

How To ...

MANAGE YOUR GRANITE OUTCROPS

by
B.M.J. Hussey



Land for Wildlife



Department of Conservation
and Land Management

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How to-- manage your
granite outcrops

DEPARTMENT OF ENVIRONMENT AND CONSERVATION

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Department of Conservation and Land Management

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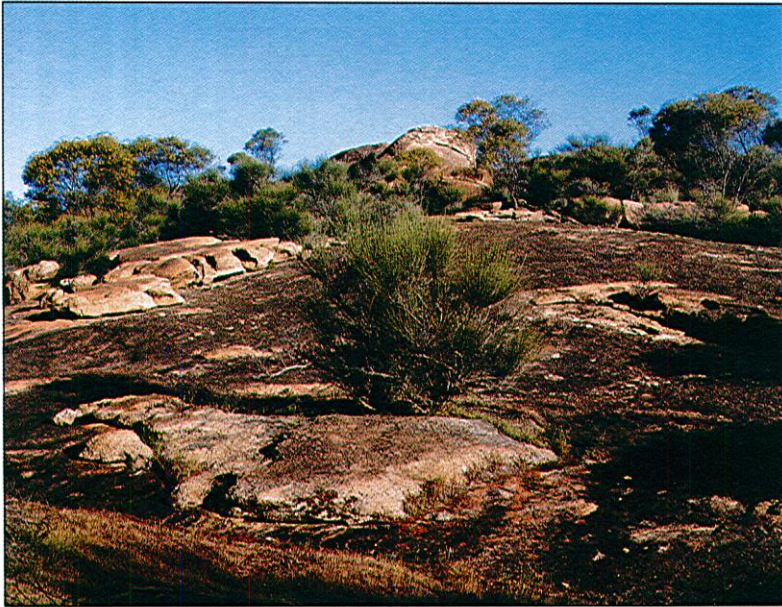
GRANITE OUTCROPS

Much of the south-west of Western Australia is underlain by an ancient continental mass, the Yilgarn Block, one of the oldest land masses on earth. Made principally of granite, it has, over thousands of millions of years, been eroded down into the almost flat landscape we see in Western Australia today. The rock basement is mostly covered by a layer of soil, but occasionally granite outcrops occur at the surface.

These outcrops may be massive, dome-shaped rocks, piles of tumbled boulders, or flat sheets at soil level. The rock surface can vary according to the mineral composition of the granite, from a smooth to a rough and sculptured surface with fissures and cracks. Flat slabs may lie on the surface, or rounded boulders erode to mushroom-shaped rocks. Ponds may form, possibly in tiers down the rockface, connected by waterfalls. Often one outcrop may contain several of these features.



Kokerbin Rock



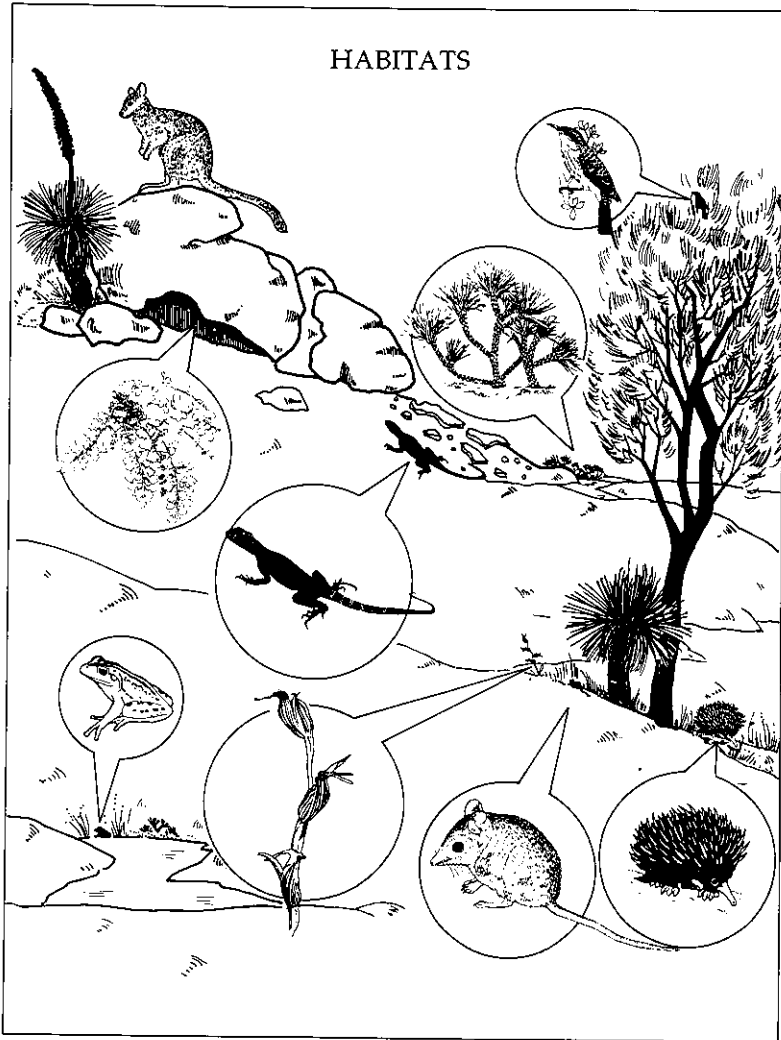
Kokerbin Rock

Soil forms slowly by weathering and the accumulation of dust and plant litter. The soil depth varies with the slope and the distance from rock. The depth of the soil will affect which plants are able to survive, with deeper soil supporting larger species. But the rock also has another important feature that affects wildlife, it is impervious to water and so will concentrate run-off to give a greater effective rainfall at its base. It is this feature which enables jarrah trees to grow at Jilakin Rock, east of Kulin, for example, where the climate would normally be far too dry to support them. So the damp areas around granites can be thought of as 'refuges' where plants and animals that flourished during a period of wetter climate, can hang on in this time of increasing aridity.

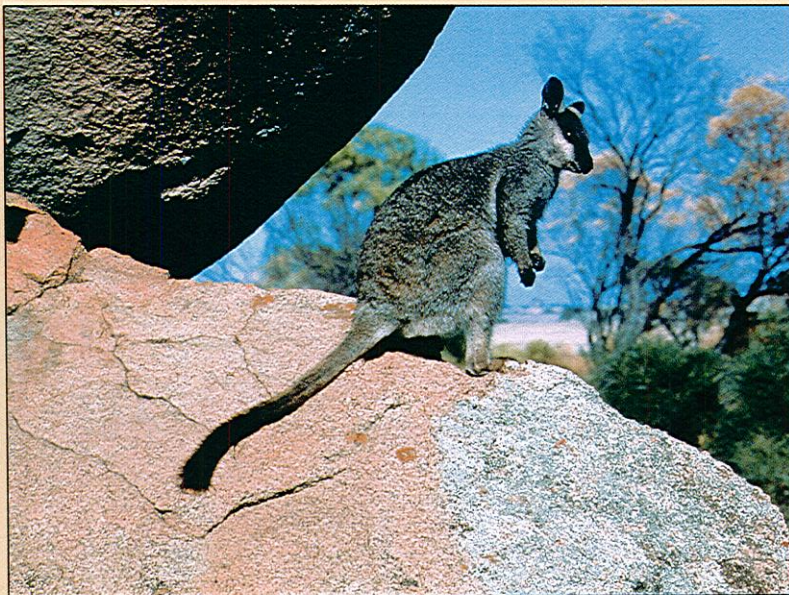
Thus the topography of the rock outcrop determines which plants and animals can survive on and around it, and creates sharply defined zones of different habitat.

