

Conservation status of *Goodenia* (Goodeniaceae) in Western Australia, including a review of threatened, rare and poorly known species

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Abstract

A comprehensive assessment of the current conservation status of *Goodenia* in Western Australia was based on information from herbarium labels at the Western Australian Herbarium (PERTH), Western Australian Department of Conservation & Land Management (CALM) filed information, original observations by the authors, the Flora of Australia volume 35, and personal communication with other botanists. Species diversity and conservation-listed taxa are assessed according to the Interim Biogeographic Regions of Australia for Western Australia. Phytogeography, biology, current conservation listings, threatening processes, apparent causes of rarity, and management and research recommendations are discussed. Many *Goodenia* are highly responsive to disturbance and prefer water-gaining sites, the margins of watercourses, or depressions. Highest diversity and conservation-listed taxa occur in the sand plain heaths of the South-West Botanical province. Recommended management procedures include a careful fire regime after research into the reproductive biology of a species, reserve design to include habitat preferences, floristic surveys of nearly all the conservation-listed, emergency actions to address threats in the South-West Botanical Province, and *ex situ* conservation measures once the true conservation status of a species is determined. *Goodenia* in Western Australia is unsatisfactorily known, with many requiring further surveying and monitoring, and over 40% of taxa listed on CALM Priority flora lists. Research into the biological, taxonomic and genetic resources of *Goodenia* is required for their effective and successful conservation.

Keywords: *Goodenia*, Goodeniaceae, Western Australia, diversity, conservation, management

Introduction

The Goodeniaceae is an indicative Australian angiosperm plant family that is “strongly significant in the Australian flora” and is well represented in the Western Australian flora (Marchant 1973; Elliot & Jones 1986). The Goodeniaceae are commonly encountered in the heathlands and shrublands in the South-West Botanical province of Western Australia (George *et al.* 1979). There are 11 genera in the family, with *Goodenia* Smith the largest genus (Carolin 1992) of over 190 species, with about 120 in Western Australia (Paczkowska & Chapman 2000; LWS, unpublished data). All but three species of *Goodenia* are endemic to Australia (Carolin 1992; Elliot & Jones 1986).

Goodenia species occur in a wide variety of temperate habitats (Elliot & Jones 1986) usually around the edges of lakes and watercourses in the arid interior (Table 1). Most *Goodenia* species are perennial sub-shrubs and forbs or annual herbs, although species such as *G. grandiflora* and *G. scapigera* are shrubs. Species are usually perennial and resprouters, responding well after disturbance (Table 2), but others are annual reseederers.

We examined specimens for taxonomic studies in Western Australian *Goodenia* (Cranfield & Sage 1997; Sage

1998; Sage & Pigott 1998; Sage 2000, 2001). We found that an overall assessment of the conservation status was required on this little studied genus. Of an estimated 120 Western Australian species of *Goodenia*, 22 were listed by the Western Australian Department of Conservation and Land Management (CALM) as threatened or poorly known (CALM filed information). This study added another 25, to total over 40% of the genus for the state.

This paper surveys the genus *Goodenia* in Western Australia for apparent rarity, potential threats and appropriate management and research recommendations.

Methods

Data on species abundance were obtained from field observations, from CALM filed information (unpublished data), the Flora of Australia volume 35 (Goodeniaceae), herbarium specimens, herbarium label information at the Western Australian Herbarium (PERTH), and personal communication with other botanists. Nomenclature of Western Australian species follows Carolin (1992) and recently published work (Sage 1998, 2000, 2001). Undescribed, distinctive species are included in this study.

All other names follow WACENSUS (Western

Table 1

Water-associated habitat observations of Western Australian conservation-listed *Goodenia* (taken from label information for collections at the Western Australian Herbarium, Perth). Conservation status (CALM) as of December 2001; see Table 3 for priority codes.

Species	Status	Comment	Voucher
<i>Goodenia byrnesii</i>	P1	"In sand at edge of creek"	H F Broadbent 624
<i>Goodenia crenata</i>	P3	"Margins to billabong"	D Dureau 118
<i>Goodenia durackiana</i>	P1	"On black cracking clay soil"	M Lazarides 6743
<i>Goodenia filiformis</i>	P3	"Sandy swamp"	E J Croxford 1359
<i>Goodenia gloeophylla</i>	P2	"Along small creekline"	D E Symon 7125
<i>Goodenia inundata</i>	P2	"Rocks in river.."	G J Keighery 9089
<i>Goodenia kakadu</i>	P3	"On damp mud at edge of swamp"	I Cowie 4378
<i>Goodenia lyrata</i>	P1	"...drainage tract in hardpan plain"	A L Payne PRP 1349
<i>Goodenia neogoodenia</i>	P4	"Damp flat at edge of claypan"	S Patrick <i>et al.</i> 41
<i>Goodenia nuda</i>	P3	"Bare river sand in dry scoured river bed"	K McCreery ecol 96
<i>Goodenia omearana</i>	P1	"Swamp on major river floodplain"	A A Mitchell PRP 727
<i>Goodenia purpurascens</i>	P3	"Bed of river"	A S Mitchell 756
<i>Goodenia schwerinensis</i>	P3	"...along creek line"	A S George 8160
<i>Goodenia stenophylla</i>	P4	"In creek bed"	A S George 7191
<i>Goodenia strangfordii</i>	P1	"On damp clay flat"	J H Willis sn
<i>Goodenia virgata</i>	P2	"...drainage line"	A R Annels ARA 12 A
<i>Goodenia</i> sp Scaddan (CD Turley 41 VM/1099)	P1	"...close to lake edge"	C D Turley 41 VM/1099

Table 2

Disturbance observations for Western Australian conservation-listed *Goodenia* taxa (taken from label information from collections at the Western Australian Herbarium, Perth). Conservation status (CALM) as of December 2001; see Table 3 for priority codes.

