Approved Recovery Plan

Caladenia arenaria Fitzg.

Recovery Plan

February 2004

Natural Heritage Trust
Helping Communities Helping Australia

Department of
Environment and Conservation (NSW)

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Cover photo: *Caladenia arenaria* at Lonesome Pine State Forest by Geoff Carr

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Prepared in accordance with the New South Wales
Threatened Species Conservation Act 1995

February 2004

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Foreword

The conservation of threatened species, populations and ecological communities is crucial for the maintenance of this State's unique biodiversity. In NSW, the *Threatened Species Conservation Act* 1995 (TSC Act) provides the framework to conserve and recover threatened species, populations and ecological communities through the preparation and implementation of recovery plans.

The preparation and implementation of recovery plans are identified by both the National Strategy for the Conservation of Australia's Biological Diversity and the approved NSW Biodiversity Strategy as a key strategy for the conservation of threatened flora, fauna and invertebrates. The object of a recovery plan is to document the research and management actions required to promote the recovery of a threatened species, population or ecological community and to ensure its ongoing viability in nature.

This plan describes our current understanding of *Caladenia arenaria*, documents research and management actions undertaken to date and identifies actions required and parties responsible to ensure ongoing viability of the species in the wild.

The NSW Department of Environment and Conservation has prepared the *Caladenia arenaria* Recovery Plan with the assistance of a number of people. I thank these people for their efforts to date and look forward to their continued contribution to the recovery of the species.

BOB DEBUS MP
Minister for the Environment

Executive Summary

Introduction

Caladenia arenaria is a perennial herb first described in 1882 and apparently not recollected until 1983. The habitat was described originally as sandhills among pine on the Edwards, Columbo, Yanco and Murrumbidgee Rivers – broadly the Riverina region. There is likely to have been a massive decline in numbers, with populations today only surviving on the eastern part of the former range.

Legislative context

The *Threatened Species Conservation Act* 1995 (TSC Act) is NSW's most comprehensive attempt at establishing a legislative framework to protect and encourage the recovery of threatened species, populations and communities. Under the TSC Act, the Director-General of the Department of Environment and Conservation has certain responsibilities including the preparation of recovery plans for threatened species, populations and ecological communities. This Recovery Plan has been prepared in accordance with the provisions of the TSC Act.

Preparation of Plan

This Recovery Plan has been prepared by the Department of Environment and Conservation (DEC). The information in this Recovery Plan was accurate to the best of the DEC's knowledge on the date it was approved.

Current Species Status

Caladenia arenaria is listed on Schedule 1 (endangered) of the NSW *Threatened Species Conservation Act*, 1995 (*TSC Act*, 1995), and on Part 1 (endangered) of the Commonwealth *Environmental Protection and Biodiversity Conservation* (EPBC) Act, 2000. Survey has revealed five populations, totalling about 2,000 individuals, with probable extinction at two other locations since 1990. The major threats are weeds, grazing and hybridisation.

Objective of the Recovery Plan:

Ensure all populations persist, and that declines in population numbers attributable to threatening processes are reversed.

Specific objectives are:

1. Population demographic factors influencing recoverability are understood.
2. The impacts of threatening processes affecting populations are minimised.
3. Long-term management strategies are developed for each *C. arenaria* population.
4. The possibility of stochastic events eliminating a population is reduced.

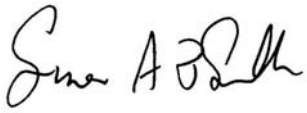
Recovery performance criteria:

1. The numbers, structure and distribution of populations is understood.
2. The population dynamics are understood.
3. The impact of weeds, grazing, hybridisation and collecting on the populations is minimised.
4. The effects of hand pollination are understood.
5. Joint Management Agreements (JMAs) and Voluntary Conservation Agreements (VCAs) are developed for each of the populations.
6. The germination requirements and most appropriate conditions for long term storage of seed and mycorrhizae are understood, and germplasm stored.

Recovery Actions:

1. Monitor all populations each year to determine trends in mortality and recruitment.
2. Pollination and seed-set is monitored for each of the populations.
3. The weed flora within each population is monitored. Weed removal experiments will be undertaken to examine the influence of weeds on the populations.
4. The identity and proportion of hybrids is monitored in each of the populations.
5. Exclosures are established to examine the influence of vertebrate herbivores on *C. arenaria*.
6. Conduct annual hand pollination (outcrossing) of plants in several subsites in selected populations to determine increase in seedling recruitment and hand pollination protocols.
7. Survey in Yarranjerry State Forest and Buckingbong State Forest. The potential locations near Ardlethan and Corowa are surveyed to determine if populations are extant.
8. State Forests and DEC negotiate appropriate strategies for the protection and recovery of *C. arenaria* in State Forests. Negotiations be undertaken with the owner of the population on private property to enter some form of conservation agreement.
9. Appropriate conditions for germplasm storage and germination requirements are investigated, and germplasm stored.

This plan will be in effect for 5 years, and be reviewed after that time. Total estimated cost of recovery for the duration of the plan is $80,440.



SIMON A Y SMITH
A/DIRECTOR-GENERAL

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1 Current Conservation Status

Caladenia arenaria is listed on Schedule 1 (endangered) of the NSW *Threatened Species Conservation Act*, 1995 (*TSC Act*, 1995), and on Part 1 (endangered) of the *Environmental Protection and Biodiversity Conservation* (EPBC) Act 1999. The species is known from five locations, with a total population of around 2,000 individuals. Under the modified IUCN criteria of Keith et al. (1997) the species is ranked as endangered due to the restricted number of populations, small total area occupied, limited capacity to regenerate after a decline, and occurrence outside conservation reserves.

