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Regaining sediments: the Orba River lower reach bank erosions (NW Italy)

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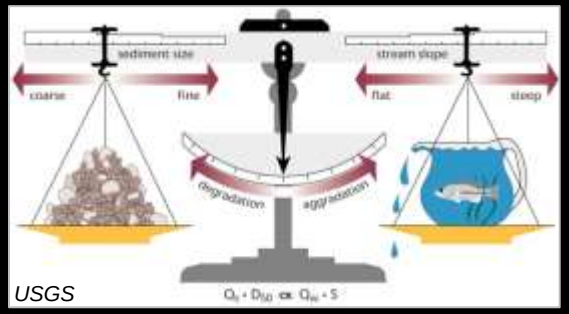


Bank erosion: a natural geomorphic process strictly related to sediment balance

The aim of this study is describing bank retreatments that occurred in the last 17 years in the lower Orba River (Alessandria, NW Italy) at site scale and at reach scale in order to:

1) **Understand something more about actual channel behavior;**
2) **Give to river and landscape management authorities relevant information about geomorphological evolutionary trend;**
3) **Develop and validate channel planform analysis GIS procedures.**

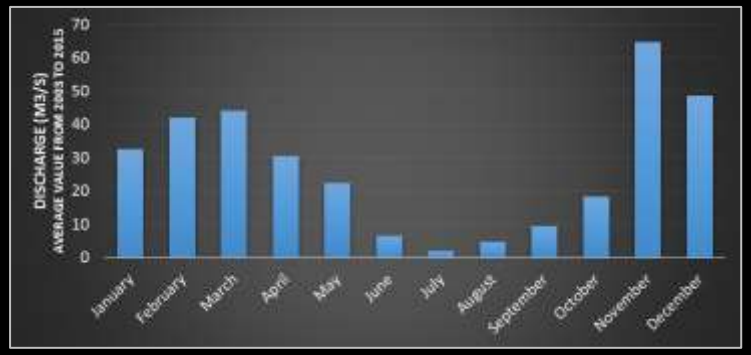
This work is part of a wider research concerning the historical and recent morphological evolutionary trend of this river.

The Orba River

Catchment elevation: min 90 m – max 1287 m
Floodplain reach length: about 25km

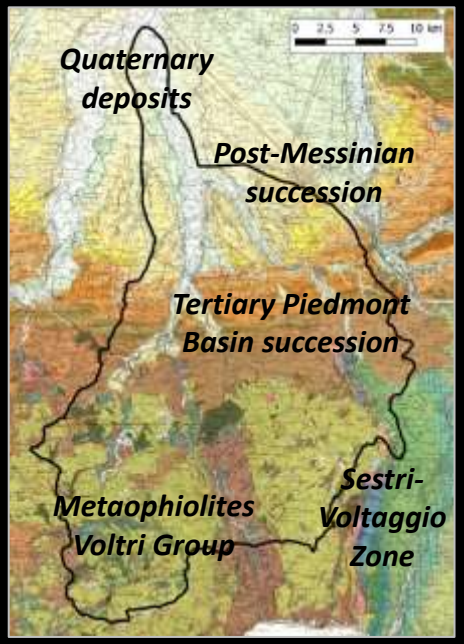
Main historical floods:
1935, 1977, 1987, 2000, 2011, 2014, 2014

Source Arpa Piemonte



The Orba river basin spreads over 776 km2; the main channel is about 68 km long, flowing northward from the Ligurian Alps, just North-West of Genova, to the Bormida River, near Alessandria.

Geological map of Italy - 1:100.000



The study reach

Length: about 13 km

Reach	Length (m)	Channel width (m)	Slope (%)
1	5264	83	0.26
2	3055	123	0.25
3	5289	108	0.19

Single-thread channel - deep incised - sinuous/sinuous with alternate bars.

Active floodplain: discontinuous and not wide, generally formed occupying old active channel surfaces.

Lateral dynamics heavily conditioned by bank protection structures.

Historical and recent channel evolution

- Quite stable river channel planform features in the last 150 years; some relevant shiftings at the turn of the nineteenth and twentieth centuries, after that the river conserved its track.
- In the last 30 years → consistent incision process that reached maximum values of 5 – 6 meters at the outlet.
- Recent soft and local channel narrowing due to stabilization of bars and simultaneous diffuse lateral erosion processes.
- *Human activities → banks protection structures (sporadic already in the Fifties) built almost everywhere after 1977 flood (gabions and reinforced concrete prisms used as ripraps) / very consistent sediment mining activity from the Fifties onwards.*

Since last years diffuse bank instability after decades of locked lateral dynamics

Materials and methods

1) Channel planform GIS analysis

We performed a **quantitative multitemporal analysis in GIS environment**, supported by **field surveys**.

