BUTTON WRINKLEWORT

RUTIDOSIS LEPTORHYNCHOIDES

ACTION PLAN

PREAMBLE

The Button Wrinklewort (*Rutidosis leptorhynchoides* F.Muell) was declared an endangered species on 15 April 1996 (Determination No. DI1996-29 under the *Nature Conservation Act 1980*). Under section 101 of the *Nature Conservation Act 2014*, the Conservator of Flora and Fauna is responsible for preparing a draft action plan for listed species. The first action plan for this species was prepared in 1998 (ACT Government 1998). This revised edition supersedes all previous editions. This action plan includes the ACT Native Grassland Conservation Strategy set out in schedule 1 to the 'Nature Conservation (Native Grassland) Action Plans 2017', to the extent it is relevant.

Measures proposed in this action plan complement those proposed in the action plans for Natural Temperate Grassland, Yellow Box/Red Gum Grassy Woodland, and component threatened species such as the Striped Legless Lizard (*Delma impar*), Grassland Earless Dragon (*Tympanocryptis pinguicolla*) and the Golden Sun Moth (*Synemon plana*).

CONSERVATION STATUS

Rutidosis leptorhynchoides is recognised as a threatened species in the following sources:

National / International

Endangered – Australian and New Zealand Environment and Conservation Council (ANZECC) Endangered Flora Network (1998).

Endangered – Rare or Threatened Australian Plant (ROTAP) (1996).

Endangered – Part 1, Schedule 1 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The species is also the subject of a National Recovery Plan (NSW OEH 2012) and Action Statement No. 28, prepared by the Victorian Department of Conservation and Environment. The National Recovery Plan identifies all populations of more than 10 plants and the habitat they occupy as critical to the survival of the species due to the small area of total occupancy and the small proportion of the total population outside formal conservation reserves, and the threat of weed invasion at most sites.

Australian Capital Territory

Endangered – *Nature Conservation Act 2014*.

New South Wales

Endangered – *Threatened Species Conservation Act 1995*.

Victoria

Threatened taxon – Schedule 2 of the *Flora and Fauna Guarantee Act 1988*.

CONSERVATION OBJECTIVES

The overall objective of this action plan is to preserve *R. leptorhynchoides* in perpetuity in the wild across its natural geographic range in the ACT. This includes the need to maintain natural evolutionary processes.

Specific objectives of the action plan:

- Conserve all large and medium size populations in the ACT. Protect small populations from unintended impacts (unintended impacts are those not already considered through an environmental assessment or other statutory process).
- Manage the species and its habitat to maintain the potential for evolutionary development in the wild.
- Enhance the long-term viability of populations through management of

adjacent grassland to increase habitat area, and by establishing new populations.

SPECIES DESCRIPTION AND ECOLOGY

DESCRIPTION

The Button Wrinklewort *Rutidosis leptorhynchoides* (Figure on the opposite page) is an erect perennial forb in the daisy family (Asteraceae). In spring and summer it produces multiple, mostly-unbranched flowering stems 20–35 cm tall. The stems are hairless above and woolly towards the base, and die back to the woody rootstock in late summer or autumn. A new basal rosette of upright leaves appears in early winter, and new stems arise from buds at the soil surface. The stem leaves are narrow, dark green ageing to yellow-green, usually 1.5–3.5 cm long, 0.5–1.5 mm wide, mostly hairless and with the edges rolled under. The yellow flat-topped hemispherical flower-heads are 8–15 mm in diameter, and develop at or near the top of the stems. Each flower-head is made up of a cluster of many small florets surrounded by rows of greenish bracts. The individual fruits are small and dark brown, each topped with whitish scales.

DISTRIBUTION

Rutidosis leptorhynchoides appears to have been formerly widespread in south-eastern Australia, with disjunct populations in New South Wales and on grassy plains in Victoria. In south-eastern NSW and the ACT it occurs from the Michelago and Canberra/Queanbeyan districts to the Goulburn area. In Victoria it is found across the western plains. Herbarium records show a reduction in the number and size of *R. leptorhynchoides* populations as the species' grassland and woodland habitat was converted to grazing (Scarlett and Parsons 1990). Nationally, 29 known extant populations occupy a total of about 13.4 hectares (ha), with a further 11 populations having become extinct in recent times. Many populations have fewer than ten plants, and only eight contain 5000 or more plants (NSW OEH 2012). Some are restricted to small, scattered refugia that have escaped grazing, ploughing and the application of fertilisers, including road margins, railway easements and cemeteries (Young 1997). Larger populations occur in grasslands and woodlands on partially modified and lightly grazed land, including a travelling stock reserve and sites on Department of Defence land.

