Catena 79 (2009) 181–188

Contents lists available at ScienceDirect

Catena

journal homepage: www.elsevier.com/locate/catena

Investigating the effects of afforestation on soil erosion and sediment mobilisation in two small catchments in Southern Italy

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ARTICLE INFO

Keywords:
Caesium-137
Erosion rates
Forest harvesting
Lead-210
Sediment yield
Southern Italy

ABSTRACT

Annual soil losses in southern Italy can exceed 100–150 t ha^{-1} $year^{-1}$. Where erosion on agricultural land is particularly severe, land use change and afforestation are frequently seen as the most appropriate means of reducing erosion risk. However, the overall effectiveness of afforestation in reducing soil erosion remains uncertain, due to the poor development of the forest cover in some areas, leading to significant areas with sparse tree cover, and the erosional impact of forest harvesting, which commonly involves clearcutting. The study reported here addresses this uncertainty and focuses on two small catchments (W2 and W3) located in Calabria, southern Italy, for which measurements of suspended sediment yield are available. Both the catchments originally supported a rangeland vegetation cover and they were planted with eucalyptus trees in 1968. Currently, only catchment W3 supports a continuous forest cover. In catchment W2 the forest cover is discontinuous and there is a significant area of the catchment (ca. 20%) where the tree cover is sparse and the vegetation cover is dominated by natural grasses. Two additional erosion plots were established within catchment W2 in 1991, in order to explore the effect of the density of the tree cover on soil erosion. Information on the sediment yields from the two catchments and the plots for 10 storm events that occurred during the period December 2005–December 2006 and associated information on the ^{137}Cs and excess ^{210}Pb of the sediment, have been used to investigate the effectiveness of afforestation in reducing sediment mobilisation and net soil loss from the catchments involved. The results demonstrate that the areas of greatest soil loss are associated with the slopes where the tree cover is discontinuous, and that forest harvesting by clearcutting causes significant short-term increases in sediment mobilisation and sediment yield. These findings, which are consistent with previous work undertaken within the same area, emphasize the importance of vegetation cover density in influencing rates of soil loss in the study catchments. The study also provided a useful demonstration of the potential for using measurements of the ^{137}Cs and $^{210}Pb_{ex}$ content of sediment, in combination with more traditional sediment monitoring, to investigate sediment sources and to compare the sediment dynamics of catchments subjected to different land management practices.

1. Introduction

The on-site and off-site impacts of soil erosion are increasingly seen as key concerns for the sustainable management of soils and river basins, since they can result in reduced soil productivity and the degradation of river water quality and aquatic ecosystems, as well as introducing problems for water resource development through reservoir sedimentation. For Southern Italy, Sorriso-Valvo et al. (1995) suggested that soil erosion rates as high as 10 mm $year^{-1}$ (ca. 100–150 t ha^{-1} $year^{-1}$) can occur in the mountainous Calabrian region. In such contexts, there has been a drive to reduce soil erosion by implementing improved management practices and erosion control measures. In some agricultural areas, where soil erosion is particularly severe, land use change and afforestation have been seen as the most appropriate means of reducing erosion risk. Some uncertainty does, however, exist regarding the effectiveness of afforestation programmes in reducing soil loss and catchment sediment yields, including the most appropriate forest species, particularly when the climate and soil conditions mean that the resulting forest cover may be sparse and not well-developed. Eucalyptus trees have, for example, been widely planted, but the canopy cover provided by such trees is generally less dense than that associated with other tree species. Furthermore, the need to obtain some economic return from the afforested land means that forest harvesting, frequently involving clearcutting, is an essential feature of the changed land management.

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doi:10.1016/j.catena.2009.01.007

Table 1
The characteristics of the study catchments.

Catchment	Drainage area Ha	Mean altitude m a.s.l.	Mean slope %	Mean soil content			Measured annual sediment yield			Estimated long term sediment yield
				Sand	Silt	Clay	Min	Max	Mean	1956–1998
				%	%	%	t ha^{-1} year^{-1}			t ha^{-1} year^{-1}
W1	1.473	122	53	14	44.5	41.5	5.1	38.4	11.6	12.4
W2	1.375	103	35	14.6	49.2	36.2	1.7	98.5	20.8	19.2
W3	1.654	98	24	20.7	45.5	33.8	2.9	25.7	7.6	7.8

