Management implications of recent research into the effect of bitou bush invasion

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Summary
We review recent research into the impact of bitou bush (*Chrysanthemoides monilifera* subsp. *rotundata* (DC.) Norl.) on coastal ecosystems which suggest this weed is having widespread impacts on ecosystem services, flora and fauna. Increased decomposition rates and altered nutrient cycling accompany changes in plant community structure and composition. Changes in invaded habitats influence invertebrate and bird assemblages. We summarize research that shows that the establishment phase of seedlings is the key phase where bitou bush out competes native species through both resource and interference competition mechanisms. Control of bitou bush at sites by hand spraying and/or hand pulling, and aerial spraying alone do not restore all species that were in uninvaded coastal communities, although these management techniques can reduce seed availability of bitou bush. We suggest that destruction of bitou bush seedlings should be specifically targeted in weed management strategies and that long term management plans are developed to ensure control of secondary weeds that are at risk of invading after bitou bush control. These activities should include using fire to encourage native seed germination and to potentially remove volatile allelopathic chemicals in the soil. Management strategies should also include replanting schemes to increase species richness of all plant structural groups to build ecosystem resilience.

Introduction
The invasion of coastal communities by the African shrub *Chrysanthemoides monilifera* subsp. *rotundata* (DC.) Norl.), bitou bush, has persisted despite widespread control efforts including the release of biocontrol agents, extensive herbicide programs and regeneration activities of state agencies, local governments and volunteers. Research initially fell behind control efforts by not providing deeper insights into the biology and ecology of invasion to help focus control efforts and to understand the impacts of management. Thus, the impacts of bitou bush on biodiversity, the mechanisms of invasion and the efficacy of different management actions were not well understood and guidelines for bitou bush control were without a sound scientific base.

Research has been continuing for over a decade to fill some of these gaps. The aim of this paper is to briefly review research on the impacts of bitou bush (summarized in Table 1) on native ecosystems and the implications for management. We restrict ourselves to reviewing the contributions from published scientific literature or current research efforts rather than management and policy documents to facilitate the incorporation of scientific findings into management. We outline the evidence for each study, although details of research methodology are avoided for brevity. We divide the findings into two broad sections. Initially, we investigate the impacts of bitou bush on all aspects of the ecosystems they invade. Secondly, we summarize studies that have investigated how different control activities influence habitats invaded by bitou bush. We then present the management implications of this research with some suggestions for new management strategies to increase the efficacy of current management efforts.

The impacts of bitou bush
1. Bitou bush changes ecosystem properties and processes
Bitou bush invasion changes the characteristics of coastal ecosystems. In Australia, the invaded habitat is darker, cooler and moister than non-invaded habitat at ground level (Lindsay and French 2004a, Ens 2007). The leaf litter layer is reduced as a result of faster decomposition of bitou bush leaves (Lindsay and French 2004a) and a lower biomass of leaves falling in invaded habitats (Lindsay and French 2005). Consequently, nutrients are released into the soil more quickly in invaded habitats, resulting in fewer nutrients being stored in the litter layer (Lindsay and French 2005). At present we do not understand if the higher soil nutrient load in invaded sites is eventually leached out of the soil or if it is re-absorbed by plants, however, current research is investigating these possibilities.

Habitats dominated by bitou bush have substantially different patterns of fleshy fruit production to uninvaded ecosystems as bitou bush produces large quantities of fruit during early winter when native fruits are scarce (Gosper 2004a). At least 18 species of birds consume bitou bush fruits, most of which are likely to disperse the seeds (Gosper 2004b). While it would be predicted that bitou bush infestations would affect dispersal of native fruits, Gosper *et al.* (2006) showed that native fruit removal is unaffected by either invasion or broad scale spraying of bitou bush.

