Regeneration of blackberry-infested native vegetation

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Summary

This paper reviews current knowledge of the distribution, biology and management of blackberry in Australia, and the floristics of native vegetation susceptible to invasion. It also outlines the threat blackberry poses to native flora and fauna, including threatened species, and describes ways of minimizing the impact on off-target species when using herbicide for blackberry control in close proximity to native vegetation.

The revegetation of sites after the control of blackberry is also discussed. The paper explains the need to regenerate bare areas resulting from blackberry control in native vegetation, to prevent reinvasion of blackberry seedlings and those of other weeds, and to provide cover for native fauna.

Based on the information collated, important areas for research identified were:

i. comparison of growth of blackberry and competitive native species under various conditions,

ii. examination of native seed banks under blackberry thickets in native vegetation,

iii. the use of fire to stimulate germination of competitive native species in the seed bank.

Introduction

Distribution

At least eight species of blackberry, along with a group of hybrids, are naturalized in Australia (Amor and Miles 1974, Bruzzese and Lane 1996, Walsh and Entwisle 1996) and are collectively referred to as *Rubus fruticosus* L. agg.

Blackberry is now a serious weed in southern Australia particularly in areas with mean annual rainfall higher than 760 mm (Amor 1968, Bruzzese 1980). Blackberry also grows along rivers and irrigation channels in areas of lower rainfall.

The largest infestations in Australia are in Victoria and New South Wales. The northern limit of blackberry is Moreton Bay in southern Queensland. Blackberry also occurs throughout Tasmania, in the Mount Lofty Ranges of South Australia and in the south-western corner of Western Australia (Amor and Richardson 1980).

Bruzzese *et al.* (n.d.) described the heaviest infestations of blackberry in Victoria as occurring in Central Gippsland, the North East and the Otway Ranges, but they noted that blackberry had been recorded from all other regions with the exception of north western Victoria. In New South Wales, blackberry is most widespread in the south-eastern parts of the State but occurs in the highland areas as far north as the Queensland border (Toth *et al.* 1981).

A major problem in blackberry management is the inaccessibility of many infestations. For example, in Victoria it was estimated in 1975 that approximately 43% of the infested area was inaccessible for herbicide control (Amor and Harris 1979). In that State, Amor and Harris (1979) described the most extensive areas of inaccessible blackberry as occurring in Gippsland, the north-eastern ranges and the Otway Ranges where the terrain is rugged, and conditions favour the spread of blackberry along river valleys and in other disturbed areas.

History of spread

Blackberry was introduced originally into Australia from Europe in the early nineteenth century and had already become a significant weed by the 1880s (Bayley 1962). It was estimated in 1958 that 146 000 hectares of Victoria were infested by blackberry (Parsons 1958), this figure increasing to about 663 000 hectares by 1975 (Amor and Harris 1979), and to three million hectares by 1980 (Lane *et al.* 1980).

In New South Wales, Mears (1981) estimated that in 1980, 171 250 hectares of the state had dense infestations of blackberry, 835,100 hectares had medium infestations, while 2 970 300 hectares had sparse infestations. By 1983 1.4 million hectares were moderately to densely infested (Vere and Dellow 1985).

Impact on native flora

In 1975 it was estimated that 58% of the area infested by blackberry in Victoria was in native forest (Amor and Harris 1979). In natural ecosystems dense infestations of blackberry suppress native plants and reduce the natural diversity of the vegetation and wildlife habitat (Amor and Richardson 1980, Bruzzese and Lane 1996).

Blackberry is contributing significantly to the decline of a number of rare and threatened plant species, as well as to several severely depleted and now rare plant communities. Blackberry invasion is threatening populations of at least four plant taxa listed by Briggs and Leigh (1996) as nationally endangered, and seven listed as nationally vulnerable (Table 1).

In the Mount Lofty Ranges of South Australia blackberry is invading *Eucalyptus dalrympleana* open forest, *E. ovata* low woodland/low open forest and *Leptospermum continentale–L. lanigerum* closed heath (Department for Environment, Heritage and Aboriginal Affairs 1997), all of which are plant communities that are poorly conserved in the region (Davies 1982, Neagle 1995).

