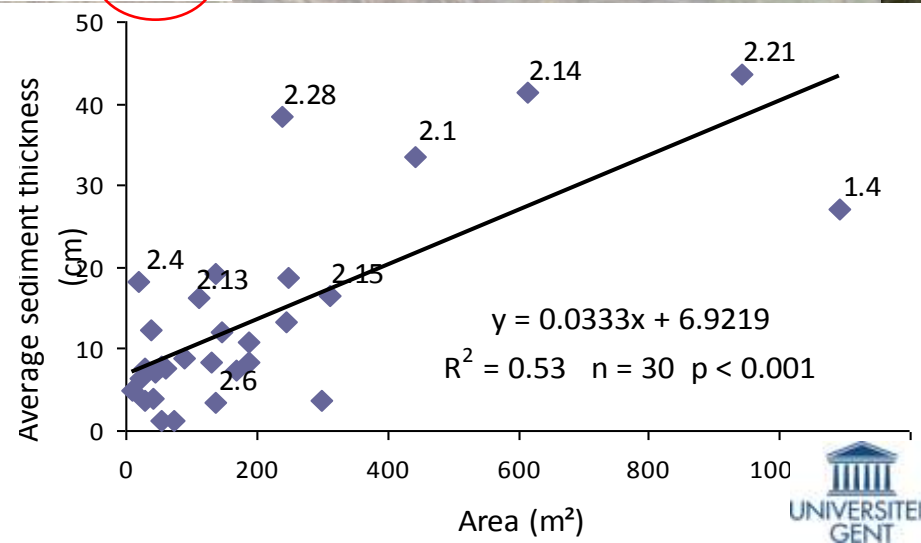
UNIVERSITEIT GENT

Sédimention dans les étangs de castor du Chevral

- Sédiment déposé depuis 2004

Mass and volume of beaver pond deposits.

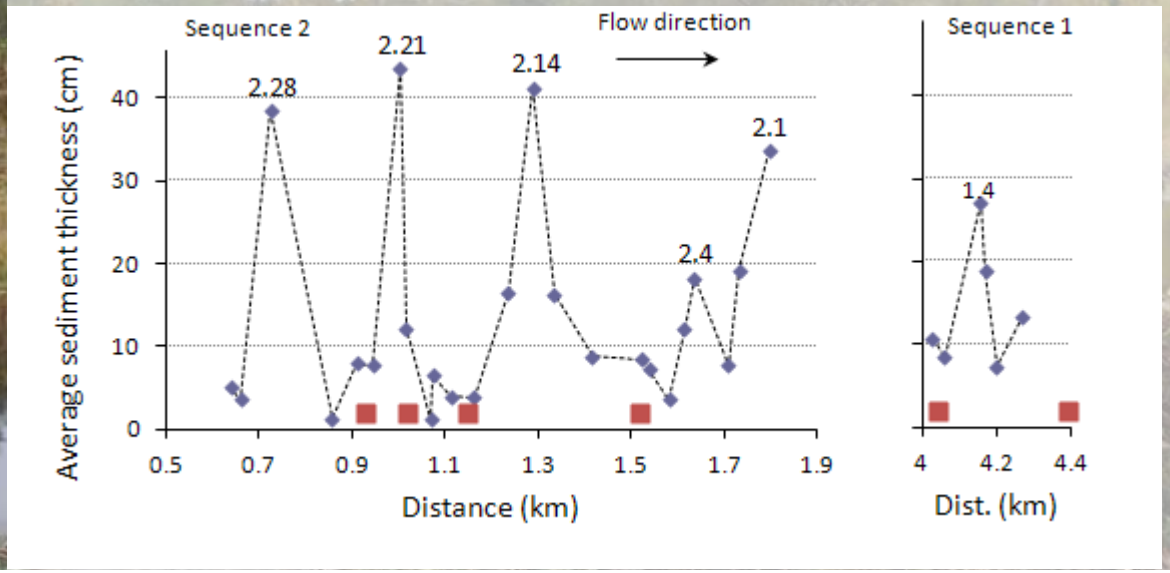
	n	Average pond area (m²)	Average sediment volume by pond (m³)	Average sediment mass by pond (ton)	Average sediment thickness (cm)
Sequence 1	6	345.2	69.9	20.3	20.2
Sequence 2	28	169.4	46.1	13.4	27.2
Total	34	200.4	50.3	14.6	25.1



The average sediment thickness as a function of pond area. Labels indicate the pond number. Sequential number displayed for ponds with a thick sediment layer as compared to the nearby ponds (Fig. 11) and/or ponds where sediment was sampled.

