Protection and Re-establishment of Glossy Black-Cockatoo Habitat in South Australia: Evaluation and Recommendations

Gabriel Crowley, Stephen Garnett, Wally Meakins and Andrew Heinrich

Report to the Glossy Black-Cockatoo Rescue Fund, South Australian National Parks Foundation

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SUMMARY

In response to a request by the Glossy Black Rescue Fund, this report summarizes and assesses community efforts to protect and re-establish Glossy Black-Cockatoo habitat in South Australia. A directory of organizations involved in this program is provided, along with profiles of the aims and activities of each group. It is hoped that this directory will allow individuals wishing to contribute to Glossy Black-Cockatoo conservation to key into existing programs and will facilitate communication between the many participants.

Information concerning habitat requirements of Glossy Black-Cockatoos and the state of the existing resources on Kangaroo Island and Fleurieu Peninsula is presented. Although the current population size does not appear to be limited by availability of feeding habitat (primarily stands of Drooping Sheoak), access to adequate feeding habitat may be limiting breeding success at the edges of the current distribution and preventing re-establishment of cockatoos on Fleurieu Peninsula. Drooping Sheoak stands suitable to support Glossy Black-Cockatoos are restricted to acidic soils on certain rock types and slopes. We therefore recommend only such sites are used in revegetation projects.

There is no evidence that availability of nesting habitat (eucalypt woodland containing Sugar Gum, South Australian Blue Gum or Manna Gum) is limiting the population size, or that revegetation projects are likely to alleviate problems associated with nest sites. We therefore recommend that emphasis be placed on protection of existing nesting areas and providing additional feeding trees in areas where it is hoped nesting will occur in the future. Highest priority is placed on maintaining and re-establishing feeding habitat for current nest sites that have access to less than 400 ha of Drooping Sheoak (A), followed by encouraging breeding on the eastern end of Kangaroo Island (B1) and on Fleurieu Peninsula (B2), and finally maintaining the security of the existing breeding population (B3).

Over 50 revegetation projects involving Drooping Sheoak or Sugar Gum on Kangaroo Island were assessed. These had used natural regeneration, direct seeding or planting of tube stock for the revegetation of Glossy Black-Cockatoo habitat. Where adult Drooping Sheoak was present, fencing out stock led to good seedling regeneration. Planting of tube stock was more successful than was direct seeding, but problems associated with direct seeding can probably be overcome with correct site selection and an avoidance of weed control, as success of all projects was greatest on sandstone slopes and where ground layer vegetation had been left intact. Successful Sugar Gum regeneration was only observed where tube stock had been planted and protected with tree guards.

Information about Glossy Black-Cockatoo habitat requirements and the evaluation of revegetation projects were combined to produce a strategy for protecting and re-establishing Glossy Black-Cockatoo habitat in South Australia. The focus of this strategy is to target funding of revegetation efforts to high priority areas and sites likely to produce good feeding trees. The most cost-

effective approach is to erect simple, stock-proof fences that allow natural regeneration and protect tube stock and direct seeding projects. Where planting is required, seed should be collected from local trees, using feeding trees if these are available. The choice between tube stock and direct seeding should be based on the requirements of individual projects, with tube stock being preferred where community involvement is a priority, and direct seeding for large scale projects. Planting should be done as early in the year as possible, with tube stock being planted only once the ground is saturated. Otherwise minimum maintenance is required, and too much care can be counter-productive. Pesticide application is not recommended at any stage.

A small proportion of Glossy Black-Cockatoo habitat is in Conservation Parks, Heritage Areas or Sanctuaries. The majority is on private land, protected by clearance controls. The current policy of the Glossy Black Rescue Fund to approve financial assistance only on sites covered by Sanctuary Agreements ensures the landholder has an on-going commitment to maintaining the area for Glossy Black-Cockatoos.

The Glossy Black Rescue Fund has financed many revegetation projects that would not otherwise have been planted. Funding criteria have been modified since the fund's inception in 1994 to ensure maximum benefit to the Glossy Black-Cockatoo. It is hoped that implementation of the recommendations in this report will again further this aim.

1 INTRODUCTION

The South Australian sub-species of the Glossy Black-Cockatoo *Calyptorhynchus lathami halmaturinus*, is now restricted to Kangaroo Island, where its population is estimated to be about 200 (Prime *et al.* 1997). The principal threat to the species on the island appears to be predation of nests by Brushtail Possums *Trichosurus vulpecula* (Crowley *et al.* 1998). However, clearance of habitat is at least partly responsible for its disappearance from the mainland (Joseph 1989). Furthermore, as the population increases on Kangaroo Island, habitat saturation may occur, and further increases will require secure habitat. The main food species required by the Cockatoo is Drooping Sheoak *Allocasuarina verticillata*, on which it feeds year round (Pepper 1994). The other major requirement is for large nesting hollows, which are found in old eucalypts, particularly Sugar Gums *Eucalyptus cladocalyx*, but also South Australian Blue Gums *Eucalyptus leucoxylon* and Manna Gums *Eucalyptus viminalis* (Pepper 1996; Pedler and Garnett unpublished data). Because of the time it takes for feeding trees to produce useful crops (10-15 years; Pepper 1992), and for eucalypts to reach a size where hollows form (up to 100 years; Saunders 1982), establishment of habitat must precede the expansion of the cockatoo population. In light of this necessity, the Glossy Black Rescue Fund was established in 1993. It has encouraged and funded the protection of 327 ha of existing habitat and establishment of 43 ha of potential Glossy Black-Cockatoo habitat. Many other individuals and groups have been involved in the effort to re-establish Glossy Black-Cockatoo habitat, both on Kangaroo Island and on nearby Fleurieu Peninsula. Until now, no guidelines existed on the most effective method of re-establishing habitat, or the extent to which effort should be put into re-establishing feeding as opposed to nesting habitat. As most of the participating groups intend to continue or even increase their work in this area, a strategic plan is required that will ensure maximum success.

In this report, we produce a strategic plan for the protection and re-establishment of Glossy Black-Cockatoo habitat in South Australia. To do this we describe the current and projected involvement of participating groups, draw on extensive research into the requirements of both Drooping Sheoak and Glossy Black-Cockatoos, evaluate past revegetation attempts, describe tenure and funding arrangements. Our recommendations include both detailed prescriptions for effective habitat protection and revegetation methods and a regional conservation plan to enable effective targeting of resources for habitat protection and re-establishment.

2 PARTICIPATING ORGANIZATIONS

There are several organizations contributing to the protection and re-establishment of Glossy Black-Cockatoo habitat in South Australia. These include community groups and government departments. There is a broad agreement of aims, and some communication and co-ordination between the groups. However, most are run by volunteers who have little spare time to find out about the activities of others. This directory aims to facilitate co-operation between groups and to inform people planning on becoming involved in Glossy Black-Cockatoo conservation about the type of projects that have been organized. Links between organizations are illustrated in Figure 1. Many private individuals have revegetated their own land, or helped others, without being part of any formal organization (Section 4). This contribution is included in Figure 1. We also acknowledge the contribution of many other groups and individuals to other aspects of Glossy Black-Cockatoo conservation which fall outside the scope of this report, including monitoring, nest protection and education.

2.1 Glossy Black Rescue Fund

The Glossy Black Rescue Fund was formed on Kangaroo Island in 1993. Its aim is to raise and distribute funds for the protection and rehabilitation of Glossy Black-Cockatoo habitat. Projects have been selected for funding on the basis of their likely contribution to the future conservation of the Glossy Black-Cockatoo. Up until the end of 1997, 22 habitat protection and rehabilitation projects had been completed and funded. These projects include the protection of 327 ha of habitat and revegetation projects totalling 43 ha. Over 7,000 seedlings have been made available free of charge to landholders. Projects from across Kangaroo Island have been approved, with most completed projects being on the Dudley Peninsula, an area where the cockatoos no longer nest, possibly as a result of habitat clearance.

Since 1994, the Glossy Black Rescue Fund has called for submissions through local Landcare Groups. More recently, landholders of areas identified as having specific benefit to Glossy Black-Cockatoos have been directly approached about setting aside areas for habitat regeneration. Information required in an application includes a site description, an outline of the work to be completed and an estimate of the funds required. Before a grant is made, the landholder must lodge an application to have the designated site proclaimed as a Sanctuary (under Section 44 of the National Parks and Wildlife Act 1972; see Section 7).

Projects that assess habitat or contribute to habitat availability are also considered. The Fund has provided financial assistance for the mapping of potential nesting and feeding habitat on western Kangaroo Island and the southern Fleurieu Peninsula, for the material for 80 nest boxes, and for the hire of equipment needed for a study of the effects of soil moisture on seed production in Drooping Sheoak.

The Glossy Black Rescue Fund is administered on Kangaroo Island by a volunteer management committee, and funds are administered through the National Parks Foundation of South Australia. Major sponsors of the fund include the National Landcare Program, Save the Bush, National

Figure 1 The network of groups and individuals involved in protecting and re-establishing Glossy Black-Cockatoo habitat

Parks Foundation of South Australia, Australian Geographic, and the South Australian Ornithologists Association. Kangaroo Island Garden Centre has donated plants for several projects. Many members of the community have also contributed money and time to this organization. The high profile and good management of the Glossy Black-Cockatoo Fund has resulted in the fund attracting continuing government, community and corporate support, and it is likely this group will continue to fund revegetation projects well into the future. The Fund commissioned the current report to enable the targeting of funds into areas that will be of maximum habitat benefit to the Glossy Black-Cockatoo.

Glossy Black Rescue Fund, P.O. Box 232, Kingscote, 5223.
Co-ordinator: Terry Dennis ph. (08) 8553 2498.

2.2 Bird Observers Club of Australia

The Bird Observers Club of Australia funded one of the first revegetation projects on Kangaroo Island about 16 years ago. It was on Borda Park at the western end of the island, where three plots of between up to 30 Drooping Sheoak were planted. These trees are now about 12 m high. Glossy Black-Cockatoos regularly visit and feed in two of the patches along the Ravine de Casoars. The original trees were well protected with tree guards. However, because stock has had access to these areas, the plots have not been self-regenerating. While the Bird Observer's Club is not presently involved in revegetation, it has been raising money for Glossy Black-Cockatoos on the mainland.

Bird Observers Club of Australia, P.O. Box 185, Nunawading, Vic. 3131.
Contact: Ellen McCulloch ph. (03) 9894 4048.

2.3 Department of Environment, Heritage & Aboriginal Affairs

The Department of Environment, Heritage and Aboriginal Affairs has responsibility for Glossy Black-Cockatoos at many levels. As part of its legislative requirement to protect the cockatoos as an native endangered animal, DEHAA chairs the Glossy Black-Cockatoo Recovery Team and administers research and management contracts approved by the team. It gazetted Lathami Conservation Park and Parndana Conservation Park, at least in part to provide secure habitat for the cockatoos. It is also responsible for over-seeing clearance controls, the declaration of Heritage Areas and the ratification of Sanctuary Agreements, all of which help to protect the Glossy Black-Cockatoo.

Lathami Conservation Park covers an area of about 1,500 ha. This land was purchased by DEHAA to provide habitat security for Glossy Black-Cockatoos, for which it is an important feeding and breeding area. Most of the native vegetation is intact, although it had been used in part for sheep grazing before 1986, and 120 ha of pasture remain. As part of the management plan of the park, DEHAA attempted to revegetate two sections of pasture with Drooping Sheoak in 1990, with the assistance of Parndana Area School and Kingscote Scout Group. Both direct seeding and tube stock were used. However, Western Grey Kangaroos, Brushtail Possums and Tammar Wallabies, which

abound within the park, completely devastated the direct seedling trials and caused serious losses to the tube stock. Electric fences have been erected around one of the areas and revegetation efforts will continue over the next few years.

Department of Environment, Heritage and Aboriginal Affairs, P.O. Box 170, Penneshaw, S.A. 5222.
Contact: Anthony Maguire ph. (08) 8553 1322.

