Conservation Assessment of *Diuris disposita* D.L.Jones (Orchidaceae)

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***Diuris disposita* D.L.Jones (Orchidaceae)**
Distribution: Endemic to NSW
Current EPBC Act Status: Not listed
Current NSW BC Act Status: Endangered

Proposed listing on NSW BC Act: Critically Endangered
Reason for change: genuine change based on recent declines in the population.

Summary of Conservation Assessment

Diuris disposita was found to be eligible for listing as Critically Endangered under IUCN Criteria A2be+3be+4be; C1. The main reasons for this species being eligible are: 1) it has experienced, and is projected to continue experiencing, a very severe reduction in population size; and, 2) it has a small population experiencing a very high rate of decline.

Photo: *Diuris disposita* from Yarravel, credit: Lachlan Copeland © (used with permission).

Description and Taxonomy

Diuris disposita (Willawarrin Doubletail) is a conventionally accepted species (CHAH 2018) within *Diuris, subgenus Diuris, section Diuris* (Indsto *et al*. 2009). *Diuris disposita* was described by Jones (1991) as a terrestrial herb with one or two linear leaves, 15–30 cm long, 4–5 mm wide, conduplicate; bearing a raceme 20–35 cm high, 2–7-flowered, with widely spaced yellow flowers with brown markings on the labellum and dorsal sepal, *c.* 2 cm across; dorsal sepal ovate, 7–11 mm long, 4–7 mm wide,

obliquely erect, margins recurved; lateral sepals linear to oblanceolate, 10–24 mm long, 1.5–2 mm wide, deflexed, parallel or crossed; petals obliquely erect; lamina broad-elliptic to obovate, 6–9 mm long, 4.5–6.5 mm wide; claw 4–7 mm long; labellum 7–9 mm long; lateral lobes linear to oblong, 2–2.8 mm long, 0.8–1.2 mm wide; midlobe narrow-ovate to ovate when flattened, 4–7 mm wide, ridged along midline; callus of 2 divergent, incurved ridges *c.* 4.5 mm long.

Distribution and Abundance

Diuris disposita occurs near Kempsey on the mid-north coast of New South Wales (NSW). This area lies within the NSW North Coast Bioregion (DAWE 2021).

Diuris disposita occurs across four extant subpopulations (as per the IUCN (2024) definition): at Rollands Plains, Yarravel NR, and at two private properties in the Collombatti area (Table 1). One additional subpopulation at Collombatti was last surveyed in 2006 and is possibly still extant (Eco Logical Australia 2019). The Rollands Plains and Yarravel NR subpopulations are currently monitored as part of the Saving Our Species (SoS) Program (P. Sheringham pers. comm. April 2024).

There are five historical records of subpopulations at Temagog Road (last reported in 1986), northwest of Hickey's Creek at Willawarrin (1992), southeast of Kempsey (1992), Dondingalong (1993) and at Skillion NR (undated) (Eco Logical Australia 2019; Table 1). None of these subpopulations have been seen since, despite recent survey effort in 2019 and 2020 at the Temagog Road and Willawarrin sites (Eco Logical Australia 2019), and they may now be extinct. The Temagog Road subpopulation was the type location for the species (Jones 1991).

Apparently suitable habitat at Bellbrook and Toms Gully Cemeteries, Old Station State Forest (SF) and Skillion Flat NR were searched in 2020 or 2019, but no plants were found (Eco Logical Australian 2019; 2020). Nevertheless, it is possible that additional undiscovered subpopulations of the species exist, as demonstrated by the recently reported (2022) Collombatti subpopulation from a currently unidentified private property (Table 1). It is possible that the species is more widespread than currently known, based on a lack of systematic surveys and the cryptic nature of the species (ECA 2019).

The total population size of *Diuris disposita* is estimated at 120 plants, based on average subpopulation counts from the last five years for likely extant subpopulations (Table 1). The maximum and minimum population estimate is 71–169 plants, based on the most recent subpopulation counts (71 plants) and maximum subpopulation counts from the last five years (169 plants).

The Rollands Plains subpopulation has been monitored for the longest period of time and is reported to have declined from approximately 150 plants in 2005 or 2006, to an average count of 30 plants over the last five years (Table 1).

Flowering of *D. disposita* is influenced by recent management actions (e.g. slashing of grassland subpopulations) and rainfall conditions, and as a result, the number of flowering plants fluctuates from year to year (Eco Logical Australia 2019). Plants may be dormant or vegetative non-flowering, in which state they are difficult to see among understorey grasses.

