NEW TRENDS IN STREAM RUNOFF AND SEDIMENT FEEDING DUE TO INCREASE IN THE VEGETATION IN A SMALL BASIN

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Introduction

We illustrate those data related to the bed load delivery from the small basin under observation (Piedmont, Italy) and under natural environmental conditions, where records have been kept since 1982 in order to provide a long-term estimate of sediment transport in relation to runoffs and rainfall amounts, with reference to volumes and grain size of sediments eroded and transported in the stream network and delivered to the main stream at the basin outlet (Anselmo, Maraga, 1985; Carononi *et al.*, 2000; Anselmo *et al.*, 2007). Because of the changes in sediment yield/year, annual variability was studied related to morphological features of the slopes and hydrological data (Figure 1).

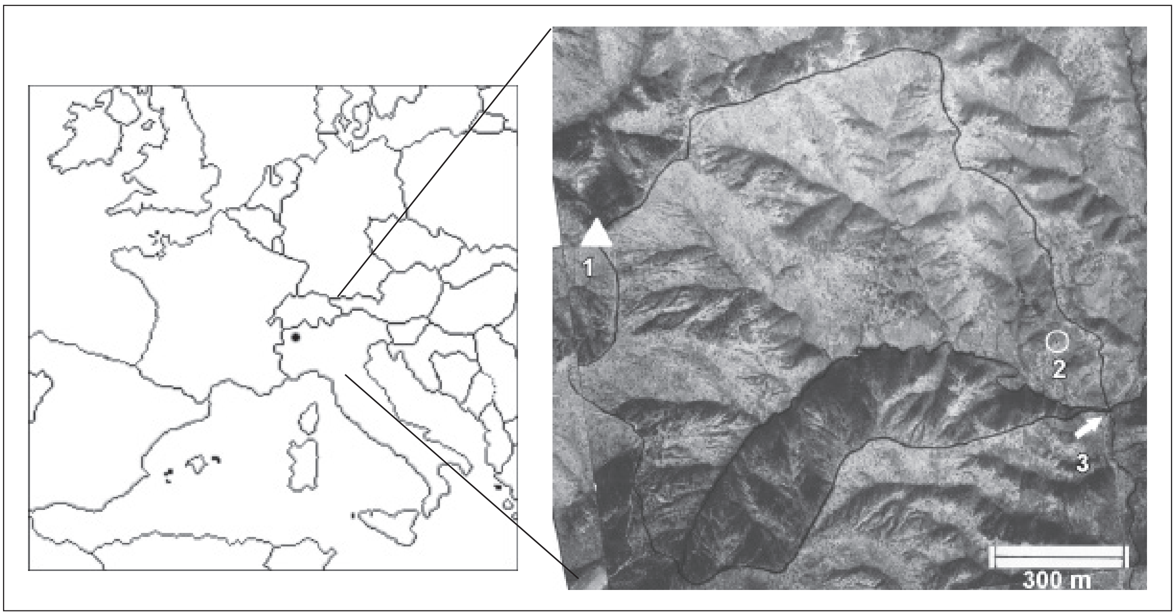

Figure. 1. Location map. The small basin *Valle della Gallina* (Italy) is presented by vertical aerial view of 1975. "*Albedo*" zones point out the erosion in the watershed.
1) head of the basin, *Monte della Gallina* (522 m a.s.l.); 2) meteorological station; 3) hydrometric and sedimentary station (330 m a.s.l.. North 45°38'28", Est 8°18'48")

Small basin case study

The small basin has drainage divide belonging to the Alpine hydrographic network of the river Sesia, a tributary of the Po, and forms a foothill region or buffer zone between the Alps and the upper Po Valley. Rainfall events range between 1300 and 1400 mm isohyets (1921-1970) and the pluviometric regime is of a continental Mediterranean-type, with minimum average pluviometric coefficients of 0.4 and 0.5 (in January and December respectively) and maximum average pluviometric coefficients of 1.2 and 1.5 (November and May respectively) (Caroni, 1979).