GRASS GIS 7.2.0 - QGIS 2.18.4

GIS analysis:

- Georeferencing of images
- **Digitizing**
- **Vector geoprocessing**

Data source - Aerial photos

- Aerial photos 1954/55 (scale 1:33.000 - 1:35.000)*
- Orthophoto 1988 and 1996 (scale 1:10.000) WMS b/w
- Orthophoto 1999, 2006 and 2012 (scale 1:10.000) WMS c
- Satellite images 2016 (Quick Map Service QGIS plugin – Google Satellite)

* Georeferenced using QGIS and identifying GCP (RMSE below 1 pixel); Transformation algorithm and resampling method: Polynomial 2 order - Nearest neighbour

CRS: EPSG 32632 – WGS 84, UTM Zone 32N

We manually digitized the active channel for each time series.

Materials and methods

- Reaches definition and characterization;
- GeoDB containing information about mapped structures like bank protections, levees, bridges and weirs;

Length: about 13 km





- unstable banks mapping;




- GIS analysis of lateral erosion → 8 main lateral erosion sites.

GIS Procedure

We developed an innovative and semi-automated GIS procedure based on GRASS GIS and QGIS FOSS to characterize retreating banks over time at site and reach scale.

Reach scale

Retreatment rate of retreating banks, 1999-2016 (following the method specified in Rinaldi et al., 2014 for the assessment of the Morphologic Dynamic Index – M4).

ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

IDRAIM

Retreatment rate = transects length average value at reach scale / number of years between t1 and t2

Site scale

Bank edge position comparison;

Retreatment assessment in space and time;

Quantification of land loss over time.

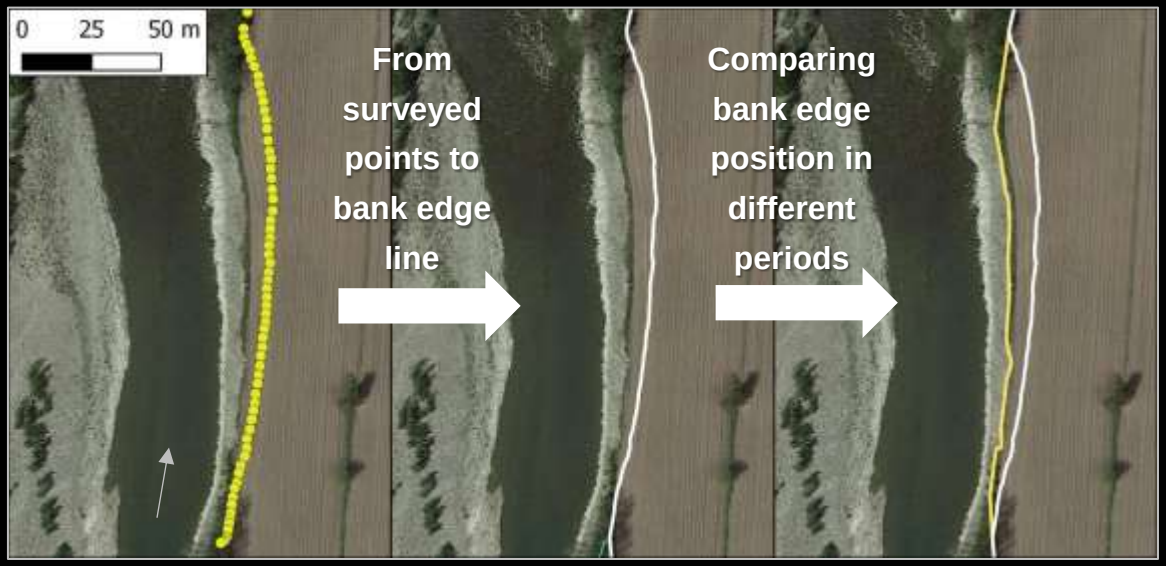
(8 sites → 4: 1999-2016, 3:2007-2016, 1:1954-2016)

Materials and methods

Work in progress!