2. Bitou bush affects fauna
Despite less litter in bitou bush invaded habitats, the abundance and richness of litter invertebrates are not adversely affected by bitou bush invasion (French and Eardley 1997, Lindsay and French 2004b). However, there is a change in the composition of the invertebrate assemblage due to the cooler, moister environment of invaded sites. Some invertebrate groups are more abundant, particularly moisture-loving species, such as springtails, millipedes, amphipods, slaters, earthworms and pseudoscorpions (French and Eardley 1997, Lindsay and French 2004b). Some groups are less abundant (ants, earwigs, spiders, centipedes and native cockroaches) or less diverse (beetles) in invaded sites (Lindsay and French 2004b). The implications of these changes in food webs are not understood, although the increase in species involved in decomposition may be one aspect causing the changes in observed increases in decomposition rates. Similarly, epigaeic and arboreal invertebrates did not differ between bitou bush invaded and native habitats, although there was evidence that the Heteroptera responded to the more mesic conditions in invaded habitats (Wilkie *et al.* 2007).

Furthermore, the effect of invasion of bitou bush on the bird assemblage is variable. Those birds that rely most heavily on plant material for food resources, such as some nectarivores and frugivores, are less abundant in invaded habitats, suggesting that these habitats provided inadequate resources for such birds (French and Zubovic 1997, Gosper 2004b). However for canopy foraging species and some insectivores, few changes were evident (French and Zubovic 1997, Gosper 2004b).

Table 1. Brief summary of impacts of bitou bush on coastal communities.

Environmental characteristic	Effect of bitou bush invasion	References
Ecosystem	Cooler, moister and darker micro-habitat	Lindsay and French 2004a
	Leaf litter decomposition rates increased	Lindsay and French 2004a
	Nutrient cycling changed	Lindsay and French 2005
	Changed patterns of fleshy fruit availability	Gosper 2004a
	Seed dispersal interactions appear unaffected	Gosper *et al.* 2006
Fauna	Invertebrate composition changed with an increase in moisture-loving species (millipedes, amphipods, earthworms, pseudoscorpions and isopods)	French and Eardley 1997, Lindsay and French 2004b
	Lower beetle diversity and abundance of ants, earwigs, centipedes and native cockroaches	French and Eardley 1997, Lindsay and French 2004b
	Epigaeic and arboreal invertebrates largely unaffected	Wilkie *et al.* 2007
	Fewer plant feeding birds	French and Zubovic 1997, Gosper 2004b
	Some bird species avoid bitou bush and predominantly use remnant native shrubs in invaded areas	Owers 1999
Flora	Threatened species impacted	Coutts-Smith and Downey 2006
	A range of other species become rare or locally extinct leading to lower occurrence along the coast	Mason and French 2007, unpublished data
	Native seedlings outgrown by bitou bush	Weiss and Noble 1984, unpublished. data
	Native seedling growth suppressed by soil-based chemicals under bitou bush plants	Ens 2007
	Moderate effects of bitou invasion on seed bank dynamics	Mason *et al.* 2007, unpublished data

We investigated behaviour of little wattlebirds (*Anthochaera chrysoptera*), New Holland honeyeaters (*Phylidonyris novaehollandiae*), silvereyes (*Zosterops lateralis*) and superb fairywrens (*Malurus cyaneus)* and found few changes in the proportion of time these species spent undertaking different behaviours in invaded and uninvaded habitats (Owers 1999). However, in invaded habitats (where bitou bush cover is over 80%), three of these species were observed using native plants preferentially. Superb fairywrens used bitou bush more than the other three species studied, but not as often as would be predicted from availability of bitou bush (Figure 1). With a reduction in abundance of native plants in invaded habitats, the reliance of nectarivores on native plants provides a potential explanation of why this group is less abundant in bitou bush invaded habitats. This study, however, showed that at least some species are using bitou bush as habitat.

