

NATURALISED PLANTS ON THE SOUTHERN SLOPES OF THE WESTERN END OF THE HELENA VALLEY, WESTERN AUSTRALIA.

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ABSTRACT

The distribution and abundance of introduced flowering plants on the southern side of the Helena Valley where it cuts through the Darling Escarpment are described. Some comparison is made with naturalised floras elsewhere in the State.

INTRODUCTION

Western Australia has a rich and varied flora which developed in isolation for millions of years. Even the advent of Aboriginal Man some 40,000 years ago probably had little effect on the species composition of the flora as the Aboriginal people were hunters and gatherers rather than agriculturalists so probably moved very few plant species from place to place. However, the advent of European people from 1829 onwards had a dramatic effect on the flora. Not only did the new settlers bring their crops and ornamental plants but they also brought, often unknowingly, numerous other species, many of which have become naturalised to become part of the Western Australian flora.

Long-settled areas and sites close to settlement usually show the greatest alteration in floristics due to the effect of introduced plants (Bridgewater and Backshall 1981). Parts of the Helena Valley have been alienated as freehold land since 1830 and subjected to landuses creating considerable disturbance - grazing, quarrying, rail transport, power and water pipeline construction - yet it still retains excellent stands of native vegetation. This study looks at the extent of introduced plants in the south-western part of the Helena Valley, on the slopes of Gooseberry Hill.

STUDY AREA

The study location covers the south-western side of the Helena Valley, from the built-up area of Gooseberry Hill to the Helena River (excluding grazed paddocks) and from the picnic ground in the east to Ridge Hill Road and grazed paddocks in the west (see

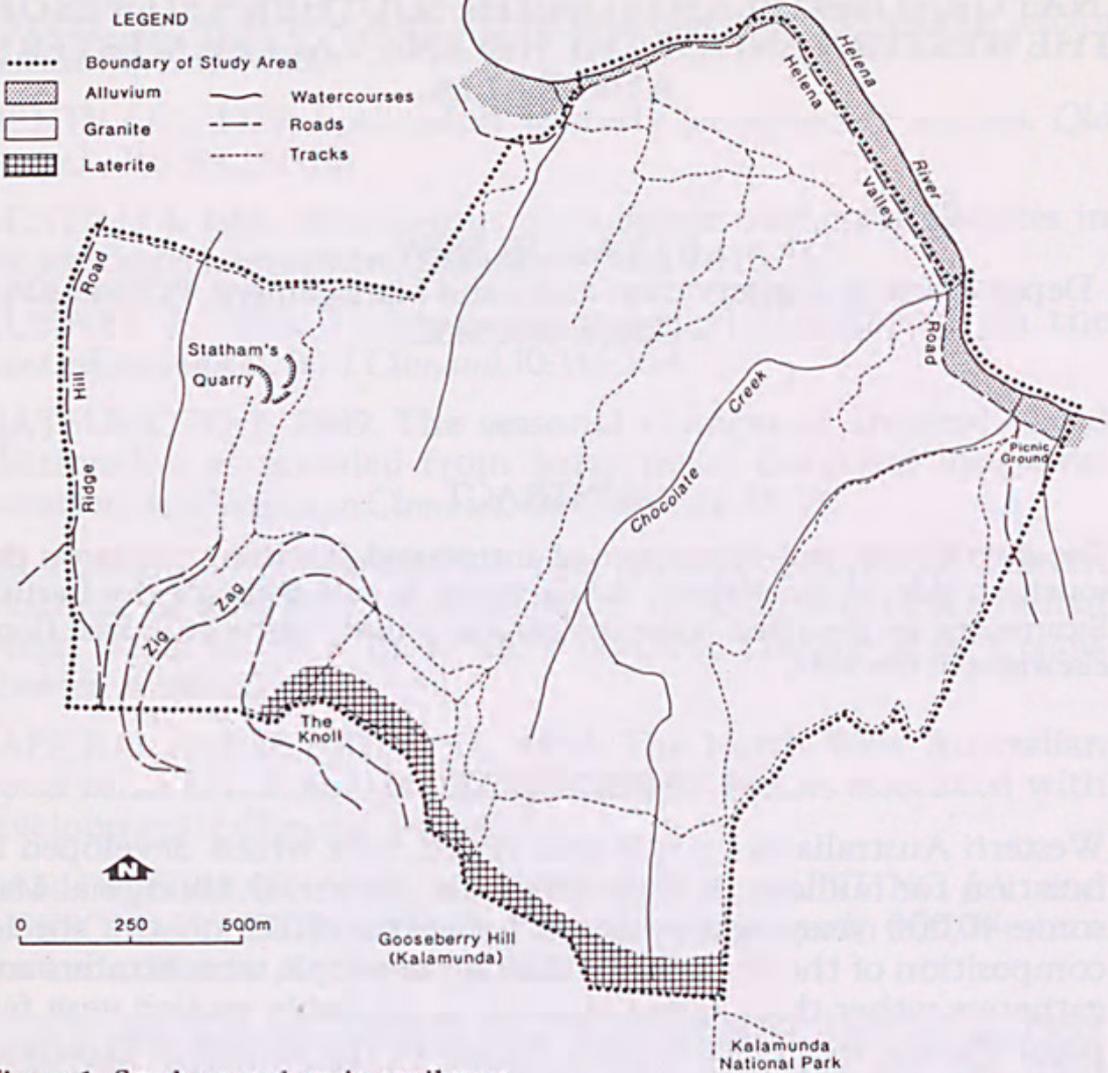


Figure 1 Study area showing soil type

Figure 1). It includes the area described by Rowley (1981) and Rowley and Brooker (1987). The picnic ground was chosen as the eastward end of this study area because upstream of this the river is still cutting into bedrock. It is only downstream of this point that alluvial terraces occur.

As movement has taken place in Western Australia along the Darling Fault, the Helena River has incised a major valley into the Darling Plateau. Where it debouches into the Coastal Plain through the Darling Escarpment (the surface feature formed by erosion back of the fault scarp), the river bed is at 25m while Greenmount to the north is 209m and Gooseberry Hill to the south is 224m, a vertical change of 184m. The width of the valley is 4km between these two points.

The geology of the area is described by Biggs and Wilde (1980). The Darling Plateau is the western margin of the archaean Yilgarn Shield, consisting of granitic rocks of about 2000my into which have been intruded somewhat younger dolerite dykes. ("Granite" is here used to cover various types of plutonic rocks.) The surface of the plateau has been lateritised in relatively recent times (Tertiary).

Lateritic gravels and duricrust occur on the uplands, skeletal soils on the valley slopes (coarse and sandy over the granite or fine clayey red earths over the dolerite) and alluvium on the river terraces (Churchward and McArthur 1980). The vegetation lies within the Darling District of the South-west Botanical Province as defined by Beard (1981).

The study area can be divided into three landform units (Churchward and McArthur 1980) with their own characteristic soils and vegetation types (Heddle and Loneragan 1980) - see Figure 1. The highest sites are occupied by lateritic upland of the "Dwellingup Unit" having duricrust on the ridges with gravel (or in some cases sandy) soils occupying depressions. The vegetation is an open forest of Jarrah, *Eucalyptus marginata*, and Marri, *Eucalyptus calophylla*, with a heath understorey. In the study area, the suburb of Gooseberry Hill occupies this landform type.

