Insect Conservation and Diversity

Insect Conservation and Diversity (2013) **6,** 393–395 doi: 10.1111/j.1752-4598.2012.00220.x

SHORT COMMUNICATION

Strengthening the case for saproxylic arthropod conservation: a call for ecosystem services research

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Abstract. 1. While research on the ecosystem services provided by biodiversity is becoming widely embraced as an important tool in conservation, the services provided by saproxylic arthropods – an especially diverse and threatened assemblage dependent on dead or dying wood – remain unmeasured.

2. A conceptual model depicting the reciprocal relationships between dead wood and saproxylic arthropod biodiversity, wildfires, climate change, forest productivity and pest outbreaks is presented. This model suggests that the ecological influence of saproxylic arthropods may extend far beyond their effects on wood decay.

3. Several predictions arising from this view are briefly summarised with the hope of stimulating research that may ultimately help strengthen the argument for saproxylic arthropod conservation.

Key words. Coarse woody debris, decomposition, forests, insects, value.

Introduction

Constituting between one fifth and one third of forest arthropod biodiversity, saproxylic species (i.e. those directly or indirectly dependent on dead or dying wood) are among the most threatened taxa in many regions due to the loss, fragmentation and degradation of forests (Grove, 2002). Although this community has received a great deal of attention among researchers in recent decades, most studies have focused on faunal descriptions and on what measures can be taken to protect these organisms in managed forests. Why these species should be protected in the first place, however, remains poorly established. The current case for conserving saproxylic arthropods therefore rests largely on the most basic argument for species conservation – essentially that biodiversity should be protected for its own sake. While this argument has been strongly defended by some (Schwartz *et al*., 2000; McCauley, 2006), others encourage a more pragmatic approach given the needs of an expanding human population (Marvier *et al*., 2006; Kareiva *et al*., 2007; Daily *et al*., 2009). Because such efforts have been shown to promote conservation (Goldman *et al*., 2008), my aim in this article is to encourage research on ecosystem services provided by saproxylic arthropods. I believe these organisms are especially promising candidates for such research given their taxonomic and functional diversity and the broad importance of dead wood to forest ecosystems.

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The size of the dead wood pool features prominently in many important areas of concern to forest ecology and management including productivity, pest outbreaks, biodiversity, wildfire, and climate change (Fig. 1). While these concerns can potentially influence one another directly, they are also indirectly linked to each other through their reciprocal relationships with dead wood. Because saproxylic arthropod diversity is positively related to the quantity and variety of dead wood (Martikainen *et al*., 2000), for example (Fig. 1, relationship e), changes in the amount of dead wood brought about by other factors (e.g. productivity, pest outbreaks, wildfire or climate change) will likely influence this community. These other factors, in turn, can be influenced by changes in the dead wood pool brought about by saproxylic arthropods (Fig. 1, relationship f). Termites (Takamura, 2001; Schuurman, 2005) and wood-boring beetles (Edmonds & Eglitis, 1989), for example, are known to accelerate wood decay and should reduce the amount of dead wood present in forests. This view gives rise to several predictions, all of which remain untested, regarding ecosystem services provided by saproxylic arthropods. These are briefly summarised below.

Forest productivity (Fig. 1, hypothesis 1)

Despite new perspectives on silviculture (Peuttmann *et al*., 2009), forest productivity will remain a dominant concern for many land owners and managers. It is therefore of considerable interest that retaining woody debris stimulates tree growth in clearcuts (Egnell, 2011) and in

