Lemon zieria (Zieria citriodora) in New South Wales

Monitoring and survey report, 2025

Saving our Species

NSW GOVERNMENT

Acknowledgement of Country

Department of Climate Change, Energy, the Environment and Water acknowledges the Traditional Custodians of the lands where we work and live.

We pay our respects to Elders past, present and emerging.

This resource may contain images, or names of deceased persons in photographs or historical content.

Artist and designer Nikita Ridgeway from Aboriginal design agency Boss Lady Creative Designs created the People and Community symbol.

Photos: All photos Genevieve Wright (DCCEEW) unless otherwise stated.

Cover photo: Lemon zieria (*Zieria citriodora*) in flower (Genevieve Wright/DCCEEW)

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Summary

This report documents the current distribution and ecology of the lemon zieria (*Zieria citriodora*) in New South Wales (NSW). It also reports on surveys conducted between 2018 and 2024, and summarises 6 years of data collected from monitoring plots established in 2019. Lemon zieria is listed as endangered on the NSW *Biodiversity Conservation Act 2016* and as vulnerable on the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. The species is also a site-managed species in the Saving our Species program. The lemon zieria occurs on the traditional lands of the Ngarigo, Yuin and Yaitmathang peoples (Saunders 2025).

Lemon zieria is a restricted species found in south-eastern Australia, with populations in New South Wales and Victoria. It is a small 20-cm tall shrub that has strongly lemon-scented leaves and produces pale pink flowers from winter to summer. First recognised as a distinct species in 1986, lemon zieria was formally described in 2002 (Armstrong 2002). Specimens not seen by Armstrong have recently been located in the Melbourne Herbarium that show the species was first collected north-east of Cooma in 1871.

Photo 1 Lemon zieria habitat, Kybeyan State Conservation Area

The species occurs in dry eucalypt open forests and woodlands (Photo 1) with a diverse understorey, and it grows in gravelly shallow soils, often on slopes. Lemon zieria is a low

sprawling shrub but its morphology can vary, forming compact plants in open areas and more diffuse plants under shrub cover. The species can layer and form clonal offshoots after disturbance.

Initial surveys conducted in New South Wales in 2018 recorded 2,154 plants across 3 locations east and south-east of Numeralla, which is east of Cooma. Five monitoring plots were established in 2019 to track long-term changes in lemon zieria populations. These plots provide detailed data on plant size, growth and browsing impacts. The monitoring has shown an increase in plant number and cover despite drought, fire and browsing pressures between 2019 and 2024. Lemon zieria plants have shown resilience to fire, with both resprouting and seedling establishment observed post fire, however, high-frequency fires in the future could stress populations. Browsing pressure varies annually, and although generally not heavy, young post-fire resprouts are particularly vulnerable to browsing by macropods. No exotic plant species have been observed in the monitoring plots, but serrated tussock (*Nassella trichotoma*) poses a potential threat to lemon zieria habitat due to its ability to invade disturbed soils.

Additional surveys of potential habitat conducted between 2018 and 2024 found 4 new localities where the species occurs and increased the known population in New South Wales to 5,677 plants.

Further targeted surveys are recommended to search for additional populations, and it is recommended that continued monitoring of existing plots be undertaken so that a clearer picture of the species' long-term responses to drought, fire and browsing can be ascertained.

Acknowledgements

Survey assistance was provided by the following NSW National Parks and Wildlife staff, Alexis Arnold, Andrew Morrison and Susannah Power.

Background

The genus *Zieria* includes shrubs and small trees which are predominantly found in eastern Australia. They are distributed from northern Queensland to the southern tip of Tasmania, with Kangaroo Island determining the south-western limit in South Australia (Figure 1). There are 59 species in Australia (Barrett et. al 2014) and only one other known species in the genus which is endemic to New Caledonia (Armstrong 2002; Morton 2015).

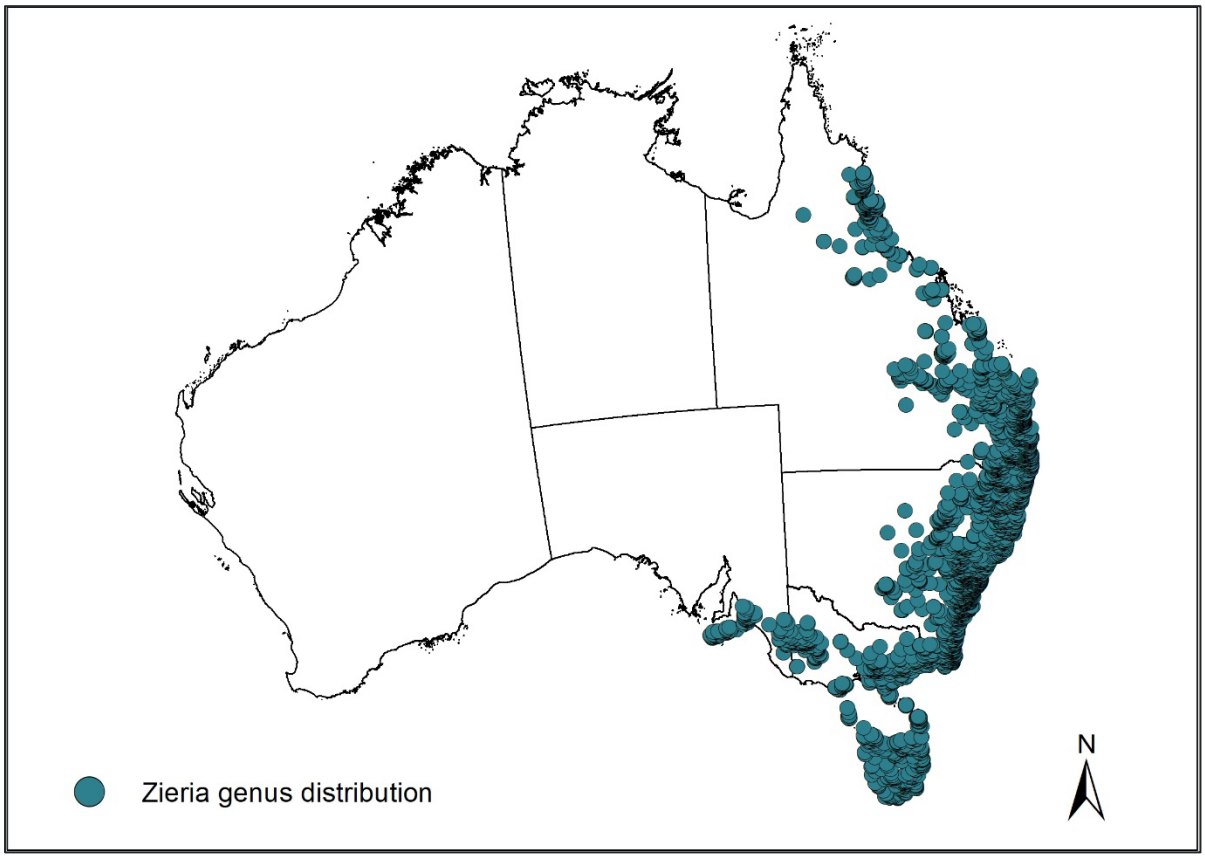

Figure 1 **Distribution of the genus *Zieria* in Australia (Source: Australian Virtual Herbarium records, accessed April 2024)**

There are several *Zieria* species that are widespread in Australia, but the majority have relatively small ranges, and many are only known from a single locality (Barrett et al. 2014). In Queensland, narrowly distributed zierias are often found on a 'small isolated island of rocky substrates' (Duretto and Forster 2007), and in New South Wales there are a number of species that are also confined to rocky outcrops (Briggs and Leigh 1990). Most species are pollinated by insects, mainly by flies and beetles, but sometimes by bees and butterflies (Armstrong 2002; Barrett 2016).

Lemon zieria (*Zieria citriodora* JA Armstrong) is a species with a restricted and disjunct range. It occurs in south-eastern Australia, within the South-eastern Highlands IBRA bioregion (Interim Biogeographical Regionalisation for Australia; Thackway and Cresswell 1995). It has 2 known localities that are separated by 125 km: one in New

South Wales and the other in Victoria (Figure 2). Each of these occurrences are locally restricted. The current extent of occurrence (EOO) of lemon zieria has been calculated to be 633 km^2 and the area of occupancy (AOO) estimated to be 24 km^2 (Saunders 2025).

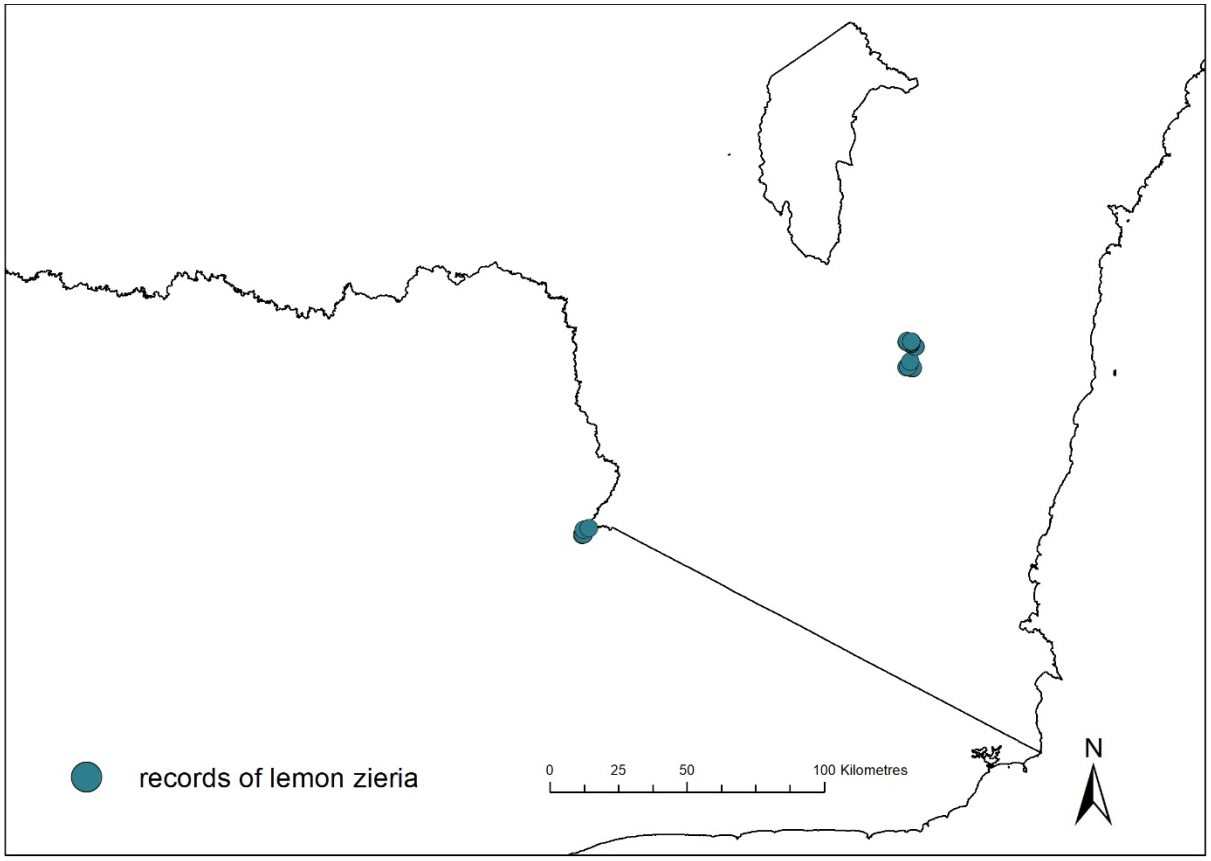

Figure 2 **Distribution of lemon zieria (*Zieria citriodora*) in Australia (Source: Australian Virtual Herbarium records, accessed April 2024)**

In Victoria, the species grows within a 3 × 2 km area in Alpine National Park on the banks of Limestone Creek. This site was discovered in early 1988 (Briggs and Leigh 1990).

