Conservation Assessment of *Prasophyllum canaliculatum* D.L.Jones (Orchidaceae)

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Prasophyllum canaliculatum D.L.Jones (Orchidaceae)

Distribution: NSW and ACT
Current EPBC Act Status: Not listed
Current ACT Nature Conservation Act Status: Not listed
Current NSW BC Act Status: Critically Endangered
Proposed listing: Endangered

Reason for change: Non-genuine change based on the inclusion of the Australian Capital Territory subpopulation and additional subpopulations found since last assessment.

Summary of Conservation Assessment

Prasophyllum canaliculatum was found to be eligible for listing as Endangered under IUCN Criteria B1ab(iii,v)+2ab(iii,v).

The main reasons for this species being eligible are (1) a highly restricted geographic range with an estimated area of occupancy of 28–32 km^2, an estimated extent of occurrence of 2,754–3,503 km^2, and 3–6 threat-defined locations; (2) an inferred continuing decline in habitat quality attributed to the activities of feral animals, competition with exotic plants, and vegetation clearing; (3) an inferred continuing decline in the number of mature individuals, primarily attributed to soil turnover by feral pigs (*Sus scrofa*).

Prasophyllum canaliculatum. Credit: Gavin Phillips/NSW DCCEEW.

Description and Taxonomy

Prasophyllum canaliculatum D.L.Jones (family Orchidaceae), commonly known as the summer leek orchid or channelled leek orchid, was most recently described in Jones (2021) as follows: "Plants 300–500 mm tall. Free part of leaf to 200 x 3–5 mm. Spike 50–110 mm long, 5–25 flowered. Ovary sessile, bright green. Flowers moderately crowded, scented, 14–16 x 7–9 mm, red, greenish-red or brownish-red, labellum reddish or brownish, callus green or reddish. Dorsal sepal 7.5–9 x 4–5 mm, decurved or recurved. Lateral sepals free, 7.5–9 x 2 mm, parallel, recurved. Petals 6.5–7.5 x 2 mm, incurved to spreading. Labellum sessile, ovate-elliptical, 6–7.5 x 5–6 mm, broadest at base, sharply recurved near apex and contracted to short tail, margins mostly entire. Callus oblong, deeply grooved, ending in short tail just beyond labellum bend." Notably, the colour of fresh flowers can vary greatly between individuals within a single subpopulation, ranging from deep red to pale yellow (McPherson 2004). Its flowers are described as "fragrant" on warm days (Jones 2021).

Prasophyllum canaliculatum is the currently accepted name (CHAH 2018a; PlantNET 2024). However, based on molecular analysis, Clements and Jones (2019) include the species in the new genus *Paraprasophyllum*. *Prasophyllum canaliculatum* has been misapplied to *Prasophyllum uvidulum*, which is considered to be confined to Victoria, and not known to occur within the distribution of *P. canaliculatum* (CHAH 2018b). It may be confused with *Prasophyllum wilkinsoniorum*, which differs from *P. canaliculatum* in having a more elongated labellum and dorsal sepal, and a labellum callus that has a flat area towards the tip, rather than the deep groove of *P. canaliculatum* (Miles 2017). The purplish base of the leaves of *P. canaliculatum* can be used to distinguish them from *Microtis* leaves (R. Armstrong *in litt.* August 2024).

There are conflicting opinions about the identification of records in the Australian Capital Territory (ACT) as *Prasophyllum canaliculatum* or *P. keltonii* (Kelton's leek orchid) (Jones 2021; Copeland and Backhouse 2022). Research is currently underway to inform a targeted sampling approach for a detailed molecular study to better understand species delimitation and genetic diversity in this group (K. Nargar *in litt*. June 2024). This assessment considers the ACT records to be *P. canaliculatum*, which is consistent with the current Australian Plant Census concept of the species' distribution (CHAH 2018a), and the determination of specimens held by the Australian National Herbarium.

Distribution

There are 4–5 known subpopulations of *Prasophyllum canaliculatum* (detailed in Table 1). These occur in disjunct habitats in the Australian Alps of the ACT, and the South Eastern Highlands of New South Wales (NSW) (IBRA Regions, Commonwealth DCCEEW 2024). The minimum number excludes the Kybeyan subpopulation, which may no longer be extant given that it had only two emergent individuals in February 2021 (NSW Government 2024a), and there was extensive damage from feral pigs at this site observed in December 2023 (R. Armstrong *in litt*. July 2024).

Several other areas of potential habitat for *Prasophyllum canaliculatum* have been searched, but to date no other subpopulations have been found (Jones 1997; McPherson 2004; Miles 2024).

Table 1. Details of *Prasophyllum canaliculatum* subpopulations. Counts refer to surveys of emergent (presumed mostly flowering) individuals.
*Post-fire surveys at Bemboka (which found no individuals) may have been undertaken at a suboptimal time since this subpopulation seems to flower later than others (Miles 2024).
#Each site in the main body of the Nimmitabel subpopulation was regularly monitored, but not all sites were monitored each year, thus the maximum count was summed from various years across sites. In 2023, two sites, which had only ever recorded one individual each, were not surveyed due to relatively low above-ground numbers at more reliable sites.

