# Ecological Health Performance Scorecard

## Royal National Park, Heathcote National Park and Garawarra State Conservation Area 2022–23

The NSW National Parks and Wildlife Service's (NPWS) Ecological Health Performance Scorecards program (Scorecards) aims to improve conservation outcomes by systematically collecting quantitative data to track long-term trends and report on the health of our national parks over time. These metrics will provide guidance on cost-effective management actions and interventions as part of a statewide approach to optimising the health of our national parks. As a pilot, the Scorecards program is operating across 8 sites. Tranche 1 of the program includes the aggregate of Royal National Park, Heathcote National Park and Garawarra State Conservation Area (this scorecard) and Kosciuszko National Park.

This scorecard covers 18,912 ha* in the Sydney Basin bioregion (Figure 1) and reports on:

- the health of conservation assets (including threatened and/or declining species)
- the status of ecological threats (including feral animals, weeds, and inappropriate fire regimes)
- the health of ecological processes (including water quality and soil health).

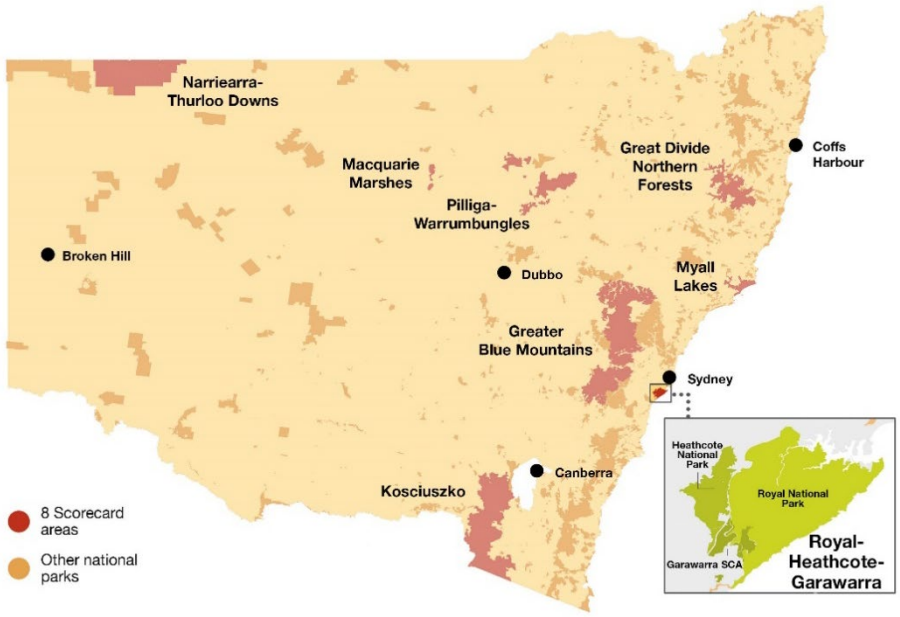


**Figure 1 Royal–Heathcote–Garawarra is one of 8 NPWS Scorecards sites**

* The gazetted park area is based on ground survey and differs to the mapped GIS area of 19,144 ha used for calculating area metrics in this Scorecard.

# Native species indicators

The scorecards surveillance monitoring program found that Royal-Heathcote-Garawarra is home to a diverse and widespread population of small and medium ground-dwelling mammals adjacent to Australia's largest city, Sydney. A total of 29 species of mammals (5 small ground-dwelling mammals, 3 medium ground dwelling mammals, 5 arboreal mammals and 16 microbats) and 80 species of bird were detected across 40 monitoring sites. Scorecard results for mammals, bats, birds, reptiles and amphibians, and threatened flora are provided in Tables 1 to 5.

## Mammals

**Table 1 Mammal indicators, metrics and results for 2022 and 2023**

| Indicator | Metric | 2023 | 2022 | Trend | Commentary |
|---|---|---|---|---|---|
| **All native mammals** | | | | | |
| | Number of species (surveillance monitoring) | 16 | 13 | - | Camera-based surveys were conducted at 34 of a proposed 40 surveillance monitoring sites targeting ground-dwelling mammals. Ultrasonic recorders targeting microbats were deployed at 34 sites.<br>The mean number of mammal species per site was 5 (range 2–8). Mammal richness was highest in dry sclerophyll forests. 2023 only includes data on microbats and 2022 only includes data on mammals detected on cameras.<br>The yellow-bellied sheath-tailed bat was detected for the first time in the park. |
| | Number of species past 5 years | 42 | - | | Data compiled from surveys, incidental records, and records from BioNet and Atlas of Living Australia (ALA) over the last 5 years (30 June 2018 to 30 June 2023). |
| | Pre-European (c. 1750) mammal assemblage | 51 | | | An initial assessment of the mammal species assemblage present c. 1750 has identified 51 species. This includes 6 species that are suspected to be locally extinct and 3 species that are extant in NSW but have not been recorded in the parks in the last 5 years (dingo, spotted-tail quoll and rakali/water rat). |

| Indicator | Metric | 2023 | 2022 | Trend | Commentary |
|---|---|---|---|---|---|
| | % of 1750 mammal assemblage | 82%–88% | | | 42 species (82%) recorded in last 5 years plus up to 3 species (6%) that may still be present.<br>The loss of up to 18% of the original mammal species assemblage represents, by global standards, a high rate of local extinction. However, compared to many parts of NSW, especially west of the Great Dividing Range, the site retains a relatively high proportion of its original mammal assemblage. This probably reflects a combination of relatively high rainfall, diverse topography and associated vegetation types and early declaration as a national park. |
| **Small ground-dwelling mammals** | | | | | |
| | Number of species | - | 5 | - | Species detected: common antechinus, dusky antechinus, common dunnart, bush rat, swamp rat. |
| | Activity | - | 12.8 (± 2.5)* | - | |
| Antechinus species | Occupancy | - | 82% | - | Detected more often in rainforests and wet sclerophyll forests. |
| | Activity | - | 8.4 (± 2.1)* | - | |
| **Medium ground-dwelling mammals** | | | | | |
| | Number of species | - | 3 | - | Species detected: long-nosed bandicoot, swamp wallaby, short-beaked echidna. |
| Long-nosed bandicoot | Occupancy | - | 62% | - | Detected more often in heathlands and wet sclerophyll forests. |
| | Activity | - | 2.4 (± 0.76)* | - | |
| Swamp wallaby | Occupancy | - | 97% | - | Detected commonly in dry sclerophyll forests, heathlands and wet sclerophyll forests and less often in rainforests. |
| | Activity | - | 13.6 (± 1.9)* | - | |
| Short-beaked echidna | Occupancy | - | 35% | - | Detected evenly across all vegetation types surveyed. |
| | Activity | - | 0.5 (± 0.2)* | - | |
| Platypus | Population estimate | 10 | | | Reintroduced 10 individuals in May 2023 and 9 confirmed alive and one individual not accounted for as of May 2024 |