In New South Wales, the species is found in the Kybeyan Range, east of Cooma, in a 11 × 3.5 km area (Figure 3). The southern extent of the NSW distribution of lemon zieria is within Kybeyan Nature Reserve and Kybeyan State Conservation Area. The northern extent was private land but has been recently acquired by NSW National Parks and Wildlife Service (NPWS). This acquisition has not yet been formally gazetted as reserve, however, the land is owned by the Minister administering the *National Parks and Wildlife Act 1974* and is being managed by NPWS in a manner consistent with nearby Kybeyan Nature Reserve until gazettal (M Pennay, NPWS, personal communication, 28 March 2024). In this report this area is referred to as 'Numeralla Mountain'.

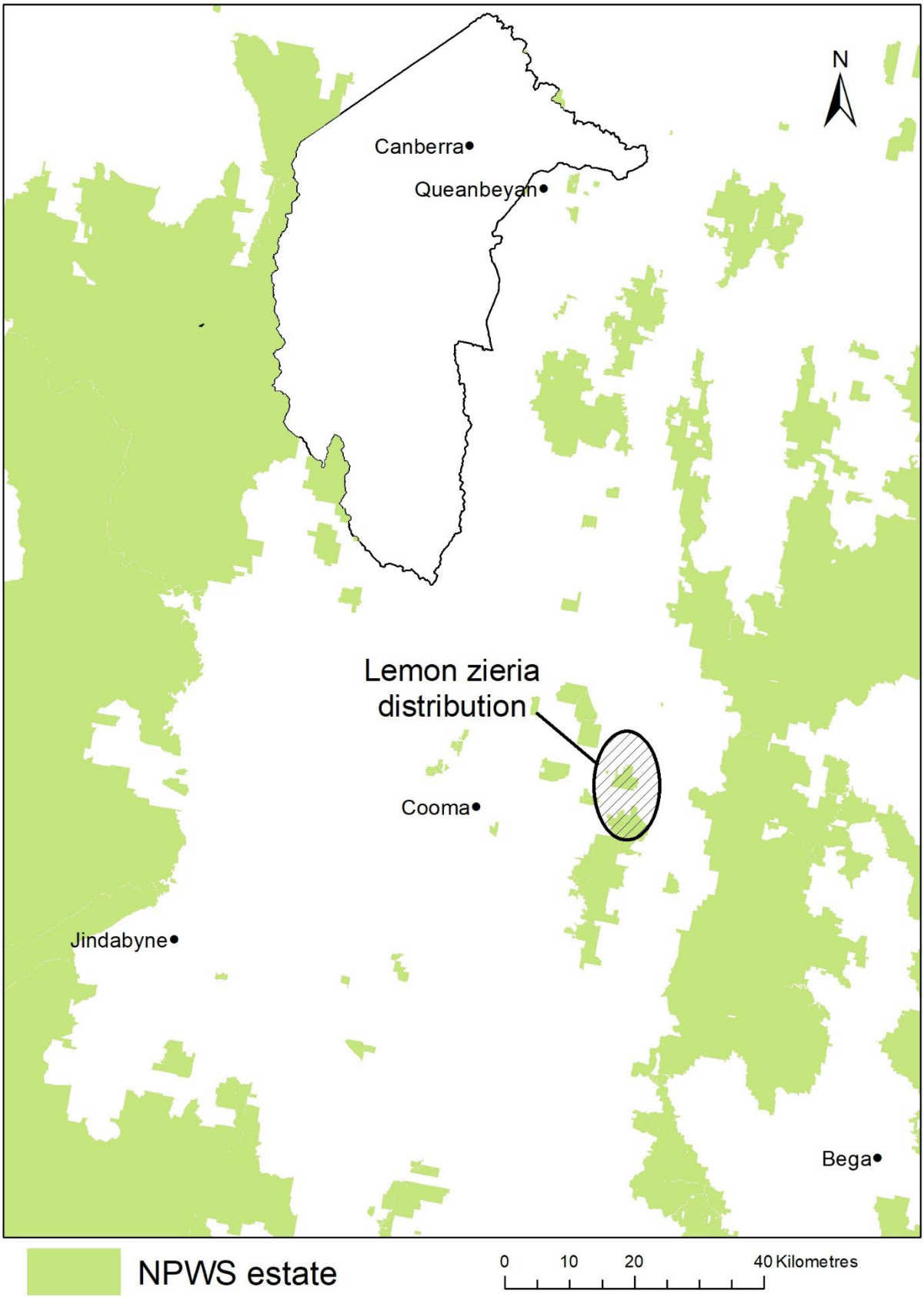

Figure 3 **Distribution of lemon zieria (*Zieria citriodora*) in New South Wales**

Species information

Discovery

The taxon known as *Zieria* sp. 2, or Zieria sp. 'B', had been recognised as a distinct species based on collections from the Numeralla area prior to 1986, from a population discovered further south near Kybeyan Trig in 1986 (Briggs and Leigh 1990), and from a population in Victoria discovered in 1988 (Briggs and Leigh 1990). The species was formally described as *Zieria citriodora* in 2002 (Armstrong 2002), based on specimens from collections beginning in the 1970s.

However, 2 undated specimens with limited locality information from the Melbourne Herbarium are the earliest collections of the species and it is now clear that they were collected in March 1871. These 2 specimens are MEL 62006 collected by 'L Atkinson' and MEL 62007 collected by Louisa Calvert ('Mrs Calvert') (Figure 4). The names L Atkinson and Louisa Calvert are both collecting names of Caroline Louisa Waring Atkinson (25/2/1854 to 28/4/1872), who used the name Louisa Atkinson for most of her collections, but changed to Louisa Calvert after marrying the botanist JS Calvert in 1869.

In March 1871 (Calvert 1871; George 2009) Louisa undertook a trip in southern New South Wales from Queanbeyan to the Monaro district ('Manero'; 'Manaro') and Numeralla River ('Umaralla'). Writing about the trip in May 1871 she remarks:

> The Umaralla, a clear stream like the Bredbo on a larger scale, was the limit of our journey…; a zieria with a delightful perfume claimed attention.
>
> *(Calvert 1871)*

It was during this journey that she must have collected the 2 specimens now in the Melbourne Herbarium, as she did not visit the Monaro at any other time. MEL 62006 has no collecting information, but MEL 62007 has a collecting note accompanying the specimen stating 'Stony Ranges. Rosebrook. 4 to 8 inches. Strong scent of lemon peel. Louisa Calvert' and a separate note stating 'Manero'. Rosebrook was a large property of approximately 6,200 ha in the Monaro district of New South Wales run by the Harnett family, situated north-east of Cooma and immediately south of the Numeralla River (Appendix A, see Figure 12). Louisa stayed there as the end point of her journey from Queanbeyan and did some limited plant specimen collecting in the locality.

The Rosebrook property as it existed in 1871 was approximately 16 km west of the current known *Zieria citriodora* populations, which are east and south of the village of Numeralla.

Louisa's 2 *Zieria citriodora* specimens could have been collected from either:

- a population in the vicinity of Rosebrook which subsequently became extinct
- a yet-to-be-rediscovered population somewhere near Rosebrook (e.g. the ranges north-east of Rosebrook on the northern side of the Numeralla River, south of

Mount Clifford Nature Reserve; or the hills on the western edge of Coornartha Nature Reserve)

- the eastern known populations, while on an outing from Rosebrook.

At this stage it is not known which of these possibilities is the most likely, but targeted surveys in rocky areas to the north and east of Rosebrook may yet reveal further populations of *Zieria citriodora.*

Figure 4 **Lemon zieria (*Zieria citriodora*) specimens collected by Louisa Calvert (nee Atkinson) near Rosebrook in 1871 (Source: Melbourne Herbarium; MEL 62006 on left; MEL 62007 on right)**

Description

The following description is based on the lemon zieria description in *NSW Flora Online (PlantNET)*.

Habit: lemon zieria (*Zieria citriodora*) is a procumbent shrub up to 20 cm tall and up to 90 cm wide. Its leaves are lemon-scented and the plant proliferates from rhizomes (Photo 2).

Branches: dotted with oil glands but not warted, ± pubescent with simple hairs, often with tufts of longer hairs at nodes; glabrescent.

Leaves: with a central leaflet lanceolate or linear, 4–5 mm long, 1.5–2 mm wide, apex rounded to acute; margins entire, ± recurved; both surfaces dotted with oil glands but not warted, hirsute with simple hairs; petiole up to 2–4 mm long.

Inflorescence: usually much longer than leaves, mostly 1–3-flowered. Calyx lobes triangular, c. 1.4 mm long, usually hairy. Petals 4–6 mm long, imbricate, pale pink fading to white, pubescent. Cocci hirsute and dotted with oil glands, often with an appendage.

Flowering: late winter to summer.

Photo 2 **Lemon zieria, Kybeyan Nature Reserve**

Habitat

In New South Wales, the species is found in dry eucalypt open forest and woodland on shallow gravelly soils derived from metasediments and granites, on west to south-west facing slopes of varying steepness. There are currently 2 main areas where the species is known to occur: Numeralla Mountain and the Kybeyan Nature Reserve – Kybeyan State Conservation Area.

At the Numeralla Mountain site there is an overstorey of *Eucalyptus mannifera, E. macrorhyncha*, *E. dives*, *E. rossii*; with an understorey dominated by *Allocasuarina nana* and *Banksia canei.* Other shrubs include *Brachyloma daphnoides, Monotoca scoparia, Astrotricha ledifolia, Daviesia leptophylla, Leucopogon fraseri, Platysace lanceolata, Olearia iodochroa* and *Acacia* spp.

Within Kybeyan Nature Reserve and Kybeyan State Conservation Area, overstorey species include *E. mannifera*, *E. dives*, *E. rossii* and *E. seiberi* with a moderately dense understorey, often dominated by *Banksia canei* and *Allocasuarina nana* but other associated shrubs include *Leucopogon attenuatus, Leucopogon fletcheri, Leucopogon microphyllus* var. *pilibundus, Pultenaea procumbens, Grevillea neurophylla*, *Hibbertia obtusifolia, Brachyloma daphnoides, Platysace lanceolata, Melichrus urceolatus, Dillwynia sericea* and *Bossiaea foliosa.*

The vegetation found in Kybeyan – Numeralla area where lemon zieria occurs conforms to Tablelands Shaley Rises Dry Shrub Forest (NPWS 2012) and is part of the Southern Tableland Dry Sclerophyll Forests (Keith 2004).

The Victorian habitat for lemon zieria is described in Sutter (2010) as northern and western aspects of open rocky slopes in *E. rubida* woodland. More recent collections in Victoria describe habitat as open woodland on steep north-facing rocky slopes growing around boulders at 930 m altitude. Associated species include *E. mannifera*, *E. dives*, *E. perriniana*, *Mirbelia oxylobioides*, *Acacia gunnii*, *Hibbertia obtusifolia*, *Dianella revoluta* and *Rytidosperma pallidum* (Andre Messina, 23 April 2024, pers. comm.).

Monitoring

Original survey (1986)

In 1986, Briggs conducted surveys of the 2 sites known at that time, namely 'Numeralla' and 'Kybeyan Trig'. At Numeralla 150 mature plants were recorded and at Kybeyan Trig 32 mature plants were recorded. All of the plants observed at that time were browsed, and at the Kybeyan Trig site they were all heavily browsed (Briggs and Leigh 1990).