In the ACT region, *R. leptorhynchoides* occurs at 11 sites in the suburbs just south of Lake Burley Griffin (Barton, Kingston, Yarralumla, Red Hill), the Majura Valley, the Jerrabomberra Valley (ACT and NSW) and at Crace Nature Reserve in Gungahlin. The largest populations are in woodland at Stirling Park, Barton (about 49,000 plants) and in grassland at the Defence-owned Majura Training Area (about 27,000 plants) (NSW OEH 2012). The ACT Jerrabomberra/Fyshwick sites are small and fragmented, but are adjacent to larger NSW populations at Queanbeyan Nature Reserve and nearby 'The Poplars' (rural property).

While there are large populations in Red Hill Nature Reserve (>3000 plants) and Crace Grassland Reserve (about 5000 plants), the other ACT sites contain 80 to 2000 plants. The species appears to have been lost from two small sites in recent years.

The most up-to-date distribution data for this species is publicly available on the ACT Government's mapping portal (Visit the ACTmapi website).

HABITAT AND ECOLOGY

In the ACT, *R. leptorhynchoides* occurs on the margins of stands of Yellow Box/Red Gum Grassy Woodland with a ground layer of various native grasses and other forbs, in secondary grasslands derived from that community, and in Natural Temperate Grassland. Soils are usually shallow stony red-brown clay loams.

Apple Box (*Eucalyptus bridgesiana*) is also occasionally present at sites. *Rutidosis leptorhynchoides* prefers an open habitat and is a poor competitor amongst tall, dense, sward-forming grasses. It is found where the soil is too shallow to support the growth of plants that may rapidly overtop it and on deeper soils where the vegetation is kept short by regular disturbance (Scarlett and Parsons 1990). It may also be adapted to the sparser growth of *Themeda* grass found under trees in woodlands (Morgan 1995a).

In Victoria, intermittent burning is prescribed to maintain floristic diversity and habitat structure at some *R. leptorhynchoides* sites (DSE 2003). In NSW and the ACT maintenance of habitat structure appears to be less dependent on burning, possibly because poorer soils and/or competition from trees restrict groundcover density and maintain inter-tussock spaces (Morgan 1997, NSW OEH 2012).

Rutidosis leptorhynchoides flowers between December and April in the ACT. The florets are insect-pollinated, and most of the wind-dispersed seed falls within one metre of the parent plant (Morgan 1995a, 1995b; Wells and Young 2002). The scales at the top of the fruit could facilitate wider dispersal by vertebrates (Scarlett and Parsons 1990). The seeds are short-lived in the soil, only remaining viable for up to 18 months, so recruitment depends on seeds from the previous year and therefore on the survival and reproductive success of the standing population (Morgan, 1995a, 1995b).

Seeds germinate after autumn rains, and seedling mortality is usually high. In Victoria, recruitment may be limited by high summer mortality of seedlings in open microsites and by deep shading in dense, unburnt grasslands (Morgan 1995b, 1997). Studies of germination under field conditions showed that emergence was greatest in larger inter-tussock gaps (30–100 cm), and seedling survival was greatest in the largest gaps. *Rutidosis leptorhynchoides* grows slowly and few or no seedlings flower in their first year (Morgan 1995b, 1997). Time from recruitment to first flowering is usually two or three years (ACT Government 1998; Young *et al.* 2000b). Established plants are believed to live longer than 10 years under field conditions (Scarlett and Parsons 1990).

There are two main chromosomal races of *R. leptorhynchoides*, diploid and tetraploid. All populations in the ACT and NSW that have been tested are diploid, though both diploid and tetraploid populations occur in Victoria (Murray and Young 2001, NSW OEH 2012). The species has a sporophytic self-incompatibility mechanism that prevents self-pollination or crosses between related plants that share self-incompatibility alleles. Self-crosses of *R. leptorhynchoides* generally result in no fruit, and crosses between unrelated plants produce up to twice as many fruits as those between plants which share one parent (Young *et al.* 2000a). Self-incompatibility systems function to prevent inbreeding and are an advantage in large, genetically diverse populations, but decreasing population size can reduce the number of self-incompatibility alleles leading to a reduction in mate availability and reduced fertilisation success. This has been demonstrated in laboratory and field studies of plants from *R. leptorhynchoides* populations of varying sizes (Pickup and Young 2008, Young and Pickup 2010).

