Effects of land-use changes during the last 60 years on river channel morphology in the Cantabrian area NW Spain): preliminary results

Effets des changements d'occupation des sols durant les 60 dernières années sur les rivières Cantabriques (nord-ouest de l'Espagne) : résultats préliminaires

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RÉSUMÉ

Les rivières s'écoulant dans le versant nord des Montagnes Cantabriques (nord-ouest de l'Espagne) se caractérisent par un style morphologique à chenal simple, des parcours courts depuis sa source jusqu'à la côte, et des fortes pentes. Ces rivières ont subi plusieurs changements ces dernières décennies, tels qu'une incision verticale du lit, un rétrécissement du chenal actif, une installation de végétation sur les marges, une perte des bancs à gravier et un abandon de bras secondaires. Des évolutions similaires ont été constatées dans d'autres régions de montagne de l'Espagne et de l'Europe. Ces types de changements sont normalement dûs à une réduction dans les apports de sédiment suite aux changements de l'occupation des sols. Nous présentons les résultats préliminaires d'un projet de recherche qui a pour objectifs d'analyser ces tendances à long-terme dans l'hydrologie et la géomorphologie des rivières Cantabriques, et aussi de déterminer les liens de ces évolutions avec le reboisement de la tête des bassins versants et les différents changements de l'occupation des sols.

ABSTRACT

Fluvial systems draining the northern watershed of Cantabrian mountains (NW Spain) to the Bay of Biscay are characterized by single-thread channels with short paths and steep slopes. During the last decades, they have experienced riverbed's incision, channel narrowing, vegetal colonization, loss of active gravels and abandonment of secondary channels. Similar trends have been described in other rivers from Spain and temperate Europe, and they have been usually related to a general decrease in sediment supply after land-use changes. Here we present the preliminary results of a research project aiming at analyzing these long-term geomorphological and hydrological trends in Cantabrian rivers, and exploring their links to afforestation and land abandonment.

KEYWORDS

Active channel, braiding index, channel morphology, hydrological changes, land use changes

1 BACKGROUND

During the last 60 years, Cantabrian fluvial systems (NW of Spain) have experienced important geomorphological changes. Similarly to other river systems from Spain and Europe, these changes were characterized by bed incision, active channel narrowing, vegetal colonization, loss of active gravels and abandonment of secondary channels (Vázquez-Tarrío et al., 2011).

Previous studies on several mountain areas have shown how this kind of changes were induced by a general decrease in sediment supplies into the channel networks after the progressive abandonment of traditional rural activities and increased afforestation during the 20th century (Liebault and Piegay, 2002; Keestra et al., 2005). Available data from the Cantabrian Mountain Range (NW Spain) are consistent with this interpretation but, up to now, no systematic analysis has been carried out in order to confirm this scenario.

As part of a research project aiming at exploring this question (*Riverchanges:* CGL2015-68824-R MINECO-FEDER), the Esva River drainage basin was selected in order to to quantify changes in channel morphology, putting them into relation to the main land use changing trends. This basin was selected because it is relatively undisturbed: anthropogenic influences are restricted to land-use modifications, whereas direct human intervetions on the channel (e.g. gravel extraction, river engineering, road construction) are lacking.

2 REGIONAL SETTING

The Cantabrian fluvial system is integrated by 28 rivers of small drainage areas (28-4900km2). The climatic conditions are Atlantic and homogeneous throughout the region. The mean annual rainfall is ~1100 mm and precipitations are well distributed the whole year round. Streams are perennial and the fluvial freshwater flow in summer is around 20% of the winter flow. Headwater channels are steep streams with coarse-bed sediment and irregular (but not ephemeral) hydrologic regimes. On the other hand, higher order channels are alluvial and featuredby a pluvial hydrological regime andcoarse beds (cobble and gravel), even very close to the river mouths.

The Esva river basin is a coastal fluvial catchment of467 km^2 located in this Cantabrian region. Maximum high at summits are close to 1300 m. Lithology of the basin comprises a diversity of Paleozoic sedimentary rocks, mainly siliciclastic (slate, sandstones and quartzite). The drainage network is dominated by bedrock in the river bed, and around only 11% are represented by alluvial reaches (most of them located in the lower part of the watershed).Mean annual discharge in the main Esva's stem is 10.5 m^3/s, whereas the maximum and minimum annual discharge are 19.2 m^3/s and 4.5 m^3/s, respectively. Higher values are recorded between December and April, corresponding to the more persistent rains of the year. The bankfull discharge is around 150 m^3/s,corresponding to a flow with a recurrence interval of 1 year. The maximum discharge registered after almost 50 years of gauging records was 729 m^3/s (200 year-flow).