Impact on native fauna

Blackberry thickets provide a harbour for rabbits which further impact on native flora and fauna (Bruzzese and Lane 1996). Blackberry fruit also acts as a seasonal food source for the common starling (*Sturnus vulgaris*) (Bruzzese and Lane 1996), an introduced bird which readily out-competes native birds for nesting sites (Clayton 1982). During summer, blackberries are a major component of the diet of foxes (*Vulpes vulpes*) (Coman 1973; Brunner *et al.* 1975), a serious predator of native vertebrates.

Table 1. Nationally endangered and vulnerable plant species under threat from blackberry invasion in Victoria and South Australia (Davies 1986, Davies and Thompson 1993, Foreman and Walsh 1993, Davies 1995, DCNR (Vic) Flora Information System 1998).

Species	Common name	Status[A]
Acacia caerulescens	Limestone blue wattle	Vulnerable
Amphibromus fluitans	River swamp wallaby-grass	Vulnerable
Astelia australiana	Tall astelia	Vulnerable
Ballantinia antipoda	Ballantinia	Endangered
Caladenia audasii	McIvor spider-orchid	Endangered
Caladenia concolor	Crimson spider-orchid	Vulnerable
Eucalyptus crenulata	Buxton gum	Endangered
Euphrasia collina ssp. *muelleri*	Purple eyebright	Endangered
Glycine latrobeana	Clover glycine	Vulnerable
Prasophyllum frenchii	Maroon leek-orchid	Vulnerable
Pterostylis cucullata	Leafy greenhood	Vulnerable

[A] Briggs and Leigh (1996).

Plant communities invaded

Victoria

Foreman and Walsh (1993) describe seven broad vegetation formations as being invaded by the various species of blackberry in Victoria. Moist sclerophyll forest, wet sclerophyll forest and riparian forest are being invaded by *Rubus cissburiensis*, *R. discolor*, *R. polyanthemus*, *R. rosaceus*, *R. ulmifolius* and *R. vestitus*. Dry sclerophyll forest and woodland, and seasonal freshwater wetlands are mainly being invaded by *R. discolor* and *R. ulmifolius*, whilst *R. polyanthemus* is a problem in warm-temperate rainforest. Lowland grasslands and grassy woodlands are only invaded by *R. discolor* (Foreman and Walsh 1993).

In East Gippsland and the north-east of the State, Riparian Forest and Montane Riparian Forest have been found to be the most prone to blackberry invasion (Forbes *et al.* 1981, Earl *et al.* 1989, Gillespie *et al.* 1990, Westaway *et al.* 1990, Robinson *et al.* 1992). Riparian Forest is similarly most prone to blackberry invasion in the Melbourne Region (Yugovic *et al.* 1981, Molnar *et al.* 1989). Frequent dominant species occurring in these and other blackberry-prone communities are given in Table 5 (see subsequently).

In the North Eastern region, Amor and Stephens (1976) found differences in susceptibility to blackberry-invasion between different sclerophyll forest communities depending on the degree of shading by the overstorey and the ability of the soil to retain moisture. The plant community found to be most extensively colonized were communities dominated by *Eucalyptus rubida* and native grasses, on heavy clays subject to waterlogging. Less prone to blackberry-invasion were drier communities dominated by *E. radiata* or *E. dives* which had more shrubby understoreys. Amor and Stephens (1976) measured lower levels of diffuse light under the latter communities. They also found blackberries to be most frequently associated with disturbed native vegetation where there was much bare ground, such as on roadsides and in old drains.

South Australia

In the Mount Lofty Ranges of South Australia, blackberry reaches the limit of its environmental range and most frequently occurs in dry sclerophyll forest dominated by *Eucalyptus obliqua*, *E. viminalis* or *E. dalrympleana* or wet heath communities, in areas of 800–1050 mm mean annual rainfall. These communities occur in gullies or on hill slopes, on alluvial or red podsolic skeletal soils. However, blackberry also extends into woodlands dominated by *E. camaldulensis* in areas with as little as 600 mm mean annual rainfall. This community occurs on lower slopes along drainage lines, on red pedal clays and other neutral to alkaline soils (Department of Environment and Planning 1988).

A quantitative analysis of quadrat data collected in the Mount Lofty Ranges (Department of Environment and Planning 1988) identified three 'floristic communities' as being particularly prone to blackberry invasion. These were referred to as 'Stringybark-Manna Gum Open Forest – Wet Heath', 'Stringybark Open Forest' and 'Red Gum Open Forest'. Frequent dominant species occurring in these communities are given in Table 6 (see subsequently).

