Some case studies of *Acacia* as weeds and implications for herbaria

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Abstract

A context for Australian *Acacia* species (wattles) as weeds is provided, both overseas and within Australia. Specific case studies from the western Victorian coast between Queenscliff and Torquay are used to illustrate some of the problems and challenges provided by weedy acacias, including confusion between indigenous and introduced species. Four species, one indigenous (*Acacia uncifolia*) and three introduced (*A. cupularis, A. cyclops* and *A. rostellifera*), are described and the reasons for their occurrence in the study area are investigated. Some key factors for the success of acacias as weeds are outlined. Possible implications for the future role of herbaria in assisting land managers to resolve weed issues are discussed and predictions about the changing role of herbaria in relation to weed issues are made.

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Introduction

There are a number of striking examples of Australian *Acacia* spp. occurring as weeds in other countries (New 1984). For example, Roux (1961) documents the introduction of *Acacia cyanophylla* Lindl. (now synonymous with *A. saligna* (Labill.) H.L.Wendl.) and *A. cyclops* A.Cunn. ex G.Don to the Cape Flats of South Africa for soil stabilisation in c. 1845 and their subsequent establishment and spread to the exclusion of other forms of vegetation by the 1890s. Both species are major environmental weeds in South Africa (Orchard & Wilson 2001b), although the impact of *A. saligna* has been reduced in that country following release of a genotype of the gall-forming rust *Uromycladium tepperianum* (Sacc.) McAlpine (Wood & Morris 2007).

There are 1381 described species of *Acacia sens. lat.* worldwide, 993 of these occur in Australia, most of which are now in the genus *Acacia sens. str.* (formerly *Acacia* subgen. *Phyllodineae*, synonym *Racosperma*) (Maslin 2004). Current data shows that 24 taxa of Australian acacias are naturalised in Victoria, ten of these are Victorian taxa naturalised outside their indigenous range, and a further three Australian species are incipiently naturalised in Victoria (Walsh & Stajsic 2007).

In this paper we compare four generally similar *Acacia* species occurring on the Victorian coast between Queenscliff and Torquay (an estimated total coast length of 28 km). One is an indigenous species in the study area, occurring in scattered remnant populations. The other three are introduced species from other parts of Australia that have become naturalised in the study area. These naturalised species have presented a number of problems in relation to their identification, status (indigenous or introduced) and management.

From late 2000 to 2002, staff at the National Herbarium of Victoria (MEL) received *Acacia* specimens, sent for identification from Barwon Heads and Torquay by collectors believing that they may be unusual forms of indigenous *Acacia uncifolia* (J.M. Black) O'Leary (previously *Acacia retinodes* Schltdl. var. *uncifolia* J.M.Black). During this process we became aware that two different species of *Acacia* were being mistaken for *A. uncifolia*, and at least one was being used in revegetation projects in the study area. Both species were known weeds in other places. In late

2004, a third similar *Acacia* was collected in the same area and sent to MEL for identification. Based on the South African experience noted above at least one of these species, *Acacia cyclops,* has the potential to create a 'weedy wattle' monoculture along the coast between Queenscliff and Torquay.

This paper does not aim to survey all acacias naturalised in the study area, but to focus on three introduced species that are superficially similar to *A. uncifolia* and to highlight issues common to many weed invasions. The presence of newly recorded weed species and their distinction from indigenous plants in the Victorian flora provides increasing challenges for botanists and land managers. This study documents in detail the steps and processes involved in the identification and assessment of three newly recognised naturalised acacias, and in doing so provides a general methodology for resolving some of the questions commonly arising from weed invasions. This methodology will be most suitable for application by botanists with access to herbarium-based resources and may form the basis for an increasing involvement in the resolution of weed issues by herbaria in the future.

Some authors use the terms 'indigenous' and 'native' as synonyms (Pyšek *et al.* 2004; Bean 2007). We consider it useful, at least in relation to this study, to distinguish between them. For the purposes of this paper, indigenous is defined as 'occurring naturally in a particular locality' and native is 'occurring naturally (indigenous) somewhere in Australia'. We acknowledge that these definitions may not adequately cover the concept of local provenance or genetic stock.