Table 1. *Diuris disposita* subpopulation information

Subpopulation	Number of plants (year)	Source
Likely extant subpopulations		
Rollands Plains	0 (2023) 12 (2022) 61 (2020) 48 (Oct 2019) ~150 (around 2005 or 2006)	P. Sheringham pers. comm. April 2024 P. Sheringham pers. comm. April 2024 P. Sheringham pers. comm. April 2024 P. Sheringham pers. comm. April 2024 L. Copeland pers. comm. April 2024
Yarravel NR	0 (2023) 6 (Oct 2020) 7 (Oct 2019) 7 (2006) "less than 20" (2004)	P. Sheringham pers. comm. April 2024 Eco Logical Australia (2020) P. Sheringham pers. comm. April 2024 Eco Logical Australia (2020) Eco Logical Australia (2020)
Collombatti, Chain O Pools Rd	71 (Oct 2018)	BioNet (NSW DCCEEW 2024a)
Collombatti area*	0 (Sept/Oct 2023) 30 (Sept/Oct 2022)	P. Sheringham pers. comm. April 2024 P. Sheringham pers. comm. April 2024
Possibly extant subpopulations		
Collombatti, Hughes Access Rd	5 (Oct 2006) 10 (Oct 2005)	Eco Logical Australia (2019) Eco Logical Australia (2019)
Likely extinct subpopulations		
NW of Hickey's Creek, Willawarrin	Not recorded (Sep 2020) Not recorded (Oct 2019) "Locally frequent" (Oct 1992)	Eco Logical Australia (2020) Eco Logical Australia (2019) BioNet (NSW DCCEEW 2024a)
Dondingalong	Not recorded (Oct 2019) Present (Sept 1993)	Eco Logical Australia (2019) Eco Logical Australia (2019)
Southeast of Kempsey	Present (Oct 1992)	Eco Logical Australia (2019)
Temagog Road	Not recorded (Sep 2020) Not recorded (Oct 2019) Present (Oct 1986)	Eco Logical Australia (2020) Eco Logical Australia (2019) BioNet (NSW DCCEEW 2024a)
Skillion NR	Not recorded (Oct 2019) Present (unknown date)	Eco Logical Australia (2019) Eco Logical Australia (2019)

*reported to be "near the rail line in Collombatti", but the exact location is currently unknown (P. Sheringham pers. comm. April 2024)

Extent of occurrence and area of occupancy

The Area of Occupancy (AOO) of *Diuris disposita* was calculated using 2 x 2 km grid cells, the scale recommended by IUCN (2024) and was estimated to be 16 km^2. This is based on the assumption that the species has four extant subpopulations (P. Sheringham pers. comm. April 2024), despite three subpopulations not flowering in 2023 (Table 1), which was likely due to drought and a lack of recent disturbance at some subpopulations (e.g. Rollands Plains; P. Sheringham pers. comm. April 2024). The maximum AOO could be 20 km^2 if the possibly extant Collombatti subpopulation last recorded in 2006 is still extant.

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 (2024). The Extent of Occurrence (EOO) is difficult to estimate for *D. disposita*, because the precise location of the recently recorded Collombatti subpopulation is unknown, other than it being located on private property "near the rail line in Collombatti" (P. Sheringham pers. comm. April 2024). Estimating possible sites near the rail line in Collombatti suggest EOO values could be approximately 90–120 km^2, or 100–130 km^2 if the Collombatti subpopulation last recorded in 2006 is included. This suggests the EOO of *D. disposita* is likely to be >100 km^2. Both EOO and AOO were calculated using QGIS (QGIS 2024), enclosing all likely extant survey records and cleaned spatial datasets. Cleaning removed two records of likely extinct subpopulations at Temagog Road (NSW586939) and NW of Hickey's Creek, Willawarrin (NSW429657), leaving 89 clean records used in this assessment. Based on these estimates, *D. disposita* has a highly restricted AOO and EOO.

Number of Locations

Diuris disposita is found at one threat-defined location when considering the most serious plausible threat of increased frequency of drought and extreme rainfall events due to climate change. This threat appears to be driver of the complete failure of flowering of the species in three subpopulations monitored in 2023 (P. Sheringham pers. comm. April 2024), which indicates the potential of the threat to cause the elimination of the species within a single generation (nine years) should conditions not abate. The species is found in small, likely isolated subpopulations, however, the viability of these subpopulations is unknown and there are no data on likely applicable minimum viable population sizes. Therefore, there are insufficient data to determine if the species is severely fragmented according to IUCN (2024).

