Conservation Assessment of *Goodenia nocoleche* Pellow & J.L.Porter (Goodeniaceae)

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***Goodenia nocoleche* Pellow & J.L.Porter (Goodeniaceae)**
Distribution: NSW and QLD
Current EPBC Act Status: Not listed
Current NSW BC Act Status: Endangered

Proposed listing on NSW BC Act: Vulnerable.

Reason for Change: Non-genuine change based on increased knowledge of species ecology, distribution and threats.

Summary of Conservation Assessment

Goodenia nocoleche was found to be eligible for listing as Vulnerable under Criterion B1(a)(b iii) and B2(a)(b iii).

The main reasons for this species being eligible are (i) *Goodenia nocoleche* has a moderately restricted Extent of Occurrence (EOO) of 12,113 km^2 and a highly restricted Area of Occurrence (AOO) of 36km^2; (ii) *Goodenia nocoleche* is known from six threat-defined locations; and (iii) continuing decline has been observed and is projected to continue in the area, extent and quality of habitat due to degradation by feral animals and domestic livestock and weed invasion.

Description and Taxonomy

Goodenia nocoleche was described by Pellow and Porter (2005) as an "ephemeral amphibious herb to 40 cm high, vegetative parts glabrous. Basal leaves with floating lamina 20–40 mm long, 7–14 mm wide, thin, glossy green above, flat, lanceolate, margins undulate and minutely toothed, apex acute with tooth. Petioles elongated to 60 cm long, much longer than lamina, lengthening with water depth. Cauline leaves present at base of flowering stem 10–40 mm long, 2–3 mm wide. Flowers in racemes. Bracts longer towards base of inflorescence, linear and sometimes resembling leaves, 10–40 mm long. Bracteoles linear, 8–10 mm long, 0.6–1 mm wide, with minute simple and glandular hairs; bracteoles occasionally producing axillary buds which extend into new inflorescence branches. Pedicels 2–5 mm long without articulation. Floral tube 3–5 mm long with minute simple and glandular hairs. Calyx lobes linear, 4–6 mm long, 0.8–1 mm wide, numbering 5 or sometimes 6, attaching in top ⅓ of floral tube and covered with minute simple and glandular hairs. Corolla yellow, 5–5.5 mm long, lobe tips often tinged with pink or purple; glandular and simple hairs present externally, glabrous internally; no enations observed; anterior pocket obscure; abaxial lobes 2 mm long with wings approximately 0.5 mm wide; adaxial lobes 2.5 mm long with wings approximately 0.5 mm wide. Staminal filaments 1.8–2.0 mm long, anthers 0.5–0.8 mm long. Ovary with numerous ovules in 2 rows on either side of the septum; septum almost as long as the ovary. Style 2–2.5 mm long with scattered long simple hairs; indusium 1–1.5 mm long, 1–1.3 mm wide, purplish in colour, hairs present on adaxial rim, abaxial rim without hairs. Fruit pale, obconical, 5–6.5 mm long, 2–3 mm wide, hispid with short simple and glandular hairs. Seed 1 mm long, 2.5 mm wide, light brown, glossy, reticulation faint, winged."

Goodenia nocoleche has also been known as *Goodenia* sp 'Nocoleche' (JLP210) prior to being formally described in 2005. It is distinguished from other *Goodenia* species predominantly in its amphibious habit with floating aquatic leaves, a feature which has only been noted in two other species which do not co-occur with *G. nocoleche: G. lamprosperma* from northern Australia and *G. berringbinensis* from Western Australia (Gibson 2014). *G. nocoleche* is then distinguished from these and other species in *Goodenia* section *Porphyranthus* by the smaller flowers with calyx lobes equal to or just shorter than the corolla lobes (NSW OEH 2019).

Distribution and Abundance

Goodenia nocoleche is a naturally rare and cryptic species currently known from nine sites in the Bulloo and Paroo River systems of northwest NSW and southwest Queensland. It has only ever been observed as standing plants at two of these sites and has been retrieved from the soil seed bank at the remaining sites (Table 1). All sites are within the Mulga Lands and Channel Country Bioregions (DAWE 2012) and on the traditional lands of the Barundji, Budjiti, Karenggapa and Bandjigali people (Horton 1996; State of Queensland 2021b).

Table 1 – Population data for all known sites of *Goodenia nocoleche* based on current survey data.

Site	Catchment	Tenure	Type of Wetland[1]	Standing plants observed	Abundance estimate[2]	Mean density of seeds[3] (per sq m)	Size of wetland (Ha)[1]
Pied Stilt Swamp	Paroo	Nocoleche NR	Fresh Temporary	Yes	5000–10000	1511	22
Momba Swamp	Paroo	Nocoleche NR	Fresh Temporary	No	unknown	10	16
Waitchie Lake	Paroo	Freehold	Fresh Permanent	No	unknown	4	140
Lake Numalla	Paroo	Currawinya NP	Fresh Permanent	No	unknown	1	3250
c. 40km north of Wanaaring	Paroo	Freehold	Fresh Temporary	Yes	unknown	unknown	unknown
Rattigan Swamp	Paroo	Nocoleche NR	Fresh Temporary	No	unknown	unknown	108
Claypan North	Paroo	Nocoleche NR	Fresh Temporary	No	unknown	unknown	7.9
Claypan 18	Paroo	Nocoleche NR	Fresh Temporary	No	unknown	unknown	3
Lake Altibouka	Bulloo	Freehold	Salt Permanent	No	unknown	3	565

[1] Taken from Porter *et al.* (2007) and Porter (2019).

[2] Based on *in situ* aboveground observations only.

[3] Based on *ex situ* soil seedbank sampling as per Porter *et al.* (2007).

Goodenia nocoleche was initially discovered from soil seedbank sampling undertaken in arid wetlands in 1997 when sediment cores that were collected from the wetland beds on foot or by boat where inundated and experimentally flooded *ex situ*, with any germinants grown on for identification (Porter 2002; Porter *et al.* 2007). This work found the species to be present in the seedbank of five wetlands, being common (mean density 1,511 seeds per m^2) in the seedbank of one freshwater temporary wetland, Pied Stilt Swamp in the Paroo catchment, and uncommon (mean density < 15 seeds per m^2) in Momba Swamp, Waitchie Lake and Lake Numalla in the Paroo catchment and Lake Altiboulka in the Bulloo catchment (Pellow and Porter 2005).

Standing plants of *Goodenia nocoleche* were subsequently recorded growing in Pied Stilt Swamp in 1998 and 2000, as well as in another unnamed wetland *c.* 40 km north of Wanaaring in 2000, bringing the number of known sites to six (Pellow and Porter 2005). Searches of 30 other wetlands within Nocoleche Nature Reserve following heavy rainfall in March 2000, including seedbank sampling of three claypans and subsequent germination trials, did not report further subpopulations of *G. nocoleche* (J. Porter *in litt*. June 2004). Visits to a further 24 wetlands in the Wanaaring–Tibooburra–Hungerford area also did not record the species at this time (J. Porter *in litt.* June 2004).

There has only been one other observation of standing plants of *Goodenia nocoleche*, when the species was found in September 2020 at Pied Stilt Swamp (RBGDT 2020). This is despite other targeted searches in Nocoleche Nature Reserve in March 2008 and February 2019 as well as non-targeted vegetation mapping surveys in September 2019 (Armstrong 2008; Porter 2019; Hunter 2020). The February 2019 survey collected further soil samples and experimentally flooded them *ex situ*, detecting *G. nocoleche* in samples from five wetlands within Nocoleche Nature Reserve, two previously known (Pied Stilt and Momba Swamps) and three new, bringing the total known sites to nine (Porter 2019). The number of *Goodenia* germinants in these sediment samples was very low however, with few plants germinating from all samples (M. Ooi *in litt.* August 2020).

