Geomorphology 310 (2018) 15–28

Contents lists available at ScienceDirect

Geomorphology

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

Longitudinal distribution and parameters of large wood in a Mediterranean ephemeral stream

T. Galia [a,*], V. Škarpich [a], R. Tichavský [a], L. Vardakas [b], K. Šilhán [a]

[a] Department of Physical Geography and Geoecology, University of Ostrava, Czech Republic
[b] Institute of Marine Biological Resources and Inland Waters, Hellenic Centre for Marine Research, Greece

ARTICLE INFO

Article history:
Received 21 December 2017
Received in revised form 7 March 2018
Accepted 7 March 2018
Available online 08 March 2018

Keywords:
Large wood
Instream wood
Ephemeral stream
Mediterranean

ABSTRACT

Although large wood (LW) has been intensively studied in forested basins of humid temperate climates, data on LW patterns in different fluvial environments are rather scarce. Therefore, we investigated the dimensions, characteristics, longitudinal distribution, and dynamics of LW along a 4.05-km-long reach of an ephemeral channel typical of European Mediterranean mountainous landscape (Sfakiano Gorge, Crete, Greece). We analysed a total of 795 LW pieces, and the mean observed abundance of LW was generally lower (14.3 m^3/ha of active valley floor or 19.6 LW pieces/100 m of stream length) than is usually documented for more humid environments. The number of LW pieces was primarily controlled by trees growing on the valley floor. These living trees acted as important LW supply agents (by tree throws or the supply of individual branches with sufficient LW dimensions) and flow obstructions during large flood events, causing storage of transported LW pieces in jams. However, the downstream transport of LW is probably episodic, and large jams are likely formed only during major floods; after >15 years, we still observed significant imprints of the last major flood event on the present distribution of LW. The geomorphic function of LW in the studied stream can only be perceived to be a spatially limited stabilising element for sediments, which was documented by a few accumulations of coarse clastic material by LW steps and jams.

1. Introduction

Large instream wood (LW) represented an important research topic over the past 50 years (Wohl, 2017). Many recent studies have acknowledged the importance of LW in the geomorphic functions of rivers and streams (e.g., increased flow resistance; more frequent occurrence of channel units, such as log steps or pools; positive effects on sediment storage) and its unique benefits for aquatic biota (e.g., increased habitat heterogeneity, providing source of food, creation of refuges for aquatic organisms) (Marston, 1982; Bilby and Ward, 1991; Nakamura and Swanson, 1993; Montgomery et al., 1995; Gurnell et al., 2002; Wohl, 2013, 2017; Livers and Wohl, 2016). However, the majority of instream wood research so far has been conducted mainly in temperate or boreal forested basins, and data about LW abundance, geomorphic function, and dynamics in different fluvial systems, such as the humid tropics or ephemeral streams, are still quite scarce (Ruiz-Villanueva et al., 2016; Wohl, 2017).

Many European Mediterranean streams naturally exhibit a nonperennial flow regime, with a distinct seasonal, interannual and spatial heterogeneity (Bonada and Resh, 2013). However, at the same time, Mediterranean river basins are turning drier because of decreasing precipitation and the unsustainable management of water resources (Skoulikidis, 2009). Direct and indirect human impacts on Mediterranean fluvial systems are mainly represented by extensive historical deforestation, agricultural activities, in-channel gravel mining, and significant changes in the water balance caused by the construction of irrigation channels or water reservoirs (Hooke and Mant, 2002; Segura-Beltrán and Sanchis-Ibor, 2013; Skoulikidis et al., 2016; Calle et al., 2017). Such strong alterations affect not only the sediment supply into the fluvial system and the hydrological regime of water bodies but also the presence and structure of riparian forests (Hooke, 2006; Boix-Fayos et al., 2007; Bombino et al., 2009; Magdaleno et al., 2014) and, therefore, the potential recruitment of LW into channels (Vaz et al., 2011, 2013). So far, very limited knowledge has been concerning LW characteristics and dynamics in ephemeral and intermittent streams and rivers draining the European Mediterranean landscape. Similarly to other European cultural landscapes (Kail, 2003; Krejčí and Máčka, 2012), instream wood is removed from these streams and rivers near inhabited areas because of safety reasons connected with the potential clogging of bridges and uncontrolled inundations during floods. Very low instream wood volumes were documented in intermittent headwater streams of the western European Mediterranean basins (central Portugal) in comparison with temperate forested basins of similar

* Corresponding author.
E-mail address: tomas.galia@osu.cz (T. Galia).

https://doi.org/10.1016/j.geomorph.2018.03.007
0169-555X/

dimensions (Vaz et al., 2013). In this region, wildfires are perceived as an important LW recruitment agent (Vaz et al., 2011, 2013). The pioneering research of LW in other environments characterized by the occurrence of nonperennial streams pointed to the ecologic importance of wood jams (Pettit et al., 2006), and these jams also have the potential to influence hydrogeomorphic processes during wet seasons similarly to the way they do in perennial streams (Dunkerley, 2014). Additionally, low volumes of LW per channel area were also measured in wider ephemeral rivers of Australia and Namibia when compared to more humid environments, which most likely corresponds to the low local production of biomass (Jacobson et al., 1999; Dunkerley, 2014).

