CAWS Oration
Weed management at the border, at the garden fence and in the bush

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Summary Some personal perspectives on weed management at three stages along the invasion pathway are presented, examples given and recommendations formulated to reduce future weed impact, especially in natural ecosystems.

Weed management at the point of entry to Australia ('at the border') has made significant progress recently, but some problems remain. Many species known to be agricultural or environmental weeds outside Australia are currently allowed legal entry if they are in permitted genera. I recommend that the concept of permitted genera be reviewed urgently.

A large number of major environmental weeds are still for sale by Australian nurseries and actively being promoted for cultivation in gardens ('at the garden fence'). Ten species are identified for immediate prohibition and many others for eventual prohibition from sale nationally.

Weeds impact on biodiversity at various levels and in various ways. Negative impacts of weeds on biodiversity of natural ecosystems can be mitigated in the future by active searching for newly naturalised species in peri-urban bushland ('in the bush') before they become widely invasive. Biological control programs for existing weeds need long-term federal funding and integration with other forms of control if they are to effectively reduce known negative impacts on biodiversity.

Keywords Plant invasions, quarantine, permitted genera, nursery sales, recent incursions, biological control.

INTRODUCTION

It is of special significance for me to give this presentation at Wagga Wagga. Firstly, because it was to Wagga that I first came at the end of 1966 to learn from Eric Cuthbertson something of the biology of the weed I had recently been appointed to work on at CSIRO Plant Industry in Canberra – namely, skeleton weed (*Chondrilla juncea* L.). And I learnt a lot from Eric on that and subsequent visits. I went on to count skeleton weed plants in permanent quadrats every three to six weeks depending on the season over a three year period on a property within sight of this campus (Groves and Hull 1970). I thus got to know Wagga well in all seasons.

Secondly, Wagga is significant to me because it was at Marrar, also very close to this campus, that the first report of skeleton weed in Australia was made in 1917. In that record Mr. E. Field wrote:

> '*It is going to be a very bad pest, and almost stops the harvesters and blocks the riddles when stripping, and generally is of a spreading, interwoven habit. It grows from the roots, remaining in the ground from year to year, and keeps on spreading.*' (Maiden 1918).

We may conclude either that Mr Field was a remarkably prescient farmer, or, alternatively, weed prediction has not progressed very much over the last 87 years. In that same one-page paper, Maiden, then the New South Wales (NSW) Government Botanist, wrote:

> '*One can quite understand the truth of Mr Field's description. It is almost as tough as a bundle of wire, and it is going to be one of the most troublesome weeds heard of for some time*' (Maiden 1918).

It was also at Wagga in 1971, five years after I first visited Eric Cuthbertson, that Jim Cullen released a strain of *Puccinia chondrillina* that went part way to eventually controlling one of the three apomictic genotypes of skeleton weed in south-eastern Australia (Cullen *et al.* 1973, Hull and Groves 1973). I am thus glad to be back close to where my career in weed ecology started and in the agricultural landscape that still has significance for me, both personally and professionally.

All the above is by way of a personal introduction to my more formal CAWS Oration in which I wish to briefly look at some ways to reduce the negative impacts of environmental weeds on biodiversity in the future, and especially in relation to some urgent changes required in the nursery and garden industry from which so many present environmental weeds have originated. This section of my talk will cover weeds and weed management both 'at the border' and 'at the garden fence'. I then make a case for the role of environmental weeds as they impact on native plant diversity and the biodiversity of three Australian vegetation types, i.e. weed management 'in the bush'. Having established that case I will formulate some recommendations to minimise the role of future environmental weeds on biodiversity.

DEFINITIONS

An environmental weed is a plant that invades native vegetation outside the geographic range in which it evolved. This definition means that environmental weeds can be either introduced or native to another Australian region. In most of what follows, I refer to environmental weeds that have been introduced to Australia, but in a few instances I refer to species, such as sweet pittosporum (*Pittosporum undulatum* Vent.), that have become environmental weeds outside the region within Australia to which they are indigenous.

I define biodiversity as all living organisms in a region, although mostly I mean native plant diversity, i.e. species number per unit area or species richness.