2.4 Landcare - Primary Industries South Australia

Many landholders on Kangaroo Island have retained remnants of native vegetation on their properties. They recognize that the productivity of the land is dependent on a healthy environment. As a result Kangaroo Island has one of the largest per capita involvements in Landcare in Australia. Landcare groups are coalitions of landholders and other members of the community who wish to contribute to environmental protection and rehabilitation in their local area.

There are 13 Landcare groups, which mostly based on catchments or regions, and cover at least 75% of the farmed areas on the island. The groups are Upper Cygnet, Lower Cygnet, Chain of Lagoons, Eleanor River, South West Kangaroo Island, Middle River, Lake Ada, Penneshaw School and Community, Bugga Bugga Creek, Timber Creek, Emu Bay, Stokes Bay and Eco-Action. Some groups formed in response to emerging land degradation, such as salinization and rising groundwater. All saw the need to protect the native vegetation before problems emerge.

Landcare on the island is facilitated by a Landcare Officer who currently operates out of the Department of Primary Industries and Resources, South Australia (PIRSA). Groups set their own agenda, but specific projects have received federal funding from the Natural Heritage Trust, and state funding through State Revegetation Grants. Projects undertaken so far include management of salinity problems, control of weeds, investigation into perennial grasses, and revegetation and conservation of remnant vegetation.

Many members of Landcare groups have participated in Property Management Planning workshops run by PIRSA. The workshops assist landholders to formulate plans for running the farm, and, as well as covering business management, human resources and enterprise performance, include managing the property's natural resources - the soil, water and vegetation. Aerial photography is used to assist in the identification of remnant vegetation with high conservation potential or areas suitable for revegetation. PIRSA also advises on the appropriate species to be planted. Where Drooping Sheoak is to be planted, landholders are directed to the Glossy Black Rescue Fund for possible financial assistance. There have been many Landcare projects to re-establish Glossy Black-Cockatoo feeding habitat, and while most are less than four years old, the first plantings are now beginning to produce cones and should soon be discovered by Glossy Black-Cockatoos.

Landcare Officer, Primary Industries South Australia, P.O. Box 115, Kingscote, South Australia, 5223.
Contact: Stephanie Thorpe ph. (08) 8553 2222.

2.5 Kangaroo Island Seed Bank / Parndana Area School

Parndana Area School is home to the Kangaroo Island Seed Bank, a unique, community-based seed-bank established with a grant from Greening Australia in 1994. The seed bank trades in seed of Kangaroo Island's native plants, including the major tree species (e.g. Sugar Gum *Eucalyptus cladocalyx*, South Australian Blue Gum *Eucalyptus leucoxylon*, Manna Gum *Eucalyptus viminalis*, Messmate Stringybark, *Eucalyptus obliqua*, and Brown Stringybark *Eucalyptus baxteri*), small trees and shrubs (e.g. Drooping Sheoak *Allocasuarina verticillata*, Ti-trees *Melaleuca* spp., *Banksia* spp. and Bottle-brush *Callistemon* spp.), Yaccas *Xanthorrhoea semiplana* and native grasses. As well contributing to the regeneration of Glossy Black-Cockatoo habitat, seed from the seed bank is used for agroforestry, windbreaks and the revegetation of degraded saline areas and areas damaged by Koalas.

The seed bank operates commercially, with seed being bought, sold or exchanged for seed of a similar value. There is a turnover of about 20 kg per year, with around 20 kg of seed held between seasons. Commercial rates are charged, with prices based on ease of collection. In 1997, Drooping Sheoak was available at $120 per kg and Sugar Gum at $ 210 per kg. Most other species cost between $100 and $180 per kg. Incoming seed is bought or exchanged at 80% of the sale price, making seed collection an attractive fund-raising exercise for community groups.

The collection location of each batch of seed is recorded, and efforts are made to provide revegetation projects with seed from a local source. Drooping Sheoak specifically for Glossy Black-Cockatoo is collected from known feeding trees, mostly from Lathami Conservation Park under permit. Being more difficult to collect because of the height of the trees, Sugar Gum seed is collected opportunistically from around the island. About 8 kg of Drooping Sheoak has been provided for revegetation projects across the island, about half of this going to Glossy Black-Cockatoo habitat revegetation programs. Around 1 kg of Sugar Gum has been used in Glossy Black Cockatoo projects.

As well as providing a service to the community, the seed bank operates as part of the school's agriculture and environment program. Students take part in collecting and processing the seeds and do germination trials to assess viability. Using seed from the seed bank they learn to store seed, grow seedlings, keep records and design revegetation plans, and are involved in planting trees for specific projects. The children from Parndana Area School have been involved in Glossy Black-Cockatoo habitat regeneration at all stages from seed collection to tree planting, both within Lathami Conservation Park and on private land. These programs have also included children from Black Forest Primary School through the schools' Land-Link program.

The equipment at the seed bank, including secateurs, loppers, fire rakes, seed sieves and reference books, is available for community use. Facilities at the bank include storage areas, a drying shed, a barbecue (for cracking Banksia cones), a propagating shade house and a hotbed propagator. The watering system will be up-graded in the coming year. The school also provides administrative support and facilities.

The seed bank does not aim to operate at a profit and its operation is currently funding dependent. It aims to become self-funding over the next few years. It is run by a co-ordinator who is paid for 6 hours a week, 20 weeks of the year, but who puts in considerable volunteer over-time.

Parndana Area School, Parndana, S.A. 5220. ph. (08) 8559 6068.
Co-ordinator: Kate Stanton ph. (08) 8559 2251.

2.6 Trees For Life

Trees For Life provide many of the seedlings used to re-establish Glossy Black-Cockatoo habitat on Kangaroo Island. Trees For Life is a non-profit community group that was established in 1982 and now has 10,000 members across South Australia. As well as providing seeds, potting materials and seedlings for revegetation projects, Trees For Life runs 130 Bushcare projects on the mainland, in which volunteers help to rehabilitate threatened bushland. There are 88 members on the island; 57 are growing trees for planting back on the island.

Trees For Life grows about 1.5 million seedlings each year. In 1998, 33,000 of these seedlings will be planted on Kangaroo Island, including 4,300 Drooping Sheoaks and 2,775 Sugar Gums. Seed or seedlings are also available for 33 other Kangaroo Island native plants suitable for firewood, fodder, erosion control, shade, shelter, honey, revegetation or reclamation of saline ground. Materials provided to growers include up to 20 boxes of tubes, soil, and slow release fertilizers. Seed provided is collected by volunteer teams or purchased from commercial sources, including the Kangaroo Island Seed Bank. All seedlings designated for Kangaroo Island are grown from locally collected seed. Landholders or volunteer growers sometimes collect their own seed and simply use the potting materials provided.

Annual membership of Trees For Life is $25 and there is an order lodgement fee of $15. Members are entitled to order up to 500 seedlings, or materials for growing up to 1000 seedlings, all of which is provided free of charge. As planning for replanting must be done in advance, orders for seedlings or seed and growing materials are placed in autumn, a full year before the seedlings are to be planted out. Seed, potting materials and growing instructions are sent to the growers in November. Landholders are advised to contact their local PIRSA revegetation officer for assistance in deciding on the most suitable plants and planting methods to use, although a landholder's advice booklet is also available on request. The cost of materials and administration is covered through sponsorship (20 cents per plant). However, the bulk of the expenses is the contribution of volunteers and landholders who grow the seedlings (80 cents per plant).

Community involvement in Trees For Life has been growing at a phenomenal rate, with the number of seedlings grown doubling every two to three years. The Drooping Sheoak and Sugar Gum grown by Trees For Life has already contributed to re-establishing Glossy Black-Cockatoo habitat on Kangaroo Island, and will continue to do so in the years to come.

Trees For Life, Brookway Dr, Campbelltown, S.A. 5074. ph. (08) 8207 8787.
Local contact: Joan Jenkins ph. (08) 8553 7193.

2.7 Penneshaw Area School - Trees For Life

The Glossy Black-Cockatoo has a high profile at Penneshaw Area School, and each year students do projects on the species in many subject areas. Since 1993, this has included growing seedlings through the Trees For Life program. Under the supervision of a volunteer co-ordinator, the children have propagated and planted thousands of plants.

The children collect seed locally and grow tube stock in pots and soil provided by Trees For Life in an open-sided shade house on the school grounds. Most seedlings go to landholders on the Dudley Peninsula who want to revegetate their properties with the native species, local demand determining which species are grown. Re-establishing Glossy Black-Cockatoo habitat is a high priority. Over the past 5 years around 2,000 Drooping Sheoak have been grown for this purpose.

Seed of Drooping Sheoak is collected in local feeding areas of the Glossy Black-Cockatoo. The seed is sown towards the end of the school year, and the tube stock is the ready for collection by landholders in April. The children often help plant the seedlings. This is done after the first rains. The seedlings are planted in the middle of a metre-wide circle from which the weeds have been pulled and top 2 cm of soil scraped away. No chemicals are used.

The work of the school is evident around the town, with stands of Drooping Sheoak doing well at the Bluff and above the Golf Course, and several of the projects funded by the Glossy Black Rescue Fund have benefited from plants grown by Penneshaw Area School.

Penneshaw Area School, Penneshaw, S.A., 5222. ph. (08) 8553 1067
Contact: Libby Barrias ph. (08) 8553 1261.

2.8 Friends of Deep Creek Conservation Park

Deep Creek Conservation Park is on the southern slopes of the Fleurieu Peninsula, an area that once supported Glossy Black-Cockatoos. Several potential foraging and nesting areas have been identified within the park. However, these are separated from the closest mainland landfall to Kangaroo Island by cleared land, both outside the park and within the park in an area known as Blow Hole Creek. The revegetation of these areas should assist any Glossy Black-Cockatoos dispersing from Kangaroo Island to settle on the peninsula.

Friends of Deep Creek Conservation Park was started 10 years ago, and has an active core of 15 families from the southern Fleurieu Peninsula. Its first project was the revegetation of the northern part of Tapanappa Ridge with the indigenous Cup Gum *Eucalyptus cosmophylla* and a range of other local plants, including Drooping Sheoak. The group has also helped with track maintenance and established a half-hour walking track from the Glenburn headquarters that is suitable for wheel-chair access. In 1997, the group began a project to re-establish 15 ha of Glossy Black-Cockatoo habitat at Blow Hole Creek, inside the western boundary of the Deep Creek Conservation Park. This site was selected because of its potential to provide a conduit for Glossy Black-Cockatoos arriving from Kangaroo Island and moving to potential feeding areas within the park. Remnant Drooping Sheoak and

steep sandstone slopes at this site indicate Drooping Sheoak probably dominated the original vegetation. About 5 ha of direct seeding was done in spring 1997 and a further 10 ha will be seeded in 1998. Before seeding, the area was sprayed with a 100:1 dilution of RoundUp®. Follow-up spraying is not planned. The site has been fenced with 9-strand electric wire powered by a solar panel. Once this area has been successfully revegetated, the group has set its sights on further revegetation projects within the park.

Friends of Deep Creek Conservation Park
Secretary, Mrs Joyce Lawrence, 22 Wilson Dve, Normanville Heights, S.A. 5204. ph. (08) 8558 2714.
President, Chris Royans ph. (08) 8598 0279.

2.9 Rotary Greening

Rotary Greening was launched in August 1997, and is a collaborative venture between Rotary International (Districts 9500 and 9520) and Greening Australia [South Australia] Inc., both of whom are national, non-profit, community-based organizations. The aim of Rotary Greening is to coordinate and implement significant on-ground revegetation and habitat restoration projects and to develop associated educational resources within South Australia. The focus of this work will be on rehabilitation of the habitat of threatened species. Greening Australia, having been in the forefront of revegetation efforts nation-wide, brings with it considerable ecological, educational and technical expertise. Rotary, which also includes several environmental programs among its achievements, brings the commitment of a large active membership. The new venture is partially funded through Environment Australia.