THE HABITATS - PLANTS AND ANIMALS

Not all rocks will have all features. The more varied the rock is, the more diverse habitats it will have and the wider the range of wildlife it will be able to support.

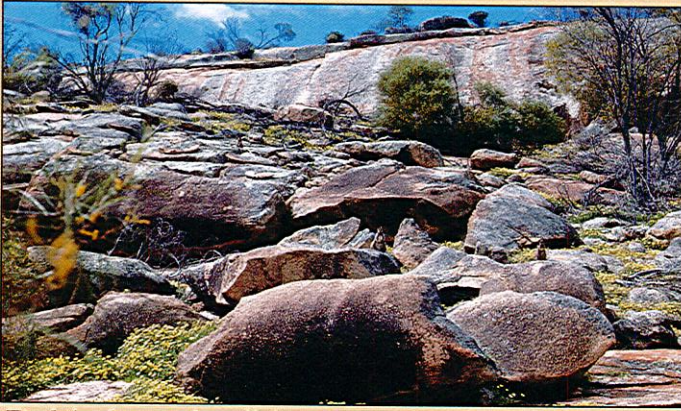


ROCK-WALLABIES



(photo: Bert and Babs Wells, CALM)

Predation by foxes has led to the decline of many mammals once characteristic of granite outcrops, one of the most important being rock-wallabies. The black-flanked rock-wallaby was once found throughout the wheatbelt, wherever there was suitable habitat. It was very common in the Avon Valley, especially around Toodyay. But by the mid 1970s it had declined to only a few populations on large, rocky, nature reserves. A delightful feature of these animals is that they are active during the day. Observing them bounding about between the boulders, long, black-tipped tail swinging in balance, or sitting perched on a ledge surveying their world, one can get a wonderful feeling for the uniqueness of Australia.



Find the four rock-wallabies among these boulders!

The places where the animals survived all had exceptionally secure hiding places under tumbled boulders and CALM scientist Jack Kinnear was certain that the decline was due to predation by foxes. He began a campaign of fox baiting, and rock-wallaby numbers boomed. (Since then, of course, it has been shown that fox predation has been responsible for the decline of most medium-sized mammals in WA.) Rock-wallabies are now being relocated to suitable nature reserves within their former range.

What are the features of an outcrop that make it suitable for rock-wallabies? It needs lots of rock, cliffs and piles of tumbled boulders. They eat ground layer plants, grasses, curly-grass, leaves and fruits. Water does not seem to be necessary. What is necessary is absolute removal of foxes and dogs - probably feral cats too. If you have an outcrop on your property, 100 ha at least in extent, with boulder habitat and plenty of shrubs on islands and apron, then you might be interested in registering with *Land for Wildlife* as a possible translocation site. To qualify, however, you must not only have the habitat, but also a proven, long-term record of fox-baiting in the surrounding area, such that very few foxes are now taken each year (or the capacity to establish and maintain a predator control program).



Pincushions surround rock sheet; Danubin Hill.

1 ROCK SHEETS

- ◆ Lichens, mosses and blue-green bacteria, dormant during the dry season.
- ◆ Invertebrates such as insects and spiders, most activity during wet season.
- ◆ Lizards bask to increase their body temperature, most actively in late spring and autumn.



Granite kunzea; Kokerbin Rock.

2 SMALL CRACKS AND CREVICES UNDER ROCKS

- ◆ Horizontal cracks shelter various invertebrates such as ants, spiders, millipedes, scorpions and centipedes, also lizards and geckos.
- ◆ Vertical cracks provide root spaces for larger plants, such as ferns, pincushions and even large shrubs like granite kunzea, whose roots widen the crack further.
- ◆ The cracks may also channel and hold water.

3 HOLES AND CAVES UNDER AND AMONG TUMBLED BOULDERS

- ◆ Where light can enter, and fine soil collects, delicate plants such as rock isotome and wild tobacco may grow.
- ◆ Large holes provide shelter for larger mammals such as echidnas, rock-wallabies, euros and grey kangaroos, also large reptiles such as goannas and carpet pythons.
- ◆ Smaller mammals such as dunnarts, native mice and bandicoots use smaller holes.
- ◆ Until recently, stick nest rats built their strange nests under overhangs and in crevices. They formed a great mound of sticks cemented together with a tarry black substance made of the animals' excretions and these can still be seen in some places. Stick nest rats are probably extinct in mainland WA but reintroductions from islands off South Australia have begun and more are planned for the future.



Pools, sward and thicket on apron; Boondi Rocks.

4 ROCK POOLS

- ◆ Shallow pools usually only hold water over winter. If the pool has a clay base over the rock, it is likely to be richer in diversity of organisms. The water supports numerous microscopic plants, algae and diatoms, while the fern-relative, quillwort, may grow in the mud, and tiny plants such as crassulas and mud-mats on the drying edges.
- ◆ The water also supports a succession of invertebrates - water-fleas, shrimp-like creatures, shelled ostracods and midge larvae, as well as water-boatmen, dragon-fly larvae and also tadpoles.
- ◆ Deeper pools in the outcrops were called 'gnammas' by the Nyoongar people, and were an important source of water for humans and animals alike.



Massed flowering on sward; St. Ronan's Nature Reserve, York.

5 ROCK MEADOWS OR 'SWARDS'

Where soil accumulates in depressions in the rock, or on the very shallow soil around the edge of the outcrop, meadows or 'swards' of plants develop. These swards contain a succession of different small plants which flower throughout the winter and spring. All of them have some mechanism to survive the long, hot summer, when the soil is baked dry.

- ◆ The most characteristic of these plants, pincushions (*Borya* species), have one of the oddest methods of survival. They are resurrection plants. As the soil dries out, the plant removes the chlorophyll and most of the water (down to only 2% of the weight) from its leaves. They turn bright orange and the whole plant goes into 'suspended animation' until the rain stimulates it to begin active growth once more.
- ◆ Lichens and moss are also common in swards. The beautiful, lacy, coral lichen cannot withstand trampling, so its presence is a good indicator of lack of disturbance.

- ◆ Many plants, e.g. the nancies and several orchids, store food in a bulb or tuber so that they have a good start for the next year. The elbow orchid not only has a tuber to get it going, but it stores food and moisture in its stem, so that it continues to flower into summer - even when pressed as a herbarium specimen!
- ◆ Many of the sward plants are annuals, surviving the summer as seeds, including tiny pink or white trigger plants, *Centrolepis* (small, grass-like plants), and numerous members of the daisy family. All are tiny, and need a close look to reveal their beauty. Among the daisies, Swan River daisy has showy white or lilac daisy-like flowerheads and soft, ferny foliage, *Rutidiosis* is an upright plant with minute massed yellow flowerheads, *Quinetia* is silvery-grey with tiny red flowers in the leaf axils and fairy pillows has a dome of soft greyish-yellow flowers surrounded by a frill of grey leaves.
- ◆ The swards are habitat for many small invertebrates, which in turn provide food for frogs, lizards and small birds such as chats, pipits and thornbills.
- ◆ The meadows around the edges of the rock, before the soil gets deep enough to support thickets, are favourite feeding places for rock-wallabies, bandicoots and kangaroos - and also rabbits.



Centrolepis pilosa, and a nancy.

6 SHRUBBY ISLANDS ON THE ROCK

Where soil accumulates to any depth among the rocks, islands of shrubs or trees may occur. These plants often are gnarled and twisted - 'natural bonsais' - and reach great age, as their isolation protects them from fire damage. When in flower, these isolated shrubs, such as the granite kunzea, can be spectacularly beautiful, as they stand alone so there is nothing to detract from their splendour.