Subpop.	Notes (including fire history)	Max. count	Most recent count
ACT	Burnt at moderate severity in the 2002–03 and 2019–20 wildfires (Barrett 2006; NSW DCCEEW 2020, NSW DCCEEW 2024). There are conflicting opinions about the identification of records here as *Prasophyllum canaliculatum* or *P. keltonii* (Jones 2021; Copeland and Backhouse 2022). Occurs at the highest elevation of known subpopulations (~1,220 m). Land use: National Park.	260 [Dec 2021] (Orchid Society of Canberra *in litt.* June 2024)	60–100 [Jan 2024] (C. Ernst-Russell *in litt.* June 2024)
Kybeyan	Fire absent >50 years. Species' type locality. Noted in 2021 to be occurring among shrubs on a road verge near a drainage line that is now cleared paddock with scattered trees (formerly woodland) (NSW Government 2024a). Extirpation of this subpopulation is suspected based on extensive damage by feral pigs observed in December 2023 (R. Armstrong *in litt*. July 2024). Land use: Road adjacent to private land, grazing native vegetation.	30 [Dec 1996] (Jones 1997)	2 [Feb 2021] (G. Phillips *et al.* in NSW Government 2024a)
Bemboka	Burnt at low-moderate severity (defined as "burnt surface with unburnt canopy" to "partial canopy scorch") in the 2019–20 wildfires (NSW DCCEEW 2020, NSW DCCEEW 2024). Land use: National Park.	10 [Mar 2021] (J. Miles in NSW Government 2024a)	0* [Dec 2023] (Miles 2024)
Nimmitabel	Fire absent >50 years. The main body comprises 5–6 scattered sites in an area of ~1.6 km^2 connected by swamps and drainage lines. In addition, there was one individual recorded ~4 km south in January 2000 (D.L. Jones in CANB 2024). Land use: National Park, travelling stock route reserve.	237# [Jan 2000, Jan 2004, Dec 2014, Dec 2016, Dec 2022] (McPherson 2004; D.L. Jones in CANB 2024; Miles 2024)	17 [Dec 2023] (Miles 2024)
Rockton	Fire absent >50 years. Occurs at the lowest elevation of known subpopulations (~745 m). Land use: Grazing native vegetation, travelling stock route reserve.	60 [Dec 2021] (Miles 2024)	8 [Dec 2023] (Miles 2024)

Area of occupancy and extent of occurrence

Prasophyllum canaliculatum has an estimated area of occupancy (AOO) of 28–32 km^2, and an estimated extent of occurrence (EOO) of 2,754–3,503 km^2. As recommended by IUCN (2024), AOO is based on 2 x 2 km grid cells, while EOO is based on a minimum convex polygon enclosing mapped records for the species. The minimum estimates exclude the Kybeyan subpopulation, which may no longer be extant (R. Armstrong *in litt*. July 2024).

The records used for these estimates were retrieved from BioNet (NSW Government 2024a), the Atlas of Living Australia (2024), the National Herbarium of New South Wales (RBGDT 2024), the Australian National Herbarium (CANB 2024), Miles (2024), C. Ernst-Russell *in litt*. (June 2024), M. Mullaney *in litt*. (June 2024), NatureMapr (2024), and the Orchid Society of Canberra *in litt*. (June 2024). Of a total of 248 records, 117 were excluded because they were duplicates or lacked coordinate attributes. An additional eight were excluded based on likely misidentifications, high coordinate uncertainty, or records of survey effort only.

Population size

Prasophyllum canaliculatum has an estimated total population size of approximately 800–2,000 mature individuals with an inferred declining trend. This range captures uncertainty resulting from the suspected extirpation of the Kybeyan subpopulation (R. Armstrong *in litt*. July 2024), and the ability of individuals to lie dormant underground for several years if conditions are not right for them to emerge (NSW NPWS 2022). A high degree of annual variability in emergence and flowering is expected for this species (Miles 2024), as is the case for *Prasophyllum correctum* (gaping leek-orchid) (Coates *et al.* 2006). In addition, it is unlikely that all emergent individuals are detected during any given survey due to its small size (especially if not flowering or when grazed), common concealment within shrubs and sedges, and human error (McPherson 2004).

The most recent surveys across subpopulations detected 97–137 emergent (presumed mostly flowering and including the two Kybeyan individuals) *Prasophyllum canaliculatum* (Table 1). This range results from the estimated range for the ACT subpopulation (*i.e*., 60–100), and uses the only count known to have been undertaken during the flowering period of the Bemboka subpopulation (*i.e*., 10).

To derive a population size estimate for *Prasophyllum canaliculatum* that includes the individuals that may not have been counted because they emerged without flowering or were dormant underground, the observations of population dynamics for *Prasophyllum correctum* (Coates *et al*. 2006) have been applied. Analysis of monitoring data showed that under fire intervals of >3 years ~78% of *P. correctum* individuals are expected to be dormant, ~18% will emerge with a leaf only, and ~4% will flower (Coates *et al*. 2006). Under fire intervals of <3 years ~53% are expected to be dormant, ~25% leaf-only, and ~21% flowering (Coates *et al.* 2006). Seedlings would be present, but are very difficult to detect, and therefore contribute less than 1% (*i.e*., a negligible proportion) to the expected population life stage distribution under either scenario (Coates *et al*. 2006). Thus, it is assumed that 21% of the *Prasophyllum canaliculatum* individuals in the ACT and Bemboka subpopulations were counted 1–2 years after the 2019–20 wildfires (Table 1). For all other subpopulations, which are long unburnt, it is assumed only 4% of individuals were

counted. This provides an estimated maximum population of 1,986 mature *P. canaliculatum* (1,936 without the Kybeyan subpopulation).