The venture has three aspects:

* Providing voluntary labour to carry out both large and small scale projects,
* Providing opportunities for students to participate in environmental projects that will enhance their environmental knowledge and skills, and
* Generating sponsorship funds and assistance to support Rotary Greening projects and services.

Over the next few years, Rotary Greening plans to undertake more than 20 revegetation projects. It will do this using about 220,000 seedlings propagated and planted by school and Rotary groups, involving 42,000 hours of volunteer labour. Glossy Black-Cockatoo habitat regeneration has been designated as one of the major projects to be undertaken. Other projects include the revegetation of Koala habitat on Kangaroo Island and Regent Parrot habitat in the Riverland.

Three Glossy Black-Cockatoo habitat restoration projects have been selected on the basis of original habitat type, suitability of the site for revegetation, long term management considerations, and likely use by Glossy Black-Cockatoos. Two projects on Kangaroo Island involve revegetation of cleared land around remnant patches of Drooping Sheoak that are fed on by breeding birds. One of these sites is within 6 km of an important group of nests. Access to Drooping Sheoak from these nests

is so limited that the birds frequently fly twice this distance to find food. The other site is in the core area of the cockatoo's population, where the increase in bird numbers has been greatest. Both these sites have already been fenced with funding assistance from the Glossy Black Rescue Fund. Another site for revegetation has been selected on Fleurieu Peninsula, within the historical range of the cockatoos. This site will help form a link between the island and potential feeding areas in Deep Creek Conservation Park.

Rotary Greening projects follow the principle that only plants that are native to the site are planted, using seed collected from the local area, and ensuring all layers of vegetation are replaced. A total of 15,000 plants will be propagated and planted to revegetate Glossy Black-Cockatoo habitat. Tube stock will be used to allow community involvement at all stages in the projects. From early summer, seed will be planted directly into tubes and tended at the Greening Australia nursery at Flaxley. A soil mixture that includes slow release fertilizer will be used. Seedlings will be planted out in winter, depending on the onset of rains. Site preparation is likely to include ripping and spraying, depending on the condition of the site. Maintenance of the sites is to be negotiated with the landholders.

These projects are being organized after consultation with Department of Environment, Heritage and Aboriginal Affairs and the Glossy Black Rescue Fund, in order to provide maximum benefit to the recovery of Glossy Black-Cockatoos.

Rotary Greening, State Tree Centre, Brookway Dr, Campbelltown, S.A. 5074.
Contact: Sheryn Pitman ph. (08) 8207 8757.

2.10 University involvement

Several university-based projects have contributed to the understanding of habitat requirements of Glossy Black-Cockatoo or the availability of suitable habitat. In 1996, John Pepper, University of Michigan, completed a PhD Thesis on the "Behavioural Ecology of the Glossy Black-Cockatoo *Calyptorhynchus lathami halmaturinus*". As well as providing detailed studies of cockatoo behaviour, John's work described the differential use of Drooping Sheoak across Kangaroo Island, and the characteristics of feeding trees and nesting sites. His research formed the basis of the first Glossy Black-Cockatoo Recovery Plan, which he wrote in 1994.

In 1994, Angela Paltridge completed an Honours Thesis at the University of Adelaide, entitled "The Feeding and Nesting Resources of the Glossy Black-Cockatoo *Calyptorhynchus lathami halmaturinus* on western Kangaroo Island, South Australia". Angela used the vegetation mapping that had been done by David Ball to identify vegetation types that were likely to support nests. This was followed up by on-ground estimation of hollow availability. This work has since been extended by the Glossy Black-Cockatoo Recovery Team, and was used as the basis of Mandy Andrew's work on the Southern Fleurieu.

In 1995, Mandy Andrews completed an Honours Thesis at the University of South Australia, entitled "Assessment of the Availability of Potential Nesting and Foraging Habitat for the Re-Introduction of the South Australian Glossy Black-Cockatoo, Southern Fleurieu Peninsula, South Australia". This project identified several extensive stands of Drooping Sheoak and suitable nesting areas on the Fleurieu Peninsula.

In 1995, Tamra Chapman, University of Adelaide began a PhD project on "Patterns of Seed Production in the Drooping Sheoak (*Allocasuarina verticillata*) and the Foraging Behaviour of the Glossy Black-Cockatoo (*Calyptorhynchus lathami halmaturinus*) on Kangaroo Island." The three focus areas of this project are

(1) Documentation of timing of flowering and seed development,

(2) Description of cones and trees usage by the cockatoos, including tree selection, cone maturity, intake rates and seasonal variation, and

(3) Examination of factors which may limit seed production, including pollination and the effects of honeybees, nutrients, and soil moisture.

The results of this work will be useful in managing Drooping Sheoak for Glossy Black-Cockatoos. It will contribute to an understanding of the type of trees the cockatoos will use, and whether cone crops should be artificially manipulated using irrigation or fertilizers.

Sophie Bickford, University of Adelaide, is using a number of techniques including vegetation mapping, pollen analysis and GIS to reconstruct the native vegetation of Fleurieu Peninsula for her PhD thesis in geography. She hopes to use the remnant patches of vegetation to identify the former distribution of Drooping Sheoak and eucalypt forests. This work will contribute to mapping former Glossy Black-Cockatoo habitat and formulating management plans for the Fleurieu Peninsula.

2.11 Kangaroo Island Bee-Keepers

One aspect of habitat protection and rehabilitation is the protection of nest hollows from feral bees, which are present in most nesting areas. Feral bees were responsible for the death of at least one Glossy Black-Cockatoo chick in 1996, and may have caused the early fledging of a second bird. Within six months of the end of the 1996 nesting season, they had colonized six productive Glossy Black-Cockatoo nests. These hives were eliminated from the hives by placing Shelltox Pest Strips™ inside the hollows.

For the last three years Kangaroo Island Bee-Keepers have been trapping feral bees from Glossy Black-Cockatoo habitat across Kangaroo Island. Trapped bees are then used to augment commercial hives or to raise new queens of commercial stock. Ten commercial bee-keepers are involved in the program, and use 100 dedicated trap hives. These are placed close to nesting areas in the spring. Placement is changed as different crops, such as Canola, or native plants, such as Broom Bush *Melaleuca uncinata*, come into flower. It is the flowering of these plants, which produce copious pollen as well as nectar, which allows the hives to build-up and swarm. Placement of trap hives has been adjusted yearly to increase the number of hives that have been trapped. Hence, the number of

swarms trapped increased from four in 1995 to ten in 1996, and 97 in 1997. The focus areas now include Dudley Peninsula, lower Cygnet River, MacGillivray, Island Beach and Cape Dutton. The program will run for at least 10 years, but is likely to be a permanent contribution of the Kangaroo Island Bee-Keepers to the conservation of Glossy Black-Cockatoos.

K.I. Bee-Keepers Association: P.O. 250, Penneshaw, S.A. 5222.
Secretary: Betty McAdam ph. (08) 8553 1237.

2.12 Glossy Black-Cockatoo Recovery Team

The Glossy Black-Cockatoo Recovery Team has the brief of over-seeing research and management to secure the future of the South Australian sub-species of Glossy Black-Cockatoo. Supported by state and federal funding, it brings together organizations involved in Glossy Black-Cockatoo conservation, as well as running a program of its own according to a recovery plan. The first recovery plan was written in 1994, and included both research and management actions. Its main concern was a low recruitment rate of juveniles to the breeding population. The research team of Stephen Garnett, Lynn Pedler and Gabriel Crowley has shown that predation at nests sites, principally by Brushtail Possums, is the main factor preventing recruitment, and is the most likely agent of decline on Kangaroo Island. However, with fragmentation of habitat and an increase in the area of crops on the island, competition for nest sites by other cockatoos is also a serious problem, a factor that may have been instrumental in the decline of the sub-species on the mainland (Crowley *et al.* 1998). Management of nesting sites to exclude possums and competing species has already reversed the decline on Kangaroo Island (Garnett *et al.* 1996; Prime *et al.* 1997). Other work by the team suggests availability of feeding habitat is more likely to be constricting the distribution of the cockatoos than to be limiting current population size (Crowley *et al.* 1998; Section 3). The team also reached the conclusion that, as long as habitat is available, an increase in the population on Kangaroo Island should lead to unassisted dispersal to the Fleurieu Peninsula, the only site for which there is incontrovertible evidence for the historical presence of Glossy Black-Cockatoos (Crowley *et al.* 1998).

As the focus of the recovery process shifts from research to management, so too has the composition of the recovery team. Bill Prime has been employed as the volunteer co-ordinator to maintain nesting sites and undertake the annual census, although Lynn Pedler will continue important population monitoring. Liaison with organizations working on the Fleurieu Peninsula has also increased, with the Threatened Species Network and Friends of Deep Creek Conservation Park assisting with the 1997 census. As the revegetation effort increases, it may be appropriate for groups contributing to habitat re-establishment to be represented on the recovery team.

Glossy Black-Cockatoo Recovery Team, Department of Environment, Heritage and Aboriginal Affairs, P.O. Box 39, Kingscote, S.A. 5223.
Contact: Bill Prime ph. (08) 8559 2268.

3 EXISTING AND POTENTIAL RESOURCES

3.1 Kangaroo Island

Drooping Sheoak is the principal food source of Glossy Black-Cockatoos on Kangaroo Island. It presently occupies 4766 ha of Kangaroo Island, representing 1.1% of the island's landscape, and 2.2% of the existing native vegetation. Most Drooping Sheoak is found on sandstone (64.9%), laterite (9.1%), mylonite (8.2%) and calcareous sediments (6.5%), with smaller patches on numerous other settings (Table 1). If the former vegetation is not known, the decision to whether to plant Drooping Sheoak at a site can be based on the relative importance of Drooping Sheoak in the native vegetation that remains on sites with similar geology and slope. We recommend that Drooping Sheoak only be planted on settings where it constitutes at least 10% of the existing vegetation. This is the case for sandstone and mylonite where the slope exceeds 5°, for basalt and neo-Proterozoic rocks, regardless of slope, and for a small area with more than 10° slope where the rock type is not known. Cleared land on these settings is thus considered suitable for revegetation with Drooping Sheoak (Table 2). Drooping Sheoak also constitutes more than 10% of the existing vegetation on areas with a slope of more than 10° that have been mapped as laterite. However, the importance of this unit is likely to have been overestimated, as our ground-truthing indicated that many of the steepest gullies mapped as laterite contained sandstone outcrops, on which Drooping Sheoak was frequently found.

Glossy Black-Cockatoos do not feed on all the Drooping Sheoak on the island (Pepper *et al.* 1997), but select trees with high food value in the cones. Food value, in turn, is related to soil type, although genetic factors are also likely to have an influence (Crowley *et al.* 1998). Trees with highest food value are most frequently found on acid soils and on rocks that tend to produce acid soils, i.e. sandstone, mylonite, neo-Proterozoic rock and basalt. We therefore recommend that the revegetation effort be concentrated on these rock types, focusing on the slope classes most likely to support Drooping Sheoak (Table 2). These preferred settings cover 8,606 ha across Kangaroo Island. Not included in the preferred list are laterite (on which the cockatoos are not known to select feeding trees) and the 10 ha of unspecified rocks (for which the feeding activity of Glossy Black-Cockatoos is unknown). However, as on-ground inspection may result in the reclassification of some of the non-referred rock types to preferred rock types, these units are included as possible revegetation areas and are mapped as potential Drooping Sheoak on Figure 2. The inclusion of these units brings the area available for Drooping Sheoak revegetation to 9,032 ha (Table 2).

As it is unlikely that all 9,032 ha suitable for Drooping Sheoak revegetation will be replanted, we prioritized areas on the basis of their likely contribution to the conservation of the existing population or the expansion of the breeding range. Movement of cockatoos is most restricted during breeding, so it is important that adequate feeding habitat is available around all potential nest sites. Distance to the closest Drooping Sheoak distinguishes active nest sites from sites selected at random within suitable eucalypt stands across the island (Garnett *et al.* unpubl. data). Average distance to the closest Drooping Sheoak is 1.0 ± 1.8 km from nest sites and 3.7 ± 2.8 km from the random sites.