| Indicator | Metric | 2023 | 2022 | Trend | Commentary |
|---|---|---|---|---|---|
| **Arboreal mammals** | | | | | |
| | Number of species | - | 5 | - | Detections from camera data: common ringtail possum, mountain brushtail possum, eastern pygmy-possum, Krefft's glider, koala. |
| Eastern pygmy-possum | Occupancy | - | 62% | - | Detected across all vegetation types surveyed except rainforest. More often detected in dry sclerophyll forests and heathlands. Vulnerable species under *Biodiversity Conservation Act 2016* (BC Act). |
| | Activity | - | 2.4 (± 0.7)* | - | |
| Koala | Occupancy | - | - | - | Targeted surveys to be developed. Koalas were recorded on camera at 2 surveillance sites. Surveys to monitor species abundance to be developed. Endangered species under BC Act. |
| | Abundance | - | - | - | |
| Southern greater glider | Occupancy | - | - | - | Targeted survey methods to be developed. Endangered species under BC Act. |
| | Density | - | - | - | |

- refers to insufficient data to determine a trend.

* mammal activity: the number of unique detections (separated per 30 minutes) per site in 100 camera days (± standard error).

# Bats

**Table 2 Bats indicators, metrics and results for 2022 and 2023**

| Indicator | Metric | 2023 | 2022 | Trend | Commentary |
|---|---|---|---|---|---|
| **All microbats** | | | | | |
| | Number of microbat species (surveillance monitoring) | 16 | - | - | Ultrasonic devices deployed at 34 sites. Fifteen species were confidently recognised from ultrasonic recordings and one genus (*Nyctophilus*) could not be distinguished at a species level. Highest species richness detected in wet sclerophyll and dry sclerophyll forests. Seven species listed as vulnerable under the BC Act, including one species previously unrecorded in the parks: yellow-bellied sheath-tailed bat |
| | Number of species past 5 years | 19 | | | Data compiled from surveys and records from BioNet and ALA over the last 5 years (30 June 2018 to 30 June 2023). |
| | Pre-European (c. 1750) microbat assemblage | 19 | | | Microbat assemblage is based on BioNet and ALA records. |
| | % of 1750 microbat assemblage | 100% | | | There have been limited surveys on microbats prior to 1994. Several species have only been described in the last 30 years making it difficult to assess historical 1750 microbat species assemblage. Data from surveys conducted in the last 30 years indicate that microbat assemblage remains intact in the park, based on available historic data. |
| Large-eared pied bat | Occupancy | 56% | - | - | Highest activity in wet sclerophyll forests. Vulnerable species under the BC Act. |
| | Activity | 1.0 (± 0.3)# | | | |
| Eastern horseshoe bat | Occupancy | 94% | - | - | Widespread species and call easily identified, detected at most sites. Highest activity in wet sclerophyll forests and heathlands. |
| | Activity | 3.1 (± 0.5)# | | | |
| Southern myotis | Occupancy | - | - | - | Difficult to distinguish calls of southern myotis. Further data validation required. Vulnerable species under the BC Act. |
| | Activity | - | | | |

- refers to insufficient data to determine a trend; # bat activity: mean number (± standard error) of unique detections (separated by 30 minutes) per site per night.

# Birds

**Table 3 Birds indicators, metrics and results for 2022 and 2023**

| Indicator | Metric | 2023 | 2022 | Trend | Commentary |
|---|---|---|---|---|---|
| **All native birds** | | | | | |
| | Number of bird species (surveillance monitoring) | - | 80 | - | Number of species detected across diurnal bird surveys at 25 of the surveillance sites, camera surveys at 34 sites, and incidental observations. Survey sites do not target coastal or aquatic species, however, they can occur at survey sites. Includes 2 species listed as vulnerable under the BC Act: varied sitella and square-tailed kite. |
| | Number of bird species past 5 years | 234 | - | - | Based on records from Bionet, ALA and eBird databases. This includes 27 species listed as threatened under the BC Act and an additional 3 species listed as threatened under the EPBC Act. |
| | Pre-European (c. 1750) bird species assemblage | 335 | - | - | An estimate based on all database records of birds collated for RHG. This includes 62 species listed as threatened under the BC Act and an additional 6 species listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act). |
| | % of 1750 bird assemblage | 70% | - | - | The number recorded in last 5 years is not yet a reliable measure of the extant bird assemblage. However, there are 4 species of particular concern that appear to no longer be present in RHG: eastern bristlebird, eastern ground parrot, bush stone-curlew and regent bowerbird. |

| Indicator | Metric | 2023 | 2022 | Trend | Commentary |
|---|---|---|---|---|---|
| **Diurnal bird** | | | | | |
| | Number of species | - | 50 | - | Highest species richness observed in wet sclerophyll and dry sclerophyll forests. Range of 3 to 23 species observed per site. Species present at highest number of sites were eastern yellow robin, grey fantail and rufous whistler. |
| Honeyeaters | Number of species | - | 11 | - | Highest number of species observed in dry sclerophyll forests. Highest number of observations were for eastern spinebill, New Holland honeyeater and yellow-faced honeyeater. |
| Australian warblers | Number of species | - | 4 | - | Species observed: brown gerygone, brown thornbill, striated thornbill and white-browed scrub-wren. |
| Australian fairy-wrens | Number of species | - | 1 | - | Species observed: variegated fairy-wren. |
| Pilotbird | Occupancy | - | 3% | - | Habitat specialist detected at one of 2 rainforest sites surveyed by diurnal bird surveys. Further results pending analysis of acoustic data.<br>Vulnerable species under EPBC Act. |
| Superb lyrebird | Occupancy | - | 29% | - | Detected across camera surveys. Audio processing under development. |
| | Activity | - | 1.23 (± 0.4)* | - | Species activity was highest in rainforests and wet sclerophyll forests, which is the preferred habitat of the species. |
| **Nocturnal birds** | | | | | |
| | Number of species | - | 3 | - | Species detected: southern boobook, tawny frogmouth and Australian owlet-nightjar from incidental observations and camera surveys. Processing of audio data is still under development. |
| Powerful owl | Occupancy | - | - | - | Audio processing under development. |
| Sooty owl | Occupancy | - | - | - | |
| Masked owl | Occupancy | - | - | - | |

- refers to insufficient data to determine a trend.