In addition to the long-known Numeralla and Kybeyan Trig populations, a third population of *Zieria citriodora* was discovered between these 2 populations in August 2013 on a rocky granite slope above the Kybeyan River, in the northern end of Kybeyan Nature Reserve.

A fence was installed in April 2017 to protect the population at the Kybeyan Trig site from browsing.

Population inventory (2018)

In 2018 the extent of existing populations was surveyed to provide data for establishing long-term monitoring. Systematic traverse searches were conducted within the 3 areas of lemon zieria in New South Wales known at that time (Figure 5):

1. south of the Numeralla – Countegany Road ('F' plots shown on the map)
2. north of Kybeyan Nature Reserve above the Kybeyan River ('C' plot)
3. the fenced site on the eastern side of Kybeyan Nature Reserve ('EZC' plots).

Geographic positioning system (GPS) coordinates were recorded as the species was encountered during traverses at each site. Where plants were sparse and separate, one GPS point per plant was recorded; and where plants were in higher concentrations, multiple plants were recorded at a single point.

At sites F and C, traverses were made within the major population concentration to the extremities until no more plants were recorded for approximately 100 m at the north, south, east and west bounds of the known population. At site EZC, traverses were only conducted within the existing fenced enclosure. At each GPS point in all 3 locations, the length and width in millimetres (mm) of each plant was recorded: to the nearest 50 mm when over 100 mm; to the nearest 10 mm when under 100 mm. Browsing damage was also recorded.

It was noted in the field that lemon zieria plants become layered in areas where soil accumulates and that as large plants age they can fragment, forming separate but clearly clonal plants. Such plants, where clearly separate, were counted as separate individuals for the purposes of the survey.

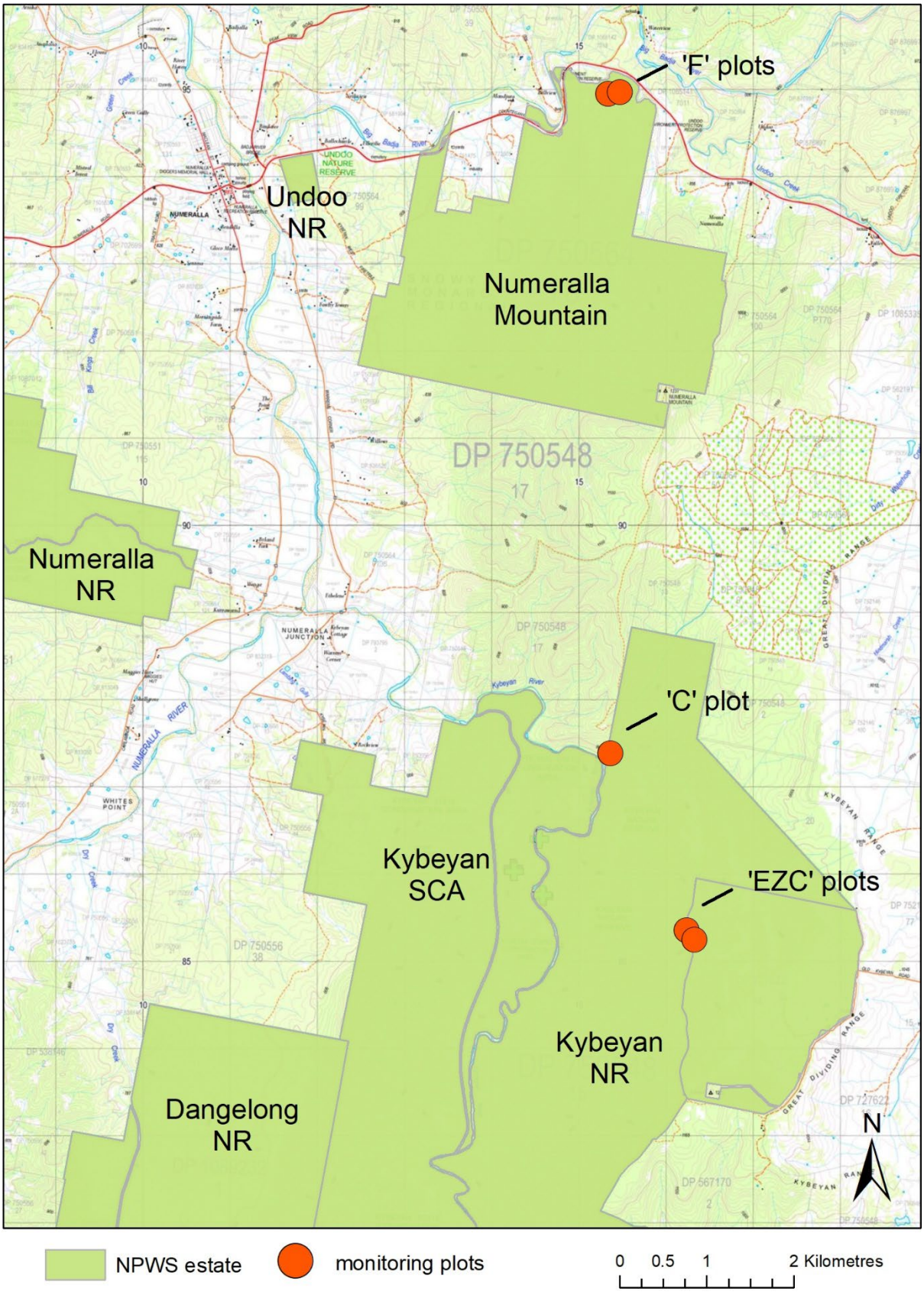

Figure 5 **Location of 5 established plots and 3 survey sites for *Zieria citriodora***

Monitoring plots

Establishment (2019)

In June 2019, a total of 5 plots were established across the 3 known sites of *Zieria citriodora* in New South Wales to enable long-term monitoring of individual plants and populations (Figure 5). The plots were established in areas of some of the densest occurrence of the species in each location. Two plots were established ('F' plots) in the Numeralla Mountain area south of the Numeralla – Countegany Road; one plot was established ('C' plot) within the north of Kybeyan Nature Reserve above the Kybeyan River, and 2 plots ('EZC' plots) were established within a fenced site on the eastern side of Kybeyan Nature Reserve (Table 1).

Methods

Plots were delineated with 4 star pickets marking the plot corners. Two tapes were laid along the edge of the plot in opposite directions starting from the origin picket to establish a coordinate system for plant location on the plot, photos of each plot were taken from the origin point (see Appendix B).

Table 1 Plot sampling details

Plot	Date sampled	Plot origin	Plot origin (Easting)	Plot origin (Northing)	Plot origin (altitude)
F1	5 June 2019	10 m × 10 m	South-west	715530	5995217
F2	7 June 2019	10 m × 10 m	West-south-west	715460	5994980
C	7 June 2019	10 m × 10 m	South-west	715357	5987402
EZC1	6 June 2019	20 m × 10 m	South-east	716325	5985249
EZC2	6 June 2019	25 m × 10 m	North-west	716242	5985366

The location of each *Zieria citriodora* individual was recorded within each plot. Each plant found was tagged, either on the plant directly (Photo 3) or, if the plant was too small, immediately next to the plant using a metal pin (Photo 4). As *Zieria citriodora* plants are essentially prostrate, plant height is not a useful measure of plant age or plant vigour. Instead, maximum length and maximum breadth measurements of each tagged plant were recorded in centimetres (Photo 5).

Photo 3 **Plant tagged directly (plant 20 in plot EZC2) (Michael Doherty/DCCEEW contractor)**

Photo 4 **Plant tagged indirectly with nearby pin (plant 27 in plot EZC2) Michael Doherty/DCCEEW contractor)**

Photo 5 **Measuring the length of a *Zieria citriodora* plant**

Although *Zieria citriodora* plants do not always form evenly ovoid symmetrical shapes, an approximate extent of the plant mat can be calculated by multiplying plant length by plant breadth. The degree of browsing by native and exotic herbivores was also noted for each plant as either no browsing, light browsing, medium browsing or heavy browsing.

After the initial measurement at plot establishment in 2019, plots were re-surveyed in 2020, 2021, 2022, 2023 and 2024 using the same methods. All tagged *Zieria citriodora* plants within the 5 monitoring plots were relocated, identified and measured, using maximum length and maximum breadth measurements of each tagged plant as per the original survey. Any new plants located in the plots were also measured and tagged, and seedling numbers recorded. The degree of browsing by native and exotic herbivores was noted for each plant and the number of flowers and fruit were counted if present.

One of the plots, F2, was burnt at high severity in the 2019–20 fire season but the other 4 plots have remained unburnt during the sampling period.

Monitoring results

Population inventory (2018)

The 2018 traverse surveys recorded GPS coordinates for 740 locations of *Zieria citriodora*, varying from 1 to 18 plants at each location. Table 2 shows the number of plants recorded at each site and mean length and mean width with standard deviation.

Table 2 Summary of plants located during traverse surveys across 3 sites

Site	No. plants	% of total	Mean length (mm)	Mean width (mm)
F	1,197	56	326 (+/- 197 SD)	217 (+/- 135 SD)
C	369	17	314 (+/- 235 SD)	184 (+/- 112 SD)
EZC	588	27	450 (+/- 276 SD)	320 (+/- 214 SD)
Total	**2,154**	**100**		

Site F had the highest number of plants, site EZC had the second highest number and site C had the lowest number of plants. In relation to mean plant size, site EZC had the highest mean plant length and plant width, site F had the second highest, and site C had the lowest. Essentially, while there are fewer plants at site EZC compared to site F, the plants at site EZC are generally larger. The larger mean size and greater proportion of larger plants at site EZC is likely the result of this site being fenced since 2017, with less browsing pressure overall, although there is still some evidence of browsing within the fenced area. The occurrence of larger plants under shrubs such as *Banksia canei* may reflect a complex of factors such as protection from browsing, but also etiolation of plants due to greater shading under shrubs.

All 3 sites had some plants is size class <100 mm, indicating that there is some ongoing recruitment occurring both under browsing pressure and in the absence of recent fire. None of the plants in this size class could be regarded as seedlings, but they appeared to be relatively young plants.

Monitoring plots (2019)

The initial survey of the monitoring plots obtained measurements for a total of 322 *Zieria citriodora* plants within the 5 plots. This represents 15% of the total 2,154 *Zieria citriodora* recorded in the 2018 survey. In relation to the proportion of individuals sampled within each of the 3 main populations, the F1 and F2 plots sampled 15% of that population (183 out of 1,197); plot C sampled 16% of that population (60 out of 369), and the EZC1 and EZC2 plots sampled 13% of that population (79 out of 588).

Table 3 shows the number of plants recorded at each plot and mean length, mean width and mean area, with standard deviation at the time of plot establishment.

Table 3 Summary of plant numbers within the 5 plots across the 3 sites

Plot	No. plants	Mean length (cm)	Mean width (cm)	Mean area (cm^2)
F1	116	29.95 (+/- 14.63)	22.0 (+/- 11.98)	817.28 (+/- 801.99)
F2	67	26.16 (+/- 11.45)	17.75 (+/- 7.13)	528.48 (+/- 388.53)
C	60	26.80 (+/- 13.49)	17.90 (+/- 11.98)	625.27 (+/- 803.13)
EZC1	48	52.27 (+/- 21.38 SD)	37.10 (+/- 17.72)	2262.96 (+/- 1813.72)
EZC2	31	29.29 (+/- 17.85 SD)	22.65 (+/- 16.38)	938.48 (+/- 1104.40)

At plot establishment, plants were clustered in relation to length and width across all the plots. The majority of plants were less than either 50 cm long or 50 cm wide, with low numbers of plants greater than 50 cm, and very few plants greater than 75 cm (Figure 6 and Figure 7).