Table 1 Distribution of Drooping Sheoak in relation to geology and slope.

Geology and slope units	Total area of each unit (ha)	Area of remaining native vegetation on each unit (ha)	Area of Drooping Sheoak on each unit (ha)	Area of Drooping Sheoak as a percentage of the remaining native vegetation on each unit (%)
Sandstone (GLcodes: 13,126; 13,130; 13,138; 13,144; 13,158; 13,178; 13,204; 13,228; 13,230; 13,262; 13,274; 13,278; 13,280; 13,282; 13,292; 13,302; 13,382; 13,384)				
> 10^{o}	7115	5350	1574	29.4
7.5 - 10^{o}	4579	3204	454	14.2
5 - 7.5^{o}	8220	4832	483	10.0
2.5 - 5^{o}	10714	4936	350	7.1
0 - 2.5^{o}	8392	3747	225	6.0
Unclassified	151	121	5	4.1
TOTAL	**39171**	**22190**	**3091**	**13.9**
Laterite (GLcode: 5,042)				
> 10^{o}	1245	855	141	16.5
7.5 - 10^{o}	1732	1018	85	8.4
5 - 7.5^{o}	5163	2256	100	4.4
2.5 - 5^{o}	15605	3720	72	1.9
0 - 2.5^{o}	44239	7283	31	0.5
TOTAL	**67984**	**15132**	**429**	**2.8**
Mylonite (GLcode: 12,680)				
> 10^{o}	1186	735	243	33.1
7.5 - 10^{o}	578	326	61	18.7
5 - 7.5^{o}	901	426	55	12.9
2.5 - 5^{o}	950	291	23	7.9
0 - 2.5^{o}	577	161	6	4.1
Unclassified	17	16	+	0.0
TOTAL	**4209**	**1955**	**388**	**19.9**
Calcareous sediments (GLcodes: 3,290; 3,316; 3,440; 3,448; 3,450; 3,452; 3,454)				
> 10^{o}	2299	2117	22	1.0
7.5 - 10^{o}	1418	1111	11	1.0
5 - 7.5^{o}	5312	4049	27	0.7
2.5 - 5^{o}	19909	15480	95	0.6
0 - 2.5^{o}	50156	39950	150	0.4
Unclassified	88	71	+	0.0
TOTAL	**79182**	**62778**	**305**	**0.5**
Sand over laterite (GLcode: 5,134)				
> 10^{o}	1214	1016	32	3.2
7.5 - 10^{o}	3011	2292	32	1.4
5 - 7.5^{o}	12210	7500	52	0.7
2.5 - 5^{o}	35128	17175	49	0.3
0 - 2.5^{o}	90526	33408	51	
TOTAL	**142089**	**61391**	**216**	**0.4**
Alluvial & fluvial sediments (GLcodes: 2,006; 2,602)				
> 10^{o}	584	549	22	4.0
7.5 - 10^{o}	1370	1252	37	3.0
5 - 7.5^{o}	3629	3084	57	1.9
2.5 - 5^{o}	7788	6257	39	0.6
0 - 2.5^{o}	11610	8687	22	0.3
Unclassified	2	1	+	0.0
TOTAL	**24983**	**19830**	**177**	**0.9**

Cont./...

Geology and slope units	Total area of each unit (ha)	Area of remaining native vegetation on each unit (ha)	Area of Drooping Sheoak on each unit (ha)	Area of Drooping Sheoak as a percentage of the remaining native vegetation on each unit (%)
Modern beach and dune sands (GLcode: 2,680)				
> 10°	321	301	1	0.3
7.5 - 10°	413	400	+	0.0
5 - 7.5°	1159	1127	+	0.0
2.5 - 5°	2698	2655	+	0.0
0 - 2.5°	5059	4343	68	2.3
Unclassified	51	43	+	0.0
TOTAL	**9701**	**8869**	**69**	**0.8**
Basalt (GLcode: 8,916)				
> 10°	221	57	8	14.0
7.5 - 10°	92	18	5	27.8
5 - 7.5°	123	21	4	19.1
2.5 - 5°	181	35	9	25.7
0 - 2.5°	265	40	4	14.8
TOTAL	**882**	**171**	**30**	**17.5**
Hindmarsh clay (GLcode: 3,318)				
> 10°	6	2		
7.5 - 10°	47	14	1	7.1
5 - 7.5°	346	69	3	4.4
2.5 - 5°	1569	219	7	3.2
0 - 2.5°	5402	308	3	0.8
Unclassified	3	2		
TOTAL	**7373**	**614**	**14**	**2.3**
Neo-Proterozoic rock (GLcode: 14,900)				
> 10°	125	21	14	66.7
7.5 - 10°	21			
5 - 7.5°	14			
2.5 - 5°	7		+	0.0
0 - 2.5°	7		+	0.0
Unclassified	1		+	0.0
TOTAL	**175**	**21**	**14**	**66.7**
Granites & other igneous rocks (GLcodes: 12,620; 12,648)				
> 10°	139	113	7	6.2
7.5 - 10°	80	54	1	1.9
5 - 7.5°	184	125	1	0.8
2.5 - 5°	313	143	+	0.0
0 - 2.5°	399	194	+	0.0
Unclassified	36	29		
TOTAL	**1151**	**658**	**9**	**1.4**
Kaolinized fluviatile sediments (GLcode: 8,920)				
> 10°	159	34	4	11.8
7.5 - 10°	57	12	+	0.0
5 - 7.5°	44	3	+	0.0
2.5 - 5°	32	6	+	0.0
0 - 2.5°	32	7		
TOTAL	**324**	**62**	**4**	**6.5**
Modern coastal marine sediments (GLcode: 2,678)				
> 10°	367	360		0.0
7.5 - 10°	500	493	+	0.0
5 - 7.5°	1639	1612	+	0.0
2.5 - 5°	4057	3988	+	0.0
0 - 2.5°	6982	6488	3	0.0
Unclassified	17	13	+	0.0
TOTAL	**13562**	**12954**	**3**	**0.0**

Cont./...

Geology and slope units	Total area of each unit (ha)	Area of remaining native vegetation on each unit (ha)	Area of Drooping Sheoak on each unit (ha)	Area of Drooping Sheoak as a percentage of the remaining native vegetation on each unit (%)
Calcrete (GLcodes: 2,002; 3,202)				
> 10°	20	17		
7.5 - 10°	37	24		
5 - 7.5°	118	71	+	0.0
2.5 - 5°	501	230	1	0.4
0 - 2.5°	10659	2632	2	
TOTAL	**11335**	**2974**	**3**	**0.1**
Aeolian sediments (GLcode: 2,030)				
7.5 - 10°	5	1		0.0
5 - 7.5°	85	21	+	0.0
2.5 - 5°	481	65	2	3.1
0 - 2.5°	789	91	+	0.0
TOTAL	**1360**	**178**	**2**	**1.1**
Glacial till (GLcode: 10,606)				
> 10°	128	17	+	0.0
7.5 - 10°	178	8	+	0.0
5 - 7.5°	520	31	+	0.0
2.5 - 5°	2648	182	+	0.0
0 - 2.5°	10711	938	1	0.1
Unclassified	5	0		
TOTAL	**14190**	**1176**	**1**	**0.1**
Lateritized alluvial sediments (GLcode: 6,670)				
> 10°	2	2		
7.5 - 10°	8	3		
5 - 7.5°	27	3		
2.5 - 5°	284	19		
0 - 2.5°	972	37	1	2.7
TOTAL	**1293**	**64**	**1**	**1.6**
Undifferentiated Tertiary rocks (GLcode: 4,400)				
7.5 - 10°	1	0		
5 - 7.5°	9	4	+	0.0
2.5 - 5°	65	20	+	0.0
0 - 2.5°	1955	257	+	0.0
Unclassified	1	0		
TOTAL	**2031**	**281**	**+**	**0.0**
Quartz veins (GLcode: 19,538)				
> 10°	4	1	+	0.0
7.5 - 10°	1	1		
TOTAL	**5**	**2**	**+**	**0.0**
Inland lakes and lunettes (GLcode: 2,020)				
5 - 7.5°	31	19		
2.5 - 5°	265	95		
0 - 2.5°	18478	6737		
Unclassified	1	0		
TOTAL	**18775**	**6851**	**0**	**0.0**
Unspecified rocks (GLcode: 99)				
> 10°	53	20	10	50.0
7.5 - 10°	15	1	+	0.0
5 - 7.5°	30	3		
2.5 - 5°	47	3		
0 - 2.5°	260	14		
Unclassified	3	2	+	0.0
TOTAL	**408**	**43**	**10**	**23.3**
Island-wide	**440183**	**218194**	**4766**	**2.2**

Table 2 Geology and slope units identified as being suitable for planting Drooping Sheoak on the basis of representation in existing vegetation.

Geology and slope units	Area of Drooping Sheoak as a percentage of remaining native vegetation on each unit (%)	Cleared land suitable for Drooping Sheoak	
		Area (ha)	Percentage of total area identified as suitable (%)
Preferred rock types for revegetation of Drooping Sheoak			
Sandstone			
> 10°	29.4	1782	19.7
7.5 - 10°	14.2	1377	15.2
5 - 7.5°	10.0	3389	37.5
TOTAL	**18.8**	**6548**	**72.5**
Mylonite			
> 10°	33.1	458	5.1
7.5 - 10°	18.7	256	2.8
5 - 7.5°	12.9	480	5.3
TOTAL	**24.1**	**1194**	**13.2**
Basalt			
> 10°	14.0	164	1.8
7.5 - 10°	27.8	74	0.8
5 - 7.5°	19.1	102	1.1
2.5 - 5°	25.7	147	1.6
0 - 2.5°	14.8	224	2.5
TOTAL	**17.5**	**711**	**7.9**
Neo-Proterozoic rock			
> 10°	66.7	104	1.2
7.5 - 10°		21	0.2
5 - 7.5°		14	0.5
2.5 - 5°		7	0.1
0 - 2.5°		7	0.1
TOTAL	**66.7**	**153**	**1.7**
Total on preferred rock types		**8606**	**95.3**
Non-preferred rock types			
Laterite			
> 10°	16.6	39.2	4.3
TOTAL	16.6	36.2	4.3
Unspecified rocks			
> 10°	66.7	34.0	0.4
TOTAL	66.7	34.0	0.4
Total on non-preferred rock types		**426.0**	**4.7**
Total island-wide		**9032.0**	**100.0**

Glossy Black-Cockatoos can fly up to 12 km between feeding and nesting areas without adversely affecting breeding success (Garnett *et al.* unpubl. data). However, that few birds fly such distances suggests they would only do so if access to suitable foraging habitat is restricted, and that breeding may be adversely affected should longer forays become necessary (Saunders 1986). Therefore, only Drooping Sheoak within 12 km can be considered accessible to the nest, at this stage. The area of accessible Drooping Sheoak also distinguishes active nest sites from the randomly selected sites (Garnett *et al.* unpubl. data). Nest sites have access to an average of 743 ± 320 ha of Drooping Sheoak, while the random sites have an average of 279 ± 240 ha. Four active nesting areas stand out by having less than 400 ha of Drooping Sheoak within 12 km. These areas include the group of nests from which the birds regularly fly 12 km to feed. All nests with access to less than 400 ha of foraging habitat have therefore been identified as being most at risk. Further loss of feeding habitat may lead to their abandonment. Moreover, access to feeding habitat may already be limiting the number of nests that can be supported in these areas. Drooping Sheoak within 12 km of these nesting areas is included in zone A and given the highest conservation priority status (Table 3).

Figure 2 Zonation of Kangaroo Island and southern Fleurieu Peninsula according to the conservation needs of the Glossy Black-Cockatoo

Table 3 Conservation ratings of Drooping Sheoak zones on Figure 2.

