FIRE INFLUENCE ON PINUS HALEPENSIS: WOOD RESPONSES CLOSE AND FAR FROM THE SCARS

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ABSTRACT

Tree rings provide information about environmental change through recording stress events, such as fires, that can affect their growth. The aim of this study was to investigate wood growth reactions in Pinus halepensis Mill. trees subjected to wildfires, by analysing anatomical traits and carbon and oxygen isotope composition. The study area was Southern France where two sites were selected: one subjected to fires in the last 50 years, the other characterised by comparable environmental conditions although not affected by fire events (control site). We analysed whether wood growth depends on the tangential distance between developing xylem cells and the limit where the cambium was directly damaged by fire. In the burnt site, thick wood sections, including fire-scar, were taken from surviving plants. Digital photo-micrographs were analysed to measure early- and latewood width, wood density, and tracheid size. Anatomical and isotopic traits were analysed in two series of tree rings (5 rings before and 5 after the fire) selected at different positions along the circumference (close or far from the scar). Anatomical and isotopic traits were quantified also on tree rings of the same years from cored trees growing at the control site. Results showed different wood reaction tendencies depending on the distance from the scar. The comparison between plants from the two sites allowed to exclude possible climate interference.

Our results are discussed in terms of two kinds of growth reactions: the local need to promptly compartmentalise the scarred cambial zone and sapwood after fire, and the general growth perturbations due to tree reaction to crown scorch during fire. Anatomical results, combined with dendrochronological and isotopic analysis, could provide an efficient way to distinguish between direct growth reactions due to heat-related damage on cambium and indirect outcomes related to defoliation.

Keywords: Aleppo pine, fire, quantitative wood anatomy, scar, stable isotopes, tree rings.
INTRODUCTION

Tree rings record information about environmental factors affecting plant growth. In Mediterranean-type ecosystems, wild- and man-induced fires have played a key role in regulating plant growth and survival, priming different fire-response strategies, thus resulting in specific ecosystem dynamics and a peculiar fire-shaped landscape made of mosaic communities (Barbero et al. 1987; Di Pasquale et al. 2004; Thompson 2005). Plant responses to fires can be variable even within a given species depending on fire intensity, growth season when the event occurs and plant age (Trabaud 1981). Wildfires are considered among natural hazards which are responsible for tree injury; such fire-induced damages determine growth anomalies in tree-ring series which are commonly analysed within dendrogeomorphic research based on the “process-event-response” concept (Schröder 1978; Stoffel et al. 2010). Fire damage can determine changes in tree growth due to both crown destruction and trunk injuries, commonly known as fire scars.

If a fire event is not destructive and trees survive, plants experience either a temporary growth reduction or a growth increase (Schweingruber 1996). The temporary decrease in tree-ring growth is a response typically ascribed to crown scorch and leaf/needle surface reduction, while temporary growth increase can be due to other phenomena such as reduced inter-plant competition, increased release of nutrients or better light conditions (Brown & Swetnam 1994; Schweingruber 1996, 2007).

From an anatomical viewpoint, after a fire event, cambium can be destroyed and the formation of new cells can be interrupted in the injured sector of the trunk or branch. The reaction of plants to cambium destruction due to fire has generally been compared with common responses after mechanical wounding. Trees react to cambium destruction after mechanical wounding through subsequent mechanisms: wood compartmentalisation, the formation of callus tissue and cell overgrowth at the edges of the injury in order to reduce the exposed area up to the complete closure of the wound (Shigo 1984; Schweingruber 2007). Depending on the species and the period of the year when wounding occurs, traumatic resin ducts can be produced at different times following injury (Stoffel et al. 2010). To study tree ring’s reaction to fires, it would be desirable to analyse the whole trunk section. Since this is not always feasible, coring techniques are often applied. It has been highlighted how the position of cores is fundamental to avoid gaining misleading information (Stoffel et al. 2010). However, studies aiming to analyse the reaction of tree-ring growth at anatomical level by systematically comparing the variability of responses in samples taken at different distances from scars are not frequent. Recently, Bigio et al. (2012) demonstrated that the combination of information about the position of scars and the measurement of other anatomical parameters is needed for accurate intra-annual dating of fire events in Castanea sativa Mill. The authors also hypothesise that specific anatomical traits, observed in subsamples along the circumference of analysed branches, arise in response to local heating of the cambium and likely to canopy damage.

Wood reaction to fire-related injury is not only a mechanical response but can also be primed by physiological alterations due to direct and indirect effects of burning. Such physiological reactions have been investigated also by combining growth obser-