2) GNSS planform monitoring

We started recently a topographic mapping activity in 4 representative sites: Banks 2,4,5 and 6.

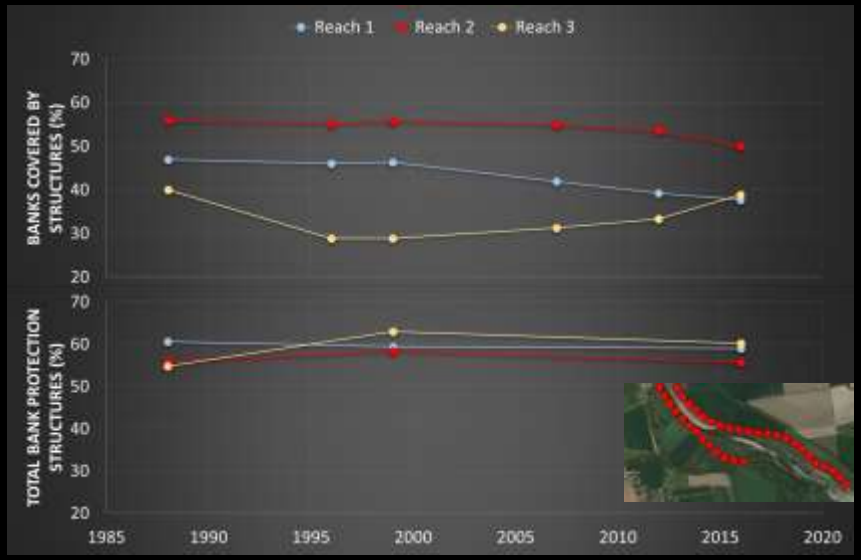


1st survey: 11/2016 – 2nd survey: 05/2017 – 3rd survey: …

Mode: **Real Time kinematic** – corrections received from the GNSS positioning service of Regione Piemonte and Regione Lombardia (GPRS/UMTS).

Instrument: Topcon Hyper Pro - CRS: ETRF2000-2008.0 RDN

Results



Reach_1 Reach_2 Reach_3

1 abstraction weir (upstream limit), 1 bridge, 2 weirs.

Nowadays (referred to the whole study reach):

- About 16 km of bank protection structures (58%);
- About 30% of unstable banks.

Results

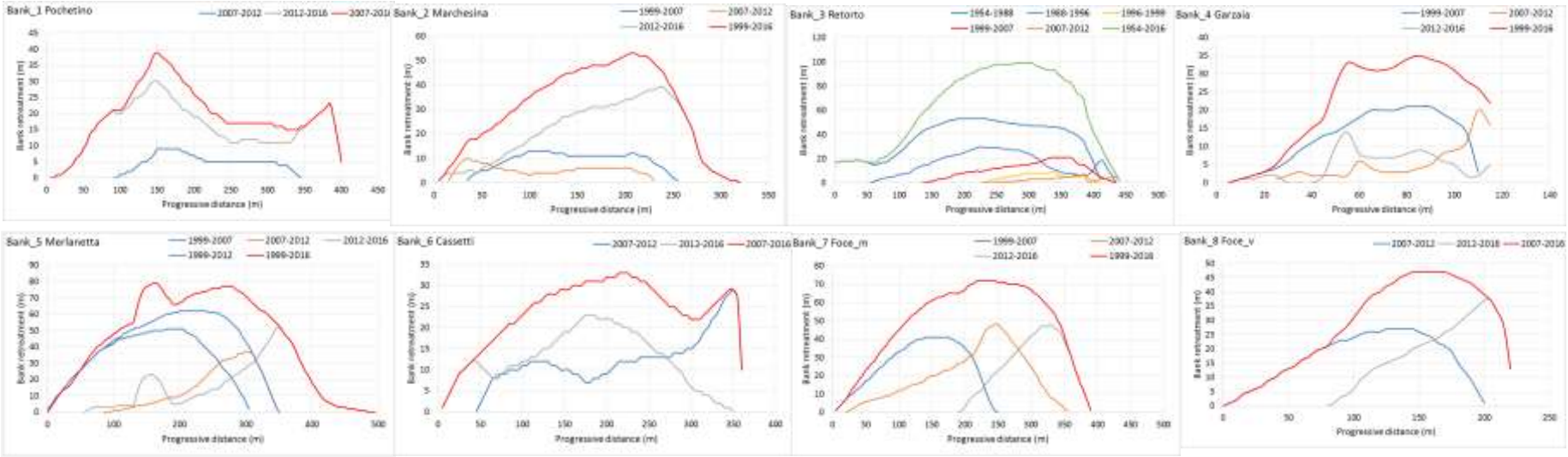
Retreatment rate of eroded banks (M4 IDM) 1999 - 2016