Zone	Classification	Likely restriction to population size	Key areas
A	Areas within the feeding range (12 km diameter) of nests with access to less than 400 ha of Drooping Sheoak	Current number of nests in active breeding areas may already be limited by restricted access to feeding habitat. Further loss of habitat, through development or fire would put nests at jeopardy and could reduce breeding population.	Kohinoor hills–Pardana C.P. Nepean Bay Borda Park Northeast River Northwest River
B1	Other areas of east of Cygnet River, Kangaroo Island within the Hundreds of Haines and Dudley	No birds currently breed in this area. The population size is small and has failed to increase along with the rest of the island's population	Muston to Ballast Head Northern Dudley Peninsula
B2	Fleurieu Peninsula west of 38^{o} 18'E	No birds currently use this area. Birds dispersing from Kangaroo Island may die or return to the island if adequate feeding areas are not available.	East of Fisheries Beach Rd, west of Deep Creek C.P. and south of Cape Jervis to Noarlunga Road and Three Bridges Road
B3	Remainder of Kangaroo Island	Conservation of existing area is essential to maintaining current population of Glossy Black-Cockatoos	Lathami C.P. Parndana C.P. Western River C.P. and intervening areas of private land

Glossy Black-Cockatoos do not currently breed east of Cygnet River. However, there are anecdotal reports of a nest at Blue Gums on Dudley Peninsula in the 1970s (M. McKelvey pers. comm.) and of nests on the Fleurieu Peninsula in the 19th century (Joseph 1989). Glossy Black-Cockatoos presently feed at American River and on the Dudley Peninsula, but do not remain there to breed. Suitable nesting hollows are scarce on Dudley Peninsula, but several areas of suitable nesting habitat have been identified around American River, and nest boxes have been provided in both areas since 1995. Despite a 13% increase in the population of Glossy Black-Cockatoos between 1995 and 1997, there has been no increase in the number of birds seen east of Cygnet River (Prime *et al.* 1997). Both breeding and the number of birds in this area may be limited by availability of feeding habitat. Nest boxes erected at American River have access to only 270 ha of Drooping Sheoak, while those a Blue Gums on the Dudley Peninsula have access to just under 400 ha. Provision of additional feeding habitat in these areas should see an increase in the number of cockatoos and the establishment of nest sites. It is essential that sites selected for planting with Drooping Sheoak are those likely to produce high food value. Increases in the number of birds breeding at the eastern end of Kangaroo Island would also seem a necessary pre-requisite to the un-assisted return of birds to the mainland. Drooping Sheoak in the area around American River and on Dudley Peninsula has therefore been zoned as B1 conservation rating. Except for areas already within zone A, Drooping Sheoak northeast of Cygnet River are not used by Glossy Black-Cockatoos. Nor would colonization of this area assist in dispersal to the mainland. Therefore this area is not included in zone B1.

The remaining areas of feeding and breeding habitat on Kangaroo Island have high conservation value because they support the bulk of the remaining population of the South-Australian Glossy Black-Cockatoo. However, there is no evidence that feeding habitat or breeding

habitat is limiting population size within this area. The core area has therefore been zoned as having a B3 conservation rating. Priority ratings are confined to sites already supporting Drooping Sheoak or which conform to the criteria used in Table 2 to identify potential Drooping Sheoak habitat.

3.2 Fleurieu Peninsula

The disappearance of Glossy Black-Cockatoos from Fleurieu Peninsula has largely been attributed to habitat loss (Joseph 1982). However, the predominance of Drooping Sheoak on steep slopes means that this plant is still relatively abundant, and Mandy Andrews identified at least 147 ha of potential feeding habitat on the southern Fleurieu Peninsula (Andrews 1995). More detailed mapping by Sophie Bickford should identify further stands. Although this would not be enough to secure a nesting area, non-breeding birds could make use of such areas, as long as they were of adequate food quality. Most of the trees sampled on Fleurieu Peninsula had poor to marginal food quality. However, high quality Drooping Sheoak is found within stands on the hills facing Kangaroo Island that are large enough to support non-breeding 50 birds. So lack of suitable feeding areas alone is unlikely to have been the sole cause of the cockatoo's disappearance (Crowley *et al.* 1998). Security of nest sites against predators and competing cockatoos, both of which appear to have been advantaged by habitat fragmentation on Kangaroo Island, is a more likely cause (Crowley *et al.* 1998). Nevertheless, as Glossy Black-Cockatoos continue to increase in number on Kangaroo Island, their return to the Fleurieu Peninsula will initially depend on the availability of adequate feeding areas close to the island.

Once the birds begin to make regular forays to Fleurieu or a feeding population is established, it may be necessary to manage nesting areas closely. Most sites with suitable hollows are used by Yellow-tailed Black-Cockatoos, Galahs, Sulphur-crested Cockatoos or Little Corellas (Andrews 1995; V. Scholz pers. comm.). If Glossy Black-Cockatoos are found prospecting in these areas, nest-boxes could be erected and sealed outside the Glossy Black-Cockatoo's breeding season, as has been done in areas where competition is a problem on Kangaroo Island.

The sites most suitable for nesting by Glossy Black-Cockatoos are those presently used by Yellow-tailed Black-Cockatoos, as long as these have adequate access to feeding areas. The closest known Yellow-tailed Black-Cockatoo nests to Kangaroo Island are within Deep Creek Conservation Park, about 12 km from the closest landfall to the island (Andrews 1995). These nests presently have access to at least 140 ha of Drooping Sheoak (Andrews 1995). Revegetation efforts on Fleurieu Peninsula should therefore aim to form increase the Drooping sheoak estate between this potential nesting area and the closest landfall to Kangaroo Island, i.e. west of 138^{o} 18' E. More than half of this region is cleared of native vegetation, and much is on sandstone slopes of more than 5° and therefore suitable for Drooping Sheoak revegetation. Two revegetation projects have already been initiated in this area, one by the Friends of Deep Creek Conservation Park at Blow Hole Creek, within the park; the other by Rotary Greening at Fisheries Creek on private property. A revegetation plan that includes direct seeding of Drooping Sheoak has also been written for Windfell (Newton 1993).

4 REVEGETATION ATTEMPTS ON KANGAROO ISLAND

To be able to provide recommendations for successful planting, we assessed 56 revegetation projects on Kangaroo Island that had included Drooping Sheoak and/or Sugar Gum. The assessment data was stored on Microsoft Excel, with separate files for site descriptions and revegetation assessment. These files can be updated and edited as required. The following analyses apply only to records in the database up until 31/12/97. The results may change as the database is updated. Data entry forms are presented in Appendix A.

The projects were on 45 different sites. Site boundaries were delineated according to management histories and soil characteristics. Sites on one property that were isolated by pasture were treated as separate sites, but sites which where part of the same revegetation enclosure were treated as a single site, even though individual projects within that enclosure may be separated by large patches of remnant bush. However, sites that spanned different substrates (e.g. sandstone and laterite), and as a result had distinct success rates, were assessed as two separate sites, even where the management regimes did not differ. An exception to this was sites that were principally located on sandstone with laterite at the boundaries, which were treated as a single site. This classification meant that separate assessment sheets were completed for areas with similar histories and outcomes, but that the sizes of sites varied considerably.

Each attempt to establish native vegetation was treated as a separate project. Hence, each direct seeding attempt was assessed separately. However, plantings of Drooping Sheoak tube stock over a number of years and using the same procedures at the same site were assessed as a single project. In some cases, especially for projects undertaken more than 5 years ago, many details were not available - hence the following summaries are not all based on the same group of sites.

Of the sites visited, most were in areas rated as a priority for Glossy Black-Cockatoo conservation (Table 4). The focus of the Glossy Black Rescue Fund to date has been increasing the area of feeding habitat on the eastern end of the island in zone B1), and to secure existing populations within the current breeding range of the cockatoos in zone B3.

While all projects included Drooping Sheoak, only a few included Sugar Gum. Sugar Gum seedlings had survived at only two of the 13 sites in which they had been planted or where there were Sugar Gum remnants. All the survivors had been planted as tube stock and protected by sturdy tree guards. Four projects involved the fencing of Drooping Sheoak remnants alone. All four had resulted in good regeneration of Drooping Sheoak within a year or two of fencing.

The remaining analyses concern only the re-establishment of Drooping Sheoak from direct seeding or tube stock. Criteria for success ratings used in this study were simplified into three classes for projects that had planted more than 12 months ago, and two classes for projects in their first year (Table 5). For examining the factors influencing the success of revegetation attempts, these classes were used separately or combined, as appropriate.

Table 4 Distribution of revegetation sites and sites approved for funding by the Glossy Black Rescue Fund in relation to priority area for Glossy Black-Cockatoo Recovery.

Class	Strategy	Revegetation sites		Sites approved or granted assistance by Glossy Black Rescue Fund	
		Number	(%)	Number	(%)
A	Secure and provide additional feeding habitat for nesting birds with limited feeding areas	6	13	1	6
B1	Expand breeding range by providing high quality feeding areas where the birds currently feed but not breed	13	29	8	44
B2	Secure existing range	10	22	6	33
Un-rated	Non-preferred settings (includes laterite or alkaline soils)	16	36	3	17
	Total	45	100	18	100

Table 5 Criteria for success rating for Drooping Sheoak revegetation trials.

Success rating	Method of planting		
	Natural regeneration	Direct seeding	Tube stock
		Long term ratings	
Failed	No regeneration	No regeneration	No survival
Poor	Less than 50 plants/ha	Less than 50 plants/ha	Less than 60% survival
Good	At least 50 plants/ha	At least 50 plants/ha	At least 60% survival
		First year ratings	
Failed	No regeneration	No regeneration	No survival
Early success	At least 50 plants/ha	At least 50 plants/ha	At least 60% survival

Of the 45 projects assessed that were more than 12 months old, about two-thirds were rated as good, one-sixth as poor and one-fifth as having failed (Table 6). All six projects that were less than 12 months old were rated as early successes. In all cases the rating given conformed to the landholder's qualitative assessment of the project. The main determinant of whether a project was successful was rock type (Table 6). As described earlier (Section 3.1), most Drooping Sheoak on Kangaroo Island is found on sandstone, and this is where the greatest success rates were found. Laterite, which is the most abundant rock type on the island, produced low success rates. Establishment on other rock types was variable, but generally successful. Planting of tube stock was more likely to result in successful establishment of Drooping Sheoak than was direct seeding (Table 6). Direct seeding tended to be either successful or a total failure, whereas one third of tube stock plantings yielded a poor result. This suggests that direct seeding needs ideal conditions for success, whereas most tube stock planted under sub-optimal conditions is likely to survive, if not flourish.

Table 6 Long-term success of Drooping Sheoak revegetation projects according to rock type and planting method.

Method	Failed (%)	Poor (%)	Good (%)	Number
Sandstone				
Tube stock	0.0	6.7	93.3	15
Direct seeding	45.5	0.0	54.5	11
Total	19.2	3.8	76.9	26
Laterite				
Tube stock	33.3	0.0	66.7	3
Direct seeding	100.0	0.0	0.0	4
Total	71.4	0.0	28.6	7
Other rock types				
Tube stock only	0.0	33.3	66.7	12
All rock types				
Tube stock	3.3	23.3	73.3	30
Direct seeding	60.0	0.0	40.0	15
Total	22.2	15.6	62.2	45
Number	10	7	28	

No unsprayed vegetation plots were a complete failure (Table 7). Spraying with glyphosate considerably reduced success of establishment. This was particularly the case when wildlife was abundant. Spraying after the seedlings emerge appears to be more damaging than spraying beforehand. However, no attempt was made to distinguish success rates on the basis of timing of spraying, as each project had a different regime, varying from a single spraying just before seeding to three sprayings over a period of years before and after seeding. However, it appears that the more comprehensive the weed control, the greater the likelihood of failure. Sometimes this was a result of a long history of pesticide use at the site, at other times because of thorough spraying after seedling emergence. These problems appeared to be worse for other species, particularly for eucalypts. At least two revegetation projects that had started as mixed species plantings resulted in monocultures of Drooping Sheoak after grazing associated with spraying. This suggests Drooping Sheoak is less sensitive to grazing than other species, and many landholders mentioned that they had lost eucalypt seedlings to grazing unless tree guards were used. However, no attempt was made to comprehensively assess revegetation of species other than Drooping Sheoak.

