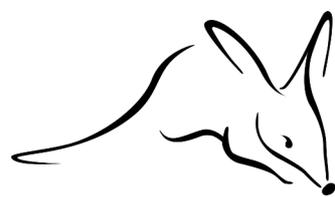


# Piccaninny Plains Wildlife Sanctuary Ecohealth Report 2021



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## Summary

Australian Wildlife Conservancy (AWC) has implemented an Ecological Health Monitoring Program (Ecohealth) across Piccaninny Plains Wildlife Sanctuary (Piccaninny Plains) to measure the changes in the status and trend of conservation assets, and threats to those assets. Metrics from the program are reported in annual Ecohealth Reports and Scorecards. This is the Ecohealth Report for 2021. Values of metrics derived in this report were based on data collected during surveys carried out between 2013 and 2021. The complete set of metrics and their values are summarised in the accompanying Ecohealth Scorecard.

In implementing the Ecohealth program in 2021, AWC conducted 2,362 camera trap nights, 32 wetland condition assessments, 572 km of aerial feral herbivore survey and 14 transects surveying arboreal mammals and nocturnal birds. These surveys detected 16 mammals, 18 birds, 2 reptiles and 1 amphibian species.

During August and September, AWC conducted the second targeted survey of the Black-footed Tree-rat (*Mesembriomys gouldii*), with cameras deployed at 67 sites in the north-eastern part of the sanctuary. This complements the targeted survey undertaken in 2020 which focused on the southern end of the sanctuary. In this survey, the Black-footed Tree-rat was detected at one of the 67 sites. This species has now been recorded at 14 locations on Piccaninny Plains since 2012. These and past data will inform the development of future surveys to examine the response of this species to management, including fire regimes.

During 2021, AWC conducted the second Rocky Outcrop Camera Survey with 18 cameras deployed along the rocky outcrops in the eastern part of the sanctuary. This survey targets the Northern Quoll (*Dasyurus hallucatus*), Cape York Rock-wallaby (*Petrogale coenensis*) and Common Rock Rat (*Zygomys argurus*). AWC did not detect any of the target species during 2021. The first Rocky Outcrop Survey was undertaken in 2015 with 32 cameras deployed in the north-eastern rocky outcrops, this first survey successfully detected the Cape York Rock-wallaby and Common Rock Rat.

Overall, the 2021 Spotlighting Survey detected two species of arboreal mammals, two flying foxes (*Pteropus* spp.) and seven species of nocturnal birds. Four species were detected for the first time in this year's Spotlighting Survey (although they were already known to occur on Piccaninny Plains): the Striped Possum (*Dactylopsila trivirgata*), Australian Boobook (*Ninox boobook*), Large-tailed Nightjar (*Caprimulgus macrurus*) and Tawny Frogmouth (*Podargus strigoides*). The Common Spotted Cuscus (*Spiloglossus maculatus*) has been detected every year and its occupancy has increased from 33% in 2014 to 85% in 2021. Arboreal mammal guild richness and abundance were similar in 2021 to when the last spotlighting surveys were conducted in 2016 but lower than results for 2014 and 2015. Spotlight Surveys in 2021 recorded the highest nocturnal bird species richness (1.5 species per site) since surveys began in 2014.

The condition of the Piccaninny wetlands was recorded as stable and improving through on-ground and aerial surveys. On-ground wetland condition assessments have been conducted at up to 39 individual sites (depending on access) in most years between 2013 and 2021. The majority of the 2021 wetland sites were in 'fair' and 'good' condition (24 out of 31), representing an improvement from prior years. Additionally, there was only one site in 'very poor' condition in 2021 (3% of sites) a clear improvement from 2013 when 24% of sites were in 'very poor' condition. An aerial assessment of wetland condition was conducted at seven sites on the largest wetland on Piccaninny Plains, Green Swamp, in November 2021. The condition of these seven sites (a subset of the on-ground monitoring sites) remained stable since November 2019; with most sites (4 out of 7) in 'good' condition. This overall improvement highlights the importance of AWC's ongoing feral control operations.

