Forest Ecology and Management 269 (2012) 229–238

Contents lists available at SciVerse ScienceDirect

Forest Ecology and Management

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

Understanding the regeneration niche: Microsite attributes and recruitment of eucalypts in dry forests

Tanya G. Bailey [a,b,e,*], Neil J. Davidson [a,b,c,e], Dugald C. Close [c,d]

[a] CRC for Forestry, Private Bag 12, Hobart, 7001 Tasmania, Australia
[b] School of Plant Science, University of Tasmania, Private Bag 55, Hobart, 7001 Tasmania, Australia
[c] Bushfire CRC, University of Tasmania, Private Bag 55, Hobart, 7001 Tasmania, Australia
[d] Tasmanian Institute of Agricultural Research, University of Tasmania, Private Bag 98, Hobart, 7001 Tasmania, Australia
[e] Greening Australia, GPO Box 1191, Hobart, 7001 Tasmania, Australia

ARTICLE INFO

Article history:
Received 3 August 2011
Received in revised form 13 December 2011
Accepted 15 December 2011
Available online 4 February 2012

Keywords:
Eucalyptus
Recruitment
Microsite
Ashbed
Water repellency
Coarse woody debris

ABSTRACT

Lack of eucalypt recruitment is a key factor in the decline of forest and woodland remnants in low rainfall agricultural regions in Australia. Key to effective management of these forests is an understanding of the requirements and conditions that promote seed germination and seedling establishment (recruitment niche) and the persistence of lignotuberous sprouts (juvenile persistence niche). Recruitment is limited by the availability of safe microsites that are suitable for the germination and establishment of seedlings. The objective of this study was to investigate the microsites of established eucalypt seedlings and lignotuberous sprouts in healthy dry forests burnt in the previous 2–6 years in the Tasmanian Midlands. The recruitment niche differed significantly to the juvenile persistence niche while the juvenile persistence niche had characteristics similar to the general forest floor. Seedling microsites were characterised by: canopy gaps and ashbeds (95% of seedlings surveyed); a predominantly northerly aspect (75% of microsites); over 220° shelter with the average distance from a sheltering object being less than 30 cm and 80% of seedlings being sheltered by coarse woody debris; soil that was significantly softer (3.8 vs. 5.0 kgf/m^2) and less water repellent (moderate vs. severe repellency) than the forest floor; and low cover of grass. These characteristics of seedling safe sites all affect moisture availability. Our results have important implications for the management of dry forest in order to facilitate eucalypt recruitment and persistence, suggesting the need for retention of coarse woody debris and the judicious use of fire.

1. Introduction

Recruitment is critical to the development and maintenance of plant populations (Fowler, 1988; Crawley, 1990; Eriksson and Ehrlen, 1992; Ribbens et al., 1994). Lack of eucalypt recruitment is a key factor in the decline of forest and woodland remnants in the low rainfall agricultural regions of Australia (Fischer et al., 2009; Weinberg et al., 2011). Key to effective management of these forests is an understanding of the requirements and conditions that promote seed germination and seedling establishment (Tozer and Bradstock, 1997; Hobbs and Cramer, 2003; Turner et al., 2009).

Not all seeds that reach the forest floor find conditions suitable for establishment (Harper et al., 1961) as conditions are highly heterogeneous at a small scale (Arp and Krause, 1984; Lechowicz and Bell, 1991; Battaglia and Reid, 1993). After germination seedling mortality is high and the physical habitat surrounding seedlings contributes to the probability of long-term survival (Collins and Good, 1987). Recruitment, therefore, is limited by the availability of safe sites, or microsites, suitable for the germination and establishment of seedlings (Fowler, 1988; Eriksson and Ehrlen, 1992). The set of environmental parameters that describes the microsites in which seeds germinate and seedlings establish has been called the recruitment niche (Young et al., 2005), and is one component of the regeneration niche as described by Grubb (1977).