- ◆ A characteristic plant in this habitat is blind grass (actually a lily!), whose blue flowers are produced throughout spring and into summer. South of Perth, in the higher rainfall areas, it has occasionally been recorded as toxic to stock, but not in the drier regions to the north and east. Sword sedge also grows in these areas, and the two plants together provide good dense habitat for small mammals.

7 SHRUBBY THICKETS

Water is channelled over the rock, and where it collects, and the soil is deep enough, dense shrubby thickets will form. Common shrubs found here include tea-trees, one-sided bottlebrush, honeymyrtles, hop-bushes, tmmas, hakeas, grevilleas, and wattles. Occasionally maliees can be found, such as silver princess, which is commonly planted in gardens. Many of these plants produce copious nectar when in flower and so are a very important food source for insects and birds. Predatory birds and insects are also attracted to the feast.

- ◆ These dense thickets are ideal as nesting sites for small birds such as honeyeaters, thornbills and wrens.

8 SHEOAK WOODLANDS

A characteristic tree around granite outcrops is the rock sheoak. It germinates in great profusion after a disturbance such as a drought or a fire that kills the adult trees, resulting in a very dense growth of young saplings. Gradually they thin out, until, perhaps 40 years after germination, an open woodland of large trees has developed. Like all sheoaks, its leaves are reduced to a papery crown round the thin, whippy branches, which are themselves green and do the photosynthesis.



Phascogale (photo: Bert and Babs Wells CALM)

When these branches (or sheoak 'needles') fall, they carpet the ground, suppressing the growth of other plants. The smooth-lipped spider orchid, however, relishes this habitat and is almost confined to it.

- ◆ Foraging woylies may turn over the soil and needle carpet under the sheoaks while searching for their favourite fungi.
- ◆ Sheoak roots contain nitrogen-fixing micro-organisms, and it is the extra nitrogen which they put into the soil which helps to make the fringes of granite outcrops so productive.
- ◆ These dense sheoak woodlands form ideal habitat for red-tailed phascogales and are a favoured habitat of western rosellas and Port Lincoln ringnecks.



Woodland, including a clump of jarrah; Jilikin Rock.

9 SURROUNDING WOODLANDS

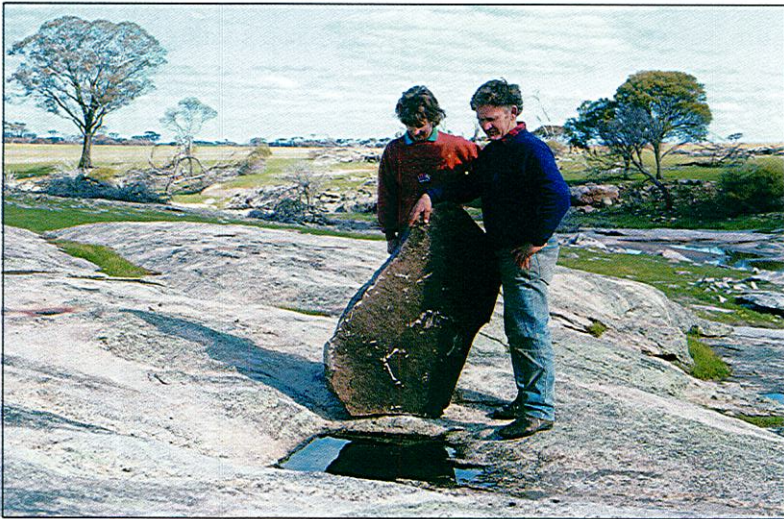
Before clearing, each outcrop would have been surrounded by bushland, for example, woodland of jarrah, wandoo, York gum, salmon gum or gimlet. The outcrop's value as a natural habitat will be increased if uncleared areas of woodland remain adjacent to the rock.



Echidna and everlastings in sheoak woodland; Avondale.

ROCKS AND ABORIGINAL PEOPLE

As one of the few reliable sources of water in an essentially dry land, granite outcrops must have always been vital sites to Aboriginal people. Apart from the water itself, animals could be hunted as they came to drink and, in addition, rock overhangs would provide shelter from the elements. The signs of occupation may be there, for those who look carefully. Around the bases of rocks, especially near outlet creeks, generations of people grinding seeds may have created basins in the hard rock or sometimes portable grinding stones can be found, and flakes of stone not local to the area are evidence of tool use. Archaeologists excavating cave shelters have discovered pits lined with blackboy leaves and filled with zamia fruits. Similar pits were used in other continents to leach the poison from nuts, prior to cooking. Near Balladonia, tools made from the leg bones of extinct megafauna have been found in the eroded material around a granite dome.



Gnammas were often covered to keep the water fresh, as Judy and Kelly O'Neill of Ongerup demonstrate.

ROCKS AND EUROPEAN SETTLEMENT - ECONOMICS

During the early exploration phase of settlement, rock outcrops were a vital source of water. Routes to the Goldfields, such as the Hann Track and the Holland Track, travelled from rock to rock, the surveyors enlarging natural pools or digging out soaks and wells. Later, rocks were developed as water supplies for towns and homesteads. Some have been promoted as recreation or picnic sites - Wave Rock at Hyden is a well-known example. Some outcrops have been mined, for monumental masonry, or railway ballast. Granite has also been used for memorials, such as the one to Donald Campbell at Dumbleyung.

► WATER

With their shallow, uneven soil, granite outcrops offer few real opportunities for economic exploitation, except for the harvesting of water. Many large outcrops were developed as water-supply sites, but few of these are now maintained. Within individual paddocks, run-off from outcrops may also be channelled into dams.



Water supply development, central wheatbelt.

Any run-off water that is not used will contribute to the problem of rising water tables and salinity on lower land. Thus it is important to utilise the water where it falls as much as possible, and this can be done by recreating a dense screen of shrubs and trees on the apron and along the outfall creeks, where they have defined channels. This will be most important in collecting water during run-off from summer storms, and minimising erosion downslope. A dense thicket of shrubs and trees and a ground cover of smaller shrubs and annuals will all be needed.

► SANDALWOOD

The possibilities of cultivating a commercial crop on the granite area are less certain. Sandalwood was once very common in the thickets and woodlands, and could be replanted, using wattles as hosts. But the growth rate is variable, since each plant is dependent on the vigour of its individual host, and it can take up to 90 years to reach harvestable size. However, there is a speciality market for sandalwood nuts, and observations have shown that fruiting commences 4 years after establishment at Northampton and 8 years at Dryandra Forest near Narrogin. However, yield quantity and quality are variable and are strongly influenced by seasonal conditions.

► FOLIAGE AND SEED

Several plants cut for foliage or flowers are also native to granite outcrops, such as the mallees silver princess, Southern Cross mallee, round-leafed mallee and Webster's mallee. In their natural state these are found in shrubby islands high on the rocks, but they would produce a better commercial crop if planted on a deeper soil. Plant them in the apron around the rock, rather than in their proper ecological niche in water-concentrating gullies. It would make harvesting easier too! Collection and sale of native plant seed may also yield some commercial return, especially if they are more unusual species with horticultural potential.

► WILDLIFE HABITAT

It is probably best to consider granite outcrops as areas to be rehabilitated for wildlife habitat and water management, rather than trying to extract a commercial crop from them. From the nature conservation point of view, rock outcrops had two important features which allowed many of them to remain as islands in the sea of agricultural land. Firstly, the soils are too shallow to plough and too steep to crop. Secondly, they often carried populations of 'poison peas'. These plants, from the genus *Gastrolobium*, contain a substance similar to the poison 1080. Native herbivores can eat this without harm, but it kills introduced stock very quickly.

