Biological control of weedy native plants in Australia

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Abstract

Biological control of weeds is the use of selected natural enemies of a plant to suppress its population to a more acceptable level, in areas where the plant is undesirable. It is a cost-effective weed management technique for larger infestations of weeds that have a lower priority for control by more rapid techniques such as herbicides. In Australia, as in other countries, the main thrust of biological control utilizes the classical approach that targets invasive exotic plants introduced without the natural enemies that suppress them in their area of origin. There is, however, a widespread belief that biological control is not possible or is inappropriate for native plants. Consequently only a small number of plants considered native to a country have ever been the targets of biological control and examples in Australia are rare.

In the last 200 years the intentional movement of native plants for horticulture, forestry and urban landscaping, coupled with changes in ecosystem management, have assisted a number of native Australian plants to become damagingly invasive within Australia. This paper looks at current efforts on biological control of weedy native plants in Australia and discusses possibilities for targeting additional species that are considered weedy. Current protocols for biological control of exotic weeds are examined and their use in biological control of native plants is discussed. We seek to demonstrate in principle that safe biocontrol of native plants in Australia is technically feasible and propose an institutional and legal framework in which it can be regulated.

Introduction

Biological control of weeds is the use of selected natural enemies of a plant to suppress its population in areas where the plant is undesirable. It is a cost-effective weed management technique for larger infestations of weeds that have a lower priority for control by more rapid techniques such as herbicides. A large number of invasive plants around the world are currently targeted by biological control programs (Julien and Griffiths 1998). In Australia, as in other countries, the main thrust of biological control utilizes the classical approach that targets invasive exotic plants that have been introduced without the natural enemies that suppress them in their area of origin. There is however a widespread belief that biological control is not possible or is inappropriate for native organisms (Carl 1982). Only a handful of plants that are considered native to a country have been the targets of biological control programs: Julien and Griffiths (1998) list 23 weeds worldwide that have been targeted in a country where the plant is in part of its native distribution. Only two of these are in Australia.

Unfortunately in the last 200 years the intentional movement of native plants for horticulture, forestry and urban landscaping, coupled with changes in ecosystem management, have assisted a number of native Australian plants to become invasive within Australia. An important factor preventing plants becoming weeds in their native habitat is the presence of biocontrol agents that have evolved with the plant. Once released, or partially released from predators and parasites through the actions of man, some native plants may obtain an advantage over the local flora and become invasive weeds.

This paper looks at past and current efforts to biologically control weedy native plants in Australia and discusses possibilities for targeting additional native plants that are considered weedy. Current protocols for biological control of exotic weeds and their use in biological control of native plants are examined and other institutional and legal constraints in which native plant biocontrol may be regulated are discussed. We seek to demonstrate in principle that safe biocontrol of native plants in Australia is technically feasible and to define the framework in which it may be regulated.

Past and present research in Australia

Very few native plants have been investigated for biological control in Australia. We have been able to find two examples in the literature totalling five species of plants. Julien and Griffiths (1998) list Chinese scrub or Sifton bush (*Cassinia arcuata* R.Br.) and coughbush (*Cassinia laevis* R.Br.) (Asteraceae) in which species of native scale insects (Kerridae or Lacciferidae) were redistributed to areas where these native shrubs were invasive in extensive pasture situations. The possibility of redistributing native scale insects for the control of *Cassinia* spp. was first reported by Campbell and Wykes (1991, 1992). Campbell *et al.* (1994) and Holtkamp and Campbell (1995) reported on the impact of a redistribution program of *Austrotachardia* sp. and *Paratachardinia* sp. scales and on rudimentary host specificity tests which indicated that *Austrotachardia* sp. was specific to *C. arcuata*, *C. quinquefaria* R.Br. and *C. longifolia.* Campbell *et al.* (1994) also commented on other native insects which they observed attacking *Cassinia* spp.

More recently, Sparks and Robinson (1997) investigated over 40 arthropods for biological control of weedy rangeland shrubs in western New South Wales and south west Queensland and found two with potential, the soft scale, *Pulvinaria* sp. (Coccidae) for *Eremophila mitchellii* Benth. and *Eremophila deserti* (A.Cunn. ex Benth.) Chinnock (Myoporaceae) and the hopbush mite (an unnamed eriophyid) for hopbush, *Dodonea viscosa* ssp. *angustissima* (DC.) J.G.West (Sapindaceae). Sparks (2000) reported that both agents established at all release sites. In the short 18 month study period, *Pulvinaria* sp. did not have an impact on the target plants while the mite killed up to 17% of hopbush in the study plots and was considered to have great potential.