Pied Stilt Swamp partially filled in September 2020 and, after a survey of all recently and currently inundated areas of the swamp, *Goodenia nocoleche* was found to occur only in the lowest accessible parts of the swamp at that time with thousands of individuals recorded across approximately 4 ha (RBGDT 2020). Other apparently similar sections of the swamp did not contain any individuals (G. Phillips pers. obs. September 2020). The subpopulation size in this swamp was estimated at 5,000–10,000 individuals at the time, with this figure regarded as conservative (G. Phillips pers. obs. 2020). In June 2021 a further targeted search was conducted in wetlands holding water along a stretch approximately 40–70 km north of Wanaaring adjacent to the Paroo River. These searches also failed to locate *G. nocoleche* (G. Phillips pers. obs. 2021).

Eight of the nine known subpopulations occur in the Paroo River catchment and one (Lake Altibouka) in the Bulloo River Overflow (Appendix 2). Most sites are filled predominantly by localised rainfall and are only connected to either the Paroo or Bulloo Rivers in years of heavy flood (Pellow and Porter 2005; Porter *et al.* 2007; Armstrong 2008; Porter 2019).

Population estimates for highly ephemeral species such as *Goodenia nocoleche*, which largely persist as seeds in the seedbank of arid wetlands and only emerge

during periods of sufficient rainfall, typically carry a high level of uncertainty. Soil seedbank data alone are an unreliable indicator of standing plant abundance and population structure as the effects of stochastic rainfall events and drought disturbance on seed dormancy, seedling growth, reproduction and dispersal are all unknown for *G. nocoleche* (J. Porter *in litt.* June 2004). Exorheic, permanent, deep and highly turbid water bodies (e.g. Lake Numalla and Waitchie Lake) and more saline, mostly dry lakes which may exhibit lethal levels of salinity at times (e.g. Lake Altiboulka) rarely meet the conditions for growth of *G. nocoleche* (Porter 2002, J. Porter *in litt.* June 2004). However, the viability of these subpopulations as well as those in wetlands apparently more suitable to the development of *G. nocoleche* such as shallow, temporary, freshwater claypans (Porter *et al.* 2007) where the species has also not been observed aboveground remains difficult to objectively determine. Given this, all subpopulations where plants have been detected aboveground and from soil seedbank sampling alone are currently considered viable, though it is possible that a number of the wetlands where seedbank samples indicate presence, yet no standing individuals have been observed, represent non-viable subpopulations.

Undiscovered populations of *G. nocoleche* may exist in the many unsurveyed and often remote wetlands of the vast inland river systems. Porter's (2002) work shows the ability for *G. nocoleche* to persist in these habitats is substantial. This includes wetlands where a soil seedbank may exist but any visit by field surveyors may not coincide with conditions suitable for germination and development of aboveground plants.

Area of Occupancy and Extent of Occurrence

The Extent of Occurrence (EOO) is based on a minimum convex polygon enclosing all mapped occurrences of the species, the method of assessment recommended by IUCN (2022) and was measured at 12,113 km^2. Area of occupancy (AOO) was calculated using 2 x 2 km grid cells, the scale recommended by IUCN (2022) and was calculated to be 36 km^2, occupying nine grid cells. Both EOO and AOO were calculated using GeoCAT software (Bachman *et al.* 2011), enclosing all recent confirmed survey records where aboveground plants have been recorded as well as those only known through soil seedbank sampling alone. Based on these estimates, *Goodenia nocoleche* has a moderately restricted EOO and highly restricted AOO.

Number of Locations

Goodenia nocoleche is an ephemeral species of arid zone wetlands, with populations responding to erratic and infrequent flooding events in this specific habitat. The most serious plausible threat to the species is therefore considered to be habitat degradation due to disturbance from feral pigs (*Sus scrofa*) as they are known to be active in areas such as the Nocoleche Wetlands and along the Paroo River in both Queensland and NSW (Dexter 1996; NPWS 2000; Choquenot and Ruscoe 2003; Gentle *et al.* 2019). Damage in these wetlands due to pig wallowing has also been directly observed in Nocoleche Nature Reserve (G. Phillips pers. obs. September 2020) and Currawinya National Park (Peck 2020). They are also highly abundant in the Cuttaburra Creek catchment (National Feral Pig Action Plan 2022) meaning that their ability to degrade habitat in the adjacent subpopulations of *G. nocoleche* is substantial. However, pigs are also largely sedentary in the region (DPI 2023), with high site fidelity based on riverine woodlands used for shelter as well as forage

availability imparting relatively small average home ranges (Dexter 1998, 1999; Choquenot and Ruscoe 2003). This means that in the Nocoleche Wetlands, sites are not affected by this threat equally, as wetlands more than 10 km from the Paroo River channel never appear to support pig populations of high enough frequency to cause widespread damage (Choquenot and Ruscoe 2003), most likely due to the large areas of unsuitable, open shrubland habitat between the endorheic basins and the Paroo River (Dexter 1999; G. Phillips pers. obs. September 2020).

Thus, based on average pig densities for the region of approximately one pig per km^2 (Gentle *et al.* 2019), average home ranges of <12 km^2 in Nocoleche Nature Reserve (Dexter 1999), differences in control between public and private lands (NPWS 2000) and distances between sites (Appendix 2), the nine subpopulations of *Goodenia nocoleche* can be considered to span six threat-defined locations as follows:

1. Lake Numalla within Currawinya National Park in Queensland. This location has regular control of feral pigs, however they remain high in number in the area and cause significant damage to wetlands (Peck 2020). This location is approximately 70 km north of the nearest other site.
2. The unnamed wetland approximately 40 km north of Wanaaring. This site is in largely unfenced pastoral lands along the Paroo River and is adjacent to the Cuttaburra Basin which has some of the highest pig densities in NSW (National Feral Pig Action Plan 2022). It is approximately 65 km north of the Nocoleche wetlands.
3. Nocoleche Wetlands within 5 km of the Paroo River, including Pied Stilt Swamp, Momba Swamp and Claypan 18. These wetlands are frequented by pigs in wet years (G. Phillips pers. obs. September 2020) and studies have shown that pigs in this area can increase in abundance by dispersing from the river corridor when food is abundant (Choquenot and Ruscoe 2003). Thus, these wetlands are likely to have constant degradation from pigs at key times in the lifecycle of *Goodenia nocoleche* despite ongoing control within the Nature Reserve (NPWS 2000).
4. Nocoleche Wetlands over 10 km west of the Paroo River, including Rattigan Swamp and Claypan North. These endorheic wetlands are 5–10 km further west from the Paroo River than the core Nocoleche Wetlands to the east, separated from them by extensive shrublands and stony rises (G. Phillips pers. obs. September 2020). This area has been shown to be highly adverse for feral pigs due to a lack of forest shelter and appropriate forage (Dexter 1998; Choquenot and Ruscoe 2003) and thus pig populations here are likely to be much more transient and far lesser in impact, even in wetter seasons.
5. Waitchie Lake south of Nocoleche Nature Reserve. This wetland is again within the 5 km band adjacent to the Paroo River that supports higher pig densities (Choquenot and Ruscoe 2003) but is also in freehold land where control programs are more variable in impact (NPWS 2000). This site is approximately 34 km south of the Nocoleche Wetland locations.
6. Lake Altibouka in the Bulloo River catchment. This site on pastoral lands is far separated from all others, approximately 120 km west of the westernmost Nocoleche Wetlands.

