The latest in environmental weed information

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There are many sources of information on environmental weeds in Australia. Many of these contacts and information resources are listed in the Weed Navigator, published by the Cooperative Research Centre for Weed Management Systems (Weeds CRC). The two book set includes the Contact Directory and Resource Guide. Together, they include over 3000 entries from around Australia and New Zealand and cover both agricultural and environmental weeds.

The Contact Directory lists over 1020 individuals and organizations who have an interest in weeds. It includes their addresses, phone and fax numbers, emails, web sites and newsletters published. Grouped by State, it also has entries for overseas organizations, consultants and media contacts.

The Resource Guide lists and describes over 1980 publications including books, brochures, web sites, CD-ROMS, posters, training opportunities, legislation and strategies. It is expected that the Weed Navigator will eventually be available on the internet.

Communication amongst environmental weed people have advanced considerably over the last year with the introduction of Enviroweeds – an email discussion group initiated by the Weeds CRC. It currently has over 350 people subscribed from around Australia and overseas (details of how to subscribe are included in the Weed Navigator available at phone 08 8303 6590 or on email crcweeds@waite.adelaide.edu.au).

Many weed brochures are now available on the internet. There are hotlinks for weed information around the world over the internet. Try starting at: http://www.agric.wa.gov.au/progserv/Plants/weeds/links.htm

Some of the new publications coming up include:

- Best practice management guides for seven environmental weeds soon to be published by the Weeds CRC.
- Many new Weedbuster Week items including magnets, posters, stickers etc. Very useful for events including weed cleanup events, field days etc.
- Environmental weed field guides – two being published in the next 12 months for SE Australia.
- Weed decks – being prepared nationally to assist identification of declared and other weeds.

It can no longer be said that there isn't much information available on environmental weeds. There is lots of information, it is just a matter of knowing where to find it and the Weed Navigator helps to give direction.

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Current research on environmental weeds

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Introduction

The aim of this paper is to provide a brief summary of current environmental weeds research projects, concentrating on those of the Cooperative Research Centre for Weed Management Systems (CRC), and to make some general observations about the rationale for different sorts of environmental weeds research. I have not attempted a comprehensive description of all the ongoing projects but rather to provide an overall impression of the current research directions, necessarily concentrating on the projects that I am most familiar with, particularly those at the Keith Turnbull Research Institute (KTRI). Failure to include some other projects is a consequence of my lack of information and shortage of time; I apologize to those concerned. Some of the work mentioned falls outside the CRC or was conducted before establishment of the CRC. Past and present funding sources for the different projects are not usually referred to in order to keep the text to a reasonable length; references to provide access to detailed information on each project have been given wherever possible.

Biological control

Classical biological control assumes that once released a biological control agent will persist and provide ongoing control without the need for repeated introductions. The steps in classical biological control of exotic weeds can be summarised as below. Fungal pathogens, insects or other invertebrates all go through essentially the same process.

i. Identify suitable target weed. Includes assessing negative impact of the weed against any benefits from it.
ii. Prospect for potential agents. Usually in the weed's home range but often also taking into account what agents have worked against this weed elsewhere. Climate matching is needed.
iii. Test promising agents for specificity. Requires a list of test species to be drawn up and approved.
iv. Gain approval for release and release at priority sites.
v. Monitor survival, reproduction, and dispersal under different site conditions.
vi. Make new releases once nursery sites become sufficiently productive.
vii. Assess agent impact.

The whole process is unavoidably expensive and would not usually be contemplated except for a widespread and serious weed. Ten years may be required to get from the first step to the last. Problems can occur at all stages but difficulties in rearing agents in quarantine conditions are often particularly troublesome. A number of different biological control agents for environmental weeds are in the later stages so there is a real prospect of some significant benefits within a few years. Successful agents are ultimately extremely cost effective, the problem of course is that large amounts of money are needed in the short term for a chance of sustainable weed control in the long term, and this is not always compatible with the timescale on which funding bodies plan.

Bridal creeper (Asparagus asparagoides)

The first biological control agent for bridal creeper in Australia, the leaf-hopper *Zygina* sp., was approved for release in May and will be released very soon. In addition to the leaf-hopper a leaf-feeding beetle, a seed wasp and a rust fungus are being tested for specificity.