A precautionary approach to the estimation of *Prasophyllum canaliculatum* population size is necessary given that the actual flowering rate for this species is unknown, and continuing decline in the number of mature individuals is inferred. In accordance with the recommendations of IUCN (2024) for resolving uncertainty, a slightly lower than mid-value of 833 (813 without the Kybeyan subpopulation) is considered a reasonable minimum estimate for the population size of *P. canaliculatum*. This value is 40% of the sum of the maximum estimate and the minimum number of individuals detected in the most recent surveys.

The inferred declining trend in population size for *Prasophyllum canaliculatum* is based on the repeated surveys of sites in the Nimmitabel subpopulation (McPherson 2004; Miles 2024). Due to uncertainties around the underground proportion of the population, variations in counts of emergent individuals should not be conflated with fluctuations or trends in population size. However, Site 5 is the only site where a recent count (in 2022) was the same as (or similar to) the 2016 count (n = 36; the first year Site 5 was surveyed) (Miles 2024). By comparison, at Site 2, the count was 43 emergent individuals in 2016, but no more than nine in any of the six survey years up to and including 2023 (Miles 2024). A similar pattern of reduced counts compared to past years is present at the two other Nimmitabel sites that have been consistently surveyed. This suggests that, in at least some sites, there are mechanisms acting to inhibit the recruitment or emergence of individuals and/or kill dormant tubers (*e.g.*, the turnover of soil by pigs), leading to the inferred decline.

Given the uncertainty in the estimate of population size, it is difficult to provide a more precise estimate of mature individuals. Improved knowledge of population biology would allow a better estimate of the number of mature individuals.

Ecology

Habitat

Prasophyllum canaliculatum is currently known to occur at elevations of ~745–1,220 m in grasslands and open woodlands near drainage lines, swamps, and bogs (Jones 2021; CANB 2024; NSW Government 2024a). The nearest weather stations to subpopulations of *P. canaliculatum* (*i.e.*, Tuggeranong, Bombala, and Nimmitabel) have recorded an average maximum temperature of 22.8–29.4°C, an average minimum temperature of -1.9–0°C, and average annual rainfall of 582.4–687.4 mm (BOM 2024).

The plant community types (PCTs) *Prasophyllum canaliculatum* is known to occur in are 'Monaro Creekflat Peat Swamp' (PCT 3942) and 'Southern Tableland Ranges Boggy Open Woodland' (PCT 3951) (NSW OEH 2024). However, *P. canaliculatum* may occur in other PCTs. It grows among grass and sedge tussocks and wet heathy shrubs, and is associated with sphagnum hummocks, *Eucalyptus pauciflora* (snow gum, white sally), *Eucalyptus viminalis* (ribbon gum), *Baeckea utilis* (mountain baeckea), *Epacris breviflora* (drumstick heath), *Epacris microphylla* (coral heath), *Hakea microcarpa* (small-fruited hakea), *Leptospermum myrtifolium* (myrtle tea-tree), *Cyperus* sp., *Juncus* sp. (rushes), *Luzula* sp. (woodrush), *Poa clivicola* (fine-leaved snow grass), *Poa sieberiana* (snowgrass), *Poa labillardierei* (common tussock-grass), *Themeda triandra* (kangaroo grass), *Acaena* sp., *Craspedia paludicola* (swamp billy-

button), *Geranium* sp., *Leucochrysum albicans* (hoary sunray), *Microtis* sp. (onion orchid), *Spiranthes australis* (austral ladies' tresses), *Stylidium graminifolium* (grass triggerplant) and *Wahlenbergia* sp. (Australian bluebell) (Jones 1997, 2021; CANB 2024; Miles 2024; NSW Government 2024a; RBGDT 2024).

Prasophyllum canaliculatum has been recorded in soils described as peaty, moist to wet brown loam, freely draining well-structured loam, moist but not waterlogged granite-derived sandy loam, peaty loams on granite, gravelly loams on granite, humus on granite, and black fines (Jones 2021; CANB 2024; NSW Government 2024a; RBGDT 2024). It is commonly found in the short grass of inter-tussock spaces (Miles 2017), though this may be because they are much more visible to the human eye in short grass (Miles 2013). The species also often occurs in association with *Poa labillardierei* tussocks and the small shrub *Epacris breviflora*, which may provide some degree of concealment from herbivores (Miles 2018).

Flowering and dormancy

Prasophyllum canaliculatum grows singly or in groups of 2–4 individuals (NSW NPWS 2022) and typically flowers in mid-late December to January (Jones 1997; Miles 2024). However, flowering has been observed from late November through to early March when suitable environmental conditions are present (Miles 2024; R. Armstrong *in litt*. December 2024). Extreme dry conditions prior to and during the flowering season may cause this species to abort flowering (Miles 2019, Miles 2024).

Some *Prasophyllum canaliculatum* individuals will not emerge at all during the flowering season, instead remaining dormant underground (NSW NPWS 2022). Additionally, as is the case in *P. correctum*, emergent *P. canaliculatum* individuals do not always produce flowers (Coates *et al*. 2006; Miles 2024). Individuals that emerge in the vegetative (*i.e*., leaf only) state appear grass-like, and as such, may be easily missed during surveys (Coates *et al*. 2006).