At the edges of the plateau, the duricrust of massive laterite breaks away to form a tumbled scree of lateritic boulders decreasing in size down the valley slope. The slopes are Churchward and McArthur's "Darling Scarp" unit of steep slopes with shallow red and yellow earths and much rock outcrop. The surface is occupied by exposed weathered and unweathered materials. The vegetation is a low open forest of Wandoo, *Eucalyptus wandoo*, and Marri over heath.

The Helena River lies within the "Swan Unit", having alluvial terraces of red earths and duplex soils which support a forest of Flooded Gum, *Eucalyptus rudis*, and Paperbark, *Melaleuca raphiophylla*, over a dense thicket.

Land Use

Aboriginal people certainly lived in Helena Valley, probably concentrating their activities on the river. It is believed that the mythical serpent, Wagyl, moved down the valley during the dreamtime and the river lies in the track he made.

European settlers very soon moved into the area and Helena Location 20a, which covered most of the study site from The Knoll to the river - as well as west to Guildford and a considerable distance east - was first allocated in 1830. The block was used for grazing and it is reported that horses (including police horses on agistment) and cattle were being run on it at the turn of the century (Quicke, 1979). A house was built at what is now the picnic ground but this was destroyed by fire in 1957. Grazing continued on the lower slopes of the valley, sheep being pastured there until 1975.

Thomas Statham established a quarry near Ridge Hill Road in 1894 from which blue metal for roadworks was quarried. It was connected to the Upper Darling Range Railway in 1906. This ingenious track reached Kalamunda by dint of pushing and pulling up the Zigzag. The railway alignment is now occupied by a road, and the railway land by the Gooseberry Hill National Park. Motor racing

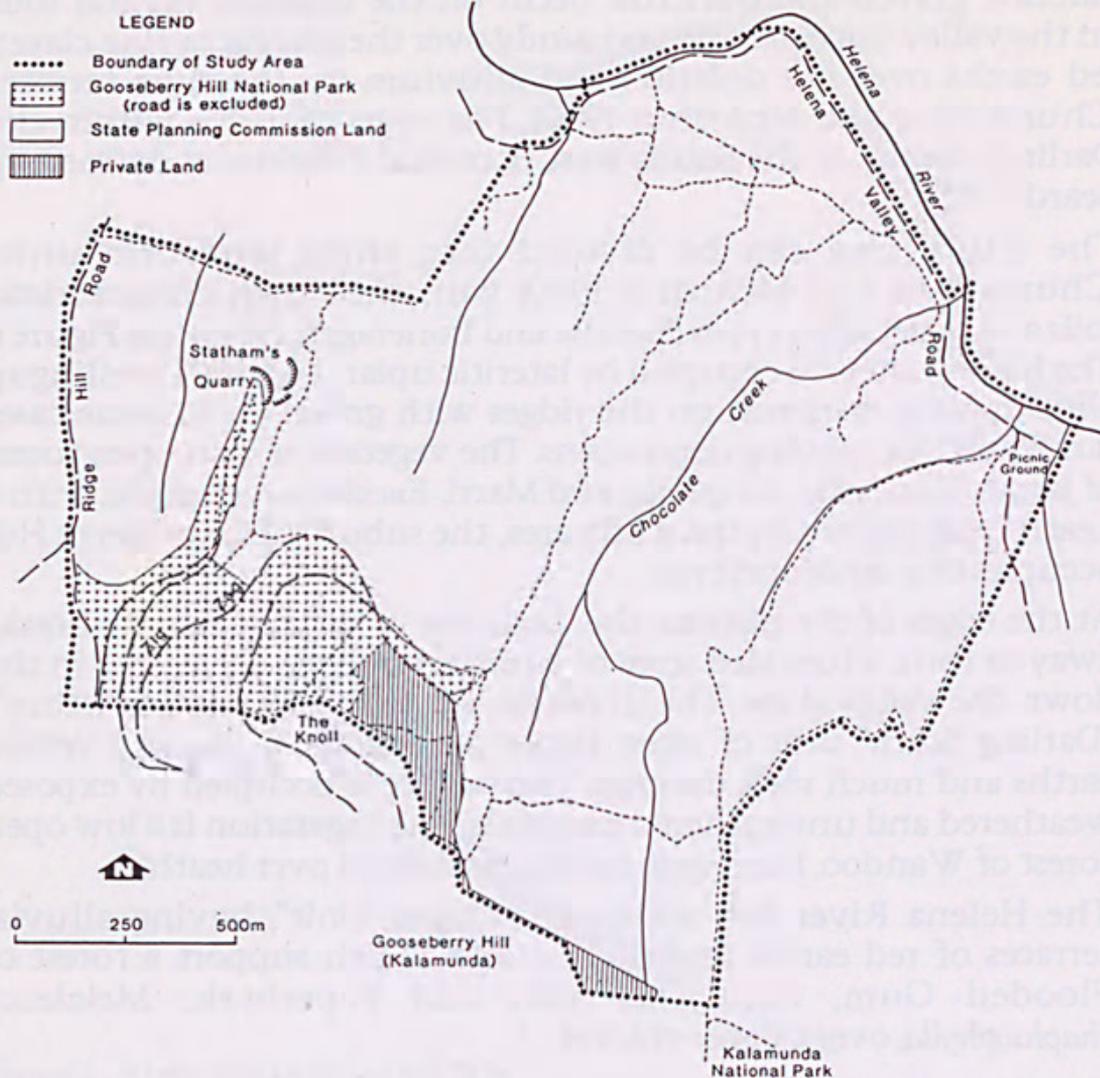


Figure 2 Study area showing land ownership

hill climbs are occasionally held on it. Statham's Quarry, now no longer operative, gets heavy recreational use as a rock climbing and abseiling training ground.

Much of the study area is zoned Regional Open Space under the Metropolitan Region Planning Scheme, but some is still in private ownership (see Figure 2).

The area is popular for recreation, with picnicking and bushwalking most favoured. Horse riding is frequent, and a marked trail has been delineated. The use of mountain bikes is increasing rapidly. Motorised recreation includes, besides the standard 4WD vehicles, trail bikes and all-terrain cycles. This has been regulated to some extent by the placing of locked gates on management tracks.

Illegal activities also occur. Rubbish, stolen vehicles and unwanted pets are dumped, while plants and rocks are removed. Fires are frequently started by carelessness or deliberate arson. Woodcutting has probably occurred in the past, but there is so little timber left now that its removal is not a problem.

Disease

In 1979 it was noted that *Macrozamia riedlei* plants in the gully opposite Lot 363 (Banksia Gully) were dying, probably from *Phytophthora cinnamomi* brought in by a vehicle which had carried persons who dug up several large *Zamias* and Blackboys. The infection spread along a track which became popular for the first couple of years after the fire in 1985, reaching a pocket of Bull Banksia, *Banksia grandis*. The last Banksia died in 1988. It is possible that soil infested with this pathogen also occurs elsewhere within the study area.