Boneseed/bitou bush (Chrysanthemoides monilifera ssp. monilifera and rotundata)

Leaf-feeding beetles released in the past have failed to establish, apparently due to heavier predation by ants than occurs in South Africa. The only exception is the Bitou Tortoise beetle (*Cassida* sp.) that has established in New South Wales, although so far it has not spread far. A seed-feeding fly from South Africa, *Mesoclanis magnipalpis* was released on boneseed at Daveys Bay and the You Yangs in June 1998. The fly is similar to *M. polana* that was released on bitou bush in New South Wales in 1996, and that species has already spread all over the New South Wales coast (Edwards *et al.* 1999) substantially reducing seed production. Establishment from the release of relatively low numbers of *M. magnipalpis* last year has not yet been confirmed but there will be more releases of larger numbers over the coming weeks in both Victoria and South Australia. A tip moth, *Comostolopsis germana* is widely established on bitou bush in NSW (Holtkamp 1996) and is having some impact, but this has not proved suitable for boneseed. Although also established on boneseed in South Australia it seems likely to have negligible impact there. An application to release a new defoliating moth has been prepared recently; this could be an extremely effective agent for both boneseed and bitou if approved. A mite, a rust fungus and a beetle are at various stages of testing as possible future agents.

English broom (Cytisus scoparius)

The twig mining moth *Leucoptera spartifoliella* has been released in the ACT, NSW, Tasmania and SA over the last six years and there is one nursery site in Victoria. More *Leucoptera* brought from New Zealand are being reared through a generation in quarantine at KTRI and will be available for release shortly. A psyllid *Arytainilla spartiophilia* has been released in NSW and Tasmania and is being reared at KTRI but has not yet been released in Victoria. Broom is a target of biological control in New Zealand and North America and quite a large number of agents are being investigated. A seed-feeding weevil and a gall mite are being considered for Australia.

Blackberry (Rubus fruticosus)

Work is in progress at the University of Adelaide using molecular techniques to clarify the taxonomy of blackberry in Australia and to identify the strains of rust fungus (*Phragmidium violaceum*) found in the field (Evans *et al.* 1998). Species names presently used in Australia are to be revised and should then agree with the names used in Europe. Without accurate identification of the different blackberry strains it is not possible to be certain why the rust fungus is working well in some places and not in others; it could be that the blackberry is not the right taxon for the rust to attack or it could be that the microclimate at the site is not suitable for the rust. Recently, further work in the CRC has started to investigate in detail what climatic factors determine the performance of the blackberry rust fungus. When this work is completed a number of useful things should become possible. Mapping of areas where the rust is expected to do well in most years, areas where it will probably be effective intermittently and areas where there is little prospect of it having much impact should be achieved. Forecasting quite early in the year whether it will be a good rust year or a poor one at a particular location and therefore whether other techniques to control blackberry will be appropriate could be possible. Finally, the information obtained will help to assess potential new imports of blackberry rust from Europe to deal with strains of blackberry or climatic conditions where the current rust is not effective.

Horehound (Marrubium vulgare)

The horehound plume moth *Wheeleria spilodactylus*, first released in 1994, is established at many sites and in some places is spreading and having a substantial impact on horehound. Work at the University of Adelaide suggests that despite fairly good natural spread the plume moth impact could be considerably speeded up by a further redistribution program. The plume moth appears to do less well in places with low rainfall and hot summers. Another agent, the clearwing moth *Chemaesphecia mysiniformis*, which is better suited to such environments, was released last year at a small number of sites and more releases will happen this year.

St. John's wort (Hypericum perforatum)

Monitoring is under way to determine the impact of the most recently released agent, the St. John's wort mite *Aculus hyperici*. Indications are that it reduces the size and density of the weed (Mahr *et al.* 1997); see below for attempts to integrate it with other techniques.

Gorse

A new project funded by the Gorse Task Force has started recently at KTRI to release the gorse spider mite, *Tetranychus lintearius,* which has proved very successful overseas. The first release was made near Ballarat in April and others are in progress.

Serrated tussock

A project is under way to prospect for fungal pathogens of serrated tussock in its home range in Argentina, with the hope of eventually identifying a specific fungus to import (see Briese and Evans 1998).

