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Effects of the native environmental weed *Pittosporum undulatum* Vent. (sweet pittosporum) on plant biodiversity

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Summary

***Pittosporum undulatum* is a tall shrub or small tree, native to the wet forests of south-east Australia that is now a serious environmental weed both within and beyond its natural geographic range. This adaptable species has exploited changes in natural disturbance regimes and increased dispersal opportunities to spread from abundant ornamental plantings into remnant vegetation. Invading populations of *P. undulatum* impose fundamental changes on the composition, structure and function of affected communities. This species is arguably the most serious native environmental weed in south-east Australia. However, *P. undulatum* plays an important role in the community ecology of its indigenous habitats. The species' dual native and weedy status often complicates management of *P. undulatum* in south-east Australia, especially in its natural range where many populations are expanding. An on-going targeted approach to *P. undulatum* management is required throughout the species' current distribution.**

Introduction

Pittosporum undulatum Vent. (sweet pittosporum) is a densely-foliaged, fleshy-fruited, fire-sensitive tall shrub or small tree, native to the wet forests of south- east Australia. This species is now a serious environmental weed across a range of habitats outside its natural range in Australia (Gleadow and Ashton 1981, Mullett and Simmons 1995). Some populations of *P. undulatum* occurring within the species' natural range are also expanding their distribution and local densities in response to altered ecological conditions (Rose 1997, Mullett 1999a,b). *P. undulatum* is a serious invader on other continents and islands throughout the temperate, sub-tropical and tropical zones (Cooper 1956, Richardson and Brink 1985, Cronk and Fuller 1995, Goodland and Healey 1997).

This paper describes aspects of the process, impacts and implications of *P. undulatum* invasion in south-east Australia, with emphasis on the species' effects on native plant biodiversity.

Distribution

The natural geographic range of *P. undulatum* extends seawards of the Great Dividing Range east of Westernport Bay, Victoria, north to the New South Wales-Queensland border region (Figure 1). *P. undulatum* occurs as a natural component of many habitat types throughout this area, but is mainly associated with wet

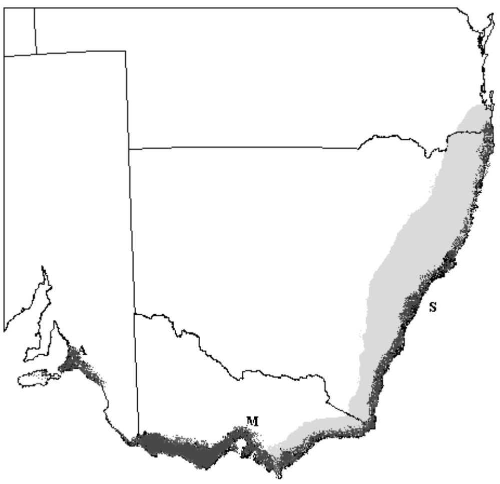

Figure 1. Distribution of *Pittosporum undulatum* on mainland south-east Australia. Light shading indicates the broad natural geographic range of this species, although the species was largely confined to wet forest and rainforest environments prior to European settlement. Dark shading indicates the distribution of invaded habitats both within and beyond the species natural geographic range.

forest and rainforest communities (Gleadow and Ashton 1981, Mullett 1999a).

Pittosporum undulatum range expansion has been particularly extensive in Victoria, where the species has invaded a diverse range of vegetation types beyond its natural range (Mullett and Simmons 1995). These include heathlands, heathy woodlands, grassy woodlands, dry sclerophyll forests, wet sclerophyll forests, coastal and riparian communities (Gleadow and Ashton 1981, Carr *et al.* 1992, Mullett and Simmons 1995). *P. undulatum* is also invasive in Tasmania, the Mount Lofty Ranges, South Australia and in the south west of Western Australia (Mullett 1999a). The species is well established on King, Norfolk and Lord Howe Islands and is naturalized on many continents and islands outside Australia. *P. undulatum* invasion poses a serious threat to biodiversity values in Jamaica, the Azores, South Africa and Hawaii (Cooper 1956, Cronk and Fuller 1995).

Considerable population expansion is also evident at many sites within the species' natural range in Victoria and New South Wales (Rose and Fairweather 1997, Mullett 1999a,b). Increasing local densities and encroachment from sheltered gully environments into adjacent vegetation communities on drier slopes are typical of this species' range expansion in natural habitats (Mullett 1999a,b). Near-coastal environments within the species' natural range also support invasive populations of *P. undulatum*, although ornamental plantings have been the source of most of these populations.