Ecology

Habitat

Goodenia nocoleche is a highly ephemeral, amphibious species that is most abundant in temporary freshwater wetlands with intermediate levels of salinity and inundation (Porter 2002; Porter *et al.* 2007). Pellow and Porter (2005) state:

> *"Pied Stilt and Momba Swamps are small (22 and 61 ha), shallow (1.3 and 1.4 m) 'claypan' basins with uneven substrates, caused partly by expansion and contraction of grey or brown cracking clays. They fill predominantly from local rainfall and only connect to the Paroo floodplain via Momba Creek after heavy local rain. From 1990-2000 the swamps held water for a total of 17 and 22 months respectively. Their water is turbid after flooding, clearing gradually during the drying phase, especially in Pied Stilt Swamp. Plant communities in these temporary wetlands undergo considerable changes during erratic filling and drying cycles, as aquatic plants, sedges, annual grasses, herbs and forbs become abundant during and after inundation, before declining again. During prolonged dry periods ground cover may be virtually absent and many species remain hidden below the surface as propagules in seedbanks or underground storage organs."*

The Paroo and Bulloo River floodplains are extensive and characterized by numerous wetlands, both endorheic and exorheic (Porter *et al.* 2007). Pied Stilt Swamp, with the highest currently recorded seedbank density of *Goodenia nocoleche*, is a temporary freshwater endorheic wetland in a claypan basin with intermediate salinity and duration of inundation (Porter 2002; Porter *et al.* 2007), possibly indicating the preferred habitat characteristics for the species. Sampled seedbank densities are far lower in environments that may limit the opportunities for development of *G. nocoleche* such as exorheic, permanent, deep and highly turbid water bodies (e.g. Lake Numalla and Waitchie Lake) and more saline, mostly dry lakes (e.g. Lake Altiboulka) (Porter 2002, J. Porter *in litt.* June 2004),

Vegetation around the wetlands where *Goodenia nocoleche* has been recorded consists of a narrow band of trees around the perimeter (typically *Eucalyptus largiflorens* and *E. populnea* subsp. *bimbil*) with trees and shrubs then absent on the swamps, with occasional grasses in dry times and sedges and submerged or partially emergent aquatics present after flooding (Pellow and Porter 2005). *Eleocharis* sp., *Sclerolaena muricata, Duma florulenta, Marsilea* sp., *Peplidium foecundum* and *Lobelia darlingensis* have all been recorded growing adjacent to *G. nocoleche* within inundated and saturated soils in Pied Stilt Swamp (RBGDT 2020). Hunter (2020) characterises these wetlands as shallow freshwater sedge swamps on inland floodplains and depressions (PCT 53) in the Inland Floodplain Swamps vegetation class of the Freshwater Wetlands formation (after Keith 2004).

Large fluctuations in environmental conditions are typical in the arid regions that *Goodenia nocoleche* occurs in, with the Paroo and Bulloo Rivers noted as having highly variable flows with long periods of low or zero flow as well as unpredictable flooding regimes (Porter *et al.* 2007). This is largely driven by the semi-arid to arid climate of these catchments, where rainfall is highly variable and average

temperatures and evaporation rates are high (Queensland Department of Natural Resources and Mines 2016). This makes the distribution of wetlands with suitable emergence conditions for the species highly variable in both space and time, meaning that the variation in water regimes across the known sites of *G. nocoleche* can result in very high variation in germination probability and relative abundance in any given season.

Life History

Pellow and Porter (2005) state that

> "Goodenia nocoleche *can germinate and grow in standing water up to 0.6 m deep, with floating leaves on greatly extended petioles, similar in appearance to Potamogeton octandrus. As water recedes inflorescences emerge and grow rapidly. The plants die back rapidly as sediments dry completely.* Goodenia nocoleche *has been observed growing in Pied Stilt Swamp during several flood events (December 1998, 2000) and appears to be a summer annual needing inundation in shallow temporary freshwater wetlands to stimulate a germination response from the persistent seedbank, followed by partial drying to initiate flowering. These observations are supported by the behaviour of the species in cultivation. Ability to initiate vegetative growth and form floating leaves early in the drying cycle of temporary wetlands may confer some advantage compared to other low growing amphibious species that also colonise the exposed sediments of drying wetlands (e.g.* Mimulus repens, Ranunculus sessiliflorus *var.* pilulifer, Pratia darlingensis*). In functional group terms,* Goodenia nocoleche *is an 'amphibious fluctuation-responder' because it alters its growth pattern or morphology in response to the presence or absence of water (Brock and Casanova 1997).*"

Goodenia nocoleche is a short-lived annual with the mean age at which a cohort first becomes reproductively fertile being only a matter of months. Seed grown plants in cultivation have been observed bearing flowers only 3 to 4 months after germination (G. Phillips pers. obs. 2021). Generation length in this species, with complete reliance on a soil seedbank, also requires the seedbank half-life or median time to germination to be added to the juvenile period (IUCN 2022). Assuming a median time between flooding (and thus germination) events for the Nocoleche wetlands of 5 years based on local annual rainfall totals exceeding 400 mm or 40% higher than average (in line with totals in years when the plants were physically observed aboveground in 1998, 2000 and 2020) (BOM 2022), the generation length of *G. nocoleche* is calculated as approximately 6 years.

Pied Stilt Swamp, the habitat with the greatest proportion of known individuals, is relatively small (c. 22 ha), mostly dry and has a very erratic flooding regime with water detected in the wetland for only 17 months in the decade from 1990 to 2000 (J. Porter *in litt.* June 2004; Pellow and Porter 2005). The presence of 5,000–10,000 individuals in Pied Stilt Swamp in 2020 across 4 ha (G. Phillips pers. obs. 2020), despite the potential for millions in that same area based on the seedbank data of Porter *et al.* (2007), shows that the population there has the ability for large population fluctuations depending on the conditions year to year given the seemingly unfulfilled germination potential, likely due to seed dormancies. This also raises the possibility of large

fluctuations in the number of aboveground, reproductively mature subpopulations as sites with far lower seedbank densities and less ideal conditions for germination may not respond simultaneously if at all in a given year with suitable conditions.

In September 2020 during a period when Pied Stilt Swamp was partially filled, it was observed that most inflorescences were submerged and growing well shorter than the floating leaves present, indicating that the plants may have been re-inundated after flowering and pollination as ripe fruit and viable seed were present on the inflorescences of most large plants extracted from underwater (G. Phillips pers. obs. 2020). This observation also shows *Goodenia nocoleche* likely has the ability to flower and produce seed in seasons other than summer, with its lifecycle predominantly dependent on the presence of water and associated drying cycles.

Pollinators

Nothing is currently known about the specific pollination ecology of *Goodenia nocoleche,* however pollination in Goodeniaceae more generally has been investigated. Goodeniaceae flowers are characterised by the unique indusium, a structure which contains both the anthers and the stigmatic surface, and which allows the presentation of pollen to occur on the stigmatic surface before the flower opens (Howell *et al.* 1993). As the flower opens, the stigmatic surface is activated, pushing the pollen forward to be accurately brushed onto the back of an insect pollinator accessing the flower, enabling effective pollination. This adaptation is considered to favour the widest possible spread of genes through a population by enhancing outcrossing (Haviland 1914, Howell *et al.* 1993).