Forest harvesting, which results in complete clearance of the tree cover prior to regrowth, can clearly be expected to increase the sediment yield from a forested catchment, relative to a catchment with a long-term undisturbed forest cover, but it would not necessarily be expected to cause the sediment yield to greatly increase above that of a catchment with natural rangeland cover. To meet a need for empirical evidence regarding the effectiveness of afforestation in reducing soil erosion and catchment sediment yields, a number of catchment experiments were initiated in southern Italy in the latter part of the 20th century. These included a study implemented in 1978 within the framework of the National Research Council of Italy (CNR) 'Soil Conservation Project', that investigated the hydrological response and sediment yield of three small catchments, ranging in size from 1.38 ha to 1.65 ha, located near Crotone in Calabria (see Avolio et al., 1980; Iovino and Puglisi, 1991). Detailed information on two of these catchments and the measurements undertaken are provided later in this paper. In essence, however, the study comprised three catchments, one (catchment W1) that was left as original rangeland with grass and scrub vegetation, one with a good cover of eucalyptus trees (*Eucalyptus occidentalis* Endl.) planted in 1968 (catchment W3) and one with a patchy (ca. 80%) cover of eucalyptus trees developed from trees again planted in 1968 (catchment W2). A summary of the main physiographic characteristics of the three catchments and the available estimates of annual sediment yield from these three catchments, over the period 1978 to 1994, which included episodes of forest harvesting, is presented in Table 1. Although it is not possible to make precise comparisons between the sediment yields of the three catchments, due to minor difference in catchment area, altitude, slope and soil characteristics between the catchments, the sediment yield data provided in Table 1 emphasize that, in this location, afforestation may not necessarily reduce the mean annual sediment yield. The sediment yield from catchment W3, which is characterized by a good forest

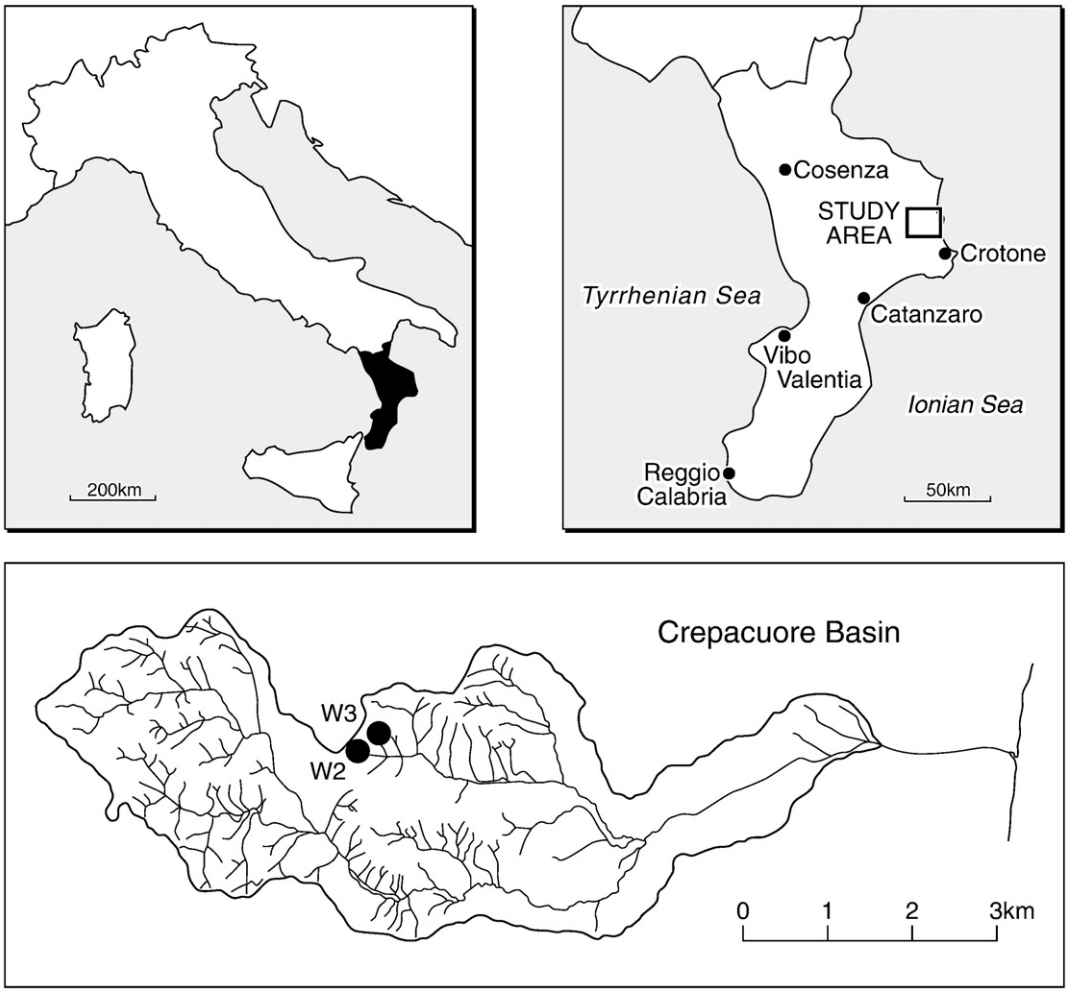

Fig. 1. The study area.