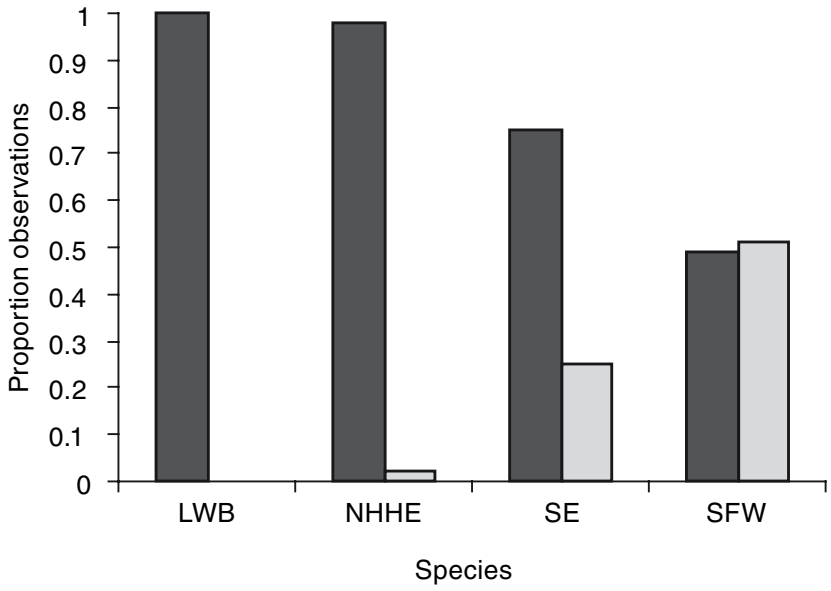

Figure 1. Proportion of observations of four species of birds in native (solid bars) and bitou bush (open bars) plants in bitou bush invaded habitats. LWB = little wattlebird; NHHE = New Holland honeyeater; SE = silvereye; SFW = superb fairywren.

3. Bitou bush invasion is associated with a lower abundance of many native plant species

While bitou bush is listed within New South Wales (NSW) legislation as affecting 46 threatened species (Coutts-Smith and Downey 2006), recent surveys have found that the threat is much greater than just those listed species. In surveys along the coast of NSW, we recorded many plant species in lower abundance or occurrence in fore dune habitats, suggesting a range of species are at risk from widespread bitou bush invasion (Mason and French 2007a, K. French unpublished data). For example three widespread species *Spinifex sericeus* R.Br, *Carpobrotus glaucescens* (Haw.) Schwantes, and *Acacia longifolia* subsp. *sophorae* (Labill.) Court) have a lower abundance and occurrence in invaded sites along the NSW coastline (Mason and French 2007a). All life forms are represented in the inventory of species

that have lower abundance or occurrence and this confirms the importance of regeneration using of a wide range of species across all structural layers following bitou bush management. Research is continuing to investigate the species identified here in the context of the NSW Threat Abatement Plan for bitou bush (DEC 2006).

4. Bitou bush changes the diversity of weed and native seeds and seedlings.

Seeds of bitou bush in invaded habitats are abundant although there appears to be a reduction since early studies by Weiss (1984). In a recent study on the central coast of NSW we have found 570 viable seeds m^{-2} in invaded habitats (K. French unpublished data). Similar densities have been found at sites in the Illawarra. Interestingly, we have not found the high seed densities measured by Weiss (1984; 2000–3000 viable seeds m^{-2}). Furthermore, viability of seeds in the soil seedbank on the central coast of NSW was only 23% with many seeds empty (K. French unpublished data). This suggests that the activity of released biocontrol agents may be effective in reducing seed production and viability, although this needs to be confirmed. Similar reductions in density of seeds in invaded areas have been measured on the north coast of NSW (Royce Holtkamp personal communication). At this stage we are cautious in concluding that biocontrol is influencing the spread of bitou bush, as a reduction in bitou bush seed densities in the soil seedbank may not result in a reduction in the number of bitou bush plants establishing if seeds are in surplus. Longevity of bitou seeds in the seedbank is also not well understood and should be a priority for future work.

In hind dunes, bitou bush seed in soil seed banks were more abundant in invaded compared to uninvaded sites (Mason *et al.* 2007b). Densities of bitou bush seeds in the soil in native areas, less than 20 m from the edge of bitou bush invaded areas, contained only two viable seeds m^{-2} (K. French unpublished data). Comparisons of species richness of seeds of most native life forms in the seed banks did not differ between invaded and uninvaded sites, although seeds of native tree species were less abundant in invaded sites and there was a trend of increased weed species richness in both invaded and managed compared to uninvaded sites (Mason *et al.* 2007b). In both fore and hind dunes, we have found dramatic differences between the above ground native species composition and the species that germinated from the seedbank, indicating that reliance on the seedbank may not return communities to preinvasion species richness (Mason *et al.* 2007b).