In November 2021, the annual aerial feral herbivore survey recorded 269 feral cattle (*Bos taurus*), higher than the 185 cattle recorded in 2020, but fewer than the 442 cattle recorded in 2016.

Active fire management began in 2009. Since then, the extent of late dry season fires has been substantially reduced, with 54 % of the sanctuary being impacted by late dry season fires before 2009 vs 16% in 2021. Fire management has also reduced distances to unburnt vegetation from within fire scars, which are important features that offer refuge and resources to wildlife. Despite a large increase in the area of early dry season prescribed fire, the total area burnt annually on Piccaninny Plains has declined since 2009, reflecting the improved and strategic fire management (76 % before 2009 vs 42% in 2021). These results highlight the success of AWC's fire management strategy.

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## Introduction

Australian Wildlife Conservancy (AWC) currently owns, manages, or works in partnerships across 31 properties in Australia, covering almost 6.5 million hectares, to implement our mission: *the effective conservation of Australian wildlife and their habitats*. AWC relies on information provided by an integrated program of monitoring and research to measure progress in meeting its mission and to improve conservation outcomes.

AWC's Ecohealth Monitoring Program has been designed to measure and report on the status and trends of species, ecological processes and threats on each of these properties (Kanowski et al. 2018). Data from the monitoring program are used to address the following broad questions relevant to our mission:

- 'are species persisting on a property?'
- 'are habitats being maintained?'
- 'are threats below ecologically-significant thresholds?'

For threatened and iconic species, including reintroduced species, AWC's monitoring program aims to obtain more detailed information related to their conservation management; for example, data on survival, recruitment, condition, distribution and/or population size.

The structure of the Ecohealth Program is as follows. AWC's Monitoring and Evaluation framework provides guidance on the development of the Ecohealth Monitoring Plans for each property managed by AWC: these plans describe the conservation values and assets of each property, the threats to these assets, and the monitoring program that will be used to track their status and trend, and to evaluate outcomes. Annual survey plans and schedules are developed to implement these plans. The outcomes of these surveys are presented in annual Ecohealth Reports and summary Ecohealth Scorecards.

This document is one of a series of annual Ecohealth Reports for Piccaninny Plains Wildlife Sanctuary (referred to here as Piccaninny Plains). The companion Ecohealth Scorecard presents the indicators and their metrics in a summary format.