These two features, if together, led to the efficient fencing of the outcrop, and so its vegetation survived in good condition. However, if there were no poison plants, the rock, though not actively cleared, has often been subjected to grazing pressure. This changes the vegetation community, sometimes leading to its total removal.

EFFECT OF GRAZING

Prolonged grazing by stock (or rabbits) has three main effects on the plant communities that occur in association with granite outcrops:

- ◆ reduction in the number and diversity of native plant species
- ◆ replacement by weed species
- ◆ increase in run-off and soil erosion, which can alter the resources available to plants.

Stock grazing and trampling by hooves takes out firstly the most palatable plants and the most easily damaged. Eventually, the shrubs show a clear browse line and ground layer plants



Capeweed is growing in this sward on a pile of rabbit dung.

seldom reach maturity. The soil seed bank begins to decline. When seedlings do germinate, they are very vulnerable to grazing and trampling, so natural regeneration is severely inhibited. Plants resistant to grazing increase in numbers. These might be prickly native shrubs, such as standback and needlebush, but they are often introduced weeds such as Cape tulip and fountain grass. Competition from these weeds decreases the survival of most native species.

Stock trails cut up the pincushion swards, which then begin to erode. Elsewhere, as plant cover decreases, soil erosion increases. Once the soil is no longer protected, flood events and soil erosion downslope increase in number and severity.

When the plant community on the outcrop is intact, water infiltrates into and is held in the soil, often seeping out many months later and maintaining water levels in the gnammas. The soil surface often has a crust of algae and lichens, which help regulate water flow and infiltration (as well as adding nitrogen to the system, since many are nitrogen-fixing). Trampling destroys this crust and the remaining soil becomes non-wetting. Plants depend on the soil water for their survival, especially over



Uncontrolled grazing has removed most of the plants on this area; Yoting



If this site were not fenced, grazing would have eliminated most of the plants; Mt Marshall.

summer. Without efficient infiltration of water, plants on the shallow soils of the apron become more subject to decline and drought death.

In all, the 'biological productivity' of the rock outcrop decreases.



MANAGEMENT

Before deciding how to manage your granite areas, first decide the values and uses you intend for the area. These become your management objectives.

Some examples might be:

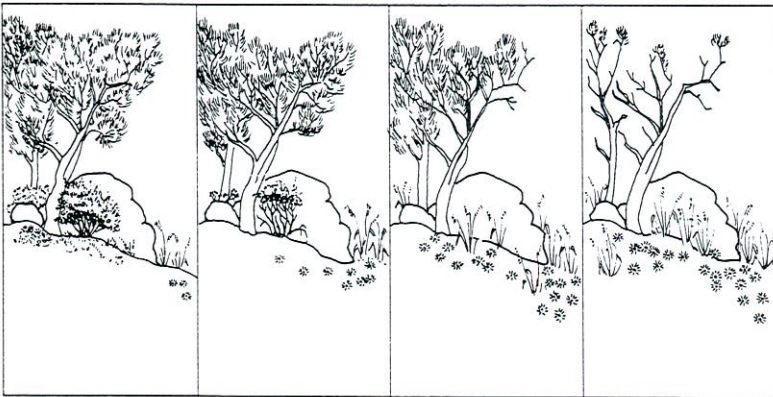
- ◆ to protect and conserve the existing native plants and animals and regenerate degraded areas
- ◆ to maximise use of water by vegetation around the rock, so decreasing recharge into the catchment and preventing erosion of crop paddocks
- ◆ to provide a supply of fencing timber and native plant seed
- ◆ to preserve an attractive picnic area
- ◆ to preserve a well or catchment built during the early days of settlement.

Next, assess the quality of the remnant vegetation, since the better the quality, the less management you will have to do. (We assume here that good quality plants will provide good quality animal habitat.) For your site, consider whether the various habitat features (as listed on pp 3 - 13) are present, and if they show signs of disturbance, and then assign it to category 1 to 4.

When deciding upon management actions, aim to go up one step in quality at a time.



Attractive picnic area; Helena Valley.



1 EXCELLENT
trees
shrubs
understorey
few weeds

2 GOOD
grazing damage
some weeds
little
regeneration

3 MODERATE
trees
few shrubs
many weeds
no regeneration

4 POOR
weeds mainly
soil erosion
evident



Regeneration 3 years after fire - note height of burnt shrubs, to which this community will eventually return; Mt. Stirling.

1 EXCELLENT QUALITY SITE - NEARLY UNDISTURBED REMNANT

This would be an area that has received minimal impact, perhaps a reserve for water or nature conservation, or a private remnant that has long been securely fenced. (It is a good idea to look at such a place to see what a local granite community should look like.)

This sort of site will largely look after itself, you merely need to minimise outside degrading influences.



Wedding bush

CHARACTERISTICS

- intact site, all expected plant communities (swards, shrubby thickets, fringing woodland) present and healthy, with trees, shrubs, ground layer, leaf litter and soil crusts as appropriate
- native plant seedlings in appropriate sites show regeneration is occurring
- little or no history of grazing
- little or no disturbance, or disturbance confined to a small area of the whole - e.g. rock removal and wall construction for water harvesting confined to only part of area
- few weeds, or on edges only

MANAGEMENT NEEDED

- minimise disturbance, or, confine it to already-disturbed areas
- maintain fence to exclude stock
- monitor and control exotic animal occurrences
- monitor and control problem weed outbreaks
- ensure that external factors do not contribute to degradation



This site has been fenced for some 30 years. After a drought year, and in the absence of fire, the shrubs are thinning out; Avondale.



Note that grass weeds have replaced everlastings where there is greater run-off; Coarin Rock.

2 GOOD QUALITY SITE - SOME DISTURBANCE

This might be an area that has received only occasional light grazing by stock. With a small management effort, it can be returned to excellent quality.

CHARACTERISTICS

- all expected plant layers present, but sparse and may show signs of stress
- few signs of natural regeneration
- signs of grazing damage to shrubs and ground layer
- soil erosion starting on swards or apron
- change in soil structure evident, but not widespread
- weeds noticeable, may be up to 50% of ground layer

MANAGEMENT NEEDED

- fence to exclude stock
- control exotic animals
- control problem weeds
- encourage natural regeneration
- ensure that external factors do not contribute to further degradation

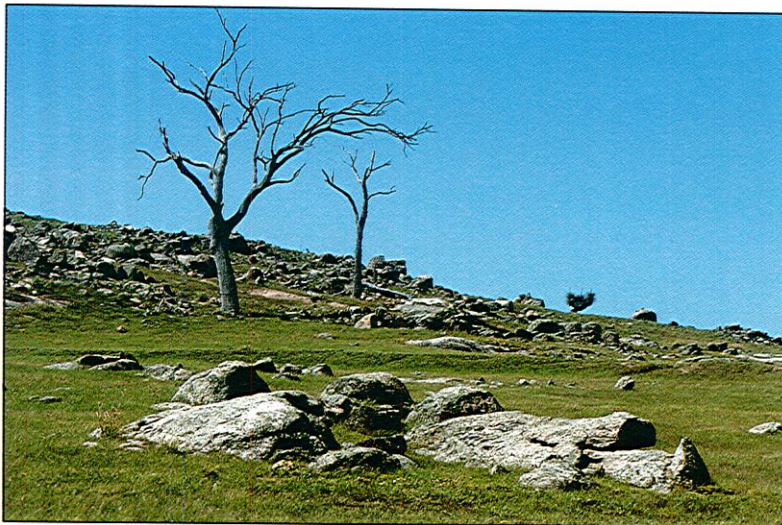


Sward totally replaced by the bulb weeds, Cape tulip and sparaxis; St. Ronan's Well, York.

