

NATIONAL RECOVERY PLAN FOR BUTTON WRINKLEWORT (*Rutidosia leptorrhynchoides*)



Australian Government



Office of
Environment
& Heritage



Department of
Sustainability
and Environment



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The attainment of objectives and the provision of funds may be subject to budgetary and other constraints affecting the parties involved, and may also be constrained by the need to address other conservation priorities. Approved recovery actions may be subject to modifications due to changes in knowledge and changes in conservation status.

Summary

This document constitutes the formal National Recovery Plan for Button Wrinklewort (*Rutidosia leptorrhynchoides*). The plan considers the conservation requirements of the species across its known range, identifies the actions to be taken to ensure its long-term viability in nature and, where possible, the parties who will undertake these actions.

Button Wrinklewort is listed as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, Endangered (Schedule 1, Part 1) on the NSW *Threatened Species Conservation Act 1995*, Endangered (Section 21) on the ACT *Nature Conservation Act 1980* and as Threatened under S.10 of the *Victorian Flora and Fauna Guarantee Act 1988*.

Button Wrinklewort is a multi-stemmed perennial forb in the family Asteraceae. It occurs from Goulburn in the Southern Tablelands of New South Wales to Wickliffe on the plains west of Melbourne in Victoria. Twenty-nine natural populations of Button Wrinklewort are currently known; 8 in NSW, 11 in the ACT and 11 in Victoria (one site straddling the NSW/ACT border has been included in both the ACT and NSW population counts). The NSW and ACT populations are markedly disjunct from the Victorian populations and there are significant genetic differences between populations across the range of the species.

The first recovery plan for this species was produced in 1998 (Briggs et al. 1998), although it was not formally adopted as a national plan or in any of the range jurisdictions. At that time a total of about 207 580 plants were known. Over the 11 years that plan has been implemented the total natural population known in 1998 has remained stable. Eleven additional natural populations totalling 8430 plants have been discovered since 1998, taking the total current natural population to about 213 270 plants. This current edition of the Recovery Plan includes an updated set of Recovery Actions that have been identified through a review of the current priority needs for the species. In addition to the natural populations there are another five planted populations in Victoria with a total population of approximately 1300 individuals.

The overall objective of this plan is to ensure that all populations consisting of more than 10 plants of Button Wrinklewort are stable or increasing in size by reducing or managing threats, encouraging sympathetic site management to promote recruitment wherever possible, use supplementary planting where appropriate and increase knowledge of the genetic diversity and response to disturbance of this species.

These objectives will be achieved through the following recovery actions:

1. Remove threatening weeds
2. Monitor populations
3. Undertake ecological burning as needed
4. Prompt recording of new sites
5. Complete a survey of the genetic composition of all populations
6. Genetic enhancement of small populations
7. Formal reservation or negotiation of management agreements for populations on non-reserve tenure
8. Undertake various site-specific actions

The Recovery Plan will be considered successful if populations at all but the smallest sites have remained stable or have increased in size over a 5 year period. Any decline due to prolonged drought is beyond the influence of this Plan.

SPECIES INFORMATION AND GENERAL REQUIREMENTS

Description

Button Wrinklewort (*Rutidosia leptorrhynchoidea* F.Muell.) is a perennial forb which produces multiple flowering stems 15 to 30 cm high during spring and summer. These stems die back in late summer or autumn and a new basal rosette of leaves is evident by early winter. Stems are hairless in the upper part, becoming woolly towards the base. The stems arise from a woody rootstock. Leaves are mostly stem-clasping at their base, linear, usually 1.5-3.5 cm long, 0.5-1.5 mm wide, hairless, and have their edges slightly rolled under. Yellow spherical flower-heads 8-15 mm in diameter are borne near the ends of the flowering stems. Each flower-head is on an individual short stalk and is comprised of numerous very small clustered yellow flowers. Flowering in NSW and the ACT occurs between December and April. In Victoria the species flowers from October to February (Scarlett and Parsons 1990).

Distribution

Button Wrinklewort occurs in south-eastern Australia, from Goulburn in the Southern Tablelands of NSW to Wickliffe on the plains west of Melbourne, Victoria. The NSW and ACT populations are markedly disjunct from the Victorian populations. Evidence suggests that the species was formerly widespread in south-eastern NSW from near Michelago to near Goulburn. In Victoria the species occurred across the Victorian Volcanic Plain, north to Casterton and as far east as Newry in Gippsland, but is now restricted to tiny refugia in the south-west, occurring on the outskirts of Melbourne, Bannockburn, Rokewood, Wickliffe and between Beaufort and Ararat. The species is not known to occur naturally in any conservation reserve in Victoria although it is sympathetically managed at the Yalla-y-Poora Recreation Reserve.

Currently there are 29 known extant natural populations (11 in Victoria, though some consist of less than 10 plants) and there are six remaining planted populations in Victoria. Eleven populations have possibly become extinct since they were first recorded (six in Victoria, three in NSW and two in ACT). Table 2 provides a summary of population size, population trends, area of occupancy and land tenure at all known sites. According to data provided by several sources undertaking monitoring programs for this species (see Table 2) approximately 213 270 naturally occurring plants are known to survive in the wild. A review of data collected frequently from some sites shows that numbers can, however, fluctuate by as much as 20% between years. Four natural populations (two in NSW and two in the ACT) with a total population of about 36 000 plants (15.3% of total natural population) occur in conservation reserves. Figure 1 shows the past and present distribution of the species. Whilst the total population size may appear large, the total area occupied by the species across its entire range is only 13.4 ha.

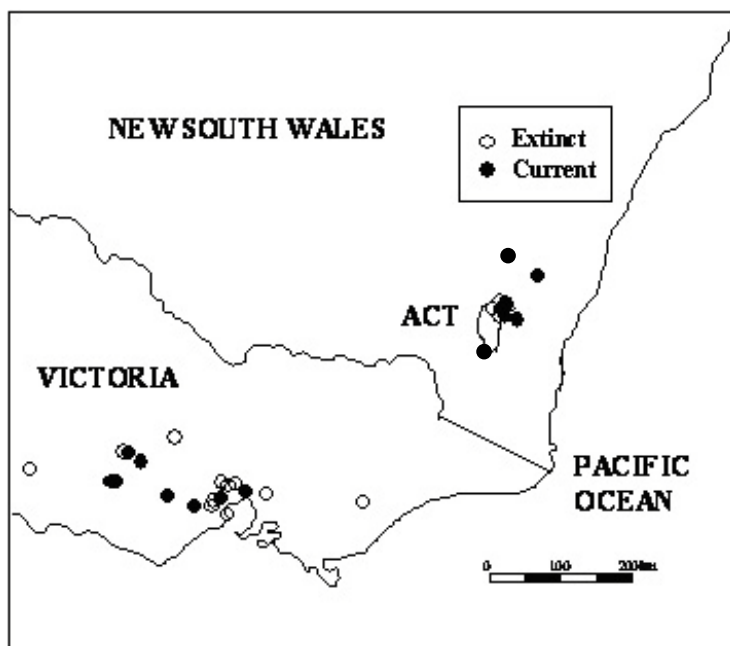


Figure 1. Map showing current known locations and presumed extinct sites of Button Wrinklewort.

Habitat

In the Canberra - Queanbeyan region Button Wrinklewort primarily occurs in the ecotone between the treeless *Themeda triandra* (syn *T. australis*) (Kangaroo Grass), *Poa* spp. (Tussock Grass) and *Austrostipa* spp. (Spear Grass) dominated grasslands and the open grassy *Eucalyptus melliodora* (Yellow Box) - *E. blakelyi* (Blakely's Red Gum) woodlands. Button Wrinklewort also often extends well into the treeless grasslands in parts of the ACT. Known sites occur at elevations between 570 and 780 metres above sea level. The soils are shallow, stony red brown clay loams.

In Victoria Button Wrinklewort is restricted to open stands of plains grassland and grassy woodlands, on fertile clays to clay loams, usually in areas where the grass cover is more open, either as a result of recurrent fires or grazing by native macropods or stock. It also occurs on low rises with shallow, stony soils at less than 100 m above sea level.

Habitat critical to the survival of the species

Given the small area of occupancy (approx. 13.4 ha), the reliance on in-situ protection of the 84% of the population that is not in formal conservation reserves, and the ongoing threat of weed invasion to most sites, all populations of more than 10 plants and the habitat they occupy are critical to the survival of Button Wrinklewort.

Legal Status

Button Wrinklewort (*Rutidosia leptorrhynchoides*) is listed as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, Endangered (Schedule 1, Part 1) on the NSW *Threatened Species Conservation Act 1995*, Endangered (Section 21) on the ACT *Nature Conservation Act 1980* and as Threatened under s.10 of the Victorian *Flora and Fauna Guarantee Act 1988*.

International obligations

The species is not listed under International Agreements. This plan is consistent with the aims and recommendations of the Convention on Biological Diversity, which has been ratified by Australia, and will assist in meeting Australia's responsibilities under that convention.

Role and interests of indigenous people

Consultation with Aboriginal communities regarding any traditional knowledge/use of this species and any comment they may have on the content and implementation of this recovery plan commenced during the public exhibition of the draft recovery plan. Consultation will continue during the implementation stage of this Plan and efforts will be made to accommodate any suggestions received regarding the action details and any interest in being involved in undertaking the actions.

Biodiversity Benefits

The preparation and long term implementation of Recovery Plans for threatened species, populations and ecological communities contributes to, and highlight the importance of, conserving biodiversity. The conservation of biodiversity has a number of wider community benefits. These include the provision and maintenance of a range of ecosystem functions and landscape health.

The appropriate protection and management of the habitat of Button Wrinklewort will contribute to the conservation of four nationally threatened ecological communities, 6 nationally threatened plant species and 8 nationally threatened fauna species. Other State and Territory listed threatened entities also occupy Button Wrinklewort habitat. These are listed in Table 1.