My definition of the nursery and garden industry is wider than the national association called the Nursery and Garden Industry of Australia (NGIA) and includes some of the bigger retailers of garden plants who are not members of NGIA, as well as the informal traders of many plants at community markets and fetes and between well-meaning friends and relatives. It also includes the research staff behind some popular television programs about gardening, as well as writers of horticultural catalogues and journals, published both in Australia and elsewhere.

In the next two sections of this talk I wish to concentrate on the need to refine weed management both 'at the border' and 'at the garden fence' as integral aspects of an overall management program for environmental weeds. Certainly, we need to direct an increased level of resources at the formidable task of managing the environmental weeds we already have that are invasive 'in the bush', but I also firmly believe that, at the same time, we need to direct some resources to trying to manage the next wave(s) of environmental weeds before they reach the bush. To do that, we need to consider weed management at all three stages along the invasions pathway.

WEED MANAGEMENT 'AT THE BORDER'

As one who sat through most meetings of the Australian Weeds Committee for 20 years or so, I am aware of how much progress has been made on the issue of stricter and more rational quarantine barriers for import to Australia of plants that could become invasive. From 86P to the 'Hazard' scheme to the present Weed Risk Assessment system (WRA) instituted in 1997 (Pheloung 2002), Australia has made significant progress by international standards. But when I read statements such as 'The 2916 permitted genera include thousands of known weedy plant species but these plants are not required to undergo any kind of weed risk assessment and can be imported into Australia without impediment' (Spafford Jacob *et al.* 2004), I believe we still have much further to go in the continued refinement of border management. I agree with the same authors when they write 'This substantial weakness undermines both the intent and purpose of the Permitted List and Weed Risk Assessment system'.

As of December 1, 2003, Schedule 5 (Permitted Seeds List) of the *Quarantine Proclamation 1998* allows the legal importation of numerous known weeds, including some that are closely related to four Weeds Of National Significance (WONS), without undergoing a WRA (Spafford Jacob *et al.* 2004). At the species level, material of two WONS – bridal creeper (*Asparagus asparagoides* (L.) W.Wight) and parkinsonia (*Parkinsonia aculeate* L.) – can still be imported legally. At the generic level, in the case of *Rubus* for example, this permission for legal introduction includes 69 species (about 30% of the total number of species in the genus) that are already known weeds in other parts of the world. Only 10 species are prohibited entry to Australia (the ones that are already here?). For the genus *Cytisus*, only Scotch broom (*C. scoparius* (L.) Link) is prohibited entry, with 32 species allowed legal entry, of which at least two are known weeds outside Australia.

When living and working in southern France some years ago, I saw plants of Portuguese broom (*Cytisus striatus* (Hill) Rothm.) spreading from roadside plantings, for which it had been deliberately introduced. The same species has been introduced to California where it is a serious environmental weed in that it displaces native plant species and produces toxic seeds (Bossard *et al.* 2000). With this information on *C. striatus,* plus the facts that its congener is a WONS in Australia and that *C. multiflorus* (L'Hér.) Sweet is beginning to invade bushland from landscape plantings in central Victoria, do we really need other species in the genus *Cytisus* to be imported and sold to unsuspecting home gardeners or for use in uninformed roadside re-vegetation programs? There are many other generic groups highlighted by Spafford Jacob *et al.* (2004) if you wish to find out more about this alarming situation.

I conclude that, while there has been significant progress made over the last 20 years in closing the border to the entry of many invasive plants, there is still a long way to go. Spafford Jacob *et al.* (2004) make five recommendations to further improve the system, of which the immediate removal of all permitted genera seems to have the greatest potential to reduce the entry of new and future environmental weeds. That is, each species not previously imported should go through the WRA process before it is legally allowed across the border and thus be made available for sale by nurseries and other importers. Only when every species in a genus has undergone a WRA and all are

permitted entry should an entire genus be added to a Permitted List for Australia. Our 'front door' is indeed still wide open to the legal importation of many known major weeds. What I regard as progress over the last 20 years is really only a slight closing of the door at the border. Furthermore, of the twenty case studies permitted entry as described by Spafford Jacob *et al.* (2004), half are potential environmental weeds.