Ecology

Habitat

Diuris disposita occurs in open forest and grassland from 40–60 m a.s.l. in an area from Rollands Plains in the south to Collombatti in the north and Willawarrin in the west. At Rollands Plains it occurs in a broad river valley on clay loam soils over metasediments in derived grassland dominated by *Themeda triandra* resulting from partially-cleared dry sclerophyll forest (NSW DCCEEW 2024a). Associated species include *Corymbia intermedia*, *Eucalyptus siderophloia*, *Acacia* sp., *Allocasuarina torulosa*, *Lophostemon confertus, Dianella* sp., *Microtis parviflora, Themeda triandra* and *Sorghum leiocladum* (NSW DCCEEW 2024a). At Yarravel NR it occurs on undulating hills and low ridgetops with a north or northeast aspect in dry sclerophyll forest on clay loam over shale in a semi-shaded understorey among tussocks, with *Corymbia maculata, Eucalyptus propinqua, Eucalyptus siderophloia, L. confertus, Acacia falcata, Acacia implexa, Acacia subfalcata, Notelaea* sp., *Pomax umbellata, Pultenaea villosa*, *Cheilanthes sieberi, Dichelachne micrantha, Entolasia stricta, Lobelia purpurascens, T. triandra*, *Lomandra longifolia*, and a formerly substantial cover of the non-indigenous *Lantana camara* (Eco Logical Australia 2020; NSW DCCEEW 2024a). The habitat at Collombatti is derived native grassland on the edge of dry sclerophyll forest, growing with a subpopulation of the threatened *Parsonsia dorrigoensis*. At Temagog Road the species was reported to occur in open forest and grassland on gravelly loam with an understorey of *T. triandra* (NSW DCCEEW 2024a). Northwest of Willawarrin it was reported to occur in open forest regrowth on a hilltop on pinkish yellow clay (NSW DCCEEW 2024a).

Based on Plant Community Type (PCT) mapping, *Diuris disposita* may be found in Lower North Spotted Gum-Mahogany-Ironbark Sheltered Forest (PCT 3249), Lower North Spotted Gum-Mahogany-Ironbark Sheltered Forest (PCT 3244), and Northern Gorges Diverse Grassy Forest (PCT 3251) (NSW DCCEEW 2024b). However, the species may occur in other related PCTs. At the time of this assessment, it was not known to occur in any State-listed or national-listed ecological communities.

Life History

Diuris disposita flowers in late September to early October (Eco Logical Australia 2019). Flowering appears to be much reduced or absent in dry years (Eco Logical Australia 2019), when the species likely persists as non-flowering or dormant plants. While *Diuris disposita* possesses a tuber and can persist in a dormant state during unfavourable conditions, long periods of dormancy are associated with increased mortality of adult plants in other Australian terrestrial orchids (Coates *et al.* 2006).

Subpopulations from grassland habitat appear responsive to slashing, which stimulates flowering (EcoLogical Australia 2019). The species' response to fire is not documented, however other spring-flowering *Diuris* species from grassy habitats generally display increased flowering following dormant-season fire (Eco Logical Australia 2019). Therefore, it appears likely that *Diuris disposita* may also have a strong post-fire flowering response, and periodic fire outside of the growing season is likely to be beneficial, by reducing the amount of competing vegetative biomass of co-occurring species and promoting growth and flowering.

Fire during the non-dormant growing season can be detrimental to the persistence of Australian terrestrial orchids (Jasinge *et al.* 2018). Tubers at this time may have insufficient resources to sustain a second flush of leaf production, resulting in tuber mortality and consequently plant senescence (Jasinge *et al*. 2018). Seedlings generally do not develop tubers until spring, and they are likely to be located at a very shallow depth, suggesting fires during the non-dormant season are likely to cause high seedling mortality (M. Freestone pers. obs.).

Reproductive Ecology

Specific information on pollinators of *Diuris disposita* is lacking. However, *Diuris* species are thought to be pollinated mainly by native bees. *Trichocolletes* bees were reported by Indsto *et al*. (2006) and Scaccabarozzi *et al*. (2020), while *Exoneura* bees were reported by Indsto *et al*. (2007). Many *Diuris* species have flowers that resemble those of Fabaceae (e.g. *Bossiaea, Daviesia*, *Pultenaea*), with which the orchids often co-occur (Beardsell *et al.* 1986; Scaccabarozzi *et al.* 2020). *Diuris* are thought to use food deceptive guild mimicry to deceive pollinators, as their flowers usually possess little or no nectar rewards (some species can produce small amounts of nectar e.g. *Diuris alba* in Indsto *et al.* 2007).

Diuris species take around three years to reach maturity in cultivation (M Freestone pers. obs.). The maximum lifespan of *Diuris* is unknown, although *Diuris* species in cultivation generally have maximum lifespans of one to two decades (M Freestone pers. obs.). Generation time is estimated based on the primary juvenile period and lifespan using the formula: *primary juvenile period + [z * (reproductive lifespan-primary juvenile period)]* where z is generally assumed to be 0.5 (IUCN 2024). Based on this,

the minimum generation length of *D. disposita* is estimated as: 3 + [0.5*(10-3)] = 6.5 years. The maximum generation length is estimated as: 3 + [0.5*(20-3)] = 11.5 years. Using the average of the maximum and minimum estimates gives an estimated generation length of 9 years, and an estimated three generation period of 27 years.

