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Short-term effect of windstorm disturbance on saproxylic beetles in broadleaved temperate forests Part I: Do environmental changes induce a gap effect?

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Abstract

Windstorm created small gaps with large amounts of sun-exposed dead wood in managed oak–hornbeam forest in France in 1999. The short-term effect of these gaps for saproxylic beetle abundance, species richness and assemblage composition were compared with closed-forest stands and seedling–sapling stands.

We observed a strong differentiation of saproxylic assemblage in gaps compared with undisturbed stands but richness was only slightly higher in gaps. Contrary to expectations, the abundance of primary wood consumers on the whole, highly dominated by bark beetles, was as high in undisturbed plots as in gaps. However, longhorn and buprestid beetles responded positively in gaps. The later-successional xylophagous beetles on the whole were not significantly less abundant in gaps, in spite of the lower abundance of some shade-preferring species (Anobiidae, Eucnemidae, Melandryidae). Gap changes had a positive impact on the floricolous and xylomycetophagous insects, even if the species response was contrasted.

Saproxylic communities were also distinct in gaps and in seedling–sapling stands. Both species richness and number of characteristic species were higher in gaps than in seedling–sapling stands. The abundance of later-successional xylophagous and xylomycetophagous insects was equal in gaps and in seedling–sapling stands. The abundance of saproxylic predators seemed to follow the population levels of all xylophagous insects.

Because of their richness and faunistic dissimilarity with other open stands and closed-canopy controls, uncleared gaps may enhance the gamma diversity at the forest scale. In response to management issues underlying this research project, saproxylic diversity would benefit from the maintenance of some uncleared gaps. Moreover, in managed temperate, deciduous forests, my results suggest to retain more sun-exposed harvesting residue in fellings in order to enhance biodiversity.

Keywords: Dead wood; Xylophagous; Insects; Biodiversity; Forest management

Abbreviations: G, gaps; F, closed-canopy control stands; C, seedling–sapling stands

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1. Context

One perceived cause of loss in forest biodiversity is the small amount of dead wood in managed forests (Ehnström, 2001). Moreover, it has been recently stressed that natural, early successional phases may be as important as old-growth stands for saproxylic biota (Kouki et al., 2001; Simila et al., 2002). The perforation of a closed-canopy forest by windstorm, for instance, creates open patches with large amounts of sun-exposed dead wood. In managed forests, these gaps may act as "*kleine Totholzinseln in stehenden Beständen* [*small dead wood islands in living stands*]" (Pfarr and Schrammel, 1991). Because of the effective prevention of fires and clearing of forests after storms, the importance of early successional stages with large volume of dead wood has decreased in forest dynamics.

Wind is the major recurrent natural disturbance in most temperate deciduous forests (Emborg et al., 2000). In Switzerland for instance, about two-thirds of all unplanned felling is caused by storm winds, and only 13% by insect calamities (Wohlgemuth et al., 2002). The catastrophic avalanches of 1999 in Switzerland only felled 160,000 m^3 of timber, compared to 5 million m^3 of timber thrown by the storm 'Vivian' in 1990 or 12.5 million m^3 by the storm 'Lothar' in 1999. Similarly, in Finnish pine and spruce forests, dead wood from windstorms represents up to 40–56% of total dead wood (Sippola et al., 1998). In Western Europe, Lothar, the huge storm in 1999, with winds reaching up to 170 km/h, created the opportunity for natural experimental conditions. In the resulting gaps, the saproxylic beetle habitat changed drastically. Opening up the canopy increased sun exposure and caused the development of flower mats. Uprooting and stem breakage increased the volume and diversity of fresh dead wood (snags, lying logs). These high, concentrated dead wood volumes are attractive to many saproxylic organisms.

The influence of wind disturbance upon insect communities is poorly understood compared to fire (Bouget and Duelli, 2004). Moreover, the insect fauna of gaps is less known in temperate deciduous forests (Alexander, 1994) than in conifer forests (Otte, 1989; Gutowski and Kubisz, 1995; Nicolai, 1995; Kopf and Funke, 1998; Wermelinger et al., 2002). Previous studies in conifer forests have shown that the richness and abundance of saproxylophagous insects in gaps culminated in the first (Gutowski and Kubisz, 1995) or the second year (Schroeder and Eidmann, 1993; Wermelinger et al., 2002) after windthrow.

2. Objectives

The present study aimed at examining if and how the saproxylic beetle communities have changed 2 years after this disturbance. We intended to assess (i) whether saproxylic assemblages had responded to the windstorm disturbance in the short term and (ii) whether these assemblages differ from those observed in man-made openings. The first point was tackled by comparing gaps with undisturbed forest controls. In other words, did gaps create habitat islands? Did ecological groups respond in abundance to changes in distribution of resources in gaps? For instance, pioneer xylophagous beetles may have benefited from the high volume and diversity of sun-exposed fresh dead wood in gaps. On the other hand, secondary xylophagous beetles are not likely to have benefited yet from fresh dead wood and may have suffered from a deleterious effect of sun exposure, except for the floricolous and heliophilous taxa. The second point was tackled by comparing windthrow gaps and man-made openings. The influence of gap size and gap isolation will be discussed in a second paper.

Two management questions underlay this research project. First, is it worth maintaining uncleared gaps for biodiversity conservation? Secondly, how can traditional fellings be adapted in order to mimic natural disturbances and to enhance biodiversity?

3. Material and methods

3.1. Research area

Three lowland hardwood forests, severely damaged by Lothar in December 1999, were included in the study: the state forests of Armainvilliers (1525 ha) and Crecy (a 1250 ha national part within a 5000-ha forest), and the Ferrieres regional forest (2890 ha) in the 'Brie' region. These three forests are quite close to each other and formed one forest block before fragmentation during the Middle Age. They are