* lyrebird activity: the number of unique detections (separated by 30 minutes) per site in 100 camera days (± standard error).

# Reptiles and amphibians

**Table 4 Reptiles and amphibians indicators, metrics and results for 2022 and 2023**

| Indicator | Metric | 2023 | 2022 | Trend | Commentary |
|---|---|---|---|---|---|
| **Reptiles** | | | | | |
| Rock-plate heath reptiles | Number of species | - | 22 | - | A range of species were detected incidentally as part of targeted broad-headed snake surveys at 26 sites in Royal National Park. These include Lesueur's velvet gecko, dark-flecked garden sunskink, copper-tailed skink and eastern small-eyed snake. |
| Broad-headed snake | Occupancy | - | 56% | ↔ | Species occupancy has been stable at 26 monitoring sites since 2017. Total number of individuals detected in 2022 was 24 (7 adult, 4 subadult, 13 juvenile). Surveys target rock platforms, preferred by juveniles. Adults favour tree hollows for nesting. Continue implementing strategies to minimise habitat disturbance and the removal of bush rock. Requires ongoing monitoring to ensure population persistence.<br>Endangered species under the BC Act. |
| | Density | - | 1.85/ha | | |
| **Amphibians** | | | | | |
| Stream breeding frogs | Number of species | - | - | | Targeted survey methods to be developed. |
| Giant burrowing frog | Occupancy | - | | | Targeted survey methods to be developed.<br>Vulnerable species under the BC Act. |

- refers to insufficient data to determine a trend.

↔ refers to stable trend

# Threatened flora

**Table 5 Threatened flora, metrics and results for 2022 and 2023**

| Indicator | Metric | 2023 | 2022 | Trend | Commentary |
|---|---|---|---|---|---|
| **Threatened flora** | | | | | |
| Villous mint bush (*Prostanthera densa*) | Plot density | 1 mature plant/5.2m$^2$ | 1 mature plant/5.8m$^2$ | ↔ | Local population is restricted to 3 small sites across Royal NP and Garawarra SCA and is in good condition with only a small proportion of senescing plants or those showing signs of stress.<br>Vulnerable species under the BC Act. A controlled burn in the Marley population could stimulate the germination of seed. |
| | Healthy condition | 87% | 88% | | |
| | Recruitment rate | 3% | 9% | | |
| Scrub turpentine (*Rhodamnia rubescens*) | Population size | - | 90 plants | ↓ | 30% of standing trees are dead. Most trees are suffering from myrtle rust infection with an average of 21% (range 2–90%) leaves alive in the canopy.<br>Critically endangered species under the BC and EPBC Acts.<br>Percentage of standing dead trees has increased between 2016 and 2022 from 23% to 47% at one site. Requires ongoing monitoring and investigation of options to treat and/or limit disease spread and impact. |
| | Healthy condition | - | 3% | | |
| | Recruitment rate | - | - | | |

- refers to insufficient data to determine a trend.

↔ refers to stable trend

↓ refers to downward trend.

# Ecological community indicators

A total of 488 native plant species and 5 weed species were recorded across 40 monitoring sites. All park-wide monitoring sites are away from disturbance boundaries (i.e. roads, trail, river, visitor areas). The vegetation surveys indicate weed incursion is low away from disturbed areas. Scorecard results for 2023 are provided in Tables 6 and 7 for vegetation formations and targeted formations, respectively.

## Vegetation formation

**Table 6 Vegetation formations, metrics and results for 2023**

| Metric | | 2023 | Trend | Commentary |
|---|---|---|---|---|
| **Dry sclerophyll forests (shrubby): 10,238 ha (53.5% of RHG)** | | | | |
| Native species richness | | Total number of species: 266<br>Mean per site: 63<br>(Range: 46–86) | - | Dry schlerophyll forests are found on sandstone ridgetops and gullies across Royal–Heathcote–Garawarra. The tree canopy includes red bloodwood (*Corymbia gummifera*), very frequently in combination with smooth-barked apple (*Angophora costata*), scribbly gums (*Eucalyptus haemastoma* and *E. racemosa*), narrow-leaved stringybark (*E. oblonga*), Sydney peppermint (*E. piperita*) and silvertop ash (*E. sieberi*). A diverse and dense shrub layer includes multiple species of *Acacia, Allocasuarina, Banksia, Boronia, Dillwynia, Hakea, Hibbertia, Grevillea, Isopogon, Leptospermum, Persoonia*, *Pultenaea* and *Xanthorrhoea*. The ground layer is comprised of a sparse cover of forbs, grasses and sedges that includes *Lomandra longifolia*, *Entolasia stricta* and bracken (*Pteridium esculentum*). The distinctive Gymea lily (*Doryanthes excelsa*) can be found amongst the ground and lower shrub layers.<br>Species richness was highest in dry sclerophyll forests compared with other vegetation formations.<br>Dry sclerophyll forests had the highest density of trees, most of these trees had a diameter at breast height <20 m, and a low proportion of medium and very large trees. |
| Stem density per ha (by tree size classes) | <20 cm | Alive: 831 (Range: 60–1,750)<br>Dead: 35 (Range: 0–280) | | |
| | 20–49 cm | Alive: 115 (Range: 20–200)<br>Dead: 5 (Range 0–30) | | |
| | >50 cm | Alive: 27 (Range: 0-70)<br>Dead: 0 (Range: 0–10) | | |
| Native vegetation (% cover) | <1 m | 67 (Range: 24–95) | | |
| | 1–3 m | 41 (Range: 2–94) | | |
| | 3–5 m | 27 (Range: 1–48) | | |
| | >5 m | - | | |
| Litter cover (%) | | 83 (Range: 41–100) | | |
| Foliage projective cover (% ± standard error) | | 52 (± 1.5) | | |