In all these cases the biological control works involved the redistribution and augmentation of natural enemies that were already present in the general area but were too slow at colonizing stands of the unwanted shrubs. The plants were invasive because of changed grazing and fire management regimes.

Possible targets

Which native invasive plants could be targeted for biocontrol? It is proposed that three main types of native weeds occur in Australia:

- Plants that increase in density in their current area of distribution due to changed management regimes.
- Plants that extend their current geographic range due to changed management regimes. These lend themselves to redistribution of native agents.
- Plants that have escaped their natural enemies because they are now separated from their natural area of distribution by geographical barriers. These lend themselves to classical biocontrol.

Invaders of disturbed areas

Terrestrial plants that increase in density in their current area of distribution due to changed management regimes are usually unpalatable species which are able to increase quickly and invade disturbed habitats resulting from land clearing, the introduction of grazing animals and changed fire regimes. They are usually rangeland shrubs unpalatable to sheep or cattle and

are considered weeds by the extensive grazing industries. Two scenarios occur with such species. Either they are able to escape their full suite of natural enemies as they increase in density, or, the distribution of their natural enemies extends with them but the plant remains at a density that is considered 'weedy' because it takes the place of more palatable species utilized by domestic animals. Data that verify these scenarios is largely unrecorded in Australia. The cases of *Cassinia* spp., *Eremophila mitchellii*, *E. deserti* and *Dodonea viscosa* mentioned above indicate that some damaging natural enemies such as scales and eriophyid mites are unable to readily disperse and increase with the population of the plant and that manual redistribution of some natural enemies does result in effective suppression of dense infestations of some native weeds. However, comparisons of the suite of natural enemies of these plants in areas where they are considered weedy and in areas where they are more in balance with nature have not been carried out. Why these plants are able to outgrow their natural enemies in the short term is not known.

Plants extending their range

Native plants that rapidly invade new habitats and extend their current geographic range due to changed management regimes and have been termed 'ecologically out of balance' (Carr 1993). These plants may be able to escape their full suite of natural enemies in the longer term by taking advantage of anthropogenic changes that allow them to grow in areas previously unsuitable for them. The new areas may be less climatically or ecologically suitable to some of their natural enemies or their natural enemies are actively or unintentionally suppressed as part of the changed management regime. *Pittosporum undulatum* Vent. in eastern Australia is one of the best known examples (Gleadow 1982) but again, comparisons of the suite of natural enemies of these plants in areas where they are expanding in distribution and areas where they were found historically have not been carried out. Such studies are required to determine whether redistribution of natural enemies into the expanded range of the plant might provide improved control, but in many cases these plants are probably suitable targets for redistribution of agents.

Plants in new bioregions

The methods of classical biological control can be applied to plants that have escaped their natural enemies and now have populations separated from their natural area of distribution by geographical barriers that their natural enemies cannot cross. Australia, being such a large landmass, offers possibilities for classical biocontrol of native plants because some plants that evolved on one side of the continent are now invasive in similar climates on the other side. The only major biological barrier in mainland Australia is the Nullarbor Plain and Great Victoria Desert that separate the southern sub-humid and humid areas of south-west Western Australia and south-eastern Australia. The differences between these regions are of the same order as those between Europe and North America (Doing 1981). Many examples occur of eastern Australian plants that are invasive in Western Australia and vice versa. These plants have often been deliberately introduced and behave in the same manner as exotic weeds. Coast tea tree, *Leptospermum laevigatum* (Sol. ex Gaertn.) F.Muell. (Myrtaceae), in Western Australia and bluebell creeper, *Sollya heterophylla* Lindl. (Pittosporaceae), in eastern Australia are good examples.

Overseas experience

The situation of native plants which invade new bioregions is directly comparable to the experience with biological control of invasive Australian plants in other parts of the world, particularly in South Africa (Olckers and Hill 1999) and with experience in other countries where local native plants have become weeds (e.g. DeLoach 1995). Many Australian native plants have become weeds in other parts of the world and are currently the target of biological control programs (Julien and Griffiths 1998). The information gained by other countries during development of programs for their weeds of Australian origin may assist us in developing programs for the same plants when they are invasive in Australia. Table 1 lists some Australian plants currently the target of biocontrol programs in other parts of the world that are also invasive in Australia.