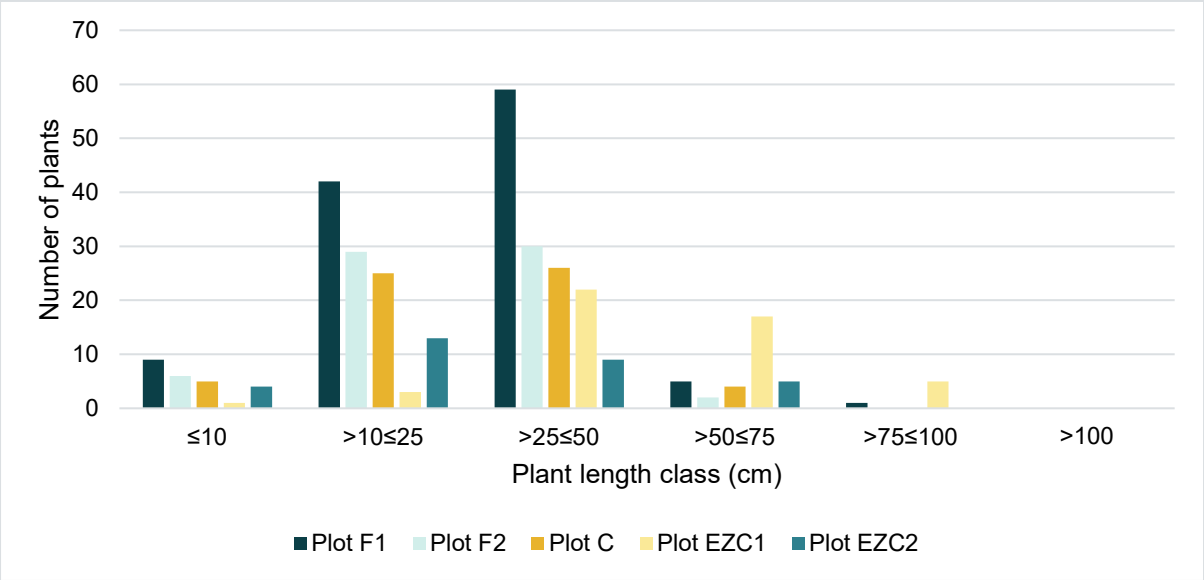

Figure 6 **Plant length across 5 monitoring plots in 2019**

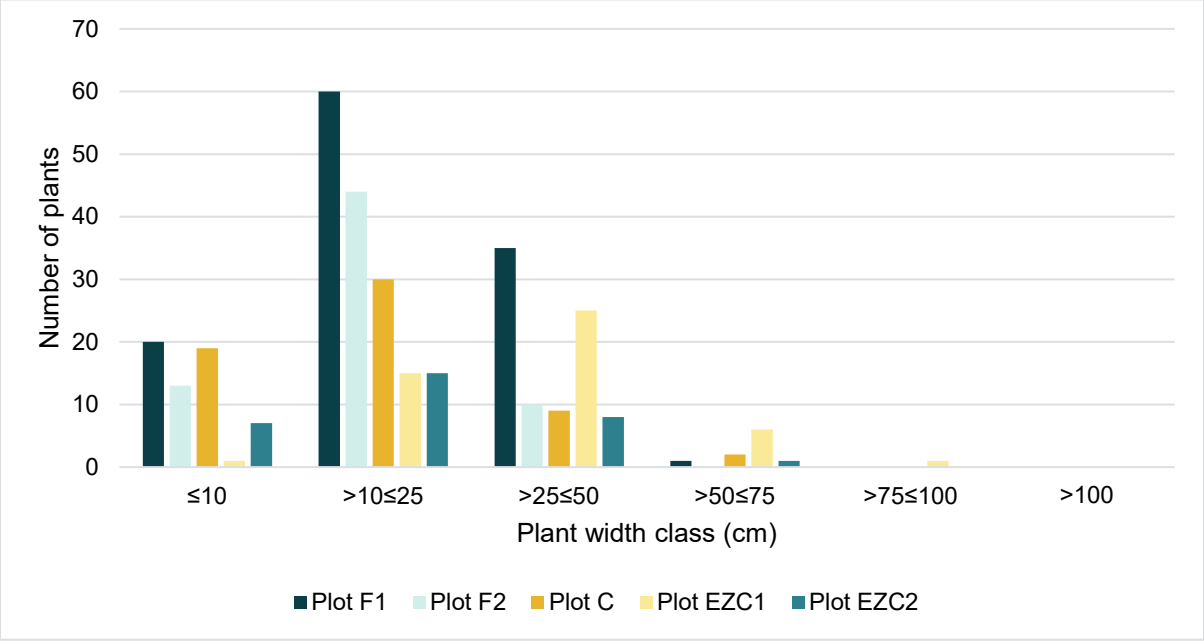

Figure 7 **Plant width across 5 monitoring plots in 2019**

Monitoring plots (2019 to 2024)

Monitoring of the 5 plots has been conducted annually between 2019 and 2024. Individual counts of plants and measurements of their cover show that despite decreases during dry periods, such as 2019 and 2020, there has been an increase in the numbers of plants over the 6-year monitoring period (Figure 8). The overall increase in

numbers is due to both the emergence or re-emergence of root suckers as well as significant seedling recruitment in 2023 and 2024. With the recovery and growth of adult plants in wetter seasons, the overall cover has also increased (Figure 9). Only a small fraction of this increase in cover was due to emerging seedlings.

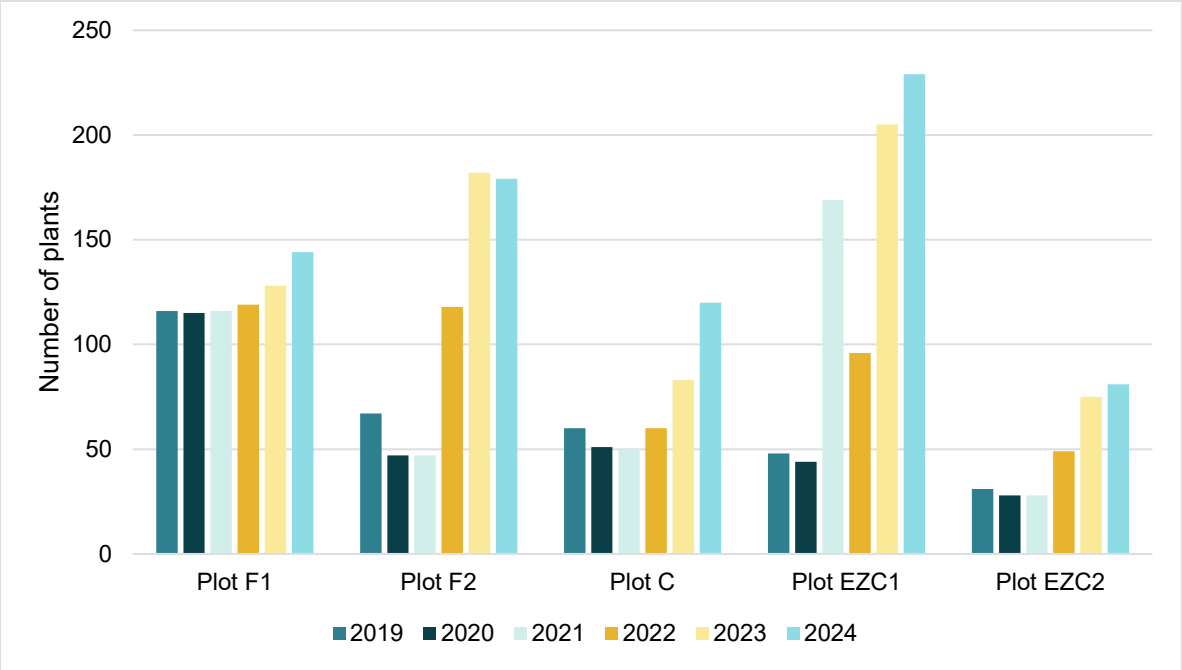

Figure 8 **Changes in numbers of *Zieria citriodora* plots over time**

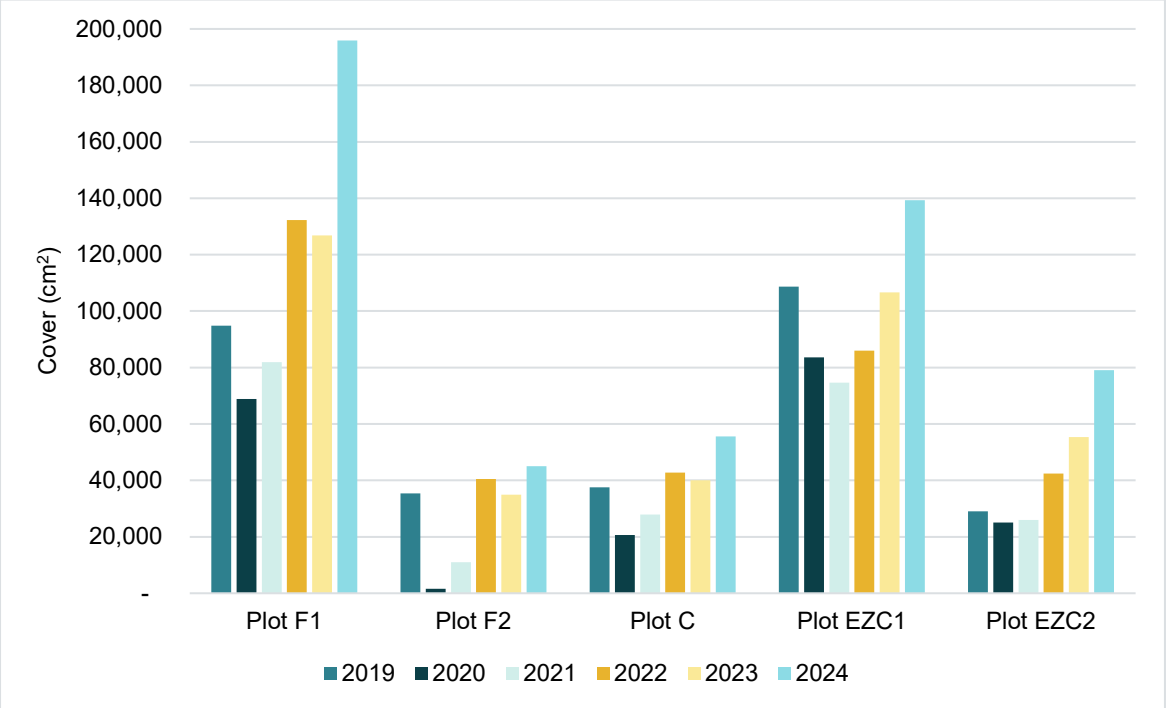

Figure 9 **Changes in cover of *Zieria citriodora* in plots over time**

Figure 10 shows the percentage change in cover between 2019 and 2024, with plot establishment in 2019 used as a baseline (i.e. as 0% cover). It shows there is a clear drop in cover in the dry years of 2020 and to a lesser degree 2021; a trend exacerbated in plot F2 because of a high-severity fire in 2019 (Figure 10). However, there was a recovery and an increase in cover from plants responding to average to above average rainfall in the wetter years of 2022, 2023 and 2024, with all plots exhibiting a higher cover of *Zieria citriodora* in 2024.