Seed Ecology

Diuris species reproduce via seed, and each plant has a single underground tuber, replaced annually, that allows it to persist underground for long periods. Orchid seeds are generally miniscule in size and wind-dispersed and are not known to form a persistent soil seedbank (Batty *et al.* 2000). *Diuris* species, like all orchids, require a fungal symbiont (a species of *Tulasnella*) for germination and nutrient uptake (Warcup 1971). In *ex-situ* germination trials, *Tulasnella* fungi lose their ability to germinate orchid seed rapidly with increasing time following their isolation from adult plants (Reiter *et al*. 2023).

Cultural significance

Diuris disposita occurs on the traditional lands of the Dunghutti First Nations people and is in the Kempsey Local Aboriginal Land Council area (NPWS 2004; NPWS 2009). This assessment is not intended to be comprehensive of the traditional ecological knowledge that exists for *Diuris disposita*, or to speak for Aboriginal people. Aboriginal people have a long history of biocultural knowledge, which comes from observing and being on Country, and evolves as it is tested, validated, and passed through generations (Woodward *et al*. (Eds.) 2020). Aboriginal peoples have cared for Country for tens of thousands of years (Bowler et al. 2003; Clarkson et al. 2017). There is traditional ecological knowledge for all plants, animals and fungi connected within the kinship system (Woodward *et al*. (Eds.) 2020). Traditional ecological knowledge referenced in this assessment belongs to the relevant knowledge custodian and has been referenced in line with the principals of the NSW Indigenous Cultural and Intellectual Property protocol (ICIP) (Janke and Company 2023).

Threats

The NSW Scientific Committee (1998) stated that threats to *Diuris disposita* include "habitat destruction, adverse fire regimes and collecting of plants." However, additional threats are now known, inferred or suspected to be adversely affecting the species (NSW DCCEEW 2024c). Of the threats listed by NSW DCCEEW (2024c), there is little evidence that competition for resources by pine seedlings or invasive grasses are significant threats to the species (P. Sheringham pers. comm. April 2024). In addition to the threats listed in NSW DCCEEW (2024c) there is concern that increased frequency of drought and extreme rainfall events associated with climate change are affecting the species (P. Sheringham pers. comm. April 2024).

Adverse biomass reduction regimes

Subpopulations of *Diuris disposita* from grassland habitat appear responsive to slashing or mowing (referred to as 'slashing' herein), which stimulates flowering (Eco Logical Australia 2019). In the absence of slashing, flowering rates of the species are low (P. Sheringham pers. comm. April 2024). Slashing reduces competition from co-occurring grasses, which would otherwise outcompete *D. disposita*. Long disturbance-free intervals are likely to result in high biomass accumulation of *Themeda triandra*, which can kill grassland forbs (Morgan 2015). When biomass accumulates over

periods of 7–11 years or more, the longer-term integrity of productive *Themeda triandra*-dominated ecosystems can be compromised by death of the dominant *Themeda triandra* sward, followed typically by weed invasion (Morgan 2015). Slashing can also control regrowth of shrubs and trees, which occur at low densities at several subpopulations, but which could increase in cover and ultimately change the open, grassy habitat to the detriment of *D. disposita* (e.g. Rollands Plains; Eco Logical Australia 2019). Small trees and shrubs (*Acacia* spp. and *Lophostemon confertus*) have recruited into an unslashed section of the Rollands Plains subpopulation in the past, although recent slashing appears to have controlled them (P. Sheringham pers. comm. May 2024). Nevertheless, the long-term absence of slashing at this site could facilitate invasion by exotic Camphor Laurel *Cinnamomum camphora* and native trees and shrubs (*Acacia* spp.) (P. Sheringham pers. comm. June 2024). Therefore, a lack of biomass control (slashing or fire) is a serious threat to the species, particularly at Rollands Plains, but probably also at other grassland sites (e.g. the Collombatti subpopulations).

However, slashing regimes must be timed so they occur during the orchid's dormant period (January–July). Slashing has been previously undertaken when the orchid was flowering (e.g. in 2018; OEH 2020). Although slashing may not cause immediate adult mortality, slashing during this time of year eliminates any chance of recruitment and if sustained over several years, may cause this subpopulation to decline. Therefore, slashing should not be undertaken when *Diuris disposita* is flowering, nor when it is in pre-flowering bud development, nor during post-flowering seed pod development. This means slashing should not occur from early August to mid-December inclusive (Eco Logical Australia 2019).