Outside the flowering season, all *Prasophyllum canaliculatum* individuals persist only as underground root tubers and are not visible aboveground. This seasonal dormancy may allow *P. canaliculatum* to avoid freezing winters (Weston *et al.* 2005). Based on the observations of *P. correctum* (Coates *et al.* 2006), it is inferred that *P. canaliculatum* individuals can remain dormant (i.e., without seasonal emergence) for 1–5 years.

It is suspected that a greater proportion of *Prasophyllum canaliculatum* individuals will remain dormant during the flowering season in years with dry or wet extremes in environmental conditions (*e.g*., waterlogging, drought), or when there is a high level of competition from dense growth of grasses and sedges (Miles 2017, 2019, 2024). The latter may arise following above average rainfall and/or in the absence of fire (Coates *et al.* 2006).

Pollination and capsule development

Prasophyllum canaliculatum produces nectar that is consumed by pollinating insects (Jones 1997). Pollen removal and deposition by small weevils (Curculionidae) has been observed on *P. canaliculatum* (Jones 1997). Flies, other beetles, bees and wasps are potential pollinators inferred from other *Prasophyllum* species (Bernhardt and Burns-Balogh 1986; Adams and Lawson 1993; Kuiter 2018; Hayashi *et al.* 2024).

Capsule (*i.e*., fruit) development varies amongst *Prasophyllum canaliculatum* individuals that are available for pollination at a similar time; the reason for this is not

yet understood (Miles 2024; R. Armstrong *in litt.* May 2024). It could be due to limited pollination success at the level of individual flowers (either naturally or due to the performance of the pollinator species), staged pollination, or some capsules not being pollinated at all (R. Armstrong *in litt*. May 2024). For the congener *P. odoratum* (scented leek-orchid), it has been suggested that the formation of viable capsules is limited by the dispersal success of pollinia (*e.g*., insects removing the pollinaria from themselves before moving to another flower), and incomplete formation of female reproductive parts in a proportion of flowers on the inflorescence (Bernhardt and Burns-Balogh 1986).

Ascertaining pollination success in *Prasophyllum canaliculatum* is further complicated by the observation that even capsules that appear under-developed (*i.e*., not swollen) can produce some seed, albeit fewer than swollen capsules (R. Armstrong *in litt*. May 2024). Whether *P. canaliculatum* can develop seed without fertilisation (*i.e*., apomixis), as occurs in *Prasophyllum lindleyanum* (but not *P. frenchii* or *P. tadgellianum*) (Freestone *et al.* 2022), has not been empirically tested.

Seed dispersal and germination

Orchids produce many tiny balloon-like seeds that are dispersed by wind and water, and may also be transported by animals in their fur, feathers, or muddy feet (Arditti and Ghani 2000). Because *Prasophyllum canaliculatum* seeds are only released at a maximum of 0.5 m high, many of them are expected to settle close to the parent plant (Murren and Ellison 1998; Arditti and Ghani 2000). However, given the large numbers produced, it is reasonable to assume that some seeds are dispersed over larger distances (Arditti and Ghani 2000).

Based on the life history of other orchid species (Coates *et al*. 2006; Shefferson *et al.* 2020), and the small population size of *Prasophyllum canaliculatum*, it is inferred that relatively few *P. canaliculatum* seeds become mature adults. Assuming a seed is deposited in an area of suitable vegetation, soil, and climate, like other orchids, *Prasophyllum* species also require the presence of specific types of mycorrhizal fungi for germination and growth (Grant and Koch 2003; Freestone *et al*. 2023). A symbiotic association is formed with the fungi, which serves to supply nutrients to the seedling (Rasmussen and Rasmussen 2009).

There is evidence indicating that the local abundance of orchids is positively related to the local abundance of their mycorrhizal fungi (McCormick *et al.* 2018). *Ceratobasidium cornigerum* was the most common mycorrhizal associate obtained from the *Prasophyllum* species studied by Warcup (1981). Several other *Ceratobasidium* species have been isolated from *Prasophyllum* species (Freestone *et al.* 2021). *Prasophyllum fuscum* (slaty leek orchid) and *P. pallidum* (pale leek-orchid) have also been germinated with *Rhizoctonia solani* (Warcup 1981), and *Tulasnella calospora* has been isolated from *P. giganteum* (bronze leek orchid, Bonnardeaux *et al*. 2007).

Lifespan and generation length

The lifespan of *Prasophyllum* species is considered to be indefinite because death occurs due to outside factors (*e.g*., unsuitable environment, herbivory) rather than inherent growth (Benson and McDougall 2005). *Prasophyllum canaliculatum* lacks the stolonoid roots that produce colonies of daughter tubers (Pridgeon and Chase 1995; Clements and Jones 2019). For *P. canaliculatum* it is inferred that a single dropper is

produced each year to form a replacement tuber (Pridgeon and Chase 1995), which is considered the same individual.

Given the difficulties of monitoring underground individuals, the lack of a reliable method for estimating the age of individuals, and that mortality rates are likely to vary temporally and between subpopulations, the generation length for *Prasophyllum canaliculatum* is uncertain. Generation lengths estimated for other *Prasophyllum* species range between 10–50 years (Commonwealth TSSC 2014; DELWP 2021, 2022; Commonwealth of Australia 2023).

