

Weed introductions: what has been learned from the past that can help stop future weed problems?

Lynley Stone

Department of Conservation and Land Management, Western Australia

Cooperative Research Centre for Plant-Based Management of Dryland Salinity

Cooperative Research Centre for Australian Weed Management

Abstract

Australia has long history of exotic plant introduction, but the last 200-300 years has seen a dramatic rise in exotic species naturalisation. Of the estimated 27,000 introduced plant species, approximately 3,480 are considered weeds, and 954 of these are weeds of agriculture. Several relatively recent efforts have been made to prevent the introduction of further high-impact weeds, and these are discussed at the Border and Post-Border level, and from an industry perspective. Suggestions for areas of improvement are made, and candidates for future weed species are identified.

Introduction

The introduction of exotic plant species to Australia has occurred for many thousands of years. However, the number of species introduced greatly increased with European discovery and settlement in the 1700s. For example in South Australia, over 900 species have naturalised in less than 200 years, compared to an estimated 60 species in the several million years prior (Kloot 1991). The last 200-300 years has seen mass global movement of plant species (Low 2002), the impact of which we are yet to fully witness and understand.

Australia currently has an estimated 27,000 introduced plant species, of which 3480 are considered weeds (Virtue *et al.* 2004). If there were no weeds in agricultural systems, producers and consumers would be an estimated \$4 billion dollars per annum richer (Sinden *et al.* 2004).

Origin of Australian agricultural weeds

Of the 954 known agricultural weeds, 26 have originated from the food crops sector, 159 from the pastures sector, 660 from the gardening sector, and 84 from accidental introduction, usually as contaminants of grain, fodder, ballast, packing or livestock (Virtue *et al.* 2004).

Many serious agricultural weeds were introduced from all around the world into Australia in the 1800s or early 1900s (Table 1). Early European explorers and settlers brought with them an enormous selection of plant species, purposely or inadvertently, the impact of which we are still realising two centuries later. Botanists were recording weed species in the Sydney area as early as 1802-1804, and *Marrubium vulgare* (horehound) and *Arctotheca calendula* (capeweed)

were dominating landscapes in Tasmania and South Australia in the 1850s and 1860s (Low 1999).

In more recent times, agricultural weed species have continued to enter Australia as contaminants of agricultural products, and purposely for ornamental or medicinal uses. Many species introduced as potential pastures have also become weeds, mainly as environmental rather than agricultural weeds. *Eragrostis curvula*, which is now a declared species in Tasmania, South Australia and New South Wales, was introduced as a potential pasture species and soil stabiliser. The palatable variety 'Consul' is a valuable pasture species in some areas, and is used successfully to control spiny burrgrass (*Cenchrus incertus* and *C. longispinus*) (Bennett and Virtue 2004), however the other unpalatable lines are serious agricultural and environmental weeds.

Learning from past mistakes

The cost of weeds to the Australian economy and environment was recently quantified (Sinden *et al.* 2004) but has been known to be significant for many decades. Awareness of invasive species has also increased globally, and Australia is now much more cautious regarding plant introductions. This is reflected in relatively recent policy changes described below.

Border control

An Australian Quarantine Act has been in place since 1908, which empowered the Australian Quarantine and Inspection Service (AQIS) to regulate the importation of all plant material into Australia. Prior to 1997, the importation of a plant species was permitted provided the species was

Table 1 Weed species common in NSW pastures (mostly from Dellow *et al.* 2002). Country of origin, year of introduction to Australia and purpose for introduction reference from Groves *et al.* (1995), Panetta *et al.* (1998), Muylt (2001), Cocks (1976).