Table 1. Some Australian plants currently the target of biocontrol programs in other parts of the world that are also invasive in Australia.

Species	Common name	Origin	Weed Australia	Weed overseas	Reference
Leptospermum laevigatum	Coastal tea tree	Vic, NSW, SA	Qld, WA, SA	S Africa*, NZ	Gordon 1999b
Acacia dealbata	Silver wattle	Vic, NSW, Tas	SA	S Africa*, NZ	Dennill *et al.* 1999
Acacia decurrens	Early black wattle	NSW	Vic, Qld, SA, Tas	S Africa*, NZ	Henderson 1995
Acacia mearnsii	Black wattle	Vic, NSW, SA	WA	S Africa*, NZ, Hawaii, Reunion	Dennill *et al.* 1999
Acacia melanoxylon	Blackwood	Vic, NSW, Qld, SA, Tas	WA	S Africa*, NZ	Dennill *et al.* 1999
Acacia longifolia	Sallow wattle	Vic, NSW, Qld, SA, Tas	Vic, SA	S Africa*, NZ	Donnelly 1995, Dennill *et al.* 1999
Acacia pycnantha	Golden wattle	Vic, NSW	WA, Tas	S Africa*	Dennill and Gordon 1991, Dennill *et al.* 1999
Acacia saligna	Orange wattle	WA	Vic, NSW	S Africa*	Morris 1997, 1999
Hakea sericea	Silky hakea	NSW, Qld	Vic	S Africa*, NZ, Spain	Kluge and Neser 1991, Gordon 1999a
Hydrilla verticillata	Hydrilla	Vic, NSW, Qld, NT, north-west WA; Europe, Africa, S and E Asia	south-west WA	USA*, Mexico*	Balcunias *et al.* 1995
Paraserianthes lophantha	Cape wattle	WA	Vic, NSW, SA, Tas	S Africa*, NZ	Dennill *et al.* 1999, Schmidt *et al.* 1999
Pittosporum undulatum	Sweet pittosporum	Vic, NSW, Qld	Vic, SA, Tas	S Africa*, Jamaica, St. Helena, Hawaii	Goodland and Healey 1997

* = biocontrol program, NZ = New Zealand.

Potential conflicts of interest

Many of the native plants invasive within Australia have been planted as horticultural, forestry or amenity plants. It is therefore very likely that if their invasive populations are targeted for biological suppression then conflicts of interest will arise between members of the community who consider the plants economically important or desirable in some areas and those who consider them to be invasive weeds. Although such conflicts are often difficult to resolve, we know from overseas experience that for commercially important plants it is possible to selectively target the reproductive parts of the plant with biological control, while preserving the desirable traits, with minimal impact on the commercial values. Such strategies aim to reduce the invasive potential of plants by disruption of plant reproductive functions. This approach has been successfully used in South Africa for invasive species from temperate Australia. For example, some Australian *Acacia* spp. are of significant economic importance in South Africa for tan bark and timber, but are also extremely serious invasive weeds that degrade natural areas and agricultural land, and consume vast quantities of water that would otherwise be harvested for domestic and agricultural use or help restore environmental flows in waterways. *Acacia*-feeding insects that reduce flower and seed production have been deliberately selected, thus reducing the invasive potential of the plants while conserving their desirable attributes (Dennill *et al.* 1999). Studies are also under way on seed destroying agents for *Pinus* spp. in South Africa (Zimmermann and Neser 1999), while a feasibility study on *Pinus* spp. has also been carried out in New Zealand (Brockerhoff and Kay 1998). A similar feasibility study is currently under way on *Salix* spp. in Australia. (J.L. Sagliocco personal communication). A biological control strategy that seeks to suppress reproduction, but not plant growth itself, would be appropriate in Australia to decrease the invasive potential of native forestry species planted outside their natural distribution e.g. *Eucalyptus globulus* Labill. and some *Acacia* and *Casuarina* species. Biological control of Australian native plants in Australia can also benefit from reviews of overseas experience with Australian phytophagous pests that damage Australian plants in foreign lands.