Methods

Fresh and dried plant material of *Acacia* species requiring determination was received by the National Herbarium of Victoria. The identifications of *Acacia cyclops, A. rostellifera* Benth. and *A. cupularis* Domin in the study area were completed using botanical literature, herbarium specimens and examination by *Acacia* specialists. A field trip was undertaken to the coastal area between Queenscliff and Torquay to collect voucher specimens of *Acacia uncifolia* and the weed species, and to assess the extent of the invasion of the weed species. The status (indigenous or introduced) of all acacias in this study was determined using herbarium specimens, distribution information and advice from *Acacia* specialists. An assessment of the means and timing of the introductions of the three naturalised acacias was made using various historical documents and communications with *Acacia* experts and people with relevant knowledge of the study area. Specimens of the three naturalised acacias were compared with all other specimens of these taxa held at MEL as part of our efforts to predict source localities and means of introduction. Morphological descriptions and distribution information was collated from relevant texts, specimens from the study area and other MEL specimens, and a table of key characters for differentiating the four species was created.

Results

Status – introduced or indigenous?

Acacia cyclops and *A. rostellifera* are not indigenous anywhere in Victoria, therefore the decision that they are introduced to the study area was straightforward. However, because indigenous populations of *A. cupularis* occur in western Victoria, some consideration was given to this species being indigenous in the study area. Except for a collection by A. C. Beauglehole of *A. cupularis* from Deep Creek, Torquay within the study area in 1983, no coastal populations of this species are known east of the South Australian border. Given that there are no coastal collections of *A. cupularis* in Victoria before 1983 the authors, in consultation with B. Maslin (Western Australian Herbarium) and M. O'Leary (State Herbarium of South Australia), decided that the plants at Deep Creek are most likely introduced. Except for nine seedlings observed at Ocean Grove following a fire in 2001, only a few well established individuals of *A. cupularis* have been observed by us in other parts of the study area, all occurring in highly modified sites. In addition, a number of old plants of *A. cupularis* were reported from bushland at Barwon Heads (B. Wood pers. comm.). We consider that all of these plants are most likely introduced, and at least some by deliberate planting.

The general morphology (mainly phyllode shape and size) of *A. cupularis* collections made by the authors from Queenscliff, Torquay and Ocean Grove in 2004 (MEL 2278496, MEL 2278498, MEL 2278499), was compared with all collections of this species from Western Australia, South Australia and Victoria held at MEL. No matches were obtained with specimens from Western Australia. The best matches, based on general morphology are with some specimens from South Australia and Victoria. Essential details of these collections are presented in Table 1. It should be noted that there are additional South Australian and Victorian *A. cupularis* collections in MEL that do not match the Queenscliff and Torquay collections. A young post-fire regenerated plant (MEL 2278497) from Ocean Grove has been excluded from morphological comparison because it has longer and broader phyllodes, which are likely to be juvenile characteristics. Based on our morphological observations, the source locality or localities of the Queenscliff and Torquay populations of *A. cupularis* are more likely to be in South Australia and/or Victoria.

Species descriptions

Acacia uncifolia (indigenous)

Acacia uncifolia is a bushy shrub or tree 5–10 m high. This species has narrow one nerved phyllodes, 30–65 mm long by 3–10 mm wide, with a hooked (uncinate) tip and mucro (Orchard & Wilson 2001a). Inflorescences are short racemes, usually with 3–10 pale yellow globular heads. Pods are linear, with slight constrictions between seeds, and are somewhat papery or leathery. Seeds are ¾ or more encircled by a red-brown to blackish funicle and have a creamy yellow aril at one end.

Acacia cupularis (introduced)

Acacia cupularis is usually a shrub 1–2.5 m high. This species has narrow phyllodes with a single nerve. The phyllodes are generally linear, straight and 30–70 mm long by 1–4 mm wide (Orchard & Wilson 2001a). As currently circumscribed, this species shows considerable variation in phyllode morphology. In the study area phyllodes are mostly 30–50 mm long by 3.5–6.0 mm wide, with a straight tip and mucro. Inflorescences are short racemes with only 2 or 3 globular golden heads in each. Pods are constricted between seeds and break readily at the constrictions. The seed is described by Orchard and Wilson (2001a) as having a small orange to red funicle/aril at one end of the seed, however in specimens from the study area the funicle/aril is brown.