Table 2. Native plant species observed out-competing rust-defoliated blackberry in native vegetation in the Strzelecki Ranges of Victoria, and observed stages in recolonization. (R. Davies personal observation, Bruzzese *et al.* n.d.)

Species	Common name	Stage of succession
Goodenia ovata	Hop goodenia	Early succession dominant
Pteridium esculentum	Bracken	Early succession dominant
Senecio linearifolia	Firewheel groundsel	Early succession dominant
Tetrarrhena juncea	Forest wire grass	Early succession dominant
Acacia melanoxylon	Blackwood	Later succession dominant
Bedfordia arborescens	Blanket leaf	Later succession dominant
Olearia lirata	Snowy daisy-bush	Later succession dominant
Pomaderris aspera	Hazel pomaderris	Later succession dominant

Competitive strategies of blackberry in native vegetation

The competitive success of European blackberry as an environmental weed in Australia arises because of several factors. Control methods for blackberry in native vegetation need to address these to be successful.

Amor (1973) particularly attributed the weediness of blackberry to an ability to produce daughter plants by tip-rooting every autumn, thereby resulting in a rapid expansion of thickets. Also of significance is the rapid growth of primocanes, with rates of five to eight centimetres per day having been measured (Bruzzese and Lane 1996). Its weediness is also because of the absence in Australia of any native pathogens and insect predators which may severely affect blackberry (Bruzzese 1980).

Blackberry is able to invade rapidly new areas of disturbed native vegetation because it can produce large quantities of seed, up to 13 000 seeds m^{-2} (Amor 1974a). The dispersal of seeds by exotic and native birds as well as foxes is also a factor. Eighty nine percent of fox droppings collected in March at one site in the Dandenong Ranges of Victoria contained blackberry seed, while droppings of emus (*Dromaius novaehollandiae*) contained a mean of 2460 blackberry seeds per dropping (Brunner *et al.* 1975).

Methods of blackberry control in native vegetation

Rust-defoliated blackberry

At least two strains of the biological control agent blackberry leaf rust (*Phragmidium violaceum*) have been introduced into Australia. One strain was apparently illegally released in 1984 (Marks *et al.* 1984), whilst another strain (F15) was released legally in all States in the summer of 1991 and 1992 (Bruzzese and Lane 1996, Bruzzese *et al.* n.d.).

In areas of reliable summer rainfall, summer rust epidemics are severely defoliating the most widespread blackberry species; viz. *R. discolor*, *R. polyanthemus* and some *R. ulmifolius* hybrids. Such epidemics have been observed in the Strzelecki and Otway Ranges of Victoria (Bruzzese *et al.* n.d.), and the Northern Tablelands of New South Wales (J. Hosking personal communication).

In the Strzelecki Ranges, native species have begun to out-compete heavily rust-defoliated blackberry thickets, although Bruzzese and Lane (1996) describe large well-established blackberry infestations taking five to ten years to open up sufficiently enough to allow native species to grow through and become overstorey species. Native species observed to out-compete blackberry in these situations are listed in Table 2.

Slashing in summer can enhance the effect of blackberry leaf rust because the resulting regrowth is very susceptible to the rust (Bruzzese and Lane 1996).

Blackberry unaffected by rust

Although *Phragmidium* has spread throughout Australia (Marks *et al.* 1984), the rust is having negligible impact on blackberry in western Victoria and parts of north-eastern Victoria, as well as infestations in South Australia (R. Davies personal observation), apparently due to climatic conditions. Also, some less widespread species (*R. rosaceus*, *R. cissburiensis*, *R. ulmifolius* and some *R. ulmifolius* hybrids) have been observed to be resistant to the rust (Bruzzese and Lane 1996).

In such situations, the use of herbicides is generally necessary since mature

Table 3. Attributes of herbicides registered in Australia for use on blackberry (Ashton and Craft 1981, Humburg *et al.* 1989, Parsons 1992, Parsons and Cuthbertson 1992, Thomson 1993).