2 Description

Caladenia arenaria is a tuberous, summer-deciduous perennial herb of the spider caladenia group. A single hairy leaf up to 15 cm long emerges from the ground in autumn or early winter from the tuber, with the flower stem appearing later from the centre of the leaf. Usually one, but occasionally two flowers are produced on a stem from c. 10 – 30 cm high. The flowers are large, with the individual floral segments (tepals) being up to 6 cm long. The segments are white to pale yellow, narrow, and taper to fine maroon tips (the colour being conferred by crimson glandular hairs). The labellum (lip) is of a similar colour to the tepals but the tip is often marked with crimson. Flowering occurs from late August until early October. If fertilised the ovary develops into a capsule, and after a maturation of 3-4 weeks the seeds are released as the capsule dries. The above ground parts wither and die, and the plant persists underground as a tuber over summer and early autumn.

Caladenia arenaria is potentially a very long-lived perennial herb. At the commencement of growth before the winter – spring growing season the more or less spherical summer dormant tuber ('mother tuber') produces a new tuber ('daughter tuber') which matures in spring at the end of the growing season. By this stage the mother tuber is exhausted and dies. In this way the whole plant is renewed annually and theoretically has somatic immortality. Reproduction in *C. arenaria* is almost exclusively by seed; vegetative production (occurring with the production of two rather than one daughter tuber) is very rare.

Plants are self fertile (ie. able to produce seed if pollen is transferred to the stigma of the same individual) but most seed production is believed to be the result of outcrossing (pollen transfer between different plants). Seeds are extremely small and without nutrient stores; they are believed to have a short longevity (perhaps one or two seasons only).

Caladenia arenaria has been beautifully illustrated by Fitzgerald (1882) and also by Bernhardt (1993) and Bishop (1996).

3 Distribution & abundance

Caladenia arenaria was described by Fitzgerald in 1882 from the "Edwards, Murrumbidgee, Yanco and Columbo Rivers, growing on the sand-hills among pines" (Fitzgerald 1882). Collections cited by Fitzgerald in the 1880's were from Deniliquin Station, Bethungra and Murrumburra. The linear distance between Deniliquin and Bethungra is about 330 km. Other collections determined as *C. arenaria* from the 1880's were from Yass and just north of Mudgee. If these specimens (particularly the specimen from Mudgee which appears to be an outlier by approximately 250 km) are *C. arenaria*, the range of the species exceeded 500 km.

The species was rediscovered in 1983 on a roadside north of Narrandera. In 1996 the species was found on private property near Urana, and survey in 1998, 1999 and 2000 has revealed three other populations on State Forest in the Riverina (G. Robertson unpubl. data; Carr 2000, 2001). Two of these populations in State Forest account for the bulk of the total known population. In Lonesome Pine State Forest there are an estimated 1,000+ individuals growing in about 5 ha. In Buckingbong State Forest over 200 were counted in about 50 ha of forest, but the plants are scattered. Total size of the populations or sub-populations is not known. In Yarranjerry State Forest the numbers are not known. The distance between the northernmost and southernmost populations is around 150 km. The estimated population numbers and area occupied by each population are given below:

Location	Roadside	Urana	Yarranjerry	Buckingbong	Lonesome Pine
Population size	20	300	40+	500+	1000+
Area of population (ha.)	0.5	12.5	60	45.6	5.1

There are reports that may be attributable to *C. arenaria* at two other locations in the south western slopes and Riverina. These locations were surveyed in 1999 and 2000, but no plants were found despite precise location data. In 2000 at one of these locations a hybrid (one plant) considered to be *C. arenaria* x *C. callitrophila* (another Riverina endemic) was found. At the other location an experienced orchidologist found a plant in 1996. Both sites show evidence of heavy grazing pressure and weed invasion and it is possible that populations are extinct.

The species has suffered a massive contraction in range and abundance in the last century, given the documented historic range and variety of habitat in which the species now occurs. There do not appear to have been any specimens lodged at herbaria between the collections in the 1800's and 1983, when the species was found north of Narrandera.

4 Tenure

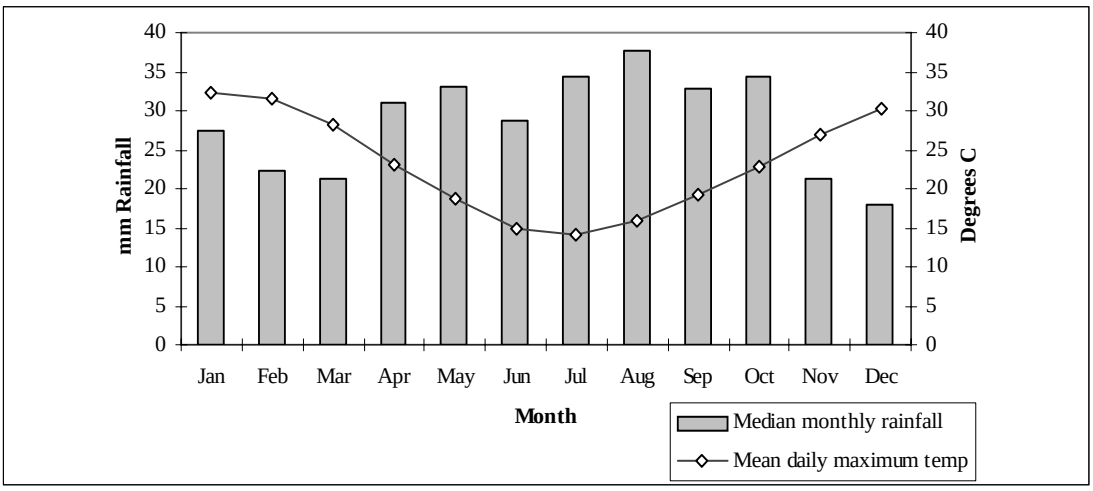
Four of the locations occur on land owned by the Crown. Three locations are State Forest and one is a Travelling Stock Reserve. The fifth location is freehold land in Urana Local Government Area, zoned rural non-urban (0-1a).