Factors contributing to the spread of *Pittosporum undulatum*

Ornamental plantings

Pittosporum undulatum has been an ornamental favourite from the earliest days of European settlement in Australia. Botanists and gardeners alike enthusiastically advocated planting of this 'sweet scented', 'fragrant', 'hardy' and 'adaptable' species in a range of cultivated settings (Mueller 1876, Maiden 1920, Miller 1964, Oakman 1964). The gardening public duly embraced this species and as early as 1920, Maiden reported that *P. undulatum* had been 'abundantly cultivated' in the cities and towns of south-east Australia (Maiden 1920).

Despite growing acknowledgment and acceptance of the species' weedy status, *P. undulatum* remains a popular ornamental specimen. These widespread ornamental plantings have been and remain, a primary source of invading populations, particularly into vegetation remnants associated with urban areas (Mullett 1999a,b).

Increased dispersal opportunities

A range of opportunistic frugivores exploit the species' abundant winter fruit crop and facilitate the dispersal of *P. undulatum* from cultivated settings into native vegetation. The introduced European blackbird (*Turdus merula* L.) and native pied currawong (*Sterpera graculina* Shaw) are identified as the most important dispersal agents of *P. undulatum* in urban and non-urban areas of Victoria, respectively (Gleadow 1982, Mullett 1999a,b). Other *P. undulatum* dispersal agents in south-east Australia are characteristically, also opportunistic generalist species and include silvereyes (*Zosterops lateralis* Latham), satin bowerbirds (*Ptilonorhynchus violaceus* Vieillot) and red-whiskered bulbuls (*Pycnonotus jocosus* L.) (Cooper 1959, Mullett 1999a,b).

Changes to natural fire regimes

The natural fire regimes of many south-east Australian ecosystems have been substantially modified since European settlement (Williams and Gill 1995). Many fire-adapted communities have become less diverse over time with the decline in regeneration opportunities. Fire-sensitive invaders such as *P. undulatum*, have been particularly successful invaders of affected vegetation types, compounding the displacement of fire-adapted species (Rose 1997, Mullett 1999a).

Inherent plasticity and adaptability

Considerable variation in *P. undulatum* habit is evident between the different habitat types occupied by this species throughout south-east Australia (Mullett 1999a). For example, individuals growing in sheltered wet forest environments have expansive, spreading canopies and may reach heights of 30 m or more. In contrast, individuals growing in harsher environments such as coastal habitats, are characteristically stunted and sheared in form and rarely exceed heights of 8 m. The diversity of habitats now occupied by *P. undulatum* over an extensive geographic and climate range is indicative of this species' inherent plasticity and adaptability. These traits are regarded as important factors in its continued invasion across a range of habitat types and climate regions (Mullett 1999a,b).

Process of population expansion

Pittosporum undulatum 'clumps' are generally located around the base of mature trees or shrubs, as these offer perching sites for frugivorous dispersers and provide micro-climatic conditions suitable for *P. undulatum* establishment (Gleadow and Ashton 1981, Mullett 1999a). Developing *P. undulatum* clumps provide a focus for further frugivore activity and thus for further seed dispersal (Richardson and Brink 1986). Significant changes are imposed on the community ecology of affected sites as the size and complexity of the *P. undulatum* clumps increase (Mullett 1999a).

Effects of *P. undulatum* invasion on ecosystem properties

Fundamental changes to community composition, structure and function occur as a consequence of *P. undulatum* invasion and population expansion (Figure 2). The deep shade cast by the dense *P. undulatum* canopy substantially alters light regimes at invaded sites contributing to changes in

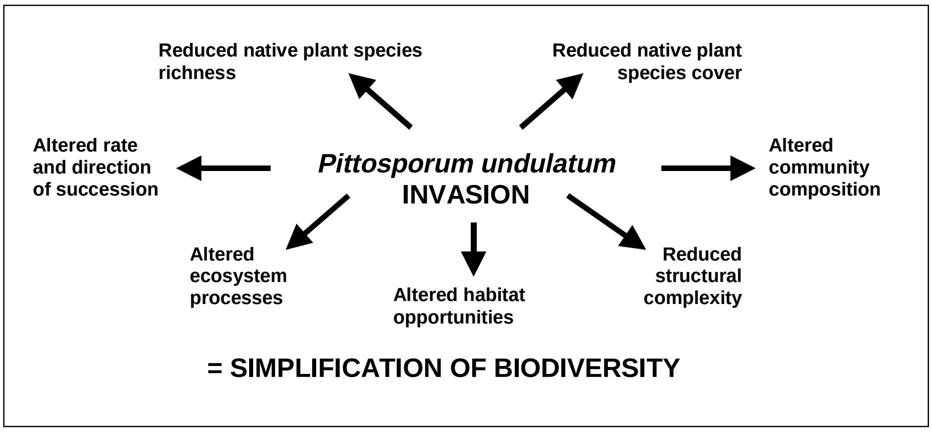

Figure 2. Invading populations of *P. undulatum* impose fundamental changes on the composition, structure and function of affected communities leading to the loss and simplification of biodiversity.