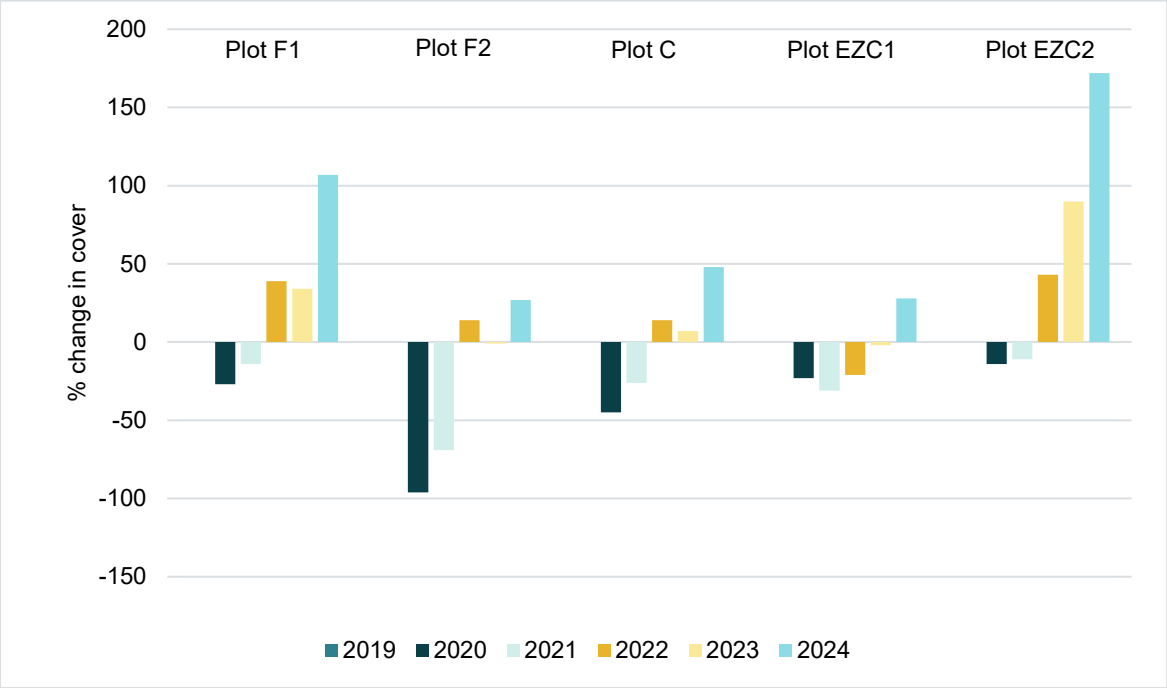

Figure 10 **Percentage (%) changes in cover of *Zieria citriodora* in plots over time, with 2019 as a baseline**

Surveys

Survey details

Numeralla Mountain

In October 2019, 2020 and 2021, surveys were conducted south of the known population at Numeralla Mountain (site 'F') to determine the extent of lemon zieria at this site. Survey technique utilised a GPS to record coordinates for plant/s located during parallel transects through the population to the extremities until no more plants were recorded for approximately 100 m at the north, south, east and west. The 2020 survey also assessed the species response to the 2019–20 wildfire which impacted the north-eastern edge of the population at Numeralla Mountain.

Kybeyan Trig

In October 2021, the area west of the fenced site in Kybeyan Nature Reserve (site 'EZC') was targeted for survey. Survey techniques were the same as used at Numeralla Mountain above.

Surveys in 2023 (26 March and 19 October), were conducted to confirm the population size and location of 2 sites previously recorded on the edge of the Kybeyan River (sites 4 and 5, Figure 11). These were about 2.5 km apart and found during an NPWS willow survey conducted in August 2022 (Alexis Arnold, NPWS). Both sites were within 2 km of the fenced site ('EZC').

In 2024, surveys of 2 new sites of lemon zieria (sites 6 and 7) were conducted. These sites were found during NPWS surveys for 2 threatened flora species, Kydra westringia (*Westringia kydrensis*) and trailing monotoca (*Monotoca rotundifolia*). Site 6 was found in February 2024 and in site 7 in May 2024. Both sites were within 3 km of the fenced site ('EZC').

In the 2023 and 2024 surveys, intensive line transect surveys of each site (4 to 7) were completed. However, plants were also found en route to these sites. In these instances, extensive surveys were not completed, but data was recorded on the number of plants encountered on the single traverse through the areas where lemon zieria occurred.

Numeralla area surveys

In June 2022, a survey of potential habitat in the local area was conducted. Survey areas were identified through visual assessment of vegetation patterns from the latest aerial imagery combined with similar topography, geology and elevation to those areas where populations were known to occur (NSW Land and Property Information [NSW LPI] and Google Earth). Survey traverses were conducted in Coornartha and Undoo Nature Reserves, Kybeyan State Conservation Area, Kybeyan Nature Reserve and on private land around the northern extent of the species distribution (Appendix A, see Figure 14).

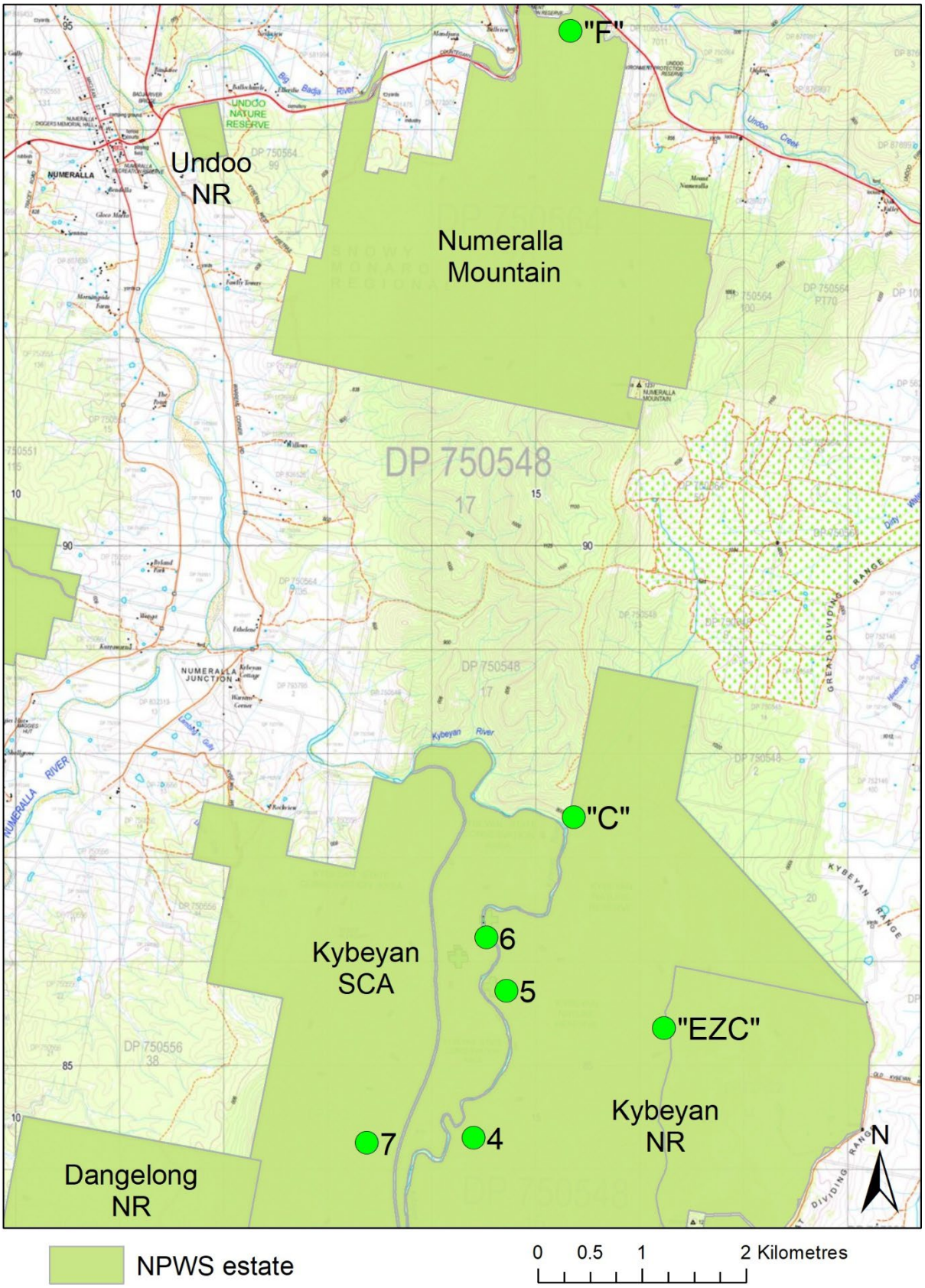

Figure 11 **Lemon zieria sites**

Survey results

Numeralla Mountain

The 3 years of survey (2019, 2020, 2021) of the Numeralla Mountain population (site 'F') increased the number of adult plants from 1,197 in 2018 to 2,885 in 2021. The 2020 surveys also recorded 60 seedlings. However, a new southern extension to this population (surveyed 15 November 2016, M Henery and D Albrecht) recorded an additional 500 adult plants in an area 300 × 150 m. This increased the total population size to approximately 3,385 adult plants (Table 4) in the Numeralla Mountain population.

The impact of the 2019–20 wildfire in the population was assessed. Field observations recorded both resprouting of mature plants as a post-fire response and recorded seedling establishment. This is discussed in more detail later in this report.

Kybeyan Trig

The October 2021 survey conducted west of the fenced area in Kybeyan Nature Reserve (site 'ECZ') recorded an additional 136 adult plants. Increasing the number at that site from 588 (2018 count) to 724.

In 2023, the lemon zieria locations on the edge of the Kybeyan River were targeted for survey. This work found new sites en route to both locations and confirmed the 2022 records. A total of 694 adult plants were recorded on 26 March at the southern site (site 4), 227 adult plants and one seedling were recorded on 19 October in the northern site (site 5).

On 12 April 2024, survey of site 6, was completed. A total of 159 adult plants were recorded. This total includes survey within the targeted site and includes lemon zieria plants found along the survey route. The survey conducted on the 29 May 2024 (site 7), found a small, localised population of 100 adult plants. This site was revisited in July 2024 and a further 19 adult plants were recorded in between the original site and the Kybeyan River to the east, giving a total population count of 119 plants.

Numeralla area surveys

No new populations of lemon zieria were found in the 2022 surveys of potential habitat in the Numeralla area. The total survey traverse length was approximately 43 km.

Current extent in NSW

Survey data collected between 2018 and 2024 have increased knowledge on the known extent of lemon zieria in New South Wales. Using the methods of assessment recommended by the International Union for Conservation of Nature (IUCN 2024), the current area of occupancy (AOO) and extent of occurrence (EOO) of lemon zieria in New South Wales is 24 km^2 and 633 km^2, respectively (Saunders 2025). The AOO was calculated using 2 × 2-km grid cells around each verified point and the EOO was calculated using a minimum convex polygon enclosing all mapped occurrences of the species. This approach produces a larger area than is actually occupied by lemon zieria,

but is comparable within the IUCN assessment process. The actual area of occupied habitat is significantly smaller, covering an area of 2.81 km^2.

