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Asplenium aethiopicum recolonises karri forest following timber harvesting and burning

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Abstract

Occurrence of the fern *Asplenium aethiopicum* (Burm.f.) Bech. was surveyed systematically in 7 ha of karri (*Eucalyptus diversicolor*) forest that formed part of a larger stand regenerated by clearfelling and burning in 1972. Much of the study area had also been thinned in 1984 to a range of densities (200–600 stems ha^{-1}) to investigate tree and stand growth responses. *A. aethiopicum* was recorded as an epiphyte growing on large ground logs and stumps in 12 of 28 plots examined during the survey, including a number that had been thinned. Large, partly decayed logs covered in dense moss provided favourable conditions for establishment and growth of *A. aethiopicum*. The most likely mechanism for re-establishment of *A. aethiopicum* in the regenerated forest is dispersal from adjoining undisturbed forest, rather than from plants persisting within the harvested area.

Keywords: *Asplenium aethiopicum*, *Eucalyptus diversicolor*, epiphytic fern, clearfelling, fire

Introduction

Unlike tall open eucalypt forests in high rainfall areas of south-eastern Australia, ferns are poorly represented in the flora of the karri (*Eucalyptus diversicolor*) forest. In south-western Australia ferns are typically confined to moist sites around granite outcrops and permanent watercourses, with the notable exceptions of *Lindsaea linearis* Sw. which is common on moist sandy soils south of the Blackwood River and the bracken fern (*Pteridium esculentum* G. Forst. Cockayne) which occurs widely throughout higher rainfall areas on a range of soil types (Wheeler *et al*. 2002). The impoverished fern flora and absence of species typically associated with temperate rainforest (for example *Nothofagus*) have been attributed to a history of periodic aridity and fire in south-western Australia during the mid to late Tertiary (Bowman 2003, Hopper 2003).

Asplenium aethiopicum (Burm.f.) Bech. is a cosmopolitan fern with a widespread but scattered distribution that includes southern Australia, tropical and southern Africa, India and Sri Lanka (Brownsley 1998). In south-western Australia the distribution of *A. aethiopicum* corresponds broadly with that of the karri forest, with outlier populations at Collie and along the southern coast (www.naturebase.net/ florabase/ index.html). *A. aethiopicum* is most commonly associated with moist crevices around granite outcrops but has also been recorded as an epiphyte on the bark of *Allocasuarina decussata* (Wheeler *et al*. 2002). The bark of *A. decussata* is corky and becomes deeply furrowed if unburnt for several decades. The conservation status of *A. aethiopicum* in Western Australia is currently Priority Four (Rare Taxa) indicating that it has been adequately surveyed, and while still rare, is not considered to be currently threatened by identifiable factors (Atkins 2005). Such taxa require regular monitoring.

Disturbances that expose the soil and understorey layers of the forest to greater drying by sun and wind may potentially disadvantage species such as *A. aethiopicum* that depend on sheltered moist sites or on substrates provided by other plants (i.e. bark). Hickey (1994) reported that epiphytic ferns in Tasmanian mixed forest containing eucalypt and temperate rainforest elements were more abundant in stands regenerated by high intensity wildfire than in stands regenerated using silvicultural treatment involving clearfelling, burning and sowing with eucalypt seed. Studies by Wapstra *et al*. (2003) and Courtney *et al*. (2005) have also recorded declines in the abundance of epiphytic ferns following clearfelling of wet eucalypt forest in Tasmania.

This note reports the findings of a systematic search for *A. aethiopicum* undertaken in a regrowth stand of karri that was regenerated in 1972 and then thinned at an age of 12 years for silvicultural research purposes.

Methods

The study was undertaken in Warren forest block 12 km south-west of Pemberton. Average annual rainfall is 1400 mm, with potential summer evaporation of 450 mm (December to February). The study site is located on a broad ridge at an elevation of 120 m a.s.l. and forms part of a 320 ha compartment of forest regenerated in autumn 1972 following clearfelling for sawlogs. Karri was the dominant overstorey tree in the original mature forest, with occasional marri (*Corymbia calophylla*). High intensity post-harvest burning was used to prepare receptive seedbed and stimulate release of seed from retained mature karri trees (Fig. 1). Seed trees were removed later in 1972 and very few living or dead trees

Figure 1. Photograph taken following the high intensity regeneration burn at Warren block in 1972.

from the original forest remained standing at the time of measurement in 2005. Residual logs unsuitable for sawmilling were retained on site, including a number of large diameter fallen karri trees with severe scarring on the stem and internal wood defect.

Seven ha of the regrowth forest were thinned in 1984 for a silvicultural experiment designed to investigate the effects of early thinning on stand growth. The experiment included 28 contiguous 50 m x 50 m plots of which four were retained as unthinned controls and the remainder non-commercially thinned to densities of 200, 400 or 600 stems ha^{-1}. Thinning treatments were assigned randomly to individual plots in the experimental design. Coppice regrowth from karri stumps was controlled two years after thinning with a one-off application of herbicide to half of the thinned plots. Fire has been excluded from the regrowth forest at the study site since 1972.

During routine re-assessment of the thinning trial in April and September 2005 three observers systematically searched each plot for *A. aethiopicum*. Observers walked throughout each plot to locate and measure trees and took additional time to search for *A. aethiopicum* on ground logs, stumps and other potential substrates. On average the team of observers spent 3 hours measuring and searching each plot.