5 Soils and geology

The Narrandera and Urana sites have gravelly, sandy-loam soils. At Narrandera the underlying Devonian sandstone outcrops in places. At Urana the soils are derived from Tertiary residual and colluvial deposits of ferricrete, silcrete, poorly consolidated pebbly sandstones, sandstone-mudstones and claystones. In State Forests the soils are sandy loams derived from Quaternary alluvial deposits.

6 Climate

Narrandera, close to the northern populations of *C. arenaria*, has a climate characterised by warm, dry summers and cool, wet winters. Average summer temperatures are around 30°C, while winter temperatures average around 15°C. Median annual rainfall is 433.7 mm, based on 32 years of records. There is a marginal winter dominance in rainfall, with approximately 50 mm more rain falling in the period April-September than in October-March.



Further south near the population at Lonesome Pine State Forest rainfall is slightly higher and winter dominance in rainfall more pronounced.
Date source: Bureau of Meteorology.

7 Habitat

The common feature at all extant populations is the presence of White Cypress Pine, *Callitris glaucophylla*. To more closely define habitat preferences is difficult since each of the sites is distinct, with differences in landforms, soils and vegetation, floristic composition and structure. Many of the associated species in the understorey are different at each of the populations, or are species that are widespread and occur in a range of habitats. It is apparent that *C. arenaria* has fairly broad habitat tolerances, occurring in *Callitris glaucophylla - Eucalyptus melliodora* (Yellow Box) woodlands, *Callitris glaucophylla – Allocasuarina luehmannii* woodlands and woodlands dominated by a mixture of *Callitris glaucophylla, E.*

dwyeri (Dwyer's Redgum) and *Acacia doratoxylon* (Currawang). Soils vary from skeletal soils over sandstone to clay loams.

One characteristic of the State Forest sites is that most of the *C. arenaria* individuals are found among dense White Cypress Pine stands. It is not known whether the plants prefer the conditions created by this relatively dense phase of growth, or whether it is an artefact of threatening processes. Both grazing pressure and the weed flora are assumed to be reduced under dense White Cypress Pine. At the Narrandera TSR site the cypress pines are larger, but most plants occur among cypress pines that are closely spaced.

8 Biology & ecology

Little is known of the specific details of the biology *C. arenaria* though they are believed to conform closely with other spider orchids, some of which have been well documented eg. *Caladenia hastata* (Carr 1988). The genus *Caladenia* is relatively well known taxonomically and biologically by virtue of the interest of enthusiasts and researchers. *Caladenia arenaria,* in common with other spider Caladenias, produces a single leaf in autumn or early winter. Flowers open in late August or September and persist for about a month, depending on seasonal conditions. Hot or dry conditions tend to result in a shorter flowering period.

Pollination in spider orchids is accomplished by male thynnid wasps in a syndrome of sexual deceit called pseudocopulation (Stoutamire 1983; Bower 1992, 1993). The wasps are attracted to the flowers by chemical anologs of the female thynnid sex pheromones. The male wasps lands on the central labellum (lip) which 'mimics' the female wasp. He attempts to copulate with the labellum, and in the process come into contact with a structure known as the viscidium against which the pollen lies. The viscidium is sticky, and the 'glue' produced by the viscidium allows the pollen to adhere to the insect's thorax (back) when it backs out of the flower after its unsuccessful attempt at copulation. If the insect is attracted to another receptive flower, pollen is transferred to the stigma, and fertilisation is effected.

This process ensures that cross pollination (outcrossing) predominates in the population rather than self-pollination (selfing). There appear to be no molecular barriers to fertilisation, so selfing , and hybridisation with other *Caladenia* species is possible. Hybrids have been found in all four populations examined to date. Several other Caladenia species are involved. Presumed intermediates between pure *C. arenaria* and *C. callitrophila, C. rileyi, C. stellata, C.* sp. aff. *tentaculata* and *C. concinna* have been identified. Introgression has occurred, where plants that represent back crosses from the hybrid to one of its parents were found. At Buckingbong State Forest the morphology of some hybrids indicates at least two species other than *C. arenaria* in some hybrid combinations.

For germination orchid seeds require infection by a suitable fungal symbiont/partner. The fungus supplies nutrients for germination and initial seedling growth (Rasmussen 1995). *Caladenia* species possess a swollen stem (the collar) immediately below the leaf just under the soil surface. The mycorrhizal

fungus invades collar. It is believed that before the orchid produces a leaf each year, reinfection of the mycorrhizal zone (collar) by the fungal partner must occur (D. Jones, pers. comm).

The implication of the specialised pollination (which is believed to be species specific) and dependence on a fungal symbiont (partner) for *C. arenaria* is that a functional ecosystem supporting these organisms is essential. Disturbance to the system that adversely affects the pollinator or fungal partner may clearly disadvantage the orchid. The identity of the fungal partner (which is normally free-living and reliant on leaf litter for its nutrition) or the pollinator of *C. arenaria* is not known, let alone their habitat requirements.

9 Legislation

The TSC Act provides a legislative framework to protect and encourage the recovery of threatened species, endangered populations and endangered ecological communities in NSW. Under this legislation the Director-General of the Department of Environment and Conservation has a responsibility to prepare Recovery Plans for all species, populations and ecological communities listed as endangered or vulnerable on the TSC Act schedules. Similarly, the *Environmental Protection and Biodiversity Conservation* (EPBC) Act requires the Commonwealth Minister for the Environment to ensure the preparation of a Recovery Plan for nationally listed species and communities, or adopt plans prepared by others including those developed by State agencies. Both Acts include specific requirements for the matters to be addressed by Recovery Plans and the administrative process for preparing Recovery Plans.