Reach_1: 1,3 (m/y)
Reach_2: 1,5 (m/y)
Reach_3: 1,7 (m/y)

Rr < 3m/y → not consistent values at reach scale

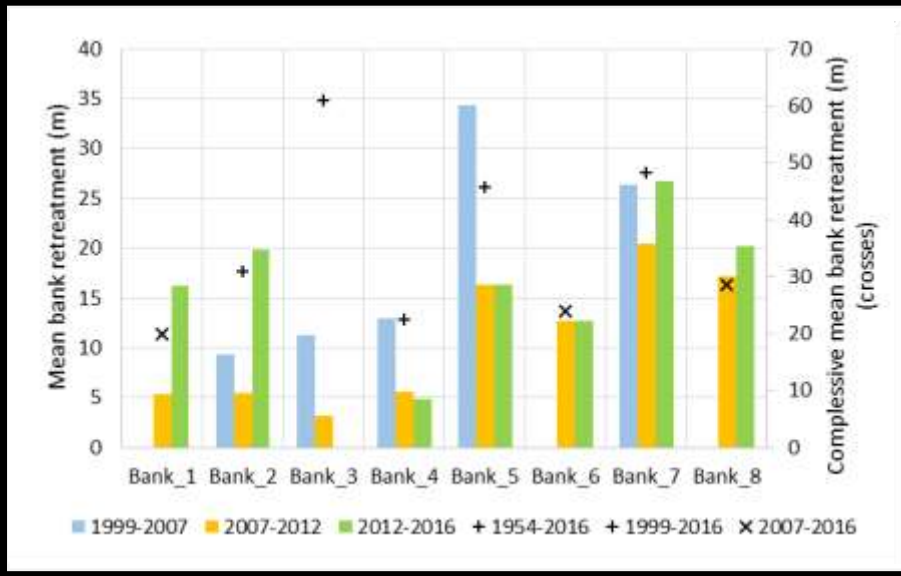
Site scale

Characterization in space and time of retreating trend.