| Metric | 2023 | | Trend | Commentary |
|---|---|---|---|---|
| Weed species richness | | Total number of species: 3<br>Mean per site: 0.14 (Range: 1–2)<br>% of sites with weeds: 13.3%<br>(2 of 15 sites) | | Three weed species were found in very low abundance: sheep's sorrel (*Acetosella vulgare*,) *Conya* spp. And flatweed (*Hypochaeris radicata)*. |
| **Heathlands: 5,557 ha (29% of RHG)** | | | | |
| Native species richness | | Total number of species: 240<br>Mean per site: 32<br>(Range: 13–57) | - | Heathlands occupy the broad, exposed sandstone plateau tops of Royal–Heathcote–Garawarra, predominately on the coastal eastern and north-eastern side but also in a mosaic with dry sclerophyll forest along narrow ridges and rocky outcrops and pavements. Heathlands generally lack trees, but multi-stemmed eucalypts or mallee growth forms are common. Red bloodwood and *Angophora hispida* are very frequent and mallee species include occasional Port Jackson mallee (*Eucalyptus obstans*) and whipstick mallee ash (*E. multicaulis*). The shrub canopy has a high cover of *Banksia species* including *B. ericifolia*, *B. serrata*, *B. marginata*, *B. oblongifolia* very frequently with a diverse combination of other shrubs and small trees including *Acacia suaveolens*, *Allocasuarina distyla, Boronia ledifolia*, *Dillwynia floribunda*, *Grevillea oleoides*, *Hakea dactyloides*, *Hakea teretifolia*, *Hemigenia purpurea*, *Isopogon anemonifolius*, *Leptospermum trinervium*, *Leptospermum arachnoides*, *Petrophile pulchella*, *Persoonia lanceolata* and *Xanthorrhoea resinosa*. The ground layer is a sparse combination of sedges, forbs and grasses. |
| Stem density per ha | <20 cm | Alive: 780 (Range: 90–1,320)<br>Dead: 17 (Range: 0–70) | | |
| | 20–49 cm | Alive: 32 (Range: 0–170)<br>Dead: 1 (Range: 0–10) | | |
| | >50 cm | Alive: 0<br>Dead: 0 | | |
| Native vegetation (% cover) | <1 m | 75 (Range: 42 -134) | | |
| | 1–3 m | 28 (Range: 0–96) | | |
| | 3–5 m | 12 (Range 0–40) | | |
| | >5 m | - | | |
| Litter cover (%) | | 58 (Range: 1–97) | | |
| Foliage projective cover (% ± standard error) | | 41 (± 1.7) | | |
| Weed species richness | | 0 | | |

| Metric | 2023 | | Trend | Commentary |
|---|---|---|---|---|
| **Rainforests: 435 ha (2.3% of RHG)** | | | | |
| Native species richness | | Total number of species: 76<br>Mean per site: 44<br>(Range: 35–61) | - | Narrow bands of rainforest occur at the bottom of the upper Hacking River valley, in the most sheltered and moist parts of the landscape, on rich shale soils. Rainforest occupies and rarely extends beyond the gully bottoms and stream sides of the Hacking and its tributaries. The tall rainforest canopy includes coachwood (*Ceratopetalum apetalum*) with lily pilly (*Acmena smithii*) and sassafrass (*Doryphora sassafras*) in varying abundance. The understory includes occasional shrubs of hairy-leaved doughwood (*Melicope micrococca*), large mock olive (*Notelaea longifolia*) and corkword (*Duboisia myoporoides*) and a diversity of ground ferns including giant maidenhair (*Adiantum formosum)* and creeping shield fern (*Lastreopsis microsora*). The mid-stratum very commonly contains the palm *Livistona australis* and vine *Gynochthodes jasminoides*, with the shrub *Tasmannia insipida* and vines *Palmeria scandens*, *Pandorea pandorana*, *Smilax australis*, *Marsdenia rostrata* and *Parsonsia straminea*. The epiphytic fern *Pyrrosia rupestris* also occurs commonly. Littoral rainforest occurs on the coastal fringe of Royal-Heathcote-Garawarra and is a targeted vegetation community.<br>Rainforest had a high density of large trees (>50cm diameter at breast height) and the highest density of medium sized trees (20–49 cm diameter at breast height). |
| Stem density per ha | <20 cm | Alive: 540 (Range: 0–1,470)<br>Dead: 0 | | |
| | 20–49 cm | Alive: 220 (Range: 110–880)<br>Dead: 0 | | |
| | >50 cm | Alive: 48 (Range: 20–90)<br>Dead: 0 | | |
| Native vegetation (% cover) | <1 m | 47 (Range: 30–60) | | |
| | 1–3 m | 36 (Range: 14–46) | | |
| | 3–5 m | 25 (Range: 6–33) | | |
| | >5 m | - | | |
| Litter cover (%) | | 93 (Range: 82–99) | | |
| Foliage projective cover (% ± standard error) | | 64 (± 1.2) | | |
| Weed species richness | | 0 | | |

| Metric | 2023 | | Trend | Commentary |
|---|---|---|---|---|
| **Wet sclerophyll forests (grassy): 270 ha (1.4% of RHG)** | | | | |
| Native species richness | | Total number of species: 167<br>Mean per site: 57<br>(Range: 48–64) | - | Wet sclerophyll forests (grassy) are tall to very tall sclerophyll open forest with a sparse layer of dry sclerophyllous shrubs and a grassy ground cover found on clay-influenced (shale) sandstone crests. The tree canopy includes red bloodwood with *Angophora costata*, species from the stringybark eucalypt group (*Eucalyptus globoidea*, *E. capitellata*, *E. sparsifolia*), blackbutt (*E. pilularis*), Sydney peppermint (*E. piperita*) and species from the mahogany eucalypt group (*E. botroides*, *E. resinifera*). The mid-stratum is multi-layered, commonly with a tall sparse layer of black she-oak (*Allocasuarina littoralis*) and a sparse cover of low dry shrubs. The shrub layer very frequently includes multiple species of *Acacia*, *Banksia*, *Hakea*, *Hibbertia* and *Persoonia*. It has a grassy ground layer with *Entolasia stricta* very frequent, often with different species of *Lepidosperma*, *Lomandra*, *Microlaena, Oplismenus* and *Poa*.<br>Wet sclerophyll forests (grassy) sites had a high density of large trees (>50cm diameter at breast height). |
| Stem density per ha | <20 cm | Alive: 900 (Range: 740–1160)<br>Dead: 143 (Range: 10–240) | | |
| | 20–49 cm | Alive: 188 (Range: 50–290)<br>Dead: 8 (Range: 0–20) | | |
| | >50 cm | Alive: 48 (Range: 0–90)<br>Dead: 3 (Range: 0–10) | | |
| Native vegetation (% cover) | <1 m | 73 (Range: 56–87) | | |
| | 1–3 m | 17 (Range: 8–3 1) | | |
| | 3–5 m | 26 (Range7–36) | | |
| | >5 m | - | | |
| Litter cover (%) | | 92 (Range: 82–98) | | |
| Foliage projective cover (% ± standard error) | | 60 (± 1.2) | | |
| Weed species richness | | Total number of species: 2<br>Mean: 0.28 (Range:1)<br>% of sites with weeds: 50%<br>(2 of 4 sites) | | |
| **Wet sclerophyll forests (shrubby): 1,287 ha (6.7% of RHG)** | | | | |
| Native species richness | | Total number of species: 116<br>Mean per site: 47<br>(Range: 45–50) | - | Wet sclerophyll forests (shrubby) are tall to very tall sclerophyll open forests with a sparse mesophyll shrub layer including scattered palms and a ground layer of |

