Approved Recovery Plan

Daphnandra sp. C 'Illawarra' (Illawarra Socketwood) Recovery Plan

January 2005

Natural Heritage Trust

Helping Communities Helping Australia

Department of Environment and Conservation (NSW)

The NPWS is part of the Department of Environment and Conservation

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Cover illustration: Suckering stem of *Daphnandra* sp. C 'Illawarra' at Avondale
Photographer: Martin Bremner

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Daphnandra sp. C 'Illawarra' (Illawarra Socketwood) Recovery Plan

Executive Summary

This document constitutes the formal Commonwealth and New South Wales State Recovery Plan for *Daphnandra* sp. C 'Illawarra' (Illawarra Socketwood), and as such considers the conservation requirements of the species across its known range. It identifies the future actions to be taken to ensure the long-term viability of *Daphnandra* sp. C 'Illawarra' in nature and the parties who will carry out these actions.

*Daphnandra s*p. C 'Illawarra' is listed as endangered on the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and as endangered on Schedule 1 of the NSW *Threatened Species Conservation Act 1995*. It is a medium sized rainforest tree (family Monimiaceae) that is endemic to the Illawarra region of NSW. The species inhabits the rocky hillsides and gully slopes of the Illawarra escarpment and coastal lowlands, growing on soils derived from volcanic or fertile sedimentary rocks. Associated vegetation includes the subtropical, moist subtropical, dry subtropical and mixed subtropical - warm temperate rainforest types of Mills & Jakeman (1995).

D. sp. C 'Illawarra' occurs in the local government areas of Wollongong, Shellharbour, Kiama and Shoalhaven, where it has been recorded from 36 sites on freehold land, three sites within Budderoo National Park and two sites on council managed land. The species is highly clonal and as a consequence, its total population size is expected to be low. Some sites are suspected of containing just one genetic individual.

Extensive clearing of the Illawarra lowlands since European settlement has destroyed much of the rainforest habitat of *D.* sp. C 'Illawarra' and the remaining habitat is highly fragmented. Extant *D.* sp. C 'Illawarra' sites are threatened by further clearing for agriculture, hard rock quarrying, residential development and road construction. Weed invasion, altered hydrological conditions, grazing and trampling by livestock and feral deer, and rubbish dumping also threatens the species.

The overall objective of this recovery plan is to provide for the continued and long-term survival of *D.* sp. C 'Illawarra' in the wild by preventing the loss of populations of the species. Specific recovery objectives include:

- To prevent the loss of sites through land-use change;
- To identify and manage the threats operating at sites that contain the species;
- To provide the community with information that assists in conserving the species;
- To raise awareness of the species and involve the community in the recovery program;
- To establish the extent of the current distribution of the species;
- To promote research that will assist with the management of the species; and
- To maintain an ex-situ seed collection for the species.

It is intended that this recovery plan will be implemented over a five year period. The total of cost to implement the plan is $90,150 over five years, although this does not include site management costs or the cost of preparing and implementing Plans of Management for community land, as these costs are yet to be determined.

Lisa Corbyn
Director General

Bob Debus MP
Minister for the Environment

Acknowledgments

The following members of the Illawarra Regional Threatened Flora Recovery Team and their respective agencies/organisations are thanked for their assistance with the preparation of this recovery plan and with the coordination/implementation of recovery actions to date:

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1 Introduction

Daphnandra sp. C 'Illawarra' is a medium sized rainforest tree belonging to the Monimiaceae family. The species is endemic to the Illawarra region of NSW where it is recorded from 41 sites in the local government areas of Wollongong, Shellharbour, Kiama and Shoalhaven.

D sp. C 'Illawarra' inhabits the rainforests of the coastal lowlands, rarely extending onto the upper escarpment slopes. These rainforests have been extensively cleared since European settlement and remaining habitat for the species is limited and highly fragmented. The main threat to the survival of the species is further clearing for agriculture, hard rock quarrying, residential development and road construction. Other threats include weed invasion, altered hydrological conditions, grazing and trampling by livestock and feral deer, and rubbish dumping.

This document constitutes the formal NSW and National Recovery Plan for *D.* sp. C 'Illawarra' and as such considers the requirements of the species across its known range. It describes the current understanding of the species, documents management actions undertaken to date and details the recovery program for the species over the next five years and the parties responsible for implementing it.

2 Legislative Context

2.1 Legal status

Daphnandra sp. C 'Illawarra' is listed as an endangered species on Schedule 1 of the NSW *Threatened Species Conservation Act 1995* (TSC Act) and as an endangered species under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Among the consequences of a species being listed on the schedules of the TSC Act are the following:

- A recovery plan must be prepared;
- Consideration must be given to the species when assessing the impacts of developments and activities, with the aim of minimising adverse impacts; and
- Other actions that are likely to result in the harming or picking of that species or damage to its habitat must be licensed.

2.2 Recovery plan preparation

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 (DEC) 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 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.

2.3 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 that are 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 plan.

The public authorities relevant to this plan are the DEC, the Department of Infrastructure Planning and Natural Resources (DIPNR), the Rural Fire Service (RFS), Wollongong City Council, Kiama Municipal Council, Shellharbour City Council and Shoalhaven City Council. Consequently, the actions outlined for these public authorities must be implemented as described in the plan.

The EPBC Act specifies that a Commonwealth agency must not take any action that contravenes a recovery plan.

2.4 Relationship to other legislation

The lands on which *D.* sp. C 'Illawarra' occurs include those that are owned or managed by the DEC, Shellharbour City Council, Kiama Municipal Council and private landholders.

Relevant NSW and Commonwealth legislation includes:

- *Environmental Planning and Assessment Act 1979;*
- *Local Government Act 1993;*
- *Native Vegetation Act 2003;*
- *National Parks and Wildlife Act 1974;*
- *Rural Fires Act 1997;*
- *Rural Fires and Environmental Assessment Legislation Amendment Act 2002;*
- *Threatened Species Conservation Act 1995*;
- *Threatened Species Conservation Amendment Act 2002;* and
- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*

2.5 Key Threatening Processes

A key threatening process (KTP) is a process listed under the TSC Act that threatens, or has the capability to threaten, the survival or evolutionary development of species, populations, or endangered ecological communities.

'*Clearing of native vegetation*' has been observed to effect *D.* sp. C 'Illawarra'. The final determination for this KTP defines clearing as "the destruction of a sufficient proportion of one or more strata (layers) within a stand or stands of native vegetation so as to result in the loss, or long term modification, of the structure, composition and ecological function of a stand or stands" (NPWS 2001).

Other KTPs that potentially affect the species include:

- *Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands;*
- *High frequency fire resulting in the disruption of life cycle process in plants and animals and loss of vegetation structure and composition;* and
- *Anthropogenic climate change*.

The NSW Scientific Committee made a preliminary determination to list '*Herbivory and environmental degradation caused by feral deer'* in October 2003 If a final determination is made to proceed with the listing of this KTP, it will be of relevance to *D.* sp. C 'Illawarra'.

In addition to these key threatening processes, a number of other threats to the survival of *D.* sp. C 'Illawarra' exist (see Section 8.3).

2.6 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.

Under the EPBC Act, critical habitat may be registered for any nationally listed threatened species or ecological community. When adopting a recovery plan the Commonwealth 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 that will significantly damage critical habitat (unless the EPBC Act specifically exempts the action). This offence only applies to Commonwealth areas. However an action which is likely to have a significant impact on a listed species is still subject to referral and approval under the EPBC Act.

To date, critical habitat has not been declared for *D.* sp. C 'Illawarra' under the TSC Act or the EPBC Act. However, this recovery plan identifies the habitat features and locations (Sections 5 and 6; Appendices 2 and 3) that would contain habitat that is critical to the survival of the species, as required by the EPBC Act.

It is not currently considered to be a high priority to nominate critical habitat for *D.* sp. C 'Illawarra', as no demonstrable conservation outcome would accompany its identification and declaration. Action 1.5 in this recovery plan provides a mechanism for the recovery team to reconsider a critical habitat declaration during the third year of implementation of the plan.

2.7 Environmental Assessment

2.7.1 New South Wales

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

The following public authorities have a decision making function in relation *D.* sp. C 'Illawarra':

- DIPNR as a consent authority, in the making of Environmental Planning Instruments under the EP&A Act and in relation to private land that is subject to the provisions of the *Native Vegetation Act 2003*;
- DEC as a land manager, licensing authority and in a concurrence role under the EP&A Act;
- Wollongong City Council, Shellharbour City Council, Kiama Municipal Council, and Shoalhaven City Council, as consent and determining authorities, in the making of Environmental Planning Instruments under the EP&A Act, and in the case of Kiama and Shellharbour Councils, as land managers;
- The Roads and Traffic Authority as a determining authority under the EP&A Act;
- Southern Rivers Catchment Management Authority, in relation to land that is subject to the provisions of *Native Vegetation Act 2003*;
- The Rural Fire Service when issuing Bush Fire Hazard Reduction Certificates.

Additional public authorities may have responsibilities if the species is located in other areas in the future.

Any activity not requiring consent or approval under the EP&A Act, and which is likely to affect *D.* sp. C 'Illawarra', requires a Section 91 licence from the Director General of DEC under the provisions of the TSC Act. Such a licence can be issued with or without conditions, or can be refused. If a significant affect on *D.* sp. C 'Illawarra' is unlikely, the Director General will issue the proponent of such an activity with a Section 95(2) certificate which acts as a defence to prosecution under sections 118A-D of the *National Parks and Wildlife Act 1974.*

A scientific licence issued under Section 132 (c) of the NP&W Act is required to 'pick' *D.* sp. C 'Illawarra' or damage its habitat for scientific, educational or conservation purposes.

Routine agricultural activities are exempt from the provisions of the TSC Act. This means, for example, that where *D.* sp. C 'Illawarra' occurs on private rural land, in some circumstances it can legally be subject to grazing by domestic stock under the provisions of the TSC Act.

2.7.2 Commonwealth of Australia

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 Minister for the Environment.

As *D.* sp. C 'Illawarra' 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.

The Commonwealth Department of Environment and Heritage has prepared administrative guidelines (www.deh.gov.au/epbc) to assist proponents in determining whether their action is likely to have a significant impact. In cases where the action does not require EPBC Act approval, but will result in the death or injury to *D.* sp. C 'Illawarra' in a Commonwealth area, a permit issued by the Commonwealth Minister for the Environment under the EPBC Act will be required.

The Commonwealth Minister for the Environment 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 complete at the date of this publication, but when in place may avoid the need for duplication of environmental assessment.

3 Conservation Status

A review of the conservation status of *Daphnandra* sp. C 'Illawarra' was undertaken during the preparation of this recovery plan using the Endangered Flora Network (EFN) modified IUCN criteria (Keith et al. 1997). This review concluded that *D.* sp. C 'Illawarra' is appropriately listed as endangered as a consequence of the following factors:

- Restricted extent of occurrence and area of occupancy;
- Severely fragmented distribution;
- Suspected low total population size; and
- Continuing declines in the area, extent, and quality of habitat are predicted.

4 Taxonomy and Description

4.1 Taxonomy

Class:	Magnoliopsida
Sub-class:	Magnoliidae
Family:	Monimiaceae *s. lat*
Genus:	*Daphnandra*
Species:	sp. C
Author:	Harden (1990)

Daphnandra sp. C 'Illawarra' (R. Schodde 3475) is synonymous with *Daphnandra* sp. C *sensu* Harden

(1990). The species was previously included in *Daphnandra micrantha* (Tul.) Benth *s. lat* prior to a revision of the genus that recognised three new species; *Daphnandra* sp. A, *Daphnandra* sp. C, and *Daphnandra* sp. D (Harden 1990). Foreman and Whiffin (MS) propose the name *Daphnandra johnsonii* for *D.* sp. C 'Illawarra'.

The Monimiaceae *s. lat* contains 30 to 35 genera (450 spp.), most of which are confined to tropical and temperate regions of the Southern Hemisphere (Harden 1990). In Australia, 11 genera and 25 species are present in Queensland, New South Wales, Victoria and Tasmania (Harden 1990). Monimiaceae is divided into smaller families by some authors. Monimiaceae *s. str* contains only three genera (*Palmeria, Hedycarya* and *Wilkiea*) with *Daphnandra, Antherosperma* and *Doryphora* are placed in a separate family, Atherospermataceae (Harden 1990).

4.2 Description

D. sp. C 'Illawarra' is a medium sized rainforest tree that grows to 20 metres and is capable of prolific suckering. Leaves are opposite, coarsely toothed, elliptic to ovate, 6 to 12 cm long, 1.5 to 6 cm wide with a raised mid-vein on the upper surface. Leaf margins are deeply, rather distantly and coarsely toothed (except for the basal half or third) with petioles 3 to 7 mm long. Inflorescence is a many-flowered panicle borne from the base of leaves. Pedicels are 3 to 6 mm long. Perianth is 2.5 to 3.5 mm long, pale greenish white, sometimes tinged pink. Fruiting receptacle is brown, more or less ellipsoid, mostly 5 to 7 mm long, glabrous or covered in fine brown hairs. Fruit are achenes, more or less ellipsoid in shape and uniformly silky hirsute (A. Bofeldt, Wollongong Botanic Gardens, pers. comm.; Foreman & Whiffin MS; Fuller & Mills 1985; Harden 1990).

4.3 Distinguishing features

D. sp. C 'Illawarra' is sometimes confused with *Doryphora sassafras* (Sassafras), a rainforest tree with similar habitat preferences. The two species can be readily differentiated however by the mid-vein on the upper surface of the leaf, which is raised for *D.* sp. C 'Illawarra'. Also, the inflorescence of *D.* sp. C 'Illawarra' consists of a many-flowered panicle while that of Sassafras is a three flowered cluster on a short stalk (Harden 1990).

Floyd (1978) describes some other useful diagnostic features of the *Daphnandra* genus including:

- Prominent leaf scars on stems;
- Conspicuously flattened branchlet nodes; and
- 'Ball and socket' joints (from which the Socketwood common name is derived) on the main stem where larger branchlets have broken away.

5 Distribution and Habitat

5.1 Definitions

5.1.1 Populations

Populations are defined by the International Union for the Conservation of Nature and Natural Resources (IUCN 1994) as "geographically or otherwise distinct groups between which there is little [genetic] exchange, typically less than one migration per year". A migration in the case of plant species is considered to be the movement of seed propagules or pollen between populations. A very low level of genetic exchange between sites is suspected for *D.* sp. C 'Illawarra' because it appears to reproduce primarily by vegetative means. Consequently, in this recovery plan each site (as defined below) is considered to contain a discrete population.

5.1.2 Sites and sub-sites

For this recovery plan, sites are defined as discrete groups of *D.* sp. C 'Illawarra' plants that are separated from other groups by an arbitrary distance of 200 metres or more. These sites have been labelled with the prefix Dc followed by a unique number for each site (eg. Dc1, Dc2 etc). Sites have been further divided into sub-sites (Dc1a, Dc1b etc) where discrete groups of plants at a site are separated from other groups within that site by an arbitrary distance of 50 metres or more.

A total of 41 sites comprising 52 sub-sites have been recorded for *D.* sp. C 'Illawarra'.