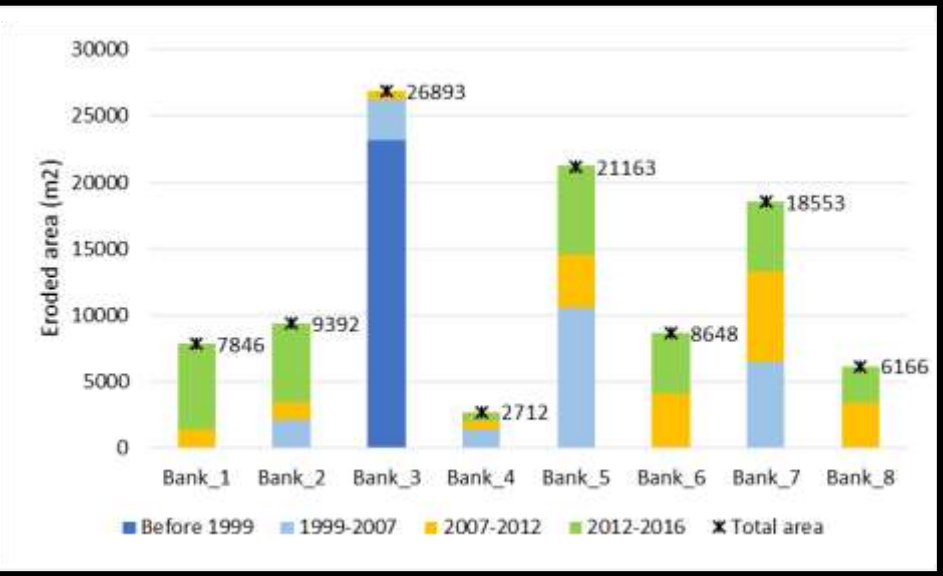


Results

	Bank_1					Bank_6					Bank_8					Bank_3				
Period	Mean/y	Mean	Median	Max	Std Dev	Mean/y	Mean	Median	Max	Std Dev	Mean/y	Mean	Median	Max	Std Dev	Mean/y	Mean	Median	Max	Std Dev
1999-2007	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	1.41	11.3	12.0	21.0	6.2
2007-2012	1.1	5.3	5.0	9.0	2.2	2.6	12.8	12.0	29.0	5.6	3.4	17.1	19.5	27.0	8.5	0.6	3.2	3.0	7.0	1.6
2012-2016	4.1	16.2	16.0	30.0	7.0	3.2	12.8	12.0	23.0	6.4	5.1	20.2	20.5	37.0	10.4	0.0	0.0	0.0	0.0	0.0
2007-2016	2.2	19.8	18.0	39.0	8.8	2.6	23.8	26.0	33.0	7.8	3.2	28.7	32.0	47.0	15.5	/	/	/	/	/
1954-2016	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	0.98	61.0	71.0	99.0	32.6
	Bank_2					**Bank_4**					**Bank_5**					**Bank_7**				
Period	Mean/y	Mean	Median	Max	Std Dev	Mean/y	Mean	Median	Max	Std Dev	Mean/y	Mean	Median	Max	Std Dev	Mean/y	Mean	Median	Max	Std Dev
1999-2007	1.2	9.3	11.0	13.0	3.4	1.6	13.0	14.0	21.0	7.0	4.3	34.4	39.0	51.0	15.1	3.3	26.3	30.0	41.0	13.2
2007-2012	1.1	5.4	5.5	10.0	1.9	1.1	5.6	3.0	20.0	5.0	3.3	16.4	12.5	37.0	12.2	4.1	20.5	19.0	48.0	13.7
2012-2016	4.9	19.8	22.0	39.0	12.7	1.2	4.8	5.0	14.0	3.8	4.1	16.3	12.0	52.0	14.3	6.7	26.8	27.0	48.0	14.8
1999-2016	1.8	30.8	34.0	53.0	17.1	1.3	22.5	27.5	35.0	11.8	2.7	45.6	51.5	79.0	26.9	2.8	48.3	56.5	72.0	22.3



Mean bank retreatment (partial for bars and total for crosses) for each investigated site.



Partial and total eroded surface for each investigated site.