The pluviometric trend of the small basin is comparable to the regional trend. Instrument data (1982-2006) show an average value equal to 1300 mm/year for rainfall amounts, with a first peak in spring and a second peak in autumn. The runoff shows an average of 750 $mm \cdot y^{-1}$, with an average discharge of 0.02 $m^3 \cdot s^{-1}$ and a runoff coefficient of 0.57. The maximum flow was 6.44 $m^3 \cdot s^{-1}$ in 1995.

The annual sediment transport at the basin outlet has varied between 1 m^3 (1985) and 73 m^3 (2002), depending on the availability of sediment in transit in the stream network and all effective discharge, mobilization and transport conditions being equal.

As regards the sediment yield and erosive rainfalls, a survey carried out between 1991-2000 showed 280 erosive rainfall events selected at the standard threshold of 12.6 mm per event and their number varied between 20 and 37 per year. On an annual scale, the correlation between accumulated sediment volumes and erosive rainfall events and their duration is almost equivalent to the total annual rainfall events, with correlation indexes of about 8 (Maggi *et al.*, 2003).

The basin, located at an average 417 m. a. s. l., with a surface area of 1.08 km^2 and a length of 1.35 Km along the basin axis, has an average slope of 43% (Caroni, 1982).

Sediment yield in the streams is favoured by the wide dendritic drainage network (52 $km \cdot km^{-2}$) which has developed all the way from the first-order heads. The yield derives from erosion of the breaking up and meteoric alteration products of the bedrock, which discontinuously generate regolithic soil with a maximum thickness of 2 meters.

In 1975 the basin had wooded vegetation cover (coppice) over about 75% of the surface, mostly distributed from the streams to just over half way up the slopes. This study has revealed a reduction since 1992 in sediment yield due to a progressive expansion of the vegetation towards the heads causing a reduction in the soil erosion which fed the sediment transport to the stream channels.

Data collection and processing

The basin is equipped for hydrometeorological and sedimentological detection, with three stations in operation since 1982. The meteorological station measuring rainfall, temperature and humidity is located on a watershed which typifies the pluviometrical patterns in the basin (Di Nunzio, 1982-2006a). The hydrometric station for water levels in the stream channel is located in the main draining stream at the basin outlet (Di Nunzio, 1982-2006b). The sedimentary station has been set up in the stream channel near the hydrometrograph by reshaping a natural pool in the bedrock as a 40 m^3 capacity sediment retention trap. A small mechanical digger is used to empty the trap and deposit the sediments into the channel downstream of the weir, so that the regular sediment load transit outside the small basin remains unaltered. The sediment load transported along the main stream-channel is therefore “captured” directly on the bed and the height of the accumulation inside the trap is measured periodically (at least once a month), until the usable capacity is exhausted.

Accumulated sediments consist of sand and gravel ranging between 0.06 and 128 mm, with rare occurrences reaching 200 mm in size. The average bed load transport measured (depending on the sediments in transit available) is 35 $m^3 \cdot y^{-1}$, with a peak sediment product of 71 m^3 in 1990 and no sediment product in 1985. Suspended sediment transport is irrelevant.

Soil characterization (regolith) was carried out in 1992 (Bellino & Maraga, 1993) by means of 57 manual surveys, distributed over the whole area of the soil cover, either with or without vegetation, and 313 cores were sampled. 1 km^2 of basin has a soil cover measuring 0.7 m. (maximum 2 m.) thick. The remaining surface is limited to the watershed heads, with the bedrock outcropping. Stratimetries of the regolithic soil have revealed a great heterogeneity in soil texture, and dominant grain sizes within medium and coarse sands, ranging between 0.25 and 2 mm. Granulometry of accumulated sediments in the sedimentary station in the stream channel at the basin outlet are similar to the ones present in the soil, with the exception of large sizes (200 mm in diameter) resulting from erosion of the bedrock banks.

Results and final considerations

These results show sediment transport to the basin outlet over the 1982-2006 period with particular reference to sediment load distribution before and after 1998 (Figure 2).