Adverse fire regimes

The mechanisms by which fire can negatively affect species are diverse and can be direct or indirect. Fire seasonality is perhaps the most likely threat to *Diuris disposita*, inferred from other terrestrial orchid species (Jasinge *et al*. 2018). *Diuris disposita* may be threatened by out-of-season fires during the non-dormant phase, from April to December (Eco Logical Australia 2019). When fire occurs out of season there are a number of mechanisms that lead to recruitment failure and reduce the recovery potential of species following fire (DAWE 2022). These include seedling mortality due to desiccation as a consequence of the interaction between out of season fires and fire-hydrological interactions (Miller *et al*. 2019); low rate of seed production due to sub-optimal flowering cues, particularly by species that rely on seasonal pollinators or specific flowering conditions (Brown *et al*. 2017); and disruption to processes that facilitate post-fire recovery and limit dispersal (Jasinge *et al*. 2018; Keith *et al*. 2020), particularly for species with seasonal growing conditions such as orchids. If fires occur soon after leaf emergence, the tubers may store insufficient resources to sustain a second flush of leaf production, resulting in tuber mortality (Jasinge *et al.* 2018). Out of season fire can also affect mycorrhizal fungal communities (Jasinge *et al.* 2018) or pollinator communities (Brown *et al.* 2017). Prescribed burns are likely to be the main source of out-of-season fire. However, the threat of out-of-season fire may interact with climate change threats, particularly the projected decrease in winter rainfall, to increase the risk of out-of-season bushfires. Dry conditions during the orchid's winter growing season may increase the risk of winter bushfires, with likely negative consequences for *D. disposita*. 'High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and

composition' is listing as a Key Threatening Process under the NSW *Biodiversity Conservation Act 2016* (NSW Scientific Committee 2000a), while 'fire regimes that cause declines in biodiversity' is a listed Key Threatening Process under the *Environment Protection and Biodiversity Conservation Act 1999* (DAWE 2022).

Fragmentation due to agricultural activities and/or roadworks

Three subpopulations are located on private land and are possibly at risk from clearing, including ploughing, sowing or fertilising native grassland for pasture improvement. The Yarravel NR subpopulation is located very close to a management track (Eco Logical Australia 2020), and at risk of track management works that affect surrounding native vegetation. One historical subpopulation was located on a roadside embankment (NSW DCCEEW 2024a) and may have been at risk of road management works, although it is not known if any direct effects occurred or contributed to the apparent loss of that subpopulation. 'Clearing of native vegetation' is listed as a Key Threatening Process under the NSW *Biodiversity Conservation Act 2016* (NSW Scientific Committee 2001), while 'Land clearance' is listed as a Key Threatening Process under the *Environment Protection and Biodiversity Conservation Act 1999* (TSSC 2001a).

Increased frequency of drought and extreme rainfall events due to climate change

Climate change projections by CSIRO (Grose *et al.* 2015) for the subregion encompassing the Kempsey area, predict with very high confidence, that average temperatures will continue to increase in all seasons, with more hot days and warm spells. Fewer frosts, increasing intensity of extreme rainfall events and a harsher fire-weather climate is projected in the future with high confidence, while decreases in winter rainfall and increases in time spent in drought are predicted with medium confidence (CSIRO and BOM 2022). Flowering of *Diuris disposita* appears to be much reduced or absent in dry years (Eco Logical Australia 2019), when the species likely persists as non-flowering or dormant plants. While *D. disposita* possesses a tuber and can persist in a dormant state during unfavourable conditions, long periods of dormancy are associated with increased mortality of adult plants in other Australian terrestrial orchids (Coates *et al*. 2006). Therefore, decreases in winter rainfall are likely to have an adverse effect on this species, which is likely dependent on adequate soil moisture during the winter growing season for reproduction (Janissen *et al*. 2021). Drought may cause increased adult mortality (Pfeifer *et al*. 2006) and alter site hydrology leading to the habitat becoming unsuitable for the species. A drought followed by extreme rainfall in 2023 negatively affected the species (P. Sheringham pers. comm. April 2024), suggesting an increasing frequency or intensity of these events may be a serious threat. Therefore, there is a high potential that climate change represents a real threat to the long-term survival of the species. 'Anthropogenic Climate Change' is listed as a Key Threatening Process under the NSW *Biodiversity Conservation Act 2016* (NSW Scientific Committee 2000b), while 'Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases' is listed as a Key Threatening Process under the *Environment Protection and Biodiversity Conservation Act 1999* (TSSC 2001b).

Competition for resources by Lantana (Lantana camara) and other weeds

Lantana was formerly extensive at the Yarravel NR subpopulation and considered a significant threat to the species at this site (Eco Logical Australia 2020; NSW DCCEEW 2024c). Recent weed control works have reduced the density of this weed

to a low level, and consequently its level of threat to *Diuris disposita* (P. Sheringham pers. comm. April 2024). However, lantana may return if weed management works cease for extended periods of time, and therefore invasion by this weed remains a threat. Camphor laurel *Cinnamomum camphora* has recently been recorded at Rollands Plains (P. Sheringham pers. comm. May 2024) and could threaten *D. disposita* if its abundance increases at this site. 'Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)' is listed as a Key Threatening Process under the NSW *Biodiversity Conservation Act 2016* (NSW Scientific Committee 2006), while 'Novel biota and their impact on biodiversity' is listed as a Key Threatening Process under the *Environment Protection and Biodiversity Conservation Act 1999* (TSSC 2013).