Active ingredient	Oral LD_{50} (mg kg^{-1}) (rats)	Root absorption	Persistence in soil (maximum)	Specificity
Amitrole	>5000	Yes	2–4 weeks	Most grasses and broadleaf species susceptible
Glyphosate	>5000	No	Not	Broad spectrum
Hexazinone	1690	Yes	>6 months[A]	Most grasses and broadleaf species susceptible
Metsulfuron methyl	>5000	Yes	22 months	Many grasses tolerant
Picloram	8200	Yes	Very	Most grasses tolerant
Triclopyr	713	Yes	>46 days[A]	Most grasses tolerant

[A] Half life.

blackberry is able to regenerate readily from roots following burning (Amor and Richardson 1980) or slashing (Amor 1974b). Winter burning of dead canes is used commonly following summer spraying to facilitate access and enable the spot-spraying of regrowth over the following summer (Bruzzese and Lane 1996). Slashing over three years can reduce the density and percentage of blackberry canes for at least nine months after treatment ceases (Amor and Harris 1981), and if undertaken fortnightly or monthly will weaken plants by depleting reserves in the root system (Bruzzese and Lane 1996).

Amor and Richardson (1980) describe grubbing as 'very effective but practical only on small areas'. Because blackberry can produce root suckers from a depth of up to 45 centimetres or more (Northcroft 1927) it is essential to remove as much of the root as possible. Hand pulling of blackberry plants is generally ineffective. Even seedlings and small plants are difficult to pull out, and blackberries will regrow from any root fragments left in the soil (Bruzzese and Lane 1996).

Bulldozing of blackberry-infested sites is undesirable because blackberry reproduces readily from root fragments (Richardson 1975) and thus can be readily transported by earth-moving equipment.

Use of herbicides

Whilst the efficacy of a herbicide on mature blackberry is an important factor to be considered when selecting herbicides to use, the likelihood of off-target damage is equally important when used on infestations in native vegetation. Herbicides which are residual in the soil and readily absorbed by roots are more likely to cause off-target damage. Other factors to be considered are the specificity, and safety for use by volunteer bush regenerators (as indicated by a high LD_{50}). Table 3 lists the attributes of herbicides registered in Australia for use on blackberry.

The method of application also affects the amount of off-target damage. When spraying in the proximity of susceptible native species, Bruzzese and Lane (1996) recommend the use of a gas-powered gun, knapsack unit, or injection of herbicide through a lance into the soil near the crown. For small areas of high conservation significance, they suggest the 'cut-and-paint' method, where the top of the crown is removed and concentrated herbicide is immediately painted on the cut.

Table 4. Introduced species frequently occurring in blackberry-infested native vegetation in South Australia determined from quadrat based survey data (DHUD and DENR 1997).

Species	Common name	Frequency[A]
Rubus fruticosus agg.	European blackberry	100%
Holcus lanatus	Yorkshire fog	45%
Senecio pterophorus var. *pterophorus*	African daisy	37%
Briza maxima	Large quaking-grass	34%
Hypochaeris radicata	Rough cat's ear	34%
Genista monspessulana	Montpellier broom	26%
Plantago lanceolata var. *lanceolata*	Ribwort	18%
Hypericum perforatum	St. John's wort	15%
Cirsium vulgare	Spear thistle	13%
Anthoxanthum odoratum	Sweet vernal grass	12%
Lotus uliginosus	Greater bird's-foot trefoil	12%
Briza minor	Lesser quaking-grass	11%
Olea europaea ssp. *europaea*	Olive	11%
Rosa canina	Dog rose	11%
Trifolium campestre	Hop clover	11%
Cytisus scoparius	English broom	10%
Trifolium angustifolium	Narrow-leaf clover	10%
Ulex europaeus	Gorse	10%

[A] Percentage of 167 quadrat sites in blackberry infested native vegetation, which contained the introduced species in question.

Native regeneration to prevent re-invasion by blackberry seedlings

High levels of seed production and the presence of highly effective seed dispersal agents mean that blackberry seedlings can often readily re-invade bare areas resulting from the spraying of mature plants or following mechanical removal. The susceptible nature of blackberry seedlings can be exploited to minimize such re-invasion, however.

Results of studies in Victoria have found that seedlings achieve much lower survival and growth rates in their first year compared with the daughter plants produced by tip rooting (Amor 1971). This is in part because of the lack of significant root development by seedlings over winter, unlike daughter plants which can obtain energy for growth from attached mature canes (Amor and Richardson 1980).

Under field conditions in southern Australia, development of blackberry seedlings is often slow, only 3–4 leaves being produced in their first summer (Amor and Richardson 1980). Under ideal conditions, however, seedling development can be much more rapid, Amor (1971) measuring an average length of 87 centimetres for the main canes of *Rubus polyanthemus* seedlings at the end of the first growth season.