Table 1. Threatened Species and Ecological Communities that co-occur with Button Wrinklewort.

Species	Common Name	Commonwealth	ACT	NSW	VIC
Ecological Communities					
	Natural Temperate Grasslands of the Southern Tablelands of NSW and ACT	Endangered	Endangered		
	White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Endangered	Endangered	Endangered	
	Western (Basalt) Plains Grasslands Community				Threatened
	Natural Temperate Grasslands of the Victorian Volcanic	Critically endangered			

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	Plains				
	Grassy Eucalypt woodland of the Victorian Volcanic Plains	Critically endangered			
Flora					
<i>Leucochrysum albicans</i> var. <i>tricolor</i>	Hoary Sunray (white form)	Endangered			Endangered
<i>Swainsona sericea</i>	Silky Swainson Pea			Vulnerable	Vulnerable
<i>Pimelea spinescens</i> subsp. <i>spinescens</i>	Spiny Rice-flower	Critically endangered			Vulnerable
<i>Senecio macrocarpus</i>	Large-fruit Groundsel	Vulnerable			Endangered
<i>Comesperma polygaloides</i>	Small Milkwort				Vulnerable
<i>Diuris fragrantissima</i>	Sunshine Diuris	Endangered			Endangered
<i>Prasophyllum suaveolens</i>	Fragrant Leek-orchid	Endangered			Endangered
<i>Microseris</i> sp. 1	Plains Yam-daisy				Vulnerable
<i>Podolepis</i> sp. 1	Basalt Podolepis				Vulnerable
<i>Glycine latrobeana</i>	Clover Glycine	Vulnerable			Vulnerable
<i>Cullen parvum</i>	Small Scurf-pea			Endangered	Endangered
<i>Cullen tenax</i>	Tough Scurf-pea				Endangered
Fauna					
<i>Delma impar</i>	Striped Legless Lizard	Vulnerable	Vulnerable	Vulnerable	Endangered
<i>Perunga ochracea</i>	Perunga Grasshopper		Vulnerable		
<i>Synemon plana</i>	Golden Sun Moth	Critically Endangered	Endangered	Endangered	Critically endangered
<i>Tympanocryptis pinguicollis</i>	Grassland Earless Dragon	Endangered	Endangered	Endangered	Critically endangered
<i>Perameles gunnii</i>	Eastern Barred Bandicoot	Endangered			Critically endangered
<i>Sminthopsis crassicaudata</i>	Fat-tailed Dunnart				Near threatened

<i>Turnix pyrrhothorax</i>	Red-chested Button-quail				Vulnerable
<i>Litoria raniformis</i>	Growling Grass-frog	Vulnerable			Endangered
<i>Stagonopleura guttata</i>	Diamond Fire-tail			Vulnerable	Vulnerable
<i>Melanodryas cucullata cucullata</i>	Hooded Robin		Vulnerable	Vulnerable	Threatened
<i>Petroica boodang</i>	Scarlet Robin			Vulnerable	
<i>Petroica phoenicea</i>	Flame Robin			Vulnerable	
<i>Daphoenositta chrysoptera</i>	Varied Sitella	Vulnerable	Vulnerable	Vulnerable	
<i>Chthonicola sagittata</i>	Speckled Warbler			Vulnerable	Vulnerable
<i>Lathamus discolor</i>	Swift Parrot	Endangered	Vulnerable	Endangered	Endangered
<i>Anthochaera phrygia</i>	Regent Honeyeater	Endangered	Endangered	Endangered	Critically Endangered

Social and economic impacts

The implementation of this Recovery Plan is not expected to cause significant adverse social impacts. There will be lost opportunity costs, mainly for the ACT and Australian Government, in the protection of some sites where urban development could otherwise occur. However, the area occupied by those sites with urban development potential is small, with by far the largest site being only 1.269 ha (Stirling Ridge site). The costs of implementation are considered to be offset by the environmental and social benefit of preventing further loss in biodiversity. Actions on public land are consistent with current land management practices identified for such land.

Biology and ecology

Flowering of Button Wrinklewort occurs between December and April in NSW and the ACT, but commences earlier in Victoria where it flowers from October to February (Scarlett and Parsons 1990). The time from recruitment to first flowering is usually two or three years (ACT Government 1998; Young et al. 2000b) and the lifespan of wild plants is believed to be well in excess of 10 years (Wells and Young 2002). Pollination is probably performed by a variety of insects however the exact vectors

are unknown (Wells and Young 2002). The seed is predominantly dispersed by wind, but mostly falls within 0.5 metres of the parent (Wells and Young 2002). The seeds do not persist in the soil for long periods and the majority of recruitment is generated from seeds of the previous year (Morgan 1995a and Morgan 1995b). The species exhibits sporophytic self-incompatibility which prevents self pollination or pollination among related individuals that share self-incompatibility alleles (these are known as *S*-alleles) (Young et al 2000b). The characteristic of limited seed dispersal results in an increasingly high probability of plants being related the closer they are to each other. The probability of relatedness within a radius of about 1 m from any plant is very high, with the majority being half or full-sibs. The implications of this for seed collection for translocation projects are that, where possible, seed should be collected from a selection of plants each located several metres apart to minimise the relatedness of progeny.

Button Wrinklewort occurs in undisturbed native grassland in Victorian sites. Lowland grassland communities need intermittent burning to maintain floristic diversity (McDougall 1987, Lunt 1990). Where frequent burning is prevented, dense swards of grass species out-compete the Button Wrinklewort and the species vanishes. In heavily grazed areas, the species is also rapidly removed because it is palatable to stock, although light grazing by sheep, particularly after peak flowering, appears to be tolerated by the species. In contrast, maintenance of the habitat in NSW and the ACT is less dependent on regular burning, probably because the less fertile and shallower soils in the northern parts of its range restrict the density of the groundcover and where inter-tussock spaces are generally retained in the absence of fire. Several northern sites also have additional competition from scattered trees.

Seed set appears to be influenced by population density rather than population size. Morgan and Scacco (2006) stated that “The low seed set observed may occur because pollinator visitation rates decline in sparse populations or, alternatively, because pollinators are less efficient at pollen transfer when individuals are at low density.”

High mortality rates of seedlings in very open sites or under heavy shading from introduced shrubs or dense tree regeneration following site disturbance may limit recruitment in certain populations (ACT Government 1998).

Two chromosomal races of Button Wrinklewort exist, comprising diploid populations that are spread across the whole range of the species and tetraploids that are confined to the south-west of the species range in Victoria. As a whole the species exhibits unusually high levels of cytological diversity (Murray and Young 2001).

Threats

The identified threats to Button Wrinklewort are urban development, physical disturbance of sites, weeds, competition from native grasses, heavy grazing, unsuitable fire regimes, demographics of small populations, reproductive limitations resulting from the self-incompatibility system, genetic incompatibility between chromosomal races, and climate change. Of these physical disturbance and weed invasion are probably the most immediate threats to most populations. The demographics and loss of genetic diversity for self-incompatibility genes poses a long term threat to small populations.

Urban development. Urban development has, and continues to be a threat to some of the Canberra, Queanbeyan and Goulburn populations. For example, in the early 1990s urban development destroyed a population of around 200 plants on Mount Jerrabomberra. Stirling Ridge remains a possible site for a new lodge for the Prime Minister and for other housing development. The Poplars and Tennant St. populations and part of the Snow Gum Ridge population near Goulburn are on land being considered for housing/industrial development, although approval authorities are likely to require exclusion of the areas supporting Button Wrinklewort from the development footprints. In Victoria, destruction resulting from urban/infrastructure development is an ongoing high risk on all linear reserves. This is a particular threat to the only large diploid population at Truganina cemetery, as the expansion of

Melbourne's Urban Growth boundary is expected to push urban development towards this site and create pressure for heavier use as a cemetery (Craigie 2009).

Physical disturbance. Button Wrinklewort has been observed to colonise areas of minor soil disturbance around existing populations, but direct disturbance of plants can also destroy established plants. Mowing and car parking continue to threaten a population at St. Mark's in Barton and unauthorised vehicle access has damaged the habitat of the Woods Lane population. The Snow Gum Ridge population is being impacted by nearby residential development and illegal dumping of garden waste and erosion has killed plants in the Captain Flat Road population. In 2009 unauthorised BMX bike track construction has damaged Button Wrinklewort habitat at the Poplars site, and over the last few years there has been ongoing damage near to the Button Wrinklewort habitat at the Queanbeyan Nature Reserve (South) from unauthorised racehorse training. Soil disturbance and compaction remains a very high risk at all Victorian sites on roads, rail reserves and cemeteries. Three of the four largest populations (Dobie, Rokewood, Truganina) are under serious potential threat from accidental damage. Incremental damage also contributes to loss of plants and habitat. All roadside sites are bordered by ploughed firebreaks which have been extended incrementally over time, e.g. Wickliffe-Willaura Rd (Craigie, 2009 DSE (in prep.)).

Climate change. Populations at the Red Hill site have been surveyed seven times since 1984. These populations are within Canberra Nature Park and are managed for conservation. The populations increased up until 2004 but have declined since. A possible cause of this decline is the on-going drought (Mulvaney pers. comm.). Whilst drought may not directly result in extinction of a population it may exacerbate the impacts of small population demographics by reducing population numbers and recruitment. More frequent drought in south-eastern Australia is one of the modelled predictions resulting from climate change and this may be an ongoing impact on many of the Button Wrinklewort populations. In Victoria, the recent dry conditions, particularly in spring are believed to have had an impact on germinant survival. Button Wrinklewort flowers from mid-spring to summer, and germinants are especially vulnerable to hot, dry conditions. Also increasing intervals between rain periods lead to greater stress on germinants. Climate change predictions across its Victorian range suggest that dry springs and hot summers may become more common and lead to reduced recruitment. For example, although there was a good reproduction event at Truganina Cemetery in 2004, no seedlings survived the subsequent dry summer/autumn (Scarlett pers. comm.).