Acacia cyclops (introduced)

Acacia cyclops is a shrub or small tree 1–6 m high. This species has narrow phyllodes with 3–4 distant main nerves. The phyllodes are 40–95 mm long by 6–15 mm wide (Orchard & Wilson 2001b). In the study area phyllodes are mostly 40–80 mm long by 5–11 mm wide, with a more or less straight tip. Inflorescences are short racemes with 1 or 2 globular golden heads. Pods are linear, not constricted between the seeds and quite

Table 1. MEL specimens of *Acacia cupularis* that are most morphologically similar to *A. cupularis* specimens from the study area.

MEL number	Locality	Collector	Date collected
Victoria			
1500511	Lochiel near Dimboola	Lowe, J.H.	24 October 1920
1500514	Dimboola	Lowe, J.H.	October 1920
523611	Victoria	Unknown	Unknown
2040703	Torquay-Barwon Heads Coastal Reserve	Beauglehole, A.C.	17 January 1983
South Australia			
2073884	?Mooroogoopa, possibly in the vicinity of Guichen Bay	?Schulzen, L.W.	July 1850
627607	c. 12km from Mount Hope toward Elliston, beside Lake Hamilton	Canning, E.M.	2 December 1982
2073876	Near Port Augusta	Giles, E.	1880
2073880	Yorke Peninsula	Tepper, J.G.O.	1879

thick and leathery. Seeds have a bright orange to red funicle/aril that completely encircles the seed.

Acacia rostellifera (introduced)

Acacia rostellifera is a dense shrub or small tree to 6 m high. This species has narrow phyllodes, with one or sometimes two nerves, 45–115 mm long by 3–17 mm wide (Orchard & Wilson 2001a). In the study area phyllodes are mostly 65–110 mm long by 5–10 mm wide, with a hooked (uncinate) tip and mucro. Infloresences are short racemes with 3–9 golden globular heads. Pods are constricted between the seeds and break readily at the constrictions. Seeds have a large orange funicle/aril at one end of the seed.

Distributions, history in the study area and means of introduction and subsequent spread

For all species the Australian distribution is given, and for the introduced species, a discussion of their discovery in the study area, notes on possible means of introduction and subsequent spread are provided.

Acacia uncifolia (indigenous)

This species is indigenous along the coast in Victoria in three main centres of distribution: Wilsons Promontory, the southern part of the Mornington Peninsula and the Bellarine Peninsula near Geelong to as far west as Point Impossible near Torquay. It is also found in coastal areas of South Australia on Kangaroo Island and the Fleurieu Peninsula, and on King and Flinders Islands in Bass Strait.

Acacia cupularis (introduced)

Acacia cupularis is indigenous in coastal and near coastal areas from Albany WA through South Australia to the Victorian border. Small populations also occur a considerable distance from the coast throughout its range including in western Victoria. A small naturalised population (of a different phyllode variant to the one in the study area) is known from Royal Park (MEL 2012013, MEL 2144434) in the Melbourne suburb of Parkville.

Sterile material of *A. cupularis* was collected at Deep Creek, Torquay by G. Stockton and sent to MEL in 1996 but remained undetermined until a flowering and fruiting specimen was collected by Stockton from the same locality in October 2000 (MEL 2156628). This collection was brought to MEL for confirmation of identification, prior to propagation for revegetation works. Stockton noted that the plants at Deep Creek were different from plants of *A. uncifolia* with which he was familiar. After thorough examination of *A. retinodes* specimens held at MEL a match for this specimen (Beauglehole MEL 2040703) was found in the herbarium incorporated as *A. uncifolia*. The Beauglehole specimen was collected in 1983 in the same area as the Stockton collection. However, it was noted that these two collections did not resemble other *A. uncifolia* specimens held at MEL and that the Beauglehole specimen was incorrectly determined. Subsequent examination in March 2003 by D. Murphy (MEL) and M. O'Leary (State Herbarium of South Australia) identified these specimens as *A. cupularis*.

In 2004, an additional population of *A. cupularis* was recorded from dune vegetation in the Buckley Park Foreshore Reserve on the south side of Collendina Caravan Park at Ocean Grove. In this area a fire in February 2001 had stimulated seedling germination of *A. cyclops, A. saligna* and nine individuals of *A. cupularis* (B. Wood pers. comm.). Large well established plants of *A. cupularis* are also present in Barwon Heads Caravan Park and on roadsides in Ocean Grove (B. Wood pers. comm.) and near Queenscliff, leading to speculation that this species was deliberately introduced for horticulture some years ago. It is not known if plants from the initial introductions of *A. cupularis* have been used as a seed source for indigenous revegetation in the mistaken belief that they were indigenous *A. uncifolia*.