Other studies in Goodeniaceae provide evidence of the possible pollinators given the function of the indusium. In *Scaevola taccada*, bees and wasps have been recorded probing flowers for nectar which effects nototribic pollination by depositing the pollen on the back of the pollinator from the indusium, with two species of bee being particularly effective (Solomon Raju *et al.* 2019). Studies on arid *Goodenia* species also support bees being the favoured pollinator, with the auricles and indusium in the flower being important structures in controlling access to the pollen and favouring pollination by bees (Lang and Davies 2017). Haviland (1914) also directly observed a “native bee” visiting flowers of *Goodenia cycloptera,* however further research is required to confirm these relationships, especially in arid environments.

Germination and Seed Dormancy

Germination of *Goodenia nocoleche* appears to be dependent on flooding and drying cycles of the ephemeral wetlands in which it occurs, with plants becoming abundant during times of inundation (Pellow and Porter 2005). Seedlings have been grown from collected sediment samples which were experimentally flooded briefly after a period of controlled drying, as drying after wetting can assist with seed dormancy breaking and increase germination of species from ephemeral habitats (Porter *et al.* 2007). Using seed collected from wild plants at Pied Stilt Swamp, 74% germination was achieved under conditions of 20° C with 12 hours of daily light on water agar, with the first germination after only five days and 15% of ungerminated seeds remaining viable at the end of the test regime, indicating at least a portion of the cohort has a physiological seed dormancy (G. Errington *in litt.* December 2021).

Research on *Goodenia fascicularis*, which occurs widely across western NSW, indicates that the physiological dormancy of seeds in that species may be regulated by environmental temperatures during the maturation and dispersal phases, with seeds from drier, warmer locations having higher levels of dormancy in order to defer germination until more favourable conditions occur (Hoyle *et al.* 2008). *Goodenia nocoleche* may also exhibit this trait given the arid and highly ephemeral nature of its habitat.

Seed Dispersal and Viability

Little is known of the seed dispersal mechanisms utilised by *Goodenia nocoleche,* but it is highly likely that water movement through the wetland systems it occupies provides the primary dispersal vector, with the ability of the fruits to persist and ripen after re-inundation supporting this (G. Phillips pers. obs. September 2020). *Goodenia* typically have seeds with small wings which may aid in short-distance dispersal by wind and develop a mucilaginous seed coat which allows the seed to adhere to the soil surface upon wetting. However, research on *G. pusilliflora*, a species of drier inland communities, found that species to be dispersal limited, with most seed falling immediately near the parent plant (Scott and Morgan 2012). It is highly likely *G. nocoleche* is similarly limited in terms of dispersal by wind, with longer range dispersal by water movement more likely only in times of increased flow given the relatively small seeds with a highly reduced wing and the largely stagnant lake systems they occupy (Pellow and Porter 2005; G. Phillips pers. obs. September 2020).

Some seed dispersal may also occur via the highly mobile, migratory and nomadic waterbirds that are abundant and widespread throughout the region when water is plentiful (Porter *et al.* 2007). Wide-ranging waterfowl common in the Paroo catchment such as Grey Teal (*Anas gracilis*) are known to be capable of dispersing aquatic plant seeds larger than that recorded for *Goodenia nocoleche.* The mucilaginous seed coat of the species may assist with this dispersal vector. Passive dispersal by waterbirds of the species is plausible, especially to and from the less hydrologically connected wetlands such as Pied Stilt Swamp (Green *et al.* 2008).

Putative viability of *Goodenia nocoleche* seed collected from wild plants at Pied Stilt Swamp was found to be high at 89% after germination trials at the Australian PlantBank (G. *Errington in litt.* December 2021).

Threats

The NSW Scientific Committee (2004) state that “The threats to *Goodenia nocoleche* include environmental and demographic stochasticity, reduced flooding due to alteration of river flows, climate change and invasion by introduced species.” However, the impact of feral and domestic animals on the freshwater wetlands in which *G. nocoleche* lives is now considered the most serious threat to the species followed by weed invasion. This is primarily due to the large numbers of feral pigs that are known to impact wetlands in the region (Dexter 1998, 1999; Peck 2020; National Feral Pig Action Plan 2022) and occurrences of Noogoora Burr within and adjacent to core *G. nocoleche* habitat (NPWS 2000; G. Phillips pers. obs. September 2020).

Degradation of habitat by feral and domestic animals

The wetlands in which *Goodenia nocoleche* occurs are largely on reserved land, however this doesn't preclude degradation of habitat by domestic and feral animals that disperse onto reserve lands and escape timely control. Feral pigs and domestic cattle can cause significant damage to freshwater wetlands, with feral pigs a known problem in Currawinya National Park (Peck 2020) and both pigs and cattle have been observed to have caused considerable damage to the wetlands in Nocoleche Nature Reserve (Hunter 2020, G. Phillips pers. obs. 2020).

Pigs (*Sus scrofa*) are highly active across the range of *Goodenia nocoleche*, having been regularly recorded from the Nocoleche wetlands, the Cuttaburra Basin and along the Paroo River in both Queensland and NSW (Dexter 1996; NPWS 2000; Choquenot and Ruscoe 2003; Gentle *et al.* 2019). In the core *G. nocoleche* wetlands within Nocoleche Nature Reserve, most feral pig activity occurs around the Paroo and Cuttaburra channels (NPWS 2000) and within a 5 km zone to the west of the river (Choquenot and Ruscoe 2003). Beyond 10 km west of the river, wetlands are still at risk but pig activity is lesser as the key habitat requirement for the pigs of shade and pasture become more scarce (Dexter 1998; Choquenot and Ruscoe 2003). Pigs cause significant damage to waterways, wetlands and other floodplain communities with their wallowing causing habitat destruction and degradation, accelerating weed spread and leading to the decline of native flora and fauna (NSW OEH 2017; Hunter 2020; National Feral Pig Action Plan 2021). 'Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa* Linneus 1758' is listed as a key threatening process under the NSW *Biodiversity Conservation Act 2016* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*

The Nocoleche wetlands are still extensively grazed by cattle including in Nocoleche Nature Reserve as a result of strays from neighbouring properties (NPWS 2000; Hunter 2020; G. Phillips pers. obs. 2020). Cattle grazing has the ability to rapidly affect the detectability and sustainability of ephemeral species in such areas and floodplain communities are generally considered at high risk from grazing pressure (Hunter 2020). With a much-lowered resilience after grazing, particularly after drought, the removal of cattle from wetland communities only results in recovery after native grazers such as kangaroos are also reduced in number, complicating recovery in reserved areas such as Nocoleche Nature Reserve as well as sites such as Lake Altiboulka and Waitchie Lake on freehold grazing properties (Hunter 2020).