Species	Status	Comment	Voucher
<i>Goodenia arthrotricha</i>	P2	"In scrub burnt previous summer"	V Mann & A S George 202
<i>Goodenia brachypoda</i>	P1	"Burnt area"	N F Norris 863
<i>Goodenia gibbosa</i>	P1	"Growing in recently burnt area"	B & B Backhouse W 206
<i>Goodenia laevis</i>	P3	"Area ? recently slashed..."	C D Turley 10/1295
<i>Goodenia modesta</i>	P3	"Recent fire..."	C P Campbell 378
<i>Goodenia perryi</i>	P3	"...restricted to disturbed areas.."	M Hislop 1848
<i>Goodenia quadrilocularis</i>	P2	"...spread by roadside disturbance"	C D Turley 13/497
<i>Goodenia schwerinensis</i>	P3	"In burnt patch..."	D J Edinger <i>et al.</i> DJE2183A
<i>Goodenia sericostachya</i>	P3	"...disturbed road verge"	A S George 16407
<i>Goodenia trichophylla</i>	P3	"Burnt 18 months previously"	M Officer B 13
<i>Goodenia</i> sp South Coast (AR Annels ARA1846)	P3	"Gravel pit"	E J Croxford 4304

Australian Herbarium database of vascular plant names for Western Australia, December 2001), Green (1985) and Albrecht (2002). All data for maps were sourced from WAHERB (PERTH) database of specimen collections and mapped using ArcView 3.1 (ESRI). See Table 3 for an explanation of the CALM Priority listing codes.

Results

Biology and ecological preference

As discussed above, most *Goodenia* species have habitat preferences for the margins of water gaining sites, depressions and watercourses (Table 1). This is true for the South-West and Northern Botanical Provinces, although most evident in the Eremaean Botanical Province where *Goodenia* species are either annuals or annually regenerate from a rootstock. Table 1 gives conservation-listed *Goodenia* species lodged with the

Western Australian Herbarium collected from such habitats. "The presence and relative abundance of plants (*G. halophila* and *G. cylindrocarpa*, from central Australia) at a particular site each year appears to be highly dependant on the amount of rainfall" (Albrecht 2002).

Many *Goodenia* taxa are highly responsive to fire (resprouters or fire/ disturbance opportunists). Table 2 lists *Goodenia* species lodged with the Western Australian Herbarium collected from recently disturbed habitats that indicate this functional trait. *G. sericostachya*, a poorly known species (CALM Priority Three), shows this response. Observed to be in abundance the year after a fire, population numbers rapidly fell in the following seasons to total absence after seven years (CALM filed information). Similar responses have also been observed for the related genera *Scaevola* and *Lechenaultia* (LWS, unpublished data; GJ Howell, NSW Agriculture, personal communication). Populations of *Lechenaultia striata* in the Little Sandy Desert were seen in the thousands the year

Table 3

CALM categories of Priority Flora according to the degree of perceived threat (after Atkins 1998).

Category	
R: Declared Rare Flora Extant taxa (= Threatened Flora = Endangered + Vulnerable)	Taxa that have been adequately searched for, and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection
X: Declared Rare Flora Presumed Extinct taxa	Taxa that have not been collected or otherwise verified over the past 50 years <i>etc</i>
1: Priority One Poorly Known Taxa	Taxa that are known from one or a few (generally < 5) populations which are under threat
2: Priority Two Poorly Known Taxa	Taxa that are known from one or a few (generally < 5) populations, at least some of which are not believed to be under immediate threat (<i>i.e.</i> not currently endangered)
3: Priority Three Poorly Known Taxa	Taxa that are known from several populations, at least some of which are not believed to be under immediate threat (<i>i.e.</i> not currently endangered)
4: Priority Four Rare Taxa	Taxa that are considered to have been adequately surveyed and which, while being rare (in Australia), are not currently threatened by any identifiable factors

after fire and adequate rain only to decline in the following years (S van Leeuwen, CALM, personal communication).

Nearly 80% of perennial species on granite habitats at Chiddarcooping Hill Nature Reserve were obligate seeders likely to be killed by fire (Hopper 2000). This is relevant to the CALM Priority listed taxa on granite outcrop habitats such as *Goodenia drummondii* subsp *megaphylla* (CALM Priority Three) and *G. scapigera* subsp *graniticola* (CALM Priority Two).

Goodenia species can generally be classed in terms of life history strategy as annuals (*e.g.* *Goodenia berrinbinensis*), resprouters (*e.g.* *Goodenia stellata*) and disturbance opportunists (*e.g.* *Goodenia decursiva*). Similar numbers of annual and perennial species occur in the threatened or poorly known groups as in the abundant categories.

Phytogeography

The total number of *Goodenia* taxa recorded from material at the Western Australian Herbarium (PERTH) for the Interim Biogeographical Regions of Australia or IBRA (Thackway & Cresswell 1995) are shown in Fig 1. The highly species-rich South-West Botanical Province is reflected in *Goodenia* with over 40 taxa occurring in the region (Carolin 1992). Highest diversity occurs on the sand plain heaths of the Avon Wheatbelt, Mallee and Esperance Plains IBRA (or bioregion) rather than the wetter forest areas of the lower south-west or the arid interior. This is consistent with that observed for the general floristic pattern of the province (Hopper 1979). The nearby Murchison IBRA of the Eremaean Botanical Province shows diversity equal to that of these regions. The intervening Yalgoo and Coolgardie bioregions have fewer species (11-15 and 26-30 taxa respectively). This may indicate a low level of collector effort in these regions, although the Murchison IBRA is significantly larger in area.