Sédimention dans les étangs de castor du Chevral

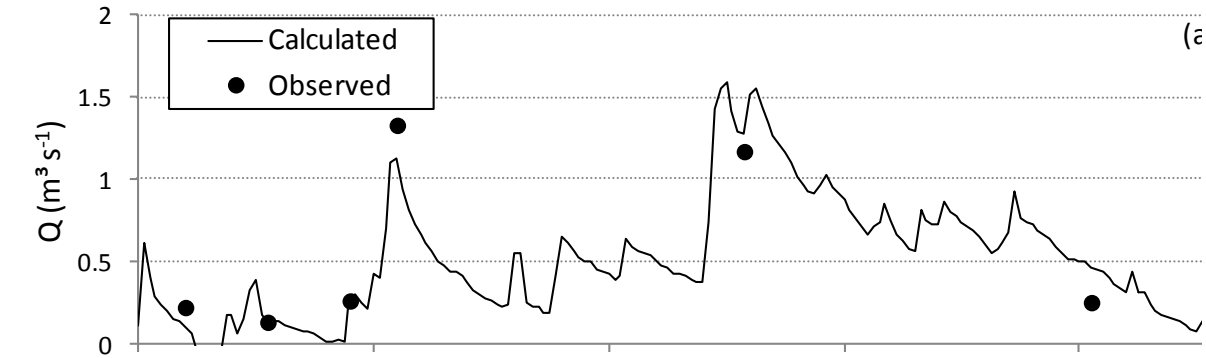
- Sédiment déposé depuis 2004
- Distribution des sédiments



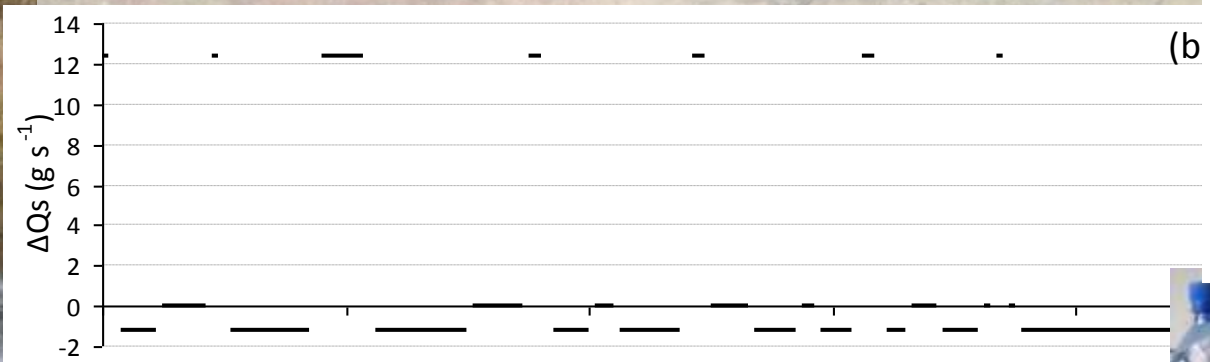
Average sediment thickness per beaver pond vs. distance from the inflow point of sequence 2; labels indicate sequential number of ponds with a thick sediment layer, as compared to the nearby ponds. Beaver dams without pond and those located in the alluvial plain away from the main stream are not indicated. Large dots at the bottom of the graphs indicate locations with major lateral inflow of water and sediment during stor

