Forest Ecology and Management 256 (2008) 2073–2077

Contents lists available at ScienceDirect

Forest Ecology and Management

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

Rain forest recovery from dieback, Queensland, Australia

Daniel J. Metcalfe *, Matt G. Bradford

CSIRO Sustainable Ecosystems, Tropical Forest Research Centre, PO Box 780, Atherton, Qld 4883, Australia

ARTICLE INFO

Article history:
Received 8 October 2007
Received in revised form 28 July 2008
Accepted 29 July 2008

Keywords:
Dieback
Rain forest
Wet Tropics World Heritage Area
Post-infection recovery
Basal area

ABSTRACT

We present a detailed account of a dieback episode in tropical rain forest. The dieback episode took place from 1977 to 1989 within a 0.5 ha long-term demography plot monitored for stem growth and mortality from 1975 to 2005. In total 770 m^2 of rain forest was affected causing 13 trees >10 cm diameter at breast height (dbh) to die, and others to sicken. The dead trees came from four families, though 14 families were represented in the area. Trees of the family Elaeocarpaceae suffered significantly higher mortality. Larger trees were significantly more likely to die than small trees, but smaller trees were more likely to recover. Recruitment to >10 cm dbh size class after dieback was greater in areas that had been affected, and in 2005 stem density and basal area were higher than in 1977, before the dieback episode started. There were no significant trends in biodiversity change between affected and non-affected parts of the plot. Dieback may have dramatic effects at onset but over the medium term its impact appears to be less serious. Longer term monitoring will permit re-evaluation of this observation in the future.

1. Introduction

Dieback, or the 'protracted malfunction in stands of trees due to the persistent action of damaging factors' (Podger, 1981 quoted in Jurskis, 2005) has been attributed to a number of separate factors, including drought, waterlogging, pests and disease, changed fire regimes and synchronous cohort senescence. In an Australian context, many of these factors have been documented from eucalypt-dominated communities, but there is little understanding of dieback in rain forests. Landscape-scale dieback can be associated with cyclonic wind damage (Metcalfe et al., 2008), more localised dieback may be attributed to drought (Edwards and Krockenberger, 2006) or wildfire (Marrian et al., 2005), and extremely localised deaths may be associated with lightning strikes. Worboys (2006) documents *Phytophthora cinnamomi* as causing some dieback episodes in the wet tropical rain forests of Far North Queensland; *P. cinnamomi* and *P. heveae* were recorded to be widespread through the tropical rain forests of Queensland from 16°2′S to 21°15′S in soil surveys carried out by Queensland Department of Forestry between 1976 and 1982 (Brown, 1999), though often in soils under apparently healthy forest (cf. Pryce et al., 2002). Dieback during this period was most frequently recorded in rain forest at Dalrymple Heights (Eungella Tableland) and in the Garrawalt area, north-west of Townsville, and "although it was not possible to prove unequivocally that *P. cinnamomi* was the cause... there is good reason to believe that this is so" (Brown, 1999).

A 0.5 ha permanently marked plot was established in 1975 in unlogged rain forest at Garrawalt, to study forest dynamics with particular reference to the important cabinet timber *Flindersia bourjotiana* F. Muell. (Graham, 2006). At establishment, a small patch of dead trees on a nearby ridge was assumed to be the result of lightning strike (Stocker, 1983), but it seems likely to have been an existing patch of dieback; tree dieback was first observed to be affecting the plot at re-measurement in 1977. The extent of dieback increased over successive years, but no extension of the dieback area was discovered at the 1989 census, and since then the forest has recovered and completely recolonised the dieback area.

In this study, we present the results of successive surveys which document the progression of the dieback from initiation until disappearance, and the subsequent recovery of the forest. The impacts of dieback and subsequent recovery are considered in terms of corresponding changes in stem number and size, and floristic composition. We discuss our findings with reference to the potential causes of dieback, and its impact on species richness and forest structure of the rain forests of the Wet Tropics bioregion.

2. Methods

CSIRO Experimental Plot 19 (18°30′S, 145°45′E, 620 m; henceforth 'the Garrawalt plot') was established in June 1975 in unlogged rain forest on the eastern side of the Seaview Range in the Bargoo Logging Area, State Forest 750, inside what is now the Girringun National Park in the Wet Tropics World Heritage Area.

* Corresponding author. Tel.: +61 7 4091 8838; fax: +61 7 4091 8888.
E-mail address: dan.metcalfe@csiro.au (D.J. Metcalfe).

0378-1127/$ – see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.foreco.2008.07.040