5.2 Distribution

D. sp. C 'Illawarra' is endemic to the Illawarra region of NSW where it has been recorded from 41 sites within the local government areas (LGAs) of Wollongong, Shellharbour, Kiama and Shoalhaven. These sites are located within the Sydney Basin Bioregion, as defined in the Interim Biogeographic Regionalisation of Australia (Thackway & Cresswell 1995).

The main distribution of *D.* sp. C 'Illawarra' extends from Avondale in Wollongong LGA to Toolijooa in Kiama LGA, a distance of 27 kilometres. An outlying site at Scarborough (northern Wollongong LGA) is located approximately 35 kilometres north of this main distribution. The species' western distributional limit follows the upper slopes of the Illawarra escarpment.

5.3 Land tenure and zoning

Table 1 describes the tenure and zoning of the 41 recorded *D.* sp. C 'Illawarra' sites. Almost 90 per cent of sites occur on freehold land, with the zoning of these sites evenly divided between rural land uses and environmental protection.

5.3.1 Conservation reserves

Three sites (Dc17, Dc27 and Dc40) have been recorded in the Minnamurra Rainforest section of Budderoo National Park.

5.3.2 Council owned land

Shellharbour City Council
A site at Blackbutt (Dc15) occupies land that is managed by Shellharbour City Council. Although the land is presently zoned 1(c) Rural, council has agreed to rezone the relevant land parcel to 6(a) Public Open Space in the draft Urban LEP (Linda Madden, Shellharbour Council, pers. comm.).

Kiama Municipal Council
A site at Jerrara Dam (Dc35) occurs on community land that is managed by Kiama Municipal Council as a public reserve.

5.3.3 Freehold land

Wollongong LGA
All five freehold sites within Wollongong LGA are zoned for environmental protection. The remnant vegetation at one of these sites (Dc3) is the subject of a Property Agreement under the *Native Vegetation Conservation Act 1997*.

Shellharbour LGA
Five sites within Shellharbour LGA are zoned for rural uses, while a further five sites are zoned for environmental protection.

Kiama LGA
Twelve sites within Kiama LGA occur on freehold land that is zoned for rural uses. One of these sites (Dc21) is the subject of a Voluntary Conservation Agreement with the DEC. A further eight sites within the LGA occur on land that is zoned for environmental protection.

Shoalhaven LGA
One site occurs within Shoalhaven LGA on land that is zoned for environmental protection.

5.4 Habitat

The following habitat details are based primarily on field observations of the 18 *D.* sp. C 'Illawarra' sites (or 27 sub-sites) that were surveyed during the preparation of this plan. The soil landscape, geology and altitude sections however, incorporate data from a desktop assessment of all 41 recorded *D.* sp. C 'Illawarra' sites (or 52 sub-sites).

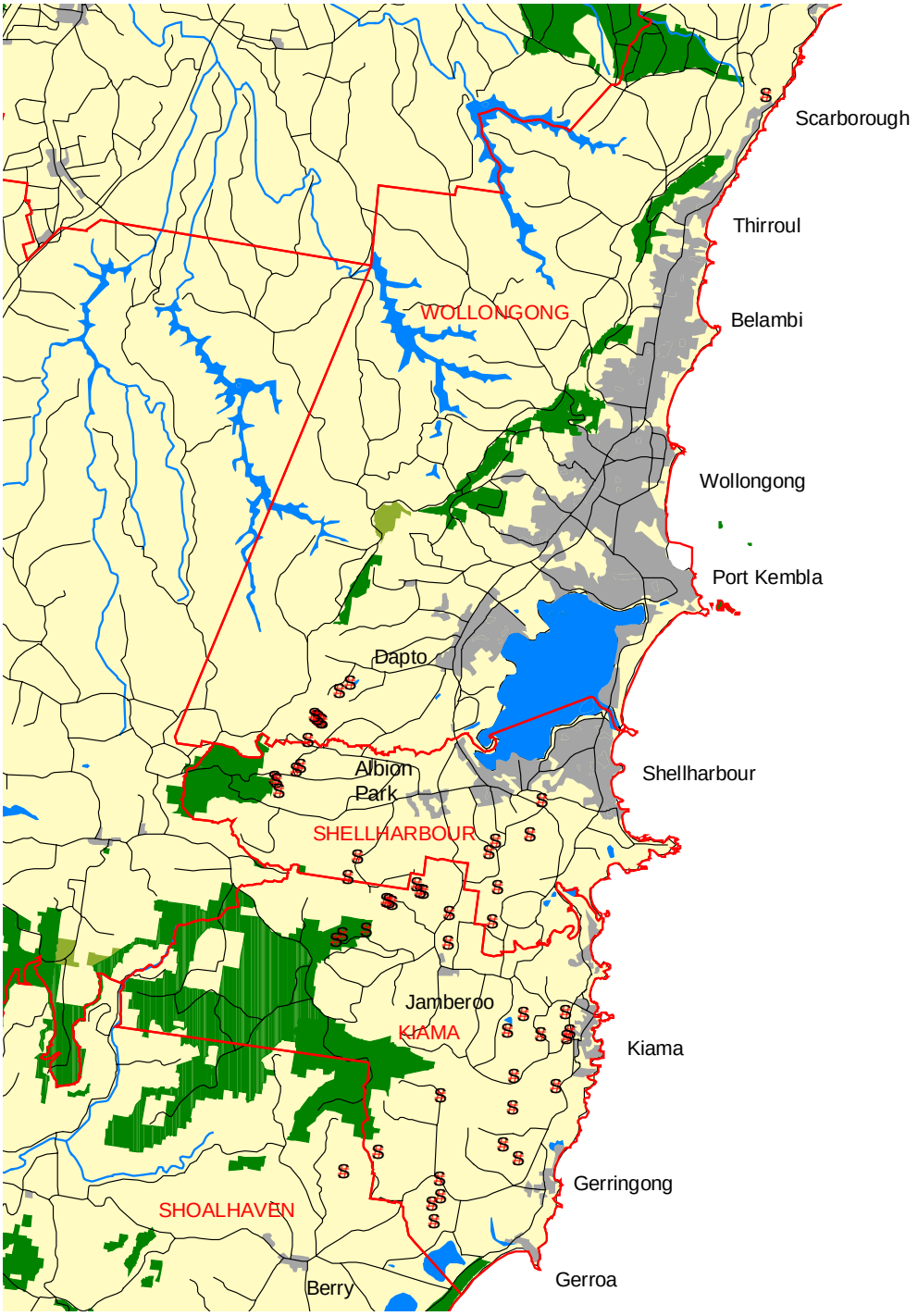
5.4.1 Landform

D. sp. C 'Illawarra' occupies the rocky hillsides and gully slopes of the Illawarra lowlands, occasionally extending onto the upper escarpment slopes. The species inhabits sites with sheltered aspects or in locations conducive to the development of moist closed forest vegetation.

Table 1: Tenure & zoning of *D*. sp. C 'Illawarra' sites

Site	LGA	Tenure	Zoning*
Dc1	Wollongong	Freehold	7(b)
Dc2	Wollongong	Freehold	7(b)
Dc3	Wollongong	Freehold	7(b)
Dc4	Wollongong	Freehold	7(b)
Dc5	Shellharbour	Freehold	1(a)
Dc6	Shellharbour	Freehold	1(a)
Dc7	Shellharbour	Freehold	1(a)
Dc8	Shellharbour	Freehold	7(e)
Dc9	Shellharbour	Freehold	7(e)
Dc10	Kiama	Freehold	1(a)
Dc11	Kiama	Freehold	1(a)
Dc12	Shellharbour	Freehold	7(d)
Dc13	Shellharbour	Freehold	7(d)
Dc14	Shellharbour	Freehold	7(d)
Dc15	Shellharbour	Council	1(c)
Dc16	Shellharbour	Freehold	1(a)
Dc17	Kiama	DEC	8(a)
Dc18	Kiama	Freehold	7(e)
Dc19	Kiama	Freehold	1(a)
Dc20	Shellharbour	Freehold	1(a)
Dc21	Kiama	Freehold	1(a)
Dc22	Kiama	Freehold	1(a)
Dc23	Kiama	Freehold	7(e)
Dc24	Kiama	Freehold	7(e)
Dc25	Kiama	Freehold	1(a)
Dc26	Kiama	Freehold	1(a)
Dc27	Kiama	DEC	8(a)
Dc28	Kiama	Freehold	7(e)
Dc29	Kiama	Freehold	1(a)
Dc30	Kiama	Freehold	7(e)
Dc31	Shoalhaven	Freehold	7(d1)
Dc32	Kiama	Freehold	7(e)
Dc33	Wollongong	Freehold	7(a)
Dc34	Kiama	Freehold	1(a)
Dc35	Kiama	Council	1(a)
Dc36	Kiama	Freehold	7(e)
Dc37	Kiama	Freehold	1(a)
Dc38	Kiama	Freehold	1(a)
Dc39	Kiama	Freehold	1(a)
Dc40	Kiama	DEC	8(a)
Dc41	Kiama	Freehold	7(e)

*1=rural uses, 7=environmental protection, 8=national park



Current record
Local Govt Areas
Roads
Major Rivers
Built Up Areas
NPWS Estate
State Forests

Daphnandra sp. C 'Illawarra'

Illawarra Socketwood

Species Distribution Map

N W E S

2 0 2 4 Kilometres

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D. sp. C 'Illawarra' sites are generally characterised by moderate to very steep slopes, with slope gradients ranging from 5 to 40°. Minimum distance to the nearest ephemeral water course at surveyed sub-sites ranges from 0 to 110 metres, although over 80% of these sub-sites are located at least partially within 30 metres of the nearest watercourse.

5.4.2 Soil Landscape

Table 2 shows the distribution of *D.* sp. C 'Illawarra' sub-sites by soil landscape unit. The species has been recorded on seven soil landscape units but is most closely associated with the Bombo, Wattamolla Rd, and to a lesser extent, Cambewarra units. Appendix 1 contains descriptions of the soil landscape units that have been recorded in association with *D.* sp. C 'Illawarra'.

Table 2: Distribution by soil landscape unit

Soil Landscape Unit*	Sub-sites
Wattamolla Rd	18 (35%)
Bombo	16 (31%)
Cambewarra	9 (17%)
Kiama	4 (8%)
Fountaindale	2 (4%)
Shellharbour	2 (4%)
Illawarra Escarpment	1 (2%)

*after Hazelton (1992) and Hazelton & Tille (1990)

5.4.3 Geology

Table 3 shows the distribution of *D.* sp. C 'Illawarra' sub-sites by substrate. The species has been recorded on eight geological units although the vast majority of sub-sites occur on Budgong Sandstone or Bumbo Latite.

Table 3: Distribution by substrate

Geology*	Sub-sites
Budgong Sandstone	25 (48%)
Bumbo Latite	20 (38%)
Illawarra Coal Measures	2 (4%)
Minnamurra Latite	1 (2%)
Cambewarra Latite	1 (2%)
Irwins Creek Breccia	1 (2%)
Narrabeen Group Sediments	1 (2%)
Quaternary Alluvium	1 (2%)

*after Bowman 1974a, 1974b and 1974c)

5.4.4 Soils

The soils present at surveyed *D.* sp. C 'Illawarra' sub-sites consist of loams and clay loams with varying amounts of unconsolidated and outcropping surface rock present. No surface soil was present at a small number of sub-sites where the species grows out of unconsolidated rock material.

5.4.5 Climate

The Illawarra area has a generally mild climate with extremes in temperature being moderated by coastal effects (Mills & Jakeman 1995). Average minimum and maximum temperatures are closely related to altitude and proximity to the coast (see Table 4).

Rainfall is very high compared with much of NSW. Average annual rainfall figures range from just below 1000 mm near Lake Illawarra to over 1800 mm at Barren Grounds with the higher rainfall isohyets closely correlated to the top of the escarpment (Mills & Jakeman 1995).

The distribution of rainfall within the area can also be attributed to winds blowing from the south (Hazelton 1992). One third of mean annual rainfall in the area occurs in January, February and March with a marked secondary rainfall peak in June (Hazelton 1992).

Westerly airflows dominate the weather during winter producing cooler drier conditions although few or no frosts occur on the coastal plain (Hazelton 1992). Drought conditions can occur in the area and rainfall data indicates the occurrence of distinct runs of wet or dry years which last between six and eight years (Mills & Jakeman 1995).

5.4.6 Altitude

Table 5 shows the distribution of *D.* sp. C 'Illawarra' sub-sites by altitude class. The altitudinal range of the species is 10 to 280 metres.

Table 5: Distribution by altitude class

Altitude Class (m)	Sub-sites
0 – 50	8 (15%)
51 – 100	19 (37%)
101 – 150	12 (23%)
151 – 200	9 (17%)
201 – 250	2 (4%)
251 – 300	2 (4%)

Table 4: Average temperatures (°C) for Moss Vale and Wollongong climatic stations*

Station	Altitude	Distance inland	Average January Maximum	Average July Minimum	Average nnual maximum	Average nnual minimum
Moss Vale	672 m	45 km	21.6	1.2	19.4	6.8
Wollongong	12 m	0.5 km	25.9	7.8	21.6	12.6

*Source: Mills & Jakeman (1995)

5.4.7 Associated vegetation

D. sp. C 'Illawarra' occupies the rainforest understorey. Associated vegetation is dominated by dry rainforest aligned species although subtropical or warm temperate rainforest species are also present to varying degrees. Emergent Eucalypts (including *E. quadrangulata* and *E. pilularis)* are present at sites that are located near the ecotone of rainforest and sclerophyll forest. An emergent *Casuarina cunninghamiana* was recorded at one site.

Vegetation descriptions for each of the sub-sites that were surveyed during the preparation of this plan are contained in Appendix 2.

The vegetation present at *D.* sp. C 'Illawarra' sites is consistent with the following NSW rainforest sub-alliances described by Floyd (1990):

- Subtropical rainforest sub-alliance no. 14 (*Doryphora – Daphnandra micrantha – Dendrocnide – Ficus – Toona*);
- Dry rainforest sub-alliance no. 23 (*Ficus – Streblus – Dendrocnide – Cassine*); and
- Warm temperate rainforest sub-alliance no. 42 (*Acmena – Doryphora – Dendrocnide – Ficus*).

The vegetation present at *D.* sp. C 'Illawarra' sites is also consistent with the following Illawarra rainforest types described by Mills and Jakeman (1995):

- Subtropical rainforest (type 1);
- Moist subtropical rainforest (type 2);
- Dry subtropical rainforest (type 3); and
- Mixed subtropical/ warm temperate (type 5).

Illawarra Subtropical Rainforest, which includes the rainforest types 1, 2, and 3 of Mills & Jakeman (1995), is listed as an endangered ecological community on Schedule 1 of the TSC Act.

NPWS (2002a) describes the following vegetation communities located in Wollongong LGA (and the Calderwood Valley area of Shellharbour LGA) as providing habitat for *D.* sp. C 'Illawarra':

- Illawarra Escarpment Subtropical Rainforest;
- Lowland Dry Subtropical Rainforest;
- Moist Coastal White Box Forest; and
- Moist Box - Red Gum Foothills Forest.