WEED MANAGEMENT 'AT THE GARDEN FENCE'

Many of the first known plant introductions to Australia were deliberately introduced woody plants – partly for their utilitarian value to provide food for the early European settlements and partly, presumably, because they were better able to survive the long sea voyage from Britain than were herbs, although some species with long-lived seeds were also early imports. This early trend has continued, as Mulvaney (1991) showed from his analysis of early nursery records for four Australian cities. Kloot (1987) provided strong evidence for the predominance of deliberately introduced ornamental plants in South Australia's naturalised flora, a trend that has continued even more recently (Groves *et al.* 1998). The deliberately introduced horticultural component of Australia's naturalised flora now represents about two thirds of the total number of species and includes many serious environmental weeds.

For the flora of Auckland, New Zealand, Esler and Astridge (1987) assigned numbers of naturalisations to definite periods of time since European settlement for different classes of introductions to that urban region: namely, accidental, horticultural and agricultural plant introductions. They showed that the number of naturalised species deliberately introduced for horticulture increased proportionally with time, as well as in terms of absolute numbers. By 1987 this sub-group constituted an increasingly higher percentage of all naturalisations than for the earlier four periods dating back to 1840. Although there are no strictly comparable data for Australia, Mulvaney's (1991) analysis showed that, while three quarters of the woody plants recorded as growing in early Sydney (up to 1810) were introduced economic plants that could be used for food, medicine, dye or building materials, the proportion of ornamental woody plants that became environmental weeds after their naturalisation increased with time.

What is the present situation in Australia? As a result of recently completed studies of Australia's naturalised flora, we know that, of a total of about 2750 naturalised species (Groves *et al*. 2003), 1037 are invasive or potentially invasive garden plants (Randall and Kessal 2004), 429 are declared noxious and/or being controlled to some degree (Groves *et al.* 2003), 28 are on a national Alert List (DEH 2004) for urgent attention and possible eradication, and 20 are Weeds Of National Significance (WONS). A further 41 species are targeted by the Northern Australia Quarantine Strategy (NAQS) for exclusion from northern Australia. Many species in these different categories are weeds of horticultural origin, for example 10 of the 20 WONS. The ornamental horticultural industry has been responsible in the past for many of Australia's present environmental weeds, a situation that predates the first quarantine proclamation in 1908. For instance, Mulvaney (1991) cites privately-owned nurseries as first operating from the 1830s in Sydney, from the 1840s in Adelaide and from the 1850s in Melbourne, although their catalogues are not always available today.

I have thus far summarised the situation at present and as it arose concerning the origins of many of Australia's worst environmental weeds. Apart from further limiting at the border the introduction of known environmental weeds coming from other regions (see earlier), what can be done currently that will limit the number of potential environmental weeds being planted in gardens in the future?

One answer is to draw the attention of legislators, the nursery industry, landscape architects and home gardeners to which major weeds are still available for sale, as indicators of what is still being grown in gardens. Roush *et al.* (1999) nominated 52 species of garden plants for voluntary withdrawal from sale in co-operation with the Nursery Industry Association of Australia, but these nominations were never agreed to by all nurseries in each state or territory and little progress was made on the withdrawal from sale nationally of these major weeds. For example, 60% of those 52 'garden thugs' are still for sale by nurseries (Glanznig pers. comm.).

A more recent national analysis (Groves *et al.* 2004) was based on an up-to-date listing of 720 naturalised invasive and potentially invasive garden plants (Randall 2001, Randall and Kessal 2004) and their availability for sale by nurseries as indicated by Hibbert (2002). Results of the analysis showed that:

1. the ten most invasive species sold currently by nurseries in Australia are asparagus fern (*Asparagus scandens* Thunb.), hybrid mother of millions (*Bryophyllum daigremontianum* (Raym.-Hamet & H.Perrier) A.Berger. × *B. delagoense* (Eckl. & Zeyh.) Schinz), broom (*Cytisus* spp.), gazania (*Gazania* spp.), glory lily (*Gloriosa superba* L.), Japanese honeysuckle (*Lonicera japonica* Thunb.), fountain grass (*Pennisetum setaceum* (Forssk.)