Acacia cyclops (introduced)

This species is notably tolerant to saline soils and salt spray (Orchard & Wilson 2001b). It is indigenous in coastal and near coastal south-west Western Australia as far north as Leeman and east to the South Australian border. In South Australia it is found in disjunct localities on the coast as far east as the Yorke Peninsula. Populations on Kangaroo Island and east of Yorke Peninsula are probably introduced (Orchard and Wilson 2001b). At MEL there is a 1994 record (MEL 2021046) of a single plant in coastal dune vegetation at Narrawong, near Portland in western Victoria.

By the time it was first identified in the study area in 2002, *A. cyclops* had become well established at Barwon Heads, including on cliff-tops at The Bluff, where it occurs as a wind pruned shrub one to three metres high (Figure 1).

The 2001 fire in dune vegetation in Buckley Park Foreshore Reserve at Ocean Grove resulted in the germination of an estimated 1000+ seedlings of *A. cyclops*, presumably from soil-stored seed (B. Wood pers. comm.). In January 2002, M. Connell, a seed collector in the study area, contacted MEL regarding a suspected local form of *A. retinodes* with a conspicuous red funicle/aril encircling the seed. At this time he submitted to MEL three separate collections of this 'form' (MEL 2156625, MEL 2156626, MEL 2156627). These plants were determined by B. Maslin (Perth Herbarium) to be *A. cyclops*.

Deliberate planting for coastal dune stabilisation is a strong possibility for the initial introduction of *A. cyclops* to the area. *Acacia cyclops* has been used to stabilise coastal sand dunes overseas (Orchard & Wilson 2001b), most notably in Africa (where is has become a widespread weed), and it may have been recommended for a similar purpose by the Natural Resources Conservation League (NRCL) in Victoria (W. Chapman pers. comm.). However, *A. cyclops* does not appear on the list of species used for remedial works since 1967, to stabilise blowouts in the coastal dunes along the Barwon Heads to Torquay Road, including the area known as 13th Beach (Alsop 1984). It was listed in at least one nursery catalogue in the 1970s (Austraflora 1978) and recorded as present in a survey of public gardens in Melbourne published in 1990 (Shann 1990). Before *A. cyclops* was identified as naturalised at Barwon Heads it had already been spread by deliberate plantings in the area under the assumption that it was *A. uncifolia*.

Acacia rostellifera (introduced)

This species is indigenous to coastal areas of south-west Western Australia, from Shark Bay in the north to Israelite Bay in the east.

Acacia rostellifera was listed in at least one nursery catalogue during the 1970s (Austraflora 1978). In the 1960s and 1970s NRCL was growing and supplying a species listed as *A. cyanophylla* (Natural Resources Conservation League of Victoria c. 1970), Orange Wattle, now synonymous with *A. saligna*. At one time in its taxonomic history *A. rostellifera* was known as *A. cyanophylla* var. *dorrienii* Domin, leading us to speculate that the NRCL may have been supplying *A. rostellifera*. However, because the population of *A. rostellifera* recorded in this study is the first Victorian record, we consider that references to *A. cyanophylla* in the NRCL catalogues most likely refer to the more widespread *A. saligna*.

Acacia rostellifera was first noted as being naturalised in Victoria from two collections by B. Wood (MEL 2278502, MEL 2278503) at a section of 13th Beach known as 40W, made in October 2004. It had presumably been overlooked for many years despite occurring in an almost pure stand of over half a hectare (c. 90m x 70m, W. Chapman pers. comm.), near a major road. By this time the collector was familiar with the presence of weedy acacias in the Barwon Heads area and this population was suspected of being introduced. In Alsop's (1984) discussion of remedial works along the Barwon Heads to Torquay Road he described the planting in 1979 of 150 plants of *A. retinodes* (variety not specified) propagated from seed collected from a single tree growing on a sand dune in Torquay. We speculate that this planting may actually include at least some *A. rostellifera*. This is supported by the discovery of two fenced areas near the 40W carpark between Barwon Heads and Black Rock, one containing *A. uncifolia*, the other containing *A. rostellifera*, and both enclosing mature specimens housed within wire treeguards (B. Wood pers. comm.). It is not known if *A. rostellifera* has ever been collected and/or propagated from this site on the assumption that it was indigenous.