Poaching and trampling

Illegal collection is a threat for rare orchids generally (Wraith and Pickering 2019), and the small population size of *Diuris disposita* means the removal of any plants could be significant to the species' population. Although there is no evidence the species has been targeted in the past, illegal removal of plants remains a suspected threat. Unintentional trampling from orchid enthusiasts seeking to photograph the species and workers engaged in weed control activities may also cause occasional damage to flowering plants and those with developing buds or seed pods.

Assessment against IUCN Red List criteria

For this assessment it is considered that the survey of *Diuris disposita* has been adequate and there is sufficient scientific evidence to support the listing outcome.

Criterion A *Population Size reduction*

Assessment Outcome: Critically Endangered under Criterion A2be+3be+4be

Justification:

The Rollands Plains subpopulation has had the most comprehensive monitoring effort of any of the species' subpopulations. This subpopulation had a historical size of approximately 150 plants in 2005 or 2006 (L. Copeland pers. comm. April 2024). The most recent count of this subpopulation was zero plants in 2023, although conditions were suboptimal following a recent drought and heavy rainfall event, combined with a lack of mowing, which is known to stimulate flowering in this species (P. Sheringham pers. comm. April 2024). Therefore, it may be more appropriate to estimate the current size of this subpopulation by using an average of recent counts. The Rollands Plains subpopulation has been monitored annually from 2019–2023, with counts of 48, 61, 12 and 0 plants respectively (Table 1), equating to an average of 30 plants. This subpopulation appears to be in decline (L. Copeland pers. comm. April 2024).

Using 2006 as the date of the historical record, this suggests an estimated population reduction of approximately 80% at Rollands Plains in 17 years from 2006 (c. 150 plants) to 2023 (c. 30 plants). However, the decline across a three-generation period is likely to be higher than 80% percent, given that this decline occurred across a period of time roughly two thirds the length of the species' three generation period.

Population decline is often estimated using exponential decay (e.g. as opposed to linear decline; IUCN 2024). Assuming exponential decline, this equates to an exponential decay rate of: $\ln(0.20)/17 = -0.0947$ per year (where 0.20 is the percentage

survival, and 17 is the time in years 2006 to 2023). To calculate the estimated decline in the Rollands Plains subpopulation over a three-generation period (27 years), it is necessary to estimate the number of mature individuals using the above rate of exponential decay.

Using the above rate of decline, it is estimated that the Rollands Plains subpopulation has undergone a decline of **92%**: 30 / ($e^{-0.0947*27}$) = 387 plants (92% decline), where 30 is the estimated number of mature individuals present at the end of the three-generation period in 2024, 27 is the three-generation period in years and -0.0947 is the decay rate.

Projecting into the future from 2024 gives a projected decline of **93%**: 30 * $e^{-0.0947*27}$ = 2 plants (93% decline), where 30 is the estimated number of mature individuals present at the commencement of the three-generation period in 2024, 27 is the three-generation period in years and -0.0947 is the decay rate.

Commencing in 2006 and using the above rate of exponential decline, the projected decline of the Rollands Plains subpopulation at the end of a three-generation period of 27 years in 2037 is **92%**: 150 * $e^{-0.0947*27}$ = 12 plants (92% decline), where 150 is the number of mature individuals present at the commencement of the three-generation period in 2006, 27 is the three-generation period in years and -0.0947 is the decay rate.

It is concluded that at Rollands Plains, *Diuris disposita* has experienced and is projected to continue experiencing a very severe reduction in population size, estimated or projected at 92–93% across a three-generation period in the past and/or future. This subpopulation is considered to be representative of the species' population as a whole, as other subpopulations either also appear to be declining (Yarravel NR) and is inferred for where population trend data are absent (all Collombatti subpopulations). In addition, five or six subpopulations may have become extinct since 1986, suggestive of a significant decline of the species' population more broadly. Therefore, the species qualifies as Critically Endangered under Criterion A.