Chiov.), sweet pittosporum (*Pittosporum undulatum*), pepper tree (*Schinus molle* L., syn. *S. areira*) and periwinkle (*Vinca major* L.);
2. many other major weeds were nominated for individual states, territories or regions that are all available for sale currently by nurseries;
3. 195 species of invasive garden plants are declared noxious by Australian states and territories, 83 (43%) of which are available for sale;
4. 4 (14%) of the total of 28 species on the national Alert List are available for sale;
5. 5 (25%) of the total of 20 WONS are available for sale; and
6. none of the 41 species targeted by NAQS is available for sale.

The earlier voluntary suasion of the nursery industry as advocated by Roush *et al.* (1999) failed nationally, although not in the ACT where eventually and with an impressive degree of persistence, such a method succeeded (Butler 2004). By drawing the attention of legislators and the public to the present alarming situation on the current availability for sale of acknowledged major weeds, I hope that the national problem can be ameliorated somewhat and the number of known environmental weeds able to move beyond the garden fence in the future can be reduced.

The continuing linear increase in the rate of naturalisation (Specht 1981, Groves *et al.* 1998) shows that many future environmental weeds remain in people's gardens awaiting an opportunity to jump the fence or have their fruits dispersed beyond the fence by birds. Public education programs and 'weed swap' schemes (in which known garden weeds are swapped for non-invasive native alternatives) must be put in place nationally to complement the much-needed federal legislative changes to prohibit the continuing sale of known weeds. A start has been made in this direction by instituting Bushland Friendly Nursery Schemes in co-operation with nurseries at both local (e.g. Ipswich, ICC 2004) and regional (e.g. North Coast NSW, Anon. n.d.; Hawkesbury-Nepean NSW, Anon. n.d.) levels. These recent moves represent progress in managing weeds at the garden fence. Only when such a system is in place nationally, however, will the future number of environmental weeds be able to be reduced and their combined impacts on Australia's biodiversity thereby be reduced.

WEED MANAGEMENT 'IN THE BUSH'

We can consider biodiversity at three levels – at the level of population genetics within a species, at the species-species population level and at the plant community level. I'm not going to say much about the first level because it basically involves genetic considerations about which I know little. I will, however, give one example of what I mean.

Weeds as threats to genetic diversity The small daisy *Rutidosis leptorhynchoides* was once a common component of natural grasslands both to the west of Melbourne and those around Canberra on the Southern Tablelands of New South Wales. The patches of these grasslands that remain are currently much modified floristically by previous grazing and nutrient regimes and by weed ingress of, especially, non-native perennial grasses such as serrated tussock (*Nassella trichotoma* (Nees) Hack.) and African lovegrass (*Eragrostis curvula* (Schrad.) Nees). In these modified grasslands, some of the dominant native perennial grasses remain, e.g. kangaroo grass (*Themeda triandra* Forssk.), but the 'functional group' that is most threatened by weeds is the group of dicotyledonous herbs including *R. leptorhynchoides.*

Within this one species, there is a group of populations in south-western Victoria and some locally around Canberra that differ genetically (Young *et al.* 1999). The species presumably has become extinct from a number of sites (including the one at St. Albans that I worked on as a Ph.D. student, Groves 1965) and is in low numbers at many of its remaining sites. Because of these low numbers it was listed as a ROTAP species, i.e. Rare Or Threatened Australian Plant (Briggs and Leigh 1988). It follows that it will be important not just to conserve *Rutidosis leptorhynchoides* as a species but also to conserve the range of genetic variability shown by the different populations of this small herb. This species thus provides an example of genetic diversity shown by populations within the one native species that is being threatened currently by weed ingress.

Weeds as threats to endangered native plant species Groves and Willis (1999) presented information on the impacts of the weed bridal creeper (*Asparagus asparagoides*) on a population of each of two endangered native plant species, namely the sandhill green-hood orchid (*Pterostylis arenicola*) and the small shrub *Pimelea spicata*.

