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Fire, humans and landscape in the European Alpine region during the Holocene

E. Valese [a,*], M. Conedera [b], A.C. Held [c], D. Ascoli [d]

[a] Dipartimento Territorio e Sistemi Agro Forestali TESAF, Università degli Studi di Padova, Viale dell'Università 16, I-35020 Legnaro, Padova, Italy
[b] Swiss Federal Institute WSL for Forest, Snow and Landscape Research, Insubric Ecosystems Research Group, Via Belsoggiorno 22, CH-6500 Bellinzona, Switzerland
[c] EFI Central European Regional Office – EFICENT, Wonnhaldestrasse 4, 79100 Freiburg, Germany
[d] Dip. Scienze Agrarie, Forestali e Alimentari, Università di Torino, via Leonardo da Vinci 44, I-10095 Grugliasco, TO, Italy

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ABSTRACT

Fire evolved on the Earth under the direct influence of climate and the accumulation of burnable biomass at various times and spatial scales. However, since humans have been using fire, fire regimes depend not only on climatic and biological factors, but also strongly reflect the cultural background of how people manage ecosystems and fire. Besides the overall global variability of biomes and cultures, common evolutionary patterns of fire regimes can be detected worldwide in relation to the geographical extension and intensification of human pressure on the land. Pyne (2001) in his historical research identified such common patterns outlining three main fire epochs that are common to most fire histories worldwide: natural, anthropogenic, and industrial fire regimes. Castellnou and Miralles (2009) further detailed the industrial fire epoch by differentiating among "generations of large wildfires".

In this paper we reconstruct the fire history and related landscape evolution that occurred in the Alps during the Holocene in relation to the classifications proposed by Pyne (2001) and Castellnou and Miralles (2009). Negative and positive impacts of current fire regimes on the value of ecosystem services in the Alps are described, as well as the incidence of human fire uses and fire suppression policies. Present and future fire management strategies are discussed assuming that fire is still an important trigger for landscape and habitat diversity, cultural landscape maintenance, and a post-management driver of forest ecosystems in the Alps. We conclude that complete removal of such a disturbance from the Alpine area is neither feasible nor advisable.

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Introduction

Fire evolved on the Earth under the direct influence of climate and the accumulation of burnable biomass at various times and spatial scales (Pausas and Keeley, 2009; Whitlock et al., 2010). However, since humans have been using fire, fire on Earth depends not only on climatic and biological factors, but also on the cultural background of how people manage ecosystems and fire (Goudsblom, 1992; Pyne, 1995; Bowman et al., 2011; Coughlan and Petty, 2012; Fernandes, 2013). A number of authors, e.g., Pyne (1995), Bond et al. (2005), Pausas and Keeley (2009), Bowman et al. (2011), Coughlan and Petty (2012), Marlon et al. (2013), have been engaged in the demanding task of illustrating this synthesis, in order to track the signature of fire on global geography and human history. In this context, spatio-temporal patterns of fire and related impacts on ecosystems and landscapes are usually described by means of the fire regime concept (Bradstock et al., 2002; Whitlock et al., 2010; Bowman et al., 2011; McKenzie et al., 2011). A wide set of fire regime definitions exists depending on the aspects considered, the temporal and spatial scale of analysis and related choice of descriptors (Krebs et al., 2010). In this review we consider the fire regime as the sum of all the ecologically and socially relevant characteristics and dimensions of fire occurrence spanning human history in specific geographical areas. With this line of reasoning, special attention is paid to the ignition source (natural or anthropogenic) and, within anthropogenic fires, to the different fire handling approaches (active fire use vs. fire use prohibition) in land management.

Beside the overall global variability of biomes and cultures, common evolutionary patterns of fire regimes can be detected worldwide in relation to the geographical extension and intensification of human pressure on the land (Hough, 1932; Goudsblom,

* Corresponding author. Tel.: +39 3496034739.
E-mail addresses: eva.valese@unipd.it, evale16@yahoo.it (E. Valese).