METHOD

The author has used the Helena Valley for recreation since 1972, and made opportunistic records of the occurrence of plant species since that time. In 1983, after moving to a block which abuts the Helena River just to the north of the study area, the observations increased in scope and frequency. In 1988, a programme of systematically recording the location and flowering time of all species in the study area was commenced, and continued with monthly records through 1989 and 1990. Voucher specimens of all plants not recorded in Marchant *et al.* (1987) have been deposited in the Western Australian Herbarium.

RESULTS AND DISCUSSION

During this study, 128 introduced plants have been recorded for the area (see Appendix 1). In addition there are 426 native plants, a combined total for the area of 554. Considering the small size of the area, (approximately 5 sq. km) this is a relatively large number of species, approximately 25% of the 2057 species recorded for the Perth region (covering 10,500 sq. km) by Marchant *et al.* (1987). The percentage of aliens is, however, at 23.5%, very similar to that recorded for the region as a whole (25% - 547 species), which is considerably higher than the state figure (some 10%).

This reflects the highly disturbed nature of parts of the study region. The quarry, including the workings, embankments, tailings dumps, abandoned buildings and access tracks, has an understorey composed almost entirely of introduced plants, although the Flooded Gums which form the dominant layer impart an aura of spurious naturalness to the scene. This type of community is similar in form to that recorded for Tuart Woodland at Star Swamp by Bell *et al.* (1979) and prognosticated as a possible future for much of Western Australia's woodland areas by Bridgewater and Backshall (1981). On the lower slopes of the valley, grazing has eliminated much of the shrub layer, which, in the 15 years since its cessation,

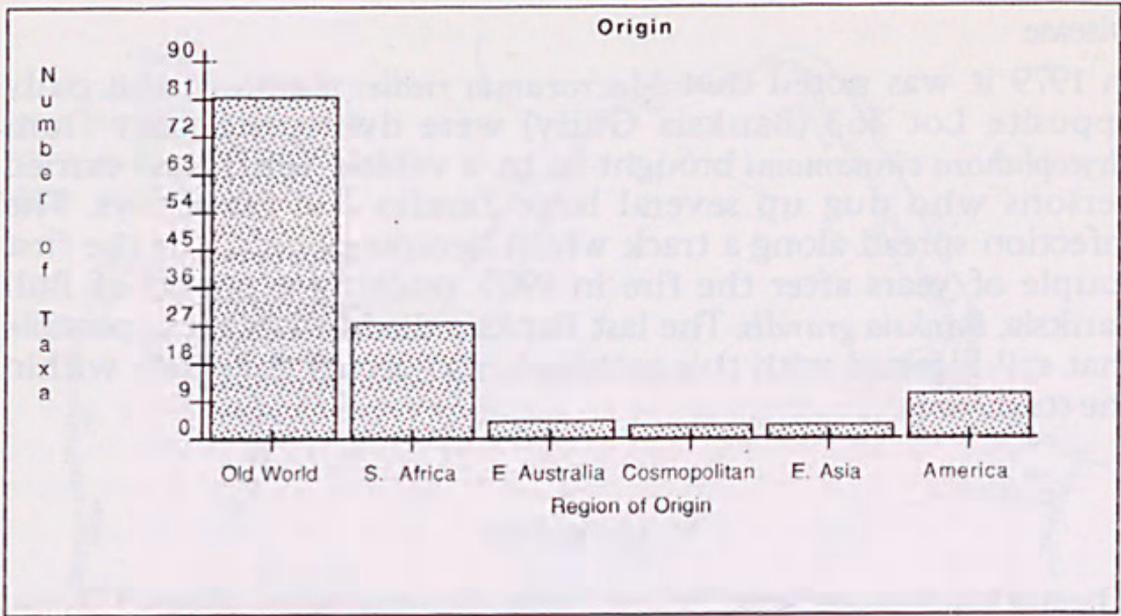


Figure 3 Region of origin of introduced plants in study area

has not yet fully returned. (A very simialar percentage and suite of exotics was recorded by Aplin *et al.* (1983) from an abandoned farm in the eastern Darling Range.) The river alluvium has been disturbed by various factors, not least being the fact that the river, with two water supply dams upstream, now has a highly artificial pattern of flow. Tracks and firebreaks form lines of disturbance ramifying across the area and in all cases they are fringed by introduced plants which are gradually invading the adjoining undisturbed bush. The picnic ground, once the site of a house, has recently been rehabilitated by deep ripping and planting with a number of species, some of which are exotic.

These 128 introduced plants are mostly from Eurasia and South Africa (see Figure 3). In life form, the majority of the species are

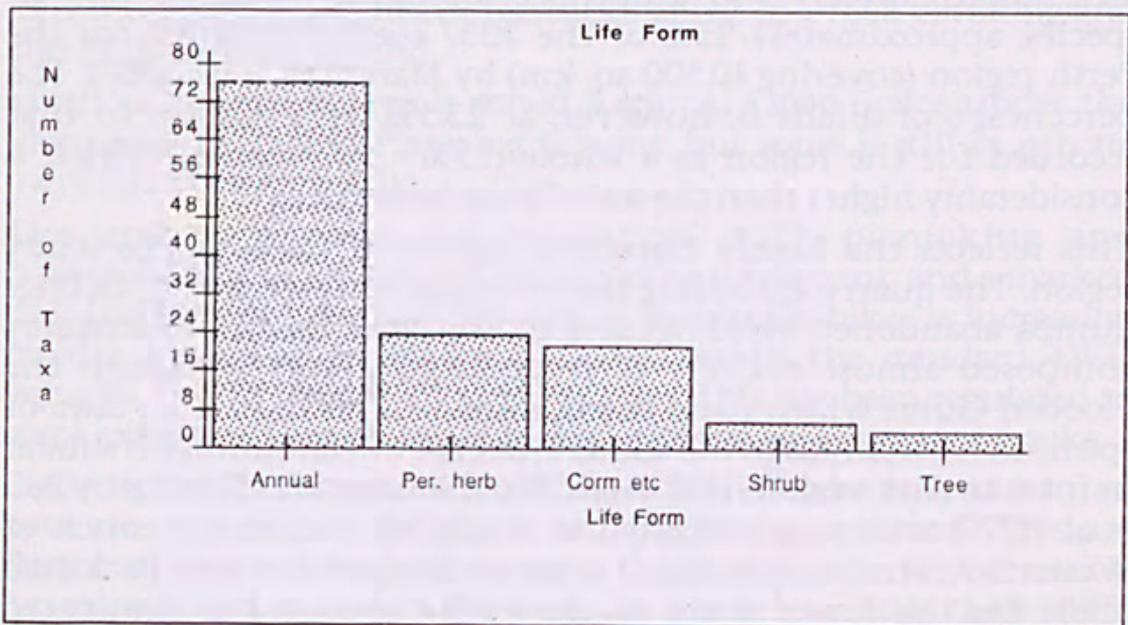


Figure 4 Life form of introduced plants in study area

annuals or perennial herbs (chiefly grasses) But a significant number are bulbous (see Figure 4). The majority of annuals are from Eurasia, of bulbous from South Africa, while the perennial herbs come from both Eurasia and South Africa. Keighery (1989) reported on introduced plants in Banksia woodlands in the Perth Region. He recorded 120 naturalised species which, in origin, were very similar to Gooseberry Hill, however the woodlands demonstrated more bulbous plants and considerably fewer perennial herbs. This reflects the greater range of perennial grasses able to establish in the heavier soils of the Darling Scarp.