Seed set appears to be influenced by population density, with sparsely distributed plants producing less seed than plants in denser groups in both natural and planted populations of various sizes (Morgan 1995a, Morgan and Scacco 2006). This may reflect the presence of fewer pollinators or less pollen being picked up and transferred among sparsely distributed plants. Other research has shown reduced seed set in small populations (<200 plants) compared to large populations (>1000 plants), despite the maintenance of pollinator service as measured by the number of pollen grains deposited on open-pollinated stigmas (Young and Pickup 2010).

Research into the genetics and demographics of *R. leptorhynchoides* has led to the development of a computer model that can be used to predict population trends and the effects of changes in demographic parameters. The model shows a clear relationship between the amount of genetic diversity in a population and how quickly it is likely to go extinct. The model suggests that diploid populations with fewer than 50 mature individuals will become extinct faster than those with more than 200 plants, and that long-term viability requires more than 400 reproductive plants with at least 20 self-incompatibility alleles (Young *et al.* 2000b; Young, unpublished data, in NSW OEH 2012).

PREVIOUS AND CURRENT MANAGEMENT

EX-SITU CONSERVATION AND TRANSLOCATION

Since the 1980s there have been several attempts to establish new populations of *R. leptorhynchoides* at a number of Victorian sites, by planting of tubestock and direct seeding into areas where the topsoil had been removed. A number of such populations died out without producing a second generation of plants, despite testing of seed from five re-established populations showing no reduction in reproductive fitness (Morgan 2000). Gibson-Roy (2011) reported 90% survival at 12 months for tubestock planted into newly constructed grasslands in Victoria, with widespread and consistent emergence from direct seeding.

There have been several attempts to establish new populations of *R. leptorhynchoides* in the ACT. An early translocation of plants onto a site near Stirling Park appears to have failed. This may have involved replanting of mature plants removed from the site of the new Parliament House in the 1980s (NCA, unpublished data in Rowell 2007a). Three groups of plants were translocated into a fenced woodland block in Yarralumla, but the site became densely covered in woody weeds and eucalypt regeneration. Six plants from one group were located in 1995, but after weed control in 2007 only one plant remained. In 2011 this plant was seen again, but no seedlings have been recorded on the block (Rowell 2007a, Rowell unpublished data 2011). Between 1994 and 1998, 1705 seedlings were planted at three locations on Red Hill. By 2007 only 14 plants remained, and no recruitment was recorded from the plantings (M Mulvaney, pers. comm. in NSW OEH 2012).

Recent research has shown that to maximise progeny fitness, seed for *R. leptorhynchoides* restoration projects should be sourced from large genetically diverse populations (Pickup *et al.* 2013). Because most *R. leptorhynchoides* seed is deposited close to the parent plant, seed should be collected from multiple non-adjacent plants to maximise diversity (especially of self-incompatibility alleles).

To maximise pollen transfer and therefore seed production in new populations, plants should be placed in groups. Because mixing of ploidy levels may result in the production of infertile offspring, diploid races should not be mixed with tetraploid races. As a precaution, ACT restoration projects should use seed sourced from ACT populations for which the chromosome number is known. In the ACT, chromosome number has not been confirmed for populations at Woods Lane, Tennant Street, Baptist Church, Campbell Park, Crace Nature Reserve and HMAS Harman (NSW OEH 2012).

The ACT Parks and Conservation Service (PCS) began a translocation trial in a fenced (kangaroo) exclosure at Jerrabomberra East Nature Reserve in 2010. Seed was collected from four populations of *R. leptorhynchoides* in the ACT, with some seed used to grow tubestock (by Greening Australia) and some seed retained for direct seeding at the site. In autumn 2010 planting of tubestock and direct seeding took place in six plots that had been prepared by weeding and grass reduction, with further plantings around the same plots in 2011. Monitoring in 2012 showed survival of 33% and 45% of tubestock planted in 2010 and 2011, but very few plants were produced from direct seeding. Almost all (93%) of plants from tubestock were flowering in 2012, while few of the plants derived from direct seeding were flowering and fewer flowers were produced by these plants. There was no evidence of recruitment from either treatment at this early stage of the trial.