Discussion

Means and timing of introduction and spread of the three weedy species

Details of the introduction and subsequent spread of the three naturalised *Acacia* species in this study are probably impossible to confirm. Historical documentation of plantings is sparse and necessitates speculation of both means and timing of the initial introductions. The means of introduction has most likely been by deliberate planting for amenity or coastal sand-dune stabilisation. Nurseries specialising in Australian native plants for farms and gardens increased in prominence from about the late 1940s (Youl 1999) and as a result the range of native plants available to horticulture increased considerably from that time. The culture of enthusiastically bringing new native species into horticulture peaked in the 1960s and early 1970s (Elliot 2002) and is possibly the context for deliberate introduction of the species under study here. Examination of nursery catalogues and plant lists supports the idea that many more *Acacia* species became available in the 1960s and 1970s. It seems likely that native plant enthusiasts helped to bring many of these plants into gardens and other plantings at this time. We consider that one possibility is that the three weedy species discussed in this paper were introduced to the Queenscliff to Torquay coast concurrently by a native plant enthusiast. At the same time (1960s and 1970s) Australian native (seldom indigenous) plants were being promoted and used for large scale land rehabilitation projects (Thompson 1968); of the three species under study here *Acacia cyclops* is the most likely to have been introduced in this way.

A significant secondary means of introduction is the deliberate propagation and spread of one, two or all of these *Acacia* spp. by people believing them to be part of the indigenous flora of the area. A contributing factor to this is misidentification, viz., the belief that one, two or all of these *Acacia* spp. was the indigenous *Acacia uncifolia*. The enthusiasm for including this species in indigenous revegetation projects was, and still is, largely driven by its relative rarity and its depletion since European settlement. The indigenous plant movement, which has grown since the 1980s, is the context for this approach. In addition, other means of local spread are possible including vegetative spread by root suckers (*A. rostellifera*), seed dispersal by ants and birds, and via movement of soil and plant material.

Various land uses and disturbance factors on the coast between Queenscliff and Torquay would have facilitated weed invasion as well as necessitating remedial works (Alsop 1984), which have also contributed to weed invasion. A specific example is the construction of the Barwon Heads–Torquay road (cut and progressively sealed from 1936, W. Chapman pers. comm.), resulting in the loss of indigenous vegetation and large blow-outs of sand by 1966 (Alsop 1984). Sluiter (1964) reports that plantings of introduced Marram grass (*Ammophila arenaria* (L.) Link) had already occurred in this area prior to 1964.

Figure 1. *Acacia cyclops* growing on the clifftops at The Bluff at Barwon Heads. The dark green shrubs closest to the sea are *A. cyclops*. Photograph D. Murphy.

Some traits of these acacias that predispose them to weediness

It is generally recognised that there are intrinsic biotic factors that predispose some acacias to weediness (McDonald *et al.* 2001). It is perhaps less recognised that certain cultural factors also contribute to weediness. Examples of both are discussed below.

Many *Acacia* species have the ability to reproduce clonally via the production of root suckers. Suckers may form as a result of root disturbance, including during control efforts to physically remove plants. *Acacia rostellifera* has been observed in the study area spreading vigorously via root suckers. One horizontal 'runner' measured 12 metres in length and had produced 18 shoots (B. Wood pers. comm.). *Acacia cyclops* is also known to sometimes produce suckers (Bartle *et al.* 2002) but has not been observed to do so in the study area. However, it does produce low lateral branches to five metres long at The Bluff at Barwon Heads (B. Wood pers. comm.) and has been observed to produce adventitious roots where lateral branches have contacted the ground (T. Wood pers. comm.).

All three species are hard-seeded, enabling long-term viability of seed in the soil seedbank. One established *Acacia* plant may be surrounded by enough soil-stored seed to constitute a major weed invasion when germination conditions occur. This enables a potential weed to progress from an apparently benign state to an environmentally harmful one in a very short time span, as well as adding complexity to attempted eradication programs.

All three species grow naturally in sand in coastal locations, predisposing them to successful colonization in the study area. *Acacia cyclops* is tolerant to sea spray and highly saline soils and it has become naturalised elsewhere in coastal environments (Orchard & Wilson 2001b).