3 MODERATE QUALITY SITE - CONSIDERABLE DISTURBANCE

These sites may have had a long history of grazing, or too frequent fires, or uncontrolled public access. By working outwards from the least affected areas, the quality can be raised to good.

CHARACTERISTICS	MANAGEMENT NEEDED
<ul style="list-style-type: none"> • plant community simplified, often with shrub and native ground layer sparse or absent • no signs of natural regeneration • any remaining palatable shrubs show heavy grazing damage • change in soil structure evident • clear signs of soil erosion and wash • weeds dominate ground layer • few surface rock slabs remain 	<ul style="list-style-type: none"> • fence to exclude stock • control feral animals • control major degrading weeds • encourage natural regeneration • replace key tree, shrub and ground layer species by a combination of planting and direct seeding



Apart from one balga, little remains of the York gum woodland which would once have covered this site; Beverley.

4 POOR QUALITY SITE - DEGRADED REMNANT

These sites will have had a long history of uncontrolled stock access. A major revegetation effort will be required.

CHARACTERISTICS

- plant community severely altered, the few remaining original species may show severe stress, may be dead or dying
- plant community dominated by weeds, crop or pasture plants, often annuals rather than perennials
- no soil crusts
- erosion and rapid run-off evident
- little or no surface rock slabs

MANAGEMENT NEEDED

- fence to exclude stock
- protect any natural regeneration which does occur
- revegetate with species appropriate to the present nature of the site and aims for its use
- control feral animals
- control invasive weeds

MANAGEMENT ACTIONS

- 1 Minimise disturbance to fragile areas
- 2 Fence to exclude stock
- 3 Control rabbits and goats
- 4 Control weeds
- 5 Encourage natural regeneration - soil preparation - fire
- 6 Replant seedlings of key species
- 7 Use direct seeding to create nodes of dense shrubbery and to re-introduce ground cover
- 8 Control foxes / feral cats
- 9 Design and install specific fauna habitat features
- 10 Install buffers to minimise external influences
- 11 Manage or create bush corridors to connect isolated sites
- 12 Special management of recreation sites

1 MINIMISE DISTURBANCE TO FRAGILE AREAS

Loose slabs of rock ('moss rock') are often removed for various purposes - this destroys a valuable habitat and should not be permitted where wildlife conservation is an aim.

Grass swards are very fragile. They can be easily damaged even by humans or stock walking on them, especially in summer when the plants are dormant. Vehicles driving over swards not only severely damage the plants, but displace the soil and start the sward eroding. To keep the rock in top condition, walk only on bare rock and try not to drive on it at all. If access to a picnic site is needed across a sward, place rock stepping stones and ensure visitors use them. If public recreation is a major purpose of the area, locate paths and trails to channel the visitors into the sites least likely to be degraded (i.e. low gradient areas).

Take care not to allow silt and extra nutrients to settle in rock pools as this will encourage weed growth and adversely

affect the diversity of aquatic invertebrates and tadpoles. For example, try to ensure that a nearby stock trail or vehicle track does not channel run-off across the granite. If necessary, construct a small diversion bank.

Aboriginal people often covered gnammas with rock sheets to keep the water sweet and prevent evaporation in summer. If these sheets are still present, they should be left as a cover.

If the area is being managed for fauna habitat, e.g. for rock-wallabies, dogs should be prohibited.

2 FENCE TO EXCLUDE STOCK

The first action often made to protect remnant vegetation is to fence it to exclude stock. Regeneration of native plants may then occur, depending upon:

- ◆ what seed is present on site - produced by living plants or stored in the soil
- ◆ how strong the weed competition is
- ◆ whether a 'disturbance event' occurs which triggers germination
- ◆ whether grazing pressure from other herbivores (rabbits, kangaroos) removes seedlings.

Seed on site could come either from existing plants, be carried in from outside, or be held in the soil as part of the 'soil seed bank'. Some plants, such as Christmas trees and many eucalypts, have seeds which lose viability quickly, and thus need to come from living plants, but others may be very long-lived. Wattles and peas are of this kind. For example, jam is notorious for appearing up to 60 years after it was last known from a site, once a disturbance occurs (such as the creation of a contour bank) to stimulate germination. However, as a general rule, the longer the seed remains in the soil the less likely it is to remain viable. In addition, on sloping sites, soil erosion may have removed the soil-stored seed. Thus the extent of the soil seed bank will depend on the length of time since the various plants produced the seed, and whether there has been much erosion.



Outcrop on 'Eden Valley'; Dumbleyung, in 1991, just after fencing.



The same site in 1997. Note natural regeneration of rock sheoak, reeds, wattles and other shrubs. (photo: Terri Lloyd)

3 CONTROL RABBITS AND GOATS

Rabbits graze the vegetation, and in drought will also ringbark shrubs and burrow to eat roots. In addition, their dung piles provide ideal sites for weed establishment and are a major cause of weed infestation in granite swards high above the landscape. Rabbits have no place in the Australian countryside.

In arid zones, feral goats are a major problem and they are sometimes found on rock outcrops in the northern wheatbelt. They tend to camp on rocks, and graze the vegetation heavily, leading to severe degradation. All feral goats should be eliminated from the agricultural area.

Consult Agriculture Western Australia for control methods.

4 CONTROL WEEDS

If the granite outcrop is an island in the middle of a paddock, the seeds most likely to enter from outside will be crop or paddock weeds. Seed of silver grass, wild oats, capeweed, lupins or radish may be blown in, while subclover germinates from sheep droppings - and these also increase the soil nutrient level, making it easier for weeds to survive. Birds eat fleshy fruits, such as bridal creeper and black nightshade, and may carry the seeds a considerable distance before excreting them in their droppings. Rabbits transport other seeds, such as capeweed.

Weeds form a dense thatch over the ground, preventing native seeds from reaching the soil. Weeds also outcompete native plant seedlings, so that only large-seeded plants, like the big wattles, are able to cope.

Another problem that weeds - especially grasses - create, is that they may alter the fire characteristics of the vegetation. They provide an annual load of very flammable fuel, with a continuous fuel-bed, which ignites easily and burns very hot at ground level. Burning of this fuel - either accidentally or to reduce the wildfire threat - usually kills the native plants and creates better conditions for increased weed growth in the following year. If there is any

possibility of fire entering the remnant from outside, a grass-free zone should be maintained around the edge.

The best defence against weeds is to prevent establishment. Do not permit rubbish dumping in the bushland. If wind blows soil and seed in from a paddock, plant a buffer of dense native vegetation between the source of the weed seeds and the remnant.

If there are few weeds, it is worth attempting eradication. Work from the least weedy areas outwards. If total eradication is not feasible, remove weeds from the most important areas first. If a new weed is noticed as it first becomes established, remove it when it is few in numbers. Tackle the most invasive and degrading weeds first, e.g. bridal creeper, and attempt complete eradication. If large areas are involved, remember to have native seed ready to fill the space left by the weed.

References for weed management can be found at the rear of this booklet.

