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This plan should be cited as:
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.

ISBN 1 74137 855 9; DEC 2006/115

Appendix 2 Development of a model to rank plant species threatened by bitou bush invasion

Invasion by bitou bush and boneseed is an enormous problem in New South Wales and its management requires planned use of limited resources. Establishing priorities is an important part of the planning process. Priorities for the Bitou TAP (i.e. this plan) include the determination of plant species, populations and ecological communities threatened by bitou bush and sites where the actions of the Bitou TAP can be achieved for each taxa (or biological entity).

Prior to the development of the draft (see DEC 2004), determination of the species, populations and ecological communities most at risk from bitou bush and boneseed invasion was a difficult task (Downey 2004). This was mostly because information that quantifies the impacts was absent across a broad range of native taxa (see Downey 2004; Downey submitted), especially with respect to fauna (see Chapter 5). For example, prior to the development of the draft only six native plants and two birds were deemed to be at risk from bitou bush and boneseed. In order to determine the species at risk the Weed Impacts to Native Species (WINS) assessment process was developed (see Downey in press). The WINS assessment process involves four systematic stages: 1) a review of the literature; 2) collation and assessment of knowledge from land managers, botanists and scientists with specific involvement, either in managing bitou bush, or the native species in bitou bush infested areas; 3) rigorous evaluation and examination of an interim list of native species identified as potentially at risk; and 4) ranking the revised list using a model. Information from stages 1–3 is not presented here, with the exception of the final list of species at risk. The model used for stage 4 of the WINS process is presented below.

The draft plan identified 63 plant species at risk and a further 70 that were potentially at risk, which were not modelled due to a lack of information. Following the public exhibition and further consultation (i.e. stage 3 of the WINS process) a further 25 species were added to the list of species at risk, bringing the total to 158. This revised list of species at risk was then run through the model described below. The full list of the species modelled along with their score for each attribute and their final ranking is presented in Appendix 3, Table A3.1. In addition, there were several species that were not modelled due to insufficient information, which are presented in Appendix 3, Table A3.2.

It should be noted that all plant species considered to be at risk from bitou bush and boneseed invasion in New South Wales were examined during the WINS selection process, not just those formally listed as threatened (i.e. under the TSC Act). Of the 158 species identified through the WINS assessment process as being at risk, 55 were listed as threatened under the TSC Act (see Table A3.3 in Appendix 3); 30 of which were also listed as threatened nationally (i.e. under the EPBC Act), highlighting the role of the WINS assessment process in capturing the full diversity of plant species at risk.

The model used in the draft TAP was the first attempt to rank native species at risk from an individual weed invasion in Australia. The model outlined below is a revision of the one presented in the draft TAP (see DEC 2004). The main changes to the species model are:

- The *Threatened status* attribute (C) was removed, as it was not an independent attribute. For example, a species with a limited distribution is more likely to be listed as threatened than a widespread species, therefore species with limited distributions could be artificially elevated in the ranking when their *Distribution* and *Threatened status* attributes were combined.
- The *Shade tolerance* attribute (D) (a measure of susceptibility) was revised to *Susceptibility of the species to invasion*, as this encompasses all of the species at risk equally, not just those at risk through shade tolerance.
- Weightings were applied to several of the attributes to ensure that no one factor was overriding the model predictions (see below for further details).

The model presented here is not definitive. Specific information was not available for some species (e.g. seed banks and dispersal rates). The model can be re-run when more comprehensive data becomes available, or if additional species are considered to be at risk.

The ranking of priority species in the revised model uses four attributes: (A) susceptibility of the habitat to bitou bush invasion; (B) native species distribution; (C) susceptibility of the native species to bitou bush invasion; and (D) native species persistence (sub-divided into (D^1) seed bank and (D^2) dispersal). Each attribute is scored with the highest score implying the highest priority.

The model for ranking plant species threatened by bitou bush invasion is:

priority rank = (habitat susceptibility [A] **x** 1.25) **x** distribution [B] **x**
((species susceptibility [C] + (persistence [D^1 + D^2]/2))/3)

Attribute A in the model was weighted (by 1.25) to account for its importance in determining the overall risk from invasion. If the habitat is not susceptible to invasion the susceptibility of the species that occur in that habitat is of little importance. The attributes that describe the individual native species' susceptibility [C] and ability of these species to persist [D] on the other hand, were scaled down due to their combined values overriding the model. The weighting therefore standardised the combined values for C and D with the individual values of A and B. Lastly, the persistence sub-attributes (D^1 and D^2) were averaged in order to maintain a consistent set of values for each attribute, again limiting these values from overriding the model.