Acacias are popular in horticulture because they possess a number of desirable features, such as prolific flowers, attractive foliage and rapid growth, among others. These features have attracted attention to the genus by nurseries and gardeners and combined with a lack of caution, have led to the wide dissemination of many Australian species. Some of these have become weeds.

Many *Acacia* species are superficially similar in growth form, and vegetative and floral features. Positive identification often requires some specialised knowledge of the genus and the examination of phyllodes, bipinnate leaves, flowers, pods and seeds. The three weed species examined in this paper are superficially similar to an indigenous species in the study area, *Acacia uncifolia*, especially when only vegetative material is available. The similarity of indigenous

Table 2. A comparison of key identification characters for the four acacias in the study area.

Character	*A. cupularis*	*A. cyclops*	*A. rostellifera*	*A. uncifolia*
Number of main nerves on phyllode	1	3–4	1	1
Phyllode length (mm)	30–50	40–80	65–110	30–65
Phyllode width (mm)	3.5–6.0	5–11	5–10	3–10
Flower colour	golden	golden	golden	pale yellow
Number of flower heads in inflorescence	2–3	1–2	3–9	3–10
Pod	constricted and readily breaking between seeds	not constricted and not readily breaking between seeds	constricted and readily breaking between seeds	slightly constricted and not readily breaking between seeds
Funicle/aril	small brown funicle/aril at one end of the seed	bright orange to red funicle/aril completely encircling seed	large orange funicle/aril at one end of the seed	red-brown to blackish funicle ¾ or more encircling seed and creamy yellow aril at one end

plants to weed species is not often recognised as a factor contributing to weediness but we believe it may become more important in the future. For the three weed species studied in this paper it is a major reason why they have been overlooked as weeds in the area and why one of these (*A. cyclops*) has been deliberately spread.

Implications for herbaria and future directions

This study documents some of the ways herbaria already support the resolution of weed issues and forecasts a likely greater role in future. Essentially this role, as exemplified by the current study, involves the provision of weed identifications and information to clients who are directly involved in weed management. Opportunities also exist for herbaria, using existing expertise and data, to contribute to the relevant parts of strategic programs concerned with weed issues.

Herbaria are likely to receive more "is it indigenous or is it introduced?" enquiries from land managers, probably at an increasing rate. The continuing fragmentation of remnant vegetation, the close proximity of introduced plantings to remnants, and the interest in indigenous revegetation (especially at the local level) are all likely to drive this trend. Such questions are, and will continue to be, challenging for herbaria to resolve. The occurrence of hybrids between indigenous and planted species (e.g. suspected *Grevillea rosmarinifolia* A.Cunn. hybrids near Melbourne), the existence of non-indigenous provenance plantings close to indigenous remnants and/or plantings of the same taxon, e.g., *Lomandra longifolia* Labill. in Greater Melbourne (Duxbury 2005), and gaps in the documentation of both remnant and planted vegetation, all add complexity to the factors already outlined in this paper. Some of these questions will probably not be resolvable.

As the central repository for botanical specimens and information in a particular geographic area, state herbaria have a clear responsibility to adequately document the flora (including the ever expanding weed flora) of that area. When new weeds are found it is important for them to be correctly identified and for collectors to lodge voucher specimens. This will require significant levels of interest and effort by collectors, many of whom only collect plant specimens

Figure 2. *Acacia rostellifera* regenerating from prolific root suckers after removal of mature plants at 13th Beach. Photograph B. Wood.

on an ad hoc basis, and a clear acknowledgment of the associated benefits by herbaria, management agencies and their funding bodies. Voucher specimens enable identifications to be verifiable over time and updated in line with taxonomic changes. Associated information on the specimen labels (e.g. distribution, habitat, abundance and impacts) provides added value. Adequate information about a particular weed enables assessment of its potential impacts, and hopefully leads to sufficient allocation of resources and management actions. It also allows state herbaria to disseminate this information to government agencies and the general public. An important part of this is the recognition of spotting characters (such as those listed in this study, Table 2) that enable land managers and other local workers to identify weed species and differentiate them from indigenous species in their area. Practical information such as this can form the basis for educational material and other publications.