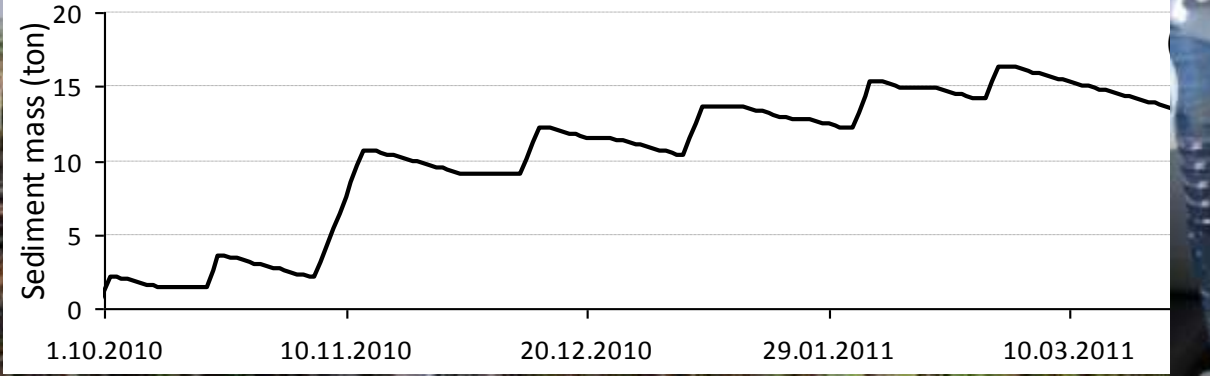
UNIVERSITEIT GENT

Sédimention dans les étangs de



- Sédiment entrant / sortant





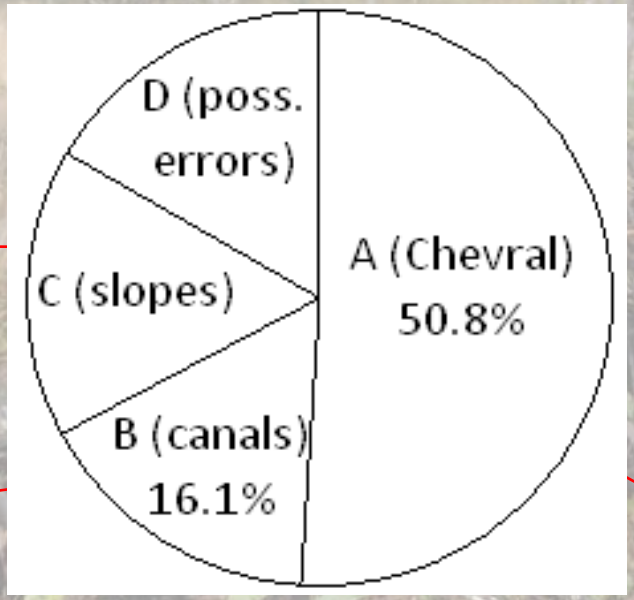
Calculation of sediment deposition in pond sequence 2 during the study period: (a) the flow discharge (Q) at the outflow of sequence 2, (b) expected rate of sediment deposition or erosion (ΔQs) in function of the rising and falling limbs of the hydrograph; for undetermined phases and also for minima and maxima in the flow discharge, hence alternance between rising and declining phase, the sedimentation rate was equalled to 0 g s^{-1}), (c) cumulative sedimentation.

! Cs entre 2 et 74 mg / L seulement!

UNIVERSITEIT GENT

Sédimention dans les étangs de castor du Chevral

- Bilan sédimentaire provisoire des systèmes de barrages du Chevral: 374 t en 7 ans



Conclusions

- Dynamisme vs long terme

4 Août 2010

UNIVERSITEIT GENT

Conclusions

- Dynamisme vs long terme

4 Août 2010
7 Janvier 2011

Conclusions

- Dynamisme vs long terme

4 Août 2010
7 Janvier 2011
12 Mars 2011

Conclusions

- Dynamisme vs long terme

4 Août 2010
7 Janvier 2011
12 Mars 2011
4 Juin 2011

Conclusions

- Dynamisme vs long terme

4 Août 2010
7 Janvier 2011
12 Mars 2011
4 Juin 2011
18 Octobre 2011

Conclusions

- Dynamisme vs long terme

4 Août 2010
7 Janvier 2011
12 Mars 2011
4 Juin 2011
18 Octobre 2011
16 Octobre 2012

Conclusions

- Dynamisme vs long terme
- Débits: effet tampon

UNIVERSITEIT GENT

Conclusions

- Dynamisme vs long terme
- Débits: effet tampon
- Stabilité


Woltz à Cornelysmillen (GDL)


Molenbeek à Viersel


Stole aux Vieux Moulins de Thilay (F.) (Croix Scaille)

UNIVERSITEIT GENT

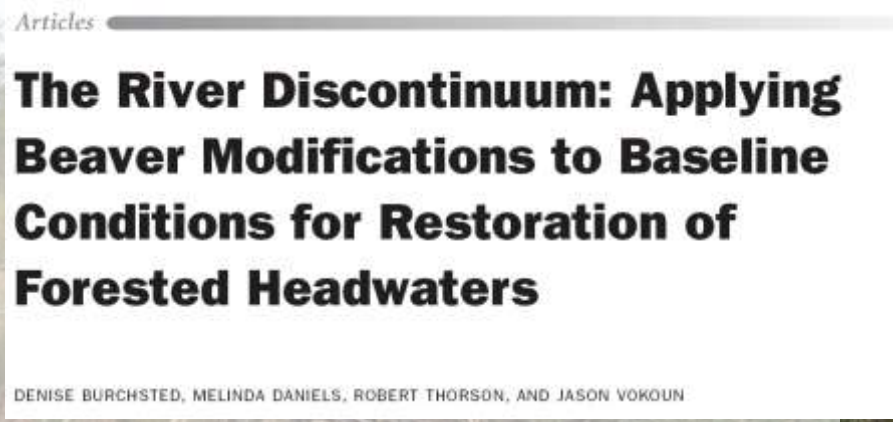
Conclusions

- Dynamisme vs long terme
- Débits: effet tampon
- Stabilité
- Sédimentation rapide: en moyenne 25 cm en 7 ans dans un bassin forestier!

UNIVERSITEIT GENT

Conclusions

- Dynamisme vs long terme
- Débits: effet tampon
- Stabilité
- Sédimentation rapide
- Discontinuité hydrologique: un concept à intégrer dans la restauration des rivières (renaturation)


Articles

The River Discontinuum: Applying Beaver Modifications to Baseline Conditions for Restoration of Forested Headwaters

DENISE BURCHSTED, MELINDA DANIELS, ROBERT THORSON, AND JASON VOKOUN

UNIVERSITEIT GENT

Merci pour votre attention

UNIVERSITEIT GENT

Références

Nyssen, J., Pontzeele, J., Billi, P., 2011. Effect of beaver dams on the hydrology of small mountain streams: example from the Chevral in the Ourthe Orientale basin, Ardennes, Belgium. Journal of Hydrology, 402 (1-2): 92-102.

De Visscher, M., Nyssen, J., Pontzeele, J., Billi, P., Frankl, A. Spatio-temporal sedimentation patterns in beaver ponds along the Chevral River, Ardennes, Belgium. Hydrological Processes, submitted.