The addition of native seed to areas that have been invaded does not result in improved establishment of native species following control. In a recent study we cleared patches of bitou bush and native vegetation in fore dune areas on the central coast and a portion of patches received an addition of native seeds. We found that adding native seeds did not increase native species regeneration in patches. There was a flush of germination of native species in both cleared and uncleared patches, and in both native and invaded patches. This flush of germination of native species was far lower than the numbers of bitou bush seed germinating in invaded sites. However, most native and exotic seedlings in all patches died following very hot weather over summer so that only the native sites continued to host native seedlings.

5. Bitou bush seedlings gain a competitive advantage through rapid germination and growth rates

Research suggests that bitou bush acts to displace native species at the establishment stage in their life cycle, rather than influencing mortality of adult plants. Two lines of evidence support this. Firstly, flower production, growth rates and photosynthetic stress indices for adult plants of three native species, *Monotoca elliptica* (Sm.) R.Br., *Correa alba* Andrews and *Lomandra longifolia* Labill., did not differ between invaded and non-invaded bitou bush habitats (Ens and French 2008) indicating few impacts on established plants. Secondly, Weiss and Noble (1984b) found that bitou bush seedlings grew faster than coastal wattle seedlings and suggested that this was a mechanism of displacement. Recently, in glasshouse experiments, bitou bush seedlings increased in biomass more rapidly and reduced the biomass of *Banksia integrifolia* L.f. and *Ficinia nodosa* (Rottb.) Goetgh. *et al*. (synom. *Isolepis nodosa*). This effect was greater than the effect of the native species on bitou bush seedlings or the effect of intraspecific competition (K. French unpublished data). Similarly, in artificially cleared plots in bitou bush invaded habitat, more bitou bush seeds germinated and grew more quickly than native seeds, suggesting that both seedling numbers and speed of growth would give bitou bush a competitive advantage (K. French, unpublished data). Therefore, faster growth rates may promote the invasive potential of bitou bush especially at the seedling stage.

6. Bitou bush exudes chemicals or changes soil processes that influence the growth of seedlings

One other mechanism may be used by bitou bush plants to increase their competitive advantage in habitats. Vranjic *et* al (2000) found the presence of litter or soil from beneath bitou bush could influence growth of the dominant shrub *Acacia longifolia* subsp. *sophorae*, which suggests chemical interference within the soil/litter layers may facilitate invasion by bitou bush. In recent research extending these findings, it was found that bitou bush actively inhibits the seedling growth of a range of species apparently through releasing toxic compounds from the roots into the soil (Ens 2007). While extracts from *A. longifolia* subsp. *sophorae* roots and soil near roots also inhibited the growth of native seedlings, the novelty of the chemicals exuded by bitou bush appeared to affect a wider range of native species (Ens 2007). Interestingly seedlings of coastal wattle, the dominant species in fore dune communities, were affected by this interference mechanism, potentially providing an effective mechanism to enhance invasion of coastal habitats.

7. Management regimes differ in their impacts on coastal biota

Management of bitou bush can also pose a disturbance that affects native plant species. In fore dune communities, on-ground management by groups such as bush regenerators improved native species recovery more than the use of non-targeted aerial spraying (Mason and French 2007). Both techniques reduced the number of bitou bush seeds in the seedbank (Mason *et al.* 2007). Interestingly, more weed species were associated with sites where groups had been working on weed control activities, perhaps as a result of the increased soil disturbance and importation of weed propagules on workers' tools and clothing (Mason and French 2007).

Comparisons between native sites, sites that have been sprayed, and sites that have received a spray-burn-spray treatment suggests that the inclusion of prescribed fire has some benefits for native regeneration (Prattis 2004). However, in addition to an increase in native species established after spray-burn spray treatments, there was also an increase in the richness of weed species. Both these studies suggest an increased risk of secondary weed invasion as a result of bitou bush management, which is of concern.