In relation to runoff and rainfall, it has been observed that annual sediment load and runoff, after the 90s, showed average values lower by about 25% for sediment load and about 10% for runoff compared with the previous period, while rainfall events were almost constant. Therefore, the values surveyed demonstrate the presence of a reduction in soil erosion on the slopes and subsequent sediment yield in the numerous streams which constitute the drainage network of the streamflows as far as the basin outlet.

An explanation for this variation is found in the development of the arboreal colonisation toward the upper slopes and watershed areas, which in the 70s were completely denudated and had extensive forms of gully erosion. (Figure 3).

The expansion of wooded vegetation causes retention of rainwater, which would otherwise cause soil erosion and sediment transport in the stream channel. Indeed, through the foliar and radical apparatus, the hydrologic balance is more dependent on processes of soil seepage and evapotranspiration (Tesar *et al.*, 2000).

The flow coefficients, equal to 0.6 per year in 1982-2001, decreased to 0.5 after 1992. This new trend, surveyed in the small basin observed, reflects the increase in wooded vegetation in mountain areas and the corresponding reduction in sediment transport along the hydrographic system, due to soil erosion decrease. This trend reflects what has been happening at a regional level.

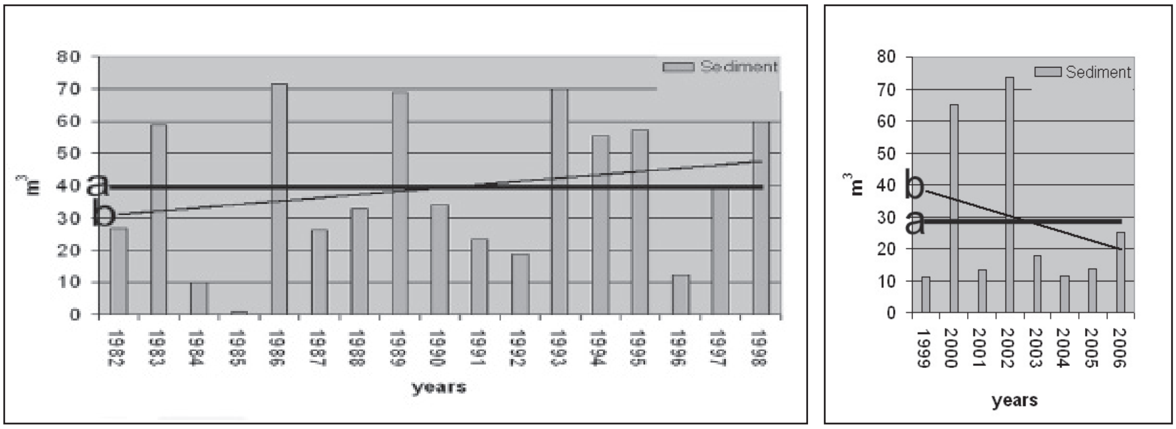

Figure 2. Sediment yield at the basin outlet as measured in a sedimentary trap in the main stream
Left: 1982-1998 and right 1999-2006 volumes. Decrease is pointed out by the different averages (a) and trends (b)