Although 23.5% of the flora on Gooseberry Hill is introduced, a very much smaller suite of species have established themselves as an integral part of the flora in undisturbed areas. Only 24 plants can be so considered (see Table 1). Of these, 12 are from South Africa, 11 from Europe and one from South America. There are nine bulbous species, all from South Africa, while the rest are annuals. The bulbous or geophyte life form represents an almost empty niche in the Western Australian ecosystem, while annuals fit well into the ephemeral flowering after a fire. Fire frequency on Gooseberry Hill is high - parts have been burnt 5 times in the last 14 years (M.

Table 2. Plants fully naturalised as part of the undisturbed flora.

Name	Origin			Life Form	
	SouthAfrica	Europe	America	Annual	Bulbous
<i>Aira caryophyllea</i>		x		x	
<i>Arctotheca calendula</i>	x			x	
<i>Babiana disticha</i>	x				x
<i>Bellardia trixago</i>		x		x	
<i>Briza maxima</i>		x		x	
<i>Briza minor</i>		x		x	
<i>Conyza albida</i>			x	x	
<i>Filago gallica</i>		x		x	
<i>Galium divaricatum</i>		x		x	
<i>Gladiolus caryophyllaceus</i>	x				x
<i>Gladiolus undulatus</i>	x				x
<i>Hesperantha falcata</i>	x				x
<i>Homeria flaccida</i>	x				x
<i>Hypochaeris glabra</i>		x		x	
<i>Linum trigynum</i>		x		x	
<i>Monadenia bracteata</i>	x				x
<i>Monopsis simplex</i>	x			x	
<i>Orobanche minor</i>		x		x	
<i>Parentucellia viscosa</i>		x		x	
<i>Polypogon monspeliensis</i>		x		x	
<i>Romulea rosea</i>	x				x
<i>Ursina anthemoides</i>	x			x	
<i>Watsonia bulbilifera</i>	x				x
<i>Watsonia meriana</i>	x				x
TOTAL 24	1	1	1	1	9
	2	1		5	

Brooker, pers. comm.) - which favours the persistence of the annual flora, even if the seeds themselves are not particularly long-lived. In addition, constant disturbance along the tracks maintains a population through years when the shrub cover closes over.

The plant which represents the greatest threat to the integrity of the Gooseberry Hill ecosystem is Baboon Flower, *Babiana disticha*. This plant is found all along Chocolate Creek and is increasing in area noticeably every year. It forms multiple corms along the stem and numerous light seeds which are easily dispersed by wind. In the upper reaches of the creek, Baboon Flower dominates the understorey both in the open and in deep shade. It completely takes over *Borya* swards on granite outcrops, occupying the same niche as orchids, sundews and liliaceous plants such as Milkmaids, *Burchardia umbellata*. All have become scarce in, or have disappeared from, this region.

Ways of Introduction

Since European settlement there are a number of ways in which plants may have been introduced to Gooseberry Hill (see Table 2). All of them probably occurred at some time, and contributed to the present introduced flora.

Many plants undoubtedly owe their introduction to domestic stock. When it was being used as pasture, seed of such plants as Subterranean Clover, *Trifolium subterraneum* and Annual Ryegrass, *Lolium rigidum*, could have been deliberately spread. Alternatively, hay brought in to feed the stock could have been the source of this or other seed. In a neighbouring paddock, *Eragrostis cillianensis* appeared in the year following a change of hay supplier. The previous supplier had been dropped because of seeds of Doublegee, *Emex australis* in his bales. Patterson's Curse, *Echium plantagineum*, and Cape Tulip, *Homeria flaccida*, could have been brought in like this. Animals may spread plants when viable seeds are voided in their droppings. Every year Wild Oats, *Avena fatua*, germinate along the tracks from horse droppings. Fruits such as those of Barley Grass, *Hordeum leporinum*, may be carried on the coats of stock.

Plants with succulent fruits may be spread by birds, who eat the fruit and void the seed in their droppings. Magpies have been observed eating the berries of Black Nightshade, *Solanum nigrum*,

Table 2. Ways in which plants may be introduced by human agency (adapted from Hill, 1977)

1.	Sown as pasture or crop
2.	Contamination in hay or other animal feed stuffs
3.	Carried by animals, internally or externally
4.	Movement of machinery and soil
5.	Dumping of refuse
6.	Deliberate introduction as garden plants
7.	Deliberate introduction for rehabilitation purposes

and Silvereyes eat Bridle Creeper, *Asparagus asparagoides*. Blackberries, *Rubus* aff. *selmeri*, are eaten by many different birds. In the adjoining paddocks, Galahs congregate in late summer to feed on the seeds of Pigweed, *Portulacca oleracea*, and Wireweed, *Polygonum aviculare*, but they have not been observed foraging in the study area so it is unlikely that they are spreading seeds there.

The movement of machinery and soil, especially during track construction and maintenance, is a very important method of plant introduction and distribution through an area. The disturbed areas so created provide a site which is quickly colonised by weeds or by native plants that relish the same pioneering niche. African Lovegrass, *Eragrostis curvula*, and Stinkwort, *Dittrichia graveolens*, are typical of this type of plant. Their seeds can be blown by wind, or actually carried by machine. For example, up to and including the summer of 1988, Stinkwort grew in two small populations, totalling no more than 40m in extent, along a ridgeline track which is central to the study area. In May 1989, just after the plants had finished seeding, the track was extensively upgraded, involving a doubling in width. In the summer of 1990, Stinkwort grew along the entire 1km length of track. Machinery also moves corms, such as those of Pink Woodsorrel, *Oxalis glabra*.

Track edges provide disturbance opportunities for Australian plants also. In some areas these consist of fire annuals such as Flannel Flower, *Actinotus leucocephalus*, and *Podolepis lessonii* but in many sites, especially on heavier soil, perennial grasses predominate. Clustered Lovegrass, *Eragrostis elongata*, and Silkyheads, *Cymbopogon oblectus*, have appeared and increased in abundance along Helena Valley Road since material was imported in 1987 to upgrade the road.

Refuse dumping may introduce plants. One certain example in the study area is provided by Pretty Betsy, *Centranthus macrosiphon*, which exists in a small population along Helena Valley Road. It first appeared in 1988, adjacent to burst bags containing household and garden rubbish. The attractive, brilliant scarlet *Sparaxis* sp. which also came up at the same site, have since been removed, presumably to be returned to a garden. In January 1990, a large pile of cut stems of an euphorbiaceous shrub was dumped on the bank of the Helena River. They have taken root and are growing vigorously.