For recruitment to occur there has to be sufficient seed supply and rainfall for germination. Subsequently conditions are needed on the forest floor that maintain enough moisture, light and nutrients for a germinated seed to establish (Mott and Groves, 1981). The microsites that have supported the germination of a seed may not always be suitable for the subsequent establishment of a seedling (Battaglia and Reid, 1993; Lamont et al., 1993). This may be particularly so in dry eucalypt forests where water supply is limiting (Potts, 1986; McCormick, 1991) and where microsite effects on moisture accumulation may be critical.

Eucalypt recruitment generally requires removal of competition and an open and sunlit environment (McCormick, 1991; Attiwill,

* Corresponding author at: School of Plant Science, University of Tasmania, Private Bag 55, Hobart, 7001 Tasmania, Australia. Tel.: +61 3 6226 2603; fax: +61 3 62262698.
E-mail addresses: tgbailey@utas.edu.au (T.G. Bailey), Neil.Davidson@utas.edu.au (N.J. Davidson), Dugald.Close@utas.edu.au (D.C. Close).

0378-1127/$ - see front matter
doi:10.1016/j.foreco.2011.12.021

1994; Gill, 1997). Episodic disturbance, particularly fire, has been shown to play a vital role in stimulating regeneration (Yates et al., 1996; Clarke and Davison, 2001; Turner et al., 2009) as seedling establishment is rare in undisturbed seedbeds (Fensham and Kirkpatrick, 1992; Yates et al., 1996). Severe disturbance reduces the forest canopy, decreases competition and increases resource availability on the forest floor. In most dry sclerophyll forests, stands are rarely killed outright by fire and recover via epicormic shoots and lignotubers (Potts, 1986), therefore the period of increased resource availability for seedling establishment is limited. Seedlings that do establish may become part of a regeneration pool that includes lignotuberous sprouts and therefore may become suppressed by vigorous vegetative regrowth. This has resulted in dry sclerophyll forests through much of Australia, including Tasmania, having recruits from many disturbance events present on the forest floor (multi-cohort) and the regeneration being multi-aged (Duncan, 1999; Turner et al., 2009).

Not all disturbance events result in successful recruitment of new individuals (Jacobs, 1955; Yates et al., 1996). However, successful recruitment events can be "stored" (Warner and Chesson, 1985) as established plants persist from one rare recruitment event to another (Bond and Midgley, 2003). Lignotuberous sprouts can persist in the landscape for decades (Potts, 1986). The persistence niche, defined as the factors that influence the probability of an established plant (juvenile or adult) maintaining its space in a community (Bond and Midgley, 2001), is therefore important for sprouting species.

Young et al. (2005) suggest that plants undergo ontogenetic niche shifts as they develop from seedlings into adults, as species can exist as adults in far broader niche space than that into which they can successfully recruit. It has been shown that the sensitivity of a plant to environmental factors changes with age (Collins and Good, 1987; Battaglia and Reid, 1993) but little is known about whether there is a shift in the physical attributes surrounding eucalypt seedlings as they age, develop lignotubers and persist in a juvenile form as lignotuberous sprouts. This will be one focus of this study.

The influence of microsite characteristics on eucalypt recruitment has been observed (Jacobs, 1955; Cunningham, 1960; Lockett, 1991; McCormick, 1991), but has been quantified in only a few studies. Battaglia and Reid (1993) concluded from their microsite study that the germination and establishment of *Eucalyptus delegatensis* seedlings was affected by small scale variation in soil conditions and this influenced the spatial distribution of seedlings. Depressions and shaded microsites were more favourable for emergence of *E. delegatensis* because of the higher humidity compared to that for microsites on flats, hillocks, shallow soils or clay soils. They also concluded that microsite requirements for seed germination and seedling survival may not necessarily be the same and may change over time. Potts (1986) showed that the establishment of *Eucalyptus amygdalina* seedlings after fire was limited to protected microsites on drier sites. These protected microsites were described as physical microhabitats, or "protected sites created by, for example, stones, depressions or fallen logs" (Potts, 1986). Sanger et al. (2010), found that the regeneration of *Eucalyptus gunnii* ssp. *divaricata*, an endangered species from the relatively wet and cold Central Plateau of Tasmania, appeared to be shifting to microsites of increased water holding capacity in response to an observed 25% reduction in summer rainfall. Microtopographic characteristics such as soil depth, concavity and slope had a strong influence over the amount of water stored in the soil profile and thus recruitment of *E. gunnii* ssp. *divaricata*.