This Recovery Plan has been prepared to satisfy both the requirements of the TSC Act and the EPBC Act and therefore will be the only Recovery Plan for the species. It is the intention of the Director-General of DEC to forward the final version of this Recovery Plan to the Commonwealth Minister of the Environment for adoption, once it has been approved by the NSW Minister for the Environment.

Recovery Plan Implementation

The TSC Act requires that a public authority must take any appropriate measures available to implement actions included in a Recovery Plan for which they have agreed to be responsible. Public authorities identified as responsible for the implementation of Recovery Plan actions are required by the TSC Act to report on measures taken to implement those actions. In addition, the Act specifies that public authorities must not make decisions that are inconsistent with the provisions of the Recovery Plan

Public authorities responsible for the implementation of this Recovery Plan are the NSW Department of Environment and Conservation.

The EPBC Act specifies that a Commonwealth agency must not take any action that contravenes a Recovery Plan.

Critical Habitat

The TSC Act makes provision for the identification and declaration of Critical Habitat. Under the TSC Act, Critical Habitat may be identified for any endangered species, population or ecological community occurring on NSW lands. Once declared, it becomes an offence to damage Critical Habitat (unless the action is exempted under the provisions of the TSC Act) and a Species Impact Statement is mandatory for all developments and activities proposed within declared Critical Habitat. The declaration of critical habitat in NSW is not considered to be a priority for the species, at this stage, as other mechanisms provide for its protection.

Under the EPBC Act, Critical Habitat may be registered for any nationally listed threatened species or ecological community. When adopting a Recovery Plan the Federal Minister for the Environment must consider whether to list habitat identified in the Recovery Plan as being critical to the survival of the species or ecological community. It is an offence under the EPBC Act for a person to knowingly take an action on Commonwealth land that will significantly damage Critical Habitat (unless the EPBC Act specifically exempts the action). Although this offence only applies to Commonwealth land, any action that is likely to have a significant impact on a listed species occurring within registered Critical Habitat is still subject to referral and approval under the EPBC Act. Proposed actions within registered Critical Habitat on non-Commonwealth areas are likely to receive additional scrutiny by the Commonwealth Minister.

The relatively broad habitat tolerances of *C. arenaria* make the definition of critical habitat difficult, although it would be possible to declare critical habitat just over the area of known populations. The major populations occur on State Forest, and are excluded from logging. Clearing of the population on private land is unlikely to be approved, given the presence of two endangered species (*C. arenaria* & *Diuris* sp. "Oaklands") and recognition of the area by Benson et al. (1996) as a unique vegetation community in the Riverina. Since development is not a significant threat, declaration of critical habitat is not necessary and is likely to be a waste of resources.

Environmental Assessment

The New South Wales *Environmental Planning and Assessment Act 1979* (EPA Act) requires that consent and determining authorities, and the Director-General of the Department of Environment and Conservation, as a concurrence authority, consider relevant Recovery Plans when exercising a decision-making function under Parts 4 and 5 of the EPA Act. Decision-makers must consider known and potential habitat, biological and ecological factors and the regional significance of individual populations.

State Forests and the Rural Lands Protection Board are public authorities that must consider *C. arenaria* when undertaking activities that may harm the species. Any other action not requiring approval under the EPA Act, and which is likely to have a significant impact on *C. arenaria*, will require a Section 91 Licence from the

Director-General of DEC under the provisions of the TSC Act. Such a licence may be issued with or without conditions, or refused.

The EPBC Act regulates actions that may result in a significant impact on nationally listed threatened species and ecological communities. It is an offence to undertake any such actions in areas under State or Territory jurisdiction, as well as on Commonwealth-owned areas, without obtaining prior approval from the Commonwealth Environment Minister. As *C. arenaria* is listed nationally under the EPBC Act, any person proposing to undertake actions likely to have a significant impact on this species should refer the action to the Commonwealth Minister for the Environment for consideration. The Minister will then decide whether the action requires EPBC Act approval.

Guidelines are available from Environment Australia to assist proponents in determining whether their action is likely to have a significant impact. In cases where the action does not require approval under the EPBC Act, but will result in the death or injury of *C. arenaria* and the plant occurs in, or on Commonwealth land, a permit issued by the Commonwealth Minister under the EPBC Act will be required.

The Environment Minister can also delegate the role of assessment and approval to other Commonwealth Ministers under a Ministerial Declaration, and to the States and Territories under bilateral agreements. The development of a bilateral agreement between NSW and the Commonwealth is not yet complete, but when in place will avoid the need for duplication of environmental assessment.

Role and interests of indigenous people

Indigenous communities involved in the regions affected by this plan have not yet been identified. Implementation of recovery actions under this plan will include consideration of the role and interests of indigenous communities in the region.

7

10 Management Issues

10.1 Threats and reasons for decline

Clearing

Historically, clearing has had a massive impact on the distribution of *C. arenaria* as inferred by the historic and current distribution, and the habitat it occupies. Fitzgerald's original identification of the species as "growing on sand-hills among pines" is informative. This description accords broadly with formerly widespread and abundant vegetation types on sandier soils of rises in the Riverina. The habitat is likely to have included woodlands dominated by Grey box (*E. microcarpa*), Yellow box (*E. melliodora*) and White Cypress Pine (*C. glaucophylla*).