Less diversity is found in the species-rich Geraldton Sandplains IBRA (16-20 taxa). This compares with

Darwinia and *Stylidium*, which also have less diversity in the Geraldton Sandplains compared with higher levels in regions such as the Avon Wheatbelt (Paczkowska & Chapman 2000).

The highest diversity in the Eremaean province occurs in the Murchison IBRA (31-35 taxa). The Pilbara bioregion (26-30 taxa) has the next highest number of species, with the central and north-west bioregions of Carnarvon, Gascoyne and the Little Sandy Desert closely following (21-25 taxa). This may be due to the diversity of habitat in these regions and a factor of higher collector effort in these regions compared to the rest of the province. The level of diversity declines in the east of the province to 0-5 taxa for the Nullarbor Hampton bioregions in the extreme south-east, though this is only for the Western Australian component of these bioregions.

In the Northern Botanical province diversity is highest in the Northern Kimberley bioregion, gradually decreasing to the south-east. Only the Western Australian components of the Tanami, Victoria Bonaparte and Ord-Victoria Plains were taken into account.

Goodenia in Western Australia is 60% endemic (Hopper *et al.* 1996, based on Carolin 1992). This is less than the average of 75% endemism for Western Australia and lower than other herbaceous genera such as *Dampiera* (91%), *Scaevola* (95%) and *Drosera* (80%). The number of *Goodenia* in the Eremaean and Northern Botanical Province whose range extends into the Northern Territory and South Australia may account for this lower level of endemism.

Threatened, rare or poorly known

Of 22 *Goodenia* species listed by CALM as Priority flora prior to this study, only one is threatened and none are presumed extinct (K Atkins, CALM, personal communication). As a result of this work a further 25 taxa were added to the CALM's Priority listings, resulting in over 40% of the genus in the state being conservation-listed. The low number of *Goodenia* species

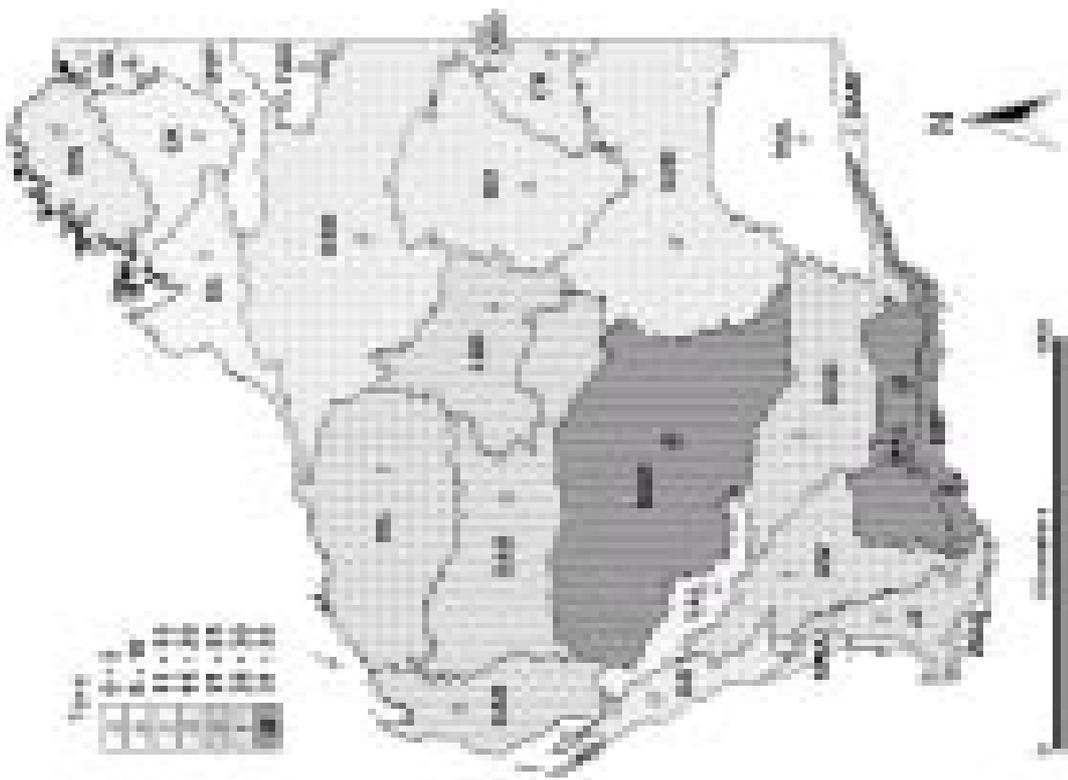


Figure 1. Total number of *Goodenia* taxa recorded for each IBRA according to PERTH (Southwest Botanical Province: AW= Avon Wheatbelt; ESP= Esperance Sandplains; GS= Geraldton Sandplains; JF= Jarrah Forest; MAL= Mallee; SWA= Swan Coastal Plain; WAR= Warren. Eremaean Botanical Province: CAR= Carnarvon; CR= Central Ranges; COO= Coolgardie; HAM= Hampton; GAS= Gascoyne; GID= Gibson Desert; GSD= Great Sandy Desert; GVD= Great Victoria Desert; MUR= Murchison; NUL= Nullabor; LSD= Little Sandy Desert; PIL= Pilbara; YAL= Yalgoo. Northern Botanical Province: CK= Central Kimberley; DL= Dampierland; NK= Northern Kimberley; OVP= Ord- Victoria Plain; TAN= Tanami).