Blackberry seed generally has a very low germination percentage in the field. For instance, Amor (1974a) measured only 10% germination of *Rubus discolor* seeds in the first two years and no germination in the subsequent two years. This compares with 22 to 33% germination of seed under ideal conditions for the same taxon (Brunner *et al.* 1976).

Blackberry seedlings are particularly susceptible to shading and competition. Amor (1974a) found no survival of *Rubus discolor* seedlings at sites receiving radiation less than a mean of 250 cal cm^{-2} day^{-1} (44% of full sunlight) in December to February. Similarly, Amor and Stephens (1976) measured significantly greater survival of blackberry seedlings on road verges where there was 70-76% diffuse light and little competition from other plants, compared with levels in adjacent intact native forest.

Thus great potential exists for preventing re-invasion by blackberry seedlings, if rapid regeneration can be achieved of fast growing native species with the capacity to out-shade these seedlings and out-compete them for water and nutrients.

Blackberry is highly dependent on a rapid uptake of nutrients following bud burst in early spring, to replace the significant nutrient capital lost in winter leaf drop and cane dieback (Taylor 1982). Consequently, native species which actively grow during this period are likely to be the most effective competitors.

Research is needed into the comparative ability of native species to out-compete blackberry seedlings under various light intensities and moisture regimes. Trials into methods of promoting the rapid regeneration of the most competitive of these species are also required, to determine ways of maximizing this competitive ability.

Whilst the introduction of non-indigenous native species into native vegetation is not recommended, the sowing of native seed collected from the near vicinity may be desirable if existing soil seed banks are depleted. However, where adequate native seed banks remain, manipulation of native species composition by treatments such as fire may be all that is required.

Native regeneration to prevent the invasion of other weeds

Many environmental weeds thrive in the presence of disturbance, and if weed propagules are present will readily colonize bare areas resulting from blackberry control activities. This is frequently the situation where blackberry has invaded native vegetation adjacent to large urban areas, such as in the Dandenong Ranges in Victoria, and in the Adelaide Hills. Table 4 presents the frequencies of weeds in blackberry-infested native vegetation in South Australia. Note that the serious environmental weed Montpellier broom (*Genista monspessulana*) occurs at more than a quarter of all sites. The frequent presence of other highly invasive weeds in blackberry-infested native vegetation, indicates the need to undertake follow-up weed control of all weed species following blackberry control.

Table 5. Native species frequently occurring as dominants in blackberry-infested native vegetation in Victoria (DCNR (Vic) Flora Information System 1998), and blackberry-prone plant communities in which they occur as dominants (Forbes *et al.* 1981, Yugovic *et al.* 1981, Earl *et al.* 1989, Molnar *et al.* 1989, Gillespie *et al.* 1990, Westaway *et al.* 1990, Robinson *et al.* 1992).

Species	Common name	Frequency[A]	Plant communities[B]
Acacia dealbata	Silver wattle	22%	WS DS R MR
Acacia mearnsii	Black wattle	9%	R W
Acacia melanoxylon	Blackwood	27%	WT WS DS R MR
Acaena novae-zelandiae	Bidgee-widgee	28%	MR
Adiantum aethiopicum	Common maidenhair	11%	R
Australina pusilla ssp. *muelleri*	Shade nettle	10%	WS
Bedfordia arborescens	Blanket-leaf	8%	WT
Blechnum nudum	Fishbone water-fern	13%	WT DS R MR
Blechnum wattsii	Hard water-fern	8%	WS MR
Bursaria spinosa	Sweet bursaria	11%	R W
Carex appressa	Tall sedge	13%	R MR
Cassinia aculeata	Common cassinia	22%	WS DS MR
Cassinia longifolia	Shiny cassinia	9%	DS R
Coprosma quadrifida	Prickly currant-bush	27%	WT WS DS R MR
Cyathea australis	Rough tree-fern	16%	WT
Dicksonia antarctica	Soft tree-fern	14%	WT WS R MR
Eucalyptus cypellocarpa	Mountain grey gum	10%	DS W
Eucalyptus obliqua	Messmate	16%	DS
Eucalyptus radiata s.l.	Narrow-leaf peppermint	11%	DS R MR
Eucalyptus viminalis	Manna gum	11%	DS R MR
Gahnia radula	Thatch saw-sedge	8%	W
Kunzea ericoides	burgan	9%	DS R
Lepidosperma laterale	Variable sword-sedge	10%	R
Lomandra longifolia	Spiny-headed mat-rush	17%	R
Microlaena stipoides	Weeping grass	23%	R W
Olearia argophylla	Musk daisy-bush	12%	WT WS
Olearia lirata	Snow daisy-bush	13%	WS
Poa australis spp. agg.	Tussock grass	9%	DS R MR
Poa ensiformis	Tussock grass	?%	R MR
Poa labillardierei	Common tussock-grass	8%	R
Polystichum proliferum	Mother shield-fern	18%	WT WS DS R MR
Pomaderris aspera	Hazel pomaderris	20%	WT WS DS R MR
Pteridium esculentum	Austral bracken	32%	WS DS R MR
Rubus parvifolius	Small-leaf bramble	14%	MR
Senecio linearifolius	Fireweed groundsel	11%	WS
Tetrarrhena juncea	Forest wire-grass	22%	WT WS DS R