Deliberate introduction occurs at the house site and the quarry, where plants grown for beauty or utility still survive. Some have not spread, for example a Radiata Pine, *Pinus radiata*, at the house site and Almonds at the quarry, so that these can not be said to be truly naturalised. Others, such as Jonquils, *Narcissus tazetta* and Easter Lilies, *Amaryllis belladonna*, increase slowly by division of bulbs, but are removed by visitors seeking garden plants, so that there is a net decrease. Yet other plants increase slowly without spreading very far, such as Cape Lilac, *Melia azedarach* and Periwinkle, *Vinca major*.

However, many plants originally brought to the State as garden plants have escaped and become truly naturalised. In the study area, all 10 species of South African Iridaceae fall into this category. In some cases their point of introduction can be traced to a horticultural enterprise on a block abutting the study area to the north, which was established in 1920 to grow flowers for the Perth market. The main crop was roses, but rows of four species of *Watsonia* were also planted. There were also several rows of the attractive grass Natal Redtop, *Rhynchelytrum repens*, to act as a "filler" behind the bunches. All have since naturalised. The nurseryman lamented sadly that he wished he had never brought them in (C. Rhodes pers. comm.).

More recently, bare ground at the picnic area was rehabilitated by ripping, seeding and planting. The introduced Rat's Tail Grass, *Sporobolus indicus*, and the native Small St John's Wort, *Hypericum gramineum*, appeared in considerable numbers after this event. The seed mix contained plants not native to the area, such as *Acacia aphylla*, and four species of *Acacia* from eastern Australia were planted.

Notwithstanding all the above, the method of introduction of some plants remains conjecture. How did seeds of *Cicendia filiformis* get here, for example? By wind, as suggested by Keighery (1978)? However, this tiny plant is found in quite isolated swamps, such as the ones on Lot 24, Avon Location 1831, near Bolgart (B.M.J. Hussey, unpublished report) so perhaps mud on the feet of birds is possible.

Establishment

Not only must it arrive on Gooseberry Hill, but, to be considered naturalised, a plant must be able to survive and reproduce. Plants which are able to do so successfully often have a number of characteristics in common (see Table 3).

On Gooseberry Hill, many of the introduced plants exhibit a combination of points 1-6 and are able to colonise disturbed ground. Thus, they are pioneers of the secondary succession caused by that disturbance. In Western Australian conditions, there must always have been small areas of local disturbance caused by such events as floods or tornados, but the most common disturbance factor is fire.

Table 3. Characteristics of successful introduced plants on Gooseberry Hill (adapted from Hill, 1977)

1	High output of seeds/propagules in favourable conditions
2	At least some output of seeds/propagules even in poor conditions
3	Seed production begins after only a short period of vegetative growth and continues for a long period
4	Considerable longevity of seeds in soil
5	No special environmental requirements for germination
6	Rapid seedling growth and establishment
7	Ability to reproduce vegetatively
8	Strong competitive ability.

Periodic fires totally remove the canopy and for a few years a whole suite of disturbance opportunists flourish.

These include, on Gooseberry Hill, plants from the family Apiaceae, for example Flannel Flower, *Actinotus leucocephalus*, and Rottnest Daisy, *Trachymene coerulea*, annual grasses such as *Stipa flavescens*, and composites such as *Asteridea pulvurilenta*, *Podolepis lessonii* and *Quinetia urvillei*. These dominate the scene in the year following the fire, but as the shrub species resprout and so close the canopy they decrease in frequency and fail to appear. Their life history records a massive response to the disturbance event, followed by a rapid descent into eclipse until the next disturbance. Firebreak grading is an event to which such plants respond positively with germination and growth, *Podolepis lessonii*, for example, being very common in such situations.

Many introduced annuals have a similar response to disturbance, and fit easily into the community. Slender Cudweed, *Fillago gallica*, and *Ursina anthemoides* are outstanding examples.

Other introduced plants, however, show survival strategies which help them to outcompete other plants and so come to dominate the community. The most important of these are (a) having a rosette of leaves and (b) having a summer growth habit

Basal rosettes shown by such plants as Flatweed, *Hypochaeris glabra*, and Paterson's Curse, *Echium plantagineum*, are able to suppress surrounding plant growth and thus maximise the exclusive space available for water and nutrient extraction.

Few plants native to Gooseberry Hill grow actively during summer, but a number of introduced plants do so, notably the perennial tussock grasses African Lovegrass, *Eragrostis curvula*, and Natal Redtop, *Rhynchelytrum repens*. These utilise summer rainfall to grow and flower when there is little other competition. Though native tussock grasses do exist, for example Greybeard Grass, *Amphipogon strictus*, the Wallaby Grasses, *Danthonia* spp. and Foxtail Mulga Grass, *Neurachne allopecuroidea*, they are smaller, winter-growing plants with a less extensive root system. Where they occur together, they are being outcompeted and replaced by the introduced species. Additionally, the native tussock grasses are preferentially grazed by kangaroos, especially during the summer months.

Frequent fires also favour the introduced tussock grasses over the native ones. All the fires since 1976 have occurred in late spring or, most often, in summer (M. Brooker, pers. comm.). The introduced grasses shoot rapidly from the base after the fire, and, given good rains, will set abundant seed by early winter. This is blown into bare areas and germinates immediately to flower by spring. The native grasses do shoot after the fire, but do not flower until the following spring. Their seedlings, too, are slower to reach reproductive maturity. *Neurachne* takes two years to go from seedling to setting seed, whereas *Rhynchelytrum* can do this in four months.

Management

Despite the high number of introduced plants occurring in the study area, most are confined to severely disturbed areas and are only very slowly invading undisturbed bush. Management should aim to limit disturbance by decreasing fire frequency and not creating any more tracks. When a fire occurs, the temptation to send a grader in to clear a line in front of it should be resisted. Instead, the current arrangement of strategic firebreaks should continue to be maintained and, as an extra, kept relatively weed-free by careful herbicide application twice a year.

Various agencies periodically spray the Brambles on the banks of the Helena River, while *Watsonias* are occasionally attacked wherever they occur. In both cases high initial kill is achieved but, so far, follow-up spraying has not been consistent enough to achieve total eradication. The programme needs also to include the seeding in of suitable local native species to fill the space left by the dying weeds, otherwise it is most likely that it will simply be reinvaded by other weeds. This is in fact occurring along Helena Valley Road where a *Watsonia* spraying campaign was carried out in 1989.

Plants that could become weeds should not be introduced, and in this respect the choice of species planted in the rehabilitated picnic ground is unfortunate. It is not too late to replace them with more suitable species.

Gooseberry Hill is an important area of natural vegetation. It provides a transect of Darling Scarp flora from the lateritic plateau to the river alluvium, uninterrupted by urban development, a sequence which is now rare elsewhere. In addition it has been the scene of several studies such as those done by Rowley (1981, 1987), and consequently its floristics and vertebrate dynamics are relatively well understood. It has a lot of potential for use as a field study area at all levels of education from primary to post-graduate, as well as being easily accessible to the majority of educational institutions in the State. However, while much of the lateritic upland the study area remains in private ownership its integrity is in doubt. Given the importance of the area, it would be appropriate for the Government to purchase undeveloped land for either Public Open Space or National Park.