Weed invasion. Disturbance at sites with high fertility can lead to invasion by weedy grass species such as *Dactylis glomerata* (Cocksfoot) and *Phalaris* spp., whilst persistently low ground cover makes sites vulnerable to *Eragrostis curvula* (African Love Grass) and *Nassella trichotoma* (Serrated Tussock) invasion. Other weed species that are known to impact sites include *Hypericum perforatum* (St Johns Wort), *Nassella neesiana* (Chilean Needle Grass), and *Paspalum dilatatum*. Overshading from the following woody weed species is also a threat to some populations in the ACT; *Pyracantha* spp. (Firethorn), *Cotoneaster* spp., *Rosa rubiginosa* (Sweet Briar) and *Acacia baileyana* (Cootamundra Wattle). In Victoria, other non-grassy weeds are Boxthorn (*Lycium ferocissimum*), Fennel (*Foeniculum vulgare*), Gorse (*Ulex europaeus*), thistles (e.g. *Cirsium* spp.), Montpellier Broom (*Genista monspessulana*) and Smilax (*Asparagus asparagoides*). The majority of sites in the ACT, Victoria and NSW are threatened in some way by weed species (ACT Government 1998; ACT Government 2005, Briggs pers. comm., Craigie pers. comm.; DSE in prep.).

Competition from other native vegetation. Button Wrinklewort prefers open sites and may be vulnerable to overshading and lack of bare ground for colonisation. At some sites native grass species such as *Themeda triandra* (syn. *T. australis*) (Kangaroo Grass) can out-compete Button Wrinklewort, and biomass control may be necessary. Where present, Kangaroo grazing can be an effective means of biomass control, and this occurs, for example, at the Queanbeyan Nature Reserve site.

Grazing. Whilst grazing is an important tool for biomass management, Button Wrinklewort is eaten by domestic stock, and set-stocking or even moderate intensity rotational grazing may cause a decline of impacted populations. Domestic stock grazing has been an identified significant past threat to several populations in NSW and the ACT, e.g. at Red Hill, Gundary, Letchworth and Michelago.

Craigie (2006) states that in Victoria this species is only found at sites with no history of domestic stock grazing. Most sites in NSW have now had stock grazing removed. It is also notable that several of the larger surviving populations are on sites that are known to have a history of grazing predominantly by sheep rather than cattle, suggesting that cattle may have more impact than sheep on Button Wrinklewort. The hemicryptophytic nature of the plant means that grazing to the soil surface or ripping off the above ground component of the plants will remove all crown buds necessary for the plant to resprout, resulting in plant death. Flowering and seed production can also be reduced by heavy grazing. Some degradation of Button Wrinklewort habitat was noted at Gundary Travelling Stock Reserve after a period of set stocking.

Kangaroos do not appear to graze the foliage of this species (Baines pers. comm.), which is consistent with their dietary preference for grasses. Therefore, Kangaroo grazing is a useful tool for biomass control for this species.

Several populations in Victoria are under moderate threat from browsing and digging by rabbits. (DSE in prep.).

Lack of Genetic Diversity in Small Populations. Small populations (<200 plants) exhibit reduced diversity in *S*-alleles compared to large populations. Reduced *S*-allele diversity results in a reduced availability of compatible mates for individual plants, which in turn reduces fertilisation success across the population (Young and Pickup 2010). Both diploid and tetraploid races are both affected by reduced *S*-allele diversity, however the effects may be more pronounced in tetraploid populations (Young et al. 2000b). Conversely fertilisation is more quickly restored by genetic rescue in tetraploid populations (Pickup and Young, 2007). Demographic and genetic simulation modelling has indicated that diploid populations with fewer than 50 mature individuals will become extinct significantly more rapidly than those with more than 200 plants (Young et al. 2000a). These simulations also suggest that any populations smaller than 400 reproductive plants and with less than 20 *S* alleles are at increased likelihood of short-term extinction (Young, pers. comm.; unpublished data).

Genetic incompatibility. Two chromosomal races of Button Wrinklewort exist, diploid populations that occur in both the north and south of the species range and tetraploid populations that are restricted to the south-western part of the range in Victoria. These different cytotypes may occupy different ecological niches. There is evidence of possible low level genetic exchange between the two races. In large populations hybridisation between races may not reduce population viability and may increase genetic diversity. In small populations the reduced individual fitness resulting from such hybridisation outweighs the benefits of increased genetic diversity across the population (Murray and Young 2001).

Inappropriate fire regimes. The effect of fire on Button Wrinklewort is poorly understood. Generally grassland species are well adapted to fire, particularly if it occurs after seed set (Eddy 2002). Fire is used as a management tool in many of the Victorian sites and long periods between fires are seen as a threat to the species. Inadequate burning can result in increased biomass of native and introduced grasses, which can outcompete and smother Button Wrinklewort. Burning is required every 2-5 years in areas of high productivity in Victoria (DSE in prep.).

However, high frequency or high intensity fires and fires during the flowering period may prove detrimental to Button Wrinklewort recruitment. The seed is only viable in the soil for a period of up to 18 months, and thus if a fire kills the seedlings and further germination conditions are poor for the following 18 months the population may have no successful recruitment. Button Wrinklewort does not flower until it is approximately three years old, and therefore two fires within a three year period that kill most of the seedlings may harm a population.

Monitoring in Victoria has shown that adult plants are rarely killed by fire (Craigie pers. comm.). In contrast, an experimental burn in the ACT in October, 2000 resulted in the death of between 40% and 50% of the adult plants on two plots. These deaths may have been exacerbated by a very dry period following the burn (Sharp pers. comm.), however on two control plots only 8% and 16% of plants died in the same period (Baines (TAMS) unpublished data). Based on these findings, where biomass

removal may be required for ACT and NSW populations a precautionary approach seems appropriate. Intervals between burning should probably be no more frequent than once every 5 years until further research can clarify the overall role of fire in managing ACT and NSW populations (Briggs, pers. comm.).

Poor reservation status. Only 15.3% of the total natural population occurs in formal conservation reserves. Two populations are reserved in NSW and two are in reserves in the ACT. There are no natural populations in Victoria that occur in designated conservation reserves. There are four small populations that occur in land managed at least partially for conservation, but all of these are translocated populations.

Table 2. Summary of population information

Site Number, Name & land tenure	Genetic Race	Area of occupancy (hectares)	Population Size Number of individuals recorded up to 1998 (year of survey)	Population Size Number of individuals at second most recent survey (year of survey)	Population Size Number of individuals at time of most recent survey (year of survey)	Population trend Indicating a change of more than 20% since last population estimate
ACT						
1. Baptist Church Kingston (Perpetual lease)	unknown	0.019	Site not recorded	50-100 (2000)	290 (2007)	Increasing
2. Campbell Park (Cwlth land - Defence)	unknown	0.102	100 (1998)	313 (2009)	310 (2011)	Stable
3. Capital Hill/State Circle (Cwlth land - NCA)	diploid	0.015	220 (1994)	220 (1994)	293 (2007)	Increasing
4. Crace Grassland Reserve (Nature Park)	unknown	0.168	Site not recorded	4000 (2000)	Approx 5000 (2007)	Increasing
5. HMAS Harman (Cwlth land - Defence)	unknown	0.400	Approx 300 (2001)	1379 (2007)	1946 (2008)	Stable The increases recorded since 2007 are largely due to the discovery of 3 additional sub-populations
6. Majura Training Area (Cwlth land -	diploid	0.630	27 263 (1996)	26,520 (2009)	27 991 (2010)	Stable

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Defence)						
7. St Marks Barton (Cwlth land)	diploid	0.026	133 (1994)	100 (2003)	80 (2007)	Decreasing
8. Stirling Ridge (Cwlth land, open space - NCA)	diploid	1.269	50 000 (1998)	50 000 (1998)	Approx 49 000 (2007)	Stable
9. Tennant Street Fyshwick (Open space)	unknown	0.199	Site not recorded	>100 (2004)	849 (2006)	Uncertain
10. Woods Lane (Unleased territory land)	unknown	0.023	350 (1998)	146 (2008)	173 (2011)	Increasing
11. Red Hill (Nature Park)	diploid	0.800	4807 (1994)	5705 (2004)	3440 (2007)	Decreasing
12. Kintore Street Yarralumla (Open space)	diploid	0	Site not recorded	1	0 (2007)	Possibly extinct
13. West Block State Circle (Cwlth land - NCA)	unknown	0	5 (1994)	5 (1994/95)	0 (2007)	Possibly extinct
Totals for ACT (natural populations)		3.821	Approx 82 750	Approx 89 000	Approx. 87 430 (Approx 81 290 for pops known in 1998)	Stable

VIC

14. Ararat-Western Highway	unknown	?	Site not recorded	31 (2003)	42 (2007)	Stable
15. Bannockburn cemetery (Crown land)	unknown	0.001	Site not recorded	2 (2005-06)	4 (2009)	Stable
16. Bannockburn Rail	tetraploid	0.4	340 (1994)	284 (2001)	774 (2009)	Increasing