6 Biology and Ecology

6.1 Habit and longevity

D. sp. C 'Illawarra' is a medium sized rainforest tree that grows to 20 metres and is capable of prolific suckering. The longevity of the species is not known although, given its clonal nature and the large size of some individuals, it is believed to be a long-lived species.

6.2 Reproductive biology

6.2.1 Vegetative reproduction

D. sp. C 'Illawarra' is capable of vegetative reproduction from stems (coppicing) and underground rhizomes (suckering) (M. Bremner, DEC, pers. comm.).

6.2.2 Breeding system

D. sp. C 'Illawarra' flowers are morphologically hermaphrodite, having both male and female organs present in each flower (Foreman & Whiffin MS). It is not known whether the species is capable of self-pollination.

The pollination mechanisms of the species are unknown and consequently, so is the potential role that pollen vectors may play in the transfer of genetic material within and between sites. However, the predominant means of reproduction in *D.* sp. C 'Illawarra' appears to be asexual.

6.2.3 Phenology

D. sp. C 'Illawarra' flowers briefly in September and early October although not all populations or individuals appear to flower each year (A. Bofeldt, Wollongong Botanic Gardens, pers. comm.). This is not uncommon behaviour amongst rainforest understorey species however as limited resources can restrict the flowering of these species to good seasons or at specific intervals (A. Bofeldt, Wollongong Botanic Gardens, pers. comm.).

Table 6 shows the flowering activity at 11 sites that were surveyed during the flowering period of the species.

Table 6: Flowering activity at surveyed sites

Site Code	Total Stems	Flowering Stems
Dc1	8	2
Dc2	109	15
Dc3	90	0
Dc7	2560*	3
Dc8	1	1
Dc12	1200*	23
Dc13	26	4
Dc14	168	5
Dc15	15	7
Dc16	18	4
Dc21	11	8

*estimate only

While ten of these sites contained flowering stems, the proportion of stems that were flowering was generally very low and only two sites (Dc7 and Dc8) contained stems that could be described as

flowering heavily (M. Bremner, DEC, pers. comm.). Whether such low levels of flowering activity is a natural response to limited resources or an indication of a lack of fitness is considered to be a critical aspect of the species' biology that requires investigation.

D. sp. C 'Illawarra' plants propagated from seed take approximately six years to flower in cultivation (A. Bofeldt, Wollongong Botanic Gardens, pers. comm.).

6.2.4 Fruit production

The fruit of *Daphnandra* spp consist of numerous hairy achenes (ie dry, indehiscent, 1-seeded fruit) that are enclosed within a fruiting receptacle. This receptacle enlarges, becomes woody and dehisces through a single slit upon maturity (Harden 1990).

The period of time that is required for the fruit of *D.* sp. C 'Illawarra' to mature is unclear. Harden (1990) states that the fruit of *Daphnandra* spp develop over six to eight months while Foreman & Whiffin (MS) describe the fruiting period for *D.* sp. C 'Illawarra' as August. It is likely however that the fruit of *D.* sp. C 'Illawarra' matures over 10 to 12 months, with the fruiting receptacle splitting to release the achenes (fruit) between July and September (A. Bofeldt, Wollongong Botanic Gardens, pers. comm.).

Low levels of seed production in *D.* sp. C 'Illawarra' are suspected. Most sites appear to only produce 'pseudo-fruit', deformed fruiting receptacles that are roughly globose in shape and contain no seeds (A. Bofeldt, Wollongong Botanic Gardens, pers. comm.). It is unknown whether the production of 'pseudo-fruit' is a consequence of seed predation, naturally low pollen viability, inbreeding depression, self-incompatibility, the absence of pollinators or some other factor.

Typical fruiting receptacles have been observed at just two sites, Willow Creek (Dc14) and Actephila Gully (Dc21) (A. Bofeldt, Wollongong Botanic Gardens, pers. comm; M. Mulvaney, DEC, pers. comm.). The fruit collected from Dc14 was found to contain viable seed while no fruit has been collected from Dc21 to date.

The extent to which the species produces viable seed and the factors responsible for the production of 'pseudo-fruit' are essential aspects of the species' biology requiring investigation.

6.2.5 Seed Ecology

Aspects of the seed ecology of *D.* sp. C 'Illawarra' are poorly understood. The morphology of the seeds (ie small with long hairs) indicates that the primary seed dispersal mechanism is likely to be wind.

In germination trials, between 30 and 50 per cent of seed collected from Dc14 germinated within two months without any special treatment (A. Bofeldt, Wollongong Botanic Gardens, pers. comm.).

Further investigation of the viability and longevity of *D.* sp. C 'Illawarra' seed will assist future management of the species.

6.3 Population size and structure

As a consequence of the highly clonal nature of *D.* sp. C 'Illawarra', it is not possible to determine the number of genetic individuals (genets) that are *present* at a site without genetic analysis. However, an indication of the number of genets present can be inferred from the number and size of stems (ramets) present and the area occupied by those stems.

Table 7 details the area of occupancy and the number of stems (ramets) present at 16 *D.* sp. C 'Illawarra' sites. Less than 20 stems are present at seven of these sites and nine sites have an area of occupancy of less than 400 m^2. From this data it is assumed that the total population size of *D.* sp. C 'Illawarra' is small. It is likely that some sites contain just one genetic individual.

6.4 Response to disturbance

D. sp. C 'Illawarra' is capable of suckering from underground rhizomes and coppicing from damaged stems in response to physical disturbance. Extensive suckering was evident at the majority of sites that were surveyed during the preparation of this plan. This suckering is considered to be at least partially attributable to 'natural' disturbances associated with the movement of unconsolidated rock material on steep unstable slopes.

Many of the vegetation remnants occupied by *D.* sp. C 'Illawarra' have been partially cleared and/or grazed in the past, and it is likely that the species survived these disturbances by suckering and/or coppicing from damaged stems. However, the clearing or grazing of *D.* sp. C 'Illawarra' sites is clearly not desirable as, in addition to physically damaging plants, these activities will modify the closed forest habitat of the species and contribute to its degradation.

As *D.* sp. C 'Illawarra' is a climax rainforest species, it is unlikely that disturbance is required to facilitate seedling recruitment (A. Bofeldt, Wollongong Botanic Gardens, pers. comm.).

Table 7: Area of occupancy and distribution of stems by size class at surveyed sites

Site Code	Area (sq. m.)	Total Stems	Stems <0.3 m	Stems 0.3 to 2 m	Stems 2 to 5 m	Stems >5m
Dc1	200	8	-	2 (26%)	3 (37%)	3 (27%)
Dc2	1000	109	3 (3%)	38 (35%)	37 (34%)	31 (28%)
Dc3	1570	90	5 (6%)	21 (23%)	39 (43%)	25 (28%)
Dc7	5800	2560*	Not recorded	Not recorded	338 (13%)	100 (4%)
Dc8	20	1	-	-	-	1 (100%)
Dc10	1420	>1000*	Not recorded	Not recorded	212 (21%)	90 (9%)
Dc11	20	12	5 (45%)	5 (45%)	1 (10%)	-
Dc12	3900	1200*	Not recorded	Not recorded	138 (11%)	17 (1%)
Dc13	100	26	2 (8%)	10 (38%)	14 (54%)	-
Dc14	600	168	16 (10%)	76 (45%)	54 (32%)	22 (13%)
Dc15	100	15	-	4 (27%)	8 (53%)	3 (20%)
Dc16	200	18	6 (33%)	8 (44%)	1 (6%)	3 (17%)
Dc17	350	105	6 (6%)	84 (80%)	12 (11%)	3 (3%)
Dc21	100	11	-	3 (27%)	8 (73%)	-
Dc27	1600	64	6 (9%)	32 (50%)	15 (23%)	11 (18%)
Dc33	3250	391	31 (8%)	313 (80%)	43 (11%)	4 (1%)
Dc40	1200	335	17 (5%)	271 (81%)	32 (10%)	15 (4%)
Dc41	400	237	51 (21%)	170 (72%)	12 (5%)	4 (2%)

*estimate only

6.5 Fire ecology

There have been no direct observations of the effects of fire frequency, intensity or seasonality on *D.* sp. C 'Illawarra'. Given its rainforest habitat, the species is unlikely to have evolved with fire and as such, fire is considered likely to impact negatively upon the lifecycle of the species. Such impacts may result from physical damage to individual plants or from changes to its habitat.

7 Previous Recovery Actions

7.1 Survey

During the preparation of this recovery plan, 18 *D.* sp. C 'Illawarra' sites were surveyed by the DEC with the assistance of Anders Bofeldt (Wollongong Botanic Gardens) and community volunteers. Habitat details, threats and observations of flowering and fruit production were recorded at each surveyed site.

7.2 Profile and environmental impact assessment guidelines

A species profile and environmental impact assessment guidelines have been prepared for *D.* sp. C 'Illawarra' (Appendix 4) to assist public authorities, community groups and private landholders in the conservation of the species. These documents also aim to assist consent and determining authorities in the statutory assessment of potential impacts on the species.

7.3 Establishment of a recovery team

The Illawarra Regional Threatened Flora Recovery Team was established in June 2001 to coordinate the recovery planning for six plant species which occur in the Illawarra region and are listed as endangered at a State and National level. These species are *D.* sp. C 'Illawarra', *Irenepharsus trypherus, Zieria granulata, Pterostylis gibbosa, Cynanchum elegans* and *Pimelea spicata*. Representatives of the public authorities that are involved in the planning and/or management of remnant vegetation in the region are present on the recovery team, as are representatives of various regional organisations and community groups.

7.4 Community awareness initiatives

- An information brochure has been prepared and distributed to raise awareness of the six "Threatened Plants of the Illawarra" including *D.* sp. C 'Illawarra'.
- In June 2002, the Australian Network for Plant Conservation and Wollongong Council hosted a workshop to raise awareness of issues relating to the conservation of threatened flora in the Illawarra. *D.* sp. C 'Illawarra' was one of the subject species of that workshop.
- In November 2002, Landcare Illawarra hosted a workshop to raise awareness of *D.* sp. C 'Illawarra' and five other endangered flora species in the Illawarra.
- The DEC has initiated a program of meeting landholders with *D.* sp. C 'Illawarra' on their property to discuss sympathetic management of the species and the opportunities for entering into conservation agreements.

7.5 In-situ protection

- A Voluntary Conservation Agreement (VCA) under the NP&W Act has been signed to protect habitat for the species at Willow Creek (Dc21).

A Plan of Management for the site has been prepared.

- A Property Agreement under the under the *Native Vegetation Conservation Act 1997* has been signed to protect habitat for the species at Marshall Mount (Dc3). Cattle have also been temporarily removed from this property until the installation of watering points and fencing of native vegetation has been completed (A. Knowlson, pers. comm.).
- Threat abatement works including fencing to exclude livestock and bush regeneration are being implemented by private landholders and the DEC at four sites (Dc17, Dc21, Dc28 and Dc41).

8 Management Issues

8.1 Introduction

The following section identifies the management issues affecting *D.* sp. C 'Illawarra' including:

- Our limited knowledge of the species' biology, ecology and distribution;
- The threats operating on the species;
- Community awareness of the species;
- Consideration of a translocation and *ex-situ* conservation program; and
- Consideration of the species' ability to 'recover'.

8.2 Limits to current knowledge

The level of information that is known about *D.* sp. C 'Illawarra' (as detailed in Sections 5 and 6) is limited and only broad assumptions can be made regarding its ecology and biology. An enhanced knowledge of key aspects of species' biology and ecology is clearly required if land managers and consent/determining authorities are to make informed judgements regarding its conservation requirements.

Future research should target aspects that are relevant to the practical management of the species and its habitat. High priority research projects for the species (as identified in Section 6) are described below.

Phenology/Fecundity

- Investigation of the extent of seed production at individual sites, with an emphasis on identifying sites where seed is produced
- Investigation of pollination mechanisms
- Investigation of the perceived low levels of seed production and the potential causes of this (seed predation, pollen sterility, self-incompatibility, loss of pollinator etc)

Seed ecology

- Investigation of seed dispersal, dormancy and germination mechanisms
- Investigation of seed viability and longevity.

Genetic investigation

While not essential to the practical management of the species, genetic investigations to determine population size and structure would greatly improve our understanding of the species and would inform land-use and recovery planning decisions.

8.3 Threatening Processes

The threats operating at *D.* sp. C 'Illawarra' sites are described below and an assessment of the threat level at each site is included at Appendix 5.

8.3.1 Clearing for agriculture

The clearing of vegetation for agriculture (primarily cattle grazing and dairying) is a potential threat to *D.* sp. C 'Illawarra' on a number of rural properties. Liaison with the owners of these properties is required to prevent the inadvertent clearing of habitat for the species.

Where clearing approvals are required, access to accurate site location records will assist consent and determining authorities in considering the conservation requirements of the species. Sufficient vegetated buffers should be retained in the vicinity of site that contain *D.* sp. C 'Illawarra' to maintain the integrity of its rainforest habitat. The extent and design of the buffers required to achieve this will be site specific, depending on factors including aspect and slope (and their influence on a site's exposure to insolation and wind and the latter's influence on drainage patterns) and the adjacent landuse.

8.3.2 Hard rock quarrying

Five *D.* sp. C 'Illawarra' sites in the Dunmore Hills area are potentially threatened (either directly or indirectly) by hard rock (latite) quarrying activities. Two of these sites (Dc14 and Dc20) lie within 100 metres of land that has been identified by the Department of Mineral Resources as containing a state significant latite resource.

Four sites (Dc12, Dc14, Dc16 and Dc20) are owned by mining interests and two (Dc16 and Dc20) of these are zoned 1(a) under Shellharbour LEP 2000. Mineral extraction is permitted with development consent within this zone. The other three sites are zoned 7(e) Environmental Protection (Scenic).

In addition to the threat of further habitat loss and fragmentation as a consequence of quarrying, the five known sites within the Dunmore Hills area lie

within catchments where hydrological conditions may be effected by upstream quarrying activities. Reductions in water quality and altered surface and groundwater flows have the potential to directly impact upon the species and to affect the viability of its rainforest habitat.

Quarrying activity upstream of one site (Dc14) has potentially altered hydrological conditions in the gully where it is located. The impact that this may have on the long-term viability of *D.* sp. C 'Illawarra' at the site (the only site confirmed to produce viable seed) and its rainforest habitat is not known.

It is expected that all of the *D.* sp. C 'Illawarra' sites in the Dunmore Hills area will come under increasing pressure from the direct and indirect impacts (altered hydrological conditions, dust etc) of quarrying activities as the mineral resource in the currently identified extraction areas becomes depleted.

Shellharbour Council is to commence preparation of a Local Environmental Plan and Local Environment Study that reviews the mineral extraction boundaries in the Dunmore Hills area. The preparation of these documents provides an opportunity to protect *D.* sp. C 'Illawarra' from the direct and indirect impacts of quarrying through the rezoning process. Targeted survey as part of this process will be necessary to ensure that all locations of the species within the study area are identified and considered in the preparation of these documents.