Its very closeness to Perth could lead to inappropriate levels and kinds of public use which could cause environmental degradation. One such use would be an increase in spectator numbers at hill climbs up the Zig Zag, or an increase in the frequency of these events. The bodies responsible for managing the area should make preservation and maintenance of the natural ecosystem their priority aim.

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APPENDIX 1

A descriptive catalogue of all introduced species in the Helena Valley study site. The arrangement follows Marchant *et al.* (1987).

FUMARIACEAE

Fumaria capreolata White Fumitory. Common in damp shady sites in disturbed areas such as the quarry and on alluvial soil along the river. Occurs along the edges of the Zig Zag. Very occasional on the wetter, shady side of granite outcrops. Native to Europe.

Fumaria officinalis Fumitory. Occasional in disturbed sites in alluvial soil along the river. Native to Europe.

PHYTOLACCACEAE

Phytolacca octandra Inkweed. A single plant occurs on a large rock adjacent to a track in the centre of the area and another appeared on river alluvium in 1989 in an area previously covered by *Watsonia*. The plant occurs in paddocks adjoining the study area. Native to tropical America.

CARYOPHYLLACEAE

Cerastium glomeratum Mouse-ear Chickweed. Sporadic in loose disturbed track edges after grading. Native to Europe.

Petrorhagia velutina Carnation Weed. Few small populations in winter-damp places, for example on the track side of granite outcrops. Native to the Mediterranean.

Polycarpon tetraphyllum Fourleaf Allseed. Sporadic in loose, disturbed track edges after grading. Native to the Mediterranean.

Silene gallica French Catchfly. Common along track edges on valley slopes. Native to Europe.

Spergula arvensis Corn Spurrey. Occasional on open ground at the quarry. Native to Europe.

POLYGONACEAE

Polygonum aviculare Wireweed. Occasional along Helena Valley Road and common on the picnic ground. Also common on the formed track leading eastwards from the picnic area and in the adjoining orchards and paddocks. A cosmopolitan weed.

Rumex acetosella Sheep's Sorrel. Occurs at the quarry and recently a dense population has become established at the picnic ground. Increasing rapidly. Native to Europe.

Rumex crispus Curled Dock. Occurs at the picnic ground, the quarry and occasional along the river. Common in adjoining paddocks and orchards. Native to Europe.

BRASSICACEAE

Brassica tournefortii Turnip. Occasional along tracks and disturbed areas low in the landscape. Does not persist. Native to the Mediterranean.

Raphanus raphanistrum Wild Radish. Common along track edges at the Zig Zag. Occasional elsewhere. Native to Europe.

PRIMULACEAE

Anagallis arvensis Pimpernel. Common on disturbed ground and along tracks on all soil types in the area. Blue Pimpernel, var. *caerulea*, is more common than Scarlet Pimpernel, var. *arvensis*, but both occur. Native to Europe.

ROSACEAE

Rosa sp. Wild Rose. A large patch of pink climbing rose occurs on the western side of Quarry Creek. Native of Europe.

Rubus aff. *selmeri* Bramble. Occurs along the banks of the Helena River and Quarry Creek. Will establish on all areas of alluvial soil if permitted. Subject to repeated eradication campaigns using various herbicides. Native of north-west Europe.

MIMOSACEAE

Acacia spp. In 1987, a large area of the Picnic Ground was "rehabilitated" by ripping and tree planting. The following exotic wattles were planted and it will be interesting to see if they naturalise. *Acacia dealbata* *Acacia longifolia* *Acacia mearnsii* *Acacia podalyriaefolia*

One plant of *Acacia podalyriaefolia* occurs on a steep granite outcrop on the south-trending tributary of Chocolate Creek.

PAPILIONACEAE

Cytisus proliferus Tagasaste. A number of bushes established along the Zigzag. Native to the Canary Islands.

Lotus angustissimus Narrowleaf Birdsfoot Trefoil. Small populations on the lower slopes of the valley where past grazing has left grassy swards. Native to Europe.

Lotus suaveolens Hairy Birdsfoot Trefoil. Occasional on lower slopes in grassy swards. Also occurs as part of the annual flora on granite outcrops close to disturbed areas such as tracks. Native to Europe.

Lupinus angustifolium New Zealand Blue Lupin. Common at the quarry and alongside the Zig Zag. Occasional along tracks low in the landscape. Native to the Mediterranean.

Lupinus cosentinii WA Blue Lupin. Common at the quarry and along the Zig Zag. Native to the Mediterranean.

Medicago polymorpha Burr Medic. Occasional plants in disturbed ground at the quarry and along the Zig Zag. Native to the Mediterranean.

Trifolium angustifolium Narrowleaf Clover. Occurs alongside tracks and other disturbed areas on laterite and granite soil. Very common at the quarry. Native to the Mediterranean.

Trifolium arvense Hare's Foot Clover. Occurs in small, dense populations alongside tracks on laterite or granite soil. Native to Europe, Asia and North Africa.

Trifolium campestre Hop Trefoil. Occasional alongside tracks or in disturbed sites throughout the area. Native to Europe.

Trifolium dubium Suckling Clover. Occasional along tracks and in disturbed areas. Native to Europe.

Trifolium glomeratum Cluster Clover. Occasional alongside tracks on laterite soil and at the quarry. Native to Europe.

Trifolium repens White Clover. Common at the quarry and small populations persist on previously grazed areas low in the landscape. Native to Europe.

Trifolium subterraneum Subterranean Clover. Occurs at the quarry and throughout previously grazed areas where there are no remaining shrubs. Native to the Mediterranean.

Vicia sativa Common Vetch. A few populations along the Zig Zag. Native to Europe.

MYRTACEAE

Leptospermum laevigatum Victorian Teatree. Five bushes grow where the track from the quarry enters Ridge Hill Road. Native to the Eastern States.

EUPHORBIACEAE

Euphorbia peplus Petty Spurge. Occurs on clay soil in deep shade. Found at the quarry and along the Helena River. Native to Europe and Asia.

Ricinus communis Castor Oil. A compact, dense stand on the northern boundary of the disturbed area below the quarry. Increasing. Native to India and tropical Africa.

LINACEAE

Linum trigynum French Flax. Widespread and abundant on granite soil, along tracks and as part of the annual flora in disturbed areas. Especially prominent in the season after a fire. Native to Europe.

MELIACEAE

Melia azedarach Cape Lilac. Small populations occur at the house site in the picnic ground and on the northern boundary of the quarry area. Native to Asia and northern Australia.

OXALIDACEAE

Oxalis corniculata Yellow Woodsorrel. Occasional on lateritic and alluvial soil. Cosmopolitan.

Oxalis glabra Pink Woodsorrel. Small populations along the edges of tracks and frequently-disturbed areas. Increasing. Native to South Africa.

Oxalis pes-caprae Soursop. Common on disturbed alluvial soil. Native to South Africa.