Fire ecology

It is evident from the long (>50 years) absence of fire from several subpopulations of *Prasophyllum canaliculatum* (Table 1) that this species does not flower exclusively within the first five years after fire, as occurs in some other *Prasophyllum* species (Ferrer-Paris and Keith 2022). However, *Prasophyllum* species generally respond with an increased proportion of individuals flowering in the year/s immediately following a fire (Orchid Society of Canberra *in litt*. June 2024). This response has been observed for *Prasophyllum bagoense* (Bago leek orchid), *P. brevilabre* (short-lipped leek orchid), *P. innubum* (Brandy Mary's leek orchid), and *P. keltonii* (Orchid Society of Canberra *in litt*. June 2024). The same response is expected to occur in *Prasophyllum canaliculatum* provided appropriate environmental conditions are present (Orchid Society of Canberra *in litt*. June 2024).

Emergent *Prasophyllum canaliculatum* stems are likely to be consumed by fire. Ecological burning in late Autumn is known to be favourable for *Prasophyllum petilum* (Tarengo leek orchid) and has been implemented to manage competition from native grasses. Appropriate intervals are still being determined and are unlikely to be prescriptive given the need to consider seasonal conditions as well as time since the last fire (R. Armstrong *in litt*. May 2024).

Cultural Significance

The traditional custodians of the lands on which *Prasophyllum canaliculatum* occurs are the Bidwell, Ngambri, Ngarigo, Ngunnawal, and Yuin peoples (Horton 1996; Native Land Digital 2024). Several *Prasophyllum* species were commonly eaten by Aboriginal peoples (Lawler 1984 in Presland 2004). The traditional Aboriginal plant use guide for the ACT region, which records traditional plant knowledge of Ngunnawal people, has the following entry for the related *Prasophyllum tadgellianum* (small alpine leek-orchid): "Like all orchids this species has an edible tuber which is best eaten roasted" (ACT Government and Ngunnawal Community 2014).

This assessment is not intended to be comprehensive of the traditional ecological knowledge that exists for *Prasophyllum canaliculatum*, 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.* 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.* 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* (ICIP) protocol (Janke and Company 2023).

Threats

The major threats to the persistence of *Prasophyllum canaliculatum* are herbivory and habitat degradation by feral animals, competition with exotic plants, and vegetation clearing. The resilience of *P. canaliculatum* to these threats may be reduced by human-induced changes to rainfall and fire regimes.

The disjunct distribution of *Prasophyllum canaliculatum*, which is thought to be a result of relatively narrow habitat requirements, makes this species susceptible to threatening processes. In addition, the adverse effects of threatening processes may be exacerbated by natural processes (*e.g*., competition with dense growth of native species; Coates *et al*. 2006; Miles 2024), and gaps in our understanding of *P. canaliculatum* ecology (*e.g*., factors influencing dormancy, emergence, and flowering).

Herbivory and habitat degradation by feral animals and livestock

There is an inferred continuing decline in the habitat quality and number of mature individuals of *Prasophyllum canaliculatum* attributed to herbivory (including consumption of tubers), digging and/or trampling by feral pigs, deer (*Cervus elaphus*, *Dama dama*, *Rusa unicolor*; Invasive Species Council 2011), and rabbits (*Oryctolagus cuniculus*). Grazing, digging, and trampling damages flowering stems and therefore adversely affects an individual's ability to produce seed in a given year (McPherson 2004; G. Phillips *in litt*. May 2024). Consecutive years of limited seed production, together with mortality caused by exposure or consumption when tubers are unearthed, places subpopulations at increased risk of extinction (McPherson 2004). In addition, bare patches created by feral animals may facilitate the encroachment of exotic plants that compete with *P. canaliculatum* (McPherson 2004).

It is inferred that pig activities (evidenced by the turnover of large areas of soil) across multiple sites in the Nimmitabel subpopulation contributed to reduced counts of *Prasophyllum canaliculatum* in 2018 (Miles 2018), and the loss of stems noted between repeat surveys in the 2020–21 flowering season (G. Phillips *in litt*. May 2024). The ACT subpopulation of *P. canaliculatum* is also susceptible to damage by pigs (FOG 2023; Orchid Society of Canberra *in litt*. June 2024) and it is suspected that extensive damage from feral pigs may have extirpated the Kybeyan subpopulation (R. Armstrong *in litt*. July 2024).

Adverse effects on *Prasophyllum canaliculatum* from the activities of deer and rabbits are suspected from evidence of their presence (McPherson 2004), and observations of rabbits digging up *Caladenia saggicola* (sagg spider orchid) tubers (Threatened Species Section 2017). Their adverse effects may be greatest during dry periods when the moisture of the swamp habitat may attract a greater number and/or frequency of these animals (McPherson 2004).

Livestock may have similar adverse effects on *Prasophyllum canaliculatum*, albeit likely at lower frequency than feral animals. The Rockton subpopulation occurs within an area that is used for travelling stock, emergency management, or biosecurity purposes (NSW LLS 2020). It is unclear whether the travelling stock route reserve in the Nimmitabel subpopulation is still used.

