Available online at www.sciencedirect.com
SCIENCE DIRECT®
Forest Ecology and Management 217 (2005) 294–306
Forest Ecology and Management
www.elsevier.com/locate/foreco

Restoration of a forest ecosystem: The effects of vegetation and dispersal capabilities on the reassembly of plant-dwelling arthropods

M.L. Moir [a,*], K.E.C. Brennan [b], J.M. Koch [c], J.D. Majer [a], M.J. Fletcher [d]

[a] *Environmental Biology, Curtin University of Technology, GPO Box U1987, Perth, WA 6845, Australia*
[b] *Forest and Ecosystem Science, University of Melbourne, Water Street, Creswick, VIC 3363, Australia*
[c] *Alcoa World Alumina Australia, PO Box 252, Applecross, WA 6953, Australia*
[d] *Orange Agricultural Institute, Forest Road, Orange, NSW 2800, Australia*

Received 25 April 2005; received in revised form 20 June 2005; accepted 20 June 2005

Abstract

Restoration of degraded forest ecosystems is critical to conservation, but it is unknown if all components can be successfully restored. Despite the obvious dependence of plant-dwelling arthropods on plants, there are few empirical tests to show if restoring the plants also restores the plant-dwelling arthropods, or if other factors inhibit recolonisation. This paper tests the congruence in reassembly trajectory between these two groups and the role of dispersal capabilities on arthropod recolonisation, using Hemiptera. Plants and arthropods were sampled along a chronosequence of individual mine pits representing increasing ages since restoration works, and surrounding unmined forest. Changes in the richness, composition and structural complexity of the vegetation are described. These data are compared to Hemiptera sampled by beating and vacuuming over 18 months. Following the initial establishment of vegetation, the richness of plant species remains at a plateau as pits age, and below that found in unmined forest. In contrast, some structural attributes of the vegetation in pits become more similar to the forest with time. As pits age, dead vegetation below 20 cm thickens and living midstorey vegetation thins. Plant species composition changes with time but is not tracking directly toward unmined forest. The abundance and richness of hemipteran species remain constant as pits age (~74.5 species), at a similar value to that in the forest. Recolonisation by Hemiptera that are brachypterous (with permanently reduced wings) is markedly slower than for winged taxa. That said, the compositions of plant and hemipteran species follow a similar trajectory after mining (i.e., there is high congruence between the two taxa). Hemipteran species composition in the oldest pits sampled (9-year-old) is not tracking directly toward that found in unmined forest. We conclude that for plant-dwelling arthropods, the early stages of reassembly are characterised by a high abundance of a generalist species and the slow recolonisation by specialist taxa and fauna with limited dispersal abilities (e.g., brachypters). Thereafter, return to a composition similar to that prior to the disturbance depends upon the progress of vegetation reassembly. To obtain plant-dwelling arthropod assemblages

* Corresponding author. Present address: Forest and Ecosystem Science, University of Melbourne, Water Street, Creswick, VIC 3363, Australia. Tel.: +61 3 5321 4258; fax: +61 3 5321 4166.
E-mail address: mmoir@unimelb.edu.au (M.L. Moir).

0378-1127/$ – see front matter
doi:10.1016/j.foreco.2005.06.012

characteristic of unmined forest, restoration must reinstate the plant species and structural complexity of the vegetation found in the forest (particularly long-lived species and ground covers).

Keywords: Assembly trajectories; Hemiptera; Phytophagous insects; Rehabilitation; Succession

1. Introduction

Restoration of forest ecosystems is critical to conserving the world's biota (MacMahon and Holl, 2001). Additionally, understanding restoration provides an alternative system for developing ecological theory on succession, and also the assembly of forest ecosystems (Bradshaw, 1993). Thus, in restoration the paradigms of succession and community assembly may converge (Young et al., 2001). In an experimental context, restoration has the advantage over most classical studies of primary succession through the replication of seres. This allows harsher tests of whether similar end-points are reached during the assembly of forest ecosystems. To date, most restoration research has focused on plants. However, restoration of forest ecosystems requires knowledge not only of how plants return, but also of how invertebrates recolonise. Invertebrates contribute more to global species diversity than any other organisms (Hammond, 1995), and are vital for ecosystem function (Wilson, 1987). From a conservation perspective, we argue that restoration is most important in the world's 25 hotspots of global biodiversity. These areas contain more than 44% of the world's plant species and have lost more than 70% of their natural vegetation (see Myers et al., 2000). Here we examine restoration for plants and invertebrates in hotspot number 22; the South West Botanical Province of Australia.

Since invertebrate herbivores are intimately associated with the plant assemblages upon which they feed, it follows that the spatial patterning of invertebrate herbivores will track plants. Empirical data support this contention; typically, phytophagous invertebrate species diversity follows plant diversity (Brown and Hyman, 1986; Crisp et al., 1998; Siemann et al., 1999). Also, there is a high congruency between herbivore and plant assemblages across landscapes (Yen, 1987; Kitching et al., 2000; Andersen et al., 2001). It is generally assumed during most (but not all) attempts at forest restoration that if the plants are reinstated then the fauna will automatically follow. However, there is little data on phytophagous invertebrates for forest restoration. Most empirical studies have been conducted in structurally simple grassland ecosystems in the Northern Hemisphere following secondary disturbances (e.g., fire – Morris, 1975, grassland management regimes – Southwood et al., 1979; Brown et al., 1988; Morris, 1990; Huusela-Veistola and Vasarainen, 2000). We tested for congruence in the recolonisation within a forest ecosystem between plants and plant-dwelling arthropods, using the fifth most speciose insect order, Hemiptera (Gaston, 1991). There are few studies of hemipteran reassembly following disturbance in the tropics or Southern Hemisphere (although see Ingham and Samways, 1996). Moreover, unlike most studies, which restrict taxonomic focus to just the Auchenorrhyncha and/or Heteroptera, we include the Sternorrhyncha.

In addition to interspecific interactions, an animal's power of dispersal may determine the likelihood of a species reaching a site. Dispersal may be a key process influencing recolonisation and assembly trajectories, but there is surprisingly scant information for most invertebrates (Miles and Walton, 1993). Invertebrates without wings or those with permanently reduced wings (e.g., brachypters) may be inhibited from recolonising by their reduced mobility. This paper assesses whether dispersal effects recolonisation by examining the rate of recolonising brachypters (permanently reduced wings), Coccoidea (females without wings), and those Hemiptera with wings.

The objectives of this study are to determine if:

1. the reassembly trajectory for plants is proceeding toward native forest,
2. the reassembly trajectory for Hemiptera is proceeding toward native forest assemblages,
3. there is congruency in the reassembly trajectories for plants and Hemiptera, and