GERANIACEAE

Erodium botrys Long Storksbill. Common along tracks and among grass swards. Native to the Mediterranean.

APIACEAE

Foeniculum vulgare Fennel. Occasional in disturbed areas on alluvial soil. Native to Europe.

GENTIANACEAE

Centaureum erythraea Century. Common along tracks on granite soil. Plants also occur in open areas among heath alongside the tracks. Native to Europe.

Cicendia filiformis Slender Cicendia. Occasional small populations in winter-wet clay soil on valley slopes. Native to Europe, North Africa and Asia.

APOCYNACEAE

Vinca major Periwinkle. Population growing with Brambles in the disturbed area on the western side of Quarry Creek. Native to the Mediterranean.

ASCLEPIADACEAE

Gomphocarpus fruiticosus Milkweed. Individual plants occur on alluvial soil and alongside tracks low in the landscape. Rapid coloniser of such soils after disturbance. Native to North America.

SOLANACEAE

Solanum nigrum Black Nightshade. Common in disturbed sites. Increasing. Native to Europe.

Solanum sodomeum Apple of Sodom. Occasional plants occur in the quarry area. Native to South Africa and the Mediterranean.

BORAGINACEAE

Echium plantagineum Patterson's Curse. Common at the quarry and along the Zig Zag. Two large, dense populations and scattered individuals occur among the grassed swards in grazed areas. Increasing, especially along tracks after maintenance. Native to the Mediterranean.

LAMIACEAE

Stachys arvensis Stagger Weed. Common on disturbed soil. Native to Europe.

PLANTAGINACEAE

Plantago lanceolata Ribwort Plantain. Occasional on disturbed alluvial soil. Large population at the quarry. Increasing. Native to Europe and Asia.

SCROPHULARIACEAE

Bellardia trixago White Bartsia. Patchy, but common where it occurs, on granite soil in mid-slope. Native to the Mediterranean.

Kickxia spuria Fluellen. Common in disturbed areas on alluvial soil, occasional on granite soil low in the landscape. Native to Europe and western Asia.

Misopates orontium Lesser Snapdragon. Common along the Zig Zag and occasional along other tracks on granite or alluvial soil. Native to western Asia.

Parentucellia viscosa Sticky Bartsia. Occasional among open heath on granite rubble soil. Native to western Europe.

Verbascum virgatum Mullein. Occurs along the embankments at the quarry, and forms a dense stand in one area of the northern firebreak. Native to Europe and western Asia.

OROBANCHACEAE

Orobanche minor Lesser Broomrape. Several widespread populations occur, usually close to tracks, on granite soil. Native to Europe.

LOBELIACEAE

Monopsis simplex. Common in winter-wet sites, mostly on clay soil, on valley slopes. Native to South Africa.

RUBIACEAE

Galium divaricatum Goosegrass. Common on winter-wet soils, among *Borya* swards or on clay under Wandoo, always in open sites. Native to the Mediterranean.

VALERIANACEAE

Centranthus macrosiphon Pretty Betsy. Small population alongside Helena Valley Road in alluvial soil. First noted in 1988, adjacent to pile of dumped garden refuse. Native to Europe.

ASTERACEAE

Arctotheca calendula Capeweed. Common along all tracks, especially after grading. Occurs in all disturbed areas. Appears among regenerating heath after fire. Often associated with rabbit dung piles. Native to South Africa.

Aster subulatus Bushy Starwort. Occasional but increasing in damp sites at the picnic ground and quarry. Native to North America.

Conyza albida Tall Fleabane. Common along the Zigzag and quarry embankments. Occasional along disturbed track edges and increasingly in the bush alongside these sites. Also quite common on the silt banks left in drying ephemeral creeks. Native to South America.

Conyza bonariensis Flaxleaf Fleabane. Grows in the picnic ground and occasional along tracks low in the landscape. Native to South America.

Crepis foetida Foetid Hawksbeard. Occasional on granite soil, usually winter-wet, associated with tracks and disturbance. Native of Europe.

Dittrichia graveolens Stinkwort. Common and increasing in disturbed soil alongside tracks. Native of Southern Europe.

Filago gallica Narrow-leaved Cudweed. Along tracks on granite soil and a significant component of the ephemera appearing on such soils immediately after a bushfire. Prefers an open site. Native of Europe.

Hypochaeris glabra Flatweed. Common and increasing on all soils. Occurs not only in disturbed areas but throughout the area, being especially obvious when it is relatively open after a bushfire. Native of Europe.

Osteospermum clandestinum Stinking Roger. Occasional along the Zig Zag. Native of South Africa.

Pseudognaphalium luteoalbum Jersey Cudweed. Common at the quarry and occasional in disturbed sites elsewhere. Cosmopolitan.

Sonchus asper Rough Sowthistle. Uncommon. An occasional plant seen in disturbed soil on both granite and alluvial areas. Native of Europe.

Sonchus oleraceus Sowthistle. Widespread over whole area, along tracks, stream courses and other disturbed areas, with some plants spreading into open bush areas. Native to Europe.

Tolpis barbata Yellow Hawkweed. Occasional populations along tracks on granite soil. Native of southern Europe.

Ursina anthemoides Ursina. Extremely common as part of the annual flora, especially following a bushfire, on both lateritic and granite soil. Native of South Africa.

Vellerophyton dealbatum White Cudweed. Single individuals seen along tracks, associated with rubbish dumping. Native of South Africa.

ARACEAE

Colocasia esculenta Taro. Two dense stands fill Chocolate Creek where it leaves the built-up area. Native of Indonesia.

Zantedeschia aethiopica Arum Lily. Small isolated clumps on alluvial soil near the Helena River. Does not seem to be increasing. Native of South Africa.

ASPARAGACEAE

Asparagus asparagoides Bridle Creeper. Several populations on the western side of the disturbed area below the quarry. Occasional plants, rapidly increasing in numbers and extent, in alluvial soil along the Helena River. Native to Southern Africa.

Asparagus officinalis Asparagus. Single clump in the Helena River bed at the picnic ground. Native to Europe.

AMARYLLIDACEAE

Amaryllis belladonna Easter Lily. A few clumps at the quarry. Periodically bulbs are removed by visitors. Native to South Africa

Narcissus tazetta Jonquil. Plants remain in the garden of the old house at the picnic ground and at the quarry, but they are not spreading. Indeed, they are decreasing in number, as each year more are dug up and removed by visitors. Native to the Mediterranean.

IRIDACEAE

Babiana disticha Baboon Flower. Common and spreading rapidly along the course of Chocolate Creek. At its headwaters the plant is extremely abundant, being the dominant understorey plant throughout the landscape from the creek eastwards to the ridgeline. (From there it is spreading downslope towards Piesse Brook). Along the length of the creek it is colonising granite soil, including *Borya* swards, laterite, red clay and alluvium, and is noticeably increasing in area every year. Native of South Africa.

Chasmanthe floribunda African Cornflag. A large population around the northern end of Quarry Creek. Native to South Africa.