Goats (*Capra hircus*) and rabbits (*Oryctolagus cuniculus*) are also common in Nocoleche Nature Reserve and the broader region, with western NSW having some of the highest densities of feral goats in any Australian arid region (NPWS 2000; Western LLS 2018). Goats can rapidly degrade vegetation communities through over-grazing and erosion of soils, especially during droughts. 'Competition and habitat degradation by feral goats (*Caprus hircus*)' is listed as a key threatening process under the NSW *Biodiversity and Conservation Act 2016* and 'Competition and land degradation by unmanaged goats' is listed as a key threatening process under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*

Rabbits, even at low densities, can also have significant impacts on threatened flora and prevent regeneration through their grazing habits and contribution to erosion by warren construction (Western LLS 2018, NSW DPE 2021). 'Competition and grazing by the feral European rabbit' is listed as a key threatening process under the NSW *Biodiversity and Conservation Act 2016* and 'Competition and land degradation by rabbits' is listed as a key threatening process under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*

Invasion by exotic weeds

Armstrong (2008) mentions that "Potential threats to *Goodenia nocoleche* include invasive weeds that [are] spread by water" and Hunter (2020) also mentions that weeds can dominate, especially in spring, in floodplain vegetation communities. Species that are known to spread fast and smother native vegetation in low lying areas prone to inundation are a particular threat, with Lippia (*Phyla canescens*) and Noogoora Burr (*Xanthium occidentale*) both problematic in the region (Pellow and Porter 2005; NSW DPI 2014, 2021; Hunter 2020).

Noogoora Burr is of particular concern in Nocoleche Nature Reserve, with the core infestations in the area around Momba Swamp and noticeable patches at Pied Stilt Swamp (NPWS 2000; G. Phillips pers. obs. 2020). Noogoora Burr is often found in low lying areas prone to flooding and proliferates when water dries back from these areas, capable of forming extensive, dominant stands when mass germination occurs after floods (NPWS 2000; NSW DPI 2014). The fruits form a woody burr with hooked spines, meaning they can easily be transported by animals or float to be spread by water (NSW DPI 2014). Given the presence of this weed in Nocoleche Nature Reserve around the key habitat of *Goodenia nocoleche,* its ability to rapidly colonise and degrade that habitat at a key time in the growth cycle of *G. nocoleche* and limited direct control to date due to lack of knowledge about off-target effects, Noogoora Burr is a serious threat to the habitat quality of the wetlands.

Increased frequency and duration of drought due to climate change

Endorheic wetland systems with variable flooding regimes are characteristic of arid and semi-arid river systems in Australia (Kingsford *et al.* 2016). Changes to flooding regimes through reductions in localised rainfall and overland runoff as predicted in future climate scenarios (Larkin *et al.* 2020) may negatively impact species occupying endorheic wetlands such as *Goodenia nocoleche* which are highly dependent on sufficient inundation and gradual drying to germinate and develop (Pellow and Porter 2005). Reduced inundation frequency of these wetlands would see a shift from aquatic to terrestrial vegetation communities in time (Kingsford 2001).

Climate change projections for northwest NSW and southwest Queensland indicate higher average temperatures, more hot days over 35°C in all seasons, longer, hotter and more frequent heat waves and increased evaporation in the period to 2070 (State of Queensland 2021a; Department of Planning and Environment 2022). It is also projected that the duration of drought and the frequency of extreme drought in the Paroo, Warrego and Bulloo catchments will increase (State of Queensland 2021a). This could lead to changes in natural flooding events and localised rainfall, causing a reduction in overland runoff (Larkin *et al.* 2020) and thus degradation of the freshwater

wetlands, especially rain-fed endorheic claypans, in which *Goodenia nocoleche* occurs. Such changes may also lead to isolation of habitat as hydrological regimes shift, lowering the number of potential recruitment events for *G. nocoleche* in coming decades.

However, the ecology of *Goodenia nocoleche* also confers a strong ability to persist in the arid zone through long periods of drought, and so this threat is not currently considered to be causing continuing decline in the population or habitat of *G. nocoleche*. Any decline through decreased rainfall due to climate change is thus considered to be only a plausible future threat at this time, requiring more consistent monitoring to substantiate. Additionally, it is likely to be very slow acting and not rapidly drive the species to extinction if it were to occur. “Anthropogenic Climate Change” is listed as a Key Threatening Process under the *NSW Biodiversity Conservation Act 2016.*

This threat may however interact with degradation of habitat by feral and domestic animals to further lower the quality and area of habitat for *Goodenia nocoleche* in time. While the riverine wetlands of the Paroo River can be in a wet phase when river flows are sustained through upstream conditions, endorheic wetlands reliant on local rainfall such as those in Nocoleche Nature Reserve can still be in a dry phase driven by prolonged dry spells in that part of the catchment. This can lead to increased grazing pressure and weed abundance in the endorheic wetlands as herbivore numbers are maintained by the riverine flooding, with increased drought exacerbating the problem and limiting the ability of the wetlands to recover afterward without substantial interventions (Hunter 2020).

Reduced flooding due to alteration of river flows

The Paroo River is considered the last free-flowing river in the Murray-Darling Basin and an agreement exists between the New South Wales and Queensland governments largely limiting overland diversion and river extraction in the catchment (Intergovernmental Agreement on the Paroo River 2003; Murray-Darling Basin Authority 2021a). Currently, 99% of natural flows from Queensland into New South Wales are maintained in the catchment, with the current entitlements only allowing for capture of overland flows in pre-existing structures (Queensland Department of Natural Resources and Mines 2016, Murray-Darling Basin Authority 2021a).

Many of the wetlands of the Nocoleche area, including the known *Goodenia nocoleche* subpopulation at Waitchie Lake, also rely on flows from the Cuttaburra Creek system which links the Paroo into the Warrego catchment, and which relies on the Warrego River for most of its flows (Armstrong 2008). The Nocoleche wetlands are postulated to require significant summer flows during flooding cycles to remain viable, so any development in the Cuttaburra Creek catchment or the Warrego River upstream of the Cuttaburra junction may have a negative effect in this regard (Armstrong 2008). Currently, extraction in the Warrego catchment in Queensland is well below the permissible entitlement of 13% of natural flows (Murray-Darling Basin Authority 2021b), so the threat of increased extraction up to the maximum entitlements limiting flows into Cuttaburra Creek and the Nocoleche wetlands cannot be discounted.

Any reduced frequency, duration and extent of flooding within the Paroo River catchment could impact *Goodenia nocoleche* by alienating habitat, reducing riverine connectivity, increasing fragmentation and affecting recruitment of aquatic flora (Kingsford 2001; Porter 2019). However, this threat is not currently acting on or considered to be causing continuing decline in the population or habitat of *G. nocoleche* as riverine extraction remains limited in the Paroo and Bulloo catchments, and so is only considered a plausible future threat with a very low certainty of occurrence.

Assessment against IUCN Red List criteria

For this assessment it is considered that the survey of *Goodenia nocoleche*, while limited due to issues with detectability and access, has been adequate for the purposes of assessment and there is sufficient scientific evidence to support the listing outcome.

Criterion A *Population Size reduction*

Assessment Outcome: Data deficient

Justification: Despite knowledge of the lifecycle and generation length of *Goodenia nocoleche*, there remains insufficient evidence of population trends over time to calculate a population size reduction.

Criterion B *Geographic range*

Assessment Outcome: Vulnerable under Criterion B1(a)(b iii) and B2(a)(b iii).

Justification: *Goodenia nocoleche* has a moderately restricted Extent of Occurrence (EOO) and Area of Occupancy (AOO). The EOO was calculated to be 12,113 km^2, meeting the threshold for Vulnerable, and AOO was calculated to be 36 km^2, meeting the threshold for Endangered.

In addition to these thresholds, at least two of three other conditions must be met (and if the species only meets a lower threat category in these sub-criteria than for the EOO and/or AOO threshold, its overall threat category for Criterion B is that lower category). These conditions are:

a) The population or habitat is observed or inferred to be severely fragmented or there is 1 (CR), ≤5 (EN) or ≤10 (VU) locations.

   Assessment Outcome: Subcriterion met for Vulnerable due to having six threat-defined locations.