Herbicide spraying over winter using glyphosate and metsulfuron methyl is an important mechanism of bitou bush control, however, we have identified a number of native plant species that are in lower abundance in areas that have been sprayed (Mason and French 2007) and have observed a range of native species that are killed by spray (personal observation). Thomas *et al*. (2006) also confirmed reductions of a number of species following spraying. Matarczyk *et al*. (2002) found significant impacts of spraying of glyphosate on an endangered plant species, *Pimelea spicata*, highlighting the conservation risks of using herbicide to control weed invasions on non-target species.

It is also possible that non-target organisms such as invertebrates may be affected by herbicides, particularly as some consume dead plant material in the litter layer. We investigated the effects on soil and litter invertebrates in bitou bush invaded habitats following spraying with both glyphosate (Lindsay and French 2004c) and metsulfuron methyl (French and Buckley 2008) and found no direct impact of herbicide spray on litter invertebrates. Species may be indirectly affected by the use of these herbicides through the alteration of habitat structure as bitou bush dies. For example, frugivorous birds were less abundant following herbicide treatment of bitou bush, presumably responding to the dramatic decline in fruit availability (Gosper 2004b).

The release of biocontrol agents can influence ecosystem structure through impacting on plant herbivore interactions. Willis and Memmott (2005) showed that the tephritid fly, *Mesoclanis polana*, which was released as a biocontrol agent for bitou bush, influences native food webs. *M. polana* reduces the number of species involved in interactions amongst plants, native seed feeders and their parasitoids in spring through increasing the abundance of native parasitoids.

Management implications

Given the range of impacts bitou bush has on ecosystem function and native species, efforts to continue mitigating the impacts of bitou bush are clearly justified. The key challenge is not so much how bitou bush can be controlled (the methods available are probably better than for most weeds), but rather on how the negative effects of bitou bush and management can be mitigated and particularly how functioning ecosystems can be restored.

Preventing spread of bitou bush

The mechanism for invasion appears to be largely the occupation of vacant spaces by bitou bush seedlings, rather than competition against native plants that have already established. This suggests that effective control may be better achieved through changing the probabilities of space occupation at this early stage. Only small numbers of viable bitou bush seeds were identified in the soil seedbanks of native areas adjacent to infestations, suggesting that seed dispersal of even a few metres is a rare event and potentially controllable in early stages. Our knowledge of dispersal patterns of frugivores suggests that this localized dispersal will be supplemented by long distance dispersal events associated with animal movements resulting in distant patches of bitou bush forming. Thus control near the invasion front will need to be complemented by searches into native vegetation to locate new patches of bitou bush seedlings. Given that the establishment of bitou bush seedlings in these native areas is likely to be high relative to establishment of native seedlings and given the rapid growth rate of bitou bush, any seedlings that do germinate have a high likelihood of forming a new weed patch.

The research summarized here suggests that management is likely to be most cost effective and successful at the germination and establishment phase. Herbicide application or hand pulling of new bitou bush seedlings within 20–30 m of invasion boundaries, followed by searches for seedlings deeper into nearby native areas, is likely to be significant in controlling spread. Furthermore, removing seedlings and young juveniles will be helpful as soil-based allelopathic chemicals are unlikely to have accumulated, allowing natural rates of establishment of native species after weed control.

Weed removal activities

The change in focus to managing bitou bush seedlings rather than adults should extend to weed removal techniques. Our results suggest that both aerial spraying and more intensive hand pulling and weeding at particular sites are not effective in allowing regeneration of many native species. Further management actions are necessary by managers, particularly following aerial spraying. Two actions appear to be necessary; burning of sites to encourage native regeneration and planting those native species that remain absent.

As burning enhances germination of the soil seedbank and increases species richness of seedlings, it is likely that burning following weed control activities will help in returning vegetation to preinvasion structure, however, it is not adequate without additional actions to ensure establishment of native species absent from the seedbank. While spray-burn spray treatments have advantages over just spraying, we suggest that the second spraying treatment is replaced by hand pulling or spot spraying bitou bush seedlings. Repeat spraying is likely to reverse many of the benefits of burning and many seedlings will suffer mortality. Many native species, particularly seedlings, are susceptible to glyphosate and while Toth *et al.* (1996) have shown limited susceptibility for seven species, a wide range of native species are impacted by spraying (Thomas *et al.* 2006, K. French and T. Mason personal observation). Furthermore, allelopathic chemicals exuded by bitou bush which build up in the soil and root mass as bitou bush grows, are likely to persist in the soil following spraying, influencing germination of native species. Early removal of bitou bush seedlings may reduce the quantity of allelopathic chemicals and reduce the stress placed on already germinated native seedlings.