Freesia aff. *leichtlinii* Freesia. Small population at the house site at the picnic ground. Frequent along the lower reaches of the Zig Zag. Increasing. Native to South Africa.

Gladiolus caryophyllaceus Pink Gladiolus. Common and increasing on both laterite and granite soil. Native of South Africa.

Gladiolus undulatus Wavy Gladiolus. Common along Chocolate Creek where it occurs in moist soil. Also occurs along Helena Valley Road on the disturbed road edges and spreading into the bush. Native of South Africa.

Hesperantha falcata. Found on winter-wet soils with a high clay content, low in the landscape, from the picnic ground westwards down the valley. Often very common where it occurs. Native of South Africa.

Homeria flaccida One-leaf Cape Tulip. Common at the quarry including the ridge above the main quarry, along the Zig Zag and in all areas low in the landscape where grazing has substantially altered the original vegetation. Native of South Africa.

Romulea rosea Guildford Grass. Common throughout the study area on granite soil. Especially frequent along disturbed areas such as track edges, but it is also a major component of *Borya* swards and granite meadows. Both var. *australis* and var. *communis* occur together, at a ratio of about 40:1. Native of South Africa.

Sparaxis bulbifera Sparaxis. A few plants on alluvial soil along the Helena River. Common on the northern bank of the river outside the study area. Native of South Africa.

Watsonia bulbifera Watsonia. Abundant, sometimes forming monospecific stands, on alluvium along the Helena River. Isolated stands occur elsewhere in the landscape, especially around granite outcrops and at the quarry but also on The Knoll under Jarrah on laterite caprock. Native of South Africa.

Watsonia meriana. Large stands occur on granite soil and around rock outcrops, usually at a middle height in the landscape. Increasing. Native to South Africa.

Watsonia versfeldii Pretty Watsonia. Occasional populations on granite or alluvial soil, frequently occurring in association with other *Watsonias*. Increasing. Native of South Africa.

ORCHIDACEAE

Monadenia bracteata South African Orchid. Common and widespread throughout the region on granite soil. Increasing. Native of South Africa.

TYPHACEAE

Typha orientalis Bullrush. Two stands along Chocolate Creek near the ford. Also in Quarry Creek and in the pool in the main quarry. Native of Eastern Australia.

JUNCACEAE

Juncus articulatus Jointed Rush. In moist silt in bed of the Helena River

and the upper reaches of Chocolate Creek. Native of Europe and Asia.
Juncus capitatus. Occasional on open areas of clay soil that ooze moisture in winter. Native to Eurasia and Africa.

Juncus microcephalus Joint Rush. In moist silt in the bed of the Helena River and the upper reaches of Chocolate Creek. Native to South Africa.

CYPERACEAE

Cyperus eragrostis Drain Flat-sedge. Occasional along Chocolate Creek and Helena River on silt banks. Native to South America.

Cyperus rotundus Nut Grass. Occasional at the picnic ground and along the Helena River. Native to northern Australia.

POACEAE

Aira caryophylla Silvery Hairgrass. Very common throughout the granite and laterite slopes, in all open areas. Native to Europe.

Arundo donax Giant Reed. Clumps occur on alluvium on the banks of the Helena River. Clumps increasing in size, but no new clumps establishing. Native to the Mediterranean.

Avena fatua Wild Oats. Occasional on laterite, common on granite and alluvial soils, on areas that have been previously grazed and those which are currently disturbed. Native to the Mediterranean and south-west Asia.

Briza maxima Blowfly Grass. Common throughout the region on all soils. Rapid coloniser after disturbance. Native to the Mediterranean.

Briza minor Quaking Grass. Occurs throughout the area, though not as common as the previous species. Native to the Mediterranean and south-west Asia.

Bromus diandrus Great Brome. Forms a component of the grass sward where grazing has eliminated shrubs on the lower part of the granite slopes, also along tracks in the same region. Native to the Mediterranean.

Bromus horadaceus Soft Brome. Occurs among grass swards at the quarry and in previously grazed areas. Native of Europe.

Cortaderia selloana Pampas Grass. Two clumps at the northern end of Quarry Creek. (A single clump occurs just east of the picnic ground, outside the study area.) Native to South America.

Cynodon dactylon Couch. Occurs on alluvial soil and along tracks low in the landscape. It is the dominant grass on clay areas at the quarry. Native to Europe.

Digitaria sanguinalis Summer Crab Grass. Occasional on alluvial soil. Native to Mediterranean.

Ehrharta calycina Veldtgrass. Occasional clumps among grass sward in disturbed areas. Native to South Africa.

Ehrharta longiflora Annual Veldtgrass. Occurs on disturbed areas on alluvial soil. Native to South Africa.

Eragrostis curvula African Lovegrass. Occasional plants occur along all graded roads that form the boundary of the area, also at the picnic ground and the quarry. Increasing rapidly. Native to South Africa.

Hordeum leporinum Barley Grass. Occurs among other grasses where grazing has eliminated the shrubs on granite soil. Native to southern Europe and south-east Asia.

Hyparrhenia hirta Tambookie. A small population (20 plants) is established along Ridge Hill Road on the boundary of the study area. Native to the Mediterranean, Africa and south-west Asia.

Lolium rigidum Annual Ryegrass. Minor component of the grass swards on granite soil low in the landscape. Also occasional on disturbed alluvial soil. Native to Southern Europe.

Paspalum dilatatum Paspalum. Common on alluvial soil along the Helena River and the upper reaches of Chocolate Creek and at the quarry. Native to South America.

Paspalum distichum Water Couch. Colonies occur on alluvial silt banks in the Helena River. Native to South America.

Pennisetum clandestinum Kikuyu. On alluvium alongside the Helena River, where Banksia Gully Creek crosses Helena Valley Road and on Quarry Creek. Native to tropical East Africa.

Pennisetum purpureum Elephant Grass. Two clumps occur on the northern boundary of the quarry area. Native to tropical Africa.

Pentaschistis airoides False Hairgrass. Occurs in disturbed areas around the Zigzag and quarry. Native to South Africa.

Phalaris aquatica Canary Grass. Small populations occur on moist alluvial soil along the Helena River and Quarry Creek. Native to South America.

Poa annua Annual Poa. Common in disturbed areas at the Zig Zag, the quarry, the picnic ground and occasional elsewhere along disturbed track edges. Native to Europe.

Polypogon monspeliensis Annual Beardgrass. Scattered in moist swampy places along Chocolate Creek and the Helena River. Native to the Mediterranean.

Rhynchelytrum repens Natal Redtop. Common at the quarry and a few places along tracks low in the landscape. Increasing. Native to South Africa.

Sporobolus indicus Rat's Tail Grass. A few clumps at the picnic ground, in the rehabilitated area and on the banks of the river. Increasing. Native to tropical Africa.

Stenotaphrum secundatum Buffalo Grass. A small population occurs on Quarry Creek at its northern boundary. Native to the tropics.

Trachynia distachya False Brome. Common along tracks and in other disturbed areas throughout the area. Native to Europe and south-west Asia.

Vulpia myuros Rat's Tail Fescue. Major component of the grass swards. Native to central Europe and south-west Asia.



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