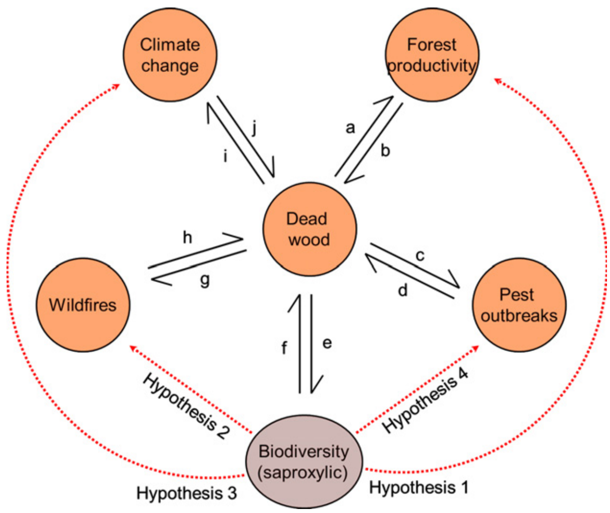

Fig. 1. Saproxylic arthropod biodiversity and four other concerns in forest ecology and management (i.e. wildfires, climate change, productivity and pest outbreaks) have the potential to influence one another either directly (not shown) or indirectly through their relationships with dead wood (solid arrows). Examples of relationships depicted here (lowercase letters) include (a): (Egnell, 2011; Helmisaari *et al*., 2011), (b): (Weslien *et al*., 2009), (c): (Schroeder & Lindelöw, 2002), (d): (Klutsch *et al*., 2009), (e): (Martikainen *et al*., 2000), (f): (Edmonds & Eglitis, 1989; Takamura, 2001; Schuurman, 2005), (g): (Brown *et al*., 2003), (h): (Tinker & Knight, 2000; Cornwell *et al*., 2009), (i): (Harmon *et al*., 1990), (j): (Weslien *et al*., 2009).

thinned stands (Helmisaari *et al*., 2011) (Fig. 1, relationship a), an observation most often attributed to the fertilising effects of nutrients released during the decay process. Considering their documented importance as decay agents (see above), saproxylic arthropods may contribute to this productivity gain. Several previous studies support this notion, suggesting insects accelerate nutrient release from dead wood (Swift, 1977; Takamura & Kirton, 1999; Takamura, 2001). Termites may be especially beneficial in this regard due to their nitrogen-fixing endosymbionts (Benemann, 1973) and tunnelling activities which improve soil porosity (Evans *et al*., 2011).

Wildfire risk (Fig. 1, hypothesis 2)

Although recognised as an important natural disturbance agent, wildfires represent a serious threat to life and property in many parts of the world. Because wildfire risk and intensity are well known to increase with increasing woody fuel quantity, especially the smaller size classes (Brown *et al*., 2003), reductions in dead wood brought about by arthropod activity may help moderate this threat. This potential relationship is complicated, however, by the increased fire risk in dry forests where arthropods probably contribute less to the decay process than in more mesic forests.

Climate change (Fig. 1, hypothesis 3)

Climate change has the potential to greatly impact future forest conditions. As such, considerable attention has been paid to dead wood as a potential source and sink of carbon (Luyssaert *et al*., 2008). As important decay agents, termites and other saproxylic arthropods release substantial amounts of methane and carbon dioxide to the atmosphere (Zimmerman *et al*., 1982), thereby possibly contributing to the warming trend. On the other hand, enhanced productivity brought about by these organisms (see above), may counteract these effects by increasing the amount of carbon sequestered in living tissues. The net effect of saproxylic arthropods, i.e. whether their actions intensify or moderate climate change, remains unknown.

Pest outbreaks (Fig. 1, hypothesis 4)

Large inputs of dead wood (e.g. from wind storms) can increase the risk of certain pest outbreaks such as *Ips typographus* (L.) (Curculionidae: Scolytinae) in Europe (Schroeder & Lindelöw, 2002). Reductions in dead wood quantity due to saproxylic arthropod activity may have little impact, however, as virtually all forest pest species are restricted to dying or freshly killed wood. The more probable suggestion that saproxylic arthropods influence pest populations through predation (including parasitism) in recently killed trees (Martikainen *et al*., 1999; Bouget & Duelli, 2004; Coyle *et al*., 2005; Hedgren, 2007; Johansson *et al*., 2007; Stokland *et al*., 2012) deserves closer consideration.

In addition to various direct benefits (e.g. pest control, see above), the reciprocal relationships described herein between dead wood and biodiversity, wildfire, climate change, forest productivity and pest outbreaks suggest the ecological influence of saproxylic arthropods may extend far beyond their effects on dead wood. Measuring such impacts and how they vary depending on faunal composition, environmental conditions and other factors is key to understanding the costs and benefits (e.g. Losey & Vaughan, 2006) of conserving these organisms, with particular relevance to forest management (Holling & Meffe, 1996).

Acknowledgements

I thank Jim Hanula, Scott Horn, Kier Klepzig and two anonymous reviewers for commenting on an early version of this article.

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Accepted 16 July 2012
First published online 29 August 2012

Editor: Raphael Didham
Associate editor: Alan Stewart