Over 80 percent of vegetation fitting this description has been cleared in the area between Ardlethan, Corowa and Deniliquin (White, M.D., Muir, A. and Webster R. in prep.) and most of that remaining has been modified, often substantially by sheep and rabbit grazing, forestry practices and other factors. The population on private property near Urana occurs adjacent to cropped pasture on the eastern and western sides. Presumably prior to clearing the population would have been more extensive.

Grazing pressure

Grazing has the capacity to eliminate orchids or severely reduce their reproduction success. Leaves and scapes (flower stems) are palatable and are often observed to have been grazed, in situations accessible to native and introduced vertebrate herbivores. Sheep and goat dung was found in all three quadrats placed among the *C. arenaria* population in Buckingbong State Forest in 2000. Heavy grazing may reduce the viability of populations by limiting the rate of reproduction and lowering the rate of resource acquisition. Adult mortality is likely to be increased in these circumstances, and coupled with insufficient recruitment, population numbers will fall. There may also be predation of the tubers by various animals, such as White-winged Choughs, rabbits or pigs.

Rabbits (among other factors) may have been responsible for eliminating the species from sand-hills on the Riverine Plain. For example, on 'Tupra' in 1890 almost one million were killed (Semple 1990). The animals can more readily burrow into the lighter soils of the sand-hills than the heavier clay soils of the surrounding plain. Given the rabbit plagues that occurred prior to the release of myxomatosis in the 1950s, it is not surprising that the species is extinct in these areas.

With domestic stock, particularly cattle, there is the added concern of pugging damage in wet conditions. Further, grazing may adversely effect plants the pollinator may rely on, or soils in which the female wasps construct nests. The level of grazing a *C. arenaria* population can sustain without being adversely affected is not known.

At Urana *C. arenaria* occurs within a fenced area that has not been stocked for some years, and in an adjacent unimproved pasture under a set stocking regime using sheep. In the fenced area the plants are scattered among regrowth White Cypress Pine. In the pasture most plants were found growing adjacent to, or within clumps of *Lomandra effusa*, an unpalatable grass-like plant with tough spiky leaves. The implication is that sheep grazing has eliminated or suppressed growth of *C. arenaria* in the open areas between the clumps of *Lomandra effusa*.

Weed invasion

There are a number of weeds that are potentially impacting on populations of *C. arenaria.* In some situations there is greater than 80% projected foliage cover of weeds, predominantly exotic annual grasses (eg. **Bromus diandrus,* Great Brome and **Vulpia* spp., Fescues). With such a significant proportion of the understorey composed of exotics, some reduction in resources (light, moisture) available to *C. arenaria* is likely. The absolute magnitude of impact on *C. arenaria* is not known but potential for harm is believed to be major, particularly in the longer term. Near Wahgunyah State Forest a *C. callitrophila* population (also an endangered Riverina endemic) is being destroyed by the invading exotic *Ehrharta calycina* (Perennial Veldt-grass).

Hybridisation

Of the four populations that have been surveyed systematically, all have hybrids present. Of greatest concern is the population on the TSR roadside, where hybrids outnumber *C. arenaria*. In Buckingbong State Forest there are double the number of *C. arenaria* as hybrids. At Urana only a few hybrids were found. Hybridisation will reduce the number of successful pollinations of *C. arenaria* , and hence may reduce the reproductive success of *C. arenaria* over time.

The question that emerges is why is the hybridisation so frequent. Hybridisation in *Caladenia* is very well known and numerous hybrid combinations have been reported (eg. Backhouse and Jeanes 1995, Bates and Weber 1990). Large hybrid swarms (where F1 & F2 hybrids plus backcrosses to the parents are present), as observed in *C. arenaria*, are rare (Carr, pers. obs.). Orchid species are generally pollinator specific. Each orchid species is believed to secrete a pheromone analogue of a different wasp species (Bower, 1996), so hybridisation is generally not presumed to occur.

An alternative hypothesis is that *C. arenaria* does not secrete an analogue of a pheromone, but that it secretes a floral scent indicative of a nectar source. The insect is attracted to the flower, and in the process of searching for the non-existent nectar effects pollination (Col Bower pers. comm.) Under this scenario a greater level of hybridisation would be expected than in a pollination mechanism dependent on sexual deceit.

* An asterisk denotes exotic species

Feral bees have been suggested as the vector responsible for the frequent hybridisation but there is no evidence to support this in *C. arenaria* and feral bees have never been reported as *Caladenia* pollinators.

Pollution

The Urana population grows adjacent to a paddock used for cropping. There is a potential risk to the population from herbicide or pesticide spray drift. Fertiliser runoff or spray drift may pose a risk to the population by directly inhibiting the orchid, the pollinator, the mycorrhizal partner, or by favouring the weed flora.

Physical disturbance

The populations on public land are potentially at risk from disturbances resulting from logging practices and the management of travelling stock. A disused gravel pit (for gravel used in roadworks) is adjacent to one of the sites and plants may have been destroyed. Three populations occur in production sections of State Forest. Known populations are excluded from logging. Logging practices may be a threat to any "undiscovered" populations via damage from falling trees, snigging and harvesting machinery (direct damage) or promotion of the weed flora following soil disturbance or opening of the canopy.

Most *C. arenaria* in State Forests are growing among regrowth White Cypress Pine. This may be due to reduced grazing pressure, suppression of weeds under the regrowth or an interaction between these and other influences. Silvicultural practice is to thin regrowth to reduce competition and promote more rapid growth in the cypress pine stand. Thinning of young White Cypress Pine is likely to be detrimental to populations of *C. arenaria*, again either by direct physical damage or by promoting the weed flora.