Table 4 Lemon zieria adult plants survey results (2018 to 2024)

Site	2018 survey (no. plants)	Survey total 2019 to 2024 surveys (no. plants)	New site (Henery 2016)	Grand total
Numeralla Mountain (F)	1,197	1,688	500	**3,385**
Kybeyan (EZC)	588	136	n/a	**724**
Kybeyan (C)	369	n/a	n/a	**369**
Site 4	n/a	694	n/a	**694**
Site 5	n/a	227	n/a	**227**
Site 6	n/a	159	n/a	**159**
Site 7	n/a	119	n/a	**119**
Totals	2,154	3,023	500	**5,677**

Ecological observations

Morphology

The form of lemon zieria as a compact, low-growing shrub means that variation in plant size, irrespective of apparent age, is a function of length and breadth rather than height. Plants growing in open situations tend to form more compact plants than those growing under shrub cover such as *Banksia canei* or *Allocasuarina nana*. Plants under shrubs can be larger but more diffuse with elongated stems, and tend not to attain the overall leaf density of plants growing in more open situations. The prostrate nature of lemon zieria and its situation on moderate slopes with gravelly soils means that rainfall runoff tends to accumulate soil around plant centres over time. Observations in the monitoring plots suggest that this results in layering and the establishment of clonal offshoots from the parent plant. Over time, these clonal offshoots can become separate from the parent plant and form new plants. This situation appears to be exacerbated by browsing where plants become broken from both browsing and trampling.

Fire response

Armstrong (2002) reported that lemon zieria plants resprouted from rootstock and had seedling establishment after wildfire at the Numeralla site in early 1998, based on post-fire observations made in August 1998 by John Briggs.

The 2019–20 wildfires burnt a section of the northern extent of the species (Appendix A, see Figure 13) and monitoring plot F2 was burnt at high intensity (Photo 6). Annual monitoring conducted in May 2020 recorded some lemon zieria resprouting in response to fire (Photo 7), but no seedlings were observed at this time. However, surveys conducted on 29 October 2020 within the burnt area found both lemon zieria seedlings (Photo 8) and resprouting plants (Photo 9) post fire.

Given the small size of the plants and their narrow stems, higher fire intensities on diffuse plants may be more likely to result in death, whereas plants already multi-stemmed and layered with stems and roots deeper in the soil may be better protected from higher fire intensities. As seed is not retained on the plant, the species has a soil seed bank, but neither the longevity of the soil seed bank nor the longevity of individual plants is currently known. The recent high number of seedling recruits occurring after fire and rainfall events in sites F2 and EZC1 is encouraging, indicating the presence of viable seeds in the soil seed bank.

Anecdotal evidence regarding other species of *Zieria* in south-east New South Wales suggests that seedling emergence is not occurring after rainfall events per se, but only after fire events which are followed by rain. This suggest that although heat and smoke effects will influence germination at a point, 'smoke water' effects in the broader area may also stimulate germination in areas without direct fire effects. Monitoring after fire and rainfall events singly and in combination will reveal over time whether *Zieria citriodora* can germinate in the absence of direct and indirect fire effects.

Given the apparent protection afforded to *Zieria citriodora* plants from browsing when they are growing under *Allocasuarina nana* and *Banksia canei* stands, the species may be quite vulnerable to browsing impacts post fire, when cover is reduced and resprouts and/or seedlings are establishing. Typically, young or new growth is targeted by herbivores, adding greater pressure on very young plants.

Photo 6 **Monitoring plot burnt in 2019–20 wildfires**

Photo 7 **Lemon zieria resprouting after fire**

Photo 8 **Lemon zieria seedling recruitment, 28 October 2020**

Photo 9 **Lemon zieria post-fire resprout, 14 cm high, 28 October 2020**

Although lemon zieria has made a successful recovery from the 2019 fires, any increase in the frequency of fire, particularly high-intensity fire, especially if coincident with low rainfall conditions post fire and high browsing pressure, would put considerable stress on the populations. Low rainfall conditions post fire will affect the survivorship of germinants and may also have an impact on the recovery and growth rates of resprouting individuals. More open post-fire environments will also mean that both germinants and resprouts are more susceptible to browsing impacts until the vegetation cover of larger shrubs increases.

Animal browsing/impacts

Plants were observed to be 'selectively and heavily browsed by native herbivores' in early survey work (Briggs and Leigh 1990). Current observations from 2019 to 2024 indicate that this browsing pressure continues, but it is variable from year to year. Overall, browsing on the majority of plants varies from none to light, with some plants moderately browsed and a few individuals heavily browsed. However, young post-fire resprouts are particularly vulnerable to browsing (Photo 10) and in rare instances, plants have been uprooted (Photo 11).

Remote cameras were deployed at one location to establish the species responsible and swamp wallabies (*Wallabia bicolor*) were found to be the only herbivore browsing *Zieria citriodora* (Photo 12).

Photo 10 **Resprouting and recently grazed tagged plant, May 2020**

Photo 11 **Dead, uprooted, tagged plant, May 2020**

Photo 12 **Swamp wallaby browsing on lemon zieria (remote camera-trap image)**

Goats have been observed in the Numeralla area (from Numeralla Mountain south to Kybeyan Trig) and they pose a potential threat to lemon zieria from heavy browsing. Pigs also occur and have potential to impact populations through physical removal and/or damage of plants through pig rooting.

Continued camera trapping will enable documentation of the presence and numbers of both goats and pigs in lemon zieria populations.

Invasive plant species

No exotic species have been observed at the 5 monitoring plots over the 6 years that monitoring has been undertaken, including the fire-affected plot F2. The low fertility soils and lack of agricultural disturbance mean that it is unlikely that weed incursion will pose a threat to *Zieria citriodora* in the short term. However, patches of serrated tussock (*Nassella trichotoma*) were noted some hundreds of metres to the east of the site C population, in what appears to be an old vehicle track leading to the Kybeyan River. Serrated tussock may potentially invade the exposed rocky creek site over time as there are many areas of bare ground, and serrated tussock does proliferate in disturbed or exposed granite soils where there is a local seed source. This will need to be monitored.

Other observations

Observations were made of seedling recruitment after the 2019–20 fires in unburnt plots. Seedlings continued to germinate for several seasons after the initial recruitment event, albeit in lower numbers. Also, one seedling was observed to produce a single fruit in March 2023. This was 2 years after germination and the plant was 15 cm tall.

Discussion

Lemon zieria is a restricted shrub species found in south-eastern Australia, with small populations in New South Wales and Victoria. It is listed as endangered on the NSW *Biodiversity Conservation Act 2016* and as vulnerable on the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. It is currently assigned to the 'site-managed' management stream in the Saving our Species program. This management stream includes species that can be secured in the wild for the next 100 years by conservation projects at specific sites. As part of this program, surveys were completed between 2018 and 2024 in potential habitat and within known sites to establish the species current extent and population size. Monitoring plots were also established in 2019 to provide data on the species' long-term stability and responses to drought, fire and browsing pressure.

The habitat of lemon zieria in the Kybeyan Range in New South Wales is dry eucalypt open forests and woodlands with a diverse understorey, on gravelly soils, often on slopes. It was also occasionally observed on the margins of *Allocasuarina nana* heath (Appendix C). Armstrong (2002) noted that zierias are most abundant as an undershrub in open eucalypt forest and in sclerophyllous heathlands of eastern Australia. *Zieria citriodora* certainly fits this description.

Extensive survey work conducted between 2018 and 2024 found that lemon zieria occupies only a small proportion of suitable habitat. However, this work increased the number of known sites from 3 to 7 and has increased the known population in New South Wales from 2,154 to 5,677 plants.

The aim of the initial 2018 population inventory surveys of the lemon zieria was to gain a more accurate count of individuals in the 3 known lemon zieria areas east and south-east of Numeralla. The subsequent establishment of monitoring plots within these populations has enabled the tracking of these populations over time.

Monitoring of plots in sites F, C and EZC established in 2019 has shown that, despite fluxes in cover from year to year, the number of plants has been maintained and that these have increased in cover over time. There has also been an increase in plant number due to recruitment. The positive response of lemon zieria in the plots has been recorded despite drought and, in one instance, fire. Plots EZC1 and F1 consistently had a significantly larger volume (i.e. greater average length and breadth) of plants compared to EZC2, F2 and C plots. This could be attributed to plots EZC1 and F1 both having a greater cover of larger shrubs such as *Banksia canei* which may provide some additional protection from browsing. The fenced area is likely to be effective in disrupting casual browsing by introduced herbivores, but the fences are not excluding all grazers, as there is still some browsing evident in the fenced plots. Encouragingly, even in unfenced areas, lemon zieria plants do recover from the effects of browsing. In more open areas, the combined effects of less protection from large shrubs and greater browsing results in compact, denser plants compared to the more diffuse form that occurs under large shrubs. Tracking the persistence of seedlings in the monitoring plots, particularly in the

unfenced open plots, will be critical to understanding whether browsing prevents the successful establishment of new plants in these populations.

Although lemon zieria would benefit from broad-area feral animal control of goats and deer, there will still be an underlying level of browsing from macropods, particularly swamp wallabies. The implications of the monitoring to date are that lemon zieria can take a low level of browsing on adult plants and at these low levels, seedling germination and establishment is also possible.

While the monitoring of known populations has shown strong persistence under disturbance, the discovery of new populations in the past few years means that the overall regional population of *Zieria citriodora* is now currently approaching over 5,700 plants, more than double original estimates and counts. Although these populations have been found relatively close to existing populations, the spread of the combined populations from north to south and across topographic positions from upper to lower slopes means that the risk of the entire population in the Numeralla – Kybeyan area being affected by a single disturbance event, such as fire, is less likely.

The security of the species has greatly improved in recent years with most of the NSW population now in conservation reserves. Continuing searches for new lemon zieria populations in suitable habitat in the broader Numeralla area, expanding systematically out from the known populations, will be worth undertaking.

Recommendations

It is recommended that further targeted surveys be conducted in the following locations:

1. on the ranges north-east of the Rosebrook property on the northern side of the Numeralla River, south of Mount Clifford Nature Reserve
2. on slopes on the western edge of Coornartha Nature Reserve
3. on flanking slopes along the Numeralla River upstream and downstream of known newly discovered populations.

Ongoing monitoring of the F, C and EZC site plots should continue, and an evaluation of the monitoring protocol should be undertaken. Currently, the original tagged plants are being remeasured and new plants are being tagged and added to the monitoring. However, this is proving complicated and unwieldy due to the recent effects of fire in plot F2 and a large cohort of seedlings in this and other plots in recent years.

Remote cameras should be deployed to establish the species responsible for ongoing browsing of lemon zieria in the fenced site north of Kybeyan Trig (i.e. site EZC).

In addition, it is recommended that the current feral animal control program implemented by NPWS targeting feral herbivores (goats, deer) should be continued to ensure the long-term protection of lemon zieria from associated browsing and trampling.