Early detection of new weeds is desirable to enable a rapid response by managers. This has the potential to save considerable time, money and resources used for weed mitigation. For example, in the present study, *Acacia cyclops* is established to such an extent on the unstable cliff-top at The Bluff at Barwon Heads that removal is now complex and potentially costly. Given the absence of thorough, on-going statewide weed surveys, the discovery of new weeds relies largely on local vigilance and chance detection. Some of these chance detections are made by botanists in herbaria as part of their normal work, including identifications of unknown plant material submitted by clients, as in this study. State herbaria can make a significant contribution to plant conservation and biodiversity management by informing the relevant people and agencies about new weed discoveries. Opportunities also exist for some state herbaria to be involved in strategic plans to manage weed invasions. For example, The New Incursion Response Protocol in Tasmania (Boersma *et al.* 1999) and the Weed Alert Rapid Response Plan (WARR) in Victoria (Smith 2006) can only progress after formal confirmation of identity by the relevant state herbarium.

Molecular methods may be used to examine and identify the geographic origins of weeds in more detail in the future and may provide higher levels of resolution than morphological methods. Herbaria may be called upon to carry out these studies. Molecular identification methods are especially powerful when inadequate plant material limits morphological identification. As noted previously there are two critical questions faced by herbaria when confronted by an unknown plant: what is it and what is its status (indigenous or introduced)? For the identification of plant species there is hope that a database comprising DNA barcodes for all plants will be available in the future. However, there are some technical difficulties to be overcome before this is possible. DNA barcoding is still being developed for plants and application of this method will require herbaria to invest in appropriate staff and equipment.

The recent use of molecular data and advances in analysis techniques have already enabled the investigation of the origin and spread of invasive plant species (Schaal *et al.* 2003). The most common methods have used DNA fingerprinting or sequencing techniques and phylogeographic analysis (Schaal *et al.* 2003; O'Hanlon *et al.* 2000). In most cases these studies have focused on species in which the weed status of the plant is known prior to the study, and generally the invasive species is separated from its indigenous areas of distribution by a substantial geographic distance and/or barrier, such as the intercontinental occurrence of invasive species (e.g. Australian occurrences of *Acacia* (*Vachellia*) *nilotica* (L.) Del., a species indigenous to India and Africa, Wardill *et al.* 2005). However, it is uncertain how molecular studies would determine the origin and status of a plant species found a relatively short distance from known indigenous populations, such as *Acacia cupularis* in this study. Population genetic theory predicts that species with small and recent introductions will display low intra-population genetic diversity, due to founder effects and genetic bottlenecks; thereby providing a possible means of distinguishing weed populations from indigenous occurrences, when combined with other sources of evidence, e.g. historical herbarium records (Barrett 1996; Amsellen *et. al.* 2000).

It is likely that herbaria will continue to rely on the examination of morphological characters and historical data to resolve various weed questions in the short to medium term. We consider that molecular methods will complement rather than replace these traditional methods in herbaria.

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References

Alsop, P.F.B. (1984). 'Coastal dune stabilization - an engineer's view', in K. Simpfendorfer (ed.), *Proceedings of the 56th Annual Conference of the Royal Australian Institute of Parks and Recreation*, pp. 177/1–177/15. Royal Australian Institute for Parks and Recreation: Melbourne.

Amsellem, L., Noyer, J.L., Le Bourgeois, T. and Hossaert-McKey, M. (2000). Comparison of genetic diversity of the invasive weed *Rubus alceifolius* Poir. (Rosaceae) in its native range and in areas of introduction, using amplified fragment length polymorphism (AFLP) markers. *Molecular Ecology* **9**, 443–455.

Austraflora (1978). 'Austraflora: specialising in Australian native plants'. Molyneux Nurseries, Montrose.

Barrett S.C.H. (1996). The reproductive biology and genetics of island plants. *Philosophical Transactions of the Royal Society of London* **351**, 725–733.

Bartle, J., Cooper, D., Olsen, G. and Carslake J. (2002). Acacia species as large-scale crop plants in the Western Australian wheatbelt. *Conservation Science Western Australian* **4**, 96–108.

Bean, A.R. (2007). A new system for determining which plant species are indigenous in Australia. *Australian Systematic Botany* **20**, 1–43.

Boersma, M., Bishop, A., Goninon, C., Ong, C., Rudman, T. and Welsh, S. (1999). 'Establishment of a weed surveillance and response protocol for new pest plant incursions in Tasmania', in A.C. Bishop, M. Boersma. and C.D. Barnes (eds), *12th Australian Weeds Conference papers and proceedings*, pp. 651–654. Tasmanian Weed Society: Hobart.