The sandhill green-hood was once a component of semi-arid low *Callitris* woodland in South Australia. Currently, there are only three populations of the species known, one of which is near Tailem Bend. At this site an average density of 40 orchids m^{-2} was measured in the absence of bridal creeper and only 10 m^{-2} in the presence of bridal creeper (Sorensen and Jusaitis 1995). It is likely that this strong negative impact on numbers of orchid arises because both species actively grow from a tuberous rootstock over autumn and winter and both also fruit and senesce during spring and

summer at the site. These similarities in growth and development complicate the management of bridal creeper, because the opportunities to apply herbicide without affecting the orchid are limited. However, in a recently commenced program of biological control, the release of a rust (*Puccinia myrsiphylli*) specific to bridal creeper may gradually lessen the negative impact of the weed on orchid numbers in the medium to longer term, and hence allow for population recovery at this site.

Pimelea spicata was once widespread over the region to the southwest of Sydney, but habitat fragmentation now restricts it to about 25 separate populations on the Cumberland Plain and a few along the Illawarra coast. The species is in danger of extinction unless adequate strategies for its conservation are initiated soon (Briggs and Leigh 1996). On the Illawarra coast, *P. spicata* is threatened primarily by invasion of bitou bush (*Chrysanthemoides monilifera* (L.) Norl. subsp. *rotundata* (DC.) Norl.) and Kikuyu (*Pennisetum clandestinum* Hochst. ex Chiov.) (Matarczyk *et al.* 2002). On the Cumberland Plain, localised remnant populations of *P. spicata* are threatened by competition from several bird-dispersed environmental weeds; in the remnant containing about one-quarter of all remaining individuals of *P. spicata,* bridal creeper is again the threatening weed. At the latter site, near Camden, bridal creeper currently co-occurs with about 60% of the *P. spicata* adults (A.J. Willis pers. comm.), completely smothering some and occurring at relatively low densities alongside some others.

Below ground, bridal creeper competes with *P. spicata* in a sustained way for nutrients, water and 'space', even after the shoot canopy of bridal creeper has died back in late spring. Indeed, preliminary evidence that the presence of bridal creeper roots, irrespective of shoots, limits the germination of *P. spicata* (A.J. Willis pers. comm.) implies that the relative impact of root competition in this case may be greater than that of shoot competition, especially at early stages in the life history of *P. spicata.* Control methods for bridal creeper that limit formation of new tubers and shorten the longevity of existing ones will reduce the threat posed at all sites, but only if they operate in the medium or longer terms, e.g. by the release of the slow-acting rust for biological control mentioned earlier. Information on the impacts of various other management methods, e.g. herbicide application, fire, soil disturbance and clearing, on both species will also be necessary before effective threat abatement plans can be developed for the species *P. spicata* endangered by bridal creeper invasion.

Weeds as threats to natural ecosystems I have elsewhere (Groves 2002) shown that while weed impacts on biodiversity at the ecosystem level are overwhelmingly negative, they can also be neutral (no impact) or even positive, depending on the taxonomic group(s) considered. These three different types of impacts applied both to tropical sedgelands invaded by mimosa (*Mimosa pigra* L.), as shown by Braithwaite *et al.* (1989) and to arid riverine vegetation invaded by tamarisk (*Tamarix aphylla* (L.) H.Karst.) (Griffin *et al.* 1989). I wish now to show that the same diversity in response holds for coastal vegetation invaded by bitou bush, based on recent information in Gosper (2003) and DEC (2004).

Bitou bush was accidentally introduced to Stockton in eastern Australia in ballast (Gray 1976). When it was observed to be an effective sand-binder of the eroded dune system at Stockton Bight, north of the port of Newcastle, it was deliberately re-planted along the coast of New South Wales wherever sand dunes were seriously eroded or had been mined for heavy minerals. From these earlier plantings bitou bush has spread, mostly by bird-dispersal, to currently occupy approximately 80% of the coastline of New South Wales (Thomas and Leys 2002).

From this description of the pattern of spread of bitou bush along the New South Wales coast it is apparent that a positive impact of the weed is its ability to bind sand masses in eastern Australia in the same way it does naturally on the east coast of South Africa. Two other positive impacts are that its fleshy fruits provide a food source for native frugivorous birds in autumn/winter at a time when few native plant species are in fruit (Gosper 2003), and the abundance of the insect group Collembola is increased at invaded sites (French and Eardley 1997). Bitou bush seems to have no known impacts on species richness of the avian community – a neutral impact. On the other hand, the negative impacts of bitou bush are many and account for its present status as a WONS and its listing as a Key Threatening Process under the New South Wales *Threatened Species Conservation Act 1995.* Bitou bush impacts negatively by providing fruit in winter for introduced frugivorous birds, such as house sparrows (*Passer domesticus*) and common starlings (*Sternus vulgaris*), and there are fewer birds overall, especially insectivorous ones, in the canopy and understorey of invaded vegetation (Gosper 2003). Invasion by bitou bush is known to threaten populations of the two native plant species *Glycine clandestina* (the broad-leaf population) and *Zieria smithii* (the low-growing population), as well as threatening 11 plant species (DEC 2004). For example, the endangered plant species *Zieria prostrata* is known to occur only in grassy heath on