Having resources available for bitou bush control after bushfire events may be crucial given the competitive ability of bitou bush seedlings. Given that coastal fires will occur, bitou bush management could be directed to a fast-response force in post-fire areas to remove newly emerged bitou bush seedlings and providing less competitive opportunities for native seedlings. Missing these opportunities may have substantial future costs (Thomas *et al*. 2006).

The loss of native plant species and the reduced capacity of native seedbanks to facilitate regeneration at sites poses difficulties for returning invaded areas to functioning healthy coastal communities. Research results provide a strong argument to supplement current control activities with planting of targeted native species and to ensure removal of secondary weeds that increase in abundance after bitou bush control. Native species chosen for revegetation planting should include all components of the vegetation community (forbs, grasses, shrubs, trees) to rebuild habitat complexity and ecosystem resilience. Replanting schemes that only focus on larger shrubs and trees will be inadequate to restore ground layer richness, which is one of the most affected strata in weed invasion (T. Mason and K. French unpublished data).

This approach suggests the need to set long-term management plans and funding schemes (for a minimum of five years), as control of bitou bush alone is not sufficient. Follow up work must be done to successfully restore coastal vegetation communities. Evaluation of communities needs to be undertaken with a clear understanding of the desired outcome. This suggests the need to develop a list of native species that should be present, perhaps based on nearby surveys of uninvaded vegetation. Revegetation with all strata rather than only larger shrubs and trees is imperative in the evaluation process. Thus funding should incorporate evaluation of sites, requisitioning and purchasing of seedling stock of missing species, planting of these into the areas and monitoring to ensure establishment. Such activities could equally be applied to current projects to assist complete ecosystem restoration. Nurseries must be encouraged to propagate an extensive range of species, not the current minimal set available.

Overall, these results represent a significant change in the way that bitou bush should be managed. Further research to establish the effectiveness of current biocontrol agents will help in predicting future invasion potential. While the management changes we suggest are more costly in the short term, they will reduce long-term costs by avoiding the need for broader replanting of more species in the future and they are likely to produce a

better biodiversity outcome. Incorporating research alongside these new approaches to management will provide an evaluation strategy of the activities to help improve future protocols.

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References

Coutts-Smith, A.J. and Downey, P.O. (2006). Impact of weeds on threatened biodiversity in New South Wales. Technical Series No. 11, CRC for Australian Weed Management, Adelaide.

DEC (Department of Environment and Conservation) (2006). 'NSW Threat Abatement Plan – invasion of native plant communities by *Chrysanthemoides monilifera* (bitou bush and boneseed)'. (Department of Environment and Conservation (NSW), Hurstville).

Ens, E. (2007). Indigenous plant recruitment limitation by bitou bush (*Chrysanthemoides monilifera* ssp. *rotundata*): effect on life history stages and allelopathic mechanisms. PhD thesis, University of Wollongong.

Ens, E. and French, K. (2008). Exotic woody invader limits the recruitment of three indigenous plant species. *Biological Conservation* (in press).

French, K. and Buckley, S. (2008). The effects of the herbicide metsulfuron-methyl on litter invertebrate communities in a coastal dune invaded with *Chrysanthemoides monilifera* ssp. *rotundata*. *Weed Science* (in press).

French, K. and Eardley, K. (1997). The impact of weed infestations on litter invertebrates in coastal vegetation. *In* 'Frontiers in ecology' ed I. D. Lunt, pp 89-102 (Elsevier Science, Oxford).

French, K. and Zubovic, A. (1997). Effect of the weed *Chrysanthemoides monilifera* (bitou bush) on bird communities. *Wildlife Research* 24, 727-35.

Gosper, C.R. (2004a). Fruit characteristics of invasive bitou bush, *Chrysanthemoides monilifera* (Asteraceae), and a comparison with co-occurring native plant species. *Australian Journal of Botany* 52, 223-30.