microclimatic conditions and the displacement of some native species. The microclimate beneath the *P. undulatum* canopy is further altered by attributes of *P. undulatum* litter fall, which varies in seasonality, abundance and nutrient composition to other key species in invaded communities (Gleadow and Ashton 1981). Other ecosystem properties and processes such as the composition, abundance, arrangement and combustibility of fuels, in addition to the cycling and availability of nutrients, are likely to be affected by *P. undulatum* invasion (Mullett 1999a).

Impacts on native plant biodiversity

Significant declines in native plant biodiversity are a critical effect of *P. undulatum* invasion at sites throughout Victoria (Mullett and Simmons 1995, Mullett 1999a,b). Effects are most profound in the centres of radiating *P. undulatum* clumps, where shading and competition pressures are most intense (Mullett and Simmons 1995, Mullett 1999a,b). The biodiversity values of sites supporting long-term invasion of *P. undulatum* are severely diminished as these clumps coalesce to form dense stands (Mullett and Simmons 1995, Mullett 1999a,b).

Incremental losses of plant species richness occur with increases in *P. undulatum* cover at invaded sites (Mullett and Simmons 1995, Mullett 1993, 1999a,b). At an invaded dry sclerophyll forest remnant on the Mornington Peninsula, Victoria, for example, species richness declined from an average of 15 species per 9 m^2 quadrat where *P. undulatum* cover was low (<20%), to 11 species where *P. undulatum* cover was between 40–60%, to just five species where *P. undulatum* cover was high (>80%) (Mullett 1999a). This pattern of declining species richness with increasing *P. undulatum* cover is consistent across invaded sites sampled in Victoria (Mullett and Simmons 1995, Mullett 1993, 1999a,b).

Substantial declines in the cover-abundance of native species compounds the attrition of species richness at invaded sites. At Portland in south west Victoria for example, where *P. undulatum* is invading dry sclerophyll forest, the average cumulative cover-abundance of all vascular plants fell from 99% in 9 m^2 quadrats supporting <20% *P. undulatum* cover to 64%, where *P. undulatum* cover was between 40–60%, and 29% where *P. undulatum* cover exceeded 80% (Mullett 1999a). Reductions in floristic and structural complexity of this order have serious consequences for the conservation of biodiversity.

Analysis of *P. undulatum* impacts on different lifeform guilds at invaded sites in Victoria indicates that grasses, herbs, twiners/trailers, low shrubs and shrubs are more likely to be affected by *P. undulatum* invasion than tall shrubs and trees (Mullett 1999a). However, the latter two guilds incorporate long-lived overstorey species for which the true impacts of *P. undulatum* invasion may unfold with time and lack of regeneration opportunities.

Cluster analysis of *P. undulatum* community relationships indicated that dry sclerophyllous species are more likely to be displaced by *P. undulatum* than species typical of shaded, mesic environments (Mullett 1999a). These findings were consistent with patterns reported for expanding populations of *P. undulatum* in Sydney sandstone vegetation communities (Rose and Fairweather 1997). This trend has important implications for the rate and direction of community succession; a process already disrupted by the suppression of natural fire regimes and the influence of the dense *P. undulatum* canopy on microclimatic conditions.

Plant communities sampled within the species' natural range showed comparatively greater resilience to high *P. undulatum* densities and cover than invaded communities (Mullett 1999a). While species richness declined with increasing *P. undulatum* cover at sites within the natural range, this generally occurred at higher *P. undulatum* cover intensities, compared to the invaded sites. Declines in community cover-abundance were evident with increasing *P. undulatum* at the natural sites sampled, but again, these natural communities showed greater resilience in this regard than invaded communities. No significant relationships were evident between *P. undulatum* and the cover of the lower strata guilds at sites within the natural range. Significant negative correlations were evident, however, between the cover of *P. undulatum* and its structural analogues – the tall shrubs/small trees guild at the natural sites sampled (Mullett 1999a).