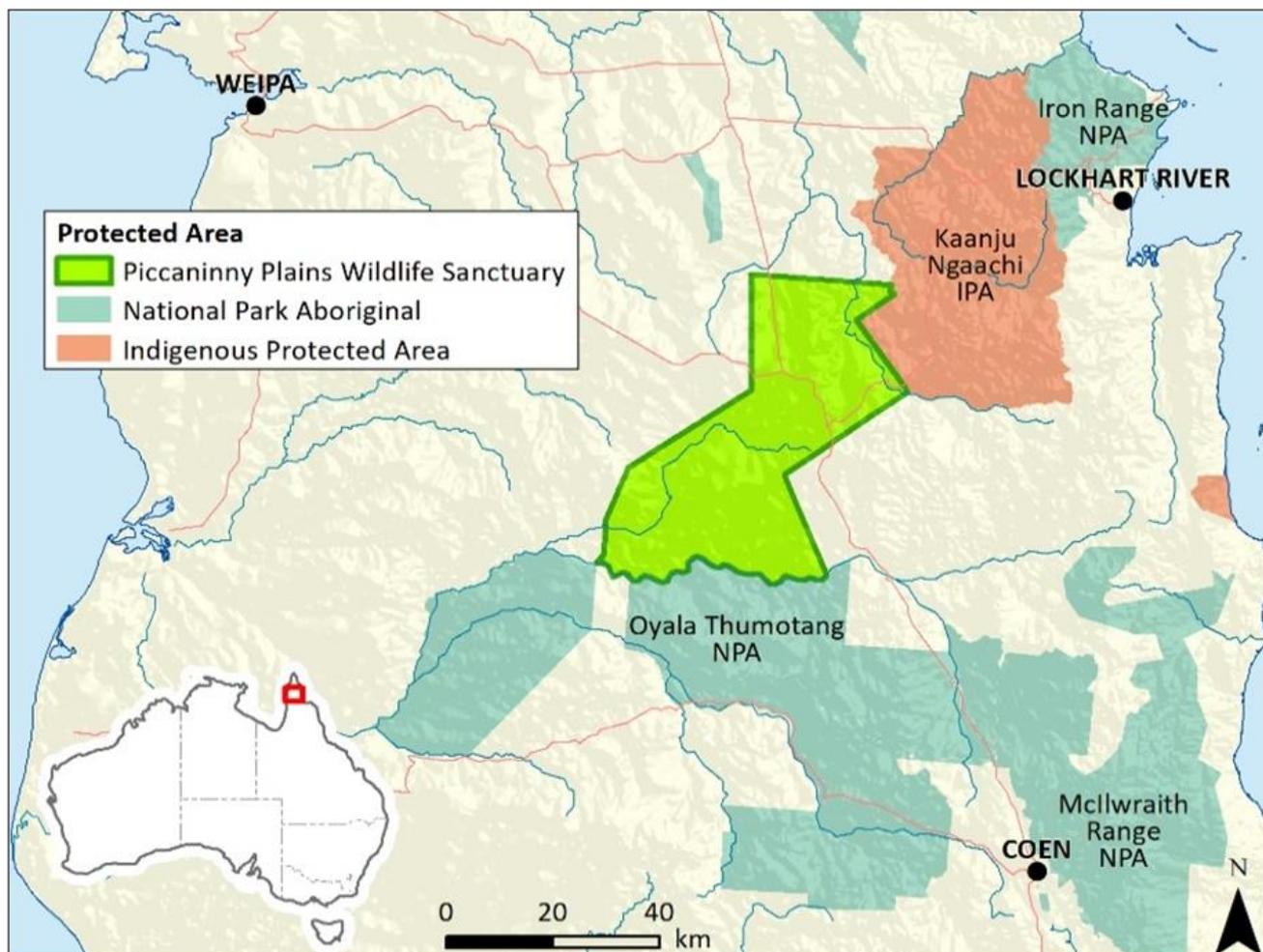
## Piccaninny Plains Wildlife Sanctuary

Piccaninny Plains is located on Cape York Peninsula, is 166,522 ha in extent (Figure 1) and is within the traditional lands of the Wik and Wik Way peoples. The property was purchased by AWC in partnership with The Tony and Lisette Lewis Foundation (TLLF) WildlifeLink in 2008 and is managed by AWC. Prior to its acquisition, Piccaninny Plains was a pastoral station.

Piccaninny Plains is an important part of the network of protected areas on Cape York Peninsula (Figure 1) protecting a diverse suite of ecosystems (Stanton et al. 2016). The terrain is mostly flat, rising to low hills in the north-east. The plains are underlain by shales and siltstones which have weathered to cracking clay soils, with distinctive gilgais ('melonholes') caused by high clay soils swelling and shrinking. The hills in the north-east are comprised of sandstone and other sedimentary rocks, weathering to sandy and gravelly soils. Alluvial sands extend over parts of the floodplains of the Archer and Wenlock Rivers. Extensive savanna woodlands occur on the sanctuary, cut by ribbons of gallery rainforest and deciduous vine thicket (Figure 2). Small rainforest patches occur in sheltered locations on low hills on the divide between the Archer and Wenlock catchments, with grasslands are present on black soil plains (Figure 2).