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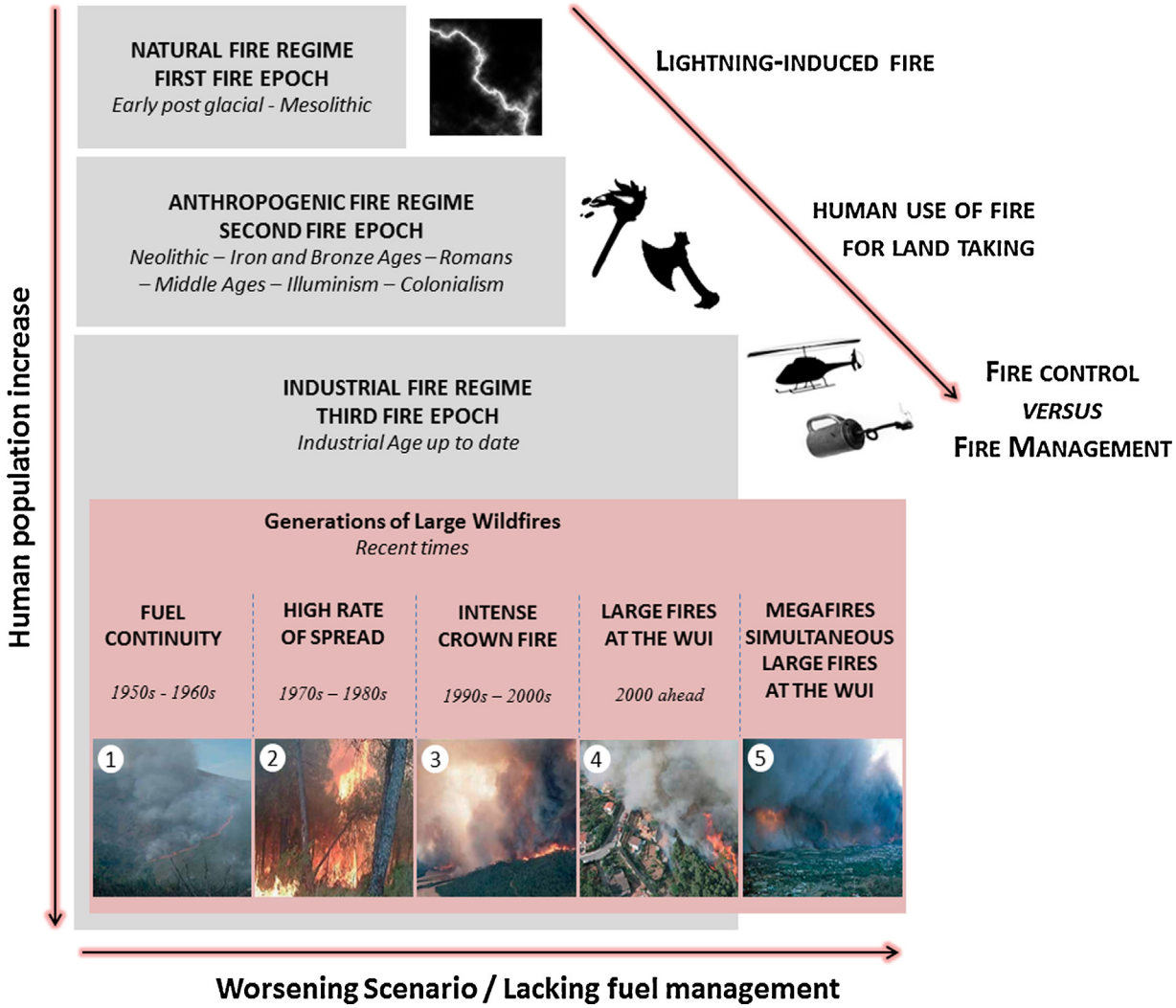

Fig. 1. Historical evolution of fire as human population grows. Global fire regimes by Pyne (2001) are shown in the grey boxes. In the red box, the recent (last century) evolution of large fires is described in five generations (Castellnou and Miralles, 2009). Each generation of large wildfires is characterized by a constraint overcoming the suppression capacity and thus leading to uncontrolled fire spread. Constraints change as fuel accumulate up to the worse possible scenario (megafires).
Photo credits: UT-GRAF Catalunya.

1992; Pausas and Keeley, 2009; Bowman et al., 2011). Pyne (2001), in his historical research, identified these common patterns outlining three main "fire epochs": natural, anthropogenic, and industrial fire regimes. Castellnou and Miralles (2009) further detailed the industrial fire epoch by differentiating among five "generations of large wildfires" (Fig. 1), where a wildfire is defined as an uncontrolled fire in an area of combustible vegetation that occurs in the countryside or a wilderness area.

Both typological systems can be applied in most regions of the world. In this review paper we integrate these definitions for the first time in the long-term and recent forest fire history of the Alpine region. In fact, despite the considerable literature produced for specific areas, e.g., Conedera et al. (2004a), Carcaillet et al. (2009), Favilli et al. (2010), Colombaroli et al. (2013), no synthesis on historical, present and future fire regimes so far exists for the European Alpine region. The proposed approach additionally allows to insert the analyzed fire history in a more global context of ongoing changes as experienced also by other regions of the world. To this purpose, the impact of the evolution of human fire uses, and fire suppression policies, on the fire regime and on the value of ecosystem services is presented; the potential influence of present and future fire management strategies on the cultural landscape maintenance, post-management forest ecosystems evolution, and the general landscape and habitat diversity is discussed.

Fire epochs and generations of large fires: pristine, cultural and post-industrial landscapes

Looking at common traits in the worldwide fire regime trajectories, Pyne (2001) identified three main fire epochs consisting of a pre-human phase driven by natural fire regimes, a successive phase dominated by land-use related anthropogenic fires, and a third phase resulting from the rise of industrial technology and the progressive banning of the use of fire in land management (Fig. 1):

- *First fire epoch*: when the human population was too scarce and scattered to have a significant impact on the fire regime and ignition sources were mostly natural (lightning and volcanoes). In this first fire epoch, fire became an important ecological factor along with climate fluctuations, influencing the selection of species life-history traits related to fire, e.g., Johnson (1996), Keeley and Zedler (2000), Pausas and Keeley (2009), and the

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