Broader implications

Changes in species composition, shading, soil and litter moisture, nutrient availability and other ecosystem effects associated with *P. undulatum* invasion fundamentally affect the community resource base and aspects of ecosystem functioning. Substantial changes of this nature inevitably influence the rate and direction of successional processes in affected communities (Luken 1997). Species or suites of species better able to tolerate the changed conditions may be favoured over the previous assemblage of established species (Luken 1997). In invaded dry sclerophyll forest communities now dominated by *P. undulatum* in Victoria and New South Wales, these changes appear to favour fire-sensitive plant species adapted to shaded, mesic environments, over the preceding suite of species dominated by fire-adapted species typical of more open, drier environments (Mullett and Simmons 1995, Rose 1997, Rose and Fairweather 1997, Mullett 1999a).

P. undulatum invasion and associated declines in floristic and structural complexity are likely to have a negative effect on native fauna. Observation and anecdotal evidence suggests that opportunistic species with more generalized habitat requirements may be better able to cope with invasion-driven changes in habitat opportunities than species with more specialized needs, and this is likely to induce changes throughout the community. For example, changes in seasonal migration patterns and increases in the distribution and abundance of pied currawongs in some areas of south-east Australia have been linked to an increased abundance of fleshy-fruited weeds in settled areas (Lenz 1990, Buchanan 1992, Bass 1996). Increased nestling predation by the omnivorous pied currawong is reported as an important implication of pied currawong population expansion (Lenz 1990, Buchanan 1992, Bass 1996). Other native birds may also be adversely affected through competition for food, nesting and shelter resources (Lenz 1990).

Disruptions to the dispersal syndromes of native fleshy-fruited plants and the diet of frugivorous vertebrates may be additional consequences as relationships between fleshy-fruited weed species and adaptive frugivores develop (Buchanan 1992, Mullett 1999a,b). At the very least, mutually beneficial relationships between fleshy-fruited weeds and their frugivorous dispersal agents are likely to lead to local population increases of both weed and dispersal agent as the system moves towards a more simplified state. The broader ecological implications of developing relationships between fleshy-fruited environmental weeds and their adaptive dispersal agents are considerable (Lenz 1990, Buchanan 1992, Bass 1996, Mullett 1999a,b). Added management complexities are created when both the weed and the dispersal agent are native species, as in the *P. undulatum*-pied currawong example described (Mullett 1999a).

Management issues

An incomplete understanding of the invaders' biology, community relationships and the ecological impacts of invasion often impedes environmental weed management. Management of native environmental weed species is further complicated by uncertainties about the plants' dual native and weedy status and in this regard, control resources are often directed towards introduced species as these have a clearer invasive status (Rose 1997, Mullett 1999a). Managers are advised not to place undue importance on whether an expanding population of *P. undulatum* occurs within the species' natural or invaded range. The processes that previously contained *P. undulatum* to its indigenous niche in the wet forests of south-east Australia have been substantially modified in some parts of this species' natural range. Populations within the species' natural range can be equally invasive and locally dominant as populations invading beyond the species' natural range, if conditions favouring expansion are available.

Management objectives need to be clearly established prior to the implementation of *P. undulatum* control programs, especially in the species' natural range. If the overall objective for management is to maintain or enhance biodiversity values, then it should first be established whether *P. undulatum* imposes a negative impact on these values. In both the natural and invaded range of this species, managers also need to anticipate the community response to reduced densities of *P. undulatum* and determine the appropriate control approach to promote the desired species composition.

Different control techniques will be appropriate to different sites and different *P. undulatum* invasion scenarios. Managers are advised to address the causes of invasion where possible (Mullett and Simmons 1995, Mullett 1999a,b). *P. undulatum*, like other native and introduced environmental weeds, has responded to a complex series of changes in ecological conditions. Successful management programs will need to address these changes in an integrated manner incorporating a range of appropriate control techniques. On-going commitment to control, management and monitoring is essential to reduce the risk of reinvasion by *P. undulatum* or a different suite of weeds. It is especially important that management is very specifically targeted at sites within the species' natural range, where *P. undulatum* may be playing an important role in its indigenous habitat *and* behaving as an environmental weed, literally within a stone's throw. This situation is evident at many sites throughout south-east Australia.

Conflicts in native weed management may also arise from apparent discrepancies in native vegetation policy and procedures. In Victoria for example, *P. undulatum* invasion is listed as a 'potentially threatening process' under Schedule 3 of the *Flora and Fauna Guarantee Act* 1988 (Scientific Advisory Committee 1994). Under the same legislation, *P. undulatum* is identified as a component of a rare plant community (Dry Rainforest (Limestone) Community) listed under Schedule 2 of the Act (Scientific Advisory Committee 1996). *P. undulatum* is also targeted as a 'Garden Thug' in Victoria (Weeds CRC and NIAA 1999), yet is still used in revegetation programs in the State's south-east (Mullett 1999a,b).