A diverse array of wetlands occurs on the sanctuary, including the extensive shallow waters of Green Swamp, long and deep water-holes such as Crescent and Watson's Lagoons, and numerous smaller waterholes and ephemeral swamps (Stanton and Murphy 2006). The sanctuary includes over 50 km frontage to the Archer River, one of the largest and least disturbed rivers on Cape York Peninsula. Gallery rainforest occurs along the Archer and Wenlock rivers and their major tributaries, forming a continuous link with the extensive rainforests of the Iron and McIlwraith Ranges (Figure 1). Its location and the diverse ecosystems that occur across the sanctuary means Piccaninny Plains supports many species endemic to Cape York and Papua New Guinea, including the Cape York Rock-wallaby (*Petrogale coenensis*), Palm Cockatoo (*Probosciger aterrimus*) and Trumpet Manucode (*Phonygammus keraudrenii*). There are 477 native vertebrate species in the

Sanctuary including 67 mammal, 265 bird, 80 reptile and 26 amphibian species; 17 of these native species are listed as threatened. The non-protected areas that border Piccaninny Plains are pastoral properties.



**Figure 1. Location and regional context of Piccaninny Plains.**

A range of conservation actions are implemented by AWC at Piccaninny Plains to protect its biodiversity. For example, pressures from introduced herbivores and pigs (*Sus scrofa*) are reduced through targeted feral animal control and annual mustering. Fire management is undertaken, with the overarching objective of re-establishing an ecologically appropriate fire regime that promotes the conservation of species, ecological communities and ecosystem processes. Since acquisition, fire management on Piccaninny Plains aims to reduce the extent of late dry season fire in the savanna woodlands; this involves strategies including burning in the early dry season to reduce fuel loads and establish fire breaks (Webb et al. 2022). A further objective of fire management is the control of woody thickening and invasive weeds in the grasslands and savanna woodlands through storm burns (fires lit in the late dry season after the initial rains; Neldner et al. 1997; Crowley et al. 2009; Stanton 2022). Key weed species including hymenachne (*Hymenachne amplexicaulis*), sicklepod (*Senna obtusifolia*), thatch (*Hyparrhenia rufa*), and grader grass (*Themeda quadrivalvis*) are targeted in ongoing control operations by managers. Several major Cape York roads run through Piccaninny Plains, creating challenges for the Sanctuary Managers including trespassers and arson attacks.