| Metric | 2023 | | Trend | Commentary |
|---|---|---|---|---|
| Stem density per ha | <20 cm | Alive: 485 (Range: 340–650) | | ferns, graminoids and climbers. It is found on the west-facing or intermediate gully slopes and shale-capped crests slopes between the rainforest that borders the valleys of the upper Hacking River and tributaries, and the dry sclerophyll forests of the upper slopes and ridge tops. The tree canopy is variable however commonly includes a high cover of blackbutt, turpentine (*Syncarpia glomulifera*) and *Angophora costata*. The mid-stratum is layered and very frequently includes a sparse cover of cabbage-tree palm (*Livistona australis*). A lower shrub layer commonly includes multiple species of *Acacia*, *Hibbertia*, *Persoonia* and *Pultanaea* and *Leucopogon lanceolatus.* The mid-dense ground layer includes *Dianella caerulea*, *Entolasia stricta*, *Lomandra longifolia* and *Pteridium esculentum*. Vines include *Clematis aristate, Eustrephus latifolius, Hibbertia scandens*, *Smilax gylcophylla and Tylophora barbata*.<br>Wet sclerophyll forests (shrubby) sites had the highest density of large trees (>50cm diameter at breast height). |
| | | Dead: 28 (Range: 0–100) | | |
| | 20–49 cm | Alive:118 (Range: 30–240) | | |
| | | Dead: 5 (Range: 0–20) | | |
| | >50 cm | Alive: 85 (Range: 40–110) | | |
| | | Dead: 3 (Range: 0–10) | | |
| Native vegetation (% cover) | <1 m | 46 (Range: 31–68) | | |
| | 1–3 m | 37 (Range: 12–67) | | |
| | 3–5 m | 38 (Range: 13–64) | | |
| | >5 m | - | | |
| Litter cover (%) | | 87 (Range: 82–95) | | |
| Foliage projective cover (% ± standard error) | | 67 (± 3.0) | | |
| Weed species richness | | 0 | | |

- refers to insufficient data to determine a trend.

# Targeted vegetation communities

**Table 7 Targeted vegetation formations, metrics and results for 2022 and 2023**

| Metric | 2023 | 2022 | Trend | Commentary |
|---|---|---|---|---|
| **Littoral rainforest** | | | | |
| Native species richness | - | 28 (Range: 19 to 46) | - | Littoral rainforest is listed as an endangered ecological community under the BC Act and can be found in escarpment gullies on the southern and northern coastal fringes of Royal-Heathcote-Garawarra. Eleven monitoring plots are located in the southern area. A total of 321 native species and 3 weed species (at low abundance) were recorded across all sites. Browsing and stem rubbing by deer were observed at close to 50% of monitoring sites. Evidence of fire from 2018 observed at 2 monitoring sites where plants are regenerating.<br>Management should continue to exclude fire from rainforest patches and control deer. |
| **Coastal upland swamp** | | | | |
| Swamp area (ha) | - | - | - | Monitoring to be developed. Swamp area changes in response to changes in long-term rainfall patterns. Royal-Heathcote-Garawarra has over 100 swamps with different data sources estimating a total area ranging from 80–180 ha. Coastal Upland Swamp in the Sydney Basin bioregion is an endangered ecological community under the BC Act. |

- refers to insufficient data to determine a trend.

# Aquatic and biological indicators

## Soil health

Soils in Royal–Heathcote–Garawarra are low in nitrogen and phosphorus reflecting the underlying sandstone geology. Rainforest soils have higher levels of nitrogen and phosphorus than other vegetation formations as they grow on higher nutrient, deep shale soils and accumulate organic matter. Table 8 shows scorecard results for 2022 and 2023.

**Table 8 Soil health metrics and results for vegetation formations for 2022 and 2023**

| Metric | 2023 | 2022 | Trend |
|---|---|---|---|
| **Dry sclerophyll forests (shrubby)** | | | |
| Total nitrogen mg/kg | Mean: 387 (Range: 300–1,200) | - | - |
| Total phosphorus mg/kg | Mean: 2.3 (Range: 1–6) | | |
| Total organic carbon g/kg | Mean: 23.49 (Range: 13.0–47.1) | | |
| Tonnes of carbon | Mean: 36.75 Range: 18.5–65.9) | | |
| pH | Mean: 3.9 (Range: 3.3–4.5) | | |
| **Heathlands** | | | |
| Total nitrogen mg/kg | Mean: 688 (Range: 500–1,300) | - | - |
| Total phosphorus mg/kg | Mean: 2.08 (Range: 1–5) | | |
| Total organic carbon g/kg | Mean: 21.23 (Range: 14.2–38) | | |
| Tonnes of carbon | Mean: 26.77 (Range:14.4–51.9) | | |
| pH | Mean: 3.9 (Range: 3.6–4.1) | | |
| **Rainforests** | | | |
| Total nitrogen mg/kg | Mean: 4,200 (Range: 3,400–5,100) | - | - |
| Total phosphorus mg/kg | Mean: 15.5 (Range: 14–17) | | |

| Metric | 2023 | 2022 | Trend |
|---|---|---|---|
| Total organic carbon g/kg | Mean: 62.8 (Range: 50.9–72.0) | | |
| Tonnes of carbon | Mean: 54.63 (Range: 35.4–66.5) | | |
| pH | Mean: 4.4 (Range: 4.2–4.6) | | |
| **Wet sclerophyll forests (grassy)** | | | |
| Total nitrogen mg/kg | Mean: 1,275 (Range: 300–1,800) | - | - |
| Total phosphorus mg/kg | Mean: 6.5 (Range: 4–10) | | |
| Total organic carbon g/kg | Mean: 38.05 (Range: 16.1–51.0) | | |
| Tonnes of carbon | Mean: 40.18 (Range: 28.4–61.2) | | |
| pH | Mean: 4.35 (Range: 3.9–5.1) | | |
| **Wet sclerophyll forests (shrubby)** | | | |
| Total nitrogen mg/kg | Mean: 2,100 (Range: 1,900–2,300) | - | - |
| Total phosphorus mg/kg | Mean: 6.3 (Range: 4–9) | | |
| Total organic carbon g/kg | Mean: 44.44 (Range: 16.3–62.1) | | |
| Tonnes of carbon | Mean: 45.35 (Range: 13.3-84.5) | | |
| pH | Mean: 4.12 (Range: 3.6–4.6) | | |

- refers to insufficient data to determine a trend.