'Predation, habitat degradation, competition and disease transmission by feral pigs, *Sus scrofa* Linnaeus 1758', 'Herbivory and environmental degradation caused by feral deer', and 'Competition and grazing by the feral European rabbit,

Oryctolagus cuniculus (L.)' are listed as Key Threatening Processes under the NSW *Biodiversity Conservation Act 2016*.

'Predation, habitat degradation, competition and disease transmission by feral pigs', 'Competition and land degradation by rabbits', and 'Novel biota and their impact on biodiversity' are listed as Key Threatening Processes under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*

Competition with exotic plants

The spread of exotic plants is inferred to contribute to continuing decline in the habitat quality of *Prasophyllum canaliculatum* through competition for space and resources, which is likely to impair the species' emergence and recruitment (NSW NPWS 2022). It has been suggested that a dense cover of tall grass and the native sedges *Machaerina rubiginosa* (soft twig-rush) and *Carex gaudichaudiana* (fen sedge) may make previously occupied areas less suitable for *P. canaliculatum* (Miles 2024). It follows that dense swathes of exotic plants may have the same effect.

The Kybeyan subpopulation, which was invaded by the exotic grass *Holcus lanatus* (Yorkshire fog) (Jones 1997), was subsequently thought extinct until the rediscovery of just two individuals in 2021 (NSW Government 2024a); though now again suspected to be extirpated due to feral pig activities (R. Armstrong *in litt*. July 2024). The spread of *Rubus* spp. (blackberry) has been a cause of concern for the Nimmitabel subpopulation (NSW Government 2019), but is currently well controlled as part of the Saving our Species program (R. Armstrong *in litt*. August 2024).

'Invasion of native plant communities by exotic perennial grasses' and 'Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants' are listed as Key Threatening Processes under the NSW *Biodiversity Conservation Act 2016*.

'Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants' is listed as a Key Threatening Process under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*

Vegetation clearing

Prasophyllum canaliculatum individuals in the Kybeyan subpopulation were located on a road verge, which was disturbed for road-widening (Jones 1997). It is inferred that the road works, adjacent land clearing (for farmland) and set-stock grazing have contributed to a reduction in the number of mature individuals, habitat area, and habitat quality for *P. canaliculatum*. Moreover, there is an ongoing risk of adverse effects on this subpopulation (if still extant) from road grading (Snowy Monaro Regional Council 2024).

'Clearing of native vegetation' is listed as a Key Threatening Process under the NSW *Biodiversity Conservation Act 2016*. 'Land clearance' is listed as a Key Threatening Process under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*

Human-induced changes to rainfall and fire regime as a result of climate change

Modelling of human-induced climate change predicts, with high confidence, that by 2090 there will be less winter rainfall (-40% to +5% change) and a harsher fire-weather climate in the regions occupied by *Prasophyllum canaliculatum* (Grose *et al*. 2015; Timbal *et al*. 2015). Adverse effects on *P. canaliculatum* from these changes are

uncertain. However, it is suspected that the combination of (1) increased frequency of dry years, in which flowering is limited (Miles 2019; Miles 2024); (2) loss of flowers to fire because they emerge during peak bushfire season (Jones 1997); and (3) wildfires occurring (or burning with greater intensity) in areas of swamp habitat not previously affected (Orchid Society of Canberra *in litt*. June 2024), would result in a greater magnitude and/or frequency of reduced reproductive output. In turn, a lower reproductive output would reduce the species' resilience to the other threats implicated in its decline (*i.e*., compounding their adverse effects).

'Anthropogenic climate change' and 'High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition' are listed as Key Threatening Processes under the NSW *Biodiversity Conservation Act 2016*.

'Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases' and 'Fire regimes that cause declines in biodiversity' are listed as Key Threatening Processes under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*

Threat-defined Locations

Prasophyllum canaliculatum occurs in 3–6 threat-defined locations. The most serious plausible threat (depending on site and point in time) that could rapidly affect all individuals in a location is feral animal activities (*e.g*., herbivory, wallowing), vegetation clearing, or rapid invasion by exotic plants. The maximum for the range of locations includes the Kybeyan subpopulation, while the minimum captures the scenario where that subpopulation is extirpated, and one of the threats occurs in multiple sites at the same time (*e.g*., a season of widespread adverse effects from feral animal activities due to the attractiveness of moisture in the orchids' swamp habitat; McPherson 2004).

Severe Fragmentation

The distribution of *Prasophyllum canaliculatum* does not meet the IUCN (2024) definition of severely fragmented "that most of its individuals are found in small and relatively isolated subpopulations". Based on post-fire (2021) above-ground observations, most (~62%) of *P. canaliculatum* individuals are found in the ACT subpopulation. Although this subpopulation appears to be isolated based on our current knowledge (*i.e*., it is ~100 km from the nearest known source of propagules), it does not meet the definition of "small" in terms of population viability. Despite only occupying an area of ~2 ha it has an estimated 519–1,238 mature individuals, which confers resilience to key threatening processes.

Assessment against IUCN Red List Criteria

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

Criterion A Population size reduction

Assessment Outcome: Data Deficient.

Justification: Assessment under this criterion requires information on the generation length of *Prasophyllum canaliculatum*. Given the difficulties of monitoring underground individuals, the lack of a reliable method for estimating the age of individuals, and that mortality rates are likely to vary temporally and between subpopulations, the generation length for *P. canaliculatum* is uncertain. Generation lengths estimated for other *Prasophyllum* species range between 10–50 years (Commonwealth TSSC 2014; DELWP 2021, 2022; Commonwealth of Australia 2023). Furthermore, quantification of the inferred decline is complicated by a limited understanding of the factors influencing the species' dormancy, emergence, and flowering.