Results

The regrowth stand was 33 years old in 2005 and codominant trees were 40–45 m tall. In unthinned plots

Figure 2. *A. aethiopicum* growing in deep moss on a large diameter karri log.

the density of live karri trees ranged from 900 to 1000 stems ha^{-1} and the understorey had largely senesced and collapsed to form a layer of woody material suspended above the leaf litter layer on the forest floor. Bracken, *Trymalium floribundum* and *Chorilaena quercifolia* were present in all plots, sometimes forming a dense understorey in the heavily thinned plots where overstorey canopy closure was incomplete.

Individual plants and small groups of *A. aethiopicum* were recorded in 12 of the 28 plots. Deep moss beds on large karri ground logs (>1 m diameter) were the favoured substrate and supported both the greatest number of *A. aethiopicum* plants, and the largest individuals some of which had multiple fronds up to 0.3 m in length (Fig. 2). A small number of plants were also observed growing in moss beds that had developed on cut stumps from the original mature forest. No *A. aethiopicum* plants were observed growing on small diameter karri logs resulting from the thinning operations in 1985 (<0.3 m diameter), on the bark of *A. decussata* saplings, or in the litter layer on the forest floor. *A. aethiopicum* occurred in 3 of the 4 unthinned plots, and in a number of thinned plots including some that had been subject to coppice control treatment (Table 1). There was no clear relationship between occurrence of *A. aethiopicum* and thinning or coppice control treatment.

Discussion

The findings of this survey demonstrate that *A. aethiopicum* is capable of recolonising karri forest within 3 decades of major disturbance from timber harvesting and fire. Although this is the first systematic survey for *A. aethiopicum* to be undertaken at the site, herbarium voucher specimens collected previously from the same location indicate that recolonisation had commenced by the time the stand was 25 years old. Individual plants of *A. aethiopicum* are unlikely to have persisted in-situ from the original mature forest because of the high level of disturbance associated with clearfelling and burning operations in 1972. Spore dispersal from plants in adjacent areas of undisturbed mature forest is the most likely source of propagules for recolonisation of the regenerated forest. The closest mature forest is about 400 m from the study site. Hickey (1994) suggested that epiphytic ferns may recolonise stands regenerated by clearfelling provided that there is adequate spore dispersal and suitable micro-sites develop prior to the next disturbance. In Tasmania, vascular epiphytes associated with late-successional stage forests may take up to 5 decades to recolonise logged substrates (Peacock & Duncan 1994).

Table 1

Occurrence of *A. aethiopicum* in plots subject to a range of thinning and coppice control treatments.

Stand density	Coppice control	No. of plots	No. of plots where *A. aethiopicum* was recorded
Unthinned	N/a	4	3
600 stems ha^{-1}	No	4	4
	Yes	4	1
400 stems ha^{-1}	No	4	0
	Yes	4	1
200 stems ha^{-1}	No	4	0
	Yes	4	3

Critical factors in the regeneration of karri include preparation of a receptive seedbed of ash or mineral soil, stimulation of seedfall and temporary removal of competition from understorey shrubs and overstorey trees (Loneragan & Loneragan 1964, Christensen 1971). Since the late 1960s, timber harvesting operations in mature karri stands have utilised a silvicultural system based on clearfelling of the overstorey followed by an intense slash burn in late spring to early autumn, with regeneration established by seedfall from retained mature trees or by planting seedlings raised in a nursery (White & Underwood 1974, Breidahl & Hewett 1995). No specific actions have been implemented to facilitate the regeneration of other eucalypts that co-occur with karri (e.g. *E. marginata*, *E. patens*, *C. calophylla*) or the regeneration of understorey plants, except on heavily disturbed sites such as log landings. Wardell-Johnson *et al*. (2004) examined floristic patterns in an age sequence of karri stands disturbed by fire and timber harvesting, and concluded that the vascular flora of the karri forest is comparatively resilient to the effects of these disturbance factors. Quadrat-based species richness (α diversity) was highest in recently burnt sites due to the influx of short-lived annuals and ephemerals, and lowest for sites having intermediate disturbance intervals (11–20 years) which were dominated by a small number of woody shrubs including *T. floribundum*, *C. quercifolia*, *Bossiaea aquifolium* subsp. *laidlawiana* and several species of Acacia (Wardell-Johnson *et al*. 2004). These shrubs all regenerate from soil stored seed and persist for several decades before declining to relatively low densities (<0.5 m^{-2}) in the absence of further disturbance (McCaw *et al*. 2002).

Differences in occurrence of *A. aethiopicum* between plots are likely to reflect the availability of large ground logs with a well developed moss layer and the current distribution of *A. aethiopicum* within the study area may be influenced by the spatial pattern of ground logs resulting from clearfelling of the mature forest. Large ground logs are now recognised as an important legacy of mature forests (Lindenmayer *et al*. 2002). Over the past two decades there has been a progressive reduction in the size of clearfell patches in karri forest and an increased emphasis on retention of mature habitat components both within harvested areas and throughout the landscape (Anon. 2004). These management actions should accelerate re-colonisation of disturbed sites by *A. aethiopicum* and other species that rely on dispersal by spores. Subsequent disturbance of the regrowth forest in 1984 by thinning and coppice control has not prevented *A. aethiopicum* from recolonising suitable substrates in thinned plots.

In the longer term, the population dynamics of *A. aethiopicum* in regrowth karri forest will also be influenced by the frequency, intensity and seasonality of fire.

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