The interim conclusion is that planting of tubestock is the preferred method of re-establishing populations in the ACT, due to the rapid result and the reduced impact of seed collection on ex-situ populations (Conservation Planning and Research, unpublished data 2012). The density of the vegetation surrounding the trial site may need to be reduced regularly to enhance *R. leptorhynchoides* survival, germination and recruitment, due to its location in an (ungrazed) kangaroo exclusion area.

CONTROLLED AND EXPERIMENTAL BURNING

In some Victorian populations burning at a frequency of 2–5 years is used to control herbage mass. Adult plants are reported to be rarely killed by fire (NSW OEH 2012). In the ACT, an experimental spring burn before a dry summer in 2000 killed 40–50% of adult plants, while many fewer died on unburnt control plots (pers. comm. S Sharp and G Baines in NSW OEH 2012). In 1995 an autumn burn of a small site containing a group of seven *R. leptorhynchoides* plants resulted in all the plants surviving the burn and most flowering in the next summer; however, the population died out because no seedlings were produced, despite some seed collected from the site being re-introduced after the fire (Rowell 1996a, 2007b).

A fuel reduction burn was carried out at the St Mark's site in Barton in 2009, with no reported ill effects on *R. leptorhynchoides* plants (Conservation Planning and Research unpublished data 2011), though it is not certain the plants were in the area burnt.

The National Capital Authority's fire hazard management plan for Stirling Park requires occasional prescribed burns in some areas for fuel reduction. Past mapping of *R. leptorhynchoides* at Stirling Park has shown changes in the density of trees, eucalypt regeneration and woody weeds, and suggested that increased shading has had a deleterious effect on *R. leptorhynchoides* (Wittmark *et al.* 1984, Rowell 1996b, Muyt and Watson 2006). In 2011 a study was undertaken of the effects of a controlled autumn burn at Stirling Park. Measurements were taken before and after the burn of *R. leptorhynchoides*, weeds, grasses, bare ground, litter and shade in burnt and unburnt plots (Ross 2011, Ross and Macris 2012), with further monitoring of the same plots in spring 2012 (C Ross, unpublished data) and spring 2014 (Matthews 2014). The immediate post-burn data showed no evidence of *R. leptorhynchoides* mortality as a result of the fire, and there was an increase in bare ground and a decrease in native grass and weed cover, changes which could favour establishment of *R. leptorhynchoides* seedlings.

Monitoring in spring 2011 recorded more seedlings in burnt plots, but results were patchy. By spring 2012 the number of *R. leptorhynchoides* had declined, but by the same amount on burnt and control plots. Monitoring in spring 2014 recorded a large number of seedlings on some plots, and few or none at others, though this did not appear to be related to the fire treatment (Matthews 2014). In 2014, numbers of established (non-seedling) plants had declined across all treatments, with the decline being greatest on heavily burnt plots and least on unburnt plots.

However, the 2014 results did not meet criteria for meaningful statistical analysis, so further research is required on the effect of fire on *R. leptorhynchoides* populations in the ACT. Fuel reduction burning at Stirling Park will provide further opportunities for monitoring.

Population modelling for *R. leptorhynchoides* has shown that a 20–30 fold increase in seedling recruitment would be required to offset a 3–5% loss of reproductive plants, such as may occur following fire (Young, unpublished data in NSW OEH 2012). Where fire is used to reduce biomass in ACT populations, a precautionary approach of burning no more than once every five years has therefore been recommended until further research determines whether fire is beneficial at some sites, and the preferred season and frequency of burning (NSW OEH 2012).

OTHER SITE-SPECIFIC MANAGEMENT ACTIONS

Sites on Territory Land:

- Conservation Research (ACT Government) inspects most sites on Territory land every 2–3 years. Reports are prepared on plant numbers and condition, area of occupancy, site condition, threats and suggested management actions.
- Conservation Research communicates with site owners/managers regarding issues identified during monitoring.

Sites on National Capital Authority Land:

- An updated management plan has been prepared and implemented for Stirling Park and associated woodlands (Sharp 2016). Major work has included removal of planted eucalypts, controlled burns and weed control.
- Friends of Grasslands and other volunteers have assisted NCA at Stirling Park with woody weed removal, spraying of herbaceous weeds and monitoring of the effects of controlled burning.

Sites on Defence Land:

- Annual weed control is undertaken following strict environmental prescriptions.
- *Rutidosis leptorhynchoides* populations at Majura Training Area, Campbell Park and Harman are monitored and mapped every two years on average. Monitoring includes counting or sub-sampling populations, measuring area of occupancy, plant size, reproductive status and size/age structure of subpopulations.
- Herbage mass in some subpopulations is managed by occasional high slashing if recommended by consultants monitoring the populations.

The size structure of the subpopulations on Defence sites is measured by recording the number of plants with stem numbers in the following classes: single stem, 2–5, 6–20, >20. Research on *R. leptorhynchoides* has shown there is a significant relationship between the number of stems and biomass (M. Pickup pers. comm. 2014), and that plant size is associated with survival in natural populations (A. G. Young unpublished data in Pickup *et al*. 2012). New germinants are also counted, being single-stemmed vegetative plants less than 5 cm in height. This monitoring has shown significant differences between sub-populations separated by only 50 to 200 metres (Harman, four sub-populations; Campbell Park, two sub-populations). At Campbell Park no new germinants were found in the eastern sub-population in 2010 and 2013, while the western population had large numbers of single-stemmed plants in 2013. This difference may have been associated with increased biomass and weed cover in the eastern population between monitoring events. At Harman a reduction of plants in the lower stem classes was noted in two sub-populations where grass or woody weed cover had increased between monitoring events, while subpopulations that had been slashed and had woody weeds removed showed an increase in numbers of small plants over the same period (AECOM 2014).

THREATS

Rutidosis leptorhynchoides is at risk from habitat loss throughout its range due to agricultural and urban development. Stirling Park is a possible future site for a new Prime Minister’s residence and Tennant Street Fyshwick could be affected by future expansion of the industrial area. Small sites are more vulnerable to incidental damage associated with human activity, such as roadside maintenance, dumping of waste, inappropriate mowing and parking of vehicles.

Weed invasion poses a risk at many sites. On formerly grazed sites, agricultural weeds are of most concern, and small sites can be invaded by weeds that thrive in disturbed areas. Woodland sites are also vulnerable to invasion by woody weeds.

Competition with other understorey vegetation presents a disadvantage to the species at some sites. In Victoria, ’intermittent’ burning of some grassland communities is recommended to maintain floristic diversity (McDougall 1987, Lunt 1990), but whether burning is advantageous to ACT populations of the species is inconclusive at this stage.

Shading and competition from eucalypt and shrub regeneration is a threat at woodland sites such as Stirling Park and Red Hill.

The species disappears under heavy grazing because it is palatable to stock, though there is some evidence to suggest that intermittent grazing in late summer may not be detrimental. Some of the larger surviving national populations had a prior history of sheep rather than cattle grazing, suggesting that light to moderate sheep grazing may not be detrimental whereas cattle grazing may be (NSW OEH 2012).

Erosion of genetic diversity and increased inbreeding may compromise both short and long-term population viability by reducing individual fitness and limiting the gene pool on which selection can act in the future. This applies to populations of fewer than 200 plants.

More frequent drought in south-eastern Australia is one of the predicted effects of climate change. This may adversely affect some *R. leptorhynchoides* populations, particularly through reduced germinant survival due to dry conditions and/or increasing intervals between rain events.

CONSERVATION ISSUES AND INTENDED MANAGEMENT ACTIONS

PROTECTION

The long term conservation of *R. leptorhynchoides* depends on the retention of its native grassy habitat, which in the ACT region is Natural Temperate Grassland and Yellow Box/Red Gum Grassy Woodland. Both of these ecological communities have been declared endangered in the ACT and management principles for each are set out in the respective action plans and strategies. In the ACT the species occurs on a range of land tenures; Territory land (land owned and managed by the ACT Government and leasehold rural land), National Capital Authority land (Commonwealth land controlled and managed by the National Capital Authority) and Defence land (Commonwealth land controlled and managed by the Department of Defence). The ACT

Government will liaise with the National Capital Authority and the Department of Defence to encourage continued protection and management of populations of *R. leptorhynchoides* on their land, in particular, Stirling Ridge and the Majura Field Firing Range.

Demographic modelling suggests that populations of *R. leptorhynchoides* need to have at least 200 plants to avoid the deleterious consequences of incompatible genes that result in low reproductive (seed) viability.

Populations of 200 or more plants are likely to be viable in the longer-term and sites where they occur should be protected by formal legal measures. The National Recovery Plan for *R. leptorhynchoides* (NSW OEH 2012) states that all populations of ten or more plants are important for the survival of the species and to maintain genetic diversity. Consistent with the National Recovery Plan (NSW OEH 2012), any loss of plants from populations of ten or more individuals should be offset by achieving improved long-term protection and management of a suitable currently unreserved population or other compensatory arrangements.

The ACT contains some of the largest and most viable (in the long term) remaining populations of *R. leptorhynchoides* and their conservation is likely to be critical to the survival of the species; only a small number of viable populations remain in NSW and Victoria. Each site contributes to the overall genetic diversity of the species, because *R. leptorhynchoides* plants are likely to be genetically distinct between sites.

Conservation effort should focus on protecting populations that are large (> 1000 plants) and medium-sized (200–1000 plants) as a cluster of sites. Small populations (< 200 plants) should be protected from unintended impacts and efforts directed to increasing their size (and hence viability) to 200 or more plants.

ENVIRONMENTAL OFFSET REQUIREMENTS

Environmental offset requirements for species and ecological communities in the ACT are outlined in the ACT Environmental Offsets Policy and associated documents such as the ACT Environmental Offsets Assessment Methodology and the Significant Species Database. In the Assessment Methodology and Database, some of the threatened species have special offset requirements to ensure appropriate protection. The Button Wrinklewort does not have any special offset requirements.

SURVEY, MONITORING AND RESEARCH

While it is possible some small populations of *R. leptorhynchoides* remain undetected in the ACT, it is likely that all medium and large populations have been discovered. Knowledge of the distribution and abundance of the species in the ACT will be refined from data collected during surveys for other plant species or from opportunistic observations from naturalists and other interested persons.

Populations of *R. leptorhynchoides* will need to be monitored to determine overall abundance trends. A representative set of sites should be monitored to evaluate the effects of management. Intermittent and ad hoc

Button Wrinklewort (E. Cook)

monitoring has shown a decline in a few populations and increases in others.

A protocol for two-yearly monitoring would involve measuring all plants for smaller populations and an appropriate sampling method for large and medium-sized populations, recording:

- Number of plants (total or samples).
- Area occupied.
- Reproductive status (vegetative or flowering, number of flowers).
- Population size structure e.g. height, stems/plant (1, 2–5, 6–10, 11–20, >20 etc.).
- Number of new germinants (<5cm, single stem, vegetative). Recording new germinants separately from established plants is desirable to monitor germination and recruitment, and to explain large variations in population numbers that may be caused by flushes of germination followed by mortality of seedlings.
- Surrounding herbage mass.
- Weed cover.
- Management history.

Seedling establishment: Monitoring is required to show whether the relative paucity of seedlings in areas of denser vegetation leads to a long-term decline in the number of adult plants present. This should be undertaken in conjunction with monitoring of small experimental burning/slashing plots in some of the larger populations. The results of any accidental burning should also be monitored.

Site inspection for damage: Sites with medium or large populations should be inspected quarterly, or as appropriate, for deliberate or accidental damage. This includes unauthorised grazing, mowing, burning or planting; access by cars, trail bikes or other motor vehicles; trampling; rock, soil, wood or plant removal; and dumping of rubbish. Fences/barriers and signs should be installed or upgraded where necessary.

A priority for research is the identification of appropriate management actions to conserve existing populations, ensuring they remain viable over the long term, and developing techniques to increase the size of small populations so they contain at least 200 plants. In particular, research is required to identify appropriate grazing, slashing and fire regimes (including intensity, frequency and season). In addition to providing the basis for a slashing, grazing or fire management regime, this information is relevant to the management of other native grassland and woodland communities.

Ongoing fuel reduction burning at Stirling Park provides a starting point for fire regime research, and any results from experimental burning or fuel reduction burning in adjacent NSW populations could also provide relevant data. A secondary priority for research is the development of techniques to establish new populations that have at least 200 plants.

The Centre for Plant Biodiversity Research (CSIRO Division of Plant Industry) is conducting ongoing research into aspects of the population biology of *R. leptorhynchoides*, including the effects of inbreeding and outbreeding depression, hybridisation, loss of self-incompatibility alleles, local adaptation, pollinator limitation, and reproductive success and mortality in small and large populations. The results of the research are being used to develop models to predict the outcome for populations of various sizes under a range of management conditions. This information is relevant to the maintenance of existing populations and to the establishment of new populations.

MANAGEMENT

Management actions for *R. leptorhynchoides* should focus on conserving it as a component of the grassland or woodland ecological community. Management actions need to take into account the need to maintain species diversity in the community, including the requirements of other sensitive species present. A key management aim should be to increase the number of plants in small (< 200 plants) populations to improve long-term population viability.

Specific management issues relating to conservation of the species:

Woody weed control: This is most important on the woodland sites; older woody weeds should be cut and removed, and the stumps dabbed with herbicide. Seedlings and suckers should be controlled annually by hand-pulling and spot-spraying with herbicide (spot spraying of herbicide should not be conducted within 2 metres of any *R. leptorhynchoides* plant).

Regeneration of native trees and shrubs: Non-indigenous native trees (e.g. *Acacia baileyana*, *A. cultriformis*) and shrubs should be treated as woody weeds. In the absence of fire, slashing or grazing, regeneration of eucalypts and some native shrubs such as *Cassinia quinquefaria*, Bitter Pea (*Daviesia mimosoides*), Silver Wattle (*Acacia dealbata*) and Green Wattle (*A. mearnsii*) may shade out *R. leptorhynchoides*. Where necessary, a selection of these should be removed (cut and dabbed) annually to maintain an open mixed-age/species woodland.

Herbaceous weed control: Priority should be given to weeds that can be invasive in native grassland/woodland, such as St John's Wort (*Hypericum perforatum*), African Lovegrass (*Eragrostis curvula*), Serrated Tussock (*Nassella trichotoma*) and Chilean Needlegrass (*Nassella neesiana*). Control methods should take account of the characteristics of each site, and proximity to *R. leptorhynchoides* plants.

Understorey competition: Intervention may be necessary where monitoring shows a continuing lack of seedling establishment around adult plants in dense understorey vegetation, and/or deterioration in the quality of the community. In some local populations (Campbell Park, Crace Nature Reserve, Red Hill Nature Reserve, Majura Training Area and Jerrabomberra East translocation site) kangaroo grazing will affect grass biomass as kangaroos eat grasses in preference to forbs. Recruitment of *R. leptorhynchoides* should be taken into account when determining the desirable level of kangaroo grazing at a site. Stock grazing may have an adverse effect on *R. leptorhynchoides* and its habitat, although the specieds has persisted for many years on sites with long histories of grazing. Any application of this form of grazing should be closely monitored. Occasional careful slashing in late summer may be used on sites where other factors (e.g. fire risk to property) make burning undesirable. Patch burning may be appropriate on other sites but its effects should be monitored. Burning should not be used as a broad-scale management tool on *R. leptorhynchoides* sites in the ACT until it has been established by experimentation that the benefits (seedling establishment) are likely to outweigh the costs (mortality of adult plants).

Population modelling and analysis of data from monitoring of populations in the ACT region indicates that the maintenance of reproductive plants should be given priority over intervention aimed at increasing germination and seedling establishment, as a large increase in germination would be required to offset the small increase in the mortality of adult plants which might follow treatments such as autumn burning (A. Young pers. comm.).

Management prescriptions also need to address a general concern about the survival of small remnant populations, namely the increased random fluctuations in demographic parameters such as seedling mortality, genetic erosion owing to genetic drift and inbreeding depression (Young 1997). Demographic and genetic simulation modelling shows that diploid populations with fewer than 50 mature individuals will become extinct significantly faster than those with more than 200 plants (Young *et al.* 2000b). A potential recovery action for small populations with reduced fertilisation success due to mate limitation is to increase genetic diversity by introducing seed, pollen or nursery-grown plants from larger, more genetically diverse populations. Research has shown that fertilisation success increases in crosses between populations, and that small populations would gain the greatest benefit from this 'genetic rescue' (Pickup and Young 2008, Pickup *et al*. 2013). Small re-established populations appear to suffer the same constraints as small remnant populations, so management should aim to maintain population size above 200 plants to avoid the effects of loss of self-incompatibility alleles, and re-establishment projects should source seed broadly for the same reasons (Young *et al.* 2000b).

A study of local adaptation in relation to population characteristics in *R. leptorhynchoides* also suggested that selecting seed from large, genetically diverse populations from environments similar to candidate sites is likely to provide the most appropriate seed sources for restoration (Pickup *et al*. 2012). Suitable candidate populations for this type of genetic enhancement would be small to medium sized populations (<1000 plants) showing poor seed set and seedling establishment below replacement rate on sites containing habitat suitable for expansion of the population. The National Recovery Plan nominates St Marks (Barton) and Capital Hill as suitable recipient populations in the ACT (NSW OEH 2012).

Given the significant problems faced by populations with less than about 200 plants, the priority for management and research should be to increase the size of extant small (< 200 plants) populations.

IMPLEMENTATION

Implementation of this action plan and the ACT Native Grassland Conservation Strategy will require:

- Land planning and land management areas of the ACT Government to take into account the conservation of threatened species.
- Allocation of adequate resources to undertake the actions specified in the strategy and action plans.
- Liaison with other jurisdictions (particularly NSW) and other land holders (Commonwealth Government and Canberra Airport) with responsibility for the conservation of a threatened species or community.
- Collaboration with universities, CSIRO, Australian National Botanic Gardens and other research institutions to facilitate and undertake required research.
- Collaboration with non-government organisations, such as Greening Australia, to undertake on-ground actions.
- Engagement with the community, where relevant, to assist with monitoring and other on-ground actions, and to help raise community awareness of conservation issues.

OBJECTIVES, ACTIONS AND INDICATORS

Table 1. Objectives, Actions and Indicators

Objective	Action	Indicator
1. Conserve all large and medium size populations in the ACT. Protect small ACT populations from unintended impacts (unintended impacts are those not already considered through an environmental assessment or other statutory process).	Apply formal measures to protect all large and medium size populations on Territory-owned land. Encourage formal protection of all large and medium size populations on land owned by other jurisdictions.	All large and medium size populations are protected by appropriate formal measures.
	Protect all small populations on Territory-owned land from unintended impacts. Encourage other jurisdictions to protect all small populations from unintended impacts.	All sites with small populations are protected by appropriate measures from unintended impacts.
	Ensure protection measures require site management to conserve the species on Territory-owned land. Encourage other jurisdictions to require site management to conserve the species on thier land.	Protection measures include requirement for conservation management.
	Identify other extant populations by maintaining alertness to the possible presence of the species while conducting vegetation surveys in suitable habitat.	Vegetation surveys in suitable habitat also aim to detect the species.
2. Manage the species and its habitat to maintain the potential for evolutionary development in the wild.	Monitor populations and the effects of management actions.	Trends in abundance are known. Management actions are recorded.
	Manage habitat to maintain its suitablilty for the species.	Suitable habitat conditions are maintained by site management. Potential threats (e.g. weeds) are avoided or managed. Populations are stable or increasing.
3. Enhance the long-term viability of populations through management of adjacent grassland to facilitate expansion	Undertake or facilitate research and trials into techniques for increasing the size of small (<200 plants) populations.	Research and trials have been undertaken to increase the size of small populations. Small population(s) have increased in size.

Objective	Action	Indicator
of populations into suitable habitat. Establish new populations.	Undertake or facilitate research and trials into establishing new populations.	Research and trials have been undertaken to establish new populations. New population(s) established.
4. Improved understanding of the species' ecology, habitat and threats.	Undertake or facilitate research on appropriate methods for managing the species and its habitat (slashing/grazing/ burning etc.), lifecycle, germination, recruitment and genetics.	Research undertaken and reported and where appropriate applied to the conservation management of the species.
5. Promote a greater awareness of, and strengthen stakeholder and community engagement in the conservation of the species.	Undertake or facilitate stakeholder and community engagement and awareness activities and promotions.	Engagement and awareness activities and promotion undertaken and reported.

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