Managers are encouraged to use other non-invasive indigenous species instead of *P. undulatum* in revegetation programs. While *P. undulatum* serves as a useful pioneer species because of its hardiness and adaptability, it is asking for trouble to actively plant this species – even within the species' natural range. (Mullett 1999b). This is especially so in restoration sites that by their very nature are highly disturbed and therefore vulnerable to invasion. Budgetary commitment to monitoring and follow up control is usually lacking in revegetation programs, thereby reducing the likelihood of early detection and management should the planted population unexpectedly expand.

Concluding comments

Pittosporum undulatum is a highly adaptable native species that has exploited changes in ecosystem connectivity, composition and function to become a serious environmental weed in a range of vegetation types. This species is arguably the most serious native environmental weed in south-east Australia. Simplification of community composition, structure and function are principal effects of *P. undulatum* invasion. Once set in train, the degradation of biodiversity values is perpetuated at invaded sites as the rate and direction of community succession moves towards a more simplified state. The continued invasion of this species contributes to loss of biodiversity and homogenization of natural areas at the site, regional and landscape scales (Mullett and Simmons 1995, Mullett 1999a). Across the natural and invaded range of this native environmental weed, a flexible, yet targeted approach to on-going management is essential if the continued invasion of this species and its attendant effects on biodiversity are to be arrested, if not reversed.

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Transcontinental invasions of vascular plants in Australia, an example of natives from south-west Western Australia weedy in Victoria

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Introduction

Australian native species have been exported all over the world for horticulture, agroforestry and rehabilitation usages. Regrettably, this extraordinary natural resource has also been the source of many serious environmental weeds. For example, acacias and eucalypts have become highly invasive in South Africa (Stirton 1980), where they have altered fire regimes and impacted water tables. That some of these species are from Western Australia should not be surprising given similar climates, latitude and trade linkages over the years (Marchant 1993). More likely, but less well documented, WA plants have invaded in the opposite direction into south-eastern Australia.

Some examples of species native to south-eastern Australia are discussed in other papers associated with this symposium: *Acacia longifolia* var. *longifolia*, *A. longifolia* var. *sophorae* and *Pittosporum undulatum* (Carr 2001, Coutts 2001, Mullett 2001). Other examples include *A. baileyana*, *Allocasuarina littoralis*, *Kunzea ambigua*, *K. ericoides*, *Melaleuca ericifolia* (Costello *et al.* 2000). One of the most serious is *Leptospermum laevigatum* weedy outside its natural range in Victoria and is listed as one of Western Australia's worst environmental weed threats (Ecoscape *et al.* 2000).

Carr (2001) regards *Acacia longifolia* var. *sophorae* and *Pittosporum undulatum* as two of the worst environmental weeds in Victoria, including all Weeds of National Significance except *Asparagus asparagoides*. Both have different reproductive and dispersal strategies and invade different habitats. *P. undulatum*, a bird-dispersed forest tree, has spread out of its native range because of altered management practices (Mullett 2001) and introduced birds, and has invaded remnant bushland from suburban gardens around Melbourne.

Acacia longifolia var. *sophorae* threatens coastal heathlands and heathy woodlands in south-west Victoria (Carr 2001). Likely to be bird-dispersed as well, *P. undulatum* has long-lived hard-coated seeds, not short-lived fleshy ones.

The issue of Australian native plants becoming weeds outside their range is well known to ecologists (Costello *et al.* 2000) but a difficult concept to educate others about. This short note examines the threat of this emerging type of environmental weed using examples of native species from south-west WA that have made a transcontinental shift eastwards.

The flora of south-west Western Australia

The South West Botanical Province of Western Australia (SWBP) is an important global centre of plant diversity, conservatively estimated at 2% of the worlds vascular flora (Beard *et al.* 2000). Of Australia's estimated 25 000 plant species, about 25% are found in the SWBP including approximately one third of Australia's listed rare or threatened flora (Briggs and Leigh 1996). This flora is characteristic of Mediterranean regional floras having relatively high values for species richness (5710 species), generic diversity (710 genera with an average of eight species per genus) and species endemism (79%) (Beard *et al.* 2000). Table 1 lists families and genera with high native plant species richness for the SWBP to quantify this.

Woody perennial trees and shrubs are the dominant life form in the Myrtaceae,