5 ENCOURAGE NATURAL REGENERATION - SOIL PREPARATION - FIRE

Many native plants require a 'trigger' to initiate germination - but the problem is that we often don't know what that trigger - or combination of triggers - might be! Heavy summer rains, held in temporary ponds, may be the key for some species, while others may respond to fire. Bushfires bare the ground and release easily-available nutrients while their heat opens woody fruits such as banksias and hakeas. Even more importantly, the chemicals released in the smoke, falling on the soil and then leaching down



Wandoo and powderbark seedlings on ashbed.

into it, stimulate the seed bank into growth. Weed seeds are not stimulated by smoke. (But note, fire is a two-edged sword - it can stimulate regeneration, but also cause local extinction. Refer to 'Managing Your Bushland' for greater detail about fire use. As a general rule, if you consider that a fire is necessary, only burn small areas in any one year.)

Even assuming that the plants on site are producing viable seed - this may not always be so, for example, the appropriate pollinator might not be present - the seed falling to the ground needs to find a niche to germinate in. A thatch of weeds and litter will prevent it reaching the ground at all. If the soil is hard-packed, seed is less likely to be able to survive, and cultivation will be needed. Where there is dense weed infestation, e.g. of Cape tulip, scalping the topsoil totally away could be useful, but appropriate seed should be collected first, ready to spread onto the bare soil areas created.

The best encouragement for natural regeneration is to eliminate weeds and then wait for nature to take its course. This may be many years ... (You can speed up the action by having some native seeds ready to scatter into the bare areas.) An ashbed, formed after a heap of logs has burnt out, provides a good site for regeneration of many plants such as wandoo, mallees and Goldfields eucalypts.

6 REPLANT SEEDLINGS OF KEY SPECIES

If a particular key element of the vegetation is missing from the site - perhaps it no longer carries nitrogen-producing wattles or peas - appropriate seedlings could be replanted. It might also be a suitable technique for adding specific beautiful or bird-attracting plants whose seed is difficult to obtain, so unlikely to be used for direct seeding, for example magnificent grevillea or scarlet honeymyrtle.

Try to imitate nature by putting the seedlings into the sort of places they would be growing anyway. (Note: seedling planting goes best around the outcrop, where there is uniformly



Revegetation of an outcrop; Avondale.

deeper soil. It's a chancy business planting seedlings into shrubby islands on the rock itself. Direct seeding is suggested here, as letting the plants grow at their own pace provides more likelihood of long-term plant survival in the more difficult habitats.)

7 USE DIRECT SEEDING TO CREATE NODES OF DENSE SHRUBBERY AND TO REINTRODUCE GROUND COVER

Success with direct seeding relies upon three features:

- ◆ being able to collect suitable seed
- ◆ good site preparation, including removing all weeds
- ◆ controlling predators such as red-legged earth mites and grazers such as rabbits.

Use direct seeding, perhaps in combination with seedling planting, to create 'habitat islands' of dense shrubs / trees / ground covers, especially on the apron around the edge of the rock. (For detail of how to collect the seed, refer to Wildlife Note No. 4 'Seed Collecting from Native Plants'.)

- ◆ Collecting seed from ground covers

Many annual plants, such as daisies, flourish wherever there is enough soil. Some, such as everlastings and trigger plants, are very attractive. Other small plants, such as orchids and lilies, are also part of the ground layer. While it is possible



Direct seeding at St. Ronan's Well Reserve; York 1993.



'Habitat island' created, 1997.

to collect seed from these plants, it is time-consuming and fiddly. Try litter brushing. During August-October, select a site where native ground covers are growing well, and there are few (hopefully no!) weeds. Mark the boundaries of the site with surveyor's tape. Return in late January. Carefully sweep up all the loose surface material from your marked area. As well as stones and leaf litter, it will, hopefully, contain lots of seeds. An additional bonus is that it may well contain useful micro-organisms. This material could be spread out directly onto a prepared site, or alternatively stored in a dry place, then incorporated with your direct seeding.

8 CONTROL FOXES / FERAL CATS

Neither of these animals have a place in the Australian countryside. They should be eradicated as far as possible. Controlling rabbits with 1080 grain baits will also help to eradicate foxes and cats by secondary poisoning. All control programs should be on-going.

Consult Agriculture Western Australia or CALM for detail of methods.

9 DESIGN AND INSTALL SPECIFIC FAUNA HABITAT FEATURES

If any of the specific habitat features, such as crevices under rock sheets, are not present on your area, it may be possible to create a substitute. For example, logs, dragged to the edge of the rock sheet, may provide an acceptable substitute for lizards. Piles of rocks removed from paddocks provide excellent habitat for dunnarts.

If rock pools have become choked with weeds and stock droppings, try removing all the soil to open them up into pools again. (But note, in-filling is a natural process. If native plants are filling the space, do not disturb!)

Plant thickets of dense, prickly shrubs to provide suitable small bird nesting habitat that will also deter nest predation by feral cats.

10 INSTALL BUFFERS TO MINIMISE EXTERNAL INFLUENCES

If material is being blown or washed in from surrounding areas, consider installing a buffer to trap the incoming soil and weed seeds, and strip out the nutrient. It could be planted along a contour bank which would prevent surface run-off from

entering the remnant. The plants used might possibly include a native wattle, e.g. golden wreath wattle, that could also be used for fodder, although in this case summer grazing could eliminate its value as a windbreak.

11 MANAGE OR CREATE BUSH CORRIDORS TO CONNECT ISOLATED SITES

Granite outcrops were always individual features but, before clearing, birds or small animals were able to move through the connecting bushland to find another site. This would have been especially important if a disaster, such as a fire, burnt out one rock. However, rocks are now isolated in farmland, and much of this connectivity has been lost.

Try to link together the rock outcrops in the local region with a network of bush corridors so that the small birds that are vital for pollination can reach all areas. Bush corridors are areas of habitat that fauna can use to move across the landscape. They are especially important for small birds. In many areas the only bush corridors left are along roadsides, but revegetation areas, whether they be for windbreak, shelter belt or water table management, can provide a corridor function if they are properly designed. A mix of species, including a variety of shrubs which flower at different seasons, and some of which form dense cover at ground level, would be a good start. Also, the wider the better!

12 SPECIAL MANAGEMENT OF RECREATION SITES

Rock outcrops are often used by people as recreation sites, and many have specific public recreation facilities. These rocks need very special management if they are not to be degraded by the visitors. If contemplating encouraging recreational use, it is suggested that you consult an expert (e.g. the recreation specialist at your local CALM office). The following points are among those that should be considered:

- ◆ Location of facilities - parking, toilets and picnic sites should be confined to the woodland around the rock. Barriers should be installed to prevent driving off the designated area. No driving should be permitted on swards or through thickets as it quickly leads to damage to fragile communities and erosion of shallow soil.
- ◆ Walk trails should follow easy gradients and cross open rock, avoiding swards.
- ◆ Lookouts should be positioned on open rock.
- ◆ Trail markers should be unobtrusive and visible only to those actually using the trail.
- ◆ Information signs should be located where they do not visually obtrude.
- ◆ BBQ sites should only be installed in open areas, and be designed so as to minimise the risk of fire escaping. Gas BBQs are preferable, if installation is feasible.
- ◆ Firewood should be provided, or visitors will scavenge dead wood or fell living trees - to the detriment of the ecosystem.
- ◆ Firebreaks should be installed and maintained around the facilities area.

MONITORING

All management actions should be monitored to see whether they are having the desired effect. The easiest technique is to use 'photo points'. This involves taking a photograph from a specific position on a regular basis - say once a year. The photographs can then be compared to note natural regeneration, plant growth rates, recovery after grazing exclusion, effect of weed management actions, extent of soil erosion, etc.

Keen naturalists might like to try something a little more detailed. Plant regeneration can be recorded in a 'quadrat' or along a 'transect' (see further reading for details). With a little bit of practice these quadrats can be done so accurately that they can



Koorda School students monitoring regeneration after fire; Kularin.

mesh in with the State's ecological database. Consult the Wildflower Society of Western Australia to see whether they can help with this technique.