Gosper, C.R. (2004b). Consequences of weed invasion and control on plant-bird interactions and bird communities. PhD thesis, University of Wollongong, Wollongong.

Gosper, C.R., Whelan, R.J. and French, K. (2006). The effect of invasive plant management on the rate of removal of vertebrate-dispersed fruits. *Plant Ecology* 184, 351-63.

Lindsay, E.A. and French, K. (2004a). *Chrysanthemoides monilifera* ssp. *rotundata* invasion alters decomposition rates in coastal areas of south-eastern Australia. *Forest Ecology and Management* 198, 387-99.

Lindsay, E.A. and French, K. (2004b). The impact of the weed *Chrysanthemoides monilifera* ssp. *rotundata* on coastal leaf litter invertebrates. *Biological Invasions* 8(2), 177-92.

Lindsay, E.A. and French, K. (2005). Litterfall and nitrogen cycling following invasion by *Chrysanthemoides monilifera* ssp. *rotundata* in coastal Australia. *Journal of Applied Ecology* 42, 556-66.

Lindsay, E.A., and French, K.O. (2004c). The impact of the herbicide glyphosate on leaf litter invertebrates within bitou bush, *Chrysanthemoides monilifera* ssp. *rotundata*, infestations. *Pest Management Science* 60, 1205-12.

Mason, T.J. and French, K. (2007). Management regimes for a plant invader differentially impact resident communities. *Biological Conservation* 136, 246-59.

Mason, T.J., French, K. and Russell, K.G. (2007). Moderate impacts of plant invasion and management regimes in coastal hind dune seed banks. *Biological Conservation* 134, 428-39.

Matarczyk, J.A., Willis, A.J., Vranjic, J.A. and Ash, J.E. (2002). Herbicides, weeds and endangered species: management of bitou bush (*Chrysanthemoides monilifera* ssp. *rotundata*) with glyphosate and impacts on the endangered shrub, *Pimelea spicata*. *Biological Conservation*, 108, 133-41.

Owen, B. (1999). The effect of bitou bush infestation on the behaviour and nest predation of birds in coastal woodlands. Honours thesis, University of Wollongong.

Prattis, K.E. (2004). An investigation into the effects of *Chrysanthemoides monilifera* ssp. *rotundata* (bitou bush) infestation and treatment on the vegetation community at Booderee National Park. Honours thesis, University of Wollongong.

Thomas, J., Hofmeyer, D. and Benwell, A.S. (2006). Bitou bush control (after fire) in Bundjalung National Park on the New South Wales North Coast. *Ecological Management and Restoration* 7, 79-92.

Toth, J., Milham, J., Meszaros, I., Kaldor, J., Fullerton, R.N. and Burrows, F. (1996). Research on chemical control of bitou bush in New South Wales. Proceedings of the 11th Australian Weeds Conference, ed. R.C.H. Shepard, pp 468-75. (Weed Society of Victoria, Melbourne).

Wilkie, L., Cassis, G. and Gray, M. (2007). The effects on terrestrial arthropod communities of invasion of a coastal heath ecosystem by the exotic weed bitou bush (*Chrysanthemoides monilifera* ssp. *rotundata* L.) *Biological Invasions* 9, 477-98.

Vranjic, J.A., Woods, M.J. and Barnard, J. (2000). Soil-mediated effects on germination and seedling growth of coastal wattle (*Acacia sophorae)* by the environmental weed, bitou bush (*Chrysanthemoides monilifera* ssp. *rotundata). Austral Ecology*, 25, 445-53.

Weiss, P.W. (1984). Seed characteristics and regeneration of some species in invaded coastal communities. *Australian Journal of Ecology* 9, 99-106.

Weiss, P.W. and I.R. Noble. (1984). Interactions between seedlings of *Chrysanthemoides monilifera* and *Acacia longifolia*. *Australian Journal of Ecology* 9, 107-16.

Willis, A.J. and Memmott, J. (2005). The potential for indirect effects between a weed, one of its biocontrol agents and native herbivores: a food web approach. *Biological Control* 35, 299-306.