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Reserve						
17. Carngham-Streatham Rd Mt Emu	unknown	0.001	Site not recorded	1 (2000)	1 (2007)	Stable
18. Dobies Bridge Rail Reserve 1	tetraploid	1.0	2616 (1994) (Sites 1 & 2)	1130 (2003) 910 (2005)	1131 (2007)	Stable
18. Dobies Bridge Rail Reserve 2	tetraploid		2616 (1994) (Sites 1 & 2)	816 (2001)	1381 (2007)	Increasing
18. Dobies Bridge Rail Reserve Cutting	tetraploid		Site not recorded	103 (2001)	224 (2007)	Increasing
19. Forsyth Rd Rail Reserve	unknown	0.25	375 (1979) 3 (1994)	0 (2004)	0 (2007)	Extinct
20. Laverton rail reserve	unknown		217 (1979)		0 (2008)	Extinct
21. Laverton North Grassland Reserve (planted)	tetraploid		1932 (1992)	20 (1997) 100 planted Aug 2007	6 2007 plantings ~ 50% lost (2008)	Decreasing
22. Little River North Rail Reserve	unknown	0.001	23 (1999)	0 (2005-06)	1-2? (2009)	Decreasing
23. Manor Rail Reserve	diploid		330 (1979) 13 (1994)	4 (2005-06)	0 (2009)	Extinct
24. Middle Creek 3 (east of Gould's Lane) Rail Reserve	tetraploid		140 (1998)	69 (2005)	83 (2009)	Stable
24. Middle Creek 1 Station (Rail Reserve)	tetraploid		35 (1998)	60 (2005-06)	81 (2007)	Increasing
24. Middle Creek 2 (Crown land)	tetraploid		64 (1999)	59 (2005)	59 (2007)	Stable
25. Mooramong (planted)	tetraploid		2203 (1985-9), 1303	approx 60 (2005)	268 (2006)	Uncertain

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			(1992)			Believed to have decreased since 2006 (Scarlett pers. comm.)
26. Organ Pipes National Park (planted)			144 (1992)	7 (1997)	0	Extinct
27. Peak School Rail Reserve	unknown		Site not recorded	5 (2005)	0 (2008)	Possibly extinct
28. Rokewood Cemetery Extension (Crown land)	tetraploid	1.0	5419 (1994)	2468 (2001)	~6000 (2009)	Increasing ? Stable in long term as population in 2009 similar to that in 1994
29. St Albans Rail Reserve	diploid		90 (1994)	17 (2001)	Approx 3 (2007)	Decreasing
30. Truganina Cemetery (Crown land)	diploid	1.0	626 (1994)	750 (2001)	652 (2007)	Stable
31. Wickliffe Road easement	tetraploid		28 (1994)	31 (2005)	0 (2008)	Possibly extinct
32. Woodnaggerak (planted)	tetraploid		1303 (1985)	N/A	12 (2005-06)	Unknown
33. Yalla-Y-Poorra Recreation Reserve (planted)	tetraploid		50 (1991)	30(2005)	29 (2009)	Stable
34. Mt Rothwell Conservation and Research Centre (planted)			N/A	212 (2002)	Approx. 100 (2009)	Decreasing
35. Iramoo Wildlife Park (planted)	diploid		Site not recorded	~2,000 (2006-09)	~at least 50% mortality (2009)	Decreasing

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36. Glenelg Hwy (planted)	tetraploid		Site not recorded	250 (2008-09) Seed sown (2008-09)	At least 10% mortality. (2010) Up to 1000 seedlings (2010)	Uncertain
Totals for Vic (natural populations)		3.651 +	Approx 10 000	5 551	10 435 (Approx 10 000 for pops known in 1998)	Increasing Note that most populations have declined, and losses offset by gains in only four sites

NSW

37. Queanbeyan Nature Reserve (North)	diploid	0.2	10 047 ± 2,766 (1995)	10 047 ± 2,766 (1995)	Approx 22 000 (2007)	Increasing
37. Queanbeyan Racecourse Railway easement	unknown	0.002	30 (1998)	30 (1998)	25 (2009)	Stable
38. Queanbeyan Nature Reserve (South)	diploid	0.082	1,171 (1994/95)	1,171 (1994/95)	5,666 (2007)	Increasing
39. Gundary Travelling Stock Reserve	diploid	4.648	95 240 ± 18 000 (1996)	95 240 ± 18 000 (1996)	Approx 77 500 (2007)	Stable
40. Jerrabomberra Heights (Council Reserve)	unknown	0	9 (1994/95)	9 (1994/95)	0	Possibly extinct
41. Captains Flat Road easement	diploid	0.009	161 (1994/95)	161 (1994/95)	692 (2007)	Increasing
42. Poplars (private)	diploid	1.0	8171 (1994/95)	8171 (1994/95)	8171 (1994/95)	Unknown
43. Snow Gum Ridge (Council Reserve)	unknown	0.053	Site not recorded	no previous data	1586 (2007)	Unknown
44. Marsden Weir	unknown	0.0018	Site not recorded	no previous data	50	Unknown

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(private)						
45. Michelago Rail Reserve	unknown	0.005	Site not recorded	no previous data	67 (2007)	Unknown
46. Michelago Private Land	unknown	0	Site not recorded	no previous data	0 (2007)	Possibly extinct
47. Googong (Cwlth)	unknown	0	1 (1996)	1 (1996)	0 (2007)	Possibly extinct
48. Bredbo - "Scottsdale" (Private)	unknown	0.01	Site not recorded	no previous data	50	Unknown
49. Bredbo - Railway Easement	unknown	0.08	Site not recorded	no previous data	150 (2009)	Unknown
Totals for NSW (natural populations)		6.09	Approx 115 000	Approx 114 800	Approx 115 400 (Approx 113 550 for pops known in 1998)	Stable
Totals for species (natural populations)		13.4 ha	207 580		213 270 (204 840 for pops known in 1998)	Stable

Guidance for Environmental Assessment

All populations of more than 10 plants are important to the long-term survival of the species and the maintenance of existing genetic diversity. To avoid significant impacts on the species, any of the following management practices or on ground works in the vicinity of the species may require assessment:-

Clearing of native vegetation for agricultural purposes, application of fertilisers, intensification of domestic stock grazing, switching the type of domestic stock, application of herbicide, urban development, rural subdivision, road and railway maintenance works, soil disturbance, slashing and recreational activities.

Detailed field surveys in appropriate seasonal conditions should be undertaken prior to the assessment and approval of any proposed developments within potential habitat.

In circumstances where loss of individuals is permitted, the loss should be offset by achieving improved long term protection and management of a suitable, currently unreserved population or other compensatory arrangements are agreed to by the consent authority.

Management Practices

Management practices required to avoid a significant impact include:

- Protect known populations from changes to land use.
- Do not undertake road works, pasture modification or other changes in land use that may affect populations.
- Limit grazing on sites where populations occur; light grazing by sheep, particularly after the peak flowering season, appears to be tolerated (following the removal of domestic stock, significant recruitment has been observed in some populations).
- Do not increase domestic stock grazing pressures on sites where populations persist - reduce domestic stock grazing pressures where possible.
- Undertake weed control in and adjacent to populations, taking care to spray or dig out only target weeds.
- Mark sites and potential habitat onto maps (of the farm, shire, region, etc) used for planning road works, residential and infrastructure developments, remnant protection, rehabilitation).
- Maintain or install, where appropriate, on-site signs to alert maintenance staff to the presence threatened species habitat.
- Search for new populations in potential habitat
- Avoid physical alteration to Button Wrinklewort habitat from changes in land use practices, land development, traffic and machinery operations – establish suitable buffer zones and/or erect fences or other appropriate barriers to minimise disturbance;
- Restore and protect damaged or depleted habitat by active revegetation works and ongoing habitat maintenance;
- Undertake relevant risk assessment and ensure appropriate management of proposed translocation and cultivation programs involving Button Wrinklewort;

- Control use of nutrients, biocides and other chemicals for any vegetation clearing adjacent to Button Wrinklewort habitat.

Previous and current recovery actions (1998 to 2012)

General Recovery Actions

Monitoring. Monitoring of threats and population numbers has been regularly undertaken by TAMS since 1998. The OEH has undertaken ad-hoc threat assessments for most populations during this period. The OEH and TAMS also undertook a comprehensive survey of NSW and ACT population numbers between April and July 2007. The Department of Defence undertakes monitoring of Button Wrinklewort populations every two years on average, for the three populations on Defence land (Campbell Park, Majura Training Area and HMAS Harman). Monitoring records the number of individuals in flower and in bud, the number of stems, and the height of plants at all three sites. Monitoring of the Majura Training Area includes recording of the boundary of the population and detailed surveys in six quadrats where the number of plants, number of stems, and the height of plants is recorded; this approach is adopted due to the size of the population. Thus, within the last five years the population size, area of occupancy and threats have been assessed for all known ACT and NSW populations, with the exception of the Poplars site.

In Victoria eight populations have been regularly monitored over the past eight years and most sites have been the subject of some monitoring.

Results of the two most recent surveys undertaken at each site, as well as numbers recorded to 1998, are shown in Table 2.

Reservation. Natural populations of Button Wrinklewort are formally conserved within Queanbeyan Nature Reserve, Crace Grassland Reserve (part of Canberra Nature Park) and the Red Hill Section of Canberra Nature Park. These reserves protect approximately 16.5% of the total Button Wrinklewort population. A planted population occurs within Laverton North Grassland Reserve in Victoria.

Those reserves with natural populations have management plans that aim to protect Button Wrinklewort populations through measures including:

- Encourage survival and expansion of Button Wrinklewort populations;
- Encouraging surveys and monitoring of Button Wrinklewort to improve knowledge of its management requirements;

Management Agreements. In Victoria, Public Authority Management Agreements (PAMAs) have been established with cemetery trusts at Bannockburn and Truganina which aim to protect 5% of the Victorian population. A draft PAMA had been written for Rokewood cemetery but has not been ratified by the cemetery trust. Vegetation Management Guidelines for Rail Corridors (VRIEF 2007) have been written to guide management of biodiversity assets on rail reserves. Sites on road reserves are not covered by management agreements (Craigie 2006).

In the ACT, Memorandums of Understanding, which include management guidelines for Button Wrinklewort, have been developed for all populations, although only 9% of ACT populations are in formal reserves.

The ACT Bushfire Operations Plan covers all ACT government reserves and National Capital Authority land in the ACT. Application of the Plan will consider the recorded locations of Button Wrinklewort by reference to the relevant GIS database and will adopt fire management strategies specific to these sites that will minimise the threat to this species.

No formal Management Agreements are in place for non-reserved NSW populations.

Research. A great deal of research has been undertaken into the genetics and demographics of Button Wrinklewort. An outcome from this research has been the development of a computer model which can be used to predict population trends and the effects of changes in demographic parameters. The model shows that there is a clear relationship between the amount of genetic diversity in a population and how quickly it is likely to go extinct.

The model can be used to identify critical life history stages for population viability. For example the survival of reproductive plants is critical. A 20 or 30 fold increase in seedling recruitment would be needed to offset the 3-5% loss of reproductive individuals which may occur following fire. The model also suggests that ideal populations in terms of maximising long-term viability should be >400 reproductive plants and have more than 20 self-incompatibility alleles (Young, unpublished data).

Summary of Site Specific Actions

NSW

- The NSW Government gazetted a southern section addition to Queanbeyan Nature Reserve in June 2004. This area was previously owned by the NSW Department of Housing and currently contains a population of about 5700 Button Wrinklewort plants. This population has increased from 450 plants in 1990 and its increase appears to be in response to the removal of stock grazing and the implementation of weed control.
- NSW OEH has undertaken judicial thinning of eucalypt seedling regeneration in the northern section of Queanbeyan Nature Reserve in order to maintain a grassy open-woodland habitat for Button Wrinklewort at the site.
- Queanbeyan City Council established a 0.5ha grassy woodland reserve specifically for the protection of a colony of nine Button Wrinklewort plants located within the Jerrabomberra Heights Housing Estate. Unfortunately this population has not persisted, probably due to lack of successful recruitment to replace the adults which have died, probably due to a combination of drought stress and old age.
- In 2009 the Goulburn RLPB erected an additional fence at Gundary Travelling Stock Reserve to separate and protect the 4 ha of grassland supporting Button Wrinklewort from another section of the TSR which had accrued a dense grass cover that required grazing to reduce the biomass levels.
- For the past several years the OEH has undertaken weed control, particularly of St. Johns Wort, Serrated Tussock and Sweet Briar in both sections of Queanbeyan Nature Reserve. The continued expansion of the population in the northern section of this reserve has been aided by this work.
- In 2001 OEH successfully removed (using herbicide) an area of about 0.3ha of Phalaris and Cocks Foot dominated groundcover in the northern section of Queanbeyan Nature Reserve. This area was sown in 2002 with Kangaroo grass in an effort to expand the area of suitable habitat for Button Wrinklewort and reduce the threat of weed invasion into existing habitat.
- In 2008 weed control (mainly for a heavy infestation of Serrated Tussock and Sweet Briar) was undertaken at the Poplars site. This work was funded by OEH, Greening Australia and the landowner.
- In 2008 control of Serrated Tussock within and adjoining the Bredbo railway easement population was undertaken by the ARTC.
- Since 2008 domestic stock grazing has been removed from the “Scottsdale” population near Bredbo (Saunders pers. comm.).
- Goulburn Mulwarree Council have erected log barriers to prevent vehicular access to the Snow Gum Ridge population located on Council land and have also undertaken woody weed control at

that site. The conditions of consent for an adjoining housing development required that run-off from the development was not to be allowed to flow onto the site (Lloyd pers. comm.).

ACT

- Park Care Groups and the ACT Parks and Conservation Service have undertaken woody weed control at the Button Wrinklewort sites on Red Hill, Stirling Ridge and Capital Circle.
- TAMS has negotiated with the Anglican Church for appropriate management of the Barton site.
- Domestic stock have been removed from the Red Hill and Majura Training Area sites.
- *Action Plan No. 8, Button Wrinklewort* *Rutidosia leptorrhynchoidea*, *An endangered species* was completed in 1998. The actions and recommendations of this plan have since been incorporated into *Action Plan No. 28, A Vision Splendid of the Grassy Plains Extended, ACT Lowland Native Grassland Strategy 2005*. This Action Plan aims to ensure the protection and survival of Button Wrinklewort in the ACT, but also addresses many management issues in a regional context.
- A Management Plan has been prepared by the National Capital Authority and is being implemented for the Stirling Ridge, State Circle and West Block sites in the ACT.
- The intent of a previous Memorandum of Understanding between the ACT Government and the Department of Defence that dealt with Button Wrinklewort populations and natural temperate grassland communities at Campbell Park Offices and Majura Training Area has been superseded by the operation of the EPBC Act which provides equivalent protection for those populations.
- The Department of Defence has undertaken and continues to undertake the following actions:
 - annual weed control in Button Wrinklewort areas using spot spraying with herbicide, with particular attention to Serrated Tussock (*Nassella trichotoma*), St John's Wort (*Hypericum perforatum*), African Love Grass (*Eragrostis curvula*), Thistle and Paterson's Curse (*Echium plantagineum*). All weed control activities are undertaken under strict environmental conditions and are monitored to ensure negative impacts do not occur;
 - marked the Button Wrinklewort areas as Environmental Exclusion Zones, where access is prohibited;
 - no stock permitted on any of the Defence sites where Button Wrinklewort is located; and
 - monitoring and mapping of the Button Wrinklewort populations on Defence land every two years (on average).
- In 1994/95 1600 seedlings were reintroduced to the Red Hill site in three sub-populations, by 2007, 14 of these remained. A further 105 seedlings were introduced at the same site in 1998, none of these seedlings remain. There was no recorded recruitment from these reintroductions (Mulvaney pers. comm.). The reasons for the low establishment rates are unclear, but may be due, at least in part, to the use of too light a potting medium (Briggs pers. comm.).

VIC

In 2004 DSE developed the Actions for Biodiversity Conservation system (ABC) to record management of all threatened species, including Button Wrinklewort. ABC identified all populations, key management actions and recorded results of the implementation of actions to inform adaptive management. The following actions are recorded in detail on ABC.

- Active management is occurring at several sites. This includes ecological burning by the Country Fire Authority (CFA) in consultation with DSE and the relevant land manager.
- 4381 individual plants have been reintroduced into more than 50 sub-populations at six sites in Victoria between 1983 and 1992. As of 2007 approximately 300 remained in two of these sites. Seedlings were reported from the reintroduced plants in just two of the sub-populations.

Further populations were established from 2003-09. A further 2500 (approx) seedlings were established at four locations, including supplementing plantings at Laverton North Grassland Reserve. As of 2009 at least 50% of the plantings had died, although plantings near Wickliffe are too recent to establish survival rates.

- Botanic Guardians projects have been undertaken at several Victorian locations to remove weeds and conduct monitoring. Ballarat Environment Network (BEN) is actively involved in the management of Rokewood Cemetery, Bannockburn rail reserve and Yalla-y-Poorra Recreation Reserve.
- Liaison with land managers including VicRoads, Vline (previously Freight Australia/Pacific National) and local government/cemetery trusts has been undertaken to ensure that weed management was undertaken and that the populations were not affected by infrastructure works.
- Rabbit grazing at Truganina Cemetery was controlled by establishment of a rabbit-proof fence, although this currently needs repair.
- Maps of Bannockburn rail reserve, Manor rail reserve south, Peak School Road rail reserve, Rokewood Cemetery and Bannockburn Cemetery have been completed and individual populations have been identified with GPS points.
- A Committee of Management (BEN) has been established at Yalla-y-Poorra Recreation Reserve.
- A Public Authority Management Agreement (PAMA) has been established with the Truganina Cemetery trust. PAMAs have been drafted for Bannockburn and Rokewood cemeteries but have not been signed.
- Fire plans have been prepared for Ararat, Dobies Bridge Rail Reserve, Middle Creek Rail Reserve, Middle Creek Station Rail Reserve and Yalla-y-Poorra Recreation Reserve.
- *Roadside Management Plan Western Highway, East of Ararat* was prepared for VicRoads by the Centre for Environmental Management, University of Ballarat June 2006.
- Most sites have had some form of environmental weed management. BEN carried out the majority of the weed control.
- Rabbit control has been implemented at Truganina Cemetery and Yalla-y-Poorra Recreation Reserve using baiting and removal of harbour.
- Ecological burns have been completed on most sites every 2-5 years.
- Fences have been erected to prevent inappropriate access to sites, and are monitored and repaired as needed.
- Signs indicating the presence of protected native vegetation have been erected and regularly monitored at most sites.
- An *ex situ* collection of approximately 12 plants was established at the Royal Botanic Gardens Melbourne from seed collected from Rokewood Cemetery in 1996.
- Regular communication about grassland threatened species including Button Wrinklewort is provided through the South West Integrated Flora and Fauna Team (SWIFFT) wiki web site.

RECOVERY OBJECTIVES AND CRITERIA

Objectives

General/long term

- All natural populations of Button Wrinklewort currently of greater than 200 plants are stable or increasing in size.
- All natural populations of Button Wrinklewort currently between ten and 200 plants are increasing in size.

Specific

- To secure five more Button Wrinklewort populations under formal protection within five years.
- To review and assess the effectiveness of all planted populations to determine whether this action is effective, and if considered effective, establish two new populations in suitable habitat in Victoria within 5 years.

Criteria

- All natural populations currently greater than 200 plants have remained stable or have increased in size over a five year period following formal adoption of this plan.
- All natural populations currently between ten and 200 plants have increased in size over a five year period following formal adoption of this plan.
- Five more Button Wrinklewort populations are under formal protection within a five year period following formal adoption of this plan.
- The effectiveness of all planted populations is reviewed to determine whether this action is effective, and if it is, two new populations are established in suitable habitat in Victoria over a five year period following formal adoption of this plan.

Plan review and evaluation

The NSW Office of Environment and Heritage (OEH) in consultation with the Victorian Department of Sustainability and Environment (DSE) and the ACT Department of Territory and Municipal Services (TAMS) will evaluate the performance of this edition of the Recovery Plan against the Recovery Objectives and criteria identified within the Plan. The Plan will be formally reviewed within five years from the date of its publication, and revised if necessary.

Proposed Recovery Actions

The estimated overall cost of the implementation of recovery actions over five years is \$410 000.

General

1. Remove threatening weeds

Weed competition is a threat to many populations of **Button Wrinklewort**. One or more of the highly invasive weeds *Hypericum perforatum* (St John's Wort), *Nassella neesiana* (Chilean Needle Grass), *Nassella trichotoma* (Serrated Tussock) and *Eragrostis curvula* (African Lovegrass) are present at many sites in NSW and the ACT, including Stirling Ridge, Poplars, Letchworth, Bredbo and Gundry TSR, and ongoing control is required.

In Victoria, undertake control of environmental weeds at all sites by targeted application of herbicides and complementary burning. Priority weeds include Serrated Tussock, Chilean Needle-grass, African Love-grass and Phalaris. Some sites also require control of Common Gorse, Wild Oats, Montpellier Broom, Smilax, Paspalum and Cotoneaster.

Excessive shading created by regenerating native and exotic species of shrubs and trees may reduce population densities. Earlier studies of **Button Wrinklewort** (Wittmark et al. 1984) have concluded that shading from woody plants has changed the distribution and density of the plant at Stirling Ridge. More recent mapping by Muyt and Watson (ACT Government, unpublished data, 2006) at the same site has shown that regenerating woody plants continue to pose a threat to the population with combined cover estimates for woody weeds and regenerating Eucalypts to be as high as 50% in some locations.

Following each monitoring event the agency undertaking the monitoring will notify the relevant landowner/manager of any problem weeds. It will be the owner/managers responsibility to control the weeds using a suitable method.

Responsibility: OEHL, TAMS, DSE (Weed control to be implemented by the relevant landowner)

Cost: NSW – Estimated at \$3000 each year for 3 spray contractor days per year. ACT – uncoded. Vic – \$97 000 (yr 1), \$77 000 (yr2), \$47 000 (yr3), \$17 000 (yr 4), \$7000 (yr5).

2. Monitor populations

Systematic monitoring of all populations is required to detect any major new or increased level of threat and to assess the effects of management actions in stabilising or increasing populations. The frequency of monitoring will depend on population size and level of threat. Button Wrinklewort populations can fluctuate rapidly in response to changes in management or as a result of a stochastic event. One large population exhibited annual increases in excess of 100%, possibly in response to management change (Crace GR). Another population in a site without significant management intervention (Red Hill) has fluctuated up and down by around 20% annually and several small populations have gone extinct within a four year period (rail reserves at Laverton, Forsyth Rd, Manor and Peak School Rd). Others have decreased to just one or two plants (Little River North Rail Reserve). Small populations need to be monitored to confirm that the populations still exists. A primary aim of monitoring is to identify trends in population change and to do so with sufficient sensitivity to provide an opportunity for management to change where declines are detected. Small populations (<200) can decline to extinction at a fast rate and therefore it is important to undertake population counts on an annual basis. Larger (>1000) populations are less likely to go extinct and it is recommended that a count be undertaken every two or three years. All populations should be inspected annually to detect obvious new or increased levels of threat and results entered on appropriate databases such as Victoria's VROTPop (rare or threatened plant populations monitoring database) and ABC (Actions for Biodiversity Conservation).

Responsibility: TAMS, OEHL and DSE

Cost: ACT & NSW - \$7000 per year (based on half day (on average) inspections of 20 sites per year @ \$350 per day, and detailed population counts for 10 sites per year @ 1 day per site @ \$350 per day). Victoria - \$2500 per year (based on \$500 per day including on-costs and vehicles, inspect 10 sites per year, half day each).

3. Undertake ecological burning as needed

In Victoria, burn all open grassland sites every 2-5 years. Assess the need for burning in areas where habitat approaches grassy woodland (i.e. Dobies Bridge) and implement burning if needed.

Responsibility: DSE

Cost: \$1000 per year (based on average cost of \$500 per ha and 2 ha burnt per year)

4. Prompt recording of new sites

It is important that relevant State and Commonwealth databases contain accurate records of Button Wrinklewort as they are a primary resource for government and non-government agencies, researchers, developers, environmental consultants and land managers. The TAMS, OEH and DSE will ensure that all Button Wrinklewort records received are entered onto the relevant State, Territory and Commonwealth databases, i.e. the Atlas of NSW Wildlife, Victorian Flora Information System, ACT vegetation database and the Commonwealth Species Profile and Threats Database

Responsibility: TAMS, OEH and DSE.

Cost: to be met within existing budgets

5. Complete a survey of the genetic composition of all populations

Button Wrinklewort populations exhibit either diploid or tetraploid cytotypes. This has significant implications for the conservation and management of each population. If any form of genetic rescue is to be undertaken it is recommended that the cytotype of the donor and recipient populations is the same. Tetraploid populations are also considered more “at risk” than diploid populations due to reduced individual fitness in these populations. Therefore tetraploid populations may be of a higher priority for management intervention to ensure their on-going survival. The cytotypes of the following 10 populations still require determination; Snow Gum Ridge, Michelago Rail Easement, Bredbo, Peak School Rail Reserve, Woods Lane, Tennant Street, Baptist Church, Campbell Park, Crace Nature Reserve, HMAS Harman. It seems likely that the NSW and ACT populations will all be diploid and therefore the highest priority populations to assess are those in Victoria. This action would most efficiently be undertaken following completion of Action 8 (comprehensive seed collection), as this would avoid duplication of site visits and repetition of seed collecting.

It has been suggested that crosses between diploid and tetraploid populations may result in infertile offspring. This needs investigation.

Responsibility: OEH, TAMS, DSE (task requires the engagement of a research institution such as the CSIRO Division of Plant Industry).

Cost: \$5000 - \$10 000 to determine all unassessed populations.

6. Genetic enhancement of small populations

Where monitoring demonstrates that a decline in a small population (populations less than 200 individuals) that can not be attributed to physical threats then it could be inferred that the decline may be due to low genetic diversity/vigour and that genetic rescue may be warranted. Pickup and Young (2007) and Pickup (2008) have undertaken research into the effects of introducing new genetic material into small populations. Their results show that an increase in seed-set of up to 30% can be achieved and that the heterosis of those offspring may improve the fitness of individuals. The benefits of genetic rescue diminish with increasing population size and the benefits decrease at a faster rate in tetraploid populations than diploid populations. As a result the maximum population size at which genetic rescue should be attempted in diploid races is 1000 individuals and in tetraploid races is 500 individuals. Genetic rescue must only be attempted between populations that have the same cytotype.

Genetic rescue can be undertaken in three ways;

1. Flowers from a donor population can be removed and taken to a recipient population of the same cytotype. These are rubbed onto the flowers of the recipient population to ensure pollination between the two plants.
2. Seed can be collected from a donor population, raised in a nursery and the young plants can be transplanted in a recipient population of the same cytotype. When the plants flower cross-fertilisation will result in genetic flow between the populations.
3. Seed can be collected from a donor population and manually scattered into suitable niches within the recipient population and allowed to germinate under natural conditions. Some minor soil disturbance is likely to assist seed germination and seedling establishment.

It is recommended that these methods are trialled and that a monitoring program be designed and implemented to compare the success of the three methods. Donor and recipient populations for the two genetic races are given in Appendix 1.

At least two donor populations should be sourced for each recipient tetraploid population to increase viability (DEH 2004)). In diploid races there should be two donor populations for each recipient if the donor population is less than 500 individuals or one donor population if the donor size is greater than 5000 individuals (DEH 2004).

Using the results from Pickup (2008), explore the augmentation of small populations of Button Wrinklewort with material from large, genetically diverse populations adopting the protocols outlined in Vallee et al. (2004).

Responsibility: TAMS, OEH, DSE

Costs: Option 1 estimated at \$1050 per site (\$350 for 3 days – 1.5 days of flower collection and 1.5 days of hand pollination). Option 2 estimated at \$4000 per site (\$500 for 100 plants, \$3500 for seed collection and planting). Option 3 estimated at \$700 per site (1 day of seed collection and 1 day of seed sowing). Costs in Table 4 are based on an initial trialling of each option at two sites, then selecting most effective option for enhancement actions at future sites (average cost across options used- 4 sites yr 3 and 2 sites yrs 4).

7. Formal reservation or negotiation of management agreements for populations on non-reserve tenure

Where opportunities arise, options for formal reservation of currently unreserved sites should be explored by State and Territory agencies. It would be desirable to have all unreserved populations covered by management agreements (e.g. Public Authority Management Agreements or Memoranda of Understanding in the ACT, Property Vegetation Plans or Voluntary Conservation agreements in NSW) or licence conditions in the ACT that would assist their survival. Currently many of the NSW and Victorian populations are not covered by any form of conservation agreement.

Responsibility: OEHL, TAMS & DSE

Cost: \$3500 per site (agency and landowner time for 5 days @ \$350 each per day). Cost for life of this Plan calculated at one new agreement per year.

8. Collection and storage of seed from all populations larger than 10 plants

A minimum of 2000 seeds from 20-40 individuals, where possible, should be collected from all populations larger than 10 plants. This seed should then be appropriately treated and stored in low temperature conditions that will ensure its viability for many decades. Such seed storage will provide a source of propagating material that can be used to replace or enhance any populations that are lost or reach critically low numbers. This seed would also provide a source of genetic material that can be used to enhance smaller populations that are suffering from decline due to loss of genetic diversity.

Collections are likely to need to be made over two or three years, particularly for smaller populations where sufficient seed to meet collection targets may not be available in one season. Collection and storage is to be coordinated by relevant sections of each State and Territory Botanic Gardens. In Victoria the seed collection component is likely to need to be undertaken by contractors engaged by DSE and this will add some additional cost to the collection component compared to that for ACT and NSW. Particular care must be taken in Victoria not to mix seed of diploid and tetraploid populations. Because of the close proximity of NSW populations to the ACT it may be most cost effective for ANBG to collect both ACT and NSW populations and then for the storage of the seed to be shared with RBG Sydney. Based on the number of current populations with more than 10 plants, seed is to be collected from a total of 21 populations in the ACT and NSW and from 10 populations in Victoria.

Responsibility: ANBG, RBG Sydney, DSE, RBG Melbourne.

Cost: \$12 600 total (ACT & NSW); \$9 000 total (Vic)

9. Increase community awareness and support

In NSW keep landholders, interest groups and the public informed of the precarious conservation status of the species, the threats operating and progress and achievements of actions being taken under this plan. This could be achieved through agency websites, newsletters, field days, the media and direct contact with agency staff. Interest groups include LandCare, National Parks Associations, Friends of Grasslands, Kosciuszko to Coast, CMAs and the Box Gum Woodland Conservation Management Network. Encourage the continued assistance of the ACT National Parks Association in hand weeding of St Johns Wort within the Queanbeyan Nature Reserve population.

In Victoria establish interpretative facilities and educational material to promote the conservation of grassland communities and associated rare plant species. Develop an education program relating to the establishment of Button Wrinklewort into new threatened species beds at the Royal Botanic Gardens, Melbourne. Promote community interest by undertaking spring "walks and talks" on suitable sites, and promote grants such as Botanic Guardians to community groups.

Responsibility: OEHL, DSE

Cost: OEH - \$1800 per year, DSE - \$3000 per year.

Site-specific actions

NSW

10. Stabilise Captains Flat Road site

The population at Captains Flat Road is susceptible to a number of threats including slashing from local council road crews, invasion by *Phalaris aquatica* and erosion of the road embankment. The population occupies a narrow strip at the top of the cutting that is never more than two metres wide. Erosion of the embankment is gradually reducing the area of occupancy. The erosion has reduced the width of the strip that supports the population by at least 50cm in the last ten years based on the locations of marker pegs placed by CSIRO researchers. The opposite edge of the population is restricted by *Phalaris aquatica* which forms a dense sward that precludes the population from spreading. The cut batter needs to be stabilised to stop further erosion and careful spot spraying of the *Phalaris* may allow the population to spread into otherwise suitable habitat. The 2007 surveys revealed that there appears to be ample seeding and recruitment of this population to ensure its short to medium term survival if the habitat can be stabilised.

Responsibility: OEH to negotiate with Palerang Shire Council to implement required action

Cost: Estimate of \$5000

11. Protect and fence Snow Gum Ridge private land population

This private land component of the Snow Gum Ridge population is located on an approved residential subdivision. This population occurs at the rear of a residential block and is afforded legal protection by a Section 88B Covenant which prevents disturbance to the Button Wrinklewort plants (Lloyd pers. comm.). However, when building construction occurs there remains a risk of inadvertent damage to the population. Construction of other nearby houses has resulted in significant disturbance in the area from the dumping of spoil and waste building materials along with builder's access tracks. Current threats include access tracks being formed by neighbouring property owners and the dumping of garden waste on and around the densest part of the population (Baines pers. comm.). Goulburn Mulwarree Council is encouraged to require specific actions, including fencing, in the construction phase and into the future to ensure protection of the Button Wrinklewort population. Sign-posting both the Snow Gum Ridge populations may help to increase the community awareness and alleviate some inappropriate uses.

Responsibility: OEH to liaise with Goulburn Mulwarree Council regarding implementation of agreed protection measures. Costs should be borne by the developer.

Cost: \$2000

12. Review and assess the effectiveness of all planted populations to determine whether this action warrants resourcing in future recovery plans

Given the low level of success in establishing new populations through previous translocation efforts in Victoria the effectiveness of such an action should be assessed and reviewed to determine whether future resourcing is warranted for such an action. Investigations should cover both the establishment of new populations and the enhancement of existing populations.

Responsibility: DSE, OEH, TAMS

Cost: Uncosted

ACT

13. Translocation into East Jerrabomberra Nature Reserve

PCL is planning to conduct experimental introductions of Button Wrinklewort into East Jerrabomberra Nature reserve using seed and seedlings sourced from five local populations. This will trial the feasibility of introducing Button Wrinklewort into ACT reserves and the best methods of doing so.

Responsibility: TAMS

Cost: To be met within existing budgets

Victoria

14. Detailed management planning

Revise, update and implement fire plans as needed at Woodnaggerak Bushland Reserve, Yalla-y-poorra RR, Dobies Bridge rail reserve and the Middle Creek rail reserves.

Undertake an annual review of VicRoads' Roadside Management Plan for the Western Highway.

Develop a management plan for Rokewood cemetery. For all other unreserved sites, develop and implement weed management plans, with emphasis on Chilean Needle-grass and Serrated Tussock where they occur.

Develop a reserve management plan for Woodnaggerak Bushland Reserve

Responsibility: DSE

Cost: To be met from existing DSE budget

15. Site protection

Undertake ongoing maintenance of fences and signs at all unreserved sites.

Responsibility: DSE

Cost: \$2000 per year

16. Liaise with land managers and planners

Inform land managers, rail managers and contractors, VicRoads and local government of the locations and management requirements of the species.

Provide maps and information about Button Wrinklewort populations to local governments such as Wyndham, Golden Plains, Ararat and Pyrenees and ensure identification and protection of sites under Municipal Strategic Statements and planning scheme overlays.

Responsibility: DSE

Cost To be met from existing DSE budget

17. Manage pest animals at Truganina Cemetery, Rokewood Cemetery and Yalla-y-Poorra Recreation Reserve

Undertake ongoing rabbit control works, baiting and harbour removal and maintenance of rabbit-proof fences. Monitor effects of rabbit grazing.

Responsibility: DSE

Cost: \$3000 per year (yrs 1 & 2), \$2000 per year (yrs 3-5).

18. Negotiate with Golden Plains Shire to establish a management agreement for Rokewood Cemetery to ensure the security of Button Wrinklewort.

Rokewood Cemetery contains the largest known population of Button Wrinklewort in Victoria. The site is sympathetically managed, but is not formally protected.

Responsibility: DSE

Cost: \$2000

19. Establish new populations in the Western Grassland Reserves

Over the ten years from 2010 to 2020 the Victorian Government will establish two new grassland reserves to the west of Melbourne. A management component of these reserves is the establishment and maintenance of populations of ‘core’ grassland herbs for future large scale re-introduction of herbs and sub-shrubs to the reserves. Seed will be collected from local sources and propagated for repeated trials to compare the efficacy of different restoration techniques. Button Wrinklewort has been selected as one of these core species, with an overall goal of establishing self-sustaining populations within the reserves.

Responsibility: DSE

Cost: funded from the Western Grassland Reserves budget

Table 4 provides a summary of desirable actions identified in this Plan and an estimate of the costs to implement these actions. Implementation of many of these actions will be dependent on the availability of adequate resourcing to those parties identified as primarily responsible for the various actions.

Table 4. Summary of costs and actions identified in the Recovery Plan

Action No.	Action Title	Action Priority	Cost Estimate (\$1000s/year)					Total Cost (\$1000s)	Responsible Party
			Year 1	Year 2	Year 3	Year 4	Year 5		
1	Remove threatening weeds	High	100	80	50	20	10	260	OEH, DSE, TAMS
2	Monitor populations	High	9.5	9.5	9.5	9.5	9.5	47.5	OEH, DSE, TAMS
3	Undertake ecological burning as needed	Medium	1	1	1	1	1	5	DSE
4	Prompt Recording of New Sites*	Low							OEH, DSE, TAMS
5	Complete survey of the genetic composition of all populations	Low		10				10	OEH, DSE, TAMS
6	Genetic enhancement of small populations	Medium		12	6	3	3	24	OEH, DSE, TAMS
7	Formal reservation or negotiation of management agreements for populations on non-reserve tenure*	High	3.5	3.5	3.5	3.5	3.5	17.5	OEH, DSE, TAMS
8	Collection and storage of seed	Medium		7.2	7.2	7.2		21.6	ANBG, RBG Sydney, DSE, RBG Melbourne
9	Stabilise Captains Flat Road cutting	Medium		5				5	OEH, Palerang Council
10	Protect and fence Snow Gum Ridge population on residential development site	High	2					2	OEH, Goulburn Mulwarree Council
11	Translocation into East Jerrabomberra Nature Reserve	Low						Not costed	TAMS
12	Review and assess the effectiveness of all planted populations to determine whether this action warrants resourcing in future	Medium						Not costed	OEH, DSE, TAMS

	recovery plans								
13	Detailed management planning*	Low						Not costed	DSE
14	Site protection	High	2	2	2	2	2	10	DSE
15	Liaise with land managers and planners*	Medium							DSE
16	Manage pest animals	Medium	3	3	2	2	2	12	DSE
17	Increase community awareness and support	Low	3	3	3	3	3	15	DSE
18	Negotiate with Golden Plains Shire to establish a management agreement for Rokewood Cemetery	High			2			2	DSE
19	Establish new populations in the Western Grassland Reserves	Medium						Not costed	DSE
Total			124	136.2	86.2	51.2	34	431.6	

*Costs will be borne by agencies as tasks to be undertaken by existing staff

References

- ACT Government (1998). Button Wrinklewort (*Rutidosia leptorrhynchoidea*): An endangered species. Action Plan No. 8. (Environment ACT, Canberra).
- ACT Government (2005). A Vision Splendid of the Grassy Plains Extended: ACT Lowland Native Grassland Conservation Strategy. Action Plan No. 28. (Arts, Heritage and Environment , Canberra).
- ACT Government (2006). Data on the distribution of *Rutidosia leptorrhynchoidea* at Stirling ridge; mapping undertaken by A. Muylt and K. Watson. (Unpublished Report).
- ACT Government (2007). Data on the monitoring of *Rutidosia leptorrhynchoidea* in the ACT. (Unpublished Report).
- Baines G (2007). Survey of New South Wales and ACT populations of *Rutidosia leptorrhynchoidea*. (Unpublished Report).
- Baines G (Personal communication). ACT Department of Territory and Municipal Services, Canberra.
- Briggs JD (Personal communication). NSW Office of Environment and Heritage, Queanbeyan.
- Briggs JD, Corrigan VT and Smith WJS (1998). *Rutidosia leptorrhynchoidea* (Button Wrinklewort) revised national recovery plan, 3rd ed. NSW National Parks & Wildlife Service.

- Department of Environment and Heritage (2004). Draft Species Profile and Threats. (Unpublished Report).
- Craigie V (2006). Submission on the EPBC Nomination to delist *Rutidosia leptorrhynchoidea* from the endangered category and list in the conservation dependant category. (Unpublished report to the Department of Environment and Heritage by the Victorian Department of Sustainability and Environment).
- Craigie V (2009). Further submission on the EPBC Nomination to de-list from the endangered category - *Rutidosia leptorrhynchoidea*. (Unpublished report to the Department of Environment and Heritage by the Victorian Department of Sustainability and Environment).
- Craigie V (Personal communication). Biodiversity and Ecosystem Services Division, Department of Sustainability and Environment, East Melbourne, Victoria
- DSE (in prep.). Button Wrinklewort *Rutidosia leptorrhynchoidea* FFG Action Statement no. 28. 2009 Draft Revision. Department of Sustainability and Environment, Victoria
- Eddy DA (2002). Managing native grassland: a guide to management for conservation, production and landscape protection. (WWF Australia, Sydney).
- Lloyd S (Personal communication). Goulburn Mulwaree Council, Goulburn, NSW.
- Lunt, I. D. (1990). Floristic survey of the Derrimut Grassland Reserve, Melbourne, Victoria. *Proc. Roy. Soc. Vic.* 102(1): 41-52.
- McDougall, K. M. (1987). Sites of Botanical Significance in the Western Region. Department of Geography, University of Melbourne.
- Morgan JW (1995a). Ecological studies of the endangered *Rutidosia leptorrhynchoidea* I. Seed production, soil seed bank dynamics, population density and their effects on recruitment. *Aust. J. Bot.* **43**(1):1-11.
- Morgan JW (1995b). Ecological studies of the endangered *Rutidosia leptorrhynchoidea* II. Patterns of seedling emergence and survival in a native grassland. *Aust. J. Bot.* **43**(1):13-24.
- Morgan JW and Scacco PJ (2006). Planting designs in ecological restoration: insights from the Button Wrinklewort. *Ecological Management and Restoration* **7**: 51-54.
- Mulvaney M (Personal communication). ACT Red Hill Park Care Group, Canberra.
- Murray BG and Young AG (2001). Widespread Chromosome variation in the Endangered Grassland Forb *Rutidosia leptorrhynchoidea* F. Muell. (Asteraceae: Gnaphalieae). *Annals of Botany* 87: 83-90, 2001.
- Parsons RF (Personal communication). LaTrobe University, Bundoora Victoria.
- Pickup M and Young AG (2007). Population size, self-incompatibility and genetic rescue in diploid and tetraploid races of *Rutidosia leptorrhynchoidea*. (Unpublished Report).
- Pickup M (2008). Local Adaptation and Outbreeding Depression in Fragmented Populations of *Rutidosia leptorrhynchoidea* (Asteraceae). Unpub. PhD thesis, Australian National University, Canberra.
- Saunders P (Personal communication). "Scottsdale", Bredbo, NSW.
- Scarlett NH and Parsons RF (1990). Conservation biology of the southern Australian Daisy *Rutidosia leptorrhynchoidea*. In: Clark TW and Seebeck JH (eds.) *Management and conservation of small populations*. Proceedings of a conference held in Melbourne, Australia. September 26-27,1989. Chicago Zoological Society.
- Scarlett NH (Personal communication). Botany Department, La Trobe University, Melbourne).
- Sharp S (Personal communication). Kaleen, ACT.

- Vallee L, Hogbin T, Monks L, Makinson B, Matthes M and Rossetto M (2004) *Guidelines for the translocation of threatened plants in Australia* 2nd ed. Australian Network for Plant Conservation, Canberra.
- VRIFE (2007). *Vegetation Management Guidelines for Rail Corridors*. Victorian Rail Industry Environment Forum.
- Wells GP and Young AG (2002). Effects of seed dispersal on spatial genetic structure in populations of *Rutidosia leptorrhynchoidea* with different levels of correlated paternity. *Genetical Research* 79: 219-226 2002.
- Whittmark B, Goodwin C and Kendall P. (1984). An ecological study of the rare daisy *Rutidosia leptorrhynchoidea* in the Canberra area. Environment Section, National Capital Development Commission. (Unpublished Report).
- Young AG (Personal Communication). CSIRO Division of Plant Industry, Canberra.
- Young AG, Brown AHD, Murray BG, Thrall PH and Miller CH (2000a). Genetic erosion, restricted mating and reduced viability in fragmented populations of the endangered grassland herb: *Rutidosia leptorrhynchoidea*. In: AG Young and GM Clarke (eds) *Genetics, Demography and Viability of Fragmented Populations*. (Cambridge University Press. pp. 335-359).
- Young AG, Miller C, Gregory EA and Langston A (2000b). Sporophytic self-incompatibility in diploid and tetraploid races of *Rutidosia leptorrhynchoidea*. *Australian Journal of Botany*. 48:667-672.
- Young AG and Pickup M (2010). *Journal of Applied Ecology in press*.

Further Reading

- ACT Government (1997). Natural temperate grassland: An endangered ecological community. Action Plan No. 1 (Environment ACT, Canberra).
- Boden R (1994), Conservation and Management Plan for Native Vegetation on National Land Managed by the National Capital Planning Authority. (Robert Boden and Associates).
- Briggs JD and Leigh JH (1985). Delineation of important habitats of rare and threatened plant species in the Australian Capital Territory, 176 pp. A National Estate Grants Project. Final Report. (CSIRO: Canberra).
- Briggs JD and Leigh JH (1988). Rare or Threatened Australian Plants: 1988 revised edition Aust. Nat. Parks Wildl. Serv. Spec. Publ. No. 14, 278 pp (Canberra).
- Briggs JD and Leigh JH (1990). Delineation of Important Habitats of Threatened Plant Species in South-eastern New South Wales, 312 pp. Research Report to the Australian Heritage Commission. 1990 (CSIRO: Canberra).
- Briggs JD and Leigh JH (1995). Rare or Threatened Australian Plants. 1995 revised edition, 466 pp (CSIRO: Melbourne).
- Humphries RK and Webster A (1992). Action Statement No. 28, *Rutidosia leptorrhynchoidea*, 6 pp. (Victorian Department of Natural Resources and Environment, Melbourne).
- Leigh JH, Boden R and Briggs JD (1984). Extinct and Endangered Plants of Australia, 369 pp (MacMillan, Melbourne).
- Leigh JH and Briggs JD (1992). Threatened Australian Plants: Overview and Case Studies, 120 pp (Australian National Parks and Wildlife Service: Canberra).
- Leigh JH, Briggs JD. and Hartley W (1981). Rare or Threatened Australian Plants. Australian National Parks and Wildlife Service Special Publication 7, 178 pp (Canberra).

- Morgan JW (1997). The effect of grassland gap size on establishment, growth and flowering of the endangered *Rutidosia leptorrhynchoidea* (Asteraceae) *J. Applied Ecology* **34(3)**: 566-576
- Morgan JW (2000). Reproductive success in re-established versus natural populations of a threatened grassland daisy (*Rutidosia leptorrhynchoidea*) *Cons. Biology* **14(3)**: 780-785
- NCDC (1988). Sites of Significance in the ACT. 2. Inner Canberra. Technical Paper 56 National Capital Development Commission.
- NSW National Parks and Wildlife Service (1998). National Recovery Plan for *Rutidosia leptorrhynchoidea*. (NSW National Parks and Wildlife Service: Hurstville).
- Woodruff B and Florence R (1992). City Parks:- Management Guidelines for Specific Sites. Technical Services Unit, ACT Parks and Conservation Service (Canberra).
- Young AG and Murray BG (2000). Genetic bottlenecks and dysgenic gene flow in re-established populations of the endangered grassland daisy *Rutidosia leptorrhynchoidea*. *Australian Journal of Botany*, 48:409-416.

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Acronyms Used in this Document

OEH	Office of Environment and Heritage (NSW)
DSE	Department of Sustainability and Environment (VIC)
EPBC Act	Commonwealth <i>Environment Protection and Biodiversity Conservation Act 1999</i>
NCA	National Capital Authority
PCL	ACT Department of Parks, Conservation and Lands
TAMS	Territory and Municipal Services (ACT)
TSC Act	NSW <i>Threatened Species Conservation Act 1995</i>

Appendix 1. Potential donor and recipient populations of each genetic race.

Diploid Populations	
<i>Potential Donor Populations (>1000 individuals)</i>	<i>Potential Recipient Populations (<1000 individuals)</i>
Majura Training Area	Capital Hill
Stirling Ridge	St Marks
Red Hill	
Queanbeyan Nature Reserve	
Gundry Travelling Stock Reserve	
Poplars	Captains Flat Road
St Albans Rail Reserve	Iramoo Wildlife Park
Truganina Cemetery	Laverton North Grassland Reserve
Tetraploid Populations	
<i>Potential Donor Populations (>500 individuals)</i>	<i>Potential Recipient Populations (<500 individuals)</i>
Dobies Bridge Rail Reserve	
Dobies Bridge Rail Reserve 2	
Rokewood Cemetery	Mooramong
	Woodnaggerak
	Yalla-Y-Poorra
Unknown Cytotypes (likely to be diploid)	
<i>Potential Donor Populations (1000>)</i>	<i>Potential Recipient Populations (<1000)</i>
Crace Grasslands Reserve	Baptist Church Kingston
Snow Gum Ridge	Campbell Park
	HMAS Harman
	Tennant Street Fyshwick
	Woods Lane
Bannockburn rail reserve	Bannockburn Cemetery
	Michelago Rail Reserve
	Bredbo