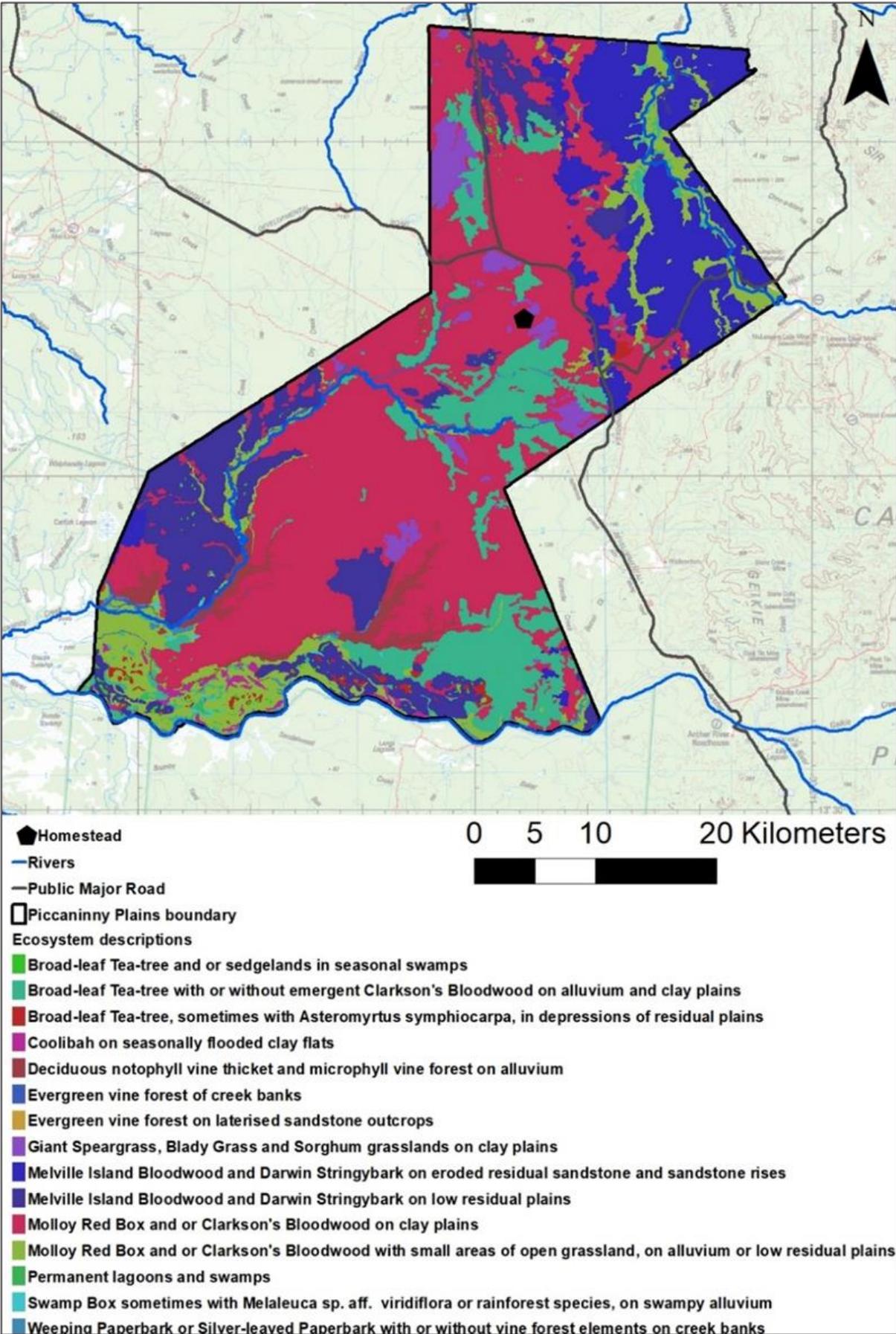
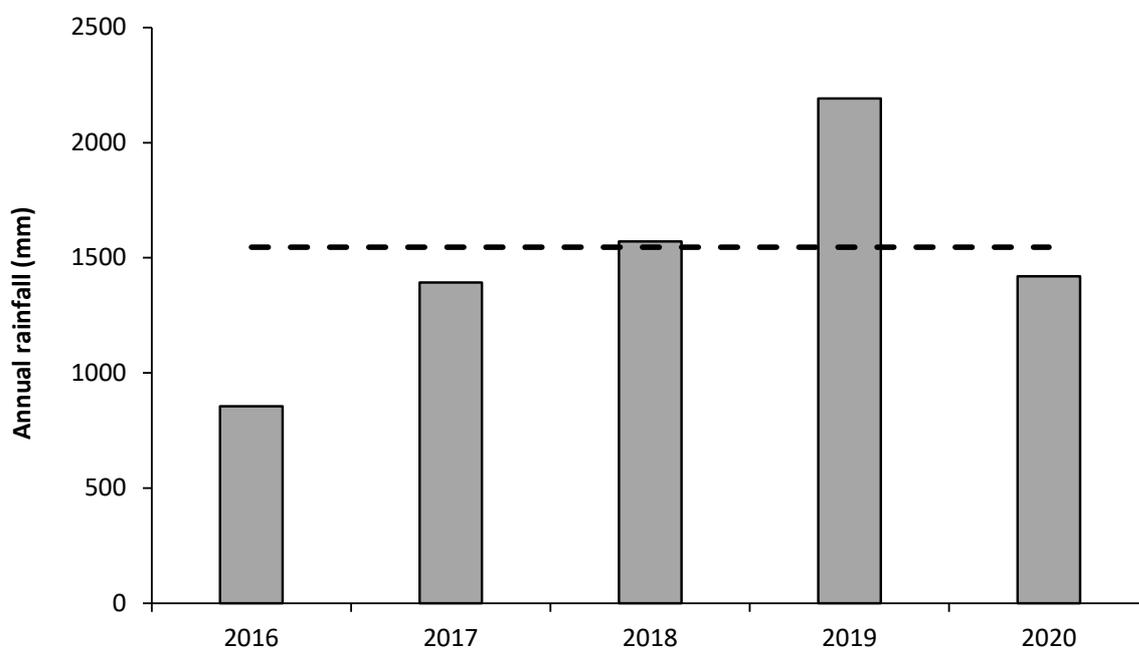


Figure 2. Extent and distribution of broad vegetation types of Piccaninny Plains. Source: Stanton et al (2016).