Appendix A: Maps

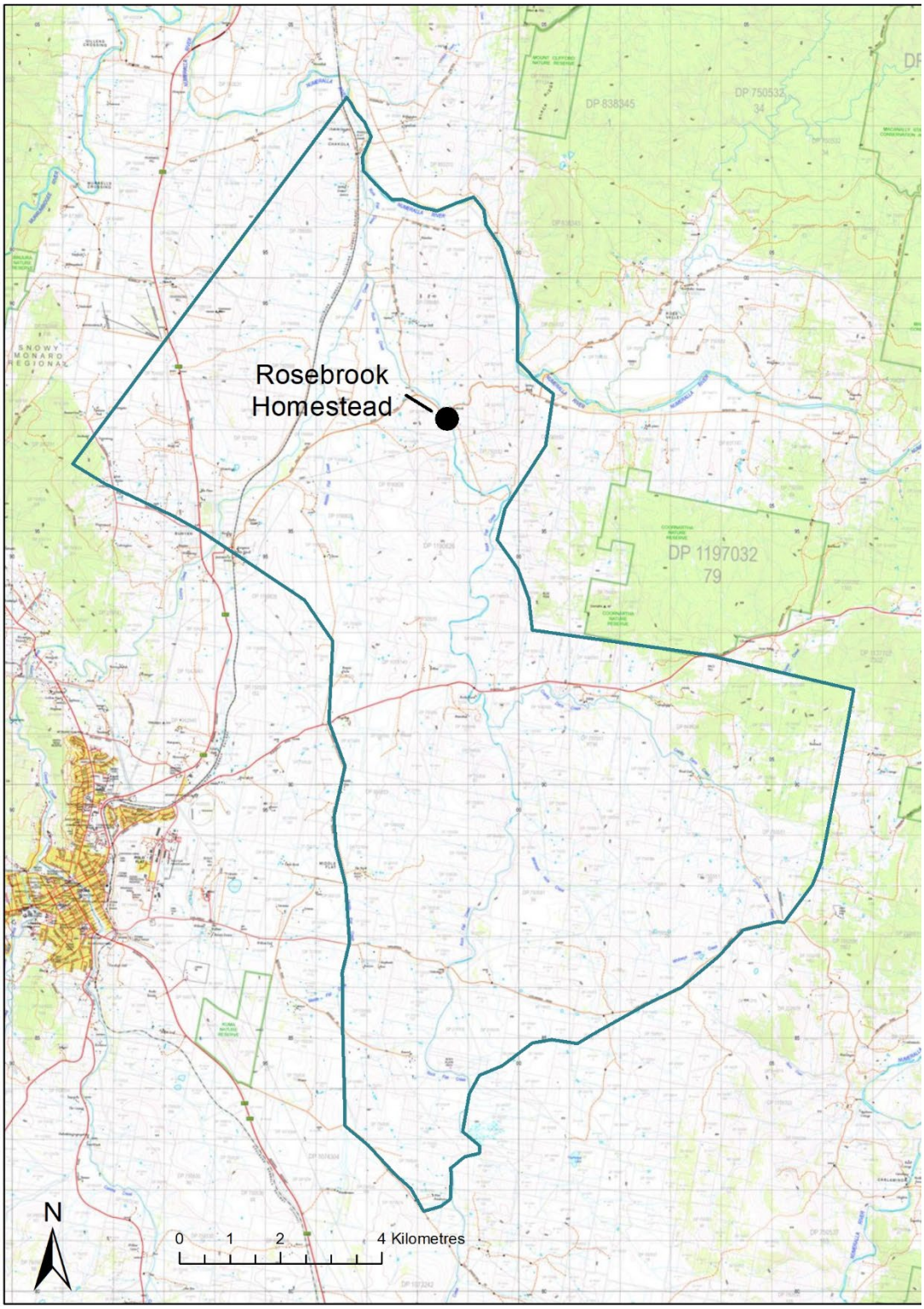

Figure 12 **Approximate boundary of the Rosebrook property in 1871 (outlined in blue), overlain on current topographic and tenure base**

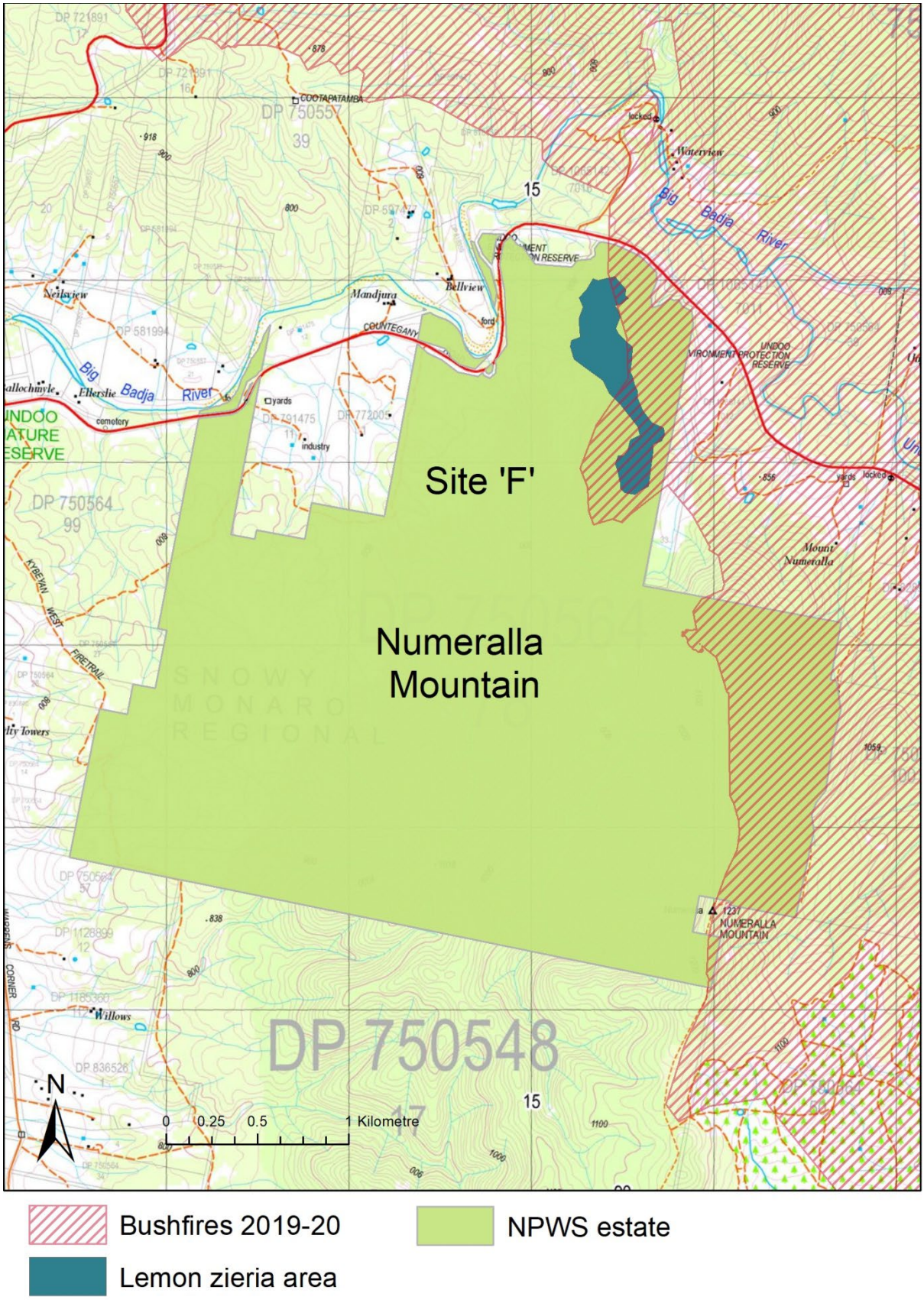

Figure 13 **Numeralla Mountain lemon zieria extent and 2019–20 fire extent**

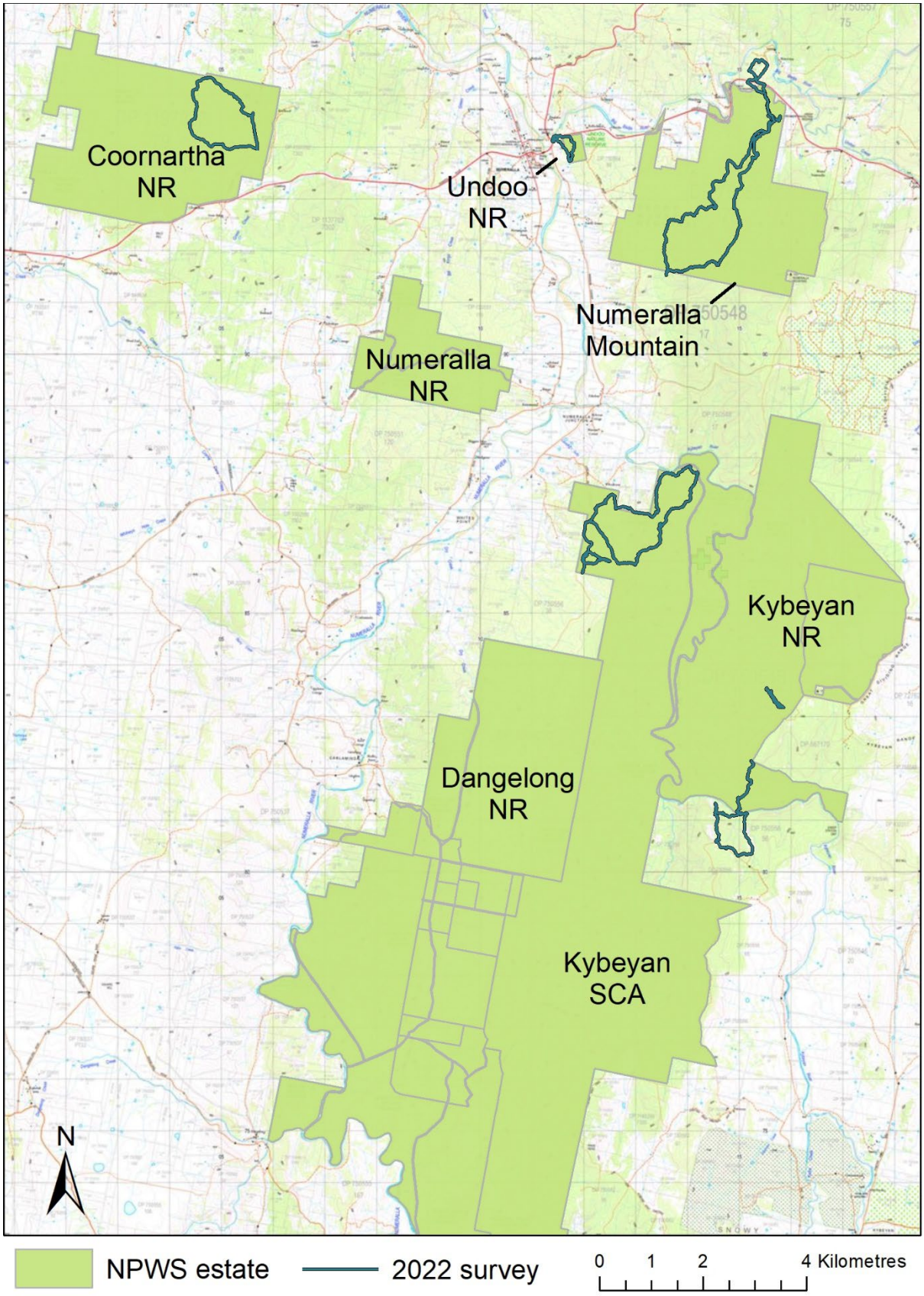

Figure 14 **Lemon zieria potential habitat survey transects, June 2022**

Appendix B: Monitoring plots

Plot F1

Photo 13 **Plot F1, plot origin image**

Grid ref. (plot origin post): (GDA94, Z55): Easting: 715530; Northing: 5995217.

Plot size: 10 m × 10 m.

Date: 5 June 2019.

Elevation: 814 metres asl.

Plot F2

Photo 14 **Plot F1, plot origin image (Michael Doherty/DEECCW consultant)**

Grid ref. (plot origin post): (GDA94, Z55): Easting: 715460; Northing: 5994980.

Plot size: 10 m × 10 m.

Date: 7 June 2019.

Elevation: 834 metres asl.