Spraying is most commonly associated with direct seeding, and may contribute to low success rates. Of the 15 direct seeding projects that were more than a year old, only two hand-seeded projects were undertaken without spraying, and these were both successful. Of the five direct seeding projects that were less than one year old, all showed early success. However, they currently have little weed cover, and this could reduce their likelihood of long-term success. Spraying was used in only 22% of 23 tube stock projects for which the spraying history was known, and was not linked to project failure.

Table 7 Effect of spraying with glyphosate on long term success of Drooping Sheoak revegetation.

Method	Failed (%)	Poor/Good (%)	Number of projects
	Wildlife abundant		
Sprayed	53.3	46.7	15
Not sprayed	0.0	100.0	16
	Wildlife rare		
Sprayed	33.3	66.7	3
Not sprayed	0.0	100.0	8
	Total		
Sprayed	50.0	50.0	18
Not sprayed	0.0	100.0	20

Grazing by wildlife was the problem most frequently cited by landholders as adversely affecting their projects (Table 8), and was considered a problem at just over half the sites where wildlife was rated as abundant (75% of all projects). The common wisdom is that tube stock grown with fertilizer, is more palatable than seedlings from natural regeneration or direct seeding. This was difficult to assess because information about fertilizer use in seedling propagation was not usually available. Of the 30 tube stock based projects, 12 had used tree guards. The only one that failed did not, but wildlife were not cited as a problem at this site, while the only site where plants appeared to be badly damaged by wildlife, had a number of other contributing problems. The planting was on laterite, and the trees seemed to be particularly brittle, tending to break off at about head height. Moreover, many of the plants had been poorly planted, so were readily knocked out of the ground. Wildlife numbers were no higher here than in many adjoining areas where planting of tube stock on sandstone slopes was highly successful. Thus damage by wildlife may be minimized by correct planting and site selection.

Table 8 Problems cited by landholders as adversely affecting their efforts to revegetate Drooping Sheoak.

Problem	Frequency of citing
Grazing by wildlife	40%
Dry conditions	20%
Grazing by stock	9%
Red-legged earth mite	7%
Sand hills	4%
Wet conditions	4%
Wind	4%
Salinity	4%
Alkalinity	4%
Borers	4%
Slashing	2%
Soil compaction	2%
Snails	2%
Sugar Gum canopy	2%
Weed invasion	0%

Most landholders tried to undertake direct seeding around the first heavy autumn/winter rains and to plant tube stock when the ground was first saturated. Even so, the next most frequently cited problem was dry conditions, as rainfall patterns were not always predictable and long dry spells ensued in many years. Although tube stock should be more sensitive to poor rainfall after planting than direct seeding, the failure rate of tube stock projects was extremely low. Difficulty in hiring machinery at the optimum time for seeding may have contributed to the higher failure rates of direct seeding projects.

Grazing by stock affected a few projects, but only where fencing was inadequate. We could find no confirmation of red-legged earth-mite being seen on seedlings, and where this was invoked as a possible cause of failure, other more tangible causes were apparent. No other problem was cited for more than 5% of the projects assessed. Weed invasion was not considered a problem by any landholder, although about half had undertaken no weed control at all. Many landholders purposely left weeds for protection against grazing.

Highest success rates on sites rated as priority A or B1 confirmed these areas as optimum sites for Drooping Sheoak revegetation (Table 9). A-rated sites had few wallabies and kangaroos, so direct seeding was fairly successful, regardless of spraying. Highest failure rates on B3-rated sites were associated with a combination of the highest rate of direct seeding (and hence spraying), and high densities of wallabies and kangaroos. Similarly high failure rate on un-rated sites probably arose from a combination of direct seeding with spraying and sub-optimal site conditions.

Table 9 Success of revegetation projects in relation to priority area for Glossy Black-Cockatoo Recovery.

Priority rating	Direct seeding : tube stock	Failed (%)	Poor (%)	Good (%)	Total (%)	Number
A	33:67	11.1	0	88.8	100	9
B1	0:100	0	0	100.0	100	6
B3	62:38	30.8	7.7	61.5	100	13
Un-rated	24:76	29.4	35.5	35.3	100	17
Total	33:67	22.2	15.6	62.2	100	45

Most landholders had received no financial assistance for their revegetation efforts (Table 10). The proportion that did not is likely to have been underestimated, as all projects which received funding assistance from the Glossy Black Rescue Fund were assessed, whereas those that did not were assessed only if they came to our attention. Many of the landholders who had received financial assistance had also revegetated further areas with no extra funding. This demonstrates a high commitment to revegetation of Glossy Black-Cockatoo habitat. Assistance of a non-financial kind was received by many landholders, including direct seeding by the PIRSA revegetation officer and donated trees by Trees For Life, KI Garden Centre or other sources. We did not attempt to quantify labour assistance, as this was not discussed consistently and was difficult to identify except where it was provided through a formal arrangement with an identifiable organization.

Table 10 Assistance received by landholders in revegetation efforts that included Drooping Sheoak or Sugar Gum.

Type of assistance	Percentage of sites
Financial	40%
GBRF	33.3%
BOCA	6.7%
Direct seeding	11%
Trees	13.3%
None	36%

In conclusion, attempts to establish Drooping Sheoak were most successful on areas marked as potential Drooping Sheoak on Figure 2. Such sites are likely to have supported Drooping Sheoak in the past and have high priority for Glossy Black-Cockatoo conservation. Rock types that are unlikely to have supported Drooping Sheoak (eg. laterite) will provide poor revegetation results that will be of little value to Glossy Black-Cockatoos. Good natural revegetation on sites that have remnant Drooping Sheoak and have been fenced to exclude stock reduces the need for additional planting. On the mainland, control of rabbits using fencing or other means will also be necessary. Where additional planting is required, planting of tube stock is likely to be more successful than direct seeding. However, direct seeding is a more cost-effective method and can be used over a greater area. Therefore efforts should be made to increase its success rates. One way to do this is correct site selection, which can be difficult when direct seeding is used where there is no remnant vegetation. This can be overcome by restricting direct seeding of Drooping Sheoak to the areas marked as suitable on Figure 2. Another aspect of direct seeding that contributes to its high failure rate is the use of glyphosate to reduce weeds. Weed cover does not appear to adversely affect Drooping Sheoak revegetation, and there is considerable evidence that it increases it. Removal of weeds makes the seedlings more visible to herbivores and removes alternative food, while chemical changes in the seedlings as a result of spraying may also increase seedling palatability (V. Scholz pers. comm.). Furthermore, removal of weeds eliminates protection from wind, sun baking and desiccation, and suppression of growth in response to pesticide increases the time over which the seedlings are vulnerable. These adverse effects are apparent even under very low concentrations of glyphosate (e.g. 1:100). It is therefore preferable that the ground layer vegetation be left intact. Finally, direct seeding should be timed to take advantage of the autumn/winter rain. If the appropriate machinery is not available, direct seeding can be done by hand-broadcasting seed on soil that has been ripped or otherwise disturbed (I. Pratt pers. comm.; W. Prime pers. comm.). The above modifications should be trialled before direct seeding is abandoned altogether.

One reason given for controlling weeds is to minimize fire risk. This can be done by slashing, with the added benefit of providing a layer of mulch at the end of the growing season. Extreme care is needed, especially when plants are less than about four years old. If plants are in well-spaced rows and marked with stakes, there should be no problems.

5 REVEGETATION STRATEGY

Information about the ecological requirements of Glossy Black-Cockatoos (Section 3) and success rates of Drooping Sheoak revegetation projects (Section 4) is used here to formulate a strategy for revegetation of Glossy Black-Cockatoos feeding habitat. This strategy aims to establish a Drooping Sheoak estate that closely resembles that which existed before clearance, so as to be of maximum benefit to the cockatoos. This should enable resources to be well targeted. Habitat protection schemes should be implemented in areas of Kangaroo Island and Fleurieu Peninsula that already support Glossy Black-Cockatoos or may do so in the near future (Figure 2: Zone A and B1 to B3). As there is no evidence that nesting sites are limiting, protection of Sugar Gum and other hollow-bearing trees is more important than the establishment of new stands. Emphasis should be placed on protecting stands that have active nests. Additional areas could be included if there are signs of Glossy Black-Cockatoos prospecting for nests. The role of fire in the regeneration of Sugar Gum may need to be investigated.

Revegetation of Drooping Sheoak should be concentrated where feeding habitat is likely to limit breeding success or population size (Figure 2: Zone A, B1 and B2; Table 11). Funding should also be restricted to sites identified as likely to support Drooping Sheoak using the criteria identified in Section 3 (see Figure 2). Revegetation efforts outside these areas will lead to poor project success rates and the resulting Drooping Sheoak stands will be unlikely to have adequate food quality to support Glossy Black-Cockatoos. A primary aim of revegetation should be to provide at least 400 ha of Drooping Sheoak around existing or potential nesting areas.

Table 11 Strategies for securing and expanding Glossy Black-Cockatoo habitat in South Australia.

Zone as shown on Figure 2 (p 20)	Strategy	Priority actions
A	Secure and provide additional feeding habitat for nesting birds with limited feeding areas	1 Protect existing Drooping Sheoak 2 Revegetate areas identified as Potential Drooping Sheoak
B1	Expand breeding range by providing high quality feeding areas where the birds currently feed but do not yet breed	1 Protect existing Drooping Sheoak 2 Revegetate areas identified as Potential Drooping Sheoak
B2	Expand feeding range to allow cockatoos to return to mainland South Australia	1 Revegetate optimal sites to provide a minimum of 400 ha of Drooping Sheoak within 12 km of potential nesting areas 2 Protect existing Drooping Sheoak
B3	Secure existing range	1 Protect existing Drooping Sheoak

6 REVEGETATION METHODS

The revegetation methods below are compiled from the experiences of landholders on Kangaroo Island (Section 4) and the available literature.

6.1 Seed collection and storage

6.1.1 Source of seed

Seed used in revegetation projects should be of a local provenance, wherever possible. This is to avoid genetic corruption of local communities and to ensure that the plants are adapted to the conditions at the site (State Tree Centre 1992a). If possible, it is desirable to use feeding trees to take advantage of any genetic component to food quality. If not, seed should be collected from as large a number of trees as possible to ensure that at least some plants will have high food value.

6.1.2 Collection and storage

Highest viability of seed is found in greyish brown cones and in seed that is mid- to dark brown (State Tree Centre 1992b). Seed in the younger, reddish brown cones may not be mature. Collection of cones close to the growing tips should avoid seed that has begun to deteriorate with age. Trees with high seed viability are preferred as these will produce a large number of seedlings, but should also produce trees that are capable of supporting cockatoos, as the cockatoos need a high proportion of viable seed to feed on. Feeding trees will have high seed viability. Seed viability of non-foraging trees should probably be tested. A quick guide to whether a batch of seed has adequate food quality to support the cockatoos is to weight seeds (in grams) and cones (in kilograms) after they have dried sufficiently for all seed to be expelled and to calculate Clout's Index. Clout's index is a rough approximation of the amount of food a cockatoo can get from a cone, and is calculated using the following equation:

$$\frac{\text{Weight of all seeds from a batch of cones (g)}}{\text{Weight of all seeds plus weight of all cones (kg)}}$$

e.g. Weight of seeds = 15 g = 0.015 kg, weight of cones is 0.2 kg

$$\frac{15\ (g)}{0.015 + 0.2\ (kg)}$$

$$= \frac{15\ (g)}{0.215\ (kg)}$$

$$= 69.8\ g/kg$$

Cockatoos will feed from trees with a Clout's Index of at least 58 g/kg, but the average value of feeding trees is 63.9 g/kg. The above example would be a good feeding tree.