Collection of plants

Illegal collection of plants or flowers by orchid enthusiasts or scientists poses some risk to the population. Several holes, probably dug by collectors, were found in 2000 at one population in State Forest. The impact of this single event on the population is minor. Caladenias require skilful management in cultivation and most growers recognise the effort required for successful cultivation and are not interested in collecting. Of greater concern perhaps is the collection of flowers, or removal of plants by people unaware of the cultivation difficulties. Given the fairly remote locations of the populations neither of these scenarios is likely to pose a serious long-term threat to the species .

10.2 Social and economic consequences

Recovery may require some change in management practices on State Forest and possibly the travelling stock reserve, but these are not likely to be significant due to the small area involved. Management of the orchid population on the freehold site at Urana could potentially be improved by avoiding grazing during the growing period (July - November). The cost of this measure could be minimised

by fencing the perimeter of the population (about 12 ha) so that management practices in the remainder of the paddock are unchanged. Access for stock within the fenced area would be required (outside the growing season) to manage the grass sward. Otherwise the orchids could become competitively disadvantaged by rank grass growth.

The social consequences of failing to implement a recovery program are high. It is likely that *C. arenaria* has become extinct at two sites in the last ten years. All of the currently known sites possess threats impinging on *C. arenaria*, with one of these sites only possessing 20 plants. Without appropriate action, this species is likely to rapidly decline into extinction.

10.3 Biodiversity benefits

At all locations where *C. arenaria* occurs it is accompanied by other rare, vulnerable or endangered orchid species (Table 1), many of which are undescribed and seven of which are apparently endemic in the Riverina region of NSW. Some of the taxa are rarer and/or more restricted than *C. arenaria*. It is probable that further study will reveal other rare orchid taxa at these locations. In addition, depleted, rare or vulnerable or endangered plant species other than orchids are likely to occur at *C. arenaria* locations, especially the Urana site which carries the best extant example of a very rare, endangered vegetation type (Benson et al. 1996).

Many of the 13 orchid taxa listed in Table 1 are eligible for listing under the TSC Act but have not yet been nominated. For many, especially *Caladenia* species, management requirements will be very similar or identical to the management actions advocated for *C. arenaria* in this Recovery Plan (although these aspects require specific study). There are considerable, clearly-identifiable biodiversity benefits from management of the *C. arenaria* sites at the vegetation community level, as vegetation in the Riverina has been severely depleted and degraded, and at the level of plant taxa, especially for orchids. Many of the actions advocated here for *C. arenaria* (eg. weed control, prescribed burning) will favour the orchid flora generally; none of the management actions are considered antagonistic to other orchid taxa.

Table 1: Rare, vulnerable and endangered orchid species occurring with *Caladenia arenaria* populations in the Riverina, NSW.

Taxon	Conservation status+ Australia (upper case) and NSW (lower case)	Australian distribution	*Caladenia arenaria* location / population				References
			TSR	Buckingbong SF	Lonesome Pine SF	Urana	
Caladenia callitrophila D.L. Jones	E, e	NSW Riverina endemic			+		Jones (1999), Bishop (1996) (p.150), G. Carr (unpubl. data)
Caladenia deformis R.Br.	R	WA, SA, Vic, NSW, Tas			+		Bishop (1996), J. Riley (pers. comm.)
Caladenia flaccida D.L. Jones	R, r	Vic, NSW, Qld, SA		+			Jones (1991), Bishop (1996), J. Riley (pers. comm.)
Caladenia rileyi D.L.Jones	V, v	NSW Riverina endemic		+			Jones (1997)
Caladenia stellata D.L.Jones	R, r	NSW, SA		+			Jones (1991), Bishop (1996), J. Riley (pers. comm.)
Caladenia sp. nov. aff *tentaculata* Schltdl. (Riverina)	R, r	NSW Riverina endemic	+	+			G. Carr (unpubl. data), J. Riley (pers. comm.)
Caladenia sp.nov. (Urana)	E, e	NSW Riverina endemic				+	G. Carr (unpubl. data)
Caladenia xanthochila D. & C. Beardsell	E, e	Vic, NSW		+			Beardsell & Beardsell (1992), Bishop (1996), G. Carr (unpubl. Data)
Diuris sp. nov. aff. *behrii*	E, e	NSW Riverina endemic		+			D. Jones (pers.

			Caladenia arenaria **location / population**				
Schtldl. (Riverina)							comm.), J. Riley (pers. comm.)
Diuris sp. nov. aff.*maculata* Sm. (Riverina)	E, e	NSW Riverina endemic			+		J. Riley (pers. comm.), G. Carr (unpubl. Data)
Diuris sheaffiana Fitzg.	R, r	NSW, Qld, Vic		+	+	+	-
Diuris sp. *"Oaklands"*	E, e	NSW Riverina endemic				+	G. Robertson (unpubl. Data)
Prasophyllum cf. *campestre* R. J. Bates & D. L. Jones	R, r (?)	NSW, Qld		+		+	D. Jones (pers. comm.)
Prasophyllum sp. nov. aff. *odoratum* R. S. Rogers	V, v (?)	NSW Riverina endemic		+			D. Jones (pers. comm.)

\+ **Conservation status** based on literature (see references), personal communication (as cited in References) or opinion of Recovery Plan authors.

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11 Species ability to Recover

Caladenia arenaria has good prospects of persisting in the long term. There are five sites, spread over 150 km, two with substantial populations. This reduces the probability of a chance event eliminating the species entirely. Management actions required are relatively straightforward, such as control of vertebrate grazing and weed control . There are no impediments to recovery, provided the recovery actions are implemented.