Plot C

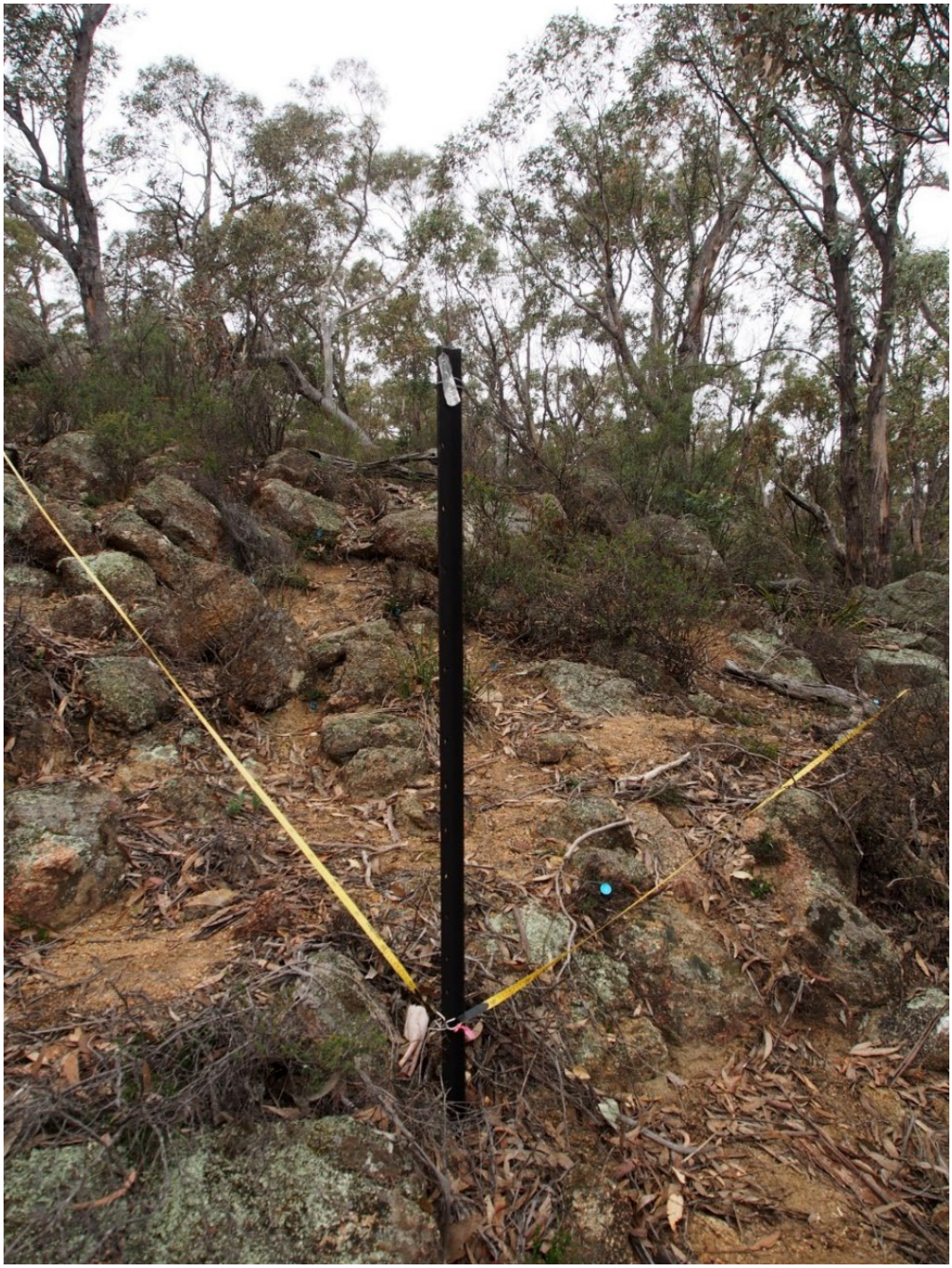

Photo 15 **Plot C, plot origin image**

Grid ref. (plot origin post): (GDA94, Z55): Easting: 715357; Northing: 5987402.

Plot size: 10 m × 10 m.

Date: 7 June 2019.

Elevation: 794 metres asl.

Plot EZC1

Photo 16 **Plot EZC1, plot origin image**

Grid ref. (plot origin post): (GDA94, Z55): Easting: 716325; Northing: 5985249.

Plot size: 20 m × 10 m.

Date: 6 June 2019.

Elevation: 981 metres asl.

Plot EZC2

Photo 17 **Plot EZC2, plot origin image**

Grid ref. (plot origin post): (GDA94, Z55): Easting: 716242; Northing: 5985366.

Plot size: 25 m × 10 m.

Date: 6 June 2019.

Elevation: 969 metres asl.

Appendix C: Recently discovered lemon zieria populations

Site 4a

Photo 18 **Site 4a habitat**

Grid ref.: (GDA94, Z55): Easting: 714511; Northing: 5984571.

Date: 27 March 2023.

Elevation: 845 metres asl.

Aspect: 270° west facing, ~ 20 degree slope

Collector/s: Genevieve Wright (GTW767), Lex Arnold, Michael Doherty.

Location: Kybeyan Nature Reserve, 125 m south of Kybeyan River on the eastern side of the river, and 2.25 km NW of Kybeyan Trig.

Habitat: *Eucalyptus mannifera*, *Eucalyptus dives* open forest with shrubby understory.

Landform: Lower slope of steep ridge.

Associated species: *Eucalyptus mannifera*, *Eucalyptus dives*, *Leucopogon fraseri*, *Veronica derwentiana*, *Bossiaea foliosa*, *Dillwynia sericea*, *Rhytidosperma pallidum*, *Poa sieberiana*, *Grevillea neurophylla*, *Hibbertia obtusifolia*, *Banksia canei*, *Daviesia ?mimosoides*.

Threats: Browsing.

Site 4b

Photo 19 **Site 4b habitat**

Grid ref.: (GDA94, Z55): Easting: 714073; Northing: 5984258.

Date: 27 March 2023.

Elevation: 840 metres asl.

Aspect: 90° slight easterly aspect, slope <5 degrees.

Collector/s: Genevieve Wright (GTW768), Lex Arnold, Michael Doherty.

Location: Kybeyan State Conservation Area, 75m east of Kybeyan River and 2.50km WNW of Kybeyan Trig.

Habitat: *Eucalyptus mannifera*, *Eucalyptus dives* open forest. Understory dominated by *Allocasuarina nana*.

Landform: flat area on western side of the Kybeyan River.

Associated species: *Eucalyptus mannifera*, *Eucalyptus dives*, *Allocasuarina nana*, *Platysace lanceolata*, *Bossiaea foliosa*, *Leucopogon microphyllus* var. *pilibundus*, *Daviesia ulicifolia*, *Melichrus urceolatus*, *Gonocarpus tetragynus*.

Threats: Browsing.

Site 5

Photo 20 **Site 5 habitat**

Grid ref.: (GDA94, Z55): Easting: 714766; Northing: 5985690.

Date: 19 Oct 2023.

Elevation: 840 metres asl.

Aspect: 270° westerly aspect, slope <5 degrees.

Collector/s: Genevieve Wright (GTW780), Lex Arnold.

Location: Kybeyan Nature Reserve, 2.8 km NNW of Kybeyan Trig, on western side of Kybeyan Trig road, 1.55 km in from road edge.

Habitat: *Eucalyptus mannifera*, *Eucalyptus rossii* and *Eucalyptus dives* open woodland.

Landform: Lower slope flat ridge area on eastern side of the Kybeyan River.

Associated species: *Eucalyptus mannifera*, *Eucalyptus rossii*, *Eucalyptus dives*, *Bossiaea buxifolia*, *Banksi canei*, *Daviesia mimosoides* subsp. *mimosoides*, *Acacia aureocrinita*, *Exocarpus strictus*, *Brachyloma daphnoides*, *Leucopogon fletcheri* subsp. *brevisepalus*, *Poa* sp., *Pultenaea procumbens*.

Threats: Browsing.

Notes: Small shrub, lemon-scented leaves, 15 cm tall x 20 cm wide. In bud.

Growing in the upper part of a patch of 226 plants, an approx 500 m line transect survey was completed. A comprehensive survey of the population was not done.

Site 6 (west of Kybeyan River)

Photo 21 **Site 6 habitat, west of Kybeyan River**

Grid ref.: (GDA94, Z55): Easting: 713024; Northing: 5984282.

Date: 14 April 2024.

Elevation: 985 metres asl.

Aspect: north-south running ridge crest.

Collector/s: No collection made, no fertile material available.

Location: Kybeyan State Conservation Area, 1.2 km east of the summit of Mount Pleasant growing on ridge crest. On the western side of the Kybeyan River,

Habitat: Open woodland with sparse understorey. *Eucalyptus* rossii, *E. dives*, *E. mannifera*.

Landform: Ridge crest.

Associated species: *Brachyloma daphnoides*, *Daviesia* ?*mimosoides*, *Acacia aureocrinita*, *Poa* sp., *Lomandra longifolia*, *Platyscace lanceolata*.

Threats: Browsing.

Notes: This location records the southernmost plant found in the population. From this point plants are scattered north for 180 m long along the ridge crest, the population is only about 20 m wide. There were 85 plants recorded in this locality.

The overstorey species stay the same across this site, but the northern end of the population flaks the eastern edge of a patch of *Allocasuarina nana* heath.

Site 6 (east of Kybeyan River)

Photo 22 **Site 6 habitat, east of Kybeyan River**

Grid ref.: (GDA94, Z55): Easting: 714670; Northing: 5986277.

Date: 14 April 2024.

Elevation: 800–860 metres asl.

Aspect: West facing lower slope above Kybeyan River.

Collector/s: No collection made, no fertile material.

Location: Kybeyan State Conservation Area, 1.6 km east of the summit of Mount Pleasant. On the eastern side of the Kybeyan River.

Habitat: Open woodland with sparse understorey. *Eucalyptus mannifera*, *E. dives*, *E. rossii*.

Landform: Mid to lower slope.

Associated species: *Banksia canei*, *Daviesia leptophylla*, *Platyscace lanceolata*, *Poa* sp., *Lomandra longifolia*.

Threats: Browsing.

Notes: This location records the northern plant found in the population. From this point plants are scattered south for 350 m. A single traverse was made through this area and a comprehensive survey was not completed. With a more systematic survey it is expected many more plants would be found in this population. There were 74 plants recorded in this locality.

Site 7

Photo 23 **Site 7 habitat**

Grid ref.: (GDA94, Z55): Easting: 713024; Northing: 5984282.

Date: 29 May 2024.

Elevation: 985 metres asl.

Aspect: 270° westerly aspect, slope <5 degrees.

Collector/s: Genevieve Wright (GTW809), Susannah Power.

Location: Kybeyan State Conservation Area, 1.9 km south of the summit of Mount Pleasant growing on ridge crest.

Habitat: Open woodland with sparse shrubby understorey. *Eucalyptus* seiberi, *E. rossii*, *E. mannifera*.

Landform: Lower slope flat ridge area on eastern side of the Kybeyan River.

Associated species: *Brachyloma daphnoides*, *Daviesia leptophylla*, *Dillwynia* sp., *Monotoca scoparia*, *Poa* sp., *Lomandra longifolia*, *Platyscace lanceolata*.

Threats: Browsing.

Notes: Small multi-stemmed shrub, 15 cm tall, sprawling, prostrate habit, leaves strongly lemon-scented.

One hundred plants in 100 m x 20 m area on ridge crest. Variety of plant sizes. 80% of plants heavily browsed, no sign of feral herbivore scats, only native species scats seen. Macropod, wombat and possum.

Cages were installed on a number of plants across this site on 23 July 2024 to protect a small number of plants from the current browsing impacts. Cameras were also installed to ascertain which species were browsing the lemon zieria.

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More information

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