8.3.3 Residential development

Population growth in the Illawarra area is likely to place *D.* sp. C 'Illawarra' sites under increasing pressure from residential development. Such development, in addition to directly impacting upon the species through habitat loss and fragmentation, can indirectly affect sites in proximate or downslope locations by modifying environmental conditions and contributing to habitat degradation.

These impacts can result from factors including:

- Altered hydrological flows (and associated problems with sedimentation and erosion);
- Altered soil pH and nutrient levels;
- Weed infestations;
- Increased pedestrian/vehicular access to sites;
- Rubbish and green waste dumping;
- Bush fire hazard reduction works;
- Inappropriate landscaping activities; and
- Arson.

Accurate and readily accessible site location records will assist consent and determining authorities in considering the conservation requirements of the species during the assessment of rezoning and development applications. Strategies to mitigate direct and indirect impacts on the species should be incorporated into the design of developments that are constructed upslope of, or proximate to, *D.* sp. C 'Illawarra' sites.

8.3.4 Road construction

Three *D.* sp. C 'Illawarra' sites (Dc37, Dc38 and Dc39) were identified during the route selection study for the proposed upgrade of the Gerringong to Berry section of the Princes Highway (Muston & Associates 1991). One of the five proposed routes investigated during that study (the North Saddle Corridor) would result in the removal of one of these sites (Dc39). However, the RTA is yet to determine its preferred route for the upgrade (Chris Cleary, RTA, pers. comm.).

Under statutory environmental impact assessment processes, the RTA is required to consider the direct and indirect impacts of the proposed road upgrade on *D.* sp C 'Illawarra', in addition to *Zieria granulata*, Illawarra Subtropical Rainforest and any other threatened species, populations or ecological communities that occur in the study area.

8.3.5 Weed invasion

Weed invasion is a threat at the majority of sites surveyed during the preparation of this plan. Lantana (*Lantana camara)* was the most commonly recorded weed species at these sites, occurring in densities of between five and 100 per cent projected cover at all but one surveyed site. Mistflower (*Ageratina riparia*), Crofton Weed (*Ageratina adenophora*) and Cape Ivy (*Delairea odorata*) are also present in high densities (>60 per cent projected cover) at a small number of sites. These weeds will potentially impact upon *D.* sp. C 'Illawarra' by inhibiting recruitment.

Madeira Vine (*Anredera cordifolia*) is in the early stages of infestation at one site (Dc14) and is established immediately upstream of this site. This weed species has the ability to establish under an intact canopy and could potentially smother mature *D.* sp. C 'Illawarra' plants, in addition to inhibiting recruitment. For this reason, Madeira Vine is considered to be a more immediate threat to *D.* sp. C 'Illawarra' than the other weed species that were recorded at the surveyed sites.

The management of weeds at *D.* sp. C 'Illawarra' sites requires targeted bush regeneration efforts. These efforts should aim to restore, maintain and expand the rainforest habitat of the species. The targeted removal of Madeira Vine (and any other weed species with the potential to smother mature *D.* sp. C 'Illawarra' plants) is considered to be a high priority.

8.3.6 Grazing by livestock and feral deer

Grazing and rubbing of *D.* sp. C 'Illawarra' stems by cattle has been observed at a number of sites that are located on rural properties. Grazing and rubbing by feral deer is also suspected at a number sites, and substantial damage resulting from the grazing of feral deer has been observed at one site (Dc28) (M. Hindmarsh, pers. comm.).

Grazing has the potential to prevent recruitment of the species, while bark damage (and subsequent infections) can affect mature individuals. General habitat degradation resulting from the presence of livestock and feral deer (including soil compaction and weed invasion) will also impact upon the species.

Liaison with landholders is required to facilitate the installation of fences where livestock or feral deer are accessing *D.* sp. C 'Illawarra' sites.

8.3.7 Rubbish dumping

Dumped rubbish (including old cars and corrugated iron sheets) has been observed at two *D.* sp. C 'Illawarra' sites (Dc11 and Dc13). The dumping of rubbish has the potential to damage *D.* sp. C 'Illawarra' and degrade its habitat through burial, physical damage and soil compaction. Liaison with landholders is considered to be the key to managing this threat.

8.3.8 Bush fire hazard reduction activities

In the absence of specific evidence to the contrary, it is assumed that *D.* sp. C 'Illawarra' would be adversely affected by prescribed burning or mechanical vegetation clearance for bush fire hazard reduction purposes (see discussion in Sections 6.4 and 6.5). Consequently, such activities should be excluded from habitat that contains the species.

To enable the conservation requirements of the species to be considered by public authorities when planning bush fire hazard reduction work or issuing Bush Fire Hazard Reduction Certificates, the species should be placed on the Threatened Species Hazard Reduction List (TSHRL). This list has been prepared as part of the Bush Fire Environmental Assessment Code established by the *Rural Fires and Environmental Assessment Amendment Act 2002.* The provision of accurate location records (ie within 100 m accuracy) to public authorities is required to ensure that the impact of managed bush fire hazard reduction activities on the species is minimised.

8.4 Community awareness of the species

An increased awareness of *D.* sp. C 'Illawarra' is required to ensure that the species is appropriately considered in statutory environmental planning and impact assessment processes and to facilitate the implementation of threat abatement works. The target groups for awareness raising initiatives are:

- Private landholders;
- Public authorities; and
- The general community

The informed support of the private landholders whose land contains *D.* sp. C 'Illawarra' is essential to the success of the recovery program. Regular liaison with affected landholders and the publication of an annual newsletter detailing progress of the recovery program are two initiatives that will be implemented through this recovery plan to facilitate such support.

Public authorities with consent, determining or environmental planning responsibilities under the EP&A Act require an understanding of the species, particularly regarding its known locations, habitat requirements and sensitivity to impacts. Some public authorities also have an operational role (Rural Fire Service, Transgrid) in potential habitat for the species and as such, may inadvertently impact upon *D.* sp. C 'Illawarra' sites.

Initiatives to assist these authorities in meeting their statutory obligations in relation to the consideration of *D.* sp. C 'Illawarra' in environmental impact assessment and land-use planning processes include:

- The preparation and distribution of a species profile and environmental impact assessment guidelines; and
- The verification and registration of site records on the DEC Atlas of NSW Wildlife.

The third target audience for awareness raising initiatives is the general community. The initiatives targeting this group aim to enhance the social benefits of the recovery program amongst this target group and include:

- The preparation of an annual newsletter detailing the progress of the recovery program, which will be distributed to affected landholders, public authorities, community groups and interested individuals;
- The preparation of press releases to highlight key recovery actions; and
- The involvement of community members in the implementation of recovery actions.

8.5 Translocation and ex-situ conservation

8.5.1 Translocation

Translocation, defined as the deliberate transfer of plants or regenerative plant material from an *ex-situ* collection or natural population to a location in the

wild, including existing or new sites or those where the taxon is now locally extinct (Vallee et al. 2004), is often raised as a possible method of conserving threatened flora. However, given the high cost and risk associated with the technique, translocation should only be considered as a last resort when all other management options are deemed inappropriate or have failed. As stated by Vallee et al. (2004), 'where possible, resources will be more effective when directed towards conserving existing populations *in-situ* through habitat protection and/or habitat rehabilitation measures and through the control of threatening processes'.

Translocation is not considered to be necessary for the survival of *D.* sp. C 'Illawarra' as the in-situ conservation measures proposed in this recovery plan are expected to meet the conservation needs of the species. Further, primarily due to the uncertainty of success and the risks associated with translocation, the technique should not be considered by consent or determining authorities to be an appropriate means of ameliorating the impact of a proposal on the species (Vallee et al. 2004).

8.5.2 Ex-situ conservation

While not considered necessary for the survival of the species, it would be prudent to maintain an ex-situ collection of *D.* sp. C 'Illawarra' seed from those sites that are found to produce viable seed. Such a collection will provide some protection against the loss of genetic material that may result from unexpected local extinctions.

8.6 Ability to recover

8.6.1 Rarity

It is not known whether *D.* sp. C 'Illawarra' is naturally uncommon or whether it has suffered minor or substantial declines in population size and/or distribution. It can be reasonably assumed however, that the extensive clearing of the Illawarra's lowland rainforests since European settlement has had a substantial impact on the distribution and population size of *D.* sp. C 'Illawarra'. The high number of threats operating at extant sites indicate that the species is likely to still be in decline.

8.6.2 Viability

The viability of a species can be broadly defined as the ability of that species to be self-replacing in nature. There is currently little information as to the viability of the *D.* sp. C 'Illawarra' populations identified in this recovery plan. Seed production has been reported from just two sites (only one of which has been confirmed to produce viable seed) and the extent to which this seed is capable of surviving in the wild is unknown. However, it has been reported that many clonal plant species do not show signs of senescence and are capable of surviving indefinitely, or at least as long as the surrounding environment remains compatible (Nooden & Leopold 1988; Eriksson 1993). All populations of *D.* sp. C 'Illawarra' should therefore be assumed to be viable unless there is clear evidence to the contrary.

8.6.3 Likelihood of recovery

'Recovery' in the context of this plan, is to maintain the current endangered status of *D.* sp. C 'Illawarra' and prevent the taxon from moving to a less desirable conservation status (ie TSC Act Schedule 1, Part 4, presumed extinct). The likelihood of recovery of *D.* sp. C 'Illawarra' in this context is high provided that the recovery actions outlined in this recovery plan are implemented, monitored and amended as required.

9 Proposed Recovery Objectives, Actions and Performance Criteria

The overall objective of this recovery plan is to provide for the continued and long-term survival of *D.* sp. C 'Illawarra' in the wild by preventing the loss of populations of the species.

The specific recovery objectives are:

- To prevent the loss of sites through land-use change;
- To identify and manage the threats operating at sites that contain the species;
- To provide the community with information that assists in conserving the species;
- To raise awareness of the species and involve the community in the recovery program;
- To establish the extent of the current distribution of the species;
- To promote research that will assist with the management of the species; and
- To maintain an ex-situ seed collection for the species.

Specific Objective 1: To prevent the loss of sites through land-use change

The vast majority of *D.* sp. C 'Illawarra' sites occur on land that is not managed primarily for conservation purposes. This objective aims to increase the legislative protection afforded these sites and protect them from the direct and indirect impacts of land-use change through the following mechanisms:

- Conservation agreements and covenants under the NP&W Act, TSC Act and *Conveyancing Act 1919*;
- Environmental Planning Instruments under Part 3 of the EP&A Act;

- Environmental impact assessment under the EP&A Act; and
- Consideration of a critical habitat declaration under the TSC Act.

Priority sites requiring action under this objective are listed in the high and moderate risk categories of the threat assessment contained in Appendix 5.

Action 1.1: The DEC will advise landholders of the opportunities and advantages of entering into conservation agreements and covenants

Opportunities for such agreements include Voluntary Conservation Agreements (VCAs) under the NP&W Act, Joint Management Agreements and Property Management Plans under the TSC Act, and appropriately worded covenants under the *Conveyancing Act 1919.*

Action 1.2: Councils will ensure that when Local Environment Plans and Development Control Plans are prepared, or reviewed, they have reference to this recovery plan and any future advice from the DEC regarding the distribution and ecology of the species

Specifically, Shellharbour City Council will ensure that the Mineral Resources LES and LEP for the Dunster Hills area considers measures to protect the species and its habitat from the direct and indirect effects of quarrying.

Action 1.3: The Department of Infrastructure Planning and Natural Resources will ensure that when Environmental Planning Instruments are prepared, or reviewed, they have reference to this recovery plan and any future advice from the DEC regarding the distribution and ecology of the species

Action 1.4: Councils and the Department of Infrastructure Planning and Natural Resources will assess developments and activities with reference to this recovery plan, environmental impact assessment guidelines (Appendix 4) and any future advice from the DEC regarding the distribution, threats, biology and ecology of the species

Action 1.5: The DEC, in consultation with the recovery team, will reconsider the need for a declaration of critical habitat following the results of survey and ecological investigations

Performance Criterion 1:

No *D.* sp. C 'Illawarra' sites lost as a result of land-use change.

Specific Objective 2: To identify and manage the threats operating at sites that contain the species

Threats operating at *D.* sp. C 'Illawarra' sites (in addition to land clearing which is addressed under Specific Objective 1) include weed invasion, rubbish dumping and grazing by livestock and feral deer. Actions under this objective aim to manage these threats through the implementation of appropriate in-situ threat abatement measures in accordance with management plans and site management statements.

Action 2.1: The DEC will prepare site management statements for sites that are located on land that is managed by the DEC, or on land that is subject to a VCA

Site management statements will be prepared following the proforma in Appendix 6. These statements will detail the specific threat abatement measures required at each site and a timetable for the implementation of these measures. Sites relevant to this action include Dc17, Dc21, Dc27 and Dc40.

Performance criterion 2.1

Site management statements for relevant sites prepared within one year.

Action 2.2: The DEC will implement threat abatement measures in accordance with the site management statements prepared under Action 2.1

Performance criterion 2.2

Threat abatement measures for relevant sites implemented in accordance with site management statements.

Action 2.3: Councils will incorporate specific in-situ protection measures for the species into Plans of Management for community land

Shellharbour City Council and Kiama Municipal Council will incorporate site specific in-situ protection measures for *D.* sp. C 'Illawarra' into Plans of Management for community land where the species occurs. Relevant community land occurs at Jerrara Dam (Dc35) in Kiama LGA and Blackbutt (Dc15) in Shellharbour LGA.

Site specific information on the species that is to be incorporated into these plans includes:

- Stem numbers, condition and location details;
- An assessment of existing and potential threats at the site;
- Details of threat abatement measures to be implemented to address these threats; and
- Details of a monitoring program to assess the effectiveness of threat abatement measures.

Where a Plan of Management has already been prepared that does not address the matters listed above, an addendum to the plan will be prepared that addresses these matters.

Performance Criterion 2.3

In-situ protection measures for the species incorporated into Plans of Management within three years.

Action 2.4: The DEC will undertake surveys to determine the status and extent of sites located on freehold land

Where possible, surveys will be undertaken between July and September to enable data on the presence and extent of flowering and fruiting stems to be recorded.

Performance Criterion 2.4

Sites on freehold land surveyed within three years, subject to landholder approval.

Action 2.5: The DEC, in consultation with landholders, will prepare site management statements for priority sites that are located on freehold land

The DEC, in consultation with, and subject to the approval of, landholders, will assess the condition of priority sites that are located on freehold land and prepare site management statements (following the proforma in Appendix 6) that detail the specific threat abatement measures required at those sites and a timetable to implement those measures.

For the purposes of this action, priority sites are those sites that are listed in the low or moderate risk categories of the threat assessment contained in Appendix 5.

Performance criterion 2.5

Site management statements prepared for relevant sites within three years, subject to landholder approval.

Action 2.6: The DEC will encourage and assist landholders in the implementation of threat abatement measures on freehold land, in accordance with the site management statements prepared under Action 2.5

Performance Criterion 2.6

Threat abatement measures for relevant sites implemented in accordance with site management statements within five years, subject to landholder approval.