Birds can be recorded by walking a set transect at a set time on four occasions during the year. Consult Birds Australia to see whether they can help with this technique.

A more informal variation of these techniques is the 'random stratified stroll'. This is a pleasant ramble, making sure you visit all the different types of habitats and recording plants in flower and fauna seen as you go. If this pleasant activity is done at different seasons, and over several years, the pattern of life on the rock will emerge.

MORE INFORMATION

For more information about local granite outcrops and their flora and fauna, contact your local *Land for Wildlife* officer or CALM office.

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FLORA AND FAUNA LISTS

LIST 1

Birds common around granite outcrops (note: this list assumes that there is also some woodland associated with the outcrop).

Emu	Willie Wagtail
Black Shouldered Kite	White-browed Babbler
Collared Sparrow Hawk	Splendid Fairy-wren
Australian Kestrel	Red-winged Fairy-wren
Australian Hobby	Blue-breasted Fairy-wren
Wedge-tailed Eagle	White-browed Scrubwren
Stubble Quail	Weebill
Banded Lapwing	Western Gerygone
Common Bronzewing	Inland Thornbill
Crested Pigeon	Yellow-rumped Thornbill
Regent Parrot	Red Wattlebird
Port Lincoln Ringneck	Little Wattlebird
Galah	Singing Honeyeater
Mulga Parrot	Yellow-plumed Honeyeater
Pallid Cuckoo	Brown Honeyeater
Tawny Frogmouth	New Holland Honeyeater
Rainbow Bee-eater (<i>spring-summer only</i>)	White-cheeked Honeyeater
Welcome Swallow	Western Spinebill
Tree Martin	White-fronted Chat
Richard's Pipit	Striated Pardalote
Black-faced Cuckoo-shrike	Silvereye
Red-capped Robin	Black-faced Woodswallow
Western Yellow Robin	Masked Woodswallow
Jacky Winter	Dusky Woodswallow
Rufous Whistler	Grey Butcherbird
Golden Whistler	Pied Butcherbird
Grey Shrike-thrush	Magpie
Grey Fantail	Australian Raven

LIST 2

Frogs and reptiles common on granite outcrops

FROGS

Granite Froglet
Spotted Burrowing Frog
Western Banjo Frog
Orange-crowned Toadlet
Gunther's Toadlet

Speckled Stone Gecko
Western Saddled Ground Gecko
Barking Gecko
Western Granite Worm Lizard
Burton's Legless Lizard
Thorny Devil
Ornate Dragon
Gould's Monitor
Black-tailed Monitor
Bobtail Lizard
Carpet Python
Mulga Snake
Dugite

REPTILES

Marbled Gecko
Western Spiny-tailed Gecko
Tree Dtella
Reticulated Velvet Gecko
Wheatbelt Stone Gecko

LIST 3

Mammals found around granite outcrops

NATIVE MAMMALS

Echidna
Red-tailed Phascogale
Fat-tailed Dunnart
Western Pygmy-possum
Brush-tail Possum
Mitchell's Hopping-mouse
Black-flanked Rock-wallaby
Euro
Western Grey Kangaroo

INTRODUCED MAMMALS

House Mouse
Black Rat
Rabbit
Sheep
Goat
Cat
Dingo/Dog
Fox



Ornate Dragon

LIST 4

PLANTS CHARACTERISTIC OF GRANITE OUTCROPS

It would be quite impractical to write a total list of the plants found on granite outcrops in the south-west - it would be far too long! Instead, the main genera of plants in each of the categories are listed. Species local to the area could then be noted by observation, perhaps enlisting the help of the local Community Herbarium (ring the WA Herbarium 08 9334 0500 for local contacts).

However, to help with rehabilitation, species that are fairly widespread, can be grown easily from seed, and are usually available commercially, are given in List 5.

TREES

<i>Allocasuarina</i>	rock sheoak	widespread throughout area
<i>Eucalyptus</i>	gums	important in deeper soil around rock
	mallees	some species restricted to granites
<i>Santalum</i>	quandong/ sandalwood	semi-parasitic, often on wattles

SHRUBS - FOUND IN ISLANDS, THICKETS AND APRON

<i>Acacia</i>	wattles	major component of rock flora, nitrogen-fixing, may be relatively short-lived
<i>Allocasuarina</i>	tammias/ scrub sheoak	thickets and apron
<i>Calothamnus</i>	one-sided bottlebrushes	bird pollinated
<i>Calycopeplus</i>	-	large shrubs with inconspicuous flowers
<i>Dodonea</i>	hopbushes	often on shrubby islands
<i>Gastrolobium</i>	poison peas	contain 1080 - nitrogen-fixing
<i>Grevillea</i>	grevilleas	attractive, mostly bird-pollinated
<i>Hakea</i>	hakeas	attractive, often prickly
<i>Kunzea</i>	kunzeas	some granite specialists
<i>Leptospermum</i>	teatree	attractive in flower

<i>Melaleuca</i>	honeymyrtles	many granite specialists
<i>Pimelea</i>	banjines	attractive in flower
<i>Ricinocarpos</i>	wedding bush	attractive in flower
<i>Verticordia</i>	featherflowers	some confined to granites

PERENNIALS - FOUND IN ISLANDS, THICKETS AND APRON

<i>Borya</i>	pincushions	characteristic of swards
<i>Cheilanthes</i>	rock ferns	cracks, crevices, swards and thickets
<i>Dampiera</i>	dampieras	always blue, thickets and woodland
<i>Glischrocaryon</i>	pop flower	thickets and woodland
<i>Ptilotus</i>	mullamullas	swards and thickets
<i>Stylidium</i>	triggerplants	swards and thickets
<i>Stypandra</i>	blind grass	widespread, characteristic of granites
<i>Xanthorrhoea</i>	balgas	mostly higher rainfall areas

GRASSES AND REEDY THINGS

<i>Amphipogon</i>	greybeard grasses	small, delicate tussocks
<i>Aristida</i>	wind grass	small tussock, often with reddish tinge
<i>Danthonia</i>	wallaby grasses	small, delicate tussocks
<i>Ecdeiocolea</i>	cord rush	large tussock, often under tamma
<i>Gahnia</i>	gahnias	very large reedy tussocks in thickets
<i>Lepidosperma</i>	sword sedges	reedy clumps, one large species specialises in cracks and islands
<i>Loxocarya</i>	curly grass	forms tangled mats
<i>Neurachne</i>	mulga grass	widespread, small tussock
<i>Stipa</i>	spear grasses	medium tussocks

GEOPHYTES - PLANTS WHICH DIE BACK EACH YEAR TO AN UNDERGROUND STORAGE ORGAN

<i>Arthropodium</i>	chocolate lily	common in thickets
<i>Caladenia</i> etc	orchids	found in all areas
<i>Chamaescilla</i>	blue squill	common in thickets and woodland
<i>Drosera</i>	sundews/ rainbows	carnivorous, trap insects on sticky leaves
<i>Haemodorum</i>	bloodroots	black flowers, red juice in root
<i>Tribonanthes</i>	-	flowers felty, usually white
<i>Wurmbea</i>	nancies	common in swards and meadows

ANNUALS

<i>Brachycome</i>	Swan River daisies	swards and thickets
<i>Brunonia</i>	blue pincushions	thickets and woodlands
<i>Calandrinia</i>	parakeelyas	swards
<i>Centrolepis</i>	-	swards
<i>Quinetia</i>	-	swards
<i>Rhodanthe</i> etc	everlastings	thickets and woodland
<i>Rutidiosis</i>	-	swards
<i>Siloxeros</i>	fairy pillows	swards
<i>Stylidium</i>	triggerplants	swards
<i>Trachymene</i>	sponge fruit	swards and woodlands
<i>Waitzia</i>	everlastings	thickets and woodlands

LIST 5

COMMON SPECIES WHICH COULD BE USED FOR REHABILITATION

All of these grow well from seed, which should be available commercially.