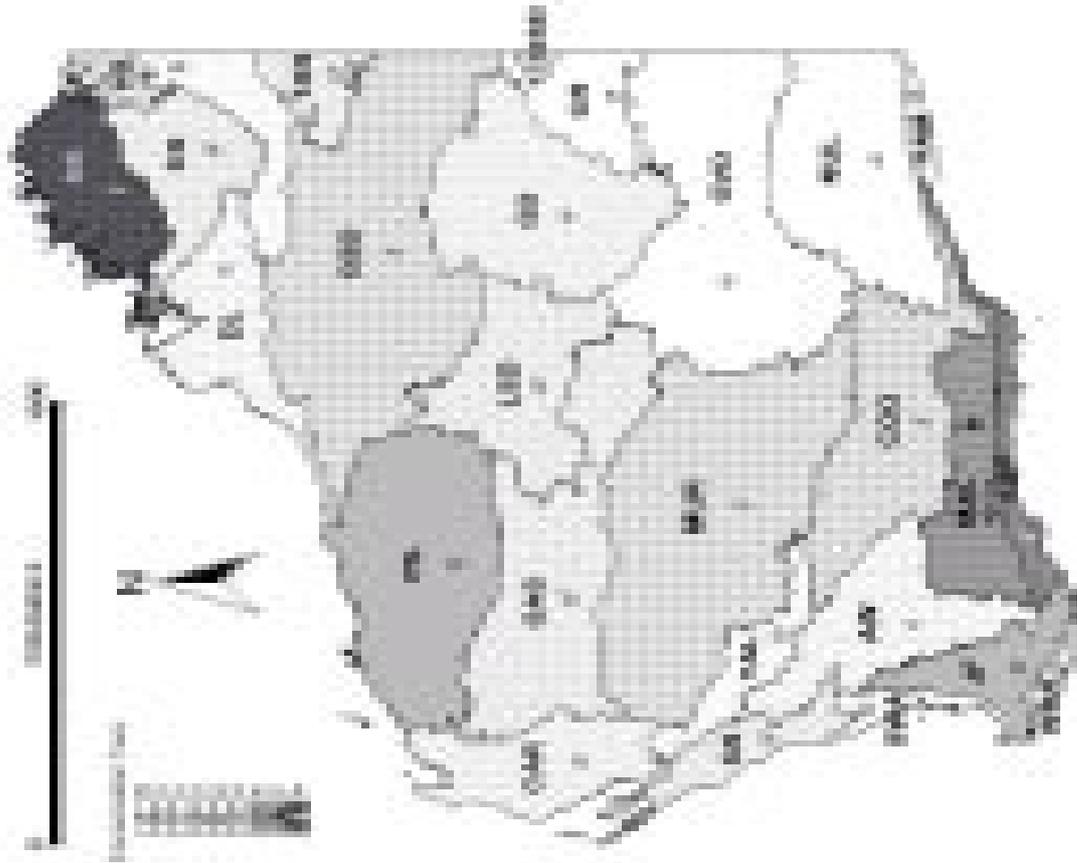


Figure 2. Total number of *Goodenia* conservation-listed taxa for each IBRA in Western Australia, as of December 2001.

currently listed as threatened may reflect the relatively recent publication of the Flora of Australia in 1992 and the paucity of previous work in Western Australia. A taxon cannot be upgraded to threatened unless it has been thoroughly searched for in the wild by botanists in the past five years and been shown to be rare or under some threat of extinction (Brown *et al.* 1998).

The number of threatened, rare or poorly known *Goodenia* species are shown for the IBRA for Western Australia in Fig. 2. The highest numbers occur in the species rich South-West Botanical Province, specifically the Esperance Plains IBRA, the area of highest diversity, survey effort, and habitat destruction and disturbance. The Northern Kimberley and the Esperance Sandplains IBRA each have eight species of conservation listed taxa. This high level of conservation-listed taxa in the Northern Kimberley may be due to the bioregion having the highest diversity of the Northern province and being very poorly collected. Prior to this study, very few conservation taxa were known to occur in the Eremaean or Northern botanical province, though the majority of the newly recommended taxa occur there.

An estimated 45% of populations of threatened or poorly known *Goodenia* species occur on the conservation estate *i.e.* reserves, national parks and state forest and local government reserves (K Atkins, CALM, unpublished data). This compares favourably with 37.9% for the all of the threatened species in the State (K Atkins, CALM, unpublished data).

The following 25 taxa were added to the CALM Codes for Priority Flora listings (see Appendix 1 for a detailed account of each taxon) as a result of this study; *Goodenia berringbinensis*, *G. brachypoda*, *G. byrnnesii*, *G. crenata*, *G. gibbosa*, *G. gloeophylla*, *G. grandiflora*, *G. hartiana*, *G. heatheriana*, *G. janamba*, *G. kakadu*, *G. lunata*, *G. modesta*, *G. omearana*, *G. pasqua*, *G. salmoniana*, *G. purpurascens*, *G. schwerinensis*, *G. strangfordii*, *G. suffrutescens*, *G. sp Lake King* (*M Gustafsson et K Bremer* 132), *G. sp Scaddan* (*C D Turley* 41VM/1099), *G. sp South Coast* (*A R Annels* ARA1846), *G. virgata* and *G. varia*.