Specific Objective 3: To provide the community with information that assists in conserving the species

The prompt and effective distribution of information on *D.* sp. C 'Illawarra' and its habitat is an important component of ensuring that the conservation requirements of the species are appropriately considered in environmental impact assessment, land-use planning, and land management processes. Actions under this objective use the following mechanisms to aid the dissemination of information about the species:

- Continued coordination of the Illawarra Regional Threatened Flora Recovery Team;
- Prompt distribution of location records to relevant parties; and
- Updated species profiles and environmental impact assessment guidelines prepared.

Action 3.1: The DEC will coordinate regular meetings of the Illawarra Threatened Flora Recovery Team

The DEC will continue to coordinate regular meetings of the Illawarra Regional Threatened Flora Recovery Team to oversee the implementation of this recovery plan. These meetings will serve to facilitate discussion on the management of the species and the dissemination of information to key stakeholders.

Performance Criterion 3.1

Meetings of the Illawarra Regional Threatened Flora Recovery Team held twice a year.

Action 3.2: The DEC will coordinate the prompt distribution of location records through the Atlas of NSW Wildlife

Performance Criterion 3.2

Location records available on the Atlas of NSW Wildlife within four months of verification or discovery.

Action 3.3: The DEC will update the profile and environmental impact assessment guidelines for the species to incorporate information acquired during the implementation of this recovery plan

Performance Criterion 3.3

Profile and environmental impact assessment guidelines updated as required.

Action 3.4: DEC will prepare a submission to have the species added to the Threatened Species Hazard Reduction List

The DEC will prepare a submission to have *D.* sp. C 'Illawarra' added to the Threatened Species Hazard Reduction List (TSHRL), which is a part of Bush

Fire Environmental Assessment Code. This will enable the conservation requirements of the species to be considered by public authorities when planning bush fire hazard reduction work or issuing Bush Fire Hazard Reduction Certificates.

Performance Criterion 3.4

D. sp. C 'Illawarra' added to the TSHRL within one year.

Action 3.5: Public authorities will inform the DEC of decisions that may affect the species, in accordance with statutory requirements

Public authorities will inform the DEC if planning or development decisions are made that may affect *D.* sp. C 'Illawarra' or its habitat, in accordance with statutory requirements. For the purposes of this action, public authorities are taken to include the following:

- Wollongong City Council;
- Shellharbour City Council;
- Kiama Municipal Council;
- Shoalhaven City Council;
- Department of Infrastructure Planning and Natural Resources; and
- Rural Fire Service.

The Rural Fire Service will implement this action, with respect to bush fire hazard reduction, by ensuring that there is adequate access by the DEC to temporal and spatial data from the Bushfire Risk Information Management System.

Performance Criterion 3.5

DEC informed of decisions that affect *D.* sp. C 'Illawarra' or its habitat.

Specific Objective 4: To raise awareness of the species and involve the community in the recovery program

In order to enhance the social benefits of the recovery program for *D.* sp. C 'Illawarra', actions under this objective aim to raise awareness of the recovery plan and involve the community in its implementation.

Action 4.1: DEC will prepare and distribute an annual newsletter detailing the progress of the Illawarra Regional Threatened Flora Recovery Program

The DEC will prepare an annual newsletter to raise awareness of the Illawarra Regional Threatened Flora Recovery Program (which includes the *D.* sp. C 'Illawarra' recovery program) and encourage community involvement in its implementation. The newsletter will be distributed to affected landholders, public authorities, community groups and interested individuals.

Performance indicator 4.1

Newsletter produced and distributed annually.

Action 4.2: The DEC and Councils will raise awareness of, and encourage community involvement in, the recovery program

The DEC, Wollongong City Council, Shellharbour City Council and Kiama Municipal Council will raise awareness of the recovery program amongst community groups and interested individuals, and will encourage involvement in the implementation of recovery actions including survey, monitoring and bush regeneration. The DEC will also liaise with Landcare Illawarra to encourage Landcare groups to become involved in the recovery program.

Shoalhaven City Council has advised that it will not be responsible for the implementation of this action.

Performance indicator 4.2

Community groups and individuals aware of the recovery program and involved in the implementation of recovery actions.

Action 4.3: The DEC and Councils will issue press releases that highlight key events in the implementation of the recovery plan

The DEC, Wollongong City Council, Shellharbour City Council and Kiama Municipal Council will issue press releases that highlight key events in the implementation of the recovery plan. Such key events may include the signing of conservation agreements, the discovery of new sites, the establishment of new bush regeneration groups etc.

Shoalhaven City Council has advised that it will not be responsible for the implementation of this action.

Performance Criterion: 4.3

Media coverage of key events associated with the implementation of the recovery plan achieved.

Specific Objective 5: To establish the extent of the current distribution of the species

Our knowledge of the distribution of *D.* sp. C 'Illawarra' sites (as detailed in Section 5) is considered to be incomplete. Actions under this objective aim to establish the extent of the distribution of the species through predictive modelling and the targeted survey of potential habitat.

Action 5.1: The DEC will undertake predictive modelling of potential habitat for the species

Performance Criterion 5.1

Potential habitat determined within one year.

Action 5.2: The DEC will coordinate targeted surveys for the species

Performance Criterion 5.2

High quality potential habitat for the species surveyed within three years, subject to landholder approval.

Specific Objective 6: To promote research that will assist with the management of the species

Actions under this objective aim to improve our knowledge of aspects of the ecology and biology of the species that will assist in the practical management of the species.

Action 6.1: The DEC will coordinate investigations into essential aspects of species' ecology and biology as identified in this recovery plan

The DEC will liaise with local research institutions (including Universities and Botanic Gardens) to encourage and facilitate research into the species that is consistent with the priorities outlined in Section 8.2. Where possible, the DEC will undertake components of this research program.

Action 6.2: The DEC will investigate basic aspects of the seed biology of the species

Performance Criterion 6

Investigations into essential aspects of the species' biology and ecology commenced within two years.

Specific Objective 7: To maintain an ex-situ seed collection for the species

As discussed in Section 8.5, the establishment of a comprehensive ex-situ germplasm collection for *D.* sp. C 'Illawarra' is not considered necessary for the survival of the species. However, to provide some protection against the unexpected loss of genetic material, it would be prudent to maintain an ex-situ collection of *D.* sp. C 'Illawarra' seed collected from the sites that produce viable seed.

Action 7.1: The DEC will aim to collect a representative sample of seed from each site that is found to produce viable seed, for placement in long-term seed storage

Action 7.2: The DEC will undertake the long-term storage of seed collected under Action 7.1

Performance Criterion 7

A representative sample of seed from each seed-producing site placed in long-term storage within two years, subject to landholder approval.

10 Implementation

The total cost to implement this recovery plan is estimated to be $90,150 over five years. This amount does not include site management costs or the costs associated with the preparation and implementation of Plans of Management for community land, as these costs are yet to be determined. A total of $36,850 will be provided as in-kind contributions with an additional $53,300 required to implement actions that are currently unfunded. Additional funds will be sought from sources including the Natural Heritage Trust, Environmental Trust, industry sponsors, the NSW State Biodiversity Program, Threatened Species Network, Threatened Species Appeal and from the DEC's annual operational provisions for threatened species programs.

Table 8 details the costs and identifies the parties responsible for the implementation of specific recovery actions.

11 Social and Economic Consequences

11.1 Social Consequences

It is expected that the implementation of this recovery plan will have positive social impacts on the community and, in particular, on the owners and managers of *D.* sp. C 'Illawarra' habitat. The implementation of recovery actions (including bush regeneration, site monitoring and surveys) will provide benefits to the environment and/or enhance the general well being of the community and individuals involved.

Increased awareness regarding the conservation of threatened species in a rural setting will encourage recognition amongst landholders of the value of remnant vegetation and the responsibility for habitat management. Personal and regular contact with landholders and local community groups is a key strategy to achieving this.

Negative social impacts are not envisaged as the implementation of the recovery plan is not expected to affect public land usage to any great extent, and modification of private land management patterns will only occur at the land manager's discretion. Continued liaison with the local community, affected landholders, and public authorities will address and minimise any unforeseen negative social impacts arising from the conservation of *D.* sp. C 'Illawarra'.

11.2 Economic Consequences

The economic consequences of this recovery plan are those that are associated with its implementation. These include on-ground habitat management,

research, survey, monitoring, community education and participation, and on-going recovery team coordination. These costs can be off-set and minimised by:

- Implementing a long-term strategic framework for managing the species and its habitat;
- Maintaining accurate information on the distribution and status of sites;
- Adopting a cooperative approach to management where the relevant land managers and local community are actively involved; and
- Seeking funds from external sources.

The improved environmental impact assessment that will result from mechanisms established in this recovery plan will assist consent and determining authorities to meet there statutory responsibilities. As these requirements already apply, the economic consequences of such improvements are not attributable to this recovery plan.

Substantial economic consequences may result where the species' conservation requirements prevent or restrict the use of land that is currently identified for mineral extraction, agriculture or urban development. These consequences will be identified and addressed through statutory environmental impact assessment processes.

12 Roles/Interests of Indigenous People

Indigenous communities with an interest in the actions proposed in this recovery plan have not yet been identified. Implementation of recovery actions under this plan will include consideration of the roles and interests of indigenous communities in the region.

13 Biodiversity Benefits

The conservation and study of *D.* sp. C 'Illawarra' will benefit other species that share the same habitat. It will also help to conserve areas of Illawarra Subtropical Rainforest, an endangered ecological community listed on Schedule 1 of the TSC Act.

The raised awareness of *D.* sp. C 'Illawarra' that will be created during the implementation of this recovery plan will raise the profile of all threatened species in the community. This in turn may lead to greater opportunities for the conservation of threatened species and increased protection of biodiversity.

14 Preparation Details

This recovery plan was prepared by Martin Bremner of the DEC Threatened Species Unit, Metropolitan Region, with the advice and assistance of the Illawarra Regional Threatened Flora Recovery Team.

15 Review Date

This recovery plan is to be formally reviewed and updated by the DEC, in conjunction with the recovery team, five years from the date of its publication.

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Table 8: Estimated costs, funding source and responsible parties for implementing the actions identified in the *Daphnandra* sp. C 'Illawarra' Recovery Plan

Action No.	Action Description	Priority	Responsible Party	Fund Source	Cost Estimate ($'s/year)					Total Cost ($'s)
					Yr1	Yr2	Yr3	Yr4	Yr5	
1.1	Notify landholders	1	DEC	In kind	700	700	700	-	-	**2100**
1.2	Preparation/review of LEPs and DCPs	1	WCC, ShellCC, KMC, ShoalCC	-	#	#	#	#	#	**-**
1.3	Preparation/review of EPI's	1	DIPNR	-	#	#	#	#	#	**-**
1.4	Environmental impact assessment	1	WCC, ShellCC, KMC, ShoalCC, DIPNR	-	#	#	#	#	#	**-**
1.5	Consideration of critical habitat	2	DEC	In kind	-	-	*	-	-	*****
2.1	Site management statements for DEC/VCA sites	1	DEC DEC	In kind	2100 1050	- -	- -	- -	- -	**2100** **1050**
2.2	Threat abatement for DEC/VCA sites	1	DEC	In kind	*	*	*	*	*	*****
2.3	Plans of Management for sites on community land	1	ShellCC and KMC	In kind	*	*	*	*	*	*****
2.4	Survey of freehold sites	1	DEC	Unsecured	5600	4900	4900	-	-	**15,400**
2.5	Site management statements for freehold sites	1	DEC	Unsecured	7700	7700	7000	-	-	**22,400**
2.6	Threat abatement for freehold sites	1	DEC	Unsecured	*	*	*	*	*	*****
3.1	Coordination of recovery team	1	DEC	In kind	3500	3500	3500	3500	3500	**17,500**
3.2	Distribution of location records	1	DEC	In kind	√	√	√	√	√	**-**
3.3	Update species profiles and EIA guidelines	1	DEC	In kind	-	-	700	-	-	**700**
3.4	Threatened Species Hazard Reduction List	1	DEC	In kind	√	-	-	-	-	**-**
3.5	DEC informed of planning decisions that may ffect the species	2	WCC, ShellCC, KMC, ShoalCC, DIPNR, RFS	-	#	#	#	#	#	**-**
4.1	Prepare and distribute annual newsletter	2	DEC	In kind	√	√	√	√	√	**-**
4.2	Encourage community involvement	2	DEC, WCC, ShellCC, KMC	-	#	#	#	#	#	**-**
4.3	Issue press releases to highlight the implementation key recovery actions	2	DEC, WCC, ShellCC, KMC	-	#	#	#	#	#	**-**
5.1	Predictive modelling	1	DEC	Unsecured	5000	-	-	-	-	**5000**
5.2	Targeted surveys of potential habitat	1	DEC	Unsecured	-	3500	3500	3500	-	**10,500**
6.1	Coordinate research	2	DEC	In kind	√	√	√	√	√	**-**
6.2	Investigate basic seed biology	2	DEC	In kind	√	√	√	√	√	**-**
7.1	Seed collection	2	DEC	In kind	1400	-	-	-	-	**1400**
7.2	Long term seed storage	2	DEC	In kind	2400	2400	2400	2400	2400	**12,000**
	Annual and total cost			**Unsecured**	18,300	16,100	15,400	3,500	-	**53,300**
				In kind	11,150	6600	7300	5900	5900	**36,850**
				TOTAL	**29,450**	**22,700**	**22,700**	**9400**	**5900**	**90,150**

Costing table explanation:
DEC – Dept of Environment and Conservation **DIPNR –** Dept of Infrastructure Planning and Natural Resources **WCC –** Wollongong City Council, **ShellCC –** Shellharbour City Council, **KMC –** Kiama Municipal Council, **ShoalCC –** Shoalhaven City Council **RFS –** Rural Fire Service. **Priority ratings: 1** - Action critical to meeting plan objectives, **2** - Action contributing to meeting plan objectives, **3** – Desirable but not essential action. **In kind** funds represent the salary component of permanent staff and recurrent resources. Salary for in-kind contributions is calculated at $350 per day, which includes officer salary and on-costs, provision of office space, vehicles, administration support and staff management. **Unsecured** funds will be sought from sources including DEC annual provisions for the implementation of threatened species programs, the Natural Heritage Trust, Environmental Trust, industry sponsors, the NSW State Biodiversity Program, Threatened Species Network, Threatened Species Appeal and DEC annual operational provisions for implementation of threatened species programs. **#** - No direct cost (either cost of action is negligible or action is a statutory responsibility of the responsible party), **√** - No additional costs (included in the cost of other actions), ***** - Amount to be determined by the responsible party.

