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Human impacts on fluvial systems in the Mediterranean region

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Abstract

The long history of substantial human impacts on the landscape of the Mediterranean region, and their effects on fluvial systems, is documented. These effects have included impacts of deforestation and other land use changes, agricultural terracing on a wide scale, water transfers, and irrigation schemes. During the 20th century, major changes were made directly to channels through channelisation, construction of dams of various sizes, and extraction of gravel, and indirectly by reforestation. These changes have caused a major phase of incision on some rivers. Runoff and soil erosion have been affected by types of crops and agricultural practices as well as by the varying extent of cultivation and grazing. Some recent agricultural practices involve wholescale relandscaping of the topography and alteration of surface properties of material. The importance of analysing the connectivity within different land units and of the spatial position of human activity within a catchment is illustrated. The analysis of connectivity is the key to understanding the variability of impact and the extent of propagation of effects.

Keywords: Soil erosion; Land degradation; Mediterrean; Rivers; Connectivity; Land management; River management

1. Introduction

The Mediterranean region of Europe has a long history of human settlement and human impacts. Much debate has focused on the environmental effects of human land use and its relative importance compared with climatic impacts, included in the volume by Thomas (1956). This debate continues in relation to recent phases of activity and phases in antiquity. The long history of human influence in the Mediterranean region means that distinguishing human impacts poses particular difficulty. The very high spatial and temporal variability of fluvial processes in the region also creates problems for measurement and monitoring and for assessment of effects. The existence of Mediterranean climatic zones elsewhere in the world with rather different histories may provide some opportunity for evaluation. Indeed, Sauer (1956) suggested this but systematic comparison is limited as yet (Roberts, 1989; Brierley et al., 2005). After the long history dominated by the clearance of vegetation and increasing exploitation of the land, abandonment of land from agriculture in southern Europe is also providing some opportunity to compare fallow land with cultivated areas. It cannot be assumed that this represents a return to a 'natural' state since the long history of cultivation and land use may have completely altered the soil condition. Dedkov and Mozzherin (1992) assembled data on rates of erosion across the world and classified the degree of disturbance of catchments. They concluded that Mediterranean mountain streams exhibit the highest anthropogenic contribution of any climatic zone.

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Several reviews of physical and environmental aspects of the Mediterranean region have been published in recent years, including a general overview by King et al. (1997) and a detailed analysis by Wainwright and Thornes (2004) that focuses on environmental issues. The issue of desertification and its threat to the region has provided impetus to much research. Major projects such as MEDALUS, funded by the EU, have promoted key publications, many giving much background on the physical state and processes in the region (e.g. Brandt and Thornes, 1996; Mairota et al., 1998; Balbanis et al., 1999; Geeson et al., 2002). A recent book arising from the EU funded MODMED project (Mazzoleni et al., 2004a), concerned with changes and dynamics of vegetation, however, challenges some of the recent assumptions and views about desertification in Europe. Much data and information on Mediterranean type regions around the world and the nature, extent and causes of land degradation in each of them were brought together by Conacher and Sala (1998). In terms of fluvial systems, the early, classic work on the region was the book by Vita-Finzi (1969). Lewin et al. (1995) have more recently discussed fluvial developments during the Quaternary, including climatic and human impacts. The volume edited by Bull and Kirkby (2002), while entitled Drylands Rivers, has a major focus on the Mediterranean region and extends from runoff processes to channels. A review by Poesen and Hooke (1997) focuses on present understanding of erosion, flooding and channel management in the European Mediterranean region and identifies research gaps.

This paper reviews the impacts of human activities on fluvial systems in the Mediterranean region, focusing on changes occurring in the 20th century and currently. Against the background of the present characteristics and dynamics and the longer-term history, it identifies the main activities and discusses the nature of their influences. It examines the functioning of the system as a whole and considers the implications of the current scales of activity. The discussion is set within the framework of connectivity (Hooke, 2003) of the system and the changes which human activities have made to this, so influencing the delivery of water and sediment down through the system from source areas to the coast. The major human impacts over the last century or so tend to have been related to water and channel management, to land use changes and land practices, and more recently to urbanisation. Some case studies are taken in particular from southeastern Spain. This is the driest part of the region and arguably can show trends which may occur elsewhere under scenarios of global warming, and also very rapid and large scale transformation of landscape and land use is currently taking place there. Finally, the region has been the focus of much research.

2. Characteristics of the Mediterranean region

Definition of the Mediterranean is quite difficult and even in major publications on the region, definitions are avoided or various alternatives are proposed (e.g. King et al., 1997; Wainwright and Thornes, 2004). In Koppen's definition it is the climatic zone in which winter rainfall is at least three times that of summer (Palutikof et al., 1996). The region is often considered as that bound by the limits of growth of olive trees. Conacher and Sala (1998) agree that the most distinctive characteristic is summer drought. The high seasonality of the climate, with mild, wet winters and hot dry summers, leads to particular characteristics in the hydrological regime. Rainfall varies within the region, ranging from semi-arid, <300 mm in SE Spain, to >1200 mm in parts of Italy and France, and higher still in parts of the Balkans. The peak rainfall varies slightly in its timing across the region but is mostly in the transitional months of autumn and spring. The climatic and hydrological characteristics are also complicated by the presence of high relief in much of the region, producing sharp climatic gradients away from the coast and altitudinally. As a result of these climatic and physical characteristics the region experiences high spatial and temporal variability of rainfall.

The runoff regime has generally been characterised by the dominance of Hortonian overland flow but, even in the driest parts of the region, this may be an over simplification (Scoging, 1989; Beven, 2002). Saturation excess overland flow may also occur; for example, Calvo-Cases et al. (2003) identified both as occurring on limestone slopes in SE Spain. Subsurface seepage within regolith layers may also contribute under certain conditions and piping is an important process in some materials and locations. Beven (2002) emphasises the spatial and temporal variability of runoff even within a storm and the case study by Bull et al. (1999) shows the importance of intense pulses of rain even within a prolonged period of rainfall. Much recent work has demonstrated the importance of the distribution of vegetation and its interaction with runoff at the patch scale, with runoff source (bare) and sink (vegetated) areas (e.g. Puigdefabregas et al., 1998, 1999). Severe problems of heterogeneity, however, emerge in scaling up from plot and hillslope to catchment scale, as demonstrated by Cammeraat (2004). Much current research on modelling runoff is using concepts and