A Susceptibility of the habitat to bitou bush invasion

Some habitats are more prone to invasion by bitou bush than others. For example, a particular habitat may provide limited competition to bitou bush, such as tussock grasslands with inter-tussock spaces. Also, a particular disturbance regime may favour invasion (e.g. fire and soil disturbance). The density of bitou bush present is not necessarily a reflection (or measure) of the invasibility of that habitat, as many invasive plants exhibit a distinct lag period between initial occurrence and dominance (even at a site level). Therefore, a site with a light infestation of bitou bush may either present a barrier to invasion, or the invasion process is in the early stages and heavier infestations may occur in the future if untreated.

Score	***Habitat invasibility***
0	*Extremely low habitat invasibility* – non-coastal habitats or those habitats close to the coast in which boneseed (or rarely, bitou bush) occurs but are generally not susceptible to invasion
1	*Low habitat invasibility* – habitats with closed canopies (e.g. closed forests or heaths), or water logged habitats (e.g. margins of swamps)
2	*Medium habitat invasibility* – habitats with open canopies (e.g. open woodlands or shrublands), or forest margins
3	*High habitat invasibility* – habitats with no or low vegetation (e.g. sand dunes or spinifex grasslands), or habitats with a limited shrub layer, or sites where the native vegetation is disturbed such that there is no or patchy vegetation

B Distribution of native species relative to bitou bush

This attribute describes the potential for bitou bush to have a major impact on an individual native species based on the degree of overlap between the distribution of bitou bush and the native species. For example, a species that occurs both within and outside the distribution of bitou bush is less likely to experience population level impacts than a species which is confined to areas occupied by bitou bush.

Score	*Distribution of native species*
0	Not known from coastal habitats
1	Distributed across a range of habitats (some of which are coastal <50%)
2	Known predominantly from coastal habitats (>50% but <100%)
3	Known only from coastal habitats
4	Known only from coastal habitats in which all locations are within the distribution of bitou bush (and/or boneseed)

C Susceptibility of individual species to bitou bush invasion

A number of specific attributes can be used to describe the susceptibility of plants to weed invasion, however, many of them could not be used because insufficient data was available for many of the species examined here (i.e. on the effects of competition). Shade sensitivity or tolerance was used in the draft TAP, but this attribute did not apply equally to all native species examined (i.e. some species were not affected by shade, but were susceptible to invasion as a result of other processes). Thus, a broader measure was used here to encompass and assess the general level of susceptibility of individual plant species to bitou bush invasion.

Score	*Species susceptibility*
1	Species persists or grows in invaded areas
2	Information about susceptibility to invasion is unknown
3	Slightly sensitive to invasion (i.e. occurs in part shade)
4	Sensitive to invasion (i.e. shade sensitive species – occurs only in full sun/does not occur in shade and thus absent in bitou bush invaded areas)

D Persistence (seed bank and dispersal)

This attribute describes the ability of the native plant species to persist at a site, as measured by their ability to survive, reproduce and disperse (immigrate and emigrate). In order to capture this information, the attribute was divided into two sub-attributes: a reflection of a species' seed bank or seed storage capability (D^1) and its ability to disperse (D^2). By obtaining the average value of the two scores (i.e. for each sub-attribute), the combined value of D^1 and D^2 was not unduly elevated as a single attribute in the model.

The size of the seed bank present, or seed storage capabilities (i.e. seeds stored in cones), and the seed dispersal ability of each species is extremely important for the longer term survival of that species, as well as for the ability of a species to respond once bitou bush has been removed. Species with no or poor seed banks may not be able to re-establish, or will have minimal recruitment following the removal of bitou bush, while those species with large seed banks are more likely to persist.

Persistence sub-attribute D^1 – seed bank:

Score	*Seed banks*
1	Long-lived seed bank and/or effective seed storage ability present
2	Information about seed dormancy/storage is unknown
3	The species has a short-lived seed bank or seed storage capability, or is primarily a-sexual or reproduction is vegetative
4	The species has a limited seed bank, seed storage capability or ability to regenerate vegetatively

Seed dispersal is another attribute that describes a species' ability to persist. Species that can disperse their propagules to sites free of bitou bush, or to areas where bitou bush control has occurred are more likely to persist than those that have poor dispersal mechanisms.

Persistence sub-attribute D^2 – dispersal:

Score	*Dispersal*
1	Seed dispersal ability is high (e.g. bird dispersed fruits)
2	Information about dispersal is unknown
3	Seed dispersal capability is limited (i.e. seeds are dispersed locally through dehiscence)
4	No or poor seed dispersal capability

Species for which there is limited information are given a lower score than those that are known to have limited seed storage or dispersal capability, because they may actually possess seed storage or seed dispersal mechanisms. For many of the species examined this information is poorly known.