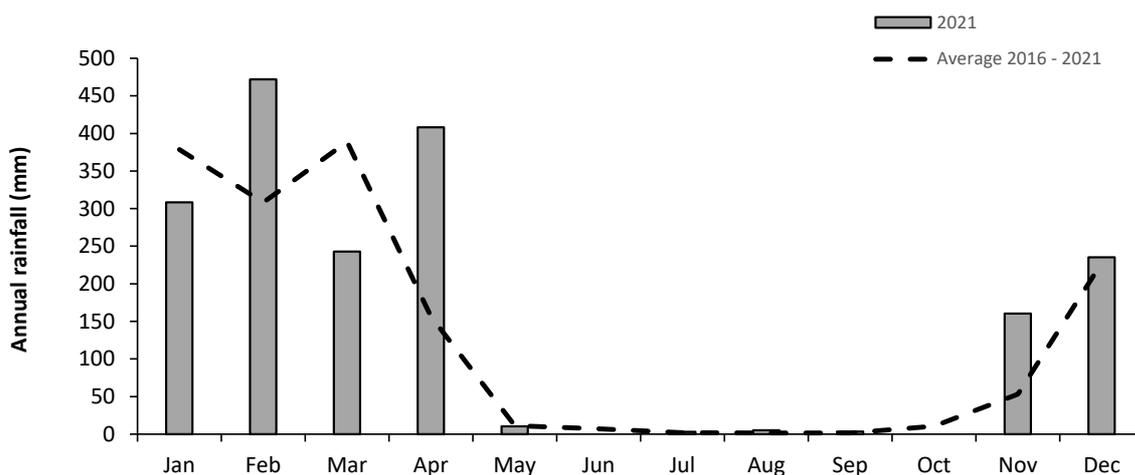
## Climate and weather summary

Piccaninny Plains experiences a tropical climate and lies in the high rainfall area of Cape York Peninsula. It has received median annual rainfall of 1,547 mm (range between 856 mm to 2,192 mm) since recording began in 1997, although only nine of those years have complete records (Bureau of Meteorology 2022; Piccaninny Plains weather station number 027064). Most rainfall occurs during the wet season between November to April. In 2021, total rainfall was 1,849 mm (Figure 3 and Figure 4). The higher rainfall in 2019 (2,192 mm) was due to three tropical cyclones in the wet season of 2018–2019 (Figure 3).

Historical temperature data are available between 1913 to 1938, and between 1968 to 1987, for Moreton Telegraph Station (77 km north of Piccaninny Plains; weather station number 027015). Since the Moreton Telegraph Station is no longer open, temperature data for 2021 used in this report were taken from the Coen Airport (weather station number 27073), 86 km from Piccaninny Plains, which opened in 2002 (Bureau of Meteorology 2022). Historical monthly mean minimum and maximum temperatures range from 16.9 °C in August to 34.9 °C in December (Bureau of Meteorology 2022, data from Coen Airport). The monthly mean minimum and maximum temperatures for 2021 were 18.2 °C in July and 36.1 °C in October (Bureau of Meteorology 2022, data from Coen Airport).



**Figure 3. Annual rainfall 2016–2021 at Piccaninny Plains.** Data are displayed from 2016 as some data were unavailable in 2014–2015. Dashed line = median rainfall for 2016–2021. Source: Bureau of Meteorology, Piccaninny Plains, weather station number 027064.



**Figure 4. 2021 rainfall and median at Piccaninny Plains.** Dashed line = average rainfall 2016–2021. Source: Bureau of Meteorology, Piccaninny Plains, weather station number 027064.