Appendices

Appendix 1: Description of associated soil landscape units

Source: Hazelton 1992, Hazelton & Tille 1990

Name	Type	Description	Soils
Bombo	Erosional	Low rolling hills with benched slopes and sea cliffs with extensive rock platforms on Bumbo Latite. Relief 40 to 100 m. Slope gradients 15 to 25% with isolated steep slopes to 40%. Extensively cleared with dairying, grazing, hobby farms, recreation areas and quarrying of latite the main landuses.	Shallow (<50 cm) Structured Loams occur on crests, moderately deep (50 to 100 cm) Krasnozems occur on upper slopes and benches. Brown Podsolic Soils occur on mid and lower slopes.
Wattamolla Road	Depositional	Long gently to moderately inclined sideslopes and undulating to rolling hills with broad benches on Budgong Sandstone. Relief <200 m. Slope gradients 5 to 15% with isolated steep slope >40%. Extensively cleared with only scattered stands of remnant forest present.	Moderately deep (50 to 100 cm) Red Podzolic Soils occur on upper slopes and benches with Yellow Podzolic Soils on mid and lower slopes.
Shellharbour	Erosional	Low rolling hills with long sideslopes and broad drainage plains on Budgong Sandstone. Relief 30 to 50 m with slope gradients <20%. Extensively cleared with dairying, horse agistment and urban development the main landuses.	Deep (>150 cm) Prairie Soils occur on crests and upper slopes, Brown Krasnozems on the midslopes and Red Podzolic Soils and Prairie Soils on the lower slopes and drainage plains.
Kiama	Erosional	Low rolling hills with broad crests and long convex slopes and steep coastal headlands on Blow Hole Latite. Extensive scattered rock outcrops present on upper slopes. Drainage plains <100 m wide. Relief 40 to 60 m with slope gradients <20%. Extensively cleared with cattle grazing and urban development the main landuses.	Deep (>150 cm) Krasnozems present on the crests and upper slopes with Prairie Soils on the lower slopes.
Cambewarra	Erosional	Steep to very steep hills with broad colluvial benches on latite. Relief 100 to 300 m. Slope gradients generally >30% with steep hillslopes (>50%) containing a talus of latite boulders and scattered rock outcrops present. Drainage lines are closely spaced and deeply incised. Partially cleared of vegetation with cattle grazing, hobby farms and conservation the main landuses.	Deep (>200 cm) Red Solonetzic Soils and Krasnozems occur on the upper slopes and benches. Lithosols occur on basinite outcrops.
Fountaindale	Depositional	Low rolling hills with long sideslopes on Budgong Sandstone in the Jamberoo Valley. Broad drainage plains (<150 m wide) and narrow to moderately incised drainage lines containing scattered rock outcrops. Relief 40 to 80 m with slope gradients <20%. Extensively cleared with cattle grazing and hobby farming the main landuses	Moderately deep (50 to 100 cm) Brown Podzolic Soils and Yellow Podzolic Soils.

Name	Type	Description	Soils
Illawarra Escarpment	Colluvial	Steep to very steep slopes of Quaternary talus. Relief 100 to 300 m. Slope gradients 20 to 50%. Large surface and subsurface sandstone boulders (2 to 25 m wide) are common. Mostly uncleared with conservation and mining the main landuses.	Deep colluvial soils. Red Podzolic Soils and Brown Podzolic Soils occur on mid-slopes. Silaceous Sands occur along drainage lines. Lithosols occur where the talus is recent.

Appendix 2: Vegetation at surveyed *Daphnandra* sp. C 'Illawarra' sites

Site	Structure*	Strata 1	Strata 2	Strata 3	Strata 4	Strata 5
Dc1	Closed Forest	10 to 15 m tall, 80% cover. *Toona australis, Syzygium australe* and *Acmena smithii*	1 to 3 m tall, 20% cover. *Pittosporum multiflorum, Daphnandra* sp C and *Streblus brunonianus*	<0.3 m tall, 40% cover. *Adiantum formosum, Doodia aspera* and *Gymnostachys anceps*		
Dc2	Woodland	25 to 30 m tall, 25% cover. *E. quadrangulata*	15 to 20 m tall, 70% cover. *Euroschinus falcata, Acmena smithii* and *Melicope micrococca*	3 to 10 m tall, 40% cover. *Daphnandra* sp C, *Cassine australis* and *Notelaea venosa*	1 to 2 m tall, <10% cover. *Pittosporum multiflorum, Cassine australis* and *Streblus brunonianus*	<0.6m tall, 40% cover. *Adiantum formosum, Phymatosorus scandens* and *Gymnostachys anceps*
Dc3a	Closed Forest	20 to 25 m tall, 70% cover. *Dendrocnide excelsa, Geijera latifolia* and *Ehretia acuminata*	6 to 10 m tall, 50% cover. *Claoxylon australe, Daphnandra* sp. C and *Baloghia inophylla*	1 to 5 m tall, 40% cover. *Livistona australis, Lantana camara* and *Doryphora sassafras*	<0.3m tall, 20% cover. *Adiantum formosum*	
Dc3b	Closed Forest	25 to 30 m tall, 70% cover. *Dendrocnide excelsa, Pittosporum undulatum* and *Syzygium australe*	10 to 15 m tall, 50% cover. *Daphnandra* sp C, *Croton verreauxii* and *Diospyros* sp.	2 to 4 m tall, 30% cover. *Doryphora sassafras, Cassine australis* and *Baloghia inophylla*	0.6 to 2 m tall, 10% cover. *Pittosporum multiflorum, Diospyros* sp.	<0.6 m tall, 50% cover. *Adiantum formosum, Phymatosorus scandens* and *Gymnostachys anceps*
Dc3c	Forest	18 to 20 m tall, 60% cover. *Acacia maidenii* and *Acmena smithii*	10 to 12 m tall, 70% cover. *Acmena smithii, Guioa semiglauca* and *Melicope micrococca*	0.3 to 1 m tall, 5% cover. *Pittosporum multiflorum, Maclura cochinchinensis* and *Stenocarpus salignus*	<0.3 m tall, 50% cover. *Lastriopsis microsora, Adiantum formosum* and *Doodia aspera*	
Dc3d	Forest	12 to 15 m tall, 50% cover. *Glochidion ferdinandi, Doryphora sassafras* and *Ficus coronata*	10 to 12 m tall, 70% cover. *Daphnandra* sp C and *Planchonella australis*	0.3 to 2 m tall, 30% cover. *Pittosporum multiflorum, Croton verreauxii* and saplings of previous.	<0.3 m tall, 30% cover. *Doodia aspera, Adiantum formosum* and *Gymnostachys anceps*	
Dc3e	Forest	15 to 20 m tall, 60% cover. *Dendrocnide excelsa, Toona ciliata* and *Doryphora sassafras*	8 to 10 m tall, 20% cover. *Pittosporum undulatum, Alectryon subcinereus* and *Streblus brunonianus*	1 to 2m tall, 70% cover. *Lantana camara, Rapanea howittiana* and *Hymenanthera dentata*	<0.3 m tall, 60% cover. *Adiantum formosum, Ageratina riparia, Carex longebrachiata* and *Delairea odorata*	
Dc3f	Low Open Forest (highly disturbed)	6 to 8 m tall, 30% cover. *Acacia maidenii, A. implexa* and *Eucalyptus quadrangulata*	0.5 to 2 m tall, 90% cover. *Lantana camara, Hymenanthera dentata* and *Syzygium australe*	>0.5 m tall, 80% cover. *Ageratina riparia* and *Delairea odorata*		
Dc7a	Open Forest	15 to 25 m tall, 40% cover. *Toona ciliata* and *Livistona australis*	10 to 15 m tall, 70% cover. *Doryphora sassafras, Ehretia acuminata* and *Ficus coronata*	5 to 10 m tall, 40% cover. *Daphnandra* sp. C, *Cassine australis* and *Streblus brunonianus*	<30 cm tall, 5% cover. *Adiantum formosum* and *Arthropteris tenella*	
Dc7b	Open Forest	15 to 25 m tall, 40% cover. *Toona ciliata* and *Livistona australis*	10 to 15 m tall, 70% cover. *Doryphora sassafras, Ehretia acuminata* and *Ficus coronata*	5 to 10 m tall, 40% cover. *Daphnandra* sp. C, *Cassine australis* and *Streblus brunonianus*	<30 cm tall, 5% cover. *Adiantum formosum* and *Arthropteris tenella*	

- following Specht (1981)

Site	Structure*	Strata 1	Strata 2	Strata 3	Strata 4

Site	Structure*	Strata 1	Strata 2	Strata 3	Strata 4
Dc8	Open Forest	25 to 30 m, 40% cover. *Eucalyptus pilularis* and *Casuarina cunninghamiana.*	12 to 15 m tall, 80% cover. *Synoum glandulosum, Melicope micrococca, Acmena smithii, Hymenanthera dentata, Claoxylon australe* and *Maclura cochinchinensis.*	<0.3m tall, 90% cover. *Tradescantia fluminensis, Adiantum formosum* and *Dichondra repens*	
Dc10a	Open Forest	18 to 22 m tall, 30% cover. *E. quadrangulata* and *E. tereticornis*	8 to 12 m tall, 70% cover. *Doryphora sassafras, Acmena smithii, Glochidion ferdinandi*	1 to 4 m tall, 20% cover. *Cassine australis, Daphnandra* sp. C and *Hymenanthera dentata*	
Dc10b	Closed Forest	12 to 16 m tall, 70% cover. *Acmena smithii, Baloghia inophylla, Pittosporum undulatum* and *Dendrocnide excelsa*	2 to 6 m tall, 30% cover. *Streblus brunonianus, Cryptocarya microneura, Cassine australis* and *Daphnandra* sp. C.	<0.3 m tall, 40% cover. *Adiantum formosum, Microsorum scandens* and *Doodia aspera*	
Dc10c	Closed Forest	14 to 20 m tall, 70% cover. *Acmena smithii* and *Glochidion ferdinandi*	6 to 10m tall, 20% cover. *Pittosporum undulatum, Ficus coronata* and *Daphnandra* sp. C.	1 to 4 m tall, 30% cover. *Eupomatia laurina, Streblus brunonianus* and *Cassine australis*	<0.3 m tall, 80% cover. *Microsorum scandens, Adiantum formosum* and *Doodia aspera.*
Dc11a	Woodland (highly disturbed)	10 to 15 m tall, 15% cover. *Glochidion ferdinandi*	2 to 8 m tall, 80% cover. *Streblus brunonianus, Baloghia inophylla, Pittosporum undulatum*	0.5 to 2 m tall, 20% cover. *Lantana camara*	<0.6 m tall, 30% cover. *Doodia aspera, Adiantum formosum* and *Gymnostachys anceps*
Dc11b	Regrowth stems in paddock				
Dc12	Closed Forest	10 to 12 m tall, 75% cover. *Pittosporum undulatum, Baloghia lucida* and *Doryphora sassafras*	1 to 5 m tall, 60% cover. *Daphnandra* sp. C , *Cassine australis, Wilkiea huegeliana, Lantana camara*	<0.3m tall, 70% cover. *Adiantum formosum* and *Arthropteris tenella*	
Dc13	Closed Forest	10 to 15 m tall, 70% cover. *Doryphora sassafras, Guioa semiglauca* and *Alphitonia excelsa*	2 to 8 m tall, 40% cover. *Daphnandra* sp. C, *Cassine australis* and *Ehretia acuminata*	<1m tall, 60% cover. *Adiantum formosum, Microsorum scandens* and *Gymnostachys anceps*	
Dc14	Open Forest	25 to 30 m tall, 30% cover. *Ficus superba, Ficus obliqua, Ficus macrophylla* and *Dendrocnide excelsa*	15 to 20 m tall, 70% cover. *Baloghia inophylla* and *Diospyros pentamera.*	2 to 8 m tall, 40% cover. *Daphnandra* sp C, *Claoxylon australe* and *Baloghia inophylla.*	<0.6m tall, 20% cover. *Adiantum formosum, Phymatosorus scandens* and *Lastriopsis microsora.*
Dc15	Closed Forest	10 to 15 m tall, 75% cover. *Acmena smithii, Guioa semiglauca* and *Geijera latifolia*	2 to 5 m tall, 50% cover. *Daphnandra* sp C, *Cassine australis* and *Streblus brunonianus*	<0.6 m tall, 30% cover. *Adiantum formosum, Gymnostachys anceps* and *Doodia aspera.*	
Dc16	Woodland	20 to 25 m tall, 25% cover. *Ficus microphylla, Ficus obliqua* and *Diospyros pentamera*	15 to 20 m tall, 70% cover. *Brachychiton populneus, Podocarpus elatus* and *Scolopia braunii.*	1 to 4 m tall, 30% cover. *Streblus brunonianus, Pittosporum undulatum* and *Lantana camara.*	<0.3 m tall, 20% cover. *Lastriopsis decomposita, Asplenium australasicum* and *Aphanopetalum resinosum.*
Dc17	Closed forest	16 to 28 m tall, 75% cover. *Acmena smithii* and *Pittosporum undulatum*	4 to 10 m tall, 30% cover. *Ficus coronata, Cassine australis, Daphnandra* sp. C, *Claoxylon australe, Baloghia inophylla,*	0.3 to 2 m tall, 10% cover. *Gymnostachys anceps, Livistona australis, Pittosporum multiflorum*	<0.3 m tall, 70% cover. *Doodia aspera, Phymatosorus scandens, Adiantum formosum, Piper novae-hollandiae, Pyrrosia rupestris*

Site	Structure*	Strata 1	Strata 2	Strata 3	Strata 4
			Diospyros australis		
Dc21	Low Open Forest (disturbed paddock edge)	2 to 12 m tall, 30% cover. Dominated by Pittosporum undulatum, *Acacia maidenii, Streblus brunonianus* and *Alectryon subcinereus*	0 to 2 m tall, 90% cover. *Lantana camara, Cayratia clematidea, Eustrephus latifolius* and *Delairea odorata*.		
Dc27	Tall Open Forest	30 m tall, 20% cover. *Toona australis*	15 to 20 m tall, 70% cover. *Dendrocnide excelsa, Ceratopetalum apetalum* and *Doryphora sassafras*	1 to 5 m tall, 30% cover. *Streblus brunonianus, Baloghia inophylla, Ficus coronata* and *Pennantia cunninghamii*	<0.3 m tall, 10% cover. *Adiantum formosum* and *Phymatosorus scandens.*
Dc33	Closed Forest	15 to 20 m tall, 70% cover. *Cryptocarya microneura, Syncarpia glomulifera, Acacia maidenii* and *Pittosporum undulatum*	1 to 6 m tall, 30% cover. *Daphnandra* sp. C, *Diospyros* sp., *Eupomatia laurina, Pittosporum undulatum, Livistona australis*	<1 m tall, 50% cover. *Lastreopsis microsora, Gymnostachys anceps, Microsorum scandens* and *Doodia aspera.*	
Dc40	Tall open forest (four strata)	35 to 40 m high with 30% cover. *Eucalyptus quadrangulata*	12 to 18 m high with 40% cover. *Pittosporum undulatum, Cryptocarya microneura,* and *Cinnamomum oliveri*	1 to 5 m high with 15 % cover. *Melicope micrococca, Pittosporum multiflorum, Cinnamomum oliveri,* and *Wilkiea huegeliana*	> 1m high with 10% cover. *Microsorum scandens, Arthropteris tenella, Gymnostachys anceps,* and *Morinda jasminoides.*
Dc41	Tall closed forest (three strata)	18 to 25 m with 70% cover. *Ficus macrophylla, Dendrocnide excelsa* and *Livistona australis*	1 to 6 m high with 30% cover. *Baloghia inophylla, Streblus brunonianus, Wilkiea huegeliana,* and *Cassine australis*	<0.5 m with 10% cover. *Adiantum aethiopicum, Doodia* sp., and *Arthropteris tenella*	

Appendix 3: *Daphnandra* sp. C 'Illawarra' site details

NB Specific location details are not included in the following table. Public authorities, land managers or others with a legitimate reason for requiring this information, may request it by contacting the *Daphnandra* sp. C 'Illawarra' Recovery Plan Coordinator on (02) 9585 6678.