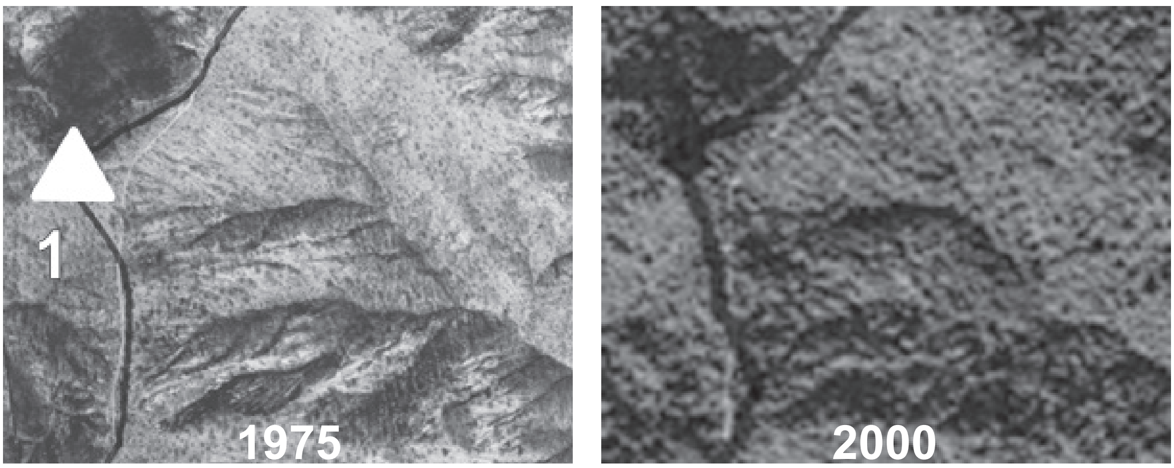

Figure 3. Particular of aerial photo in 1975 and 2000 in watershed head of *Monte della Gallina* (1). Erosion features in 1995 (rill, furrow and gully) are recovered by the vegetation in 2000 (2)

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References

Anselmo V., Maraga F., 1985: *Cobble Movement and Sediment Transport in a Streambed*. CNR-PAN Meeting on "Progress in Mass Movement and Sediment Transport Studies", Turin (Italy), 5-7 Dec. 1985: 245-264.

Anselmo V., Maraga F., Pelissero C., 2007: *Sediment delivery from a small river basin*. Proc. of IUGG XXIV General Assembly "Earth: our changing planet" Perugia (Italy), 2-13 Jul. 2007, www.iugg2007perugia.it, IAHS, HW3007-4803.

Bellino I., Maraga F., 1995: *Tempi di saturazione in bacino idrografico montano.* Atti II Incontro Internazionale dei Giovani Ricercatori in Geologia Applicata, Peveragno (Italy), 11-13 ott. 1995, Politecnico di Torino, Dipartimento di Georisorse e Territorio: 254-259.

Caroni E., 1979: *Pluviometria del Biellese Orientale*. Bollettino dell'Associazione Mineraria Subalpina, 16(4): 889-909.

Caroni E., 1982: *Piccoli bacini tenuti in osservazione dalle Unità Operative - Schede segnaletiche*. Atti del Convegno Conclusivo del Progetto Finalizzato "Conservazione del Suolo", CNR, Roma, 9-10 giu. 1982: 85-101.

Caroni E., Arattano M., Maraga F., 2000: *Results from bed load measurements in a small catchment (Rio della Gallina, Italy)*. Quaderni di Idronomia Montana, Editoriale Bios, 20: 99-110.

Di Nunzio F., 1982-2006a: Bacino sperimentale Valle della Gallina. Afflussi. Diagrammi mensili delle piogge orarie e giornaliere. CNR-IRPI, Torino, Internal Reports.

Di Nunzio F., 1982-2006b: *Bacino sperimentale Valle della Gallina. Deflussi. Idrogrammi mensili delle portate*. CNR-IRPI, Torino, Internal Reports.

Maggi I., Maraga F., Ottone C., 2003: *Heavy rains related to the in-channel sediment deliverying in a small Alpine basin (North-Western Italy)*. Proc. of ERB2002, 9th International Conference " Interdisciplinary approaches in a small catchement hydrology: monitoring and research", Demanovska dolina (Slovakia), 25-28 Sept.2002, IHP-VI UNESCO, Technical Documents in Hydrology, 67: 91-98.

Tesar M., Buchtele J., Sir M., Dinunzio F., 2000: *Simulation and verification of evapotranspiration and rainfall-runoff processes in the Liz (Czech Republic) and Gallina (Italy) experimental basins.* Proc. of ERB1998 8th International Conference "Catchment hydrological and biochemical processes in changing environment", Liblice (Czech Repubblic), Sept. 22-24, 1998, UNESCO IHP- V Technical Documents in Hydrology, 37: 131-138.