Criterion B Geographic range

Assessment Outcome: Endangered under Criterion B1ab(iii,v)+2ab(iii,v).

Justification: *Prasophyllum canaliculatum* meets the thresholds of <500 km^2 and <5,000 km^2 for Endangered, with an estimated AOO of 28–32 km^2, and an estimated EOO of 2,754–3,503 km^2, respectively.

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 Endangered with 3–6 locations.

   Justification: *Prasophyllum canaliculatum* occurs in 3–6 threat-defined locations, which meets the threshold of ≤5 for Endangered under the recommended precautionary approach (IUCN 2024). The most serious plausible threat (depending on site and point in time) that could rapidly affect all individuals in a location is feral animal activities (*e.g.*, herbivory, wallowing), vegetation clearing, or rapid invasion by exotic plants. The maximum for the range of locations includes the Kybeyan subpopulation, while the minimum captures the scenario where that subpopulation is extirpated, and one of the threats occurs in multiple sites at the same time (*e.g.*, a season of widespread adverse effects from feral animal activities due to the attractiveness of moisture in the orchids' swamp habitat; McPherson 2004).

   The distribution of *Prasophyllum canaliculatum* does not meet the IUCN (2024) definition of severely fragmented because although the ACT subpopulation appears to be isolated (*i.e.*, it is ~100 km from the nearest known source of propagules) and has ~62% of the species' total population (based on 2021 observations), it is a viable population. Despite only occupying an area of ~2 ha this subpopulation has an estimated 519–1,238 mature individuals, which confers resilience to key threatening processes.

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 (iii) area, extent and/or quality of habitat, and (v) number of mature individuals.

Justification: There is an inferred continuing decline in the habitat quality of *Prasophyllum canaliculatum* attributed to herbivory, digging and/or trampling by feral pigs, deer, and rabbits (Miles 2018; FOG 2023; G. Phillips *in litt*. May 2024; Orchid Society of Canberra *in litt*. June 2024).

The inferred continuing decline in the number of mature individuals of *Prasophyllum canaliculatum* is based on the repeated surveys of sites in the Nimmitabel subpopulation (McPherson 2004; Miles 2024), and is primarily attributed to soil turnover by pigs (with mortality caused by exposure or consumption). Site 5 is the only site where a recent count (in 2022) was the same as (or similar to) the 2016 count (n = 36) (Miles 2024). By comparison, at Site 2, the count was 43 emergent individuals in 2016, but no more than nine in any of the six survey years up to and including 2023 (Miles 2024). A similar pattern of reduced counts compared to past years is present at the two other Nimmitabel sites that have been consistently surveyed.

The spread of exotic plants is inferred to contribute to continuing decline in the habitat quality of *Prasophyllum canaliculatum* through competition for space and resources, which is likely to impair the species' emergence and recruitment (NSW NPWS 2022).

Prasophyllum canaliculatum individuals in the Kybeyan subpopulation were located on a road verge, which was disturbed for road-widening (Jones 1997). It is inferred that the road works, adjacent land clearing (for farmland) and set-stock grazing have contributed to a reduction in the number of mature individuals, habitat area, and habitat quality for *P. canaliculatum*. Moreover, there is an ongoing risk of adverse effects on this subpopulation from road grading (Snowy Monaro Regional Council 2024).

Compounding these threats is the recent (December 2023) observation of extensive feral pig damage at the Kybeyan site, leading to suspicions that this subpopulation has now been extirpated (R. Armstrong *in litt*. July 2024).

c) Extreme fluctuations.

Assessment Outcome: Not met.

Justification: *Prasophyllum canaliculatum* is not known to undergo extreme fluctuations in geographic distribution, number of locations or subpopulations, or number of mature individuals.

Criterion C Small population size and decline

Assessment Outcome: Vulnerable under Criterion C2a(i).

Justification: *Prasophyllum canaliculatum* has an estimated total population size of approximately 800–2,000 mature individuals (derived using the method in the 'Population size' section), which is less than the threshold of 2,500 mature individuals for Endangered. However, the additional conditions required for assessment of Criterion C are only met for Vulnerable.

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: Not met.

Justification: Assessment under this condition requires information on the generation length of *Prasophyllum canaliculatum*. Given the difficulties of monitoring underground individuals, the lack of a reliable method for estimating the age of individuals, and that mortality rates are likely to vary temporally and between subpopulations, the generation length for *P. canaliculatum* is uncertain. Generation lengths estimated for other *Prasophyllum* species range between 10–50 years (Commonwealth TSSC 2014; DELWP 2021, 2022; Commonwealth of Australia 2023). Furthermore, quantification of the inferred decline is complicated by a limited understanding of the factors influencing the species' dormancy, emergence, and flowering.

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

Assessment Outcome: Met with continuing decline in number of mature individuals.

Justification: There is an inferred continuing decline in the number of mature individuals of *Prasophyllum canaliculatum*, primarily attributed to soil turnover by feral pigs, particularly in the Nimmitabel and ACT subpopulations (Miles 2018; FOG 2023; G. Phillips *in litt*. May 2024; Orchid Society of Canberra *in litt*. June 2024).