The forest was classified as simple notophyll vine forest, i.e. type 8 of Tracey and Webb (1975) and Tracey (1982), and RE 7.12.16 of Queensland Government Environmental Protection Agency (2005). *F. bourjotiana* contributes the greatest proportion of the basal area of the plot, and *Brombya platynema* F. Muell. (both Rutaceae) is the most abundant (Graham, 2006) species present. The underlying soils are derived from rhyolites of the Glen Gordon volcanics (Brown, 1999). The plot was surveyed to provide a slope-corrected 100 m × 50 m, giving a plan-projected area of 0.5 ha, around which a 20 m buffer zone was established within which no logging activities took place by agreement with the Queensland Department of Forestry. Values in this paper are converted to a true ground area of 0.515 ha, which takes account of the slope within the plot. In the plot all trees ≥10 cm diameter at breast height (dbh) were identified, measured and painted with a unique number. The plot was visited for recensus every 2 years from 1975 to 1991, and thereafter in 1998 and in 2005. During this time the development and progress of a dieback episode was documented – linear spread of dieback was measured as the furthest extent of dieback (visually assessed from expression of symptoms above-ground only) at a census period from the closest point of dieback at the previous census. At each census all trees that recruited into the ≥10 cm dbh size class were measured and all trees that died were noted. Trees that were documented as dead at a census event prior to the recording of dieback (i.e. dead 2–4 years before new dieback recorded) within a particular area were not counted as dieback fatalities. Trees that died up to 2 years after new dieback was recorded were included as dieback fatalities. Mortality rates were calculated as the number of deaths within a census period (i.e. 2 years) divided by the number of live trees which had been within the area affected at the previous census.

At establishment an inventory of all species of vascular plants was compiled, with species' presence in each of 16 subplots (12.5 m × 25 m); this inventory was recompiled in September/October 2005.

3. Results

Dieback was first noticed on a ridge outside and downhill of the plot at establishment in 1975; by 1977 the area of infection had spread uphill into the bottom of the plot (Fig. 1). During the 1979, 1981, 1983 and 1987 plot censuses, extensions of area over which dieback occurred were mapped. Annual rates of movement exceeded 20 m year^{-1} in the years immediately preceding dieback appearing on the plot in 1977, but slowed to ca. 8 m year^{-1} by 1979 and to 1 m year^{-1} by 1983. In total 770 m^2 (15%) of the plot was affected from 1977 to 1987. Notes taken during the active dieback period suggest that the area affected outside the plot was at least equal to that inside the plot. Dieback was recognised by rapid mortality (i.e. death and partial disintegration between two successive census dates) of most understorey plants followed by sickening and sometimes death of subcanopy and canopy trees within 1–2 years; trees typically lost leaves and tertiary branches or twigs from some or all of their canopy, with dead trees rapidly shedding bark and small branches, and larger branches and sometimes the entire trunk either collapsing down on itself or falling over. The understorey vigorously regenerated 1–2 years after initial signs of dieback, often while the trees (>10 cm) were still dying.

Out of 63 trees ≥10 cm dbh present within the dieback area, 13 trees died. This equates to a mean annual mortality rate of 9.20% compared to a mean annual rate outside the affected area of 0.87% across the same period. Mortality outside the dieback area is consistent with annual mortality rates for the three other comparable 0.5 ha CSIRO permanent plots in the Wet Tropics of Queensland (0.36%, 0.77% and 0.97%). These plots are floristically

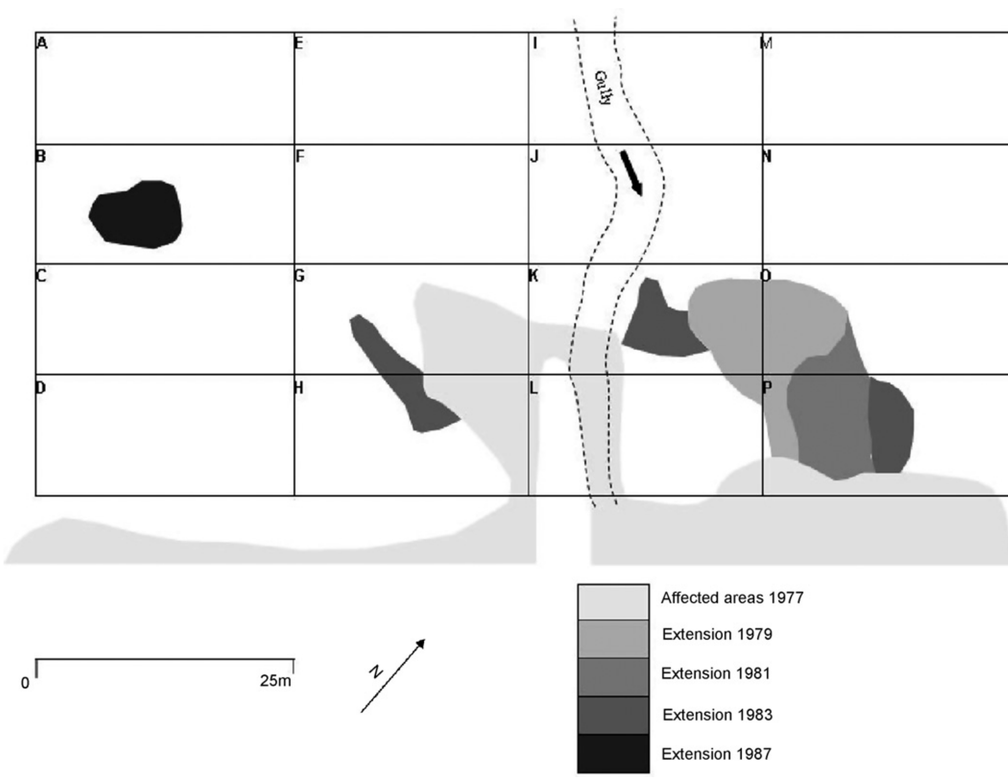

Fig. 1. Map of dieback-affected areas in the Garrawalt 0.5 ha plot detected from 1977 to 1989. Approximate gully position and direction of slope indicated. Subplots (25 m × 12.5 m) are lettered A–P.