TREES

<i>Allocasuarina huegeliana</i>	rock sheoak	all areas (also a nitrogen-fixer)
<i>Eucalyptus loxophleba</i>	York gum	central wheatbelt
<i>Eucalyptus wandoo</i>	wandoo	Darling Range and western wheatbelt
<i>Santalum acuminatum</i>	quandong	all areas, semi-parasitic, wattle host, edible fruit
<i>Santalum spicatum</i>	sandalwood	all areas, semi-parasitic, wattle host, edible fruit, perfumed wood
<i>Pittosporum phylliraeoides</i>	weeping pittosporum	all areas except high rainfall and south coast

MALLEES - (rare - but seed is available)

<i>Eucalyptus caesia</i>	silver princess	islands and thickets, eastern wheatbelt
<i>E. crucis</i>	Southern Cross mallee	"
<i>E. orbifolia</i>	round-leafed mallee	"
<i>E. websterana</i>	Webster's mallee	"

LARGE SHRUBS - NITROGEN-FIXERS

<i>Acacia acuminata</i>	jam	all areas
<i>Acacia faunfleroyi</i>	-	eastern wheatbelt
<i>Acacia inophloia</i>	-	central and eastern wheatbelt
<i>Acacia lasiocalyx</i>	caterpillar wattle	all areas
<i>Acacia microbotrya</i>	manna wattle	all areas
<i>Acacia saligna</i>	golden wreath wattle	all areas
<i>Acacia tetragonophylla</i>	kurara	northern and eastern wheatbelt
<i>Acacia trigonophylla</i>	-	central and eastern wheatbelt
<i>Allocasuarina acutivalvis</i>	black tamma	wheatbelt
<i>Allocasuarina campestris</i>	tamma	wheatbelt and south coast
<i>Allocasuarina humilis</i>	scrub sheoak	all areas, especially higher rainfall

SMALL SHRUBS - NITROGEN FIXERS

<i>Acacia horridula</i>	-	Darling Range
<i>Acacia pulchella</i>	prickly moses	all areas
<i>Acacia restiaceae</i>	-	all areas except higher rainfall
<i>Daviesia decurrens</i>	prickly bitterpea	higher rainfall and western wheatbelt
<i>Gastrolobium callistachys</i>	granite poison	wheatbelt
<i>Gastrolobium spinosum</i>	prickly poison	all areas
<i>Hovea pungens</i>	devil's pins	higher rainfall and central wheatbelt
<i>Indigofera australis</i>	-	northern wheatbelt
<i>Mirbelia ramulosa</i>	-	all areas
<i>Nemcia acutum</i>	-	Darling Range
<i>Senna nemophila</i>	Cassia	northern and eastern wheatbelt

LARGE SHRUBS

<i>Calothamnus gilesii</i>	-	eastern wheatbelt
<i>Calothamnus rupestris</i>	mouse ears	Darling Range
<i>Dodonea attenuata</i>	hop bush	all areas
<i>Hakea petiolaris</i>	urchins	central and southern wheatbelt and higher rainfall
<i>Hakea preissii</i>	needlebush	all areas
<i>Hakea prostrata</i>	rough hakea	all areas
<i>Hakea recurva</i>	standback	northern, central and eastern wheatbelt
<i>Grevillea bipinnatifida</i>	fuchsia grevillea	Darling Range

<i>Grevillea magnifica</i>	magnificent grevillea	central and eastern wheatbelt
<i>Grevillea paniculata</i>	-	wheatbelt and south coast
<i>Kunzea baxteri</i>	Baxter's kunzea	south coast
<i>Kunzea pulchella</i>	granite kunzea	central and eastern wheatbelt
<i>Leptospermum erubescens</i>	roadside teatree	all areas
<i>Melaleuca elliptica</i>	granite bottlebrush	eastern wheatbelt and south coast
<i>Melaleuca fulgens</i>	scarlet honeymyrtle	central and southern wheatbelt and south coast
<i>Melaleuca macronychia</i>	-	central and eastern wheatbelt
<i>Melaleuca radula</i>	graceful honeymyrtle	northern and central wheatbelt, Darling Range
<i>Ricinocarpos glaucus</i>	wedding bush	southern wheatbelt and Darling Range
<i>Santalum acuminatum</i>	quandong	all areas
<i>Santalum spicatum</i>	sandalwood	all areas except very high rainfall

SMALL SHRUBS

<i>Beaufortia purpurea</i>	-	Darling Range
<i>Calothamnus quadrifidus</i>	one-sided bottlebrush	all areas
<i>Calothamnus sanguineus</i>	silky bloodflower	higher rainfall, northern and central wheatbelt
<i>Diploleana microcephala</i>	-	northern and central wheatbelt
<i>Melaleuca scabra</i>	rough honeymyrtle	all areas

PERENNIALS

<i>Ptilotus polystachyus</i>	green mullamulla	northern, central and eastern wheatbelt
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CREEPERS

<i>Clematis microphylla</i>	old man's beard	higher rainfall, central wheatbelt and south coast
<i>Kennedia prostrata</i>	running postman	all areas
<i>Sollya heterophylla</i>	Australian bluebell	higher rainfall, central wheatbelt and south coast

LIST 6

WEEDS

Major problem weeds - should be eradicated if possible

<i>Asparagus asparagoides</i>	bridal creeper	will smother low vegetation
<i>Babiana</i> spp.	baboon flowers	will totally replace ground layer in sward and thicket
<i>Chamaecytisus palmensis</i>	tagasaste	replaces large wattles
<i>Echium plantagineum</i>	paterson's curse	replaces other annuals
<i>Homeria</i> spp.	Cape tulips	major paddock weeds also
<i>Watsonia meiriana</i>	watsonia	will replace all plants to dominate sward
<i>Zantedeschia aethiopica</i>	arum lily	higher rainfall areas

WIDESPREAD WEEDS, ERADICATION PROBABLY IMPRACTICAL

<i>Aira</i> spp.	hair grasses	delicate annuals in sward and woodland, very widespread
<i>Arctotheca calendula</i>	capeweed	common paddock weed - spread in rabbit droppings
<i>Avena</i> spp.	wild oats	replaces annuals such as everlastings
<i>Briza</i> spp.	blowfly/ shivery grasses	very widespread, replaces annuals such as everlastings
<i>Ehrharta</i> spp.	veldt grasses	very widespread
<i>Freesia</i> hybrids	freesia	spread from settlement sites
<i>Gynandris setifolia</i>	thread iris	wheatbelt woodlands
<i>Hypochaeris</i> spp.	flatweed	replaces annuals such as everlastings
<i>Lolium perenne</i>	ryegrass	common paddock weed, may be herbicide resistant
<i>Osteospermum clandestinum</i>	stinking roger	annual in thicket and woodland
<i>Oxalis pes-caprae</i>	soursob	paddock weed also
<i>Romulea rosea</i>	Guildford grass	ubiquitous
<i>Solanum nigrum</i>	black nightshade	seed spread by birds and rabbits
<i>Ursina anthemoides</i>	ursina	annual in sward, thicket and woodland

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