# Waterways

**Table 9 Waterways metrics and results for 2022**

| Metric | 2023 | 2022 | Trend | Commentary |
|---|---|---|---|---|
| **Water quality** | | | | |
| Site condition | - | 70% very good and good<br>10% fair<br>20% poor and very poor | - | Water quality was sampled at 21 sites. Most waterways are in very good and good condition. Bundeena, Saville and Wilsons creeks and one site on the Hacking River near Audley visitor area had poor or very poor water quality, recording poor macroinvertebrate communities and water quality values outside Australian and New Zealand water quality guidelines due to high levels of nitrogen and phosphorus. In general, there is a low proportion of pollution-sensitive macroinvertebrates present at sites indicating some habitat degradation. |
| Macroinvertebrate taxa richness | - | 18.5 (Range 8–24) | - | A high diversity of macroinvertebrate taxa is associated with healthy waterways, which is found in most of the waterways in Royal–Heathcote–Garawarra. Bundeena and Saville creeks had the lowest macroinvertebrate diversity. |
| EPT richness | - | 4.3 (Range 0–9) | - | Ephemeroptera, Plecoptera and Trichoptera (EPT) are indicator family groups of macroinvertebrate taxa commonly sensitive to water quality issues or habitat degradation. No EPT taxa were found in Bundeena Creek. |
| Total nitrogen (µg/L) | - | 236 (Range 95–570) | - | Elevated nitrogen levels (>300 µg/L) were found at Bundeena, Saville and Wilsons creeks and at the upper Hacking River sites and are associated with urban runoff. |
| Total phosphorus (µg/L) | - | 6.3 (Range 2.5–20.5) | - | Elevated phosphorus levels (>30 µg/L) were found at Bundeena, Saville and Wilsons creeks and at the upper Hacking River sites and are associated with urban runoff. |
| Conductivity (µS/cm) | - | 122 (Range 71–220) | - | Conductivity increases with increased salinity, chemicals and minerals in the water. Elevated levels (>300 µS/cm) on the Hacking River and upstream tributary may be associated with mine discharge. |
| Turbidity (NTU) | - | 3.8 (Range 0.7–15.6) | - | Elevated turbidity levels (>6 NTU) were found at the upper Hacking River, Wilsons, Kellys and Saville Creek which are associated with urban run-off. |

- refers to insufficient data to determine a trend.

# Fire indicators

## Area burnt

**Table 10 Area burnt in Royal–Heathcote–Garawarra**

| | 2022–23 FY | | 20-year average | |
|---|---|---|---|---|
| | Area (ha) | % of reserve/s | Area (ha) | % of reserve/s |
| Total area burnt | 3.1 | 0.02 | 336.7 | 1.76 |
| Total area with canopy burnt | 0 | 0 | 152 | 0.79 |
| Total area unburnt | 19,139 | 99.98 | 18,805 | 98.24 |
| Prescribed burn area | 3.1 | 0.02 | 189 | 0.99 |
| Prescribed burn - canopy burnt | 0 | 0 | n/a | n/a |
| Prescribed burn by zone type | | | | |
| Area of SFAZ | 2,218 | 11.59 | n/a | n/a |
| Prescribed burn - actual area burnt - SFAZ | 3.1 | 0.02 | 87.4 | 0.46 |
| Area of LMZ | 16,775 | 87.64 | n/a | n/a |
| Prescribed burn - actual area burnt - LMZ | 0 | 0 | 101 | 0.53 |
| Bushfire area burnt | 0 | 0 | 148 | 0.77 |
| No. of bushfires | 0 | 0 | 3.5 | n/a |
| % of bushfires < 10 ha | n/a | n/a | n/a | n/a |
| % of bushfires contained on park | n/a | n/a | n/a | n/a |

Note: SFAZ = strategic fire advantage zone; LMZ = land management zone.

Area burnt metrics are calculated from NPWS Fire History data, and fire severity (canopy fires) is calculated from Fire Extent and Severity Map data.

**Table 11 Fire patchiness in Royal–Heathcote–Garawarra**

| Fire patchiness | 10-year average | 20-year average | 30-year average |
|---|---|---|---|
| Average distance (m) between burnt and long-unburnt patches | 7,558 (Range: 282–13,262) | 7,558 (Range: 282–13,262) | 7,105 (Range: 1,178–12,306) |
| Heterogeneity index (burnt/unburnt) | Being developed | | |
| Heterogeneity index (canopy burnt) | Being developed | | |

# Dry sclerophyll forests (shrubby): 10,238 ha

**Table 12 Fire history for dry sclerophyll forests (shrubby) in Royal–Heathcote–Garawarra**

| Fire history | | Area (ha) burnt | % of formation | Area (ha) burnt by canopy fire | % of formation |
|---|---|---|---|---|---|
| **Time since last fire** | | | | | |
| 1 to 5 years | (2018–19 to 2022–23) | 1,510 | 14.54 | 366 | 3.53 |
| 6 to 10 years | (2013–14 to 2017–18) | 1,736 | 16.72 | 646 | 6.22 |
| 11 to 15 years | (2008–09 to 2012–13) | 299 | 2.88 | 150 | 1.44 |
| 16 to 20 years | (2003–04 to 2007–08) | 18 | 0.17 | 1 | 0.01 |
| 21 to 25 years | (1998–99 to 2002–03) | 5,523 | 53.20 | 1,969 | 18.97 |
| 26 to 30 years | (1993–94 to 1997–98) | 1,263 | 12.17 | 1,999 | 19.25 |
| 31 to 40 years | (1983–84 to 1992–93) | 7 | 0.07 | n/a^ | n/a^ |
| 41 to 50 years | (1972–73 to 1982–83) | 10 | 0.10 | n/a | n/a |
| 50+ years | (pre 1972–73) | n/a | n/a | n/a | n/a |
| **30-year fire history** | | | | | |
| Area unburnt | | 33 | 0.32 | 5,094 | 49.07 |
| Area burnt once | | 2,906 | 27.99 | 4,130 | 39.78 |
| Area burnt twice | | 5,601 | 53.95 | 920 | 8.86 |
| Area burnt 3 times | | 1,798 | 17.32 | 81 | 0.78 |
| Area burnt >3 times | | 44 | 0.42 | 0 | 0.00 |

**Note:** Desired fire interval 11 to 30 years based on plant species fire response.

Area burnt metrics are calculated from NPWS Fire History data, and fire severity (canopy fires) is calculated from Fire Extent and Severity Map data.