## Methods

### Monitoring and evaluation framework

Piccaninny Plains' Ecohealth Monitoring Program has been designed to measure and report on the status and trends of selected biodiversity and threat indicators on the property, using metrics derived from data collected through a series of purpose-designed surveys. Where possible, outcomes will be evaluated against performance criteria relevant to each species, guild or assemblage.

### Key threatened and iconic vertebrates

The Ecohealth program is focused on species of high conservation value, including threatened and 'iconic' species (e.g., regional endemics, species with high public profile and other species of conservation importance because of the role they play in an ecosystem, etc). Where relevant, reintroduced species are also in this category. AWC will aim to develop *Conservation Plans* for the extant threatened and iconic species to ensure early detection of any serious issues that arise and to trigger timely responses. These plans will specify metrics to monitor outcomes for target species against nominated performance criteria.

### Vertebrate assemblages and surveillance species

AWC's mission involves the conservation of all wildlife, not only threatened or reintroduced species. For this reason, AWC's monitoring program extends to surveillance monitoring of faunal assemblages (mammals, birds, reptiles, frogs) and surveillance species. The monitoring program aims to address questions relevant to the conservation of assemblages and surveillance species.

At the most basic level, the program seeks to establish whether all species that are known to occur on the property are persisting on the property (i.e., 'are all species present?').

With increasing information, the monitoring program can address more detailed questions relating to conservation of assemblages, such as 'have species maintained their distributions or abundance?' However, the boom/bust conditions of most Australian environments can lead to large variations in the numbers of individuals in a population and the habitats or sites occupied by a species – these variations may not necessarily be informative in relation to the conservation of a species at a property over the long term.

AWC is currently working on developing an evaluation framework for surveillance monitoring of faunal assemblages and surveillance species. At present, we will continue to present data on a range of metrics relating to indicator species and guilds.

## Indicators and metrics

On Piccaninny Plains, 26 biodiversity (species, guilds and ecosystem processes) indicators have been selected for monitoring. Fourteen of these indicators were reported on in 2021, including one related to threatened and iconic species, and the remainder to surveillance monitoring of faunal assemblages and ecosystem processes (Table 1).

Threat metrics are selected to monitor the status and trends of introduced weeds, predators and herbivores, and fire regimes. Six threat indicators have been selected for monitoring (Table 2). Three of these threat metrics were reported on in 2021.

**Table 1. Biodiversity indicators and metrics for Piccaninny Plains.**

### Key threatened and iconic vertebrates

Indicator	Survey name	Survey method	Metric/s
<b>Mammals</b>			
Black-footed Tree-rat ( <i>Mesembriomys gouldii</i> )	Black-footed Tree-rat Targeted Survey	Camera traps	Abundance, occupancy
<b>Birds</b>			
Australian Palm Cockatoo ( <i>Probosciger aterrimus</i> )	Palm Cockatoo Targeted Survey	Transects, playbacks.	Occupancy
Magnificent Riflebird ( <i>Ptiloris magnificus</i> )	Magnificent Riflebird Targeted Survey	Transects, playbacks.	Occupancy