[A] Percentage of 4319 quadrat sites in blackberry infested native vegetation, containing the native species in question.

[B] Key: WT=Warm Temperate Rainforest, WS=Wet Sclerophyll Forest, DS=Damp Sclerophyll Forest, R=Riparian Forest, MR=Montane Riparian Forest, W=Woodland.

Selection of competitive native species

The aim of managing blackberry in native vegetation is not only to kill the target species but also to promote the natural regeneration of native species naturally occurring at the site previous to it being degraded by weeds or other factors. Thus, when researching the ability of native species to outcompete blackberry seedlings, it is most useful to target species which are very common as dominants in blackberry infested vegetation, and occur over a wide range of blackberry prone plant communities. It is important to target species which frequently occur as dominants in these communities as such species are likely to have the greatest competitive ability. Thus, a knowledge of the most common dominant species in the various plant communities subject to invasion is essential. Only with this knowledge, and an understanding of the growth biology of these species, can broadscale treatments which promote native plant regeneration be devised.

Native species frequently occurring as dominants in blackberry-infested native vegetation in Victoria are presented in Table 5, along with the blackberry-prone plant communities in which they occur as dominants. A similar list for South Australia, is given in Table 6. Of these species, *Acacia melanoxylon* (blackwood), *Acaena novae-zelandiae* (bidgee-widgee), *Carex appressa* (tall sedge), *E. obliqua* (messmate stringybark), *E. viminalis* (manna gum), *Microlaena stipoides* (weeping grass), *Poa* spp. and *Pteridium esculentum* (bracken

fern) are common dominants at a range of blackberry-prone communities in both States, while *Acacia dealbata* (silver wattle), *Cassinia aculeata* (common cassinia), *Pomaderris aspera* (hazel pomaderris) and *Tetrarrhena juncea* (forest wire-grass) are common dominants in a range of such communities in eastern Victoria. Similarly, *Acacia myrtifolia* (myrtle wattle), *A. pycnantha* (golden wattle), *A. retinodes* (swamp wattle), *Goodenia ovata* (hop goodenia), *Leptospermum continentale* (prickly tea-tree), *Pultenaea daphnoides* (large-leaf bush pea) and *Themeda triandra* (kangaroo grass) are common dominants in blackberry prone communities in South Australia. The research into the ability of these species to out-compete blackberry seedlings under various environmental conditions and management regimes, is of highest priority.

Baumea rubiginosa (soft twig-rush), *B. tetragona* (square twig-rush), *Empodisma minus* (tangled rope-rush), *Gahnia sieberiana* (red-fruit cutting-grass), *Lepidosperma laterale* (sharp sword-sedge), *Leptocarpus tenax* (slender twine-rush), *Leptospermum lanigerum* (silky tea-tree) and *Senecio linearifolius* (fireweed groundsel), are also common dominants in blackberry infested vegetation, but are a lower priority for research as they are restricted to specific habitats.

A number of ferns, *Adiantum aethiopicum* (common maiden-hair), *Blechnum minus* (soft water-fern), *B. nudum* (fishbone water-fern), *Cyathea australis* (rough tree-fern), *Dicksonia antarctica* (soft tree-fern) and *Polystichum proliferum* (mother shield-fern), occur as common dominants in blackberry-prone communities but are probably unable to out-compete blackberry seedlings due to their initial slow growth rates when establishing from spores. Similarly, a number of other common dominants never achieve adequately dense cover to out-shade blackberry. *Acrotriche fasciculiflora* (Mount Lofty ground-berry), *Bursaria spinosa* (sweet bursaria), *Coprosma quadrifida* (prickly currant-bush), *Hibbertia exutiacies* (prickly guinea-flower), *Lepidosperma semiteres* (wire rapier-sedge) and *Lomandra longifolia* (spiny-headed mat-rush) are probably in this category.

Table 6. Native species frequently occurring as dominants in blackberry-infested native vegetation in South Australia (DHUD and DENR 1997), and blackberry-prone plant communities in which they occur as dominants (Department of Environment and Planning 1988, R. Davies personal observation).

Species	Common name	Frequency[A]	Plant communities[B]		
Acacia melanoxylon	Blackwood	28%	SB-MG	SB	
Acacia myrtifolia	Myrtle wattle	32%	SB-MG	SB	
Acacia pycnantha	Golden wattle	27%		SB	RG
Acacia retinodes	Swamp wattle	33%	SB-MG	SB	RG
Acaena novae-zelandiae	Biddy-biddy	24%			RG
Acrotriche fasciculiflora	Mt. Lofty ground-berry	41%	SB-MG	SB	RG
Adiantum aethiopicum	Common maiden-hair	22%	SB-MG	SB	
Baumea rubiginosa	Soft twig-rush	16%	SB-MG		
Baumea tetragona	Square twig-rush	16%	SB-MG		
Blechnum minus	Soft water-fern	20%	SB-MG		
Bursaria spinosa	Sweet bursaria	27%		SB	RG
Carex appressa	Tall sedge	10%	SB-MG		
Daviesia leptophylla	Narrow-leaf bitter-pea	13%		SB	
Empodisma minus	Tangled rope-rush	15%	SB-MG		
Eucalyptus camaldulensis	River red gum	9%			RG
Eucalyptus dalrympleana	Mountain gum	10%	SB-MG		
Eucalyptus fasciculosa	Pink gum	15%		SB	
Eucalyptus leucoxylon	South Australian blue gum	12%		SB	RG
Eucalyptus obliqua	Messmate stringybark	45%	SB-MG	SB	
Eucalyptus viminalis	Manna gum	17%	SB-MG	SB	RG
Gahnia sieberiana	Red-fruit cutting-grass	26%	SB-MG		
Gleichenia microphylla	Coral fern	13%	SB-MG	SB	
Goodenia ovata	Hop goodenia	30%	SB-MG	SB	
Hakea rostrata	Beaked hakea	13%		SB	
Hibbertia exutiacies	Prickly guinea-flower	33%		SB	
Lepidosperma laterale	Sharp sword-sedge	15%		SB	
Lepidosperma longitudinale	Pithy sword-sedge	13%	SB-MG		
Lepidosperma semiteres	Wire rapier-sedge	26%		SB	
Leptocarpus tenax	Slender twine-rush	14%	SB-MG		
Leptospermum continentale	Prickly tea-tree	54%	SB-MG	SB	RG
Leptospermum lanigerum	Silky tea-tree	23%	SB-MG		
Melaleuca decussata	Totem-poles	11%	SB-MG		
Melaleuca squamea	Swamp honey-myrtle	11%	SB-MG		
Microlaena stipoides	Weeping rice-grass	11%	SB-MG	SB	RG
Phragmites australis	Common reed	13%	SB-MG		RG
Poa clelandii	Matted tussock-grass	15%	SB-MG	SB	
Poa crassicaudex	Thick-stem tussock-grass	11%		SB	
Pteridium esculentum	Bracken fern	62%	SB-MG	SB	
Pultenaea daphnoides	Large-leaf bush pea	41%	SB-MG	SB	
Themeda triandra	Kangaroo grass	16%		SB	RG

[A] Percentage of 167 quadrat sites in blackberry infested native vegetation, containing the native species in question

[B] Floristic plant communities as defined by Department of Environment and Planning (1988): SB-MG = Stringybark-Manna Gum Open Forest – Wet Heath community, SB = Stringybark Open Forest, RG = Red Gum Open Forest.

The use of fire to promote germination of competitive native species

Whilst burning of blackberry results in vigorous regrowth from blackberry roots (Amor and Richardson 1980), its use following spraying to stimulate simultaneous germination of competitive native species needs further investigation.

Results of research in New South Wales (Auld and O'Connor 1991) have shown that a temperature increase of 60°C in the first three centimetres of soil was necessary to break dormancy in 100% of Leguminosae seed. Similar research is needed to determine the optimum timing and intensity of burning blackberry to stimulate maximum germination and survival of competitive native species. As well, the persistence of residual herbicides in soil under sprayed blackberry thickets needs investigation, to determine adequate delay times between spraying and burning.

The natural regeneration of competitive native plant species depends on an adequate viable soil seed bank. No seed bank was present under a *Rubus polyanthemus* thicket in a remnant open-forest dominated by *Eucalyptus viminalis*, *E. obliqua* and *E. radiata* in central Victoria studied by Panetta (1982). Despite a low tree stratum of *Acacia melanoxylon*, *A. mearnsii* and *Exocarpos cupressiformis* and occasional individuals of *Coprosma quadrifida* and *Cassinia longifolia* in the blackberry-dominated shrub stratum, Panetta found only 8% of the soil seed bank was native, consisting of only three species, all small herbs. In such situations, direct seeding after spraying using locally collected seed of competitive native species may be needed.

Table 7. Plant species listed by Lang and Kraehenbuehl (1997)[A] as threatened in South Australia, and recorded by DHUD and DENR (1997) as occurring in blackberry infested native vegetation.

Species	Common name	Conservation status[A]
Cryptostylis subulata	Moose orchid	Vulnerable in SA
Juncus prismatocarpus	Branching rush	Endangered in SA
Restio tetraphyllus	Tassel cord-rush	Vulnerable in SA
Schizaea bifida	Forked comb-fern	Vulnerable in SA
Schizaea fistulosa	Narrow comb-fern	Vulnerable in SA
Thelymitra holmesii	Slender blue swamp sun-orchid	Vulnerable in SA
Thelymitra venosa	Veined sun-orchid	Endangered in SA
Todea barbara	King fern	Endangered in SA
Utricularia laterifolia	Small bladderwort	Vulnerable in SA

Research is needed into factors influencing native soil seed banks under blackberry, to enable prediction of situations when direct seeding is necessary. The age of the blackberry thicket is one of the factors that could be particularly important.

Need for caution when controlling blackberries in native vegetation

Blackberry occurring adjacent to significant flora

While dense infestations of blackberry will out-compete most native understorey species, native species are able to persist at lower levels of infestation. In some habitats (in particular *Leptospermum continentale–L. lanigerum* closed heath in South Australia) threatened plant species occur amongst or immediately adjacent to blackberry thickets (Table 7).

These cases illustrate the need for detailed botanical surveys to locate significant plant species or plant communities adjacent to or within infestations, before blackberry control is commenced in native vegetation. Where sites of botanical significance occur, the preparation of weed management plans is advisable, detailing what minimal impact methods should be employed, such as cutting and paint application of herbicide or protection from spray drift with plastic.

Blackberry thickets as habitat for native fauna

With the clearance of native vegetation some native birds and mammals have adapted to using blackberry as protection from predators. For example, Nias (1986) found that blackberry thicket was the most favoured nesting substrate used by the superb fairy-wren (*Malurus cyaneus*).

Similarly, blackberry thickets provide protection from cats and foxes for the southern brown bandicoot (*Isoodon obesulus*). This small mammal, which is vulnerable in South Australia (Watts 1990), has been recorded using blackberry thickets along creeklines to extend their range up to 350 metres into paddocks adjacent to native vegetation (Paull 1993).

Where populations of significant fauna depend on such thickets, Bruzzese and Lane (1996) recommend the implementation of blackberry control 'in stages or blocks to allow movement of such fauna from the blackberry cover back to natural cover, or the establishment of alternative cover of native plants'.

Conclusions

Given the ability of mature blackberry to invade native vegetation, including sites of high biological significance, the maintenance of native biota is often an important issue in the control of blackberry. If smaller native species are made locally extinct by careless spraying, their re-establishment is impractical, and in many cases is impossible, given the poor current knowledge of germination requirements and mycorrhizal relationships.

While the growth and reproductive biology of the most common species of blackberry in Australia have been extensively researched, relatively little is known of the ecology of native vegetation infested by blackberry. Similarly, whilst several herbicides have been found to control blackberry effectively, the off-target impact of these herbicides on adjacent native vegetation is poorly known.

Further research is needed to determine treatments which may encourage regeneration of native species following blackberry control. A greater understanding of the native soil seed bank under blackberry infested native vegetation, will assist managers to determine when direct seeding is necessary and what local species should be used.

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