four coastal headlands north of Coff's Harbour, NSW, where bitou bush plants shade individual *Z. prostrata* plants. Although the immediate threat of continuing weed invasion has been alleviated to some extent by local community programs of hand-weeding, bitou bush (and lantana) still pose a serious threat to the four occurrences of this threatened native plant species.

Four native plant communities are threatened by bitou bush invasion, among other factors. They are Eastern Suburbs Banksia Scrub, Kurnell Dune Forest, Sutherland Shire Littoral Rainforest in the Sydney region and, more generally, Littoral Rainforest widely distributed along the NSW coast (DEC 2004). The latter vegetation type contains elements of both subtropical and dry rainforests, with a high diversity of plants and animals, including many rare and threatened species, as well as providing habitat for many migratory and nomadic animals (DEC 2004). Other coastal vegetation types, such as the grassy heaths that occur on the coastal headlands in which *Z. prostrata* occurs, are also probably at risk in the future from invasion by bitou bush and other weeds.

Earlier evidence for the predominance of negative impacts of two major weeds on various measures of biodiversity is thus further supported by the example of bitou bush invading coastal vegetation in New South Wales, although we also acknowledge that environmental weeds have some positive and neutral impacts on biodiversity (Groves 2002). In other words, there are many 'losers' but also some 'winners' as a result of environmental weed invasion (Low 2003). I remain surprised that similar detailed studies on biodiversity impacts attributable to invasion by other major environmental weeds, including other WONS, are not yet available (see also Adair and Groves 1998).

CONCLUDING DISCUSSION

I have presented some personal perspectives on weed management at three stages along the invasions pathway from the stage before introduction of plants to Australia (at the border) to their deliberate introduction to cultivated gardens and re-vegetation plots (at the garden fence) through to the naturalisation of plants in natural vegetation remnants, national parks and nature reserves (in the bush). Significant progress in weed management over the last 10 or more years has been made at each of these stages of the invasion process I believe, even if I have concentrated on some of the remaining problems. In my opinion least significant progress has been made in understanding the transition from a horticultural introduction growing in a garden to a naturalised plant in the bush and the factors governing that transition. It heartens me to see that this latter transition is now receiving some much-needed attention and some small attempts to reduce the future numbers of plants effecting this transition have commenced recently.

In conclusion, I present seven recommendations to reduce the future numbers of species moving between the different stages along this invasion pathway.

At the border

1. All genera should be removed from the Permitted List immediately.
2. A review of the Permitted List should be undertaken as a matter of urgency.

Both these recommendations are taken directly from the report of Spafford Jacob *et al.* (2004) discussed earlier. The fact that a large number of plant species known to be invasive outside Australia can still be legally introduced without undergoing a Weed Risk Assessment is against the national interest. If Mr Field, a farmer near Wagga, could correctly predict in 1917 that skeleton weed would become a major problem in cereal growing regions, I am equally certain in predicting that many of the species that are known weeds elsewhere, such as *Cytisus striatus* referred to earlier, will eventually become invasive in Australian natural ecosystems if they continue to be allowed entry at the border. How can such permission continue to be justified in 2004?

At the garden fence

3. The few local and regional partnerships existing at present between weed managers and nurseries to prevent the continuing sale of plant species known to be invasive be further encouraged and widened to state and national levels.
4. The sale of 10 species – asparagus fern (*Asparagus scandens*), broom (*Cytisus* spp.), glory lily (*Gloriosa superba*), hybrid mother of millions (*Bryophyllum daigremontianum* × *B. delagoense*), Japanese honeysuckle (*Lonicera japonica*), pepper tree (*Schinus molle,* syn. *S. areira*), periwinkle (*Vinca major*) and sweet pittosporum (*Pittosporum undulatum*) – be prohibited nationally.