Why are so many agents involved for some weeds? Experience with biological control of weeds is that a small proportion of the agents provide adequate control unassisted, some agents provide measurable impact on the weed but not control and many agents either do nothing much to the weed or completely fail to establish. Continued study of the factors leading to the outcome of each case will increase the proportion of successes in future, but there will always be a fairly large element of uncertainty for each agent. One justification for bringing in multiple agents is therefore that it increases the chances of at least one being highly effective. Another consideration is that agents, especially ones that reproduce relatively slowly, may take years before we have even early indications of what their final effect is likely to be. If we waited after each release to see whether an agent was going to control a weed problem before going for another we might be allowing the weed problem to worsen. The opinion of weed biological control scientists now is that for most weeds there will never be a single 'super-agent' that provides effective control. After all, in their countries of origin few weeds are kept in check by just one insect or pathogen, most are affected by a number of different ones. The current approach with biological control is to try to find a suite of compatible biological control agents that attack different parts of the plant or different ages of plant or are most effective in different circumstances e.g. shaded and unshaded.

Mycoherbicides

Mycoherbicides differ from fungi used for classical biological control in that the fungus is not expected to maintain itself at a high enough population to continue to control the weed. Instead a large amount of the fungus is cultured then introduced, usually as a spray or cut stump treatment, colonises and kills the weed and then declines to a low level. New applications are then needed if the weed reappears. Fungi that are less selective than those used for classical biological control may still be acceptable mycoherbicides because if non-target plants are not treated they should not be affected. Suitable fungi may be found already in the country, which avoids the need for applications to import and quarantine testing. There has been some research on fungal pathogens for bitou bush in NSW (Cother and Nickandrow 1997). Advantages of mycoherbicides are: (i) specificity; (ii) high safety factor for applicators and for wildlife; (iii) can be used in water supply catchments; (iv) may generate income from continued sales. Difficulty has so far been experienced in devising stable and reliable formulations and (for spray applications) getting around the problem that particular weather conditions in the days after spraying are needed for the pathogen to establish. Both these problems may be overcome in the future, but the cost of application by cut stump or spot spray will still be the same as for applying herbicide. Mycoherbicides perhaps have their best potential for situations either where for some reason chemical control is unacceptable, or when specificity is high enough to allow application over mixed stands of vegetation without the need to avoid desirable species.

Chemical control

Herbicide application is an expensive technique, usually requires repeating, is unpopular with a significant section of the public and is often not feasible for large-scale weed infestations. The most effective role of herbicides is at the small to medium scale e.g. protecting valuable remnant vegetation, or controlling spread at edges of large infestations, or in achieving local elimination when a new weed has arrived. There may also be a case for larger scale use of herbicides as a holding measure to prevent complete loss of valuable communities while other techniques that may be more sustainable in the long term are pursued. For example, ultimately we hope that a suite of biological control agents may greatly reduce the threat of broom to alpine areas, but even optimistically this will take years. Herbicides provide one way to reduce the amount of degradation due to broom invasion during that time.

The first problem with many of the environmental weeds is often that no really effective herbicide has been identified and there is little knowledge of the best spray concentrations or volumes, additives, time of year to apply or anything else. Finding a treatment that works effectively using a product and rate that will be environmentally acceptable can be a lengthy process. A large program of such work on bridal creeper has been in progress at KTRI for some years (Pritchard 1996). Only one herbicide has been registered to control bridal creeper so far, but extensive trials of another product have also been conducted and an application to register it may be submitted, giving users an alternative which may be more suitable in some circumstances. Trials have also been going on in recent years with English ivy, bluebell creeper, serrated tussock and others. A problem with many environmental weeds is that the amount of herbicide used on them is very small in commercial terms. Generating sufficient data to justify adding a new species to a herbicide label has costs which in the case of most environmental weeds will not be covered by any resulting increase in sales. Research results are sometimes supplied free to herbicide companies in return for them registering a new use. This is not the complete answer because companies still have to consider issues of staff time to process the new use; of making themselves legally liable for damage caused by following the label, and also the possibility that misuse on the new weed might endanger the good name of their product. Legislation regarding the use of products that are not registered to control a particular weed (off-label use) varies in different States and Territories and it is beyond the scope of this article to explain it. Not only does the law regarding the actions of herbicide users vary but the policies of government departments on what recommendations they will make for off-label use also vary widely. Obviously nobody wants a free-for-all where any product can be tried without restriction and recommendations are made without proper research. On the other hand over-caution can restrict the flow of information to the users who need it and lead to less effective weed control.