About 200 to 300 grams of seed is required for each hectare or kilometre of direct seeding (State Tree Centre 1992c; Greening Australia undated publication). A seed batch of 350 g collected from feeding trees will contain an average of 100,000 seed with a germination rate of about

78%. About 4.5 grams would be required to produce 1,000 tube stock seedlings. The seed will germinate readily within 3 to 4 weeks and does not need pre-treatment.

Good regeneration can be achieved by laying cone-bearing branches that have been pruned from roadsides or fence-lines over freshly disturbed soil (W. Prime pers. comm.). Seed can also be collected by laying the branches on clean sheets of plastic until the seed is expelled. Otherwise, cones should be collected and placed in a warm dry environment. The cones will open inside paper bags, as long as the batches of cones are small enough to allow airflow. Plastic bags should not be used as these will sweat and the seed may go mouldy. If seed is to be dried in an oven, a trial batch should be used to determine the temperatures the seeds can tolerate before their viability is reduced. The seed should be separated from any trash and stored in dry, airtight containers until required. Permits are required for the collection of seed from National Parks or Conservation Parks, and permission may be required from local councils to collect seed from other public land.

6.2 Site selection

Site selection is the most important aspect of a Drooping Sheoak revegetation project. As described in Sections 3 and 4, planting of Drooping Sheoak for Glossy Black-Cockatoos optimum settings for revegetation are sandstone, mylonite and Neo-Proterozoic rock, with a slope of more than 5°, and basalt, regardless of slope. Examination of remnant trees may indicate whether Drooping Sheoak was in the original vegetation. Highest priority should be given to areas that Glossy Black-Cockatoos already use regularly for feeding or that have remnant trees with high food value (see Section 6.1). Protection and maintenance of nesting should focus on active nests on Kangaroo Island, and west of 138^{o} 18' E on the Fleurieu Peninsula.

6.3 Revegetation methods

6.3.1 Natural revegetation

Wherever Drooping Sheoak is present, new seedlings will emerge each year. However, unless stock is excluded, most seedlings will be grazed. There are numerous sites on Kangaroo Island that have regenerated successfully simply by fencing remnant stands to exclude sheep. Even high numbers of wallabies and kangaroos do not appear to be an insurmountable problem, as long as no weed control is undertaken. On the mainland, rabbits have also limited regeneration, and fencing or other control methods are required. Fencing of remnant stands is likely to be the most cost-effective method of regenerating Drooping Sheoak. However, care must be taken to ensure that the cleared areas are likely to have supported Drooping Sheoak in the recent past. In many areas on the island, clearance lines followed soil types, with the level laterite plateau being cleared up to the edge of a rocky sandstone slope on which Drooping Sheoak remains. However, Drooping Sheoak might not have been part of the vegetation that was cleared, as different species usually occupy the plateau (Ball 1994). Fencing of such areas would not usually increase the Drooping Sheoak estate, and if it did, it would not be to the advantage of Glossy Black-Cockatoos.

As availability of nest sites is not presently limiting Glossy Black-Cockatoo numbers on Kangaroo Island or the Fleurieu Peninsula, maintaining existing stands of Sugar Gum and other hollow bearing trees is probably more approriate and cost-effective than replanting cleared land. A study of the factors controlling the natural regeneration of nesting trees and hollow formation should be undertaken before extensive revegetation of nesting habitat is contemplated.

6.3.2 Direct seeding

Direct seeding is often the preferred method of revegetation as it can be a cost-effective method for achieving broad-acre revegetation. It has several advantages. A single person using a direct seeding machine can seed several hectares a day. Plants resulting from direct-seeding form good root systems and grow faster than tube stock do (State Tree Centre 1992c). Also, the initial high density of seedlings characteristic of direct seeding means projects can be successful even with large losses. Aesthetics are often cited as a reason for direct seeding, as the regular spacing and monoculture effect characteristic of many tube stock plantations can be easily avoided. However, this is less of a consideration for Drooping Sheoak because the species often occurs as a monoculture in its natural environment. However, there are also major disadvantages to direct seeding. Conditions for establishment of seedlings might not be suitable every year, and seeding in dry years or very wet years can be a total failure. Therefore, direct seeding should be contemplated only if the landholder is prepared to wait two or more years for a good strike. The greatest difficulty with direct seeding is maintaining landholder commitment and enthusiasm in the face of repeated failure. Even landholders who have had many successful direct seeding attempts have abandoned individual sites after two successive failures (B. Hannaford pers. comm.). It is therefore important that the best methods are used in order to maximize success rates. Success can be increased by careful site selection combined with no weed control (Section 4). Protection against stock, particularly sheep, is essential, and rabbit control measures should be taken where necessary. On all but the wettest sites, seeding should be timed to take advantage of the first heavy autumn rains. Irrigation is not usually required or practicable. Direct seeding across the contours will trap moisture running downhill, and will prevent the furrows from acting as drainage lines. This is important to prevent the seeds from being washed away. Short furrows, or furrows that cut across each other can also help the flow of water.

Direct seeding involves making a furrow and breaking up the soil, separating and dropping the seed at correct intervals, and covering the fallen seed with a thin layer of topsoil. This can all be done manually using a fire rake or rake hoe (State Tree Centre 1992c). Dedicated equipment is available and not expensive to hire (ca. $50/day from PIRSA), but jack-built machinery can also be effective, such as a furrow plough fitted with a tube seed (P. Dunstan pers. comm.). Sophisticated machines have tickler tines to break up lumpy soil and a press wheel to cover the seed with soil (Greening Australia undated publication). Watering afterwards is not recommended unless follow-up rains are a certainty, as any seed that germinates will die if it is not kept wet for several weeks. Seed can also be hand broadcast in freshly ripped soil with great effect, simply tamping down the soil over

the seed with the foot. One person, using a fire rake, can prepare about 600 plant sites per day, or about one hectare (State Tree Centre 1992c), and using a machine, can cover between 3 and 5 km in an hour, or about 3 to 5 ha (Greening Australia undated publication). Plants should be spaced at about 4 metre intervals, giving a coverage of just over 600 plants per hectare. Hand broadcasting into ripped soil should be at least twice as fast as using a fire rake.

Ripping or direct seeding by machine is easiest where there is no standing vegetation and on slopes of less than about 7.5°. Hand seeding with a fire rake or similar implement may be necessary on steep slopes, rocky sites or other difficult terrain, but can be equally successful on all sites if it follows ripping or other forms of soil disturbance. Spacing of rows or plant sites should be wide enough to allow for future direct seeding attempts, and should take into consideration whether slashing to reduce fire risk may be necessary.

The best time to seed will depend on the site and the pattern of rainfall. The rainfall on Kangaroo Island is highly seasonal, with most rain falling between May and November. Well-drained sites should be seeded as early as possible after the first decent rains. In most years this will be in June, although in 1997, it was as late as August. If seeding is done too late, the seeds may fail to germinate and seedlings that do germinate are unlikely to survive through the summer and early autumn, which are typically dry on the island. On wet sites, it is important to wait until the soil begins to dry off, and this may be as late as early November.

Direct seeded plantings may be subject to infestations of red-legged earth-mite, although we could find no confirmation of this pest being identified. If an infestation occurs, it can be controlled by sprayed with organo-phosphate.

6.3.3 Tube stock

Planting out tube stock has several advantages over direct seeding, the hands-on experience being the most palpable. Large numbers of people can be involved in tube stock projects, especially school and community groups. The largest Drooping Sheoak revegetation projects using tube stock on Kangaroo Island have involved school children planting about 2,000 seedlings over three or four years.

The seed generally takes three to four weeks to germinate and the seedlings grow well with standard techniques using slow release fertilizers and potting mix (see Section 6.4.2). Many people think the fertilizers used in the potting mix makes tube stock palatable to grazing animals, and that the disturbance of the root stock caused by planting-out seedlings reduces growth rates. Despite this, tube stock projects on Kangaroo Island enjoy a high success rate (Section 4).

The most effective method of planting tube stock we saw on Kangaroo Island was to use a crow bar to wedge an opening in the soil, flip out the 4 to 6 month old seedling from its tube and drop it into the opening, which is then heeled closed with the foot (B. Buick pers. comm.). If this is done when the soil is wet, then recruitment rates are high. With a spacing of about 4 metres between plants, a density of 625 plants per hectare can be achieved, and this can be done as rapidly as manual direct seeding with a fire rake. A similarly successful method of planting tube stock involved the used of a

5 cm diameter auger designed for drilling fence postholes. However, care should be taken to ensure the soil around the holes is not compacted, as this can lead to plants becoming "pot-bound".

Timing of planting is more crucial for tube stock than for direct seeding. Tube stock must be planted out at the onset of the winter rains. If they cannot be watered artificially, they require a full season of rain to get established. On Kangaroo Island the best planting times have usually been June or July.

6.4 Maintenance

As long as stock and rabbits are excluded, it appears that the best approach to maintenance of Drooping Sheoak is to leave the plants alone and only intervene when essential. Some of the best revegetation attempts we saw were ones that had been neglected. Their owners, assuming the plants had long ago perished, were pleasantly surprised when numerous tops of Drooping Sheoak were seen emerging from a tall, dense cover of weeds.

6.4.1 Weed control

The most contentious aspect of revegetation is weed control, especially around the seedlings after germination. Our analyses indicate that any measures that reduce ground cover are undesirable (Section 4). We therefore recommend against weed control. To return natural integrity to revegetation plots, removal of weeds is desirable, but it is essential that this is not counter-productive - control can come at a later date. Many weeds will die out simply through the removal of stock, the return of the canopy and long term lack of disturbance. After the Drooping Sheoak is established, intervention may then be used for weed control as appropriate. Another reason for keeping ground cover to a minimum is to reduce fire risk. Rather than spraying, slashing at the end of the growing season may be required on some sites. This would at least leave a cover of mulch to assist plants through the summer.

The one exception where weed control is desirable is in the control of noxious weeds, particularly Bridal Creeper. Bridal Creeper forms a dense mat of corms in the leaf litter and can inhibit seed germination and seedling growth. However, Bridal Creeper is most likely to be a problem under established canopy, from which perching Grey Currawongs defecate the seed (D. Ball, pers. comm.). Control of Bridal Creeper is usually achieved by directly spraying the foliage with BrushOff™ or related products, and need not impede the success of revegetation projects.

6.4.2 Fertilization and nodulation

Slow release fertilizer is frequently used in raising tube stock, but rarely added to plants in the field. Addition of fertilizers is unnecessary good quality soil is used, especially if soil comes from the revegetation site. This soil will not only provide the essential nutrients, but also contain spores of nodulating micro-organisms that assist the plant to obtain nutrients (Lawrie 1982). While application of fertilizer increases growth rates, it may result in soft, palatable plants, less able to cope with stress and more likely to be grazed. However, in our assessment if revegetation projects, we found very low

mortality of tube stock seedlings. Tube stock need not be grown with fertilizers at all if good topsoil is used, and especially if the plants are nodulated. Nodules are fungal growths that naturally occur on the roots of most Drooping Sheoak on the island, and they provide the plant with nitrogen. Tube stock can be nodulated by mixing into the potting mix either particles of crushed nodules or soil that has collected from beneath mature Drooping Sheoak stands. Dean and Bev Overton watered their seedlings once or twice with rainwater to which they had added crushed nodules. They found nodules on the roots of most plants when they examined them 9 months later. Nodulation is an alternative to fertilization - both nodulated plants and fertilized plants have faster growth rates than plants grown in pure potting mix. However, nodulation is not essential, and it is not known whether nodulated plants do better once they are planted in the field than seedlings that have been grown with fertilizer.