These are the 10 species that have been identified recently by weed scientists as the most invasive species still for sale by nurseries in two or more states or territories (Groves *et al.* 2004).

5. As community awareness is increased by horticultural journalists, nursery staff and weed scientists working together, other known weedy species be added progressively to a future national list of species prohibited for sale.

After all, if seed of a certain purple-flowered cottage garden plant had not been available for Mrs. Paterson of Albury to plant in her garden adjoining a travelling

stock reserve, then *Echium plantagineum* L. may not be such a 'curse' today to graziers and, increasingly, to managers of biodiversity in remnant bushland.

In the bush

6. Bushland areas adjoining peri-urban settlements in Australian cities be actively and regularly searched by experienced botanists to detect and eradicate newly naturalised plant species that have 'jumped the garden fence'.

A start has been made by Program 1 of the CRC for Australian Weed Management in devoting resources to searching the edges of the Blue Mountains National Park where they abut peri-urban housing developments and communication lines. There remains an urgent need to do the same for other Australian cities.

7. Biological control programs for Australia's major weeds be granted long-term funding as a matter of priority and be integrated with other methods of control to minimise the on-going negative impacts of those weeds on biodiversity.

The major environmental weeds now present in Australia's natural ecosystems have all been introduced, cultivated, become widely naturalised and are currently invasive. A few of them are known to be having negative impacts on Australia's biodiversity. What can be done to minimise these negative impacts? The formulation of national management strategies to integrate different methods of control is basic to reduce the impact of such weeds. A start has been made in this regard for the 20 WONS and the two CRCs' lists of candidate weeds. Those for environmental weeds necessarily rely heavily on biological methods but the deleterious effects of introduced insects and fungi on weed growth and development must be complemented by other methods of control. Such integration of different methods of control should do much to increase the stability of the invaded ecosystem and thereby render it less likely to re-invasion by the same or other weeds (Groves 1989). The latter is one of the major research challenges for weed scientists in the 21st Century.

Consideration of the impact of weeds on ecosystems is made more complex by the fact that the same species may affect both natural and agricultural ecosystems. This paper has concentrated on the weeds impacting natural ecosystems that we call 'environmental weeds'. Blackberry (*Rubus fruticosus* agg.) is a major environmental weed, but also a major weed of southern Australian pastures. Furthermore, blackberry is strongly weedy in the establishment phase of forest plantations and after fire. When the weediness of St John's wort (*Hypericum perforatum* L.) was first recognised, it was as a weed of dairy pastures. Land use changed as a result of this early status from pasture to plantations of *Pinus radiata* D.Don in some regions. Currently the same species occurs mainly in natural ecosystems and on roadsides, along which it spreads, although it continues to be a weed in pine plantations.

From these two examples (and there are many others able to be cited), it becomes clear that the distinction between weeds in natural and agricultural ecosystems is far from rigid, and many widespread weeds may affect and impact both ecosystems. What's more, their relative impacts on each system – whether negative or positive – may change with time and land use.

This contribution started with some personal associations with Wagga. The Riverina landscape surrounding Wagga is a mosaic dominated by cropping land in which one introduction of skeleton weed had first taken hold by 1917. Fifty five years later that one infestation was estimated to cost $20 million (Marsden *et al.* 1980). But as well as cropping land I remind you that the mosaic also includes bushland remnants, corridors of riverine vegetation, and home and public gardens. And in all of these components of the landscape mosaic, people live and work as well as garden and travel and bushwalk and recreate in general. Different weeds will impact strongly on all these elements of the peopled landscape in different ways and there will be movement of propagules between these different but inter-connected segments of the landscape. The boundaries between environmental and agricultural weeds are becoming increasingly blurred in practical weed management systems. It seems to me that now is the time to do away with such boundaries in thinking and funding, and especially those existing at federal and state government levels of bureaucracy, in the hope that the impacts of weeds at all levels – at the border, at the garden fence, in the bush and on the farm or at the catchment level – are better managed and their future impacts on people and the Australian landscape are minimised.

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