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 for Vulnerable with ≤1,000 individuals in each subpopulation.

Justification: Based on the 2021 count (*i.e*., 260; Orchid Society of Canberra *in litt*. June 2024) and the post-fire flowering rate of *Prasophyllum correctum*, the ACT subpopulation of *Prasophyllum canaliculatum* is thought to be the largest, with an estimated maximum of 1,238 mature individuals in 2021. However, given the inferred continuing decline, and limited understanding of the factors influencing the dormancy, emergence, and flowering of *P. canaliculatum*, it is reasonable and precautionary to assume that the ACT subpopulation has less than 1,000 mature individuals, with a minimum estimate of 519, thereby meeting the threshold for Vulnerable. The maximum number of mature *P. canaliculatum* individuals estimated in other subpopulations ranges from 48–450.

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

Assessment Outcome: Not met.

Justification: It is estimated that no subpopulation of *Prasophyllum canaliculatum* has more than 62% of the total population of mature individuals.

b. Extreme fluctuations in the number of mature individuals

Assessment Outcome: Not met.

Justification: *Prasophyllum canaliculatum* is not known to undergo extreme fluctuations in the number of mature individuals.

Criterion D Very small or restricted population

Assessment Outcome: Vulnerable under Criterion D1.

Justification: *Prasophyllum canaliculatum* has an estimated total population size of approximately 800–2,000 mature individuals. This crosses the threshold of 1,000 mature individuals for Vulnerable. For this assessment, and in accordance with the recommended precautionary approach (IUCN 2024), the minimum value is used to avoid underestimating the risk of extinction for this species. This value is 40% of the sum of the maximum estimate and the minimum number of individuals detected in the most recent surveys (excluding the Kybeyan subpopulation).

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 for Vulnerable with <1,000 mature individuals.

Justification: *Prasophyllum canaliculatum* has an estimated total population size of 813–1,986 mature individuals. This crosses the threshold of 1,000 mature individuals for Vulnerable. For this assessment, and in accordance with the recommended precautionary approach (IUCN 2024), the minimum value is used to avoid underestimating the risk of extinction for this species. This value is 40% of the sum of the maximum estimate and the minimum number of individuals detected in the most recent surveys (excluding the Kybeyan subpopulation).

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: Not met.

Justification: *Prasophyllum canaliculatum* has an estimated AOO of 28–32 km^2 and occurs in 3–6 threat-defined locations. However, there is no plausible future threat that could drive the species to Critically Endangered or Extinct within a very short time.

Criterion E Quantitative Analysis

Assessment Outcome: Data Deficient.

Justification: There are currently insufficient data to undertake a quantitative analysis to determine the extinction probability of *Prasophyllum canaliculatum.*

Conservation and Management Actions

Prasophyllum canaliculatum 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 (SoS) 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. *Prasophyllum canaliculatum* sits within the site-managed species management stream of the SoS program.

There are two priority management sites identified for *Prasophyllum canaliculatum*: South East Forest National Park and Rockton. Activities currently recommended by the SoS program (NSW Government 2024b) to assist the species at these sites include:

Control of feral animals

- Cage up to 80 flowering orchids until seed has dispersed to reduce impacts of pest species.
- Control feral pig densities and maintain at low levels.
- Control programs to reduce grazing and disturbance by feral deer.
- Conduct rabbit control to reduce grazing and disturbance when found in *Prasophyllum canaliculatum* habitat.

Control of exotic plants

- Control existing invasive weeds if they expand into *Prasophyllum canaliculatum* habitat.
- Reduce and maintain blackberry densities at low levels with spot spray or cut and paint.
- Hand pull or spot spray invasive exotic herbs and grasses if required.
- Remove existing pines and any new recruits.
- Remove any newly detected invasive species of concern.

Survey and Monitoring Priorities

- Conduct complete census of swamps to track species abundance/condition over time (*i.e.*, annual count of flowering individuals).
- Monitor the extent and impact of herbivory by native herbivores, and if necessary, undertake more extensive orchid caging to reduce this threat.
- Deploy remotely activated cameras in appropriate habitat throughout the site to monitor deer occupancy and activity.
- Monitor site to detect presence of pigs.
- Monitor area of blackberry throughout swamps.
- Monitor density of herbaceous weeds and exotic grasses by measuring cover of these species in a series of random sample plots.

- Monitor distribution of rabbits and weeds of concern to detect any expansion into *Prasophyllum canaliculatum* habitat.
- Monitor percent cover of competitive native species in a series of random sample plots.
- Monitor biomass and cover in permanent plots.

Information and Research Priorities

- Search areas with previous records and areas of apparently suitable habitat to identify additional subpopulations.
- Investigate community composition and structure in apparently suitable habitat in which *Prasophyllum canaliculatum* does and doesn't occur.
- Investigate and monitor native herbivores contributing to low flowering stem survival rates.
- Monitor pollination rates and flowering stem survival and investigate if necessary to hand pollinate to promote reproduction.

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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: *Prasophyllum canaliculatum* was found to be Endangered under Clause 4.3(b)(d)(e i,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: Endangered under Clause 4.3(b)(d)(e i,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: Vulnerable under Clause 4.4(c)(e i,ii A(III))

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: Vulnerable under Clause 4.5(c)

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.