### Vertebrate assemblages and surveillance species

Indicator	Survey name	Survey method	Metric/s
<b>Mammals</b>			
Assemblage richness	Black-footed Tree-rat Targeted Survey, Rocky Outcrop Camera Survey, Standard Trapping Survey, Incidentals	All mammal survey methods	Number of species
<b>Arboreal mammals</b>			
Assemblage richness	Spotlighting survey, Incidentals	Transects, incidentals	Number of species detected
Arboreal Mammal Guild	Spotlighting survey	Transects	Abundance, richness
Common Spotted Cuscus ( <i>Spiloglossus maculatus</i> )	Spotlighting survey	Transects	Abundance, occupancy
<b>Other mammals</b>			
Savanna small-medium mammal guild	Standard Trapping Survey	Live trapping	Abundance, richness
Rainforest small-medium mammal guild	Standard Trapping Survey	Live trapping	Abundance, richness
Grassland small-medium mammal guild	Standard Trapping Survey	Live trapping	Abundance, richness
Rocky outcrop small-medium mammal guild	Rocky Outcrop Camera Survey	Camera traps	Abundance
Bandicoot complex: Northern Brown Bandicoot ( <i>Isodon macrourus</i> ) Cape York Bandicoot ( <i>Isodon peninsulae</i> )	Standard Trapping Survey	Camera traps	Abundance, occupancy
Large herbivores	Standard Trapping Survey	Camera traps	Abundance
Dingo ( <i>Canis dingo</i> )	Standard Trapping Survey	Camera traps	Abundance, occupancy
<b>Reptiles</b>			
Assemblage richness	Standard Trapping Survey, Incidentals	All reptile survey methods	Number of species
Savanna small-medium reptile guild	Standard Trapping Survey	Live trapping	Abundance, richness

Indicator	Survey name	Survey method	Metric/s
Rainforest small-medium reptile guild	Standard Trapping Survey	Live trapping	Abundance, richness
Grassland small-medium reptile guild	Standard Trapping Survey	Live trapping	Abundance, richness
<b>Birds</b>			
Assemblage richness (all birds)	Standard Bird Survey, Targeted Surveys, Spotlighting Survey, Incidentals	All bird survey methods	Number of species
Nocturnal bird guild	Spotlighting survey	Transects	Abundance, richness
Red-backed Fairy-wren ( <i>Malurus melanocephalus</i> )	Playback Survey	Transects, playbacks.	Occupancy
Golden-headed cisticola ( <i>Cisticola exilis</i> )	Playback Survey	Transects, playbacks.	Occupancy
Black-throated Finch ( <i>Poephila cincta</i> )	Playback Survey	Transects, playbacks.	Occupancy
Trumpet Manucode ( <i>Phonygammus keraudrenii</i> )	Playback Survey	Transects, playbacks.	Occupancy

### Vegetation indicators and surveillance species

Indicator	Survey name	Survey method	Metric/s
Wetland condition	Wetland condition assessment (on-ground)	Wetland assessment	Wetland assessment score (mode)
Wetland condition: Green Swamp	Wetland condition assessment (aerial)	Wetland assessment	Wetland assessment score (mode)

**Table 2. Threat indicators and metrics for Piccaninny Plains.**

Indicator	Survey name/ methods	Metric/s	Performance criteria
<b>Pest animals</b>			
Feral cat ( <i>Felis catus</i> )	Targeted survey	Number of cats detected	TBD
Horse ( <i>Equus caballus</i> )	Feral Herbivore survey (aerial)	Number of horses detected	TBD
Cattle ( <i>Bos taurus</i> )	Feral Herbivore survey (aerial)	Number of cattle detected	TBD
Pig ( <i>Sus scrofa</i> )	Feral Herbivore survey (aerial)	Number of pigs detected	TBD
<b>Weeds</b>			
Sicklepod ( <i>Senna obtusifolia</i> )	Scheduled control	Area infested	TBD
Sensitive weed (Mimosa pudica)	Scheduled control	Area infested	TBD
Giant Rat's Tail Grass (GRT) ( <i>Sporobolus</i> sp.)	Scheduled control	Area infested	TBD
Thatch grass ( <i>Hyparrhenia rufa</i> )	Scheduled control	Area infested	TBD
Hymenachne ( <i>Hymenachne amplexicaulis</i> )	Scheduled control	Area infested	TBD
Knobweed ( <i>Hyptis capitata</i> )	Scheduled control	Area infested	TBD
<b>Fire</b>			

Indicator	Survey name/ methods	Metric/s	Performance criteria
Fire	Remote sensing	Extent/area burnt (EDS, LDS, long unburnt) Modal frequency Distance to unburnt/long unburnt	Reduce the extent and frequency of LDS wildfires, increase long unburnt vegetation, decrease distance to unburnt/long unburnt vegