

# Weedy blackberry and raspberry species in Western Australia and strategies for their management

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## Introduction

European blackberry (*Rubus fruticosus* L. agg.) has been designated as a “Weed of National Significance” (WONS). It is a serious weed throughout temperate Australia where it threatens both agricultural and natural ecosystems. A National Strategic Plan has been developed with the aim to minimising the spread and reducing the impact of weedy blackberry infestations across Australia (ARMCANZ, 2000). National Weed management guides for European blackberry are available via the internet that give a good overview of the weed and the general methods of control currently available within Australia (Bruzzese et al., 2000; DEHCRCWM, 2003). These guides do not however address Western Australian (WA) specific issues that are relevant to the control of weedy blackberry. These issues are largely introduced because of the complexity of the taxonomy of the weedy blackberry. Blackberry and raspberry are both in the genus *Rubus*. Hybrids between these species also occur and although blackberry is the major problem, other *Rubus* species are also weedy in parts of WA.

The aim of this document is to

(1) describe how to identify the weedy *Rubus* that is likely to be within any particular area within WA.

(2) summarize the control options that are currently being recommended and adopted in WA.

(3) suggest the research and “on the ground” control activities that if conducted now, should facilitate the integration of current and future control options and lead to a reduction in WA’s overall weedy *Rubus* problem.

### The complicated taxonomy of weedy *Rubus* species

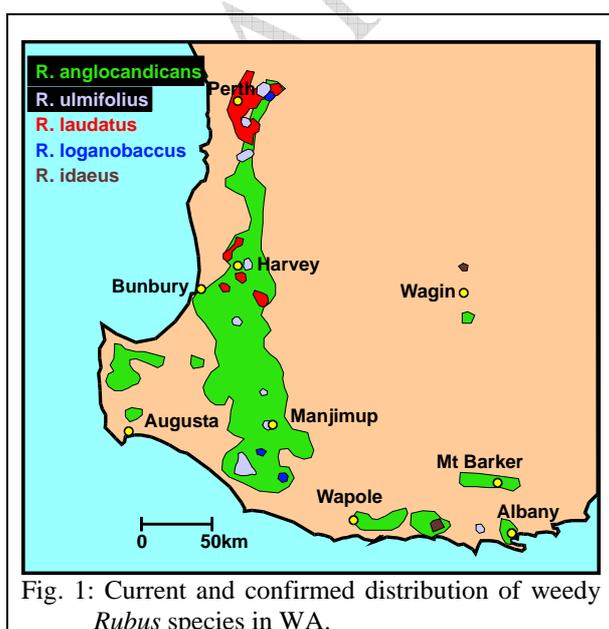
The most recent review of the Australian weedy blackberry (*Rubus spp.*) is an excellent identification key by Barker and Barker (2005). Their key also includes any other non-blackberry *Rubus* species for which Australian herbarium specimens existed. Unless otherwise stated, all the taxonomic information that follows in this document has been taken from this key and the reader is also encouraged to use it.

European blackberry (*Rubus fruticosus* L. agg.), the plant that is commonly referred to as weedy “blackberry” in Australia, is not just one species but instead belongs to at least 15 closely related but different species. In addition to this, Australia also has weedy raspberry (eg. *Rubus idaeus*; originally from Asia/Europe), weedy American blackberry (eg. *R. laudatus*), naturalized American cultivars derived from raspberry x blackberry hybrids like the loganberry, *R. loganobaccus* and the dewberry, *R. roribaccus* (see [www.oregon-berries.com/cx1/cx1a.htm](http://www.oregon-berries.com/cx1/cx1a.htm) for the heritage of these plants) and at least nine Australian native *Rubus* species. To make things even more complicated, often several different names have been used for the same plant taxa within the literature (see attached “Field guide for the identification of WA blackberry” for the alternative names that have been used for just the species in WA).

Fortunately, WA has only a few weedy and no native *Rubus* species. This is known because in 2004/5 a large scale herbarium collection of blackberry was undertaken by Commonwealth Scientific and Industrial Research Organisation (CSIRO), Department of Agriculture and Food WA (DAFWA) and Department of Environment

and Conservation (DEC) officers to determine the overall distribution and incidence of weedy blackberry taxa in Western Australia, and to identify new incursions. A total of 484 new herbarium specimens supplemented the existing 96 records, the results of which are summarized in Figure 1 (created from results in Batchelor et al. (in prep)).

Batchelor *et al.* (in prep) established that only five species of weedy *Rubus* are currently present in WA. Most blackberry infestations are found along water courses. There are only 2 species of European Blackberry, *R. anglocandicans* and *R. ulmifolius*.



*Rubus anglocandicans* is the most common of all weedy *Rubus* found, representing 86% of their 2005 collection. Its distribution, although minor in the Perth metropolitan area, extended throughout the south-west with it being common along most rivers in the Bunbury-Harvey-Manjimup area.

*Rubus ulmifolius* occurred as isolated patches throughout the state but did not dominate whole river systems. The American blackberry, *R. laudatus*, is the main weedy blackberry species in the Perth metropolitan area although there are also several infestations near Harvey. DEC Herbarium had records of *R. laudatus* species been sighted near Esperance (400km E of Albany, not shown on map), Pemberton (25km south of Manjimup), Walpole, Augusta and Margaret River (40km north of Augusta). The Pemberton and Walpole sites were revisited during the survey but only *R. anglocandicans* plants were now at these sites. An American raspberry-blackberry hybrid, probably *R. roribaccus* (dewberry) (identified by the Barker and Barker 2005 key) was found instead. Weedy raspberry (*R. idaeus*) was also collected from Denmark (between Walpole and Albany). They, similarly to the loganberry (*R. loganobaccus*) found near Pemberton, are likely to be escapees from berry/hobby farms in the area. Batchelor *et al.* (in prep) failed to locate any specimens of two other *Rubus* species that have also been previously reported in WA, *R. rugosus* (earlier misidentified as *R. hillii* and only collected from Rollystone, a suburb of Perth.) and *R. parviflorus* (two samples collected from the Albany area). Site information for these species were ambiguous and the latter may be eliminated by a residential development. At one site near Perth, *R. laudatus*, *R. ulmifolius* and *R. anglocandicans* were all found together showing that these species have the potential to all colonise the same habitat.

### **Does it matter what species of blackberry you have?**

Unfortunately, yes! The European species (ie. *R. fruticosus* L. agg.) are all 'declared plants' and therefore landholders are legally required to control the spread of these plants. The degree of control needed depends upon the location (see table 1). The different species vary in their methods of reproduction (eg, sexual or asexual, presence/absence of arching canes which may or may not tip root, amount of seed produced etc). They may also differ in their tolerance to different habitats and control pressures, especially in their susceptibility to potential biological control agents that are currently being introduced within the state (see control section below). This will in turn determine the potential weediness of the species and its rate of invasion into native bushland.

### **How to identify your weedy *Rubus* species**

The following section allows you to identifying the weedy *Rubus* species from WA on the assumption that it is one of the species found in the 2004/5 survey. The criteria mentioned below are influenced by environmental conditions (light, nutrients, competition etc) and some, like leaflet number/size and thorn shape, vary between different places of an individual plant. This should be taken into account when making your decisions (look at several canes of several plants).

**Is it a rose?** Plants from the genus *Rose* (eg sweet briar, *Rosa rubiginosa*) can be confused with the blackberry (both are in the same family) as their canes, prickles and flowers can be similar. They are easy to distinguish apart by their leaflets and fruit.



**Roses:** 3-7 leaflets; when more than 3, those non-terminal are attached in pairs (=pinnate). In WA, loganberry leaflets are also pinnate but all other weedy *Rubus* leaflets are usually palmate (all leaflets arising from a common spot).

**Fruit** of the rose is a hard, smooth, flask like “hip” that forms below the dead sepals. The *Rubus* fruit are soft, fleshy berries that form above the sepals.

The weedy raspberry species, *R. idaeus*, is easily segregated from the other weedy *Rubus* (including the raspberry/blackberry hybrids) as the mature fruit are red not black, and the ripe fruit separates from the receptacle to produce a hollow berry rather than being firmly attached.

The raspberry/blackberry hybrids, dewberry and loganberry, have prickles on their stems that tend to be relatively skinny and straight in shape and less than 6mm long. This separates them from all the weedy blackberry except *R. ulmifolius* var *anoplothysus*, a thornless variety. The thorny blackberry have prickles that are broad at their base, stout and curved like that on a rose (=recurved). The canes of raspberry are round in cross-section unlike that of the blackberry (including the thornless variety) which tend to be strongly angled with furrows (“star” shaped in cross section). Dewberry and loganberry have stems with a cross-sectional shape that is in-between, being rounded or bluntly angled, with the angles channelled on dried specimens of dewberry. Table 2 compares the features.

Separating the European blackberry species (*R. anglocandicans* and *R. ulmifolius*) from the American *R. laudatus* is easy at the right time of the year as, from observations made during 2004-2006, the *R. laudatus* flowers in September to November (Perth area is about 1 month ahead of Manjimup) and is in fruit before the European species starts flowering (December to January). *Rubus ulmifolius* can be separated from *R. anglocandicans* when in flower because the former has distinctly pink flowers whereas the latter’s are predominantly all white although they may have a pink tinge when in bud or after treatment with herbicides. In WA, *R. ulmifolius* has colloquially been referred to as the “small leaf” blackberry because of its smaller leaves (terminal leaflets are 4-8cm vs 4-12cm on the others). The leaves of *R. laudatus* differ from that of both European species because they are approximately the same colour (usually green) on both sides in *R. laudatus* whereas on the European species, usually the underside appears white in contrast to the upper green surface. With this report, we wish to encourage landholders to distinguish between *R. anglocandicans* and *R. laudatus*, so we will colloquially refer to them as the “common” blackberry (based upon distribution and abundance) and the “early” blackberry (based upon flowering time) respectively (see attached “Field guide for the identification of WA blackberry”). In the USA, *R. laudatus* is called the “Bundy” (after Mr. T.B. Bundy) or the “Plains” blackberry.

## Field guide for the identification of WA blackberry

### ***Rubus anglocandicans* (common blackberry)**

Previously referred to as *R. chloocladus*, *R. discolour*, *R. ulmifolius* hybrids, *R. fruticosus* or *R. procerus*.



- Originally from Europe and susceptible to the rust *Phragmidium violaceum*.
- Canes long and arching, canes at non-flowering stage (primocanes) often tip-root.
- Flowers white but may have a pink tinge in bud (or after treatment with herbicides).
- Flowers produced December-January in WA.
- Leaves have 3-5 leaflets, terminal leaflets 4-11 cm long.
- Non-terminal leaflets (mostly) arise from a common spot (ie. palmate).
- Underside of (most) leaves “white” compared to “green” upper side.
- Numerous fruit (can be 100 per tip). Inflorescence narrowly pyramidal to broadly cylindrical.

### ***Rubus ulmifolius* (small leaf blackberry)**



- Originally from Europe. Partially susceptible to *Phragmidium violaceum*.
- Canes arching. Occurs along river edge but also forms mounds in pasture.
- There is a thornless variety.
- Flowers pink at all stages. Produced December-January in WA.
- Leaves have 3-5 leaflets, terminal leaflets 4-8 cm long.
- Non-terminal leaflets (mostly) arise from a common spot (ie. palmate).
- Underside of (most) leaves “white” compared to “green” upper side.
- Inflorescence compact cylindrical.

### ***Rubus laudatus* (early blackberry in WA)**

Previously referred to as *R. bellobatus*, *R. fruticosus* and *R. aff. selmeri*.



- Originally from North America. Completely resistant to *Phragmidium violaceum*.
- Canes long and arching. Occurs mainly along river edge.
- Flowers pure-white (no pink tinges). Produced September-November in WA.
- Leaves have 3-5 leaflets, palmate. Terminal leaflets 4-12 cm long.
- Underside of (most) leaves “green” and similar to upper side.
- Inflorescence a series of short, 5-20cm stems from leaf axils of cane. Each has 3-12 flowers.
- With hand lens- can see red glandular hairs (look like red dots) on cane’s surface.

### **The seeds of weedy *Rubus***

The weedy *Rubus* can produce seedlings from their numerous seeds that are within their highly palatable fruit. Seed production will differ between the *Rubus* species and it will also be influenced by environmental factors (see Appendix 1 for variations of *R. anglocandicans* seed production within the Manjimup – Pemberton area, 2006). *Rubus ulmifolius* is the only European blackberry in Australia to reproduce sexually and requires cross pollination to produce viable seeds. Sexual reproduction increases gene diversity and favours the survival of some of the individuals under changing environmental conditions. Compared to asexually reproducing species, there should also be more potential for sexually reproducing individuals to vary in their tolerance to control measures (herbicide resistance, susceptibility to particular rust strains etc). *Rubus anglocandicans* plants also require pollination (cross or self) to induce fruit/seed production, but then most seed is formed asexually and so they are genetically identical to the plant from which they developed. Progeny formed in this way will be favoured to survive under the same environmental conditions that favoured the parent plant. Low rates of sexual reproduction and mutations allow some genetic diversity but for *R. anglocandicans* the diversity is very low, even across the whole of Australia (Evans and Weber, 2003). In WA, 92% of the flowers on *R. anglocandicans* plants successfully set fruit/seed indicating that pollination is not a limiting factor (appendix 1).

Seed dormancy and viability is also extremely variable within the *Rubus* genus. It is a critical issue because even if all the parent plants within an area are removed, any long lived seeds within the seed bank will have the potential to re-establish infestations. Amor et al. (1998) states that *R. anglocandicans* (referred to as *R. procerus* in their publication) has high levels (28%) of defective seeds. They considered that this contributed to the low rates of germination found in a Victorian study where only 10% of *R. anglocandicans* seed planted had germinated during a four year observation period. All of the germination occurred during the initial 2 years. This may however be an underestimate of the true number of viable seed, as for many plants the germination of the seeds is inhibited until environmental conditions are favourable. In some *Rubus* species the seedlings are known to be unable to penetrate through a layer of leaf litter (Whitney, 1986) and for many *Rubus* species germination is triggered by soil disturbance (Graber and Thompson, 1978; Whitney, 1986; Zasada and Tappeirner, 2003). Raspberry (*R. idaeus*) seeds planted in the field for five years and then dug up and placed on moist filter paper within a growth cabinet were also initially found by Granstrom (1987) to have low germination rates with only 16% germinated within the first 15 days of treatment. This however rose to 100% germination when the seeds were given repeated exposure to several weeks at 5°C followed by several weeks under summer conditions. Studies that examined *R. idaeus* seed banks from locations where there are no longer seed-producing plants found that the half-life of *R. idaeus* seeds was conservatively estimated at 23.5 years and that some seeds were still viable after 100 years (Whitney, 1986). Similarly, *R. idaeus* and an American blackberry, *R. allegheniensis*, were estimated by Graber and Thompson (1978) to have a maximum longevity in the field of 50 to 100 years. In contrast, the seed bank of another raspberry, *Rubus pubescens*, was considered by Whitney (1986) to be transient with 69% germinating in the first year and 20% of the remaining seed being nonviable.

Comparisons of our WA blackberry seed banks with those of the same species from overseas is difficult because many of the overseas studies refer to the *Rubus fruticosus* aggregate or they pool all the *Rubus* species from the study site together because they couldn't identify the seedlings apart. Older studies may also have misidentified the plants at the species level in a similar way to how our *R. anglocandicans* was generally called *R. procerus* prior to Evans and Weber (2003). As soil moisture, composition and temperature will also all influence the dormancy period and survival rates of seeds in the soil, the only reliable way of reliably knowing how long the weedy *Rubus* seeds in our soils can persist would be to study them. To date, no such studies have been undertaken.

Regardless of how low germination rates are, extremely high rates of seed production are possible. *Rubus anglocandicans* plants in the Manjimup-Pemberton region were found to produce on average 1,800 seeds per plant (8,600 seeds/m<sup>2</sup>) during 2006 (Appendix 1). The largest plants within an infestation generally had 9,800 seeds but one individual plant produced 30,000 seed. This means that even if there is only a 10% germination rate, potentially up to 3,000 seedlings can be produced from one plant annually. Animals such as emus and foxes ingest the fruit and then disperse the seed that passes through their alimentary canal unaffected (figure 2). High numbers of seeds can be dispersed this way with 22-35% of *R. anglocandicans* seeds collected from emu and fox scats found to germinate in a study by Brunner et al. (1976).



Fig. 2: *Rubus anglocandicans* seed in fox and emu scats.

## Control options current available in WA

### 1. Physical removal

The weedy *Rubus* plants can also reproduce vegetatively with daughter plants forming whenever the tips of their canes touch the ground or from advantageous shoots (suckers) that form from their laterally growing roots or from root fragments. Blackberry plants are hard to kill because even when as young as 11 months, they will recover after being cutting off at ground level, sending up new canes. Mechanical removal is difficult because fragments of cane and roots have the potential to regenerate so when grubbing the plant, the crown and all root material down to at least 45cm needs to be removed (Amor et al. 1998). In Victoria, fire is sometimes used before herbicides to enable access to the plants, or as a follow-up to herbicides, so as to remove the dead canes and enable access for rehabilitation. Cool burns result in rapid regrowth from the crown. Hot burns may kill the crowns but then rapid regrowth from root suckers occurs (Faithfull, 2004). The ability of the plant to regenerate from its below ground parts usually makes it impractical to rely solely upon any particular physically or mechanically control methods once the infestation occupies more than a small area.

### 2: Herbicides

Herbicides maybe more suitable than mechanical removal for killing blackberry in larger areas of infestations or when there is a high erosion risk such as along the banks

of rivers as this method leaves the root mass intact to help hold the bank together (Water and Rivers Commission, 2001). Effective herbicide application can be hampered by access problems because the plants can produce dense thickets of prickly canes (figure 3). They also often occur in habitats that are inaccessible to conventional spray machinery. Although there is no published data for WA, the proportion of areas of blackberry infestations with accessibility problems is probably similar to that of Victoria where in 1975, they estimated 43% of their total 663 000ha blackberry-infested area was inaccessible (Amor et al., 1998).

Herbicide choice and method of application may also be restricted due to off target effects as blackberry often grow in habitats that are environmentally sensitive such as along waterways. In such situations, methods such as injecting individual crowns or slashing and painting the herbicides onto the plants ensure that herbicide only targets the blackberry, but this is very time/labour consuming. For foliar applications, extra care should be taken to minimise drift and run-off. Anybody spraying herbicides should read the product label and consult with local Agriculture department advisors if they have any doubts. Table 3 summarises the recommended methods of chemically controlling blackberry, as stated July 2006 on the DAFWA web site ([http://agspsrv34.agric.wa.gov.au/dps/version02/01\\_plantview.asp?page=2&contentID=10&#control](http://agspsrv34.agric.wa.gov.au/dps/version02/01_plantview.asp?page=2&contentID=10&#control)).



Fig.3: Thorny thickets make access difficult

The current registration of many herbicides precludes their use in many environmental weed situations. To overcome this problem, off-label permits (PER4984 valid until 31 Sept 06 and PER 4590 valid until 31 Dec 2010) have been obtained by DAFWA (formally known Department of Agriculture, WA) that allows any person in the state to use a range of herbicides in non-agricultural situations to control environmental weeds. Permit 4984 (which allows for some chemicals to be used at above label rates) is due to expire soon but it is intended that it will be renewed. See <http://permits.apvma.gov.au/PER4984.PDF> and <http://permits.apvma.gov.au/PER4590.PDF> for the current status of the permits and the list of herbicides that are available with their conditions of usage.

In general, herbicide effectiveness is enhanced by applying the chemicals to vigorously growing plants. For blackberry, this means spraying the plants in their growing season (spring-summer), but avoiding the times when the plants may be drought stressed as even the most efficacious herbicide can produce poor results when soil moisture is low (Milne and Dellow, 1998). The production of fresh, new leaves is an indication of an actively growing plant. As the flowering season of the American species is several months ahead of that of the European species, care should be taken to not spray any mixed stands either too early or too late in the season. Local and Victorian anecdotal evidence exists that the small leaf blackberry (*R. ulmifolius*) is harder to kill with some herbicides than the common blackberry (*R. anglocandicans*). This may also be related to the growth of the plant as the common blackberry is in general considered the more vigorous of the two species.

Timing of the application of the herbicide may also influence the potential for the infestation to spread during that season. Field trials conducted by applying standard rates of metsulfuron-methyl plus Pulse<sup>®</sup> mix to *R. anglocandicans* at the stage that they were starting to flower (Manjimup: 01 Dec 2005), found that the herbicide caused yellowing of leaves, stunted growth and killed flowers so that there was no fruit set. Even the growth of large thick healthy canes was arrested, with the tips dying so that no tip- roots or daughter plants were produced (figure 4). Note, the root-suckers did not grow, nor show signs of herbicide damage in either the sprayed or unsprayed plots during the study period (6 months). For plants treated with metsulfuron-methyl, growth stops as soon as the chemical is translocated to the growing points. In perennial species this may be many months after treatment and new growth may start elongating before dying at the tip. Death then progresses from the tip back to the base of the plant (HerbiGuide, 2005). Usually the woody blackberry plants don't fully succumb to



Fig. 4. Yellow leaves in foreground are from early (01 Dec 05) applications of metsulfuron with Pulse<sup>®</sup>. Flowers on untreated plants are in the background. Growing tips of new canes died due to the herbicide.

this herbicide until the following season. It is assumed that the crowns from the parent plants in our 2005/6 study will also die. It is probable that the apparently unaffected root-suckers will be the main source of re-infestation in the herbicide-treated plots during the following 06/07 season. Herbicide applications made later in the season are known to also be effective upon the parent plants but they may be too late to prevent seed production and dispersion. This should be considered when planning the order in which to treat various infestations.

Land managers of areas containing weedy *Rubus* infestations are faced with the difficulty of choosing from a range of different methods (eg. table 3, PER4984 and PER 4590) to manage a weed that is hard to control, within habitats that are highly variable and often sensitive. Prioritising on-ground weed control activities is difficult or impossible if the primary methods of control are inappropriate or ineffective for your weed. With this in mind, questionnaires, asking what methods of weedy *Rubus* control were being implemented and what levels of control achieved, were sent out to land managers distributed throughout the areas that currently contain dense populations of the common blackberry, *R. anglocandicans*. The demography of the selected interviewees was as follows: private land owners (3), landcare groups (3), plantation resource managers (1), DEC offices (8), Shire offices (12), DAFWA offices (14) and private spray contractors (5). There was some redundancy which has been removed, for example Shires using the private contractors. Table 4 contains the responses and lists the general situation and region for which the method was tried. Note that the comments made are those of the respondent not of the writers of this report. Although they collectively reflect decades of experience tackling this weed, all data should be considered anecdotal. The responses for the effectiveness of Grazon<sup>™</sup> DS and Pulse<sup>®</sup> are however consistent with experimental data published by Moore and Hoskins (1985). It should be stressed that the herbicides used may or may not be the best choice for either their or your intended application.

This report will only address the herbicides that were reported as being used by any of our questionnaire respondents or that were listed on DAFWA's web site (see table 3) as being recommended for the control of weedy blackberry. We will therefore not address herbicides containing anitrole/ammonium thiocyanate (eg. Nufarm Amitrole T<sup>®</sup> or Ciba-geigy TL plus<sup>®</sup>; registered for blackberry control in the eastern states) nor herbicides containing hexazinone (eg. Velpar L<sup>®</sup>; registered for controlling blackberry in pine plantations).

All respondents to our questionnaire reported using a surfactant with their herbicides. This was usually an organosilicone such as Pulse<sup>®</sup> which is designed to increase leaf wettability and spray penetration and therefore enhance overall herbicide absorption. Note, many surfactants are more toxic to aquatic organisms than the herbicides that they are mixed with.

**Glyphosate**, without being mixed with any other type of herbicide, is not usually recommended for blackberry control by the State's agriculture department (DAFWA). They state "Use only when other herbicides are thought to be undesirable. Not as reliably effective as Garlon<sup>™</sup>" (table 3). It was a control option listed by 2 respondents who, when using it, reported achieving 70 to 90% control. By far the most common method of blackberry control was with mixtures containing metsulfuron-methyl. Mixtures containing glyphosate and metsulfuron-methyl gave over 90% control rates (2 people reported 100%) however, because of the glyphosate, the solution is completely non-specific, killing grasses and sedges as well as any broadleaf plants. As a consequence, it was noted that it was unsuitable for river banks containing grasses/sedges and that it was usually used on roadsides, fence lines and other areas with little or no native vegetation.

**Metsulfuron-methyl, triclopyr and picloram** are partially selective in their actions and they are all primarily broadleaf weed killers but some products containing metsulfuron-methyl (eg Brushoff<sup>®</sup>) are registered to kill certain monocots (eg. bridal creeper, guildford grass, cape tulip) and some of the labels of products with triclopyr with or without picloram (eg. Garlon<sup>™</sup> & Grazon<sup>™</sup>) state "Grasses are normally unaffected" so users need to take some care to avoid spraying off target plants and any contact by runoff. In general however, sedges and grasses will be either undamaged or will recover from any minor damage that has resulted due to exposure to these active ingredients.

With respect to off-target effects on fauna, metsulfuron-methyl, triclopyr and picloram all have a negligible ("practically non-toxic") to low toxicity to birds and terrestrial invertebrates with metsulfuron-methyl having the same rating for animals and aquatic organisms. Picloram is considered "slightly to moderately" toxic to fish and aquatic invertebrates (EXTOXNET, 2006) and triclopyr, when in its butoxyethyl ester form (=Garlon<sup>™</sup> & Grazon<sup>™</sup>), it is moderately toxic to fish and other aquatic organisms and to livestock. In soil and water, triclopyr butoxyethyl ester breaks down to triclopyr acid which then has low toxicity (HerbiGuide, 2005). None of these chemicals are thought to accumulate in fauna.

**Metsulfuron-methyl** is a systemic compound that is absorbed through the roots or leaves and then translocated to the sites of cellular activity where it inhibits further

cell division. Tolerant plant species degrade metsulfuron-methyl (by hydroxylation) much faster than do sensitive species. Degradation products are non toxic and herbicidally inactive. In the soil, metsulfuron-methyl is non-volatile, but will move through the soil profile with the water flow. Mobility usually increases with increasing soil pH and decreasing organic matter, but it is not expected to cause problems in the environment because of its low rates of use, quick degradation and low toxicity. Its half life in typical WA blackberry-preferred soils is approx 2 weeks to 1 month. It is broken down by ultraviolet light (EXTOXNET, 2006, HerbiGuide, 2005).

**Triclopyr** is also a leaf/root absorbed compound, is well translocated and interferes with cell division. Its half life within woody plants can be 2-3 months. Triclopyr decomposes in water with a half life of 1 to 2 days. It is broken down in soil by photo decomposition and microbial action and is slightly more persistent than metsulfuron-methyl with a half-life in soil of about 40 days. Minimal leaching may occur on light soils in high rainfall conditions (EXTOXNET, 2006, HerbiGuide, 2005).

**Picloram** is readily absorbed by the plants roots but less so by the foliage. Picloram also rapidly translocates within the plant but it interferes with cell elongation. It remains stable within the plant and so can impact upon it for an extended period. Picloram binds poorly to the soil and because it is soluble in water, it is also considered mobile through the soil profile. It has a half-life in water of 1 to 40 days in water which is dependent mainly on sunlight intensity. In the soil it is degraded by aerobic microorganisms and it can be highly persistent. Its half life in soil ranges from weeks to months (EXTOXNET, 2006, HerbiGuide, 2005). On the label of Grazon™, plant-back times of up to 18 months are given under some situations. It also warns that when aerial spraying for blackberry, eucalyptus species up to 4m may be killed.

The levels of weedy *Rubus* control using only metsulfuron-methyl with a surfactant was usually only 70-80% in the first year and everybody reported that a follow-up treatment was usually needed. Only one respondent reported using an herbicide with only triclopyr as its active ingredient (Garlon™ 600) and they noted they used it prior to burning but that its level of control was poor (50%) without follow-up treatments. The herbicide mixtures containing both triclopyr and picloram (respondents listing Grazon™ DS) were however consistently quoted as giving very high levels of control of blackberry (>95%). Even with this mixture, subsequent treatments were still needed for at least the following year to obtain eradication.

A major advantage of metsulfuron-methyl over the mixtures containing triclopyr, with or without picloram, is that it is much cheaper; comparable pack-sizes of metsulfuron-methyl products being approx 1/10 the cost/m<sup>2</sup> of triclopyr/ picloram products when all sprayed at label rates. The cost of triclopyr only or premixed metsulfuron-methyl/glyphosate mixtures fell midway in-between. As glyphosate is much cheaper than even metsulfuron-methyl, home-made more-effective but non-specific mixtures of metsulfuron-methyl/glyphosate can be produced for just a bit more than a herbicide containing only metsulfuron-methyl (prices all based upon HerbiGuide (2005), which lists default prices of bulk purchased generic brands). Organosilicone surfactants, although significantly increasing efficacy, can also considerably add to the price of the herbicide solution. Of note is the sensible strategy of large-scale spraying with the cheap, relatively safe and non-persistent metsulfuron-methyl (with summer oil rather

than the more expensive organosilicates), then following up with localised applications of the more expensive, toxic and persistent triclopyr/ picloram products such as Grazon™ DS. The respondent who used this method reported that 3yrs total treatment was sufficient to achieved complete control in about one third of their sites.

Landholders with smaller infestations may find their choice of herbicide type and/or brand influenced by their ability to obtain appropriate amounts of the herbicides. One respondent said Grazon™ DS was good but not an easy product for a farmer to buy and that it was easier and more convenient to pick up a packet of Trounce® as far as transport and mixing goes. Similarly, the Torbay Catchment Group's website (<http://www.torbay.scrib.org/caring/weeds/weedcontrol.html>) states that many of their landholders prefer Brush-off® over another metsulfuron-methyl product, Glean®, purely because it is available as a small carton containing individual 5g sachets rather than being supplied as a single, much larger container. Conversely, landholders with large infestations were more likely to save money by buying bulk quantities of individual herbicides (eg Brushoff® and Powermax®) and mix them together themselves rather than buying a single product that contained a mixture of the same active ingredients (eg. Trounce®).

No respondents indicated that they were using grubbing or slash and paint/ injection methods of control. This is highly likely to be because of the audience that was canvassed. Most, if not all, were under time and financial constraints. Some reported that they would like to spray infestations every year but lack of funds/staff meant that in reality they were only able to treat half of their infestation each year so by default any individual plant was therefore only treated every second (or third) year.

### **3. Biological control**

Biological control is the use of other living organisms to control your pest problem. The prickles on the blackberry plant are there to stop animals eating the plant! Goats have been used to suppress plants in New Zealand, but like mowing/slashing, this is more to contain an infestation rather than eradicate it as the plants recover once the grazing pressure is removed (Amor et al. 1998).

A more suitable biological control organism is one of the plant's natural enemies, the blackberry rust fungi, *Phragmidium violaceum*. This attacks the European blackberry in Europe. A prerequisite to importing any potential biological agent into Australia is that it must be tested to ensure that it only attacks the pest for which it is intended. Potential agents are also usually collected from plants and/or locations that most closely match the situation in Australian. This maximises the probability of collecting a biotype (=strain) that will establish and have an impact on the pest in Australia. Selecting and importing biological agents is a lengthy process. A strain (F15) was found that was highly virulent on *R. anglocandicans* under laboratory conditions. It was found to be highly specific to the European blackberry and does not survive on the American blackberry or raspberry or any species of Australian plant. It was released in 1991. Another strain, that is less virulent on *R. anglocandicans*, appeared in Australia (Victoria) in 1984. It did not undergo the prescribed importation protocols and it is not known how it got into the country. It is referred to as the "illegal strain". The illegal strain, although less damaging to the plant, appears to be more competitive than F15. It is thought to be the one that exists upon Blackberry plants across Australia (Amor et al., 1998).

All rust fungi reproduce by spores that require moisture to germinate. The blackberry rust (all strains) will also only develop upon newly emerged leaves, which are only available in the summer. In areas with high summer rainfall (Gippsland, Vic: 40-50mm/month <http://www.worldweather.org/185/c00490.htm> ) the illegal rust thrives and regularly defoliates the plants. The blackberry rust has curtailed tip rooting with daughter plant production down by 96%. The effects upon the existing adult plant population is however very slow with a depletion in plant biomass of only 38-56% (depending upon the *Rubus* species) after a minimum of 8-10 years (Bruzzese et al., 1999). Although the illegal rust preventing the spread of blackberry plants in these summer-wet sites, its impact is minor and patchy for most other areas. This includes Western Australia, where only a few spots are normally seen on the plants or the damage occurs so late in the season that the plants have already started to loose their leaves and so defoliation has little or no effect.

Currently we are striving to establish more suitable strains of blackberry rust in the more typical Mediterranean climatic areas of Australia. Eight new blackberry rust strains were approved for release and then releases of these, as well as of the previously introduction F15, begun in WA in 2004. The main strategy that is being followed is to release all rust strains simultaneously at any one experimental site. It is anticipated that natural selection will result in survival of the strain that is best suited to the local conditions and the local species of European blackberry. It is hoped that these will then out-compete the existing, but low-virulent, illegal rust populations (for further information see <http://www.ento.csiro.au/weeds/blackberry/project.html>).

#### **4: Integrated Control**

An integrated approach is thought to be essential to the successful control of weedy *Rubus* plants in WA. “Trap gardens”, consisting of Australian blackberry plants that were planted in France, were used to collect the potential strains of rust fungi that would eventually be released in Australia (Scott et al., 2002). Three of the 8 new strains were collected from *R. anglocandicans*. The others were from species that do not occur in WA. It is likely that the new strains will therefore be more effective on *R. anglocandicans* than on *R. ulmifolius*. This was proven to be the case for F15.

All other weedy *Rubus* in WA are not susceptible to the blackberry rust. Contrarily, if it impacts severely upon *R. anglocandicans*, then potentially suitable habitats will suddenly become available to others and we may purely see a species switch; different species of weedy *Rubus* causing the same problems in the same areas.

It is hoped that some of the new strains of rust can handle the drier WA conditions better than the existing illegal strain and therefore reproduce more rapidly during our spring/summer. Realistically the fact that all type of rust, of any species, require moisture for their spores to germinate, means that some areas will always be more suited to the blackberry rust than others. Fortunately the suitable areas are also likely to be those areas that are hardest to access and/or to use conventional control methods within, ie the creeks and other waterways.

The Victorian studies at Gippsland indicates a best case scenario as the blackberry rust is virtually growing under ideal conditions with epidemics occurring most years. This study indicated that without intervention, land managers will be waiting more

that 10 years before there will be significant reductions in blackberry densities and the possibility to start recovery. To facilitate regeneration of native bush areas or reclaiming of valuable farm land, it will therefore be advantageous to integrate other more immediate control methods with the rust epidemics.

We conducted experiments in Oct. 2005–Apr. 2006 to see if enhanced control could be achieved by applying both herbicide (metsulfuron-methyl with Pulse<sup>®</sup>) and the blackberry rust onto *R. anglocandicans* plants in the same season. When both control methods were applied in the same season, the results clearly showed that the two methods were not compatible. Plants sprayed with the herbicide did not promote the growth or development of blackberry rust with the volume of rust (which is next season's inoculum) being reduced by an average of  $81.6 \pm 10.9\%$  (SE) per site when metsulfuron-methyl/Pulse<sup>®</sup> was applied. The overall average volume of rust produced when no herbicides was used was 122 mg of spores/m<sup>2</sup> compared to only 17.8 mg/m<sup>2</sup> when the herbicide mixture was applied (n=8 sites). Valuable spores, which are currently laboriously cultured under sterile laboratory conditions, are therefore wasted if they are sprayed upon blackberry plants that have been treated with what is currently the most common practice of herbicide treatment. During the period of the study, WA had unusually high summer rainfall and epidemics of the illegal strain of rusts were widespread. Such outbreaks occurred at some, but not all of our experimental sites. The presence of the high levels of blackberry rust did not prevent fruit set, but did kill the growing ends of the canes and therefore prevented tip-rooting and daughter plant production (figure 5).



Fig 5. The blackberry rust forms yellow pustules on the underside of leaves. Heavy infestations of spores, even on the flowers, didn't necessarily stop fruit production. However it often killed the growing ends of the canes and therefore prevented tip-rooting and daughter plant production.

Our 2005/6 studies showed the application of metsulfuron-methyl base herbicides with Pulse<sup>®</sup> onto blackberry plants inhibited the growth and development of the blackberry rust on these plants during that year. As this herbicide is not persistent in either the soil or the plant it is also unlikely to be present in the shoots and leaves produced by surviving plants in the following season. Although currently untested, it is possible that the blackberry rust will attack and weaken the new growth of the struggling plants that managed to survive the previous year's application of the metsulfuron-methyl herbicide. The greatly reduced number of blackberry plants (typically over 70% from our survey) will open up the area to allow re-colonization of the area by adjacent native plants, the survival of seedlings emerging from the native seed bank and/or the growth and establishment of any transplanted plants.

Evans and Weber (2003) noted that once established, *R. anglocandicans* remained a dominant species in the understorey of Australian forests whereas in Europe it is an early successional species; invading new clearings within a forest but becoming less

and less common as the forest canopy closes back up again. Although undocumented, it is likely that the difference between the ability of *R. anglocandicans* plants to survive within European and Australian forests is at least partly due to the plant's increased competitive advantage within Australia. This is because here it lacks most of its natural diseases and predators, for example suitable strains of the European blackberry rust.

If this is true, then adequate control of *R. anglocandicans* within Australian forests may be achieved using an integrated management program that utilizes a single application of a non-persistent and semi-specific herbicides, the new strains of blackberry rust and then, depending upon the degree of degraded in the area, a re-vegetation program. Currently it appears that levels of control that prevent the encroachment of the blackberry further into our forests are only being achieving by either on-going applications of metsulfuron –methyl based herbicides like Brush-off<sup>®</sup> or by completely removing the infestation using several repeated applications of more persistent chemicals like Grazon<sup>™</sup> DS or less specific chemical mixtures like metsulfuron –methyl with glyphosate. The latter methods in particular require extreme care so as to prevent off-target effects to other plant species and therefore hinder the recovery of the area.

Despite the blackberry rust being native to Europe, a 40 year study in a semi-natural woodland in England (Peterken and Jones, 1989) found that “the chief change in the ground vegetation after felling was an upsurge of bramble, *Rubus fruticosus*”. Most of the woodland was clear-felled in 1943, with only natural regeneration of trees occurring after that date. They reported that blackberry occupied at least 20% of all areas and well over 80% in others in 1944. By 1948 blackberry was dominant and forming 1m high thickets though-out the areas with young tree growth. It was not until 1955, when the trees were large and the canopy mostly closed, that the blackberry was either dead or losing vigour. They commented that the decline could have been enhanced by shading but that blackberry in non-shaded positions was also declining. This suggests that our weedy European *Rubus* species (*R. anglocandicans* and *R. ulmifolius*) are also unlikely to be adequately controlled by the new blackberry rust stains alone if given suitable environmental conditions and the absence of competition from other plant species.

No biological control agents have been imported into Australia for the control of the American species of blackberry, *R. laudatus*. Before this could happen, the plant would need to be formally identified as a problem and then nominated as a target for biological control (see [http://www.ento.csiro.au/weeds/biocontrol/target\\_weed.html](http://www.ento.csiro.au/weeds/biocontrol/target_weed.html) for the general procedures). Potentially suitable agents would then need to be located upon *R. laudatus* in America and these tested and given approval to be imported into Australia. There are over 1000 species of American blackberry and although they can be found in all stages of forest succession, Zasada and Tappeirner (2003) state that they typically dominate areas after major disturbances such as forest harvesting and fire; when light, water and nutrients become readily available. In this regard, they are therefore similar to the European blackberry. If any suitable rusts were to be approved for release as biological control agents upon *R. laudatus* in Australia, it is likely that they would also be require to be incorporated into an integrated management system exactly like the European blackberry rust on the European blackberry.

### **Eradication as an option for WA's weedy *Rubus* species**

Eradication is the removal of every individual of a species from an area where this area is defined so that recolonisation is an unlikely event. Removal of blackberry from one property would not be considered eradication if nearby properties still had blackberry or if viable blackberry seeds were still in the soil. Eradication is appealing because if it is completely successful, then further control efforts are not needed until new infestations occur. For any eradication programs to be successful, the rate of removal of the pest has to exceed the rate of increase. Panetta and Timmins (2004) summarize the primary factors that must be considered when considering the feasibility of eradication for terrestrial weed incursions. They suggest that eradication is an ineffective management strategy if immigration can't be prevented, if effective control measures are unavailable for some situations, if it costs more than other management strategies such as on-going chemical control or if there are insufficient resources to fund the program to its conclusion. Under these criteria, eradication of wild raspberry (*R. idaeus*) would not be a viable option for WA until crops of cultivated plants are no longer grown as these provide a continual source of re-infestation.

Panetta and Timmons (2004) define the effort required to achieve eradication of a weed (E) to be the product of the size of the infestation (A) by the difficulty in controlling the weed (= "impedance" or I). Weeds have a high impedance value when they are hard to find (eg. in difficult terrain or inconspicuous), reproduce by vegetative fragmentation as well as by seeds/propagules which are long lived, and when the weed is difficult to control in certain or all situations. The size of the infestation is the actual search area. It is not just where the adult plants are known to occur but also includes any areas in which the seeds/propagules may have dispersed. Four examples of successful Australian weed eradication programs are cited in Panetta and Timmons (2004) paper, but using their criteria, our weedy *Rubus* would be more difficult to control than any of them. Any WA eradication campaign that targets *Rubus* is therefore only likely to be viable if the infestation area is very small. It should also be noted that one of the successful programs listed by Panetta and Timmons (2004) targeted *Eupatorium serotinum* (violet mist flower) which was only over an initial 0.5 Ha area. It still took 18 years before this program achieved eradication.

*Rubus anglocandicans* is far too widespread and abundant to be currently considered for eradication. Hopefully the new strains of blackberry rust will establish and either be an effective control method in their own right or allow effective control by integration with existing current control methods. *Rubus ulmifolius* is likely to be less attacked and *R. laudatus* not attacked by the new rust strains and both these species are known to potentially inhabit similar habitats to *R. anglocandicans*. It is therefore critical that they are at least restricted to their current distributions rather than allowed to expand into any areas that may be freed up by declining *R. anglocandicans* populations. The feasibility of eradication is related to the size and accessibility of current infestations and to the longevity of their seeds in the soil. As raspberry is known to have very long lived seeds, it is critical that it is not allowed to spread beyond its current distribution. However the feasibility to eradicate any of the wild populations will be similar to that for the American raspberry-blackberry hybrids in that it will not be possible as long as they continue to be grown by hobby farms and commercial berry growers.

## **On-ground and planning activities needed to enhance future integrated weed management**

### ***1. Summary of the key factors to consider for weedy *Rubus* in WA***

- Common blackberry is widespread and the most susceptible to blackberry rust.
- Small leaf blackberry is patchy and partially susceptible to blackberry rust.
- Available chemical and biological control methods are possibly less efficient on small leaf blackberry than they are on the common blackberry.
- No available biological control agents exist for all other weedy *Rubus*.
- Early blackberry is very common in Perth but also occurs near Harvey.
- The raspberry and blackberry-raspberry hybrids appear to be very localised.
- The easiest time to identify species is when flowering as timing differs.
- Only areas with weedy *Rubus* are currently recorded - not areas free of them.
- Methods of control need to persist for several seasons before all the parent plants are killed
- It is not known how long the various weedy *Rubus* species can persist in our seed banks.
- It is unlikely that the rust will provide satisfactory rates of control without being integrated with other control methods.
- The current common-practice method of chemical control is not compatible with the establishment of populations of the new rust strains (applied the same year).
- Legislation requires landholders to prevent current infestations of the European blackberry from spreading beyond existing boundaries.
- Eradication will only be feasible if infestations are small and re-infestation unlikely, but all weedy *Rubus* should be controlled so as to prevent species substitution should the common blackberry populations decline.

### ***2. Recommendations to enhance future integrated weed management***

1. Surveys are still needed for many parts of the state, especially along the waterways between the Shannon River and the Fitzgerald River National Park. These should be done around November – December (before the common blackberry starts flowering) so that it is easiest to spot infestations of the early blackberry. It is very important to also record areas that are free of any weedy *Rubus* as the edges of the infestation will determine future control priorities.
2. Assuming all *Rubus* species other than the common blackberry are not widely present within the currently unsurveyed areas, chemical resources should be prioritised with the aim to contain, control or eradicate all smaller infestations that are outside of the Perth metropolitan area. Use a 2 stage chemical control approach if suitable, eg: 1<sup>st</sup> year: all of infestation treated with a relatively cheap, safe, non-persistent chemical (eg. metsulfuron-methyl), 2<sup>nd</sup> (and if needed, 3<sup>rd</sup>) year: spot spray remaining persistent individual plants with chemicals that are more effective but also more expensive and likely to have off-target effects (eg. triclopyr/ picloram or glyphosate/ metsulfuron-methyl mixtures).

3. Control in areas of larger infestations should concentrate on chemically treating the invading edges that border on high value conservation land. Off-target effects are minimised and efficacy maximised when plants are small, isolated and accessible. Rust will then be encouraged to form epidemics at the centre of any European blackberry infestations, but release sites restricted to along waterways as this is where both resource will be maximal, and conditions most favourable for the development of the rust. The dispersal range of the rust is likely to be far greater than that of the blackberry seeds, so spores that build up in the first year of treatment should be able to disperse to infect plants that have been chemically treated the previous year. Alternatively spores can be physically collected and translocated.
4. Literature reviews, impact assessments (surveys) and ecological studies should be done on *R. laudatus* (the early blackberry) so as to determine if the species is likely to have a significant impact upon the native flora and fauna and to gauge its invasive potential. If warranted, applications should be made to make *R. laudatus* a declared plant (with an appropriate category) and also to make it an approved target for biological control. Further research will subsequently be needed to identify, test and release any potential biological control agents for this American species. Note that many of the Australian cultivated varieties are closely related to the early blackberry and as the approval to release biological agents is a national process, there may be “conflict of interests” issues to resolve.
5. Conduct further studies on the possible synergistic or detrimental effects of using herbicides the year before inoculating areas with rust. Similarly, the use of physical (mechanical and/or fire) methods of control should be investigated to see if they can substitute for either part or all of the chemical control methods (as outlined in recommendation 2) when integrated with follow-up inoculations with rust. Information is also needed on how many years the seeds of the weedy *Rubus* can remain viable in our soils.

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Table 1: landholders obligation under the provisions for the Agriculture and Related Resources Protection Act.

Blackberry (except named culticars) (*Rubus fruticosus* agg.) is a declared plant. Declared plants are assigned to a category so as to help the landholders understand what control actions they are required to carry out. The categories can vary depending upon which shire you are within.

For Blackberry the categories are as follows:

Category	Location	Details of required control measures
P1 (Prohibits movement)	For the whole of the State	The movement of plants or their seeds is prohibited within the State. This prohibits the movement of contaminated machinery and produce including livestock and fodder.
P2 (Aims to eradicate infestation)	For the municipal districts of Boddington (S).	Treat all plants to destroy and prevent propagation each year until no plants remain. The infested area must be managed in such a way that prevents the spread of seed or plant parts on or in livestock, fodder, grain, vehicles and/or machinery.
P4 (Aims to prevent infestation spreading beyond existing boundaries of infestation.)	For the municipal districts of Albany (C), Augusta-Margaret River (S), Boyup Brook (S), Bridgetown-Greenbushes (S), Bunbury (C), Busselton (S), Capel (S), Collie (S), Cranbrook (S), Dardanup (S), Denmark (S), Donnybrook-Balingup (S), Harvey (S), Mandurah (C), Manjimup (S), Murray (S), Nannup (S), Plantagenet (S), Serpentine-Jarrahdale (S), Waroona (S).	Manage infested area in such a way to prevent the spread of seed or plant parts within and from the property on or in livestock, fodder, grain, vehicles and/or machinery. Treat to destroy and prevent seed set all plants:-within 100m inside of the boundaries of the infested property, 50m of roads, highwater marks on waterways, sheds, stock yards and houses. Treatment must be done prior to seed set each year. Properties with <2 Ha of infestation must treat the entire infestation. Additional areas may be ordered to be treated.
<b>P4: Special considerations</b>		In the case of P4 infestations where they continue across property boundaries there is no requirement to treat the relevant part of the property boundaries as long as the boundaries of the infestation as a whole are treated. There must be agreement between neighbours in relation to the treatment of these areas .

Note: information contained within this table was downloaded from Depart. of Agriculture and Food, WA website (27/07/06) ([http://agspsrv34.agric.wa.gov.au/dps/version02/01\\_plantview.asp?page=2&contentID=10&#control](http://agspsrv34.agric.wa.gov.au/dps/version02/01_plantview.asp?page=2&contentID=10&#control))

Table 2: summary of features that can be used to separate the weedy *Rubus* of WA (using criteria listed in Barker and Barker, 2005).

Weedy <i>Rubus</i> Species (BB=blackberry)	Sucept. to rust?	Flower colour	Angled& grooved stem	Stout recurved thorns	Red glands on canes	Leaf* shape& colour
<i>R. anglocandicans</i> (common BB)	yes	white if open	yes	yes	no	palmate G/W
<i>R. ulmifolius</i> (small leaf BB)	partly	pink	yes	yes	no	palmate G/W
<i>R. ulmifolius var anoplothyrus</i> (thornless)	partly	pink	yes	no	no	palmate G/W
<i>R. laudatus</i> (early BB)	no	white	yes	yes	yes	palmate G/G
<i>R. loganobaccus</i> (loganberry)	no	white	slight	no	no	pinnate G/G
<i>R. roribaccus</i> (dewberry)	no	white	if dried	no	no	palmate G/G
<i>R. idaeus</i> (raspberry)	no	white +fruit hollow	no	no	no	palmate G/Y

\*leaf colour for upper/lower surface (G=green, W=white (or grey), Y=yellow)

Table 3: current (July 2006) recommendations for chemical control of weedy blackberry in WA.

Herbicide	Garlon™ 600 (various trade names)	Glyphosate (various trade names)	Metsulfuron (various trade names)	Grazon™ DS (various trade names)
Active ingredient	600 g/litre triclopyr (Group I)	360 to 540 g/litre and 680 g/kg glyphosate (Group M)	600 g/kg Metsulfuron methyl (Group B)	300 g/litre triclopyr + 100 g/litre picloram (Group I)
Rates of dilution for spot spraying	1:250 (a) or 1:350 (b) or 1:750 (c) <b>Note: see remarks below</b>		10 g/100 litres	350 – 500 mL/ 100L water
Amount of product per 10 litres water	40 mL (a) or 30 mL (b) or 15 mL (c) <b>Note: see remarks below</b>	120 mL of 360 g/L to 80 mL of 540 g/L or 63 g of 680 g/kg formulation	1 g	35 - 50 mL
Rate of product per hectare	Not Recommended	Not Recommended	Not Recommended	Not Recommended
Wetting agent dilution	1:400 plus summer spraying or crop oil at 1% may be useful	Addition of Pulse @ 1:500 may give faster kill	Pulse 1:400	1:400 plus summer spraying or crop oil at 1% may be useful
Time of application	Flowering to fruit maturity usually from December-April	December to April	December - April	Flowering to fruit maturity usually from December-April
Remarks	Rate varies with age of cane and density of absorptive surface. (a) sparse canes with low absorptive surface; (b) average regrowth in 2nd year or bushes damaged by insect attack; (c) dense growth with high absorptive surface.	Use only when other herbicides are thought to be undesirable. Not as reliably effective as Garlon™. Best results usually obtained early flowering to early fruit set. Repeat application every 12 months is essential.	Use as high a water volume as possible for best results. When retreating use a residual product, such as Grazon™. Relatively slow acting. Also controls bracken. Can be used in restricted spray areas.	Spray 1-2 metre strip around edge of infestation to help control suckering. Permit required in restricted spraying areas. Do not use close to trees or streams. Use the higher rate where plants have been damaged by grazing stock or insects.
More information and other control methods	In conjunction with spray treatment - burn or slash dead canes in spring - encourage heavy grazing of regrowth - respray regrowth in summer.	Roundup Biactive or Razor preferred glyphosate treatment near watercourses. Other formulations of glyphosate available.	Mixtures of granular formulation of glyphosate (680 g/kg) and metsulfuron are promising. Suggested rate to use is 600 g glyphosate + 3 g (metsulfuron) per 100 litres water add the surfactant. Pulse at the rate of 0.2% (200 mL/100 litres).	

Note: information contained within this table was downloaded from Depart. of Agriculture and Food, WA website (27/07/06) ([http://agspsrv34.agric.wa.gov.au/dps/version02/01\\_plantview.asp?page=2&contentID=10&#control](http://agspsrv34.agric.wa.gov.au/dps/version02/01_plantview.asp?page=2&contentID=10&#control))

Table 3 (cont.): recommendations for chemical control of weedy blackberry in WA.

Herbicide	Glyphosate + Metsulfuron	Trounce®	Cut-out®
<b>Active ingredient</b>	360 g/litre or 700 g/kg glyphosate + 600 g/kg Metsulfuron	10 g/kg metsulfuron + 835 g/kg glyphosate	63.2 g/kg metsulfuron + 760 g/kg glyphosate
<b>Rates of dilution for spot spraying</b>	600 g/100 litres + 3 g/100 litres	173 g(1 pack)/100L	1 pack (95g)/100L water
<b>Amount of product per 10 litres water</b>			
<b>Rate of product per hectare</b>	Not Recommended		
<b>Wetting agent dilution</b>	Pulse 1:500	Pulse 1:1000 (100 mL/100 L) or non-ionic @ 1:400	
<b>Time of application</b>	December - April	Flowering to start of leaf yellowing	Flowering to start of leaf yellowing
<b>Remarks</b>	Use as high a water volume as possible for best results. When retreating use a residual product, such as Grazon™. Relatively slow acting. Also controls bracken. Can be used in restricted spray areas.	Use as high a water volume as possible for best results. When retreating use a residual product, such as Grazon™. Relatively slow acting. Also controls bracken. Can be used in restricted spray areas.	Use as high a water volume as possible for best results. When retreating use a residual product, such as Grazon™. Relatively slow acting. Also controls bracken. Can be used in restricted spray areas.
<b>More information and other control methods</b>	Mixtures of granular formulation of glyphosate (700 g/kg) and metsulfuron are promising. Suggested rate to use is 600 g glyphosate + 3 g (metsulfuron) per 100 litres water add the surfactant. Pulse at the rate of 0.2% (200 mL/100 litres).	If picking mature fruit avoid treatment at fruit formation.	If picking mature fruit avoid treatment at fruit formation.

Note: information contained within this table was downloaded from DAFWA website (27/07/06)  
([http://agspsrv34.agric.wa.gov.au/dps/version02/01\\_plantview.asp?page=2&contentID=10&#control](http://agspsrv34.agric.wa.gov.au/dps/version02/01_plantview.asp?page=2&contentID=10&#control))

Table 4. questionnaire responses from shire, contractors and state agency officers currently concerned with on-ground blackberry management.

Treatment (active ingred.)	Common Name Herbicide1	Applic rate herb1 per 100L	Common name herbicide2	Applic rate herb2 per 100L	Wetting Agent Used	Wetting agent applic rate	Time of Year Sprayed	Area Type Sprayed	Frequency of Treatment	Results: Degree of control	Respondents Comments	Resp #	From Region
Triclopyr	Garlon™ 600	285ml/100L			Pulse®	250ml/100L	Dec to Apr	Very large infest when Quick Knockdown is Required		Initial spray 50%, After followup >90%	Use when very quick result is needed.(e.g.2 weeks then burn)	9	Denmark
Glyphosate	Glyphosate 360	1L/ 100L			Pulse®	250ml/100L	Early Dec to Mid Apr	Only when Land Holder insists on using Glyphosate	At least every 2 years	70% - 80%	Spray only clean bushes i.e. after heavy rain, or use vast quantities of mixture to clean bush.	9	Denmark
Glyphosate	Roundup®	as per label			Pulse®	as per label	Spring	Wetland reserve	Initial + followup	90% kill	Yarloop railway reserve. Handspray unit used.	13	Harvey
Triclopyr + picloram	Grazon™ DS	Off-label permit PER4984 rate1L/100L			Pulse®	250ml/100L	Nov-Apr	Native bush, road verge, banks of waterways	1/year	approx 95% in first year	This treatment was recommended by Ag Dep and Food, WA.	8	Albany
Triclopyr + picloram	Grazon™ DS	500ml/100L			Pulse®	250ml/100L	Nov to May	Small Infests. Under 1000 sq metres	Possible follow up after 2 yrs	>99%	Undoubtedly the top Rec. A bit nervous about using Large quantities in any one area.	9	Denmark
Triclopyr + picloram	Grazon™ DS	Off-label permit PER4984 rate1L/100L			Pulse®	250ml/100L	Nov-Apr	30m² infestations in pasture	Annually for 3 years	100% control in 30% of sites	Successful eradication assessed 10yrs after the 3 years of treatment	11	Albany
Triclopyr + picloram	Grazon™ DS	as per label. Mostly spray unit or bkpck.			Pulse® (+Red-eye® dye)	label rates	Jan and Feb	Bushland, along streamlines. Also in open paddocks	Annual program, until 100% kill. Some areas only every2yrs	Smaller plants killed. Larger bushes, some canes again at year 2.	Grazon gives a better result than either Brushhoff or Garlon, which seem to have more canes regenerating	5	Bridgetown
Metsulfuron	Brushhoff®	as per label			Agral®	as per label	Apr	Bush Verge	Yearly	2004: Good very pleased		2	Busselton

Table 4 (cont.) questionnaire responses

Note: herbicide 1 is mixed and sprayed together with herbicide 2 and wetting agent unless otherwise stated.

Treatment	Common Name Herbicide1	Applic rate herb1 per 100L	Common name herbicide2	Applic rate herb2 per 100L	Wetting Agent Used	Wetting agent applic rate	Time of Year Sprayed	Area Type Sprayed	Frequency of Treatment	Results: Degree of control	Respondents Comments	Resp #	From Region
Metsulfuron	Brushhoff®	as per label			Agral®	as per label	Apr	Bush Verge	Yearly	2006: Pleased with treatment		2	Busselton
Metsulfuron	Brushhoff®	10g/ 100L			Brushwet®	160ml/ 100L	Lat Dec- Jun	Sensitive sites such as rivers and parks	Annually, Biannually or Triannually.	Unsure. Will know in 2007	This mix is kinder to grass-leaf natives. Results are very slow. We will know more about its success in 07.	12	Manjimup
Metsulfuron	Metsulfuron	10g/ 100L			BS1000®	250ml/ 100L	Jan	Preston River Bank	Annual until killed	Good Result (75%). Follow up planned 07	Contractor	1	Bunbury
Metsulfuron	Metsulfuron	10g/ 100L			BS1000®	250ml/ 100L	late Mar	Capel River Bank	Annual until killed	Report on this in 2007	Contractor	1	Bunbury
Metsulfuron	Metsulfuron	10g/ 100L			BS1000®	250ml/ 100L	Jan	Collie River Bank	Annual until killed	Good Result (60%) with follow up planned 2007	Contractor	1	Bunbury
Metsulfuron	Metsulfuron	15g/ 100L			Pulse®	250ml/ 100L	Mar	Road reserve	Annual until killed	Good Result (80%). Follow up planned 07	Contractor/Shire	1	Bunbury
Metsulfuron	Metsulfuron	10g/ 100L			Pulse®	250ml/ 100L	Early Dec to Mid Apr	Wetlands	At least every 2 years	70% - 80%	Difficult to obtain good results	9	Denmark
Metsulfuron	Metsulfuron	10g/ 100L			Pulse®	250ml/ 100L	Early Dec to Mid Apr	1000sq Metres+ In open paddock	Initial Treatment Then Follow up after 2 yrs	>90%	Standard private property treatment in this area	9	Denmark

Table 4 (cont.) questionnaire responses

Note: herbicide 1 is mixed and sprayed together with herbicide 2 and wetting agent unless otherwise stated.

Treatment	Common Name Herbicide1	Applic rate herb1 per 100L	Common name herbicide2	Applic rate herb2 per 100L	Wetting Agent Used	Wetting agent applic rate	Time of Year Sprayed	Area Type Sprayed	Frequency of Treatment	Results: Degree of control	Respondents Comments	Resp #	From Region
Metsulfuron	Metsulfuron	10g/ 100L			Pulse®	1 L/ 100L	Jan -May	Along River banks to be less damaging on reedy plants	Annual	75 -80 %	This work is restricted by available finance. Biannual applications will eventually kill blackberry	10	Manjimup
Metsulfuron	Brushhoff®	as per label			Agral®	as per label	Apr	Bush Verge	Yearly	2005: Negligible. Disappointed as same mix gave good results prev. year		2	Busselton
Metsulfuron	Brushhoff®	10g/ 100L			Pulse®	250ml/ 100L	January	Native bush	Annual	70% knock back - requires follow up		3	Albany
Metsulfuron + glyphosate	Brushhoff®	10g/ 100L	Powermax® (Glyphosate 540)	400ml/ 100L	Brushwet®	160ml/ 100L	Lat Dec-Jun	All areas	Annually, Biannually or Triannually.	Good kill but follow up required to treat new germination	The 3 products in this mix will kill everything if applied to runoff. Mature plants can be sprayed anytime Dec-Jun. Regrowth is best sprayed later. Annual treatment will give the best results, biannual is more efficient in \$\$\$ terms. If left 3 years, regrowth may be out of control again.	12	Manjimup
Metsulfuron + glyphosate	Metsulfuron	10g/ 100L	Glyphosate (450)	500ml/ 100L	BS1000®	200ml/ 100L	Nov to early Apr	River banks & native Bush	Annually	80% to 95%	Most sites sprayed generally need follow-up spraying. Good results have been achieved by burning sprayed B/B areas, second year after spraying and then the area is retreated.	7	Albany
Metsulfuron + glyphosate	Brushhoff®	10g/ 100L	Roundup®	1L/ 100L	Pulse®	200ml/ 100L	Summer	Pine plantations near neighbours	Annually	Good kill but follow up required to treat new germination	Chemical/mechanical methods do work if all landholders are forced to treat their weeds at the same time and persist until seedbank is depleted. Very little chemical is required once the large bushes are dealt with in the first attack. Generally a containment exercise but try to eradicate small infestations.	4	Wellington

Table 4 (cont.) questionnaire responses

Note: herbicide 1 is mixed and sprayed together with herbicide 2 and wetting agent unless otherwise stated.

Treatment	Common Name Herbicide1	Applic rate herb1 per 100L	Common name herbicide2	Applic rate herb2 per 100L	Wetting Agent Used	Wetting agent applic rate	Time of Year Sprayed	Area Type Sprayed	Frequency of Treatment	Results: Degree of control	Respondents Comments	Resp #	From Region
Metsulfuron + glyphosate	Metsulfuron	10g/ 100L	Glyphosate	1L/ 100L	Pulse®	250ml/ 100L	Jan-Mar	Roadsides	once	Browning of leaves evident when inspected one month later	First year of spraying	6	Bridgetown
Metsulfuron + glyphosate	Metsulfuron	10g/ 100L	Glyphosate (360)	1L/ 100L	Pulse®	250ml/ 100L	Early Dec to Mid Apr	Only Where rushes and grasses need controlling also	Will require follow up after 2 yrs with either Metsulfuron or Grazon to control	>90%	Not generally recommended on Creek/River banks. Normally recommend retaining Rush cover in this case	9	Denmark
Metsulfuron + glyphosate	Metsulfuron 600g/kg	10g/ 100L	Biactive Glyphosate (360g/kg)	1L/ 100L	Pulse®	250ml/ 100L		Native bush, along creeklines (used for all areas, with care taken to avoid chemicals entering waterways and affecting non target species)	Annually until infestation controlled/ eradicated	60-70% (varies with accessibility due to dead canes)	Main issue for further control of large, dense infestations is inaccessibility due to abundance of dead canes. Looking to undertake low intensity control burns to reduce dead canes for access	14	Blackwood
Metsulfuron + glyphosate	Trounce®	1 packet/ 100L (or 173g)			Pulse®	1 L/ 100L	Jan -May	Open areas with little native vegetation	Bi annual	95 -100 %	This work is restricted by available finance. Biannual applications will eventually kill bberry. Easier to obtain required quantites and to use than Grazon. Much more effective than only metsulfuron.	10	Manjimup
Metsulfuron yr1&2 then triclopyr + picloram yr3 onwards	Metsulfuron	10g/ 100L	follow up after 2yrs with Grazon™ DS	500ml/ 100L	Pulse®	250ml/ 100L	Early Dec to Mid Apr	1000sq Metres+ In open paddock	Initial Metsulfuron treatment, follow up after 2yrs with Grazon	>99%	Recommendation where landholder does not object to using Grazon	9	Denmark
Metsulfuron + summer oil yr1 then triclopyr + picloram + pulse yr2 onwards	Metsulfuron	10g/ 100L	After 1 or 2 years switch to Grazon™ DS	Off-label permit PER498 4 rate1L/ 100L	Sum.oil +Metsulf. 1st years, then Pulse® + Grazon	250ml/ 100L	Nov-Apr	Pasture or native bush	Several consecutive seasons	Only 80% first year but then upto 100% with repeated followup sprays.	Metsulfuron is very cheap and more selective. Used to reduce the size of initial infestation. Grazon® will damage most broad-leaved species but is the only chemical that has provided reliable eradication. It has little effect on grasses, so the area is not left bare	11	Albany

Appendix 1: baseline data collected for *R. anglocandicans* October 2005 - April 2006 (Yeoh, Scott, Fontanini unpublished).

Quadrats (each 3m <sup>2</sup> ) scored at beginning of season	Using site averages		Lowest density from sites*		Highest density from sites**		#Samples per site	
	Mean ± SE (n=8)	Range	Mean ± SE (n=8)	Range	Mean ± SE (n=8)	Range	Mean	range
Plants/m <sup>2</sup>	5.4 ± 0.54	[3.7-8.2]	2.8 ± 0.38	[1.7-5.2]	8.9 ± 1.13	[5.8-15.2]	16.0	[16-16]
Live cane/m <sup>2</sup> (last seasons)	8.6 ± 1.50	[5.0-18.2]	3.9 ± 0.87	[1.7-9.7]	15.1 ± 2.62	[9.0-32.0]	16.0	[16-16]
Root suckers/m <sup>2</sup>	0.6 ± 0.16	[0.1-1.6]	0.0 ± 0.00	[0.0-0.0]	2.3 ± 0.46	[0.7-4.3]	16.0	[16-16]
Tip rooted daughter plants/m <sup>2</sup>	0.8 ± 0.24	[0.2-2.4]	0.1 ± 0.09	[0.0-0.7]	2.2 ± 0.55	[0.7-5.7]	16.0	[16-16]
Live cane/m <sup>2</sup> (this seasons -few weeks old)	0.5 ± 0.37	[0.0-3.0]	0.0 ± 0.00	[0.0-0.0]	1.8 ± 1.06	[0.0-9.0]	16.0	[16-16]
Seedlings (few weeks old)	0.1 ± 0.10	[0.0-0.8]	0.0 ± 0.00	[0.0-0.0]	0.5 ± 0.54	[0.0-4.3]	16.0	[16-16]
Plants/m <sup>2</sup> - excluding seedlings	5.3 ± 0.52	[3.7-8.2]	2.8 ± 0.38	[1.7-5.2]	8.3 ± 0.77	[5.8-11.5]	16.0	[16-16]

Random plants dug up when fruit set	Using site averages		Smallest from each site*		Largest from each site**		#Samples per site	
	Mean ± SE (n=8)	Range	Mean ± SE (n=8)	Range	Mean ± SE (n=8)	Range	Mean	range
Crown diam (mm)	37 ± 4	[24-55]	15 ± 2	[6-21]	71 ± 4	[55-87]	15	[11-18]
#Live canes/plant	2.2 ± 0.17	[1.8-3.2]	0.6 ± 0.18	[0.0-1.0]	4.6 ± 0.71	[3.0-9.0]	15.9	[12-18]
Av diam at base of canes (mm)	8.5 ± 1.01	[5.5-14.9]	3.6 ± 0.38	[1.8-5.0]	20.2 ± 7.28	[10.9-70.9]	15.0	[11-18]
Total stem length/plant (cm)	1274 ± 148	[393-1782]	111 ± 24	[16-250]	4500 ± 664	[802-6821]	15	[11-18]
#Fruit/plant	95 ± 18	[19-153]	0 ± 0	[0-0]	440 ± 101	[75-1025]	14	[9-17]
#Seed/fruit	16.0 ± 0.90	[12.8-21.2]	8.4 ± 1.73	[1.0-14.4]	23.2 ± 1.37	[18.0-30.4]	9.8	[9-17]
#Seed/plant	1797 ± 420	[281-3940]	0 ± 0	[0-0]	9811 ± 3216	[1222-30387]	14	[4-15]
%Flowers to produce fruit	91.6 ± 2.14	[83.5-98.5]	53.8 ± 13.26	[0.0-88.2]	99.9 ± 0.13	[98.9-100.0]	10.3	[4-15]
Av age flowering stems (yrs)	1.3 ± 0.04	[1.2-1.5]	1.0 ± 0.00	[1.0-1.0]	2.1 ± 0.06	[2.0-2.5]	13.8	[9-17]
# Primocanes (non-flowering)	0.8 ± 0.10	[0.3-1.2]	0.4 ± 0.18	[0.0-1.0]	1.5 ± 0.27	[1.0-3.0]	15.9	[12-18]
Max reach of primocane from crown (cm)	220 ± 23	[102-280]	53 ± 13	[16-100]	395 ± 43	[200-550]	13	[5-18]
# Tip rooting primocanes	0.2 ± 0.06	[0.0-0.4]	0.0 ± 0.00	[0.0-0.0]	0.8 ± 0.16	[0.0-1.0]	12.5	[5-18]

Using site means from both data sets above	Using site averages	
	Mean ± SE (n=8)	Range
Fruit/m <sup>2</sup>	459 ± 85	[153-882]
Seeds/m <sup>2</sup>	8621 ± 1985	[2304-17731]

\* represents typical smallest plant or lowest density in a heavy infestation.  
 \*\* represents typical largest plant or highest density in a heavy infestation.  
 Min or max values for different variables may be from different individual plants  
 eg. plants with no fruit are different individuals to those used to calculate #seed/fruit.

Quadrats/plants were all from within heavy infestations at 8 sites in the Manjimup-Pemberton Region (WA). Planks of wood were used to create access paths so as to collect samples. The sites included Jarrah, Karri and Pine forests and samples were taken from both the floodplains and the higher, drier areas. They therefore give a good representation of the whole region. The mean of the site averages are the values you would expect if you were to go to any random infestation and sample a similar number of plants/quadrats. The lowest/smallest and highest/largest values show the expected variation within a particular sites.

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