Approved Recovery Plan for *Daphnandra* sp. C 'Illawarra': Appendix 3

Code	Location	Source	Total Stems	LGA	Tenure	Zoning	Geology	Soil	Relief (m)	Easting	Northing
Dc1	Lower Avondale	AB	8	Wollongong	Freehold	7b	Psg	wt	90		
Dc2	Upper Avondale	AB	109	Wollongong	Freehold	7b	Psg	wt	140		
Dc3a	Marshall Mount	AB	5	Wollongong	Freehold	7b	Pipm	wt	230		
Dc3b	Marshall Mount	AB	29	Wollongong	Freehold	7b	Pi	wt	200		
Dc3c	Marshall Mount	AB	13	Wollongong	Freehold	7b	Pi	wt	190		
Dc3d	Marshall Mount	AB	32	Wollongong	Freehold	7b	Psg	wt	170		
Dc3e	Marshall Mount	AB	6	Wollongong	Freehold	7b	Psg	wt	160		
Dc3f	Marshall Mount	AB	5	Wollongong	Freehold	7b	Psg	wt	15		
Dc4	Calderwood North	AB	-	Wollongong	Freehold	7b	Psg	wt	70		
Dc5	Calderwood South 1	AB	-	Shellharbour	Freehold	1a	Psg	ca	170		
Dc6	Calderwood South 2	AB	-	Shellharbour	Freehold	1a	Psg	ca	200		
Dc7a	Shortland Gully	AB	2000*	Shellharbour	Freehold	1a	Psg	ca	130		
Dc7b	Shortland Gully	AB	500*	Shellharbour	Freehold	1a	Psg	ca	110		
Dc7c	Shortland Gully	AB	60	Shellharbour	Freehold	1a	Psg	ca	80		
Dc8	Yellow Rock	AB	1	Shellharbour	Freehold	7e	Qa	ca	60		
Dc9	Stockyard Mountain	AB	-	Shellharbour	Freehold	7e	Psg	ca	150		
Dc10a	Curramore	AB	60	Kiama	Freehold	1a	Psg	bo	100		
Dc10b	Curramore	KM	46	Kiama	Freehold	1a	Psg	bo	80		
Dc10c	Curramore	KM	>1000	Kiama	Freehold	7e	Psg	bo	130		
Dc11a	North Curramore	AB	12	Kiama	Freehold	1a	Psgb	bo	120		
Dc11b	North Curramore	AB	-	Kiama	Freehold	1a	Psgb	bo	100		
Dc11c	North Curramore	KM	-	Kiama	Freehold	1a	Psg	wt	170		
Dc12	Croom Road North	AB	1200*	Shellharbour	Freehold	7d	Psgb	bo	70		
Dc13	Croom Road South	AB	26	Shellharbour	Freehold	7d	Psgb	bo	60		
Dc14	Actephila Gully	AB	168	Shellharbour	Freehold	7d	Psgb	bo	80		
Dc15	Blackbutt	AB	15	Shellharbour	ShellCC	1c	Psgb	sh	50		
Dc16	Whispering Gallery	AB	18	Shellharbour	Freehold	1a	Psgb	bo	40		
Dc17	Minnamurra RF 2	MR	105	Kiama	DEC	8a	Psg	wt	120		
Dc18	Tootawallin Gully	DB	-	Kiama	Freehold	7e	Psgb	bo	280		
Dc19	North Jamberoo	AB	-	Kiama	Freehold	1a	Psg	fo	30		
Dc20	Flying Fox Gully	AB	-	Shellharbour	Freehold	1a	Psg	bo	110		
Dc21	Willow Creek	DEC	11	Kiama	Freehold	1a	Psg	bo	50		

* estimate only

Code	Location	Source	Total Stems	LGA	Tenure	Zoning	Geology	Soil	Relief (m)	Easting	Northing
Dc22	Spring Creek	AB	-	Kiama	Freehold	1a	Psgb	bo	80		
Dc23	Bland Street	AB	-	Kiama	Freehold	7e	Psgb	ka	70		
Dc24	Old Saddleback Road	AB	-	Kiama	Freehold	7e	Psg	ka	50		
Dc25	Jerrara	AB	-	Kiama	Freehold	1a	Psgb	bo	30		
Dc26	Jamberoo Road	AB	-	Kiama	Freehold	1a	Psgb	sh	60		
Dc27	Minnamurra RF 1	AB	64	Kiama	DEC	8a	Psg	ca	270		
Dc28	South Saddleback	AB	-	Kiama	Freehold	7e	Psgb	bo	140		
Dc29	Taballa	AB	-	Kiama	Freehold	1a	Psg	wt	60		
Dc30	Irwins Creek	AB	-	Kiama	Freehold	7e	ib	ca	180		
Dc31	Broughton Vale	AB	-	Shoalhaven	Freehold	7(d1)	Psg	wt	140		
Dc32	Foxground	KM	-	Kiama	Freehold	7e	Psg	fo	140		
Dc33	Scarborough	AB	391	Wollongong	Freehold	7a	Rn	ie	10		
Dc34	Toolijooa 1	KM	-	Kiama	Freehold	1a	Psgb	ka	100		
Dc35	Jerrara Dam	KM	-	Kiama	KMC	1a	Psgb	bo	60		
Dc36	Boona Ridge	KM	-	Kiama	Freehold	7e	Psgb	wt	180		
Dc37	Toolijooa 2	MA	-	Kiama	Freehold	1a	Psgb	wt	100		
Dc38	Toolijooa 3	MA	-	Kiama	Freehold	1a	Psgb	ka	110		
Dc39	Toolijooa 4	MA	-	Kiama	Freehold	1a	Psgb	wt	80		
Dc40	Minnamurra RF 3	MR	335	Kiama	DEC	8a	Psgc	wt	240		
Dc41	Alne Bank	MH	237	Kiama	Freehold	7e	Psgb	wt	70		

Geology		**Soil Landscape Unit**		**Zoning**	
Qa	Quaternary Alluvium	Bo	Bombo	1(a)/1(c)	Rural
Pi	Illawarra Coal Measures	Wt	Wattamolla Road	7(a)/7(d)/7(d1)7(e)	Environmental protection
Psg	Budgong Sandstone	Sh	Shellharbour	8(a)	National Park
Psgb	Bumbo Latite	Ka	Kiama		
Ib	Irwins Creek Breccia	Ca	Cambewarra		
Rn	Narrabeen Group Sediments	Fo	Fountaindale		
Pipm	Minnamurra Latite	Ie	Illawarra escarpment		
Source					
AB	A. Bofeldt pers. comm.	MR	M. Robinson pers. comm.		
KM	Mills (1988)	MA	Muston & Associates 1991		
DB	D. Black pers. comm.	MH	M. Hindmarsh pers. comm.		
DEC	NPWS (2002b)				

Appendix 4: Profile and environmental impact assessment guidelines

Daphnandra sp. C 'Illawarra'

(R. Schodde 3475)

Common name: Illawarra Socketwood

Conservation Status

Daphnandra sp. C 'Illawarra' is listed as an **endangered species** on Schedule 1 of the NSW *Threatened Species Conservation Act* 1995 (TSC Act) and as an **endangered species** under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act).

Photo: M. Bremner/DEC

Description

Daphnandra sp. C 'Illawarra' (R. Schodde 3475) is synonymous with *Daphnandra* sp. C *sensu* Harden (1990). The species was previously included in *Daphnandra micrantha* (Tul.) Benth *s. lat* prior to a revision of the genus (Harden 1990). Foreman & Whiffin (MS) propose the name *Daphnandra johnsonii* for the species.

D. sp. C 'Illawarra' (Monimiaceae) is a medium sized rainforest tree that grows to 20 metres and is capable of prolific suckering. Leaves are opposite, coarsely toothed, elliptic to ovate, 6 to 12 cm long, 1.5 to 6 cm wide, with a raised mid-vein on the upper surface. Flowers are small, pale greenish white, rarely with a pink margin, and are borne in a many-flowered panicle from the leaf base. The fruit consists of hairy achenes (dry, indehiscent one-seeded fruit) that are enclosed within brown fruiting receptacles, 5 to 7 mm long, and roughly ellipsoid in shape. The fruiting receptacles become woody and dehisce through a single slit upon maturity (A. Bofeldt pers. comm; Foreman & Whiffin MS; Fuller & Mills 1985; Harden 1990).

Distribution

D. sp. C 'Illawarra' is restricted to the Illawarra region of NSW where it has been recorded from 41 sites within the local government areas (LGAs) of Shoalhaven, Kiama, Shellharbour and Wollongong.

The main distribution of the species extends from Avondale (Wollongong LGA) to Toolijooa (Kiama LGA), a distance of 27 kilometres. An outlying site is located at Scarborough (Wollongong LGA), 35 kilometres north of this main distribution. The western distributional limit of the species follows the upper slopes of the Illawarra escarpment (DEC 2005).

Recorded occurrences in conservation reserves

D. sp. C 'Illawarra' has been recorded from three sites within the Minnamurra Rainforest section of Budderoo National Park.

Photo: M. Bremner/DEC

Habitat

D. sp. C 'Illawarra' occupies the rocky hillsides and gully slopes of the Illawarra lowlands, occasionally extending onto the upper escarpment slopes (DEC 2005). Associated soils are loams and clay loams derived from volcanic or fertile sedimentary rocks (DEC 2005).

Vegetation types recorded at *D.* sp. C 'Illawarra' sites include the subtropical, moist subtropical, dry subtropical, and mixed subtropical - warm temperate rainforest types

of Mills & Jakeman (1995). The species occurs within the Illawarra Subtropical Rainforest endangered ecological community (Schedule 1, TSC Act) at a number of sites.

D. sp. C 'Illawarra' is occasionally found in moist Eucalypt forest in association with *Eucalyptus tereticornis* (Forest Red Gum), *E. pilularis* (Blackbutt), *E. quadrangulata* (White Box) or *Casuarina cunninghamiana* (River She-Oak) (NPWS 2002; DEC 2005).

Ecology

D. sp. C 'Illawarra' occupies the rainforest understorey. It flowers briefly in September and early October with fruits taking up to 12 months to mature (DEC 2005). Flowers are morphologically hermaphrodite, having both male and female organs present in each flower (Foreman & Whiffin MS). It is unknown whether the species is capable of self-pollination.

Not all populations or mature individuals appear to flower each year although this is not uncommon behaviour amongst rainforest understorey species (A. Bofeldt pers. comm.). Low levels of seed production in the species are suspected, with stems at most sites appearing to only produce 'pseudo-fruit' which lack seeds (A. Bofeldt pers. comm.). Pollination and seed dispersal vectors are unknown although wind dispersal of the small plumed seeds is likely (DEC 2005).

D. sp. C 'Illawarra' is a clonal species that is capable of vegetative reproduction from damaged stems (coppicing) and rhizomes (suckering). Extensive suckering is evident at many sites and this is considered to be at least partially attributable to 'natural' disturbances associated with the movement of unconsolidated rock material on steep unstable slopes (DEC 2005).

The population size of the species is unknown, as individual plants (genets) are difficult to differentiate from clonal stems (ramets). However, the small number and limited extent of stems observed at surveyed sites indicate that the total population size of the species is small. Some sites are suspected of containing just one genetic individual (DEC 2005).

Threats

Extensive clearing of the Illawarra lowlands since European settlement has destroyed much of the rainforest habitat of *D.* sp. C 'Illawarra'. Remaining habitat is limited, highly fragmented and threatened by further clearing for agriculture, hard rock quarrying, road construction and residential development. Habitat modification and degradation as a consequence of weed invasion, altered hydrological conditions, rubbish dumping, and grazing and trampling by livestock and feral deer also threatens the species. Low levels of seed production are potentially a long-term threat to the survival of the species (DEC 2005).

Management

Future management must aim to increase the level of legislative protection afforded land upon which the species occurs. This can be facilitated on public and private land through a range of mechanisms including:

- Conservation covenants and agreements under the TSC Act, *National Parks & Wildlife Act 1974*, and *Conveyancing Act 1919;*
- Environmental Planning Instruments prepared under Part 3 of the *Environmental Planning & Assessment Act 1979*; and
- Critical habitat declared under the TSC Act.

Appropriate threat and habitat management practices include bush regeneration to restore and maintain suitable habitat and fencing to exclude livestock, feral animals and machinery. Remnant vegetation containing *D.* sp. C 'Illawarra' should also be managed to exclude fire (DEC 2005).

Research into aspects of the species' ecology and biology that will assist in its practical management is required. Investigation of the factors contributing to low levels of seed production is a priority for such research.

Targeted survey is required to determine the full extent of the species' distribution (DEC 2005).

Recovery Plans

A recovery plan for the species was approved in January 2005.

For Further Information contact

Threatened Species Unit, Metropolitan Region, Environment Protection and Regulation Division, Department of Environment and Conservation, PO Box 1967, Hurstville NSW 2220 Phone 02 9585 6678.

www.npws.nsw.gov.au

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January 2005

Daphnandra sp. C 'Illawarra'

Schodde

Common name: Illawarra Socketwood

The following information is provided to assist authors of Species Impact Statements, development and activity proponents, and determining and consent authorities, who are required to prepare or review assessments of likely impacts on threatened species pursuant to the provisions of the *Environmental Planning and Assessment Act* 1979. These guidelines should be read in conjunction with the NPWS *Information Circular No. 2: Threatened Species Assessment under the EP&A Act: The '8 Part Test' of Significance* (November 1996).

Survey

Survey for *Daphnandra* sp. C 'Illawarra' may be undertaken at any time of the year. A combination of leaf, branch and habit characteristics should enable the species to be identified in the absence of flowers.

D. sp. C 'Illawarra' can be confused with the morphologically similar *Doryphora sassafras* (sassafras) which occupies similar habitats. The two species can be readily differentiated however by the mid-vein on the upper surface of the leaf, which is raised for *D.* sp. C 'Illawarra'. Also, the inflorescence of *D.* sp. C 'Illawarra' consists of a many-flowered panicle while that of Sassafras is a three flowered cluster on a short stalk (Harden 1990).

Other useful diagnostic features of the *Daphnandra* genus described in Floyd (1978) include:

- Prominent leaf scars;
- Conspicuously flattened branchlet nodes; and
- "Ball and socket" joints (from which the Socketwood common name is derived) on the main stem where larger branchlets have broken away.

Low stem numbers and a limited extent of occurrence are characteristic of *D.* sp. C 'Illawarra' sites. Consequently, the search effort that is required to confirm the presence or absence of the species at a particular site is high.

Where new sites are located, sites details including stem numbers, habitat and location should be recorded and forwarded to the DEC.