Model output for canopy burnt in the 26-to-30-year period was greater than the total area burnt. This is due differences in data sources for mapping of FESM and Fire History data.

^ current fire severity data is only available to 1990–91, in subsequent years reporting of canopy fires will be extended to better represent the desired fire–interval range limits.

# Heathlands: 5,557 ha

**Table 13 Fire history for heathlands in Royal–Heathcote–Garawarra**

| Fire history | | Area (ha) burnt | % of formation | Area (ha) burnt by canopy fire | % of formation |
|---|---|---|---|---|---|
| **Time since last fire** | | | | | |
| 1 to 5 years | (2018–19 to 2022–23) | 960 | 17.04 | 663 | 11.77 |
| 6 to 10 years | (2013–14 to 2017–18) | 1,294 | 22.96 | 1,068 | 18.95 |
| 11 to 15 years | (2008–09 to 2012–13) | 38 | 0.67 | 31 | 0.55 |
| 16 to 20 years | (2003–04 to 2007–08) | 18 | 0.32 | 14 | 0.25 |
| 21 to 25 years | (1998–99 to 2002–03) | 1,874 | 33.26 | 1,068 | 18.95 |
| 26 to 30 years | (1993–94 to 1997–98) | 1,445 | 25.64 | 1,751 | 31.07 |
| 31 to 40 years | (1983–84 to 1992–93) | 1 | 0.02 | n/a^ | n/a^ |
| 41 to 50 years | (1972–73 to 1982–83) | 2 | 0.04 | n/a | n/a |
| 50+ years | (pre 1972–73) | n/a | n/a | n/a | n/a |
| **30-year fire history** | | | | | |
| Area unburnt | | 6 | 0.11 | 1,032 | 18.31 |
| Area burnt once | | 1,819 | 32.28 | 2,764 | 49.05 |
| Area burnt twice | | 2,983 | 52.94 | 1,639 | 29.09 |
| Area burnt 3 times | | 827 | 14.68 | 197 | 3.50 |
| Area burnt >3 times | | 0 | 0 | 3 | 0.05 |

**Note:** Desired fire interval 10 to 30 years based on plant species fire response

Area burnt metrics are calculated from NPWS Fire History data, and fire severity (canopy fires) is calculated from Fire Extent and Severity Map data.

^ current fire severity data is only available to 1990–91, in subsequent years reporting of canopy fires will be extended to better represent the desired fire–interval range limits.

# Wet sclerophyll forests: 1,557 ha

**Table 14 Fire history for wet sclerophyll forests in Royal–Heathcote–Garawarra**

| Fire history | | Area (ha) burnt | % of formation | Area (ha) burnt by canopy fire | % of formation |
|---|---|---|---|---|---|
| **Time since last fire** | | | | | |
| 1 to 5 years | (2018–19 to 2022–23) | 66 | 4.15 | 0 | 0 |
| 6 to 10 years | (2013–14 to 2017–18) | 260 | 16.33 | 15 | 0.94 |
| 11 to 15 years | (2008–09 to 2012–13) | 37 | 2.32 | 5 | 0.31 |
| 16 to 20 years | (2003–04 to 2007–08) | 1 | 0.06 | 0 | 0 |
| 21 to 25 years | (1998–99 to 2002–03) | 483 | 30.34 | 11 | 0.69 |
| 26 to 30 years | (1993–94 to 1997–98) | 611 | 38.38 | 49 | 3.08 |
| 31 to 40 years | (1983–84 to 1992–93) | 12 | 0.75 | n/a^ | n/a^ |
| 41 to 50 years | (1972–73 to 1982–83) | 9 | 0.57 | n/a | n/a |
| 50+ years | (pre 1972–73) | n/a | n/a | n/a | n/a |
| **30-year fire history** | | | | | |
| Area unburnt | | 134 | 8.42 | 1512 | 94.97 |
| Area burnt once | | 675 | 42.40 | 76 | 4.77 |
| Area burnt twice | | 538 | 33.79 | 4 | 2.20 |
| Area burnt 3 times | | 242 | 15.20 | 0 | 0.38 |
| Area burnt >3 times | | 3 | 0.19 | 0 | 0 |

**Note:** Desired fire interval 13 to 60 years based on plant species fire response.

Area burnt metrics are calculated from NPWS Fire History data, and fire severity (canopy fires) is calculated from Fire Extent and Severity Map data.

^ current fire severity data is only available to 1990–91, in subsequent years reporting of canopy fires will be extended to better represent the desired fire–interval range limits.

## Rainforests: 438 ha

**Table 15 Fire history for rainforests in Royal–Heathcote–Garawarra**

| Fire history | | Area (ha) burnt | % of formation | Area (ha) burnt by canopy fire | % of formation |
|---|---|---|---|---|---|
| **Time since last fire** | | | | | |
| 1 to 5 years | (2018–19 to 2022–23) | 10 | 2.23 | 2 | 0.45 |
| 6 to 10 years | (2013–14 to 2017–18) | 74 | 16.48 | 4 | 0.89 |
| 11 to 15 years | (2008–09 to 2012–13) | 6 | 1.34 | 1 | 0.22 |
| 16 to 20 years | (2003–04 to 2007–08) | 0 | 0 | 0 | 0 |
| 21 to 25 years | (1998–99 to 2002–03) | 189 | 42.09 | 3 | 0.67 |
| 26 to 30 years | (1993–94 to 1997–98) | 63 | 14.03 | 15 | 3.34 |
| 31 to 40 years | (1983–84 to 1992–93) | 6 | 1.34 | n/a^ | n/a^ |
| 41 to 50 years | (1972–73 to 1982–83) | 6 | 1.34 | n/a | n/a |
| 50+ years | (pre 1972–73) | n/a | n/a | n/a | n/a |
| **30-year fire history** | | **Area (ha)** | **% of formation** | **Area (ha) - canopy fire** | **% of formation** |
| Area unburnt | | 107 | 23.83 | 423 | 94.34 |
| Area burnt once | | 165 | 36.75 | 22 | 4.90 |
| Area burnt twice | | 139 | 30.96 | 3 | 0.67 |
| Area burnt 3 times | | 38 | 8.46 | 0.4 | 0.09 |
| Area burnt >3 times | | 0 | 0 | 0 | 0 |

**Note:** Vegetation is sensitive to fire.

Area burnt metrics are calculated from NPWS Fire History data, and fire severity (canopy fires) is calculated from Fire Extent and Severity Map data.

^ current fire severity data is only available to 1990–91, in subsequent years reporting of canopy fires will be extended to better represent the desired fire–interval range limits.