Off-target effects

A frequently used method of treating environmental weeds is spot-spraying. Despite the intention to direct the spray only on to the weed there is of course always some unintentional contact with desirable vegetation growing under, amongst or next to the weeds. Choice of herbicide may thus be greatly affected by how much damage results when this happens and there is a severe lack of good information on how different herbicides affect different native species. A large-scale trial has recently been completed in Western Australia using around 40 different herbicides on roughly the same number of native tree and shrub seedlings (Moore 1999). The results should help users to select products that are least likely to adversely affect desirable vegetation. Whilst it is obviously impossible to test all the species we might be concerned about, knowledge of a bad effect on closely-related species might lead to avoidance of a particular product. I would be more cautious the other way round i.e. assuming that a herbicide will not affect a desirable species because related species are relatively tolerant. A situation in which sensitivity information is particularly useful is in restoration schemes where only a few species are sown or planted and it may be possible to plan in advance to use only species tolerant of a particular herbicide, perhaps introducing others later when weed control has been achieved. Another situation where herbicide sensitivity information is required occurs when spraying of weeds exposes a rare or threatened species to herbicide; thus the rare species may be threatened by both weed encroachment and by the measures used for weed control. A project to study one such situation is being run at CSIRO Plant Industry (Willis 1998).

There has also been recent work at KTRI looking at the susceptibility of a smaller number of woody species to foliar or root absorption of some herbicides, testing them in different soils and under field and glasshouse conditions.

Integrated approaches

Fire and herbicides

Experiments have been going on for almost three years on boneseed at the You Yangs and Arthurs Seat to study the response to different post-fire control techniques, principally different herbicides at different post-fire intervals and also hand-pulling. There is never going to be one prescription that suits all situations, but with sufficient understanding of the processes involved it should be possible to predict which strategies will be worthwhile in different circumstances. From the results so far brushcutting or uprooting the boneseed to get a better fire seems to be well worth the effort, because of the importance of an even hot burn in killing boneseed seeds or stimulating them to germinate. The work is being carried out by a CRC Ph.D. student based at the University of Adelaide; other CRC researchers at Adelaide and CSIRO Canberra are involved in studies with bitou bush and broom that include fire and herbicides, so we may be able to derive some general principles in addition to getting data specific to each weed.

Biological control and herbicides

Once St. John's wort has become established on a large scale in a natural ecosystem herbicide use has often been considered to be a waste of resources. However effective the herbicide St John's wort will re-establish from the huge and long-lived seed bank as soon as conditions are suitable. However, some studies on the St. John's wort mite suggest that whilst it only stunts established plants it is frequently lethal to seedlings. Perhaps at sites where the mite does well it is now worthwhile to spray the weed because the mite may prevent it from regaining anything like its former dominance. A trial has been running for the last 18 months and the early signs are that the plots with mites removed are recolonized by St. John's wort much more quickly than the ones where the mites are kept off by spraying miticide. The effect of a biological control agent may thus be to make other control techniques more effective than they were before it was introduced, and this is true for other weeds too.

Experiments have been going on for the last two years to see how horehound plume moth reacts when horehound is sprayed with herbicides. Total weed kill would drive the moth to local extinction whilst leaving a future problem with new horehound seedlings. Spraying part of the infestation each year so that moths can move to healthy plants seems to be feasible, but tedious over large areas because the moths are not especially mobile and would need unsprayed plants only a few metres away. Rates of herbicide required to kill horehound are often unacceptably damaging to native species. Another option is to spray with a rate of herbicide that does not directly kill most of the horehound, and is also less damaging to native plants. If larvae feeding on the horehound survive the spray their effect could become greater as they are concentrated onto a smaller plant. A proportion of plants may be killed by the combined stress. Even if the immediate combined effect is not entirely successful the moth will at least have been preserved in sufficient numbers for a continued impact in subsequent years. When the next generation of adults emerge they will have a smaller choice of plants, so that any horehound which is missed or little affected by the herbicide would attract many more eggs than usual and then suffer heavy feeding damage. Glasshouse and field trials so far support these ideas and I hope soon to be able to issue a recommendation based on the results.

Conclusions

To summarize: there is progress with developing herbicide treatments and assessing their off-target effects, constrained by the fact that environmental weeds, which we see as a huge problem, are in a commercial sense terms usually a small market. Biological control offers long-term hope for weeds that have got beyond treatment by other techniques. There are notable current biological control success stories and we hope more on the way but developing biological control is not quick, cheap or simple. Integration of the different techniques is happening to some extent already and should develop further as we gain the required understanding of the ecology of weeds, biological control agents and the native vegetation, and also move to an holistic view of managing ecosystems rather than focusing entirely on weed control. Finally, none of this research will produce long-term benefits if new weeds are allowed to arrive and establish faster than we can control the existing ones.

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