Criterion B Geographic range

Assessment Outcome: Endangered under Criterion B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v)

Justification: *Diuris disposita* is endemic to a small area near Kempsey on the NSW North Coast and has a highly restricted geographic distribution. The Area of Occupancy (AOO) has been calculated as 16 km^2 based on likely extant subpopulations, or 20 km^2 if the Collombatti subpopulation last recorded in 2006 is included, meeting the threshold for listing as Endangered. The Extent of Occurrence (EOO) is more difficult to estimate for *D. disposita*, because the precise location of one of the four likely extant subpopulations (the Collombatti subpopulation recorded in 2022) is unknown, other than it being located on private property "near the rail line in Collombatti". Estimating possible sites near the rail line in Collombatti suggest EOO values when this subpopulation is included could be around 90–120 km^2, or 100–130 km^2 if the Collombatti subpopulation last recorded in 2006 is included. This suggests the EOO of *D. disposita* is likely to be >100 km^2, meeting the threshold for listing as Endangered.

In addition to these thresholds, at least two of three other conditions must be met. 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: Met for Critically Endangered, due to the species having one threat-defined location.

Justification: *Diuris disposita* is found at one threat-defined location when considering the most serious plausible threat of increased frequency of drought and extreme rainfall events due to climate change. This threat appears to be driver of the complete failure of flowering of the species in three subpopulations monitored in 2023 (P. Sheringham pers. comm. April 2024), which indicates the potential of the threat to cause the elimination of the species within a single generation (nine years) should conditions not abate. The species is found in small, likely isolated subpopulations, however, the viability of these subpopulations is unknown and there are no data on likely applicable minimum viable population sizes. Therefore, there are insufficient data to determine if the species is severely fragmented according to IUCN (2024).

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: Met for continuing decline observed, inferred and/or projected for (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.

Justification: Decline has been observed, inferred and is projected to continue in all of the EOO, AOO, area, extent and/or quality of habitat, number of locations or subpopulations, and the number of mature individuals of *Diuris disposita*. At least five historical subpopulations appear to be extinct, one additional subpopulation has not been recorded since 2006, and three of the four likely extant subpopulations are very small with <50 individuals. This suggests historical and continuing decline in all of the above metrics. In addition, increasing frequency of drought and extreme rainfall events, lack of biomass management, and weed invasion threaten the species' likely extant subpopulations, and the quality of the species' habitat is inferred to be declining as a result.

c) Extreme fluctuations.

Assessment Outcome: Not met.

Justification: The number of flowering individuals in subpopulations of *Diuris disposita* can fluctuate depending on recent rainfall and management conditions. However, this does not suggest a fluctuation in the number of mature individuals, as many individuals likely persist as dormant or non-flowering plants during such years.

Criterion C Small population size and decline

Assessment Outcome: Critically Endangered under Criterion C1

Justification: The population size of *Diuris disposita* is estimated at 120 mature individuals, meeting the threshold for Critically Endangered.

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: Met at Critically Endangered threshold

Justification: Continuing decline at Rollands Plains is discussed in Criterion A. Using this justification, subpopulation decline at Rollands Plains across one generation (nine years) is projected at **43%**: 30 * $e^{-0.0947*9}$ = 13 plants (43% decline) where 30 is the estimated subpopulation in 2023, -0.0947 is the rate of exponential decay from Criterion A, and 9 is the generation length in years. This estimate appears plausible, as the Rollands Plains subpopulation has been observed to decline by 80% in 17 years (Criterion A).

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

Assessment Outcome: Met at Endangered threshold

Justification: Continuing decline in the number of mature individuals is projected and inferred due to the effects of climate change (increased frequency of drought and extreme rainfall events), inappropriate biomass management, and other threats (weeds, clearing, adverse fire regimes, poaching).

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: Met at Endangered threshold

Justification: The largest subpopulation of *Diuris disposita* at Chain O Pools Road, Collombatti recorded 71 flowering plants in 2018 (Table 1). All other extant subpopulations are estimated to contain less than 30 mature individuals (Table 1).

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

Assessment Outcome: Not met.

Justification: The total number of mature individuals of *Diuris disposita* is estimated at 120 plants, of which the largest subpopulation of the species contains 71 plants (59%).

b. Extreme fluctuations in the number of mature individuals

Assessment Outcome: Not met

Justification: Extreme fluctuations in the number of mature individuals is not known for this species.

Criterion D Very small or restricted population

Assessment Outcome: Endangered under Criterion D1

Justification: The estimated population of *Diuris disposita* is 120 mature individuals, based off average counts of likely extant subpopulations from 2018–2023.

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: Met at Endangered threshold

Justification: The estimated population of *Diuris disposita* is 120 mature individuals, based off average counts of likely extant subpopulations from 2018–2023, meeting the threshold for Endangered.

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: Vulnerable under Criterion D2

Justification: The species has an estimated AOO of 16–20 km^2 and is found at one threat-defined location when considering the most serious plausible threat of increased frequency of drought and extreme rainfall events due to climate change. This threat appears to be behind the complete failure of flowering of the species in all three surveyed subpopulations in 2023 (P. Sheringham pers. comm. April 2024; Table 1), which indicates the potential of the threat to cause the elimination of the species within a very short time (e.g. a single generation; nine years) should conditions not abate.