Duxbury, K. (2005). From strictly indigenous to 'ubiquitous but worthy': *Lomandra longifolia* as a cultivated garden plant. *Indigenotes* **16**, 10–14.

Elliot, R. (2002). 'Australian Flora: Horticultural use in Australia', in R. Aitken and M. Looker (eds), *The Oxford Companion to Australian Gardens*, pp. 54-58. Oxford University Press: Australia.

Maslin, B.R. (2004). 'World Wide Wattle. Species numbers'. Viewed 22 June 2006. http://www.worldwidewattle.com/infogallery/species

McDonald, M.W., Maslin, B.R. and Butcher, P.A. (2001). 'Utilisation of Acacias', in A.E. Orchard and A.J.G. Wilson (eds), *Flora of Australia Volume 11A, Mimosaceae,* Acacia *part 1*, pp. 30–40. ABRS/CSIRO Publishing: Melbourne.

Natural Resources Conservation League of Victoria (c. 1970). *Trees for farm and roadside planting*. Natural Resources Conservation League of Victoria: Springvale South.

New, T.R. (1984). *The Biology of Acacias*. Oxford University Press: Melbourne.

O'Hanlon, P.C., Peakall, R. and Briese, D.T. (2000). A review of new PCR-based genetic markers and their utility to weed ecology. Weed Research **40**, 239–254.

O'Leary, M.C. (2007). Review of *Acacia retinodes* and closely related species, *A. uncifolia* and *A. provincialis* (Leguminosae: Mimosoideae: sect. *Phyllodineae*). *Journal of the Adelaide Botanic Gardens* **21**, 95–109.

Orchard, A.E. and Wilson, A.J.G. (eds) (2001a). *Flora of Australia Volume 11A, Mimosaceae,* Acacia *part 1*. ABRS/CSIRO Publishing: Melbourne.

Orchard, A.E. and Wilson, A.J.G. (eds) (2001b). *Flora of Australia Volume 11B, Mimosaceae,* Acacia *part 2*. ABRS/CSIRO Publishing: Melbourne.

Pyšek, P., Richardson, D.M., Rejmánek, M., Webster, G.L., Williamson, M. and Kirschner, J. (2004). Alien plants in checklists and floras: towards better communication between taxonomists and ecologists. *Taxon* **53**, 131–143.

Roux, E.R. (1961). History of the introduction of Australian acacias on the Cape Flats. *South African Journal of Science* **57**, 99–102.

Schaal, B.A., Gaskin, J.F. and Caicedo, A.L. (2003). Phylogeography, haplotype trees, and invasive plant species. *Journal of Heredity* **94**, 197–204.

Shann, F. (1990). *Australian native plants in Melbourne: where to find them*. Society for Growing Australian Plants – Victoria: Melbourne.

Sluiter, G.B. (1964). A basic approach to foreshore erosion control. *Victoria's Resources* **5**, 123–125.

Smith, N. (2006). 'The Victorian Weed Alert Rapid Response plan: Weedspotters and the Weed Alert Contact Officers', in C. Preston, J.H. Watts and N.D. Crossman (eds), *15th Australian Weeds Conference papers and proceedings*, pp. 743–746. Weed Management Society of South Australia: Adelaide.

Thompson, G.T. (1968). The Natural Resources Conservation League of Victoria. *Victoria's Resources* **10**, 12–15.

Walsh, N.G. and Stajsic, V. (2007). *A census of the vascular plants of Victoria, 8th Edition*. Royal Botanic Gardens: Melbourne.

Wardill, T.J., Graham, G.C., Zalucki, M., Palmer, W.A., Playford, J. and Scott, K.D. (2005). The importance of species identity in the biocontrol process: identifying the subspecies of *Acacia nilotica* (Leguminosae: Mimosoideae) by genetic distance and the implications for biological control. *Journal of Biogeography* **32**, 2145–2159.

Wood, A.R. and Morris, M.J. (2007). Impact of the gall-forming rust fungus *Uromycladium tepperianum* on the invasive tree *Acacia saligna* in South Africa: 15 years of monitoring. *Biological Control* **41**, 68–77.

Youl, R. (1999). Choosing the best species. *Trees and Natural Resources* **41**, 15–20.