Forest Ecology and Management 364 (2016) 27–38

Contents lists available at ScienceDirect

Forest Ecology and Management

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

Review and synthesis

A meta-analysis on the effects of changes in the composition of native forests on litter decomposition in streams

Verónica Ferreira [a,*], Julia Koricheva [b], Jesús Pozo [c], Manuel A.S. Graça [a]

[a] MARE-Marine and Environmental Sciences Centre, Department of Life Sciences, Faculty of Sciences and Technology, University of Coimbra, 3004-517 Coimbra, Portugal
[b] School of Biological Sciences, Royal Holloway University of London, Egham, Surrey TW20 0EX, UK
[c] Department of Plant Biology and Ecology, Faculty of Science and Technology, University of The Basque Country, P.O. Box 644, E-48080 Bilbao, Spain

ARTICLE INFO

Article history:
Received 19 October 2015
Received in revised form 29 December 2015
Accepted 1 January 2016

Keywords:
Commercial tree plantation
Decomposer
Ecosystem functioning
Native forest
Systematic review
Woody species invasion

ABSTRACT

Native forest replacement by plantations and invasions by exotic plant species are occurring worldwide. We conducted a meta-analysis of studies reporting the effects of these forest changes on litter decomposition in streams. Overall, forest change significantly inhibited litter decomposition rate by ca 18%. However, only the replacement of native forests by deciduous broadleaf or eucalyptus (*Eucalyptus globulus*) plantations resulted in significant inhibition of litter decomposition (26% and 22%, respectively) whereas conifer plantations or the invasion by exotic species did not significantly affect litter decomposition. The replacement of native forests by eucalyptus plantations was the most common type of forest change in our database. The effect of eucalyptus plantations on litter decomposition was significant when they were present simultaneously at the catchment and riparian scales and when native litter input was replaced by eucalyptus litter input in a manipulative experiment at the stream reach level. This suggests that a strong effect of eucalyptus plantations on ecosystem functioning is mediated by changes on litter inputs to streams. Eucalyptus plantations significantly inhibited the decomposition of high quality litter and total leaf litter decomposition but not the decomposition of wood and low quality leaves, or microbial-driven leaf litter decomposition. This indicates that eucalyptus plantations inhibit (likely through changes in litter inputs) litter decomposition by affecting detritivores. Eucalyptus plantations may thus have stronger negative effects on decomposition rates in streams receiving high quality litter and where detritivores are abundant. The presence of native tree species in the riparian area may mitigate the negative effects of eucalyptus plantations on stream processes. The inhibitory effect of deciduous broadleaf plantations on litter decomposition was likely due to beech (*Fagus sylvatica*) being used in the majority of the plantations, and beech litter is of low quality for detritivores and decomposers. The lack of significant effects of conifer plantations and invasions might be due to contrasting effects of the different conifer or invasive species on decomposers. This meta-analysis also identified several research gaps that may guide future studies on the effect of forest change on stream functioning.

Contents

* Corresponding author.
E-mail address: veronica@ci.uc.pt (V. Ferreira).

http://dx.doi.org/10.1016/j.foreco.2016.01.002
0378-1127/

1. Introduction

In small forest streams, autochthonous primary production is limited by low solar irradiation and the decomposition of litter produced by the terrestrial vegetation is a fundamental ecosystem process that fuels aquatic food webs with carbon (C), nutrients and energy (Vannote et al., 1980; Wallace et al., 1997). The decomposition of organic matter is carried out mainly by microbes (mostly aquatic hyphomycetes) and invertebrate detritivores (Hieber and Gessner, 2002; Pascoal and Cássio, 2004) and is highly sensitive to changes in environmental conditions (Gessner and Chauvet, 2002; Young et al., 2008). Given the heterotrophic nature and high aquatic–terrestrial interface of these small streams, aquatic communities and processes are highly vulnerable to changes in the surrounding vegetation.

Forest clearance (e.g. conversion into pasture or agriculture) has strong effects on aquatic communities and ecosystem functioning as the system shifts from heterotrophic to autotrophic in response to the decrease in litter inputs and increase in solar irradiation (Hladyz et al., 2011a). The replacement of native forests by commercial tree plantations, or their invasion by exotic woody species, can also affect aquatic communities and processes despite the fact that the heterotrophic nature of the streams is generally maintained, i.e. shade continues to be provided and foodwebs are based on the decomposition of allochthonous litter (Graça et al., 2002; Kominoski et al., 2013). However, the studies addressing the effects of the replacement of native forests by tree plantations or their invasion by exotic woody species on litter decomposition often show contrasting results. For instance, previous studies reported stimulation (Whiles and Wallace, 1997; Lecerf et al., 2007; Menéndez et al., 2013), inhibition (Abelho and Graça, 1996; Kennedy and Hobbie, 2004; Lecerf and Chauvet, 2008), or no major difference (Bärlocher and Graça, 2002; Lecerf et al., 2005; Riipinen et al., 2010; Hisabae et al., 2011) in litter decomposition rates in streams flowing through altered forests when compared with streams flowing through native forests.

The variability in the reported results suggests that the effects of forest change could be moderated by other factors. For instance, the replacement of native forests by tree plantations with very dissimilar traits (e.g. deciduous vs. evergreen species) is likely to produce stronger effects on streams than the replacement by trees with similar traits (e.g. mixed deciduous broadleaf forest vs. deciduous broadleaf tree plantations) or moderate invasion by exotic species (Kominoski et al., 2013). In addition, stronger effects might be expected when forest changes occur both at the catchment and riparian level than only in the riparian area or at the catchment level. The effects may also differ depending on whether they are driven by changes in litter inputs (stronger when forest change occurs at the riparian level) or by changes in hydrology and water chemistry (stronger when forest change occurs at the catchment level).

The effects of forest change may also depend on physical and chemical litter properties; the decomposition of soft, high nutrient (low C:nutrient ratio) litter is likely to respond to forest change if this affects detritivores, while the decomposition of tough, low nutrient litter is likely to be less sensitive to forest change since this is mostly carried out by microbial decomposers, whose communities are reported to be functionally redundant (Dang et al., 2005; Ferreira et al., 2006; Gulis et al., 2006). High quality litter may also decompose faster in streams flowing through tree plantations if it acts as an island of good quality resource in a streambed of recalcitrant litter (e.g. *Alnus glutinosa* litter in streams flowing through eucalyptus or conifer plantations); when given a choice, detritivores prefer soft, high quality litter (Canhoto and Graça, 1995).

Total litter decomposition (i.e. carried out by both microbes and invertebrates) is likely to be more sensitive to forest change than microbial-driven litter decomposition if invertebrates are the main players on litter decomposition (Gulis et al., 2006). Also, since invertebrate activity on decomposing litter highly depends on microbial conditioning (Canhoto and Graça, 2008), any negative effects of forest change on microbes may be amplified by invertebrates.

The region where forest change takes place can also moderate the magnitude of its effect on litter decomposition. Streams in drier regions such as in the Mediterranean may dry out during the warmer months and it has been shown that these streams have lower invertebrate richness than permanent streams (Datry et al., 2011). Intermittent streams may thus be more susceptible to further environmental changes as forest change than streams in humid regions (Ferreira et al., 2006).

Changes in dissolved nutrient availability could also moderate the effect of forest change on litter decomposition (Molinero et al., 1996; Díez et al., 2002). If the replacement of native forests