This study considers the microsite attributes surrounding eucalypt seedlings and lignotuberous sprouts in lowland dry Tasmanian forests. Specifically, this study examines the following questions: (i) What are the attributes of the microsites that support the establishment of eucalypt seedlings in dry forests? (ii) Is there a distinct recruitment niche for seedlings, and/or a persistence niche for lignotuberous sprouts, and do they differ from the general forest floor?

2. Methods

2.1. Sites

Four sites were studied in the dry agricultural district of the Tasmanian Midlands: Tom Gibson Reserve, Barton Farm Private Reserve, Elderslie Nature Reserve and Gravelly Ridge Conservation Area (for details see Table 1). At all sites eucalypt seedling recruitment was restricted to sections of the reserves that had been burnt recently (in the last 2–6 years). Within the burnt areas eucalypt seedlings and lignotuberous sprouts were present. Unburnt areas in the reserves studied had a well developed shrubby understorey with some eucalypt lignotuberous sprouts but no seedlings.

2.2. Sampling design

An area of 5–15 hectares was assessed in the recently burnt section of each site. The position of each seedling and lignotuberous sprout was recorded with a handheld GPS unit (Explorist 1000, with 3 m accuracy). Fifteen seedlings and fifteen lignotuberous sprouts were then randomly selected from the total using computer generated random numbers. Seedlings were differentiated from sprouts by the amount of lignotuber development and the number of shoots arising from the lignotuber. Seedlings had small lignotubers (<5 mm) and a single stem, were less than 50 cm tall

Table 1
Description of four survey sites in the Midlands of Tasmania, Australia.

Site	Latitude Longitude Elevation	Area (ha)	Vegetation and soil type	Average annual rainfall (mm) [a]	Date of fire	Date site surveyed (time since burn)
Tom Gibson Reserve, Epping Forest, Northern Midlands	147.302°E 41.772°S 215 m	660	Grassy/heathy *Eucalyptus amygdalina* forest on Cainozoic deposits	562.8 LT (1928) 536 P10 5.5 km	May 2003	August and November 2007 (4 years 3 months)
Barton Farm Private Forest Reserve, Epping Forest, Northern Midlands	147.226°E 41.828°S 176 m	17	Grassy/heathy *Eucalyptus amygdalina* forest on Cainozoic deposits, surrounded by pasture	506.6 LT (1932) 528.7 P10 7.3 km	October 2004	December 2007 (3 years 2 months)
Gravelly Ridge Conservation Area, Campania, Southern Midlands	147.462°E 42.547°S 340 m	2285	*Eucalyptus amygdalina* forest on sandstone and inland *Eucalyptus tenuiramis* forest	754.6 LT (1915) 699.5 P10 8.5 km	2002	January 2008 (approx 6 years)
Elderslie Nature Reserve, Elderslie, Southern Midlands	147.047°E 42.611°S 240 m	100	Inland *Eucalyptus tenuiramis* forest on mudstone on steep north facing slope	576.9 LT (1969) 516 P10 4.7 km	December 2006	February 2009 (2 years 2 months)

[a] LT is long term average rainfall with date of first measurements in brackets and P10 average annual rainfall over the previous 10 years to 2009 for the closest meteorological station (distance away in km) to each site: Bureau of Meteorology (2009) http://www.bom.gov.au/climate/data/.