# Threat indicators

## Feral animals

**Table 16 Feral animal and feral animal control metrics, 2022–23 financial year (FY)**

| Indicator | 2022–23 FY expenditure ($) | | Management activity | 2022–23 FY input | 2022–23 FY output | Metric | 2023 | 2022 | Trend | Commentary |
|---|---|---|---|---|---|---|---|---|---|---|
| **Feral predators** | | | | | | | | | | |
| Feral cat | $0 | | Trapping | 0 | 0 | Occupancy | - | 0 | - | No cats detected in 2022. Cats likely present but possibly occur in very low density. |
| | | | | | | Activity | - | 0 | - | |
| | | | | | | Density | - | 0 | - | |
| Red fox | $9,637 | $0 | Ground shooting | 0 | 0 | Occupancy | - | 85% | - | Foxes detected across all vegetation types. |
| | | $0 | Trapping | 0 | 0 | Activity | - | 3.5 (± 0.7) | - | |
| | | $9,637 | Aerial baiting | # | 820 aerial baits over 80 km | | | | | |
| **Herbivores and omnivores** | | | | | | | | | | |
| Rusa deer | $90,000 | $0 | Ground shooting | 0 hrs | 0 | Occupancy | - | 44% | - | Deer activity predominantly detected in the southern and northern ends of Royal-Heathcote-Garawarra in rainforest and wet sclerophyll forest with almost no activity in heathland. Methodology to monitor density to be developed. |
| | | $90,000 | Aerial shooting | 489 hrs (35 hrs of shooting) | 164 shot | Activity | - | 6.5 (± 3.5) | - | |
| | | | | | | Density | - | - | | |

- refers to insufficient data to determine a trend.

# Data not currently available.

# Weeds

**Table 17 Weed and weed control metrics 2022–23 financial year (FY)**

| Indicator | 2022–23 FY expenditure ($) | Management activity | 2022–23 FY input | 2022–23 FY output | Metric | 2023 | 2022 | Trend | Commentary |
|---|---|---|---|---|---|---|---|---|---|
| All weed species | $123,419 | Foliar spraying, cut and paint, hand pulling | 2,798 hrs | 243 ha | Area occupied | - | - | - | Weed survey methodology to be developed. |
| Boneseed | $20,711 | Searching, hand pulling and foliar spray | 124 hrs | 47 ha | Area occupied | - | - | - | Eradication priority species. |
| Sea spurge | $5,188 | Hand pulling | 58 hrs | 39 ha | Area occupied | - | - | - | Eradication priority species. |
| Holly-leaved senecio | $1,088 | Hand pulling | 12 hrs | 5 ha | Area occupied | - | - | - | Eradication priority species. |
| Aquatic weeds | $8,502 | Foliar spray, aquatic tablet | 104 hrs | 28 ha | Area occupied | - | - | - | Control species: Senegal tea, yellow water poppy, *Ludwigia peruviana*. |
| Exotic perennial grasses | $87,930 | Foliar spray, cut and paint, stem injection, hand pulling | 2,500 hrs | 6 ha^ | Area occupied | - | - | - | Control species: pampas grass. |
| Vines and scramblers | | | | 17 ha^ | Area occupied | - | - | - | Control species: blackberry, ground asparagus, turkey rhubarb, *Asparagus asparagoides*, corky passionflower, trad, moth vine, *Tecoma* sp., lantana. |
| Woody weeds | | | | 74 ha^ | Area occupied | - | - | - | Control species: camphor laurel, lantana, African olive, coral tree, small-leaved privet, broom, tree of heaven, green cestrum, winter cassia, cotoneaster, wild aster. |
| Other widespread weeds | | | | 27 ha^ | Area occupied | - | - | - | Control species: mother of millions, thorn apple, arum lily, apple of Sodom, formosa lily, crofton weed. |

- refers to insufficient data to determine a trend.

^ ha of control based on the primary weed reported in the NPWS Pest and Weed Information System (PWIS), as a consequence weed metrics may be overstated for some species and understated for others. Recording process for weeds to be reviewed.

# Glossary

| Term | Meaning |
|---|---|
| Abundance | the average number of individuals per survey or by survey effort (e.g. trap nights), for the case it refers to the number of individuals enumerated that comprise a population within a defined area, ecosystem or habitat |
| Activity | Activity from camera traps (mammals and lyrebirds) is the number of unique detections (separated by 30 minutes) per site in 100 camera days (± standard error). Microbat activity is the the number of unique detections (separated by 30 minutes) per site in 100 camera days (± standard error). |
| ALA | Atlas of Living Australia – Australia's national biodiversity database |
| BioNet | NSW BioNet – the repository for biodiversity data products open to any user and managed by the Department of Climate Change, Energy, the Environment and Water |
| BC Act | *Biodiversity Conservation Act 2016* |
| Canopy fire | area derived from Fire Extent and Severity Map (FESM) classes: High – full canopy scorch/partial consumption; and Extreme – full canopy consumption |
| Density | the number of animals or plants per unit area in sampled habitat |
| Foliage projection cover | a canopy cover index derived from satellite imagery |
| Litter cover | average percentage of litter cover per vegetation formation or community |
| LMZ | Landscape management zone |
| Native cover | average percentage cover of native vegetation per vegetation formation or community |
| Native species richness | average number of native species detected |
| Occupancy | naïve occupancy, proportion of sites where a species was detected |
| Patchiness | average distance between burnt patches |
| Population estimate | the total number of individuals within a defined area, ecosystem or habitat —his is regarded as a more accurate and comprehensive estimate compared to abundance |
| Recruitment rate | the proportion or percentage of the total population size (mature individuals) that are seedlings |
| SFAZ | strategic fire advantage zone |
| Stem density per hectare | number of tree stems, categorised by diameter at breast height classes, per hectare |

| Term | Meaning |
|---|---|
| Tonnes of carbon | total tonnes of carbon per hectare of soil (tC/ha) |
| Total nitrogen | milligrams of nitrogen per kg soil (TN mg/kg soil) |
| Total organic carbon | grams of total organic carbon per kg of soil |
| Total phosphorus | milligrams of phosphorus per kg of soil (P mg/kg soil) |
| Waterway site condition | overall site grade (very good, good, fair, poor and very poor) was assessed using water quality variables (dissolved oxygen, electrical conductivity, pH, filterable reactive phosphorus, ammonia, nitrogen oxides, total dissolved phosphorus, total dissolved nitrogen, turbidity), aquatic macroinvertebrates (EPT ratio, EPT Richness, SIGNAL2–Family average, Taxa Richness, AUSRivAS OE50), and riparian and geomorphic condition data |
| Weed species richness | total number of weed species detected |

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