6.4.3 Irrigation

Tube stock seedlings should be planted in wet ground, preferably before the end of June, so that they experience several wet months before having to survive dry conditions. We could find no tube stock failures that could be attributed to dry conditions, but in several cases plants had been watered intermittently through the first year. Dry conditions could have contributed to losses of direct seeding projects, but this could be alleviated simply by the selection of favourable sites (Sections 3 & 4). If seeding is timed to coincide with the first rains of the season, irrigation is usually unnecessary. Irrigation should therefore be used only in response to parching conditions that appear to be jeopardizing the success of the project.

6.4.4 Protection against grazing animals

The most important animals to exclude from newly seeded areas are stock, and these can be successfully excluded by fairly simple fencing, such as well-constructed 5-strand wire fencing. Pig-netting is frequently used, but we could see no difference in the establishment rate in areas with pig-netting or stranded fencing. Fencing is preferable to the use of tree guards, because although most tree guards are inadequate to exclude persistent stock, they can lead to a false sense of security.

Wildlife can also do a lot of damage, but are far more difficult to control. The only fences we have seen that seem to exclude all wildlife were electric fences at least 1.4 m high. However, most Drooping Sheoaks appear to survive or escape grazing by kangaroos, wallabies and possums. Good management (i.e. good site selection and lack of weed control) can minimize the effects of native herbivores. A creative approach to protecting emerging seedlings from wildlife involves the use of live or dead vegetation. Seedlings can be obscured by woody prunings, such as those removed from fence lines or roadsides. In some cases, seed falling from the dumpings of Drooping Sheoak prunings with no intention to revegetate has led to dense regrowth of sheoaks (M. & L. MacKenzie pers. comm.). In other cases, strategic placement of Drooping Sheoak prunings on disturbed soil has resulted in successful regrowth, with no further input required (W. Prime pers. comm.). Other prunings are also useful to obscure seedlings from wildlife, particularly where revegetation is combined with control of

noxious weeds. Dead branches of Prickly Acacia and Boxthorn are superior to tree guards as a disincentive to sensitive snouts (I. Pratt pers. comm.; C. Hobbs pers. comm.). These methods of protection are less unsightly than artificial tree guards and are ultimately biodegradable.

Goats are the only feral animal pests that could prevent Drooping Sheoak regeneration on Kangaroo Island. There have been no records of goats affecting revegetation projects. However, goats may be a problem on the rocky slopes in the north-western section of the island. Hunting of goats in this area continues, but does not appear to reduce their numbers significantly. Shooting around affected areas would be required to insure against goats damaging revegetation plots.

Rabbits are a more serious problem and are probably responsible for the failure of sheoaks to persist in some area on Fleurieu Peninsula in the face of habitat clearance and burning. Rabbit Calici Virus is temporarily depressing rabbit numbers, and should provide a window of opportunity for both natural sheoak regeneration and plantings. Where rabbit control is required 1080 bait can be appropriately employed and small-mesh tree guards and fences should be used to protect the Drooping Sheoaks. Fencing to exclude rabbits requires a small mesh wire buried to an adequate depth.

Sugar Gums are more likely to require protection from tree guards with or without fencing, as they are more likely to be killed by grazing. The most effective guards are pig-netting at least 1.1 m high and about 1.5 m in diameter (W. Prime pers. comm.). These cannot be knocked over easily, and as a final spacing of about 10 m between trees is desirable, such a large investment per tree can be afforded. Therefore, if tree guards are to be used at all, they should be made of material that can be easily removed. Chicken wire is cheap, but can usually be tipped over, and is a nightmare to remove. A generous cylinder of pig-netting (up to 1 m diameter for Drooping Sheoak and 1.5 m for Sugar Gum), joined with three or four twitches of wire that can be snipped, is sturdy, durable, easy to remove and can be readily re-used.

6.4.5 Invertebrate pests

Invertebrates are rarely a significant problem for Drooping Sheoak (Section 4). Therefore control measures should only be used in the face of an outbreak. Infestations of red-legged earth-mite can be sprayed with a synthetic pyrethrum, such as Mavrick™. Borers generally only infest plants that are under stress (J. Cooper pers. comm.), so are probably an indication of poor site conditions, and should be avoided by correct site selection.

6.4.6 Protection against fire

Fire is a natural part of the environment and losses of Drooping Sheoak to fire will occur from time to time. However, Drooping Sheoak does not need fire for its regeneration, and is more likely to dominate stands where fire is excluded (Withers and Ashton 1978). Fires occurring before a stand has produced mature cones will remove Drooping Sheoak from the site, as will fires that are hot enough to destroy the canopy. After a fire, it may be 10 to 15 years before Drooping Sheoak are mature enough to provide enough cones to support Glossy Black-Cockatoos (Pepper 1992).

Fires can be minimised with good management. Appropriate measures will vary between sites and will depend on legal obligations and weather conditions. Such measures could include clearance and or ploughing alone fence lines and slashing of weeds. Once the Drooping Sheoak canopy begins to close over, fuel loads will decline naturally, so fire risks will be minimized.

6.5 Long-term viability

To achieve long-term viability, it is necessary to achieve a mature stand of vegetation that produces viable seed, and for self-generated seedlings to survive. Site selection is the most important factor determining whether this will occur (Sections 3 & 4). Exclusion of stock is also essential, as is avoidance of fire, at least until the trees are large enough to produce seed. Finally, the commitment of the landholder, and continuing community support for the Glossy Black-Cockatoo is essential.

7 TENURE

National Parks, Conservation Parks and Heritage Areas contain 36% of existing and 3% of potential Drooping Sheoak (Table 12). The area of Drooping Sheoak in Sanctuaries is not known. However, the Glossy Black Rescue Fund has been responsible for placing 327 ha under sanctuary agreements. Habitat on private land that is not covered by either Heritage Agreements or Sanctuary Agreements is mostly protected by clearance controls.

Table 12 Conservation status of Drooping Sheoak on Kangaroo Island.

Conservation status	Priority A		Priority B1&B2		Total	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
Existing Drooping Sheoak						
Conservation Parks	231	24.7	915	25.3	1146	25.2
Heritage Areas	8	0.9	483	13.3	491	10.8
Unprotected	696	74.4	2220	61.4	2916	64.0
Total	935	100	3618	100	4553	100
Potential Drooping Sheoak						
Conservation Parks	2	0.1	34	0.5	36	0.4
Heritage Areas	10	0.5	214	3.1	224	2.5
Unprotected	2006	99.4	6766	96.5	8832	97.8
Total	2018	100	7014	100	9032	100

7.1 National Parks and Conservation Parks

National Parks and Conservation Parks afford maximum protection for habitat and are appropriate where sites have conservation significance for a number of organisms or landscape features. Important Glossy Black-Cockatoo habitat has been included in Lathami Conservation Park, Parndana Conservation Park and Western River Conservation Park. Nepean Bay Conservation Park contains Drooping Sheoak, but this is generally of low food value and is not used by the cockatoos. Important potential habitat on Fleurieu Peninsula is contained within Deep Creek Conservation Park and Talisker Conservation Park. It is important that key areas are represented within reserves, although it is unlikely that a viable population of cockatoos could persist within the current reserve system alone. However, in most cases acquisition has been unnecessary to secure Glossy Black-Cockatoo habitat, as there is a high level of commitment to conservation by landholders on Kangaroo Island and nearby Fleurieu Peninsula, as has demonstrated in this report (Section 4).

7.2 Heritage Agreements

Heritage Agreements are legal contracts between landholders and the minister responsible for the Native Vegetation Act, 1991 that aim to protect specific areas of native vegetation. They apply to a defined piece of private land and prevent grazing and clearance, while the landholder retains ownership. The agreement is registered on the title and continues if the property is sold. Through the Native Vegetation Council, the landowner may receive compensation for loss of property value or

financial assistance to fence and otherwise manage the land. Heritage Agreements cover remnant vegetation rather than areas of revegetation. Applications for Heritage Agreements are currently handled by the Department of Environment, Heritage and Aboriginal Affairs.

7.3 Sanctuaries

The majority of Glossy Black-Cockatoo habitat is on private land not covered by Heritage Agreements (Table 12). Protection of this habitat requires no more than landholder commitment. However, Sanctuary agreements formalise this commitment. Sanctuaries can apply to land containing remnant vegetation or revegetation projects. Approval for financial assistance for revegetation from the Glossy Black Rescue Fund is conditional upon a Sanctuary Agreement being made. No attempt has been made to place habitat under Sanctuary Agreements in cases where no financial assistance has been provided. All native plants and animals in the sanctuary are protected.

The Sanctuary agreement is made between the landholder and the minister responsible for the National Parks and Wildlife Act, 1972, and can be revoked by the land owner at any time by a written request to the minister. Applications for Sanctuary status are currently handled by the Department of Environment, Heritage and Aboriginal Affairs.

8 FUNDING ARRANGEMENTS

Although many landholders have undertaken the revegetation of Glossy Black-Cockatoo habitat without financial assistance (Section 4), others could not have done so without funding from the Glossy Black Rescue Fund. All landholders were appreciative of the availability of financial assistance. However, enthusiasm has commonly waned after the initial work has been completed and the funds have been spent. In some cases, the need to make up-front payments for materials before being reimbursed has been seen as a deterrent.

Each year the Glossy Black Rescue Fund has modified its funding procedures to provide increased benefits to the cockatoos. This means that selection criteria have become more stringent. In the first two years, all applications for revegetating with Drooping Sheoak were considered. In the third year, specific sites were targeted. No call for funding was made for the 1997/8 financial year, pending the findings of this report. We recommend continuation of this refinement, with the adoption the priority system described in Section 5 (Table 11). It may also be appropriate for the fund to commit itself for a number of years to specific sites or networks of sites within these priority areas.

The most cost-effective approach to protecting or re-establishing feeding areas would be to fence land systems that contain remnant Drooping Sheoak. Where this is not possible, planting of tube stock or direct drilling of Drooping Sheoak will be required. Subsidizing the cost of fencing materials for such projects would be an appropriate use of Glossy Black Rescue Fund money. This fencing need be no more than the minimum required, e.g 5-strand wire fencing to exclude stock. Project success does not appear to require anything more elaborate, but where a landholder wishes to use more expensive fencing, partial funding could be provided.

There are many organizations prepared to donate tube stock and labour (Section 2). So it should not be necessary for the Glossy Black Rescue Fund to do so. However, purchase of seed and hire of equipment for direct drilling may need to be covered, with the back up of repeat funding if a project fails in the first year. In some cases, it may be desirable for the Glossy Black Rescue Fund to approve the purchase of materials by a landholder, with the account being forwarded directly to the fund. Provision would need to be made for the landholder to reimburse expenses if the work is not completed within an appropriate time frame. However, if such arrangements are made only where commitment to Glossy Black-Cockatoo habitat regeneration has been demonstrated by a landholder over a number of years, such problems are unlikely to occur.

9 CONCLUSIONS

There is an enormous community commitment to conservation of the Glossy Black-Cockatoo on Kangaroo Island and nearby Fleurieu Peninsula. This has been demonstrated in the high number of habitat protection and re-establishment projects in the area. Some of these projects have received funding from the Glossy Black Rescue Fund, but most have gone ahead without even applying for assistance. Most have also been successful, particularly those using tube stock.

This report has identified factors which will ensure a higher success rate of habitat protection and revegetation projects, will maximize their chance of being of benefit to the Glossy Black-Cockatoos, and will make them more cost-effective.

First, it is essential that site selection be based on the criteria for potential Drooping Sheoak distribution, i.e. sandstone, mylonite and neo-Proterozoic rock, with a slope of more than 5°, and basalt, regardless of slope. These areas are identified in Figure 2. It is preferable that there is also some other evidence of the former presence of Drooping Sheoak at the site, notably some remnant trees.

Second, projects should be allocated funding according to the priorities listed in Table 11. Highest priority should be given to sites where at least one of the following is present: (1) trees already in use by Glossy Black-Cockatoos, (2) remnant trees high food value, or (3) site characteristics indicative of high food value (e.g. acid soils on sandstone slopes).

Funding should be restricted to simple, stock-proof fencing, and seed and machine hire for direct seeding.

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APPENDIX DATA ENTRY FORMS