   Justification: *Goodenia nocoleche* is known from six threat-defined locations considering the most serious plausible threat of habitat degradation due to disturbance from feral pigs (*Sus scrofa*). Feral pigs are known to be active in areas such as the Nocoleche Wetlands and along the Paroo River in both Queensland and NSW (Dexter 1996; NPWS 2000; Choquenot and Ruscoe 2003; Gentle *et al.* 2019). Based on average pig densities for the region of approximately one pig per square kilometre (Gentle *et al.* 2019), average home ranges of <12 km^2 in Nocoleche Nature Reserve (Dexter 1999), habitat requirements (Dexter 1998; Choquenot and Ruscoe 2003), differences in control between public and private lands (NPWS 2000) and distances

between sites (Appendix 2), the population of *G. nocoleche* is considered to span six locations as the effects of pigs are likely to differ between sites, especially in Nocoleche Nature Reserve (Choquenot and Ruscoe 2003).

Goodenia nocoleche is not considered to be severely fragmented. This assessment depends on a combination of (i) subpopulation viability and (ii) isolation (IUCN 2022). (i) The vast bulk of above-ground individuals were recorded from a single subpopulation, Pied Stilt Swamp in Nocoleche Nature Reserve, and so greater than 50% of individuals exist within what is clearly a viable subpopulation. All other sites of *G. nocoleche,* aside from the unnamed claypan north of Wanaaring, are known only from propagules detected in soil seedbank sampling; however, soil seedbank data alone is an unreliable indicator of aboveground plant abundance and subpopulation viability as the effects of stochastic rainfall events and other factors on seed dormancy, seedling growth, reproduction and dispersal are all unknown for *G. nocoleche* (J. Porter *in litt.* June 2004). Given the life history strategy of the species and its confirmed presence in soil seedbanks at these locations, there is no evidence that other subpopulations should be considered non-viable at this time. (ii) However, all known subpopulations are considered to be isolated: they are separated from each other by large distances relative to the apparent dispersal ability of the species, with seed dispersal and gene flow between sites considered unlikely based on current knowledge of pollination mechanisms, seed dispersal limitations and the distances between the poorly interconnected, often endorheic, wetland habitats. In combination, the definition of severely fragmented from IUCN (2022) is not met by the species.

b) Continuing decline observed, estimated, inferred or projected in any of: (i) Extent of Occurrence; (ii) Area of Occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals.

Assessment Outcome: Subcriterion met for continuing decline observed, inferred and projected for (iii) area, extent and/or quality of habitat.

Justification: Continuing decline is strongly inferred and projected in area, extent and quality of habitat for *Goodenia nocoleche* due to degradation of habitat by feral and domestic animals, in particular feral pigs, and the invasion of exotic weeds, especially Noogoora Burr (*Xanthium occidentale*). Feral pigs are a known problem in Currawinya National Park (Peck 2020) and both pigs and cattle have been observed to have caused considerable damage to the wetlands in Nocoleche Nature Reserve (Hunter 2020, G. Phillips pers. obs. 2020). Pigs cause significant damage to waterways, wetlands and other floodplain communities with their wallowing causing habitat destruction and degradation, accelerating weed spread and leading to the decline of native flora and fauna (NSW OEH 2017; Hunter 2020; National Feral Pig Action Plan 2021). This observed degradation of habitat is enabling the proliferation of weeds such as Noogoora Burr which further suppress the growth of ephemeral species when conditions allow and further limits habitat availability for wetland species (NPWS 2000; NSW DPI 2014). Habitat degradation by pigs and invasion of weeds may then interact with changed hydrology regimes due to climate change in the future to further enhance

degradation of habitat. While the riverine wetlands of the Paroo River can be in a wet phase when river flows are sustained through upstream conditions, endorheic wetlands reliant on local rainfall such as those in Nocoleche Nature Reserve can still be in a dry phase driven by prolonged dry spells in that part of the catchment. This can lead to increased grazing pressure and weed abundance in the endorheic wetlands as herbivore numbers are maintained by the riverine flooding, with increased drought exacerbating the problem and limiting the ability of the wetlands to recover afterward without substantial interventions (Hunter 2020). These threats mean that the quality and availability of habitat of *G. nocoleche* is undergoing continuing decline and is likely to remain under pressure and continue to decline into the future.

c) Extreme fluctuations.

Assessment Outcome: Data deficient

Justification: There are not enough data to quantitatively assess extreme fluctuations in *Goodenia nocoleche.* The species appears to be highly ephemeral, reliant on localised rainfall and flooding and subsequent drying cycles to initiate germination and reproduction. However, aboveground plants have only been observed at two sites of the nine known, with demographic data only collected once, so the true levels of seasonal variation in seedling emergence and aboveground population size among and between subpopulations is not known.

Criterion C Small population size and decline

Assessment Outcome: Criterion not met.

Justification: Based on observations from Pied Stilt Swamp in 2020, there are at least 5000–10,000 *Goodenia nocoleche* present at that site when conditions are suitable for growth (G. Phillips pers. obs. 2020). Given the extremely low densities of seed in the soil seedbanks and absence of any aboveground observations from all other sites except the unnamed claypan north of Wanaaring from which no abundance data was taken, 10,000 can be considered an acceptable maximum number of mature individuals in a given season. Thus, *G. nocoleche* meets the threshold for listing as Vulnerable under Criterion C. However, neither subcriteria C1 or C2 are met.

At least one of two additional conditions must be met. These are:

C1. An observed, estimated or projected continuing decline of at least: 25% in 3 years or 1 generation (whichever is longer) (CR); 20% in 5 years or 2 generations (whichever is longer) (EN); or 10% in 10 years or 3 generations (whichever is longer) (VU).

Assessment Outcome: Data deficient.

Justification: There are insufficient data to assess if a decline in mature individuals is occurring or has occurred despite declines in habitat quality across the species' range.

C2. An observed, estimated, projected or inferred continuing decline in number of mature individuals.

Assessment Outcome: Data deficient.

Justification: There are insufficient data to assess if a decline in mature individuals is occurring or has occurred despite declines in habitat quality across the species' range.

In addition, at least 1 of the following 3 conditions:

a (i). Number of mature individuals in each subpopulation ≤50 (CR); ≤250 (EN) or ≤1000 (VU).

Assessment Outcome: Subcriterion not met.

Justification: The majority of the observed aboveground population of *Goodenia nocoleche* is within Pied Stilt Swamp where 5,000–10,000 individuals occur, which is greater than the minimum threshold of ≤1000.

a (ii). % of mature individuals in one subpopulation is 90-100% (CR); 95-100% (EN) or 100% (VU)

Assessment Outcome: Subcriterion met for Endangered.

Justification: With almost all aboveground observations and 95% of soil seedbank propagules sampled occurring in Pied Stilt Swamp, it is reasonable to assume that this single subpopulation contains at least 95% of mature individuals of *Goodenia nocoleche,* meeting the threshold for Endangered.

b. Extreme fluctuations in the number of mature individuals

Assessment Outcome: Data deficient.

Justification: There is not enough data to quantitatively assess extreme fluctuations in *Goodenia nocoleche.* The species appears to be highly ephemeral, reliant on localised rainfall and flooding and subsequent drying cycles to initiate germination and reproduction. However, aboveground plants have only been observed at two sites of the nine known, with demographic data only collected once, so the true levels of seasonal variation in growth among and between subpopulations is not known.

Criterion D Very small or restricted population

Assessment Outcome: Criterion not met.