Bank_8


Legend
bankfull_2007
bankfull_2012
bankfull_2016


Legend

Bank_4

Legend
bankfull_2007
bankfull_2012
bankfull_2016


17-6-2006

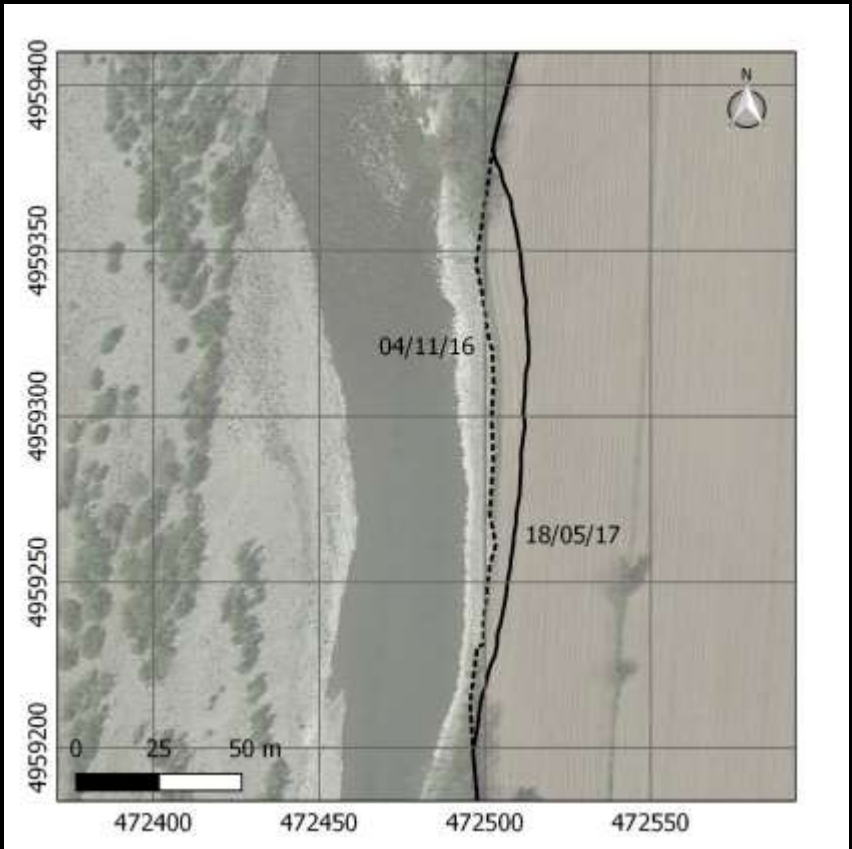

29-3-2014


Bank_6
25-10-2014

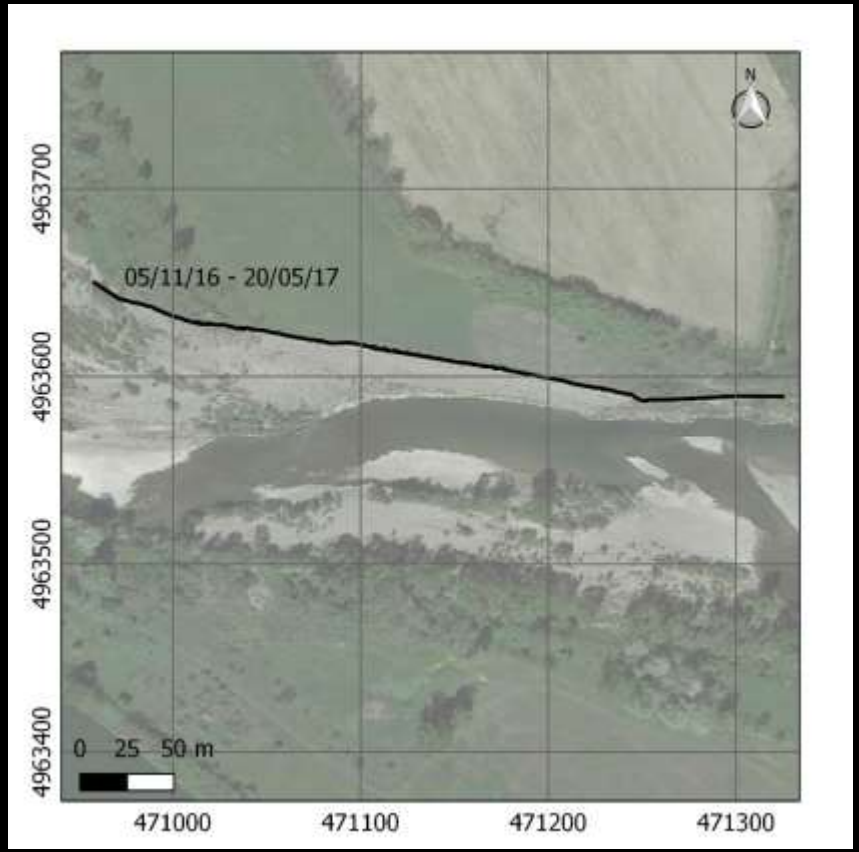

05-11-2016

Results

GNSS planform monitoring



Bank 2 → Consistent retreatment and shifting downstream; loss of land: 0,14 ha – retreatment values: average 3,7 m, max about 13 m



Bank 6 → No planform changes in last months (toe sediment deposition).

Conclusions

This research, conducted in a wider framework of geomorphologic analysis, allows to derive important information about the ongoing lower Orba River dynamics.

The Orba reach subject to the identified incision processes in turn reactivated lateral dynamics after decades of quescience. The river is widening where possible and bank protection structures result often dug out at their base or already collapsed.
On the contrary field evidences show in-channel deposition just downstream the main lateral erosions (now in verification phase).

GIS procedure → we developed a procedure using FOSS GIS able to describe quantitatively retreating banks in space and time, very useful for river management aims.

- Loss of lands
- Conflicts with landowners and among stakeholders

To face current dynamics new but “old school” works are requested by population and municipalities and planned by river management authority to stabilize landscape.

Articles

Bank Erosion as a Desirable Attribute of Rivers

Bank Erosion as a Desirable Attribute of Rivers Florsheim, Joan L;Mount, Jeffrey F;Chin, Anne Bioscience; Jun 2008; 58, 6; ProQuest Central pg. 519

Rivers → dynamic systems

Bank erosion:

+ natural evolution of rivers

+ dynamic habitats creation

It’s evident that society, and rivers, need a change of perspective in river management to restore the fluvial environment and to reduce risks.


«Free the rivers»
John Miur
Thank you for your attention.