Species	Common name	Country of origin	Year introduced	Purpose for introduction
<i>Bromus diandrus</i>	Annual brome grass Great Brome	Eurasia - Mediterranean	1875	Most likely contaminant of ballast, seeds, forages, livestock
<i>Carduus nutans</i> <i>ssp. nutans</i>	Nodding thistle	Europe, Asia, North Africa, Siberia	1950	Seed contaminant
<i>Carthamus lanatus</i>	Saffron thistle	Mediterranean, Western Asia	Probably 1860s	Possibly medicinal, contaminant of fodder or seed
<i>Echium plantagineum</i>	Paterson's curse Salvation Jane	Western Mediterranean (Spain, Portugal, Morocco)	1850s 1917	Ornamental Seed contaminant
<i>Eragrostis curvula</i>	African lovegrass	South Africa	Unknown	Pasture and soil stabilisation
<i>Hordeum spp.</i>	Barley grass	Europe, Western Asia, North Africa	Prior to 1848	Unknown, possibly in fodder or livestock
<i>Hypericum perforatum</i>	St John's wort	Eurasia, North Africa	1904 1957	Ornamental Medicinal
<i>Hypochaeris radicata</i>	Catsear, flatweed, false dandelion	Europe	Likely pre-1866	Most likely ballast contaminant
<i>Nasella trichotoma</i>	Serrated tussock	Peru, Chile, Uruguay, Argentina	Early 1900s	Most likely agricultural contaminant
<i>Rubus fruticosus</i>	European blackberry	Europe	Early 1800s	Garden (fruit), hedgerows
<i>Vulpia bromoides</i> <i>Vulpia myuros</i>	Squirrel tail, Rat's tail fescue, Silver grass	Western Mediterranean, SW and central Europe	1886	Possible ornamental, contaminant of ballast, forage, livestock

not on the 'Prohibited List', a list of known weed species. Recognising that significant new weed species were still entering Australia, a new approach was developed, and a 'Permitted List' approach was adopted by AQIS in 1997.

This approach is a three-tiered screening process (Walton 2001).

Tier 1 is the identification of the species, referring to lists of prohibited and permitted species, and determination of its Australian distribution. If the species is on the permitted list, it is allowed entry to Australia, and does not proceed through the second and third tiers. If the species is widely distributed in Australia and not under official control (i.e. not a declared species in any State), it is also permitted. International trade agreements forbid the exclusion of any species from Australia if it is already present and not a quarantine pest. It is for this reason that certain (undeclared) weed species found in Australia can still be imported.

A grain import contaminant list is also consulted, which describes weed seeds for which AQIS have a nil tolerance in grain shipments.

If the species of interest not appear on any of the above lists, it proceeds to Tier 2 of the screening process, which is a weed risk analysis (Walton *et al.* 1999). This is a pre-entry analysis to determine the risk of the species becoming a weed in Australia. The weed risk analysis consists of 49 questions concerning the history, biogeography, biological and ecological attributes of the species. The answers generate a score which corresponds to an outcome of high or low weed risk, or of a 'further evaluate' assessment where the weed risk is still not certain. If a minimum number of questions are not answered, the outcome is also 'further evaluate'. Species deemed as low weed risk are added to the Permitted List, and importation into Australia is allowed. Species of high weed risk are not permitted entry to Australia. Species in the further evaluate category undergo Tier 3 of the screening process.

Tier 3 of the screening process enables more information on a species to be collected to better estimate the potential weed risk to Australia. This may be through a wider literature search, quarantine glasshouse trials, or field trials overseas to collect more data. Currently, there are no formal protocols

for assessing Tier 3 species; therefore these species are, by default, prohibited entry to Australia. A recent review of the Border screening process recommended that Tier 3 protocols be developed as originally envisaged in 1997.

Post-border

Post-border, the level of assessment on whether species should be permitted entry to individual States or Territories varies between jurisdictions. Western Australia and Tasmania use the Australian Border system to determine the weed risk to their States. As a consequence, there are several species that are permitted in Australia, but are not permitted entry into Western Australia and/or Tasmania. Some states, such as Victoria and South Australia, implement a prioritising weed risk assessment process where weeds are ranked in terms of priority for control or eradication, however this does not stop the movement of non-declared species into or around the State. Fortunately, a national protocol for post-border weed risk management has been developed, and will be published soon by Standards Australia (Virtue *et al.* in press). This will assist States/Territories in developing weed risk assessment processes that are consistent with other states, and provide some protection from potentially invasive species from within Australia.