Protocols and legislation

Existing protocols and legal and institutional frameworks to regulate biological control of exotic weeds should be of assistance in resolving conflicts relating to native plant biocontrol. Biological control of pest species, including weeds, is regulated by both Commonwealth and State legislation in Australia. The Commonwealth Biological Control Act 1984 and corresponding legislation in each state (e.g. Biological Control Act 1986 in Victoria), allows for the declaration of target species and of individual biological control agents. The legislation was developed to identify and resolve any potential conflicts of interest over the targeting of a pest for biocontrol and the use of particular agents. In addition to the legislation, strict administrative and scientific protocols are currently in place for the declaration of a target weed and the importation, testing and release of exotic biological control agents (Paton 1995, Withers *et al.* 1999).

Nominations of target weeds for biological control are initially presented to the Australian Weeds Committee (AWC), one of the technical committees of the Standing Committee on Agriculture and Resource Management (SCARM). The nomination is circulated for comment within each State and if no conflicts of interest are identified then the AWC recommends that SCARM endorse the weed as a target. If conflicts of interest are identified then the recommendation is for the applicant to use the processes of the Biological Control Act. Administrative and scientific protocols on the testing and release of exotic biological control agents are administered by the Australian Quarantine and Inspection Service, in conjunction with Environment Australia, and again involve extensive consultation with government departments in all States. Public consultation occurs only if State agencies identify conflicts of interest and the procedures of the Biological Control Act are brought into operation.

Because most native plants that are considered weeds have, or are currently being used for horticultural, forestry or ornamental purposes, it is highly likely that conflicts of interest will arise if they are targeted for biological control. It is therefore proposed that any native plant nominated as a target for biological control should be automatically referred to the Biological Control Act.

Because of the close relationship of native weeds to non-target species, it is important to identify biocontrol agents with very high specificity. We therefore further propose that protocols for host specificity testing and releases should follow the current protocols for exotic agents, developed by AQIS and Environment Australia and endorsed by experts in government agencies from each State and Territory, but with an appropriate opportunity for community input. In the case of native weeds and native biocontrol agents, there is no need for the involvement of AQIS. Environment Australia should therefore administer the protocols and approve the release of any agent that is sufficiently specific. Again, because of the likelihood of conflicts of interest, it is proposed that the candidate agent be also declared an agent under the Biological Control Act.

Discussion

Enabling of public consultation is likely to increase the costs of such programs but will enable a wider range of experts in the community to comment upon and examine potential ecological problems and consequences, and will enable better assessment of the potential costs and benefits of the programs. Initially we expect that community consultation will expose widespread resistance to the idea of biocontrol of native plants, largely based on fears of off-target damage. Such resistance could be moderated by improving our understanding of the extent to which native 'biocontrol agents' are becoming established around Australia as a result of unintentional human introductions. The extent of such 'naturalizations' is probably much greater than is known. There does not appear to be any adequate research program to systematically document them or to quantify their impact. Opposition by some sections of the community is also likely to reduce with a better knowledge of the increasing rates at which new exotic organisms that impact on native plants are being introduced and dispersing. AQIS quarantine interception records and surveys around major ports provide a substantial basis but again the existing knowledge base appears to be inadequate. In the longer term, public consultation should have a positive effect on community attitudes and build up public confidence in the process.

In summary we would like to reinforce the following points: redistribution of natural enemies of some rangeland shrubs has resulted in them being successfully suppressed; additional native weeds could be targeted by redistribution of natural enemies or classical biocontrol programs; agents can be selected for specific purposes e.g. target the whole plant or more specifically target reproductive organs of those species being grown for economic reasons; institutional and legal frameworks already exist for biocontrol of exotic weeds and should be used for native weeds with minor amendment to legislation; safe biocontrol of native plants is technically feasible in Australia and the need for effective biocontrol of such plants is becoming more pressing. Basic studies of the natural enemy complexes of major native weeds in their natural and introduced Australian ranges have not been undertaken. Such studies should be initiated and we suggest that appropriate candidates would be bluebell creeper (*S. heterophylla*) in eastern Australia and coastal tea tree (*L. laevigatum*) in Western Australia.

Acknowledgments

We thank Royce Holtkamp (Agriculture NSW) for information and assistance with obtaining literature, and J.L. Sagliocco (KTRI) for information about biological control of willows.

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