Most wood in perennial rivers is transported during relatively infrequent high flows, but flows under bankfull can transport up to 30% of stored LW (Kramer and Wohl, 2017). Currently, observations of LW mobility in (semi)arid environments are limited to only a few case studies from south Africa, pointing out to the flashy character of LW transport during very infrequent extraordinary floods (Jacobson et al., 1999; Pettit et al., 2005, 2006). These studies also recognized the riparian and in-channel living trees as important roughness elements that cause LW deposition and the formation of extensive jams. A two-dimensional numerical model together with post-event assessments documented the notable increase in flow depth and inundated areas of a flash flood in a Mediterranean mountain stream (Spanish Central System) caused by the retention of large quantities of wood, particularly at critical sections, such as bridges (Ruiz-Villanueva et al., 2014). A long-term LW budget has been studied in a river in California's Mediterranean climate with a much shorter duration of human impact on the landscape (<200 years) when compared to the European Mediterranean basins (usually thousands of years). Episodically extreme climatic events and subsequent hydrologic responses resulted in three floods of ≥20-year recurrence intervals, which were responsible for the majority of the total wood export over a 30-year study period (Senter et al., 2016). This result implies that these frequency-magnitude relationships of LW transport observed in California and south Africa correspond well with geomorphic observations in semiarid fluvial Mediterranean landscapes, where these low-frequency, high-magnitude flood events exert major impacts on the resulting channel morphology (Graf, 1983; Hooke, 2016).

To our knowledge, no summary of the data of LW characteristics and dynamics, except for a few sites that experienced wildfires (Vaz et al., 2011, 2013), are available from nonperennial Mediterranean streams in southern Europe. Therefore, the main aims of this study were:

- to quantify storage of LW;
- to report a range of dimensions (length, diameter) and other selected parameters of wood pieces;
- to assess geomorphic functions of LW; and
- to characterize LW recruitment processes and mobility in an ephemeral, low-order, relatively wide and steep mountain Mediterranean channel located on the largest Greek island, Crete.

2. Study area

We examined a 4.05–km-long reach of the Sfakiano Gorge valley floor, located in SW Crete, Greece (35°13′20″N; 24°09′04″E), that adequately displays similar geomorphic and hydrologic characteristics found also in other ephemeral streams typical of the European Mediterranean region. This means the frequent occurrence of steep gorge-like valleys in mountainous landscapes under semiarid conditions, the floors of which are filled by coarse sediments (gravels, cobbles, boulders) with local patches of exposed bedrock. These valleys have lower density of vegetation when compared to more humid environments, and they are usually drained by streams with nonperennial flow regime (Maas and Macklin, 2002; Sandercock et al., 2007; Skoulikidis et al., 2016). Although similar gorges occur nearby, the Sfakiano Gorge was selected for a detailed study because of two main reasons: (i) absence of tourist infrastructure, which would otherwise affect large wood distribution, e.g., by maintenance of the tracks like in the Imbros Gorge (see Fig. 1

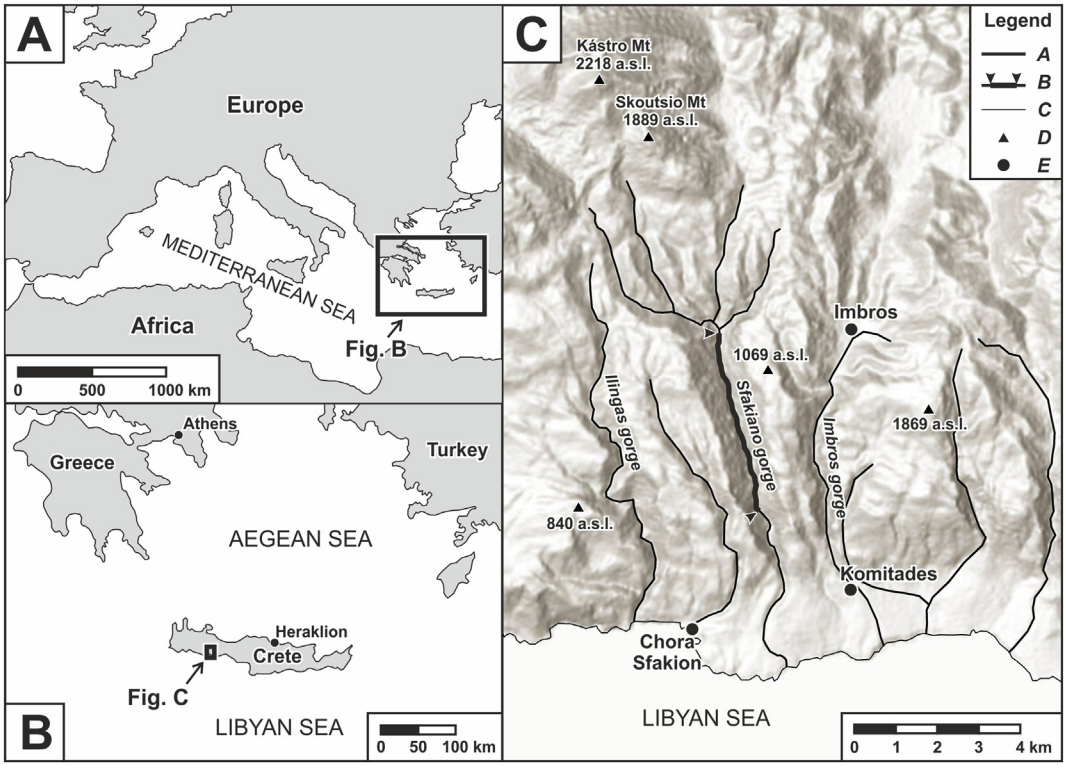

Fig. 1. Geographical position of the study area; A – location within Europe; B – location within south-eastern Europe; C – geographical location of the surroundings of the study area; legend: A – streams, B – study reach, C – shoreline, D – mountain peaks, E – settlements.
(Data sources: Esri, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community.)