A changing culture

Industries involved in exotic plant importation are becoming increasingly aware of the weed risk issues surrounding new plants, thanks to efforts from individuals and organisations such as the Cooperative Research Centre (CRC) for Australian Weed Management. Historically, scientists and horticulturalists could import species quite freely to test for potential uses in pastures, crops and the gardening sector. However, it is now viewed that these groups have a duty of care not to import species that will become serious pests. The CRC for Plant-Based Management of Dryland Salinity is incorporating weed risk analyses into their research programs to ensure that species of high weed risk are not promoted in the wider community. Trial site hygiene will be improved so that abandoned trials sites, such as those investigated by Emms and Virtue (2005), will no longer contain persistent species that can escape from former trial plots. The nursery and garden industry is also beginning to improve its awareness of weed risk and take steps to minimise sale of weedy garden plants.

Many useful and valued pasture species are serious weeds of the environment, just as many highly prized garden plants are serious pests of agriculture. Put simply, a weed is a plant that is unwanted in a

particular time and place, and therefore there will always be debate about what is a weed species and what isn't. Conflicts of interest will remain, but strategies can be employed to minimise impacts, such as developing Codes of Practice (eg the Code proposed by the (now disbanded) Northern Australian Pasture Plant Evaluation Committee for evaluation and release of pasture plants) (Anon. 2005). Bennett and Virtue (2004) suggested conflicts between weedy economic plants in Australia could be resolved by:

- i) having a standard assessment for weed risk, utility and feasibility of management;
- ii) developing, implementing and monitoring weed risk management guidelines; and
- iii) improving our understanding of the attributes of high impact weeds.

Room for improvement

Although we have learnt a lot from the legacy of invasive species that our early European explorers and settlers left us, there is still much we can do to prevent new weeds from appearing and impacting on agriculture and the environment in the next 200 years. We may now have in place an effective means of screening exotic plants at the Australian border, but the true test of this system will take many decades. Many future weeds will come from movement of both native and exotic species beyond their natural or naturalised range (both intra and inter-state). There are many examples already, of Australian native species becoming weeds within Australia, such as several *Acacia* and *Pitiosporum* species growing beyond their natural distributions (Groves 2001; Low 2001). 'Sleepers' weeds that are currently limited in their distribution and impact due to a restricted genetic base, limited suitable habitat, limited opportunities for recruitment, low intrinsic population growth rate, absence of mutualists, or an incorrect perception of their invasiveness (Grice and Ainsworth 2003) may overcome these barriers and become more prominent. The effects of impending climate change on the distribution and impact of weed species is an area of increasing research, but it would be expected that certain species will increase their range of naturalisation, and others may not adapt to the changing environment.

The globalisation of commodity trading brings with it inherent risks of importing undesirable plant species. Contamination of grains, fodder or livestock has been a common route of importation of Australian agricultural weeds (Table 1), so it is vitally important that appropriate precautions are taken. AQIS continue to be vigilant in their screening, but it is also

important for the consumer or grower to be on the look out for any unusual plant species emerging.

Conclusion

Australia leads the world in taking a pro-active approach to assessing new plant species for weed risk. We hope that no new high-impact weeds will be introduced to Australia, but any predictive assessment system has its limitations because it is impossible to account for every ecological scenario and environmental condition. Post-border, we can be pro-active in preventing new weeds from emerging by:

- i) being cautious in introducing new plant species to an area, whether native or exotic.
The most cost-effective form of weed control is to avoid introducing the plant in the first place.
- ii) being vigilant.
Early detection is essential for eradication and control. The feasibility of eradication declines rapidly with increasing area of weed infestation (Panetta and Timmins 2004).

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