12 Previous Actions Undertaken

The only studies of *C. arenaria* so far completed are surveys conducted in 1998, 1999 and 2000 (G. Robertson unpubl. data; Carr 2000, 2001). The survey in 1998 examined remnant vegetation close to the Narrandera and Urana sites. In 1999 around 40 person days survey were spent in the area between Ardlethan and the southern Riverina near Savernake (Carr 2000). In 2000 about 30 person days survey were undertaken (Carr 2001).

13 Recovery objectives and performance criteria

13.1 Objective of the Recovery Plan

Ensure all populations persist, and that declines in population numbers attributable to threatening processes are reversed.

13.2 Specific objectives

1. Population demographic factors influencing recoverability are understood.

2. The impact of threatening processes affecting populations is minimised.

3. Long-term management strategies are developed for each *C. arenaria* population.

4. The possibility of stochastic events eliminating a population are reduced .

13.3 Recovery performance criteria

1. The distribution, numbers and structure of populations is known.

2. The population dynamics are understood.

3. The impact of weeds, grazing, hybridisation and collecting on the populations is minimised.

4. The effects of hand pollination are understood.

5. Joint Management Agreements (JMAs) and Voluntary Conservation Agreements (VCAs) are developed for each population.

6. The germination requirements and most appropriate conditions for long term storage of seed and mycorrhizae are understood, and germplasm stored.

14 Recovery Actions

14.1 Action 1 Population monitoring

Monitor all populations each year to determine trends in mortality and recruitment. This requires the establishment of permanent plots, and the recording of the location of individuals so that mortality and recruitment can be followed over time.

Outcome:
Some understanding of population demography is developed.

14.2 Action 2 Monitor population fecundity

Pollination and seed set is monitored for each of the populations. At present levels of seed set and year-to-year variation in fruiting numbers are not known. These measures are necessary to provide an understanding of reproductive output so that ameliorative actions can be implemented in the event that population numbers decline.

Outcome: Reproductive output is known for each population.

14.3 Action 3 Weed control

The weed flora within each population is monitored. This can be undertaken when the populations are surveyed each year. The principal weeds among the population are introduced annual grasses and dicot herbs. Weed removal experiments will be undertaken to examine the influence of weeds on the populations.

Outcome: The nature and significance of the impact of weeds or orchid plants as well as appropriate weed control techniques are understood.

14.4 Action 4 Monitor hybridisation

The types and proportion of hybrids needs to be monitored in each of the populations. This can be conducted concurrently with the population monitoring.

Outcome: Hybridisation as a potentially threatening process is better understood.

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14.5 Action 5 Establish exclosures

All populations are subject to grazing by native and introduced herbivores. To monitor the impact of vertebrate grazing exclosures must be established, which exclude rabbits, hares, stock (sheep, cattle and goats) and kangaroos.

The annual monitoring of plants, seed set, hybridisation, weed impacts and grazing impacts would be best incorporated in an experiment at three of the four sites. The populations are too large, and spread over too big an area at Buckingbong, Urana and Lonesome Pine to accurately monitor all individuals. The only practical means of monitoring to sample the population. There are insufficient plants at the roadside location to undertake experimental work. If sufficient plants are found through survey of Yarranjerry State Forest, the population could be incorporated into the experiment.

Four management regimes are needed:

- Exclosure that excludes all vertebrate herbivores with weed control
- Exclosure that excludes all vertebrate herbivores without weed control
- No exclosure, with weed control
- No exclosure, no weed control

The number of replicates and quadrat size will be constrained by the distribution of the orchid. Four replicates with a quadrat size of 5 metres square can probably be accommodated at Buckingbong, Urana and Lonesome Pine.

Outcome: Exclosures are established to examine the influence of vertebrate herbivores on *C. arenaria*.

14.6 Action 6 Hand pollination

The effect of hand pollination in stimulating seedling recruitment is determined. Hand pollination has been shown to increase recruitment by one to several orders of magnitude in other endangered *Caladenia*. Several peripheral subsites at the Lonesome Pine SF and the Buckingbong SF populations will be selected where plant numbers are low (to avoid the masking of recruitment outcomes in denser sub-populations) and all flowers hand pollinated (outcrossed or cross-pollinated) each year. Seedling recruitment will be monitored and documented.

Outcome: The effect of hand pollination as a method of increasing seedling numbers is understood.

14.7 Action 7 Survey

The population in Yarranjerry State Forest, discovered in 2000, requires survey to establish the extent and size of the population or sub-populations. The potential locations near Ardlethan and Corowa are surveyed to determine if the populations

are extant. Buckingbong State Forest needs survey to define the population boundaries.

Outcome: Survey in the State Forests is undertaken and the distribution mapped so that forestry operations can be planned to account for the populations. One more season of survey in potential habitat is undertaken to determine if the species is extant at those locations.

14.8 Action 8 Management Agreements

State Forests and DEC negotiate appropriate strategies for the protection and recovery of *C. arenaria* in State Forests. This could be formalised in a Joint Management Agreement (JMA) which would stipulate buffer distances around populations, pre-logging survey intensities, and a protocol for thinning of cypress pine regrowth in potential habitat. Management and research responsibilities could be detailed as well. The JMA would be informed by the results of the experimental work, and so would be developed later in the life of the plan.

Develop strategies with the landowners of the Urana site to minimise the potential impact of farming practises on the population. Discussions be undertaken to enter some form of conservation agreement, preferably a VCA under the NPWS Act.

Outcome: The impact of forestry operations and agricultural activities on *C. arenaria* is minimised, and management agreements developed that ensure long-term security.