Life cycle of the species

The ecology of *D.* sp. C 'Illawarra' is described in the recovery plan and summarised in the species profile. Proposals that are likely to effect the life cycle of the species include those that contribute to the following:

- Loss of individuals

The significance of a particular activity that destroys stems will require examination of the number of individuals to be destroyed in relation to the size of the population and a discussion of how recruitment, gene flow and the overall health of the population will be affected.

It is not possible to determine the number of genetic individuals (genets) of *D.* sp. C 'Illawarra' that are present at a site without genetic investigation. In the absence of a genetic study demonstrating otherwise, all stems of *D.* sp. C 'Illawarra' must be considered to be genetically distinct.

Primarily as a consequence of the uncertainty of survival in the long term, translocation should not be considered to be an appropriate means of compensating for the loss of individuals.

- Loss and fragmentation of habitat

As the breeding system of *D.* sp. C 'Illawarra' is not understood, the effects of loss and fragmentation of its habitat are not known. Total destruction of habitat will place a population at risk of extinction.

- Modification of habitat

Urban development in close proximity to *D.* sp. C 'Illawarra' sites is likely to cause modification of habitat through altered hydrological conditions and soil pH, soil nutrification, weed invasion, potential introduction of plant pathogens and altered fire frequency. Subsequent increases in pedestrian

and/or vehicular traffic to sites may result in trampling, soil compaction, soil erosion and the rubbish dumping.

Quarrying activities upstream of *D.* sp. C 'Illawarra' sites have the potential to modify its habitat by altering hydrological conditions including the quality and quantity of surface and groundwater flows.

The grazing and slashing of understorey vegetation will modify the habitat of the species.

- Damage to soil seedbank

Disturbances that will destroy or prevent germination of *D.* sp. C 'Illawarra' seed include rubbish dumping, the removal of leaf litter and topsoil, and spraying with residual herbicides that are capable of killing seeds in the soil. Frequent disturbances (from grazing, slashing, herbicide spraying or burning for example) may prevent any soil seed bank of the species from being recharged.

- Burning of habitat

Any proposal that increases the susceptibility of a population to fire is likely to put that population at risk of extinction.

Threatening processes

There are four key threatening processes listed in Schedule 3 of the NSW *Threatened Species Conservation Act* 1995 (TSC Act) that are potentially relevant to *D.* sp. C 'Illawarra'. These are:

- *Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands;*
- *Anthropogenic climate change;*
- *Clearing of native vegetation;* and
- *High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition.*

The NSW Scientific Committee made a preliminary determination to list '*Herbivory and environmental degradation caused by feral deer'* in October 2003. If a final determination is made to list this KTP, it will be relevant to *D.* sp. C 'Illawarra'.

In addition to these key threatening processes, a number of other threats to the survival of *D.* sp. C 'Illawarra' exist. These include weed invasion, rubbish dumping, grazing and trampling by livestock and feral deer, and habitat modification resulting from upslope and upstream developments (DEC 2005).

Viable local population of the species

The viable population size for *D.* sp. C 'Illawarra' is unknown. Small population size is not likely to be a relevant factor when assessing the viability of the species, as most recruitment appears to result from vegetative reproduction. In the absence of a detailed assessment demonstrating otherwise, all populations should be assumed to be viable.

A significant area of habitat

Assessment of habitat significance for *D.* sp. C 'Illawarra' requires consideration of the following:

- Number of genetic individuals present and whether the population is capable of producing viable seed;
- Location in relation to the current distributional limits of the species and proximity to the nearest reserved population;
- Size, condition and connective importance of the habitat; and
- Management potential including the likelihood of ameliorating any existing threatening processes.

The DEC considers all populations as occupying a significant area of habitat until such times as adequate and representative examples are conserved across the species' range.

Isolation/fragmentation

D. sp. C 'Illawarra' habitat has been fragmented by vegetation clearance for agriculture, urban development and quarrying across its range. Fragmentation is greatest on the low-lying areas of the coastal plain and is less significant on the upper slopes of the Illawarra escarpment.

The distance between populations of *D.* sp. C 'Illawarra' that will create genetic isolation is unknown, as its pollen vectors and seed dispersal mechanisms are unknown. The clearing of interconnected or proximate areas of habitat for the species (or its pollen/seed vectors) is clearly undesirable as this may

expose populations to an increased risk of genetic isolation and subsequent decline.

Regional distribution of the habitat

The known distribution of *D.* sp. C 'Illawarra' is confined to the Sydney Basin Bioregion as defined in the Interim Biogeographic Regionalisation of Australia (Thackway & Cresswell 1995).

Limit of known distribution

The known distribution of *D.* sp. C 'Illawarra' extends from Scarborough in Wollongong local government area to Toolijooa in Kiama local government area. The species' western distributional limit follows the upper slopes of the Illawarra escarpment.

Adequacy of representation in conservation reserves or other similar protected areas

D. sp. C 'Illawarra' is not considered to be adequately represented in conservation reserves.

Critical habitat

Critical habitat has not been declared for *D.* sp. C 'Illawarra'.

For Further Information contact

Threatened Species Unit, Metropolitan Region, Environment Protection and Regulation Division, Department of Environment and Conservation (NSW), PO Box 1967, Hurstville NSW 2220 Phone 02 9585 6678.

www.npws.nsw.gov.au

References

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DEC (2005) *Daphnandra sp. C 'Illawarra' (Illawarra Zieria) Recovery Plan.* NSW Department of Environment and Conservation, Hurstville.

Thackway, R. & Cresswell, I.D. (1995). *An Interim Biogeographic Regionalisation for Australia: A Framework for Setting Priorities in the National Reserves System Cooperative Program*. Version 4.0. Australian Nature Conservation Agency, Canberra.

Appendix 5: Threat assessment for *Daphnandra* sp. C 'Illawarra' sites

The following threat assessment for *D.* sp. C 'Illawarra' sites has been undertaken to provide direction to decision makers as to where the recovery effort for the species will be most effectively applied. The assessment is based primarily on the zoning and tenure of sites although adjustments have been made where site specific knowledge, regarding sites that are subject to conservation agreements for example, allows. The assessment is based on available data in September 2004.

For this assessment, threats have been categorised into the following classes developed by Keith et al. (1997):

- Class I threats are processes capable of causing a sudden, substantial and irreversible loss of individuals or habitat. An example is vegetation clearance followed by land-use change, such as residential development.
- Class II threats are processes capable of causing gradual, substantial and possibly irreversible loss of individuals or habitat. Examples include habitat degradation due to overgrazing or weed invasion. These processes may be reversible but mitigation may be technically difficult or expensive to achieve.

High risk

High risk sites are those sites that are considered to be at greatest risk from Class I threats. This category contains all sites that are located within 100 metres of areas identified as containing state significant mineral resources and those that are threatened by road construction proposals.

Recovery actions at high risk sites should focus on reducing the risk from Class I threats. This can be achieved by increasing the level of legislative protection afforded these sites through mechanisms including the negotiation of conservation agreements and in the preparation of environmental planning instruments. The implementation of on-ground threat abatement works at high risk sites is not recommended until the risk from Class I threats is reduced.

Site Code	Location	LGA	Stems	Tenure	Zoning
Dc14	Actephila Gully	Shellharbour	168	Freehold	7d
Dc20	Flying Fox Gully	Shellharbour	-	Freehold	1a
Dc39	Toolijooa 4	Kiama	-	Freehold	7e

Moderate risk

Moderate risk sites are those sites that are considered to be at a low to moderate risk of Class I threats and are primarily at risk from Class II threats. This category contains sites that are zoned rural and which occur outside the area of State significant mineral resources. It also contains sites that are zoned for environmental protection but are not located within crown reserves, council reserves or national parks.

Recovery actions at these sites should focus on reducing the risk from Class I. This can be achieved by increasing the level of legislative protection afforded these sites through mechanisms including the negotiation of conservation agreements and in the preparation of environmental planning instruments. Recovery actions should also aim to address Class II threats. This can be achieved through liaison with landholders to encourage land-use change and to prevent inadvertent damage to the species. On-ground threat abatement works should be implemented where the landholder indicates a desire to assist in the recovery program.

Site Code	Location	LGA	Stems	Tenure	Zoning
Dc1	Lower Avondale	Wollongong	8	Freehold	7b
Dc2	Upper Avondale	Wollongong	109	Freehold	7b
Dc3	Marshall Mount	Wollongong	90	Freehold	7b
Dc4	Calderwood North	Wollongong	-	Freehold	7b
Dc5	Calderwood South 1	Shellharbour	-	Freehold	1a
Dc6	Calderwood South 2	Shellharbour	-	Freehold	1a
Dc7	Shortland Gully	Shellharbour	2560 (e)	Freehold	1a
Dc8	Yellow Rock	Shellharbour	1	Freehold	7e
Dc9	Stockyard Mountain	Shellharbour	-	Freehold	7e

Site Code	Location	LGA	Stems	Tenure	Zoning
Dc10	Curramore	Kiama	>1106	Freehold	1a/7e
Dc11	North Curramore	Kiama	12	Freehold	1a
Dc12	Croom Road North	Shellharbour	1200 (e)	Freehold	7d
Dc13	Croom Road South	Shellharbour	26	Freehold	7d
Dc16	Whispering Gallery	Shellharbour	18	Freehold	1a
Dc18	Tootawallin Gully	Kiama	-	Freehold	7e
Dc19	North Jamberoo	Kiama	-	Freehold	1a
Dc22	Spring Creek	Kiama	-	Freehold	1a
Dc23	Bland Street	Kiama	-	Freehold	7e
Dc24	Old Saddleback Road	Kiama	-	Freehold	7e
Dc25	Jerrara	Kiama	-	Freehold	1a
Dc26	Jamberoo Road	Kiama	-	Freehold	1a
Dc28	South Saddleback	Kiama	-	Freehold	7e
Dc29	Taballa	Kiama	-	Freehold	1a
Dc30	Irwins Creek	Kiama	-	Freehold	7e
Dc31	Broughton Vale	Shoalhaven	-	Freehold	7(d1)
Dc32	Foxground	Kiama	-	Freehold	7e
Dc33	Scarborough	Wollongong	391	Freehold	7a
Dc34	Toolijooa 1	Kiama	-	Freehold	1a
Dc35	Jerrara Dam	Kiama	-	KMC	1a
Dc36	Boona Ridge	Kiama	-	Freehold	7e
Dc37	Toolijooa 2	Kiama	-	Freehold	7e
Dc38	Toolijooa 3	Kiama	-	Freehold	7e
Dc41	Alne Bank	Kiama	237	Freehold	7e

Low risk

Low risk sites are those sites that are considered to be primarily at risk from Class II threats. This category includes sites that are located in national parks, crown reserves, or council reserves. It also includes privately owned lands that are subject to Voluntary Conservation Agreements (VCAs) under the *National Parks & Wildlife 1974* or Registered Property Agreements (RPAs) under the *Native Vegetation Conservation Act 1997*. Recovery actions at these sites should focus on addressing the Class II threats through liaison with landholders and the implementation of on-ground threat abatement works in accordance with plans of management and site management statements.

Site Code	Location	LGA	Stems	Tenure	Zoning
Dc15	Blackbutt	Shellharbour	15	SCC	1c
Dc17	Minnamurra Rainforest 2	Kiama	105	DEC	8a
Dc21	Willow Creek	Kiama	11	Freehold	1a
Dc27	Minnamurra Rainforest 1	Kiama	64	DEC	8a
Dc40	Minnamurra Rainforest 3	Kiama	335	DEC	8a

Appendix 6: Site management statement proforma

SITE NAME: **SITE CODE:**

PREPARED BY: **DATE:**

OWNER DETAILS

Name: Phone number:

Street address: Postal address:

PARCEL DETAILS

LGA: Portion/Lot:

Tenure: Zoning:

Current Landuse:

POPULATION DETAILS

AMG Zone: Easting: Northing:

Local Abundance: frequent/occasional/rare

Area covered: Total number of stems:

Stems > 5 m tall: Stems 2 to 5 m tall:

Stems 0.3 to 2 m tall: Stems < 0.2m tall:

Flowering (% of stems): Fruit (% of stems):

RECORDS

Site map attached: Yes/No

Photographs Taken: Yes/No

Extent of Survey: complete/incomplete/unknown

HABITAT CHARACTERISTICS

Aspect: Slope:

Altitude: Geology:

Soil Texture: sand/loam/clay Soil Depth: skeletal/shallow/deep

Outcropping rock (%): Surface rock (%):

Drainage: waterlogged/damp/well drained dry/well drained moist

Disturbance: intact/logged/grazed/topsoil removed/landfill/other

ASSOCIATED VEGETATION

Vegetation structural formation:

Associated species (list dominant species):

- Canopy:
- Understorey:
- Groundcover:
- Vines/Climbers:

THREATS

Weed invasion (specify species and % cover):

Trampling/grazing:

Isolation/fragmentation:

Erosion:

Inappropriate fire regimes:

Inappropriate access:

Rubbish dumping:

Other (specify):

SITE MANAGEMENT

Previous management actions (describe apparent success):

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Recommended threat abatement measures:

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Recommended monitoring/evaluation program:

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Timetable for the implementation of management actions/monitoring:

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Appendix 7: Photographs

Photo 1: Illawarra Socketwood bark (M. Bremner/DEC)

Photo 2: Inflorescence (M. Bremner/DEC)

Photo 3: Pseudo-fruit (M. Bremner/DEC)

Photo 4: Pseudo-fruit (M. Bremner/DEC)

Photo 5: Suckering stem in disturbed habitat (M. Bremner/DEC)

Photo 6: Undisturbed habitat (M. Bremner/DEC)

Photo 7: Undisturbed habitat (M. Bremner/DEC)

Appendix 8: Summary of advice from the NSW Scientific Committee

Under Section 66A of the TSC Act (1995), recovery plans must include a summary of any advice given by the NSW Scientific Committee, details of any amendments made to the plan to take account of that advice and a statement of reasons for any departure from that advice. The Scientific Committee's comments on the draft *Daphnandra* sp. C 'Illawarra' Recovery Plan and details of the amendments made are tabled below.

Section	Comment	Response
-	Replace NVC Act with NV Act	Amended
5.2	How certain is the identity of the Scarborough population? It is considerably disjunct.	No amendment necessary. The identity of the Scarborough population has been confirmed by Anders Bofeldt, Wollongong Botanic Gardens.
6	There is good distributional data in the plan but virtually no biological data.	No amendment necessary. All known biological data for the species is included in the plan. Actions 6.1 & 6.2 aim to improve knowledge of the biology and ecology of the species.
8.3.5	Deer damage is suspected but is not presently considered to be significant. What is the basis for saying it is not significant.	Amended. Substantial damage resulting from the grazing of feral deer was reported by a landholder subsequent to the draft recovery plan being placed on public exhibition. This has been acknowledged in the final plan.
Table 8	Does the Mount Annan Botanic Gardens have the capacity, budget and resources to handle seed for all the threatened plants in NSW?	No amendment necessary. The DEC has committed in-kind funds to undertaking the long-term storage of seed of this species.
Table 8	In light of DEC budget stringency, are the proposed budgets feasible?	No amendment necessary. The proposed budget is feasible provided that external funds can be secured to implement the actions identified in Table 8 as having 'unsecured' funds.

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