Justification: *Goodenia nocoleche* has a minimum population size of 5,000–10,000 mature individuals, the population occurs at nine locations and has an AOO of 36 km^2.

To be listed as Vulnerable under D, a species must meet at least one of the two following conditions:

D1. Population size estimated to number fewer than 1,000 mature individuals

Assessment Outcome: Subcriterion not met.

Justification: *Goodenia nocoleche* has a minimum population size of 5,000–10,000 mature individuals.

D2. Restricted Area of Occupancy (typically <20 km^2) or number of locations (typically <5) with a plausible future threat that could drive the taxon to CR or EX in a very short time.

Assessment Outcome: Subcriterion not met.

Justification: *Goodenia nocoleche* has an AOO of 36 km^2, occurs at six locations and it is currently the subject of ongoing threats and continuing decline, and so cannot be assessed under D2.

Criterion E Quantitative Analysis

Assessment Outcome: Data deficient.

Justification: Currently there is not enough data to undertake a quantitative analysis to determine the extinction probability of *Goodenia nocoleche.*

Conservation and Management Actions

Goodenia nocoleche is currently listed on the NSW *Biodiversity Conservation Act 2016* and a conservation project has been developed by the NSW Department of Planning and Environment under the Saving our Species program. The conservation project identifies priority locations, critical threats and required management actions to ensure the species is extant in the wild in 100 years. *Goodenia nocoleche* sits within the data deficient management stream of the SoS program.

Activities to assist this species currently recommended by the SoS program (NSW OEH 2019) include:

Habitat loss, disturbance and modification

- Control weeds in key sites, particularly Noogoora Burr.

Survey and Monitoring priorities

- Monitor sites to determine changes in weed populations.
- Report any new records of *Goodenia nocoleche* to relevant authorities.
- Undertake further surveys to understand species' ecology and abundance, including sites where no aboveground individuals have previously been observed.

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APPENDIX 1

Assessment against NSW Biodiversity Conservation Act criteria
The Clauses used for assessment are listed below for reference.

Overall Assessment Outcome:
Goodenia nocoleche was found to be Vulnerable under Clause 4.3 (c) (d) (e iii).

Clause 4.2 – Reduction in population size of species
(Equivalent to IUCN criterion A)
Assessment Outcome: Data Deficient

(1) - The species has undergone or is likely to undergo within a time frame appropriate to the life cycle and habitat characteristics of the taxon:			
	(a)	for critically endangered species	a very large reduction in population size, or
	(b)	for endangered species	a large reduction in population size, or
	(c)	for vulnerable species	a moderate reduction in population size.
(2) - The determination of that criteria is to be based on any of the following:			
	(a)	direct observation,	
	(b)	an index of abundance appropriate to the taxon,	
	(c)	a decline in the geographic distribution or habitat quality,	
	(d)	the actual or potential levels of exploitation of the species,	
	(e)	the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.	

Clause 4.3 - Restricted geographic distribution of species and other conditions
(Equivalent to IUCN criterion B)
Assessment Outcome: Vulnerable under Clause 4.3 (c) (d) (e iii)

The geographic distribution of the species is:			
	(a)	for critically endangered species	very highly restricted, or
	(b)	for endangered species	highly restricted, or
	(c)	for vulnerable species	moderately restricted,
and at least 2 of the following 3 conditions apply:			
	(d)	the population or habitat of the species is severely fragmented or nearly all the mature individuals of the species occur within a small number of locations,	
	(e)	there is a projected or continuing decline in any of the following:	
		(i)	an index of abundance appropriate to the taxon,
		(ii)	the geographic distribution of the species,
		(iii)	habitat area, extent or quality,
		(iv)	the number of locations in which the species occurs or of populations of the species,

	(f)	extreme fluctuations occur in any of the following:				
		(i)	an index of abundance appropriate to the taxon,			
		(ii)	the geographic distribution of the species,			
		(iii)	the number of locations in which the species occur or of populations of the species.			

Clause 4.4 - Low numbers of mature individuals of species and other conditions
(Equivalent to IUCN criterion C)
Assessment Outcome: Not met.

The estimated total number of mature individuals of the species is:						
	(a)	for critically endangered species			very low, or	
	(b)	for endangered species			low, or	
	(c)	for vulnerable species			moderately low,	
and either of the following 2 conditions apply:						
	(d)	a continuing decline in the number of mature individuals that is (according to an index of abundance appropriate to the species):				
		(i)	for critically endangered species		very large, or	
		(ii)	for endangered species		large, or	
		(iii)	for vulnerable species		moderate,	
	(e)	both of the following apply:				
		(i)	a continuing decline in the number of mature individuals (according to an index of abundance appropriate to the species), and			
		(ii)	at least one of the following applies:			
			(A)	the number of individuals in each population of the species is:		
				(I)	for critically endangered species	extremely low, or
				(II)	for endangered species	very low, or
				(III)	for vulnerable species	low,
			(B)	all or nearly all mature individuals of the species occur within one population,		
			(C)	extreme fluctuations occur in an index of abundance appropriate to the species.		

Clause 4.5 - Low total numbers of mature individuals of species
(Equivalent to IUCN criterion D)
Assessment Outcome: Not met.

The total number of mature individuals of the species is:			
	(a)	for critically endangered species	extremely low, or
	(b)	for endangered species	very low, or
	(c)	for vulnerable species	low.

Clause 4.6 - Quantitative analysis of extinction probability
(Equivalent to IUCN criterion E)
Assessment Outcome: Data deficient.

The probability of extinction of the species is estimated to be:			
	(a)	for critically endangered species	extremely high, or
	(b)	for endangered species	very high, or
	(c)	for vulnerable species	high.

Clause 4.7 - Very highly restricted geographic distribution of species– vulnerable species
(Equivalent to IUCN criterion D2)
Assessment Outcome: Not met.

For vulnerable species,	the geographic distribution of the species or the number of locations of the species is very highly restricted such that the species is prone to the effects of human activities or stochastic events within a very short time period.