Discussion

Threatening processes

Threatening processes affecting Western Australian *Goodenia* were observed by the authors and other botanists. They can often be inferred from the habitats the species occur in, the life history strategy and general threats to other species as discussed in Brown *et al.* (1998). Critically small remnants are directly threatened by degradation and destruction (Coates & Atkins 2001). Other threats are introduced weeds, *Phytophthora* root rot disease, and feral and agricultural animal grazing. All specifically relate to the highly altered and fragmented *Goodenia*-'rich' Kwongan sand plain heaths of the South-West Botanical Province, and except for *Phytophthora* are relevant to the Eremaean and Northern Botanical Provinces. Overall these processes vary between IBRA and the broader Botanical Provinces.

Rising salinity and water tables is a significant problem to the flora of the South-West Botanical Province (Brown *et al.* 1998) and threatens species such as *Goodenia*

integerrima (currently listed as threatened by CALM) and *G. sp Lake King* (*M Gustafsson et K Bremer* 132). Both taxa occur in halophytic vegetation on the edge of a few salt lakes in the Avon Wheatbelt IBRA (and are therefore saline tolerant at some level).

Phytophthora cinnamomi root rot disease is a significant threat to the families Proteaceae, Epacridaceae, Papilionaceae and Myrtaceae of the South-West Botanical Province (Brown *et al.* 1998). Goodeniaceae in general are affected as the family is the sixth highest vascular plant family affected by plant pathogens, including *Phytophthora cinnamomi*, rusts and other fungal infections (Shearer 1994). The related genera *Dampiera* and *Scaevola* (Goodeniaceae) are susceptible to *Phytophthora* species infection (Malajkuk & Glenn 1981; McDougall *et al.* 2001). Thus species of threatened or poorly known *Goodenia* occurring within the higher rainfall zones of the South-West Botanical Province should be treated as potentially susceptible to *Phytophthora* root rot disease.

Invasive weeds are a major threat in the highly fragmented Avon Wheatbelt IBRA. Agriculture has altered this bioregion from a vast mosaic of perennial vegetation associations to only small remaining fragments of native vegetation (Hobbs 1998; Scanlan *et al.* 1992). A survey of the relatively undisturbed Yilliminning Rock Reserve (east of Narrogin in the central Avon Wheatbelt IBRA) found 8% of flora to be introduced weeds (Pigott & Sage 1997). Another survey found 10% of plant species in Jingaring Nature Reserve to be introduced weeds (Obbens *et al.* 2001). These percentages are consistent with relatively undisturbed remnants, while highly disturbed remnants contain much higher percentages. Generally weeds are difficult to remove once introduced, and prevent perennial species regenerating (Hobbs & Atkins 1991). This threat is highly relevant to the *Goodenia*-'rich' Avon Wheatbelt IBRA and should be addressed in any management regimes for threatened or poorly known *Goodenia*.

For the Eremaean and Northern Botanical Provinces the main threatening process are feral and agricultural herbivores that degrade the margins of water bodies, a major habitat of *Goodenia* species. Pickard (1993) states that semi-arid ecosystems, such as the margins of water bodies, are under threat from current land use practices involving domestic and feral herbivores as well as feral carnivores. Mining activities may also be a threat, especially in the Pilbara where species have small distributions or restricted habitats.

Apparent causes of rarity

Loss of suitable habitat, through natural or anthropogenic processes, for those species that are habitat dependent and occur in regions of the greatest habitat destruction (such as the South-West Botanical Province) may be a cause of rarity in certain *Goodenia* species. *Goodenia katabudjar* is an example of habitat limitation mostly through anthropogenic habitat destruction (Cranfield & Sage 1997). This species is restricted to upland Jarrah-Wandoo woodland intergrade on the central border of the Jarrah Forest and Avon Wheatbelt IBRA, which has been cleared over most of its known range. Recently discovered and described, this species is known from only three populations and is under immediate threat from mining activities (Cranfield



Figure 3. *Goodenia arthrotricha* Benth (photograph by H Bowler, used with permission).

& Sage 1997). Urgent field surveys are required to determine the true conservation status of this species.

Difficulty in identification can hinder knowledge of a species and survey work. *Goodenia* can be relatively difficult to identify correctly as some species are polymorphic and diagnostic characters can be hard to recognize. Taxonomic bias can contribute to this. Some of the perennial species tend to die off in summer, and without adequate flowering material identification may be impossible, or the species may be totally missed by collectors (e.g. *Goodenia arthrotricha*, is often confused with *Scaevola calliptera*; Fig 3).

Low collector effort (i.e. few herbarium specimens collected and lodged for a given area) can create an apparent rarity of a species particularly when herbarium specimens are the sole source of population data (Fig 4). An example of this is *Goodenia drummondii* sp. *megaphylla*, a new subspecies only recently described from the Jarrah Forest IBRA near the Perth metropolitan area (Sage 1998). This taxon was listed as a Priority Three species with only a few known populations. Recent collector effort in the area has turned up a further fifteen populations, all in state forest. Thus we recommend the taxon for removal from the Priority list.

Fig 4 illustrates the total collector effort for *Goodenia* lodged at the Western Australian Herbarium. As expected, the highest concentration of collector effort is in the south-west of the state, becoming more restricted to major roads towards the interior. Hence some poorly known species, from poorly collected areas, might more be a factor of collector effort than actual rarity.

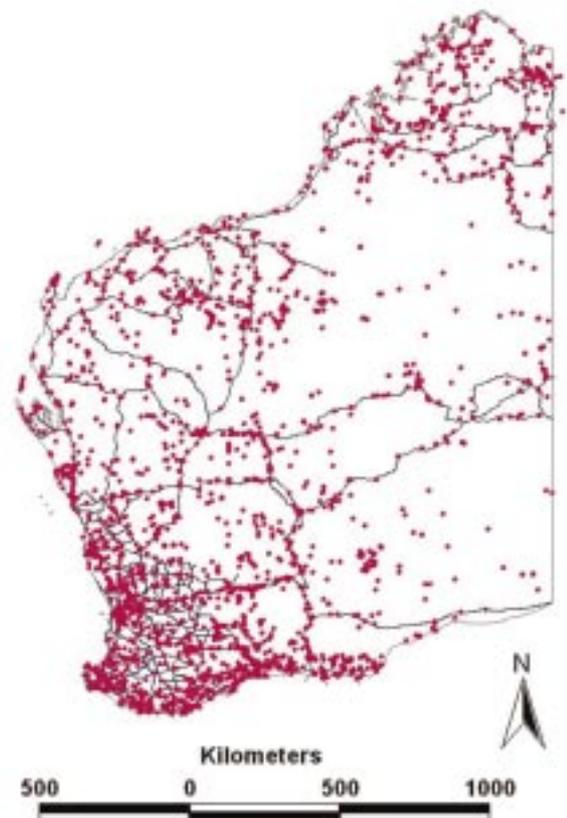


Figure 4. Total *Goodenia* collector effort for Western Australia (WA Herbarium; PERTH) as of September 1999; major roads are shown.

Collections from the South-West Botanical Province may give a more accurate picture of conservation status than collections from either the Eremaean or Northern Botanical Provinces (Fig 4). An assessment scale in relation to collector effort for each Botanical Province may help determine the conservation status for respective taxa. However even in the 'better' collected South-West Botanical Province there are large collecting "gaps" due to various factors such as accessibility (P Gioia, CALM, personal communication). This may be taken into account when making a conservation assessment of a species from the Eremaean or Northern Botanical Provinces, though difficult to assess. The CALM Priority rankings are used to indicate areas where further surveying is currently required for poorly known species and this is relevant for a species regardless of its region (or that region's collector effort). In the Eremaean and Northern Botanical Provinces *Goodenia* species are more likely to be associated with water bodies but roads (concentrations of collector effort) are built to follow ridges and avoid drainage lines (Burgman & Lindenmayer 1998).

Management and research considerations

A clear understanding of plant taxonomic and genetic resources is required for effective and successful biological conservation (Hopper 1994). This is highly relevant to *Goodenia* and the Goodeniaceae in general, which are currently poorly known in both areas. This may be a consequence of resources and interest being directed towards previously listed conservation taxa as currently only *Goodenia integerrima* is legislatively protected as threatened or declared rare flora. This work aims to direct attention to species of *Goodenia* and Goodeniaceae recommended for conservation listing. We are working towards delineating the taxa in *Goodenia* that require further conservation efforts (Hopper 1994). Determining (genetic) conservation units in threatened taxa that allows a delineation of suitable units for conservation also provides the appropriate geographical scale for management (Coates 2000). This is relevant to the highly fragmented *Goodenia*-'rich' South-West Botanical Province.

We recommend the following procedures for managing threatened, rare and poorly known *Goodenia*;

1. **Fire Regimes.** Fire regimes for reserves that contain threatened, rare or poorly known *Goodenia* should take into account the fire response of the individual species involved and the habitat type. Research into the longevity of the seed soil bank and the reproductive biology of species is a priority. Non-invasive practices such as smoke-induced seed germination (Roche *et al.* 1998) should be considered in any management program. Most *Goodenia* species respond favourably after a fire event, often demonstrating the true abundance of a species (Table 2). Some species of *Scaevola* may "disappear" if fire is excluded from a management regime (GJ Howell, NSW Agriculture, personal communication) and this may be the case for *Goodenia* as well.
2. **Reserve Design.** Reserve design should take into account the habitat preference of *Goodenia* species for the margins of water bodies and water gaining sites. *Goodenia* are often found associated with water

features (temporary lakes and watercourses) in central Australia, although this is not indicative of an aquatic phase (Table 1). Their habitat is often not covered by arbitrary reserve boundaries or may be affected by upstream water flow (salinity, silt or nutrients). Reserve design should also ideally support pollinators. Population management should include the genetic resources of species and plant numbers as well as the availability and abundance of pollinators (Coates & Atkins 2001).

3. **Flora Surveys.** Urgent surveys are required for nearly all conservation-listed *Goodenia* taxa in Western Australia. Only *G. neogoodenia*, *G. stellata* and *G. integerrima* have been adequately searched for in the wild. Survey efforts in the Eremaean and Northern Botanical Provinces should be directed to those conservation-listed taxa that are threatened by mining unless the taxon is highly restricted or otherwise requires immediate attention (*e.g.* *Goodenia salmoniana*, which is known only from the holotype collection, made in 1889). Collected material should be identified by specialist botanists, as some Western Australia *Goodenia* are problematic (*e.g.* *Goodenia aff pascua*, currently being examined by LWS).
4. **Threats.** Measures to protect conservation-listed *Goodenia* in the South-West botanical province, specifically the Avon Wheatbelt IBRA, are essential to the future survival of species such as *G. integerrima* and *Goodenia* sp Lake King (*M Gustafsson et K Bremer* 132) which are under direct threat from rising salinity and hydrological changes.
5. **Ex situ conservation.** Once a better understanding of the true conservation status of many *Goodenia* conservation taxa is gained, cryogenic storage and long term seed banking should be undertaken for those species requiring it.

Conclusion

Goodenia in Western Australia is unsatisfactorily known and requires further surveying and monitoring, and biological research. Many taxa have never been surveyed or are known from a few historical collections or only a holotype collection and little is known of their biology. Over 40% of Western Australian *Goodenia* species are now on CALM Conservation Codes for Western Australian Flora Priority lists. Many species may prove to be more common than currently thought due to factors such as poor collector effort, taxonomic bias and difficulty in identification. Life history strategy may affect the abundance of *Goodenia* species at any given point in time. Relatively similar numbers of annuals and perennials occur among poorly known and abundant species. Though quite well conserved on the conservation estate in the South-West Botanical Province, *Goodenia* species are under direct threats from land clearing, rising salinity, invasive weeds and habitat degradation, including the margins of water points in the Eremaean and Northern Botanical Provinces, a major *Goodenia* habitat in these regions. We would encourage professional and amateur botanists with the relevant licenses to lodge good material of *Goodenia* species with accurate site and plant details with the Western

Australian Herbarium (PERTH), as this can contribute significantly to the knowledge of our flora.

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Appendix 1

Conservation-listed *Goodenia* from Western Australia. Data taken from CALM filed information and Western Herbarium (PERTH) label information, as of December 2001.

Taxa	Status * (CALM; ROTAP)	Number of populations (total; in conservation reserves)	WA Distribution (IBRA)	Number of plants (estimated)	Main threats	Closest relative	Notes
1. <i>Goodenia anfracta</i>	P1; 3K	3; 0	GSD	?	?	<i>G. fascicularis</i>	Surveys required; photograph of holotype for PERTH; very poorly known in WA.
2. <i>Goodenia arthrotricha</i>	P1; 2K	ca 4; 1	SWA	< 50	urban clearing	-	Urgent surveys required; populations of scattered individuals.
3. <i>Goodenia berringinensis</i>	P1; 3K	4; 0	CAR, MUR, GAS	> 1000	water point degradation	-	Probably more common than is apparent; requires surveys.
4. <i>Goodenia brachypoda</i>	P2; 2K	5; 0	VB	?	unknown	<i>G. sepalosa</i>	Restricted range; very poorly known.
5. <i>Goodenia byrnesei</i>	P1; 1K	1; 0	DL	?	water point degradation	<i>G. sepalosa</i>	Extended range across northern Australia, although poorly known in WA.
6. <i>Goodenia crenata</i>	P3; 3K	5; 0	TAN, OVP, CK	> 500	?	<i>G. hirsuta</i>	Probably more common than is apparent.
7. <i>Goodenia drummondii</i> subsp <i>megaphylla</i>	P3; 3C-	15; ca 2	JF, AW	> 500	?	<i>G. helmsii</i>	Not currently under immediate threat with some populations on reserves.
8. <i>Goodenia durackiana</i>	P1; 2K	2; ?	CK, VB	?	?	<i>G. leiosperma</i>	Surveys required.
9. <i>Goodenia filiformis</i>	P3; 2KC-	ca 6; 1	WA, ESP	< 300	land clearing	<i>G. pulchella</i>	Confusion with <i>G. pulchella</i> .
10. <i>Goodenia gibbosa</i>	P1; -	ca 3; 0	CR	?	?	<i>G. pinnatifida</i>	Common and widely distributed in the NT; surveys required.
11. <i>Goodenia gloeophylla</i>	P2; -	ca 2; 0	NK	< 100	?	<i>G. purpurascens</i>	Widely distributed across NT.
12. <i>Goodenia grandiflora</i>	P1; -	1; 0	CR	< 50	?	<i>G. kingiana</i>	A variable species common across eastern central Australia, although very poorly known in WA.
13. <i>Goodenia hartiana</i>	P2; 2K	2; 0	GSD, LSD	< 100	mining activities	<i>G. azurea</i>	May prove to be more common than apparent, due to visual similarity to <i>G. azurea</i> .
14. <i>Goodenia heatheriana</i>	P1; 2K	ca 3; 0	AW, COO	< 100	mining activities	<i>G. pinnatifida</i>	Urgent surveys required; previously unsuccessfully searched for.
15. <i>Goodenia hirsuta</i>	P1; -	?	?	?	?	<i>G. cycloptera</i>	No collections located at PERTH; distribution unknown.
16. <i>Goodenia integerrima</i>	Endangered; 2ECIT	2; 2	AW	< 50	salinity, hydrological change	-	Known from only a handful of plants in 2 populations.
17. <i>Goodenia janamba</i>	P1; -	3; 0	DL, NK, VB	?	?	-	May prove to be more common than apparent.
18. <i>Goodenia kakadu</i>	P3; -	5; ?	NK	?	?	<i>G. pumilo</i>	Found in NT and may prove to be more common than is apparent.
19. <i>Goodenia katabudjar</i>	P2; 2K	3; 0	JF	< 150	mining activities	<i>G. leptoclada</i>	Urgent surveys required as is under threat from mining activities.
20. <i>Goodenia laevis</i> subsp <i>laevis</i>	P3; 3K	6; 0	COO, ESP, MAL	< 600	?	<i>G. laevis</i> ssp <i>humifusa</i>	Surveys required.
21. <i>Goodenia lunata</i>	P1; -	1; 0	CK	?	?	<i>G. fascicularis</i>	Common throughout inland eastern Australia; should prove to be more common in WA than is apparent.
22. <i>Goodenia lyrata</i>	P1; 3K	ca 1; 0	MUR	?	?	<i>G. modesta</i>	Taxonomically confused with <i>G. modesta</i> , requires clarification.
23. <i>Goodenia modesta</i>	P3; 3K	ca 4; 0	TAN, CR, GSD	?	?	<i>G. lyrata</i>	As per <i>G. lyrata</i> .

Appendix 1 (cont.)

Taxa	Status* (CALM; ROTAP)	Number of populations (total; in conservation reserves)	WA Distribution (IBRA)	Number of plants (estimated)	Main threats	Closest relative	Notes
24. <i>Goodenia neogoodenia</i>	P4; 3R	+6; ca 1	CAR, MUR, YAL	< 1000	mining activities, water point degradation	-	Well surveyed in recent years with a number of populations not vouchered, which should facilitate removal from Priority listings.
25. <i>Goodenia nuda</i>	P1; 3K	ca 8; 0	PIL	?	mining activities	<i>G. microptera</i>	Recently surveyed and found to be more common than previously thought.
26. <i>Goodenia omearana</i>	P1; 2K	3; 0	PIL	< 150	mining activities	<i>G. pascua</i>	Requires urgent surveys; 2 populations under immediate threat.
27. <i>Goodenia pallida</i>	P1; 1K	1; ?	PIL	?	?	<i>G. nuda</i>	No collections at PERTH, requires surveys to relocate only population.
28. <i>Goodenia pascua</i>	P3; 3K	ca 6; ?	PIL, CAR	?	?	<i>G. glauca</i>	Surveys required; poorly known (including taxonomically).
29. <i>Goodenia perryi</i>	P3; 1K	6; ?	AW, YAL	< 500	salinity, weeds	<i>G. incana</i>	More common than previously thought, although still requiring Priority listing.
30. <i>Goodenia phillipsiae</i>	P1; 1K	ca 1; 0	ESP	?	?	-	Surveys required to relocate holotype populations.
31. <i>Goodenia purpurascens</i>	P3; -	ca 3; 0	LSD, NK	?	?	<i>G. paludicola</i>	Common in NT and QLD, although very poorly known from WA.
32. <i>Goodenia quadrilocularis</i>	P2; 2KC-	ca 3; 3	ESP, JF	< 500	?	-	Surveys required to substantiate the Porongurups population.
33. <i>Goodenia salmoniana</i>	P1; 1K	1; 0	GAS	?	land clearing	-	Urgent surveys are required to relocate the species (known only from holotype).
34. <i>Goodenia scapigera</i> subsp <i>graniticola</i>	P2; 2KC-	ca 3; 3	MAL	< 150	?	<i>G. drummondii</i>	Fully represented on conservation reserves though from only 3 small populations.
35. <i>Goodenia schwerinensis</i>	P3; 3K	6; 0	CR, MUR	?	?	<i>G. glabra</i>	Known from a wide range.
36. <i>Goodenia sepalosa</i> var <i>glandulosa</i>	P3; 3K	ca 6; 0	DL, NK, VB	?	?	-	Known from a wide range.
37. <i>Goodenia sericostachya</i>	P3; 3K	ca 5; ?	CAR, GS	< 1000	land clearing	-	Surveys required.
38. <i>Goodenia</i> sp Lake King (M Gustafsson et K Bremer 132)	P2; 3KC-	3; 2	AW	< 50	salinity, hydrological changes	<i>G. pinnatifida</i>	Urgent surveys required; very poorly known.
39. <i>Goodenia</i> sp Scaddan (CD Turley 41VM/1099)	P1; 2K	2; 0	ESP	< 200	salinity, hydrological changes	<i>G. claytoniacea</i>	Urgent surveys required; very poorly known.
40. <i>Goodenia</i> sp South Coast (AR Annel's ARA 1846)	P3; 3K	ca 3; 3	JF, WAR	< 200	hydrological changes	<i>G. caerulea</i>	A poorly known species requiring taxonomic study.
41. <i>Goodenia stellata</i>	P3; 3KC-	8; ?	MUR, GAS, LSD, PIL	> 1000	mining activities	<i>G. crenata</i>	Wide range but still under potential threat.
42. <i>Goodenia stenophylla</i>	P4; 2RC-	ca 7; ca 4	ESP	?	?	<i>G. helmsii</i>	Requires continued monitoring.
43. <i>Goodenia strangfordii</i>	P1; -	ca 3; 0	GSD, VB	?	water point degradation	<i>G. fascicularis</i>	Occurs across NT and into QLD, although poorly known in WA.
44. <i>Goodenia suffrutescens</i>	P1; 2K	4; 0	GSD, TAN	?	?	<i>G. azurea</i>	Surveys required.
45. <i>Goodenia trichophylla</i>	P2; 3KC-	ca 7; ?	ESP, GS, COO, MAL	?	?	<i>G. caerulea</i>	Further surveys required.
46. <i>Goodenia varia</i>	P2; -	ca 3; 0	COO, MAL	?	?	<i>G. ovata</i>	Common across southern Australia.
47. <i>Goodenia virgata</i>	P2; -	3; 0	GD; GSD	?	?	<i>G. nuda</i>	Surveys required; also known from NT.
48. <i>Goodenia xanthotricha</i>	P1; 3KC-	ca 4; ca 3	GS, SWA	?	?	-	Known mostly from historical collections.

* See Table 3 for an explanation of CALM Priority list codes. See Briggs & Leigh (1996) for an explanation of ROTAP codes.