Criterion E Quantitative Analysis

Assessment Outcome: Data Deficient

Justification: A quantitative analysis of extinction probability is not currently available for this species.

Conservation and Management Actions

Diuris disposita 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. *Diuris disposita* sits within the site-managed management stream of the SoS program. There is no National Recovery Plan for this species.

Habitat loss, disturbance and modification

- Continue regular slashing/mowing at Rollands Plains between late December to late July. Do not slash or mow from early August to mid-December (Eco Logical Australia 2019; NSW DCCEEW 2024b).
- Prevent ongoing habitat loss associated with intensification of rural land use (e.g. pasture improvement).

- Ensure surveys associated with proposed habitat removal or detrimental modification address this species.
- At Rollands Plains, trial an ecological burn of some areas of the unslashed section between mid-January to early March. Do not burn outside of this period and do not burn the plants observed in the slashed area. A late summer fire is known to enhance the flowering rates of spring-flowering *Diuris* species (Eco Logical Australia 2019). Ideally the fire should be of moderate intensity and, if shown to successfully promote flowering of *D. disposita*, repeated every 3–5 years (NSW DCCEEW 2023b).
- Where possible, and with the consent and support of landowners, explore options to legally protect *Diuris disposita* subpopulations on private land (e.g. through conservation covenants or land purchases for inclusion into the conservation estate).

Invasive species

- Continue to control lantana at Yarravel NR, and consider implementing a weed control program at Rollands Plains to control Camphor Laurel if necessary.
- Remove sapling native tree and shrubs from Rollands Plains if they pose a threat to *Diuris disposita*.

Ex situ conservation

- Continue targeted seed and mycorrhizal fungal collection for ex situ seed banking and propagation. Seed/tissue collection and storage should be conducted in accordance with best practice guidelines and procedures (Martyn Yenson *et al.* 2021 or Commander 2021). With such few remaining individuals, consider collecting seed from all remaining individuals to maximise genetic diversity of ex-situ collections. Fungal collections of *Tulasnella* (e.g. from *Diuris*) rapidly lose the ability to germinate seed and should be stored at -80°C immediately following isolation (Reiter *et al*. 2023).
- Implement conservation translocations or, if threats are adequately addressed, supplementation of existing subpopulations. Translocations should be conducted in accordance with best practice guidelines and procedures (Commander *et al*. 2018), including monitoring translocated subpopulations through to recruitment to ensure they are viable.

Stakeholders

- Liaise with landowners and managers of sites where there are known subpopulations (particularly at Chain O Pools Road Collombatti and Rollands Plains) and consult with these groups regarding options for conservation management and protection of the species.
- Engage cultural knowledge custodians in conservation actions, including the implementation of Indigenous fire management and other survey, monitoring and management actions. Enable the sharing of knowledge, while ensuring the processes and protocols to record, store, and share any knowledge are agreed and appropriately resourced. Information on the application of integrated Caring for Country practices to protect and enhance habitat is of critical importance.

- Engage local residents, particularly in the Collombatti area, to participate in surveys, monitoring or other conservation actions for the species.

Survey and Monitoring priorities

- Locate the Collombatti subpopulation reported in 2022.
- Survey the Collombatti subpopulation last reported in 2006 if possible.
- Conduct further targeted surveys in areas of suitable habitat on public and private land.
- Continue monitoring of extant subpopulations, including annual monitoring of Rollands Plains and Yarravel NR. Ideally, collect monitoring data on individual plants (that are accurately located and tagged), and record emergence, flowering and pollination data, which could help answer questions about the species ecology (below).
- Monitor threats and their impact at all extant subpopulations where possible.

Information and Research priorities

- Identify the pollinator/s of *Diuris disposita* and conduct research into their ecology.
- Conduct research into the ecology of *D. disposita*, including fire response, emergence and flowering cues (e.g. slashing/fire requirements; rainfall timing and amount), pollination rates, recruitment, fire ecology, etc.

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APPENDIX 1

Assessment against *Biodiversity Conservation Regulation 2017* criteria

The Clauses used for assessment are listed below for reference.

Overall Assessment Outcome: *Diuris disposita* was found to be Critically Endangered under Clause 4.2(1 a)(2 b,e) and Clause 4.4(a)(d i)

Clause 4.2 – Reduction in population size of species
(Equivalent to IUCN criterion A)
Assessment Outcome: Critically Endangered under Clause 4.2(1 a)(2 b,e)

(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: Endangered under Clause 4.3(b)(d)(e i,ii,iii,iv).

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: Critically Endangered under Clause 4.4(a)(d i)

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: Endangered under Clause 4.5(b)

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: Clause not met.

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: Vulnerable under Clause 4.7

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.