APPENDIX 2

Species Distribution Maps

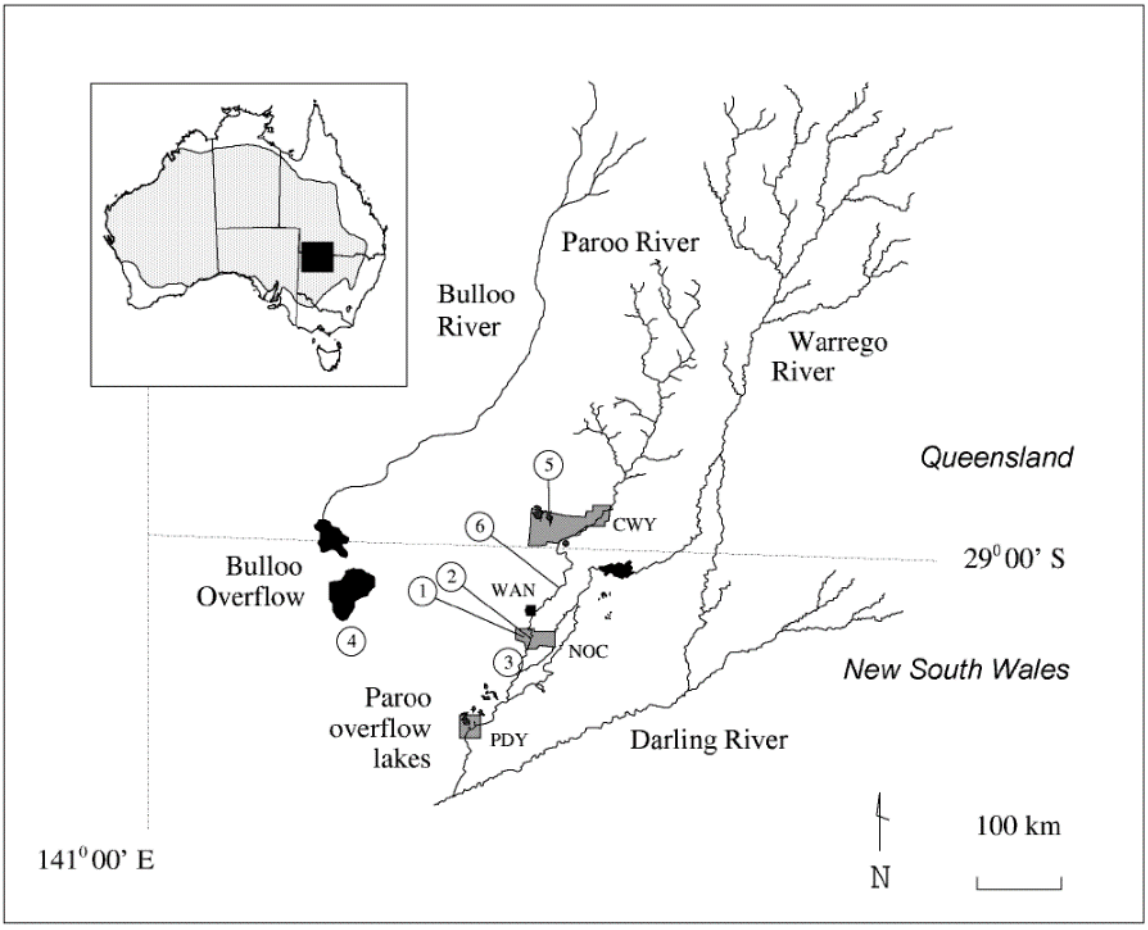
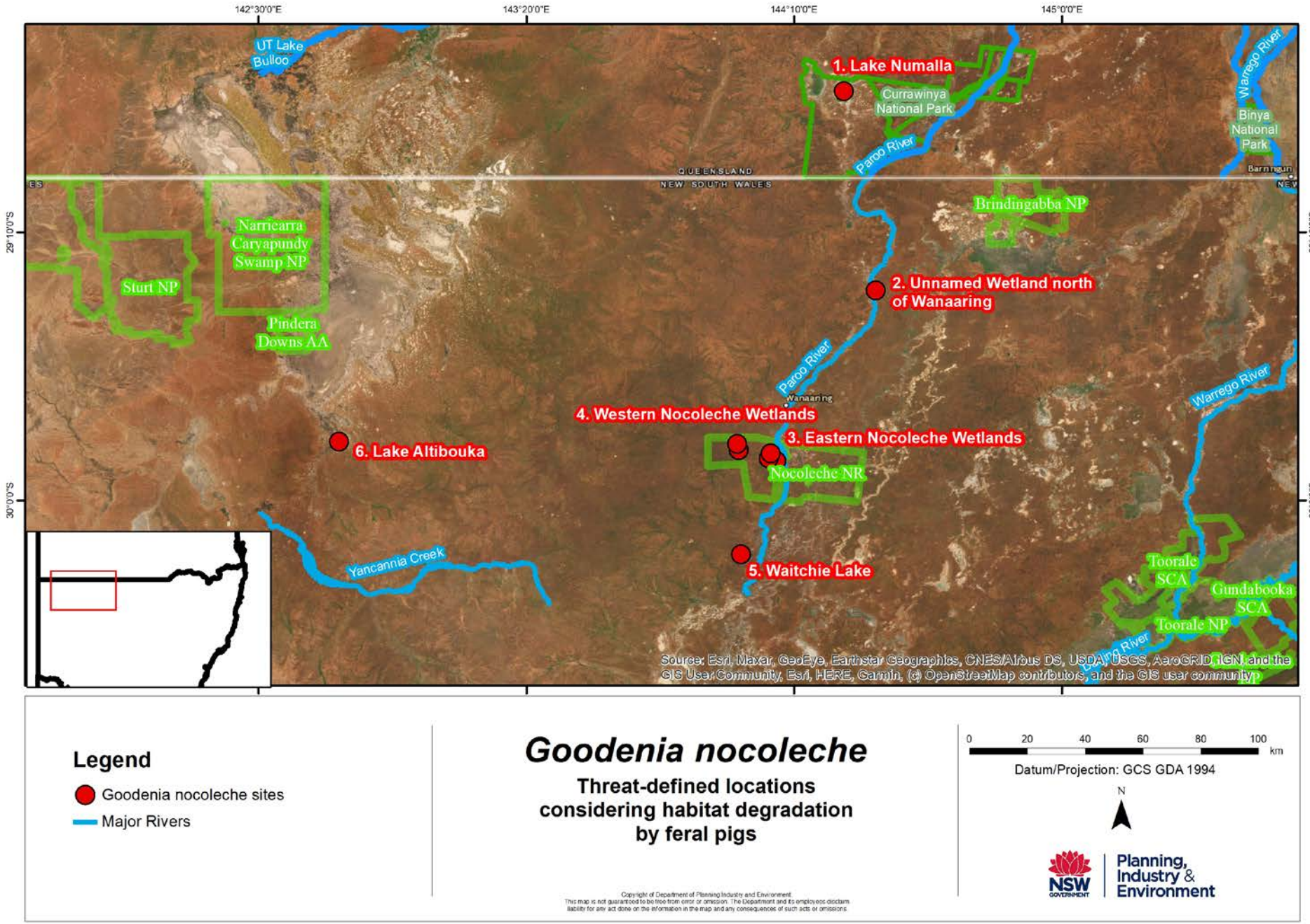


Figure 1 - Distribution of Goodenia nocoleche in the Paroo and Bulloo River Catchments. Sites indicated are Pied Stilt Swamp (1) and Momba Swamp (2) in Nocoleche Nature Reserve (NOC), Waitche Lake (3), Lake Altiboulka (4), Lake Numalla (5) in Currawinya National Park (CWY) and the unnamed wetland north of Wanaaring (6). Not indicated are the later found sites of Claypan North, Rattigan Swamp and Claypan 18, all within Nocoleche Nature Reserve. Map taken from Pellow and Porter (2005).


142°30'0"E
143°20'0"E
144°10'0"E
145°0'0"E
29°10'0"S
30°0'0"S
UT Lake Bulloo
1. Lake Numalla
Currawinya National Park
Warrego River
Binya National Park
Barringun
Paroo River
QUEENSLAND
NEW SOUTH WALES
Brindingabba NP
Narricarra Caryapundy Swamp NP
Sturt NP
Pindera Downs AA
2. Unnamed Wetland north of Wanaaring
Wanaaring
4. Western Nocoleche Wetlands
3. Eastern Nocoleche Wetlands
Nocoleche NR
6. Lake Altibouka
Yancannia Creek
5. Waitchie Lake
Toorale SCA
Gundabooka SCA
Toorale NP
Darling River
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
Legend
Goodenia nocoleche sites
Major Rivers
Goodenia nocoleche
Threat-defined locations considering habitat degradation by feral pigs
0 20 40 60 80 100 km
Datum/Projection: GCS GDA 1994
N
NSW GOVERNMENT
Planning, Industry & Environment
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