Note: Cost of JMA shared between SF and DEC (in kind)
Note: Cost of VCA incurred by DEC (in kind)

14.9 Action 9 Germplasm storage and germination

The populations are separated by around 40-50 km and are isolated, both reproductively and by dispersal of seed. Two populations have a limited extent with the bulk of the individuals occupying less than 1 hectare. The other populations do not occupy more than 100 hectares in total. There is a possibility of the populations becoming extinct from chance events. To eliminate this possibility seed should be collected from a representative sample of individuals in each population and kept in the most appropriate conditions

Storage in liquid nitrogen has been demonstrated to be optimal for orchid seed and mycorrhizal symbionts from four Western Australian species of *Caladenia*, *Diuris*, *Pterostylis* and *Thelymitra* (Batty *et al* 2001). There was considerable variation in response to storage methods, dessication, and the influence of cryoprotectants on the fungi. The knowledge is not yet available to establish a single best technique or routine procedure. As yet eastern Australian species have not been investigated. Study of *Caladenia arenaria* will be required to determine the most appropriate technique.

The efficacy of storage methods is best conducted by germination trials in conjunction with the fungal symbiont. Testing seed viability using histochemical staining procedures appears to overestimate the proportion of seed that will germinate in culture with the appropriate fungal symbiont (Batty *et al* 2001). Thus germination trials will need to be conducted with the germplasm storage study.

Outcome: Optimal storage conditions are established and an adequate sample of seed and the fungal symbiont from each population is stored.

15 Alternative Management Strategies

15.1 No action taken

Caladenia arenaria has:

- a total known population of approximately 2000 individuals
- four discreet populations, each covering a limited area
- several threatening processes
- an apparent loss of two populations in the last 10 years.

There is a high likelihood of extinction. No management action is an inappropriate response.

15.2 No monitoring

A cost effective option could be to fence all populations and undertake weeding, without the expense of the experiment or annual monitoring. The disadvantage of this approach is the threats recognised may not, in fact, have any measurable impact on *C. arenaria*. Pre-empting the outcome of the experiment could mean that any fencing and weed control works are a waste of resources, or worse that they have a deleterious impact. For example in the absence of some grazing the grass sward may competitively exclude *C. arenaria*. The precautionary approach where the effects of management are measured is preferable. Hence, annual monitoring is a necessary part of the recovery strategy, particularly given the variability in plant numbers in any one year due to climatic conditions or other variables.

15.3 The longer term issue of White Cypress Pine

The occurrence *C. arenaria* in dense stands of juvenile or reproductively mature but suppressed White Cypress Pine may require investigation in the long term. The small cypress pines will eventually self thin, albeit at a very slow rate. The habitat currently occupied by the orchid populations may then become unsuitable. Juvenile or suppressed pines may simply afford protection from other threatening processes, or it may be that stands of juvenile or suppressed pines are necessary for the other reasons, for example, they may have the highest densities of the orchid's fungal symbiont.

If structurally suitable stands of pine are required, the mature pine stand around the juvenile or suppressed pine may have to be manipulated to promote recruitment of pine seedlings, providing habitat for the orchid population to expand or colonise. White Cypress Pine successfully recruits in open habitats only – hence if recruitment of pine is not occurring naturally the dominant pines must be thinned to provide suitable conditions.

The necessity of undertaking this action can be assessed after the experiments into the impact of the threatening processes have shown results. It may be decades before white cypress stand structure is a major issue for *C. arenaria*. There are several possible experiments that could be conducted. Seed could be sown into suitable areas carrying pines or seedlings planted. Alternatively, the juvenile pines among the populations could be thinned. This option is inappropriate at present, given the small total area occupied by the orchid populations. If the species proves to be more widespread in Buckingbong or Yarranjerry State Forests this option could be considered.

15.4 Studies of the fungal symbiont and the pollinator

Studies of the fungal partner and wasp pollinator could be undertaken. The fungal partner has been isolated from several species of Caladenia. The difficulty is that no fungus isolate has ever become fertile in vitro, and so cannot be identified. Hence, establishing the distribution of the fungus in the field is problematic. Another complication is that after some time isolates can become pathogenic to orchid seed (Kingsley Dixon pers. comm.). Solutions to these challenges are likely to take a substantial commitment of resources and time, beyond the scope of this plan.

Investigation of the pollinator would assist understanding of hybridisation, and help define habitat elements critical for the pollinator. This has not been included in the plan, since it appears that there is an adequate level of pollination in all populations. The implicit assumption is that the habitat presently occupied by the orchids provides for the requirements of the wasps. Further studies would be informative, but are not required for recovery at this stage.

15.5 Re-introduction in potential habitat

Once there is some understanding of the population dynamics and germination biology re-introduction could be considered in potential habitat. This measure should be considered when the review of the plan conducted.

16 Implementation

The following table summarises costs and allocates responsibility for the implementation of recovery actions specified in this plan to relevant government agencies for the period 2003 to 2007. The actions have been costed on the assumption that contractors undertake all works at $640/day plus inflation at 6%. DEC management costs are $350/day.

Table 3: Implementation schedule

Action	Description	Responsibility for implementation	Cost	Timeframe	Priority
1	Monitoring	DEC	20864	2003-2007	H
2	Seed set	DEC	6933	2003-2007	H
3	Weeding	DEC	3250	2003-2007	H
4	Hybridisation	DEC	0	2003-2007	H
5	Exclosures	DEC	3100	2003	H
6	Hand pollination	DEC	11873	2003-2007	H
7	Surveys	DEC	1920	2003-2004	H
8	Conservation agreements	DEC/SF	0	2004	H
9	Germination and seed storage	DEC	15000	2004	H
	DEC management	DEC	17500	2003-2007	H
		Total cost	80440		

17 Preparation details

This plan was prepared by Geoff Robertson, DEC and Geoff Carr, Director, Ecology Australia Pty Ltd.

17.1 Date of last amendment

No amendments have been made to date.

17.2 Review date

This plan will be reviewed within five years of the date of publication.

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