3 MATERIALS AND METHODS

The morphology of the riverbed and the historical land uses were mapped from a series of old and recent aerial photographs taken at 1956, 1985, 2003 and 2014. The identified land uses were grouped into five units: forest, young forest, recently abandoned fields, grassland and fields. Aerial photographs were also used in order to to estimate changes in active channel surface, channel sinuosity andbraiding intensity.

Additionnally, meteorologica data sequences from five stations managed by the AEMET (Spanish Meteorological State Agency) and one stream gauging station located along the lower reach of Esva River have been used aiming at defining the main hydrological and rainfall trends.

4 RESULTS

From 1957 to 1985, the active channel decreased only 0.6% in the lower reach of Esva river. Conversely, from 1985 to 2003 the surface of the active channel experienced an important decrease (~13%). This decreasing trend change radically during the time period 2003-2014: active channel width increased at that moment, exceeding the active width in 1957. Similarly, braiding index also increased in that period (from 0.49 to 0.70). Channel sinuosity did not change significantlyfrom 1957 to 2014. By contrast, the braiding index show a continue decreasing from 0.81 in 1957, 0.58 in 1985 and

0.49 in 2003, a total decrease of 39.5%.

These morphometrical trends may be related to land use changes and channel hydrology. Aerial photograph analysis show a progressive increase in the percentage occupied by forested surfaces since 1957: a slow increase (6%) from a 1957 to 1985, was followed by an important increment (~18%) since 1985. This catchment-scale increases in forest cover may involve lower sediment supplies and explain active channel-width reduction. The inversion in morphometrical trends registered during the 2003-2014 time period can be explained by hydrology. This was a highly active decade in hydrological terms, recording 5 of the 10 largest floods occurred during the last 60 years (Figure 1).

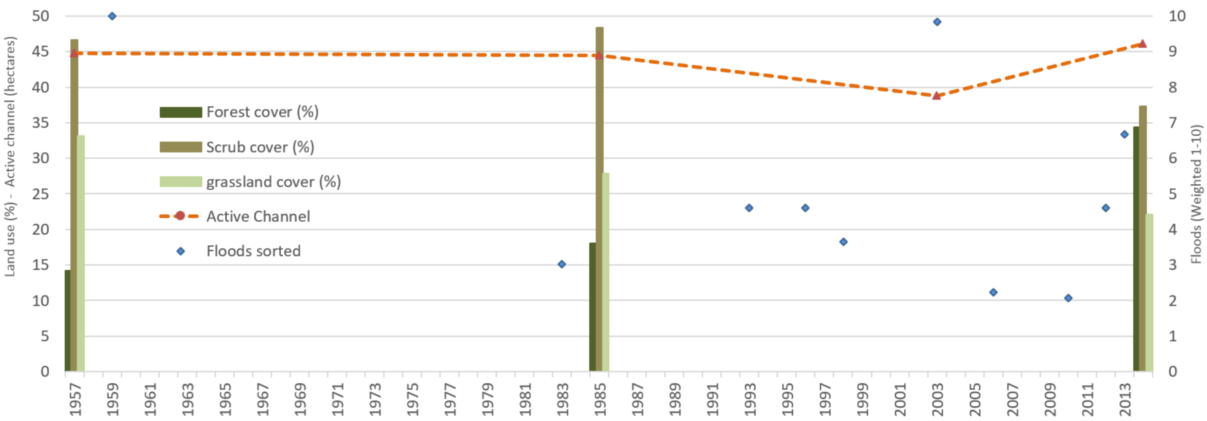

Figure 1. Active channel (Hectares), sorted floods (weighted 1-10) and land use changes (%) focused on forest, scrub and grassland cover.

5 SUMMARY AND PERSPECTIVES

This paper presents the preliminary results of a research project (*Riverchanges*) aiming at explore the effects of catchment-scale changes in land uses on the channel geomorphology of the relatively undisturbed Esva River (NW Spain). These results show that a slight active channel-width decrease from 1957 to 1985 (0.6%), and a very important decrease (close to 13%) from 1985 to 2003. This trend is well correlated to the main changes in the forest cover, which also increases slighly from 1957 to 1985 and more importantly 1985-2003.

Extrem floods may explain a radical change in the morphological trends during the period 2003-2014: Esva's channel surface increased from 2003 to 2014. This outlines how reduction in sediment supply could also be explained by hydrological changes, and not only by land use changes. Preliminary analysis on mean yearly discharge and rainfall data do not show any trend explaining the morphological changes in the morphology river. Nevertheless, additional statistical analysis concerning the recurrence of extreme hydrological events are going to be develop in this project.

Finally, these results will be also used to explore on the main temporal trends in channel habitats and biodiversity. New researchs will be carried out on the spawning habitat of fishing populations (*Salmo trutta* and *Salmo salar*) in Esva's channel. Loss of active gravels during the last 60 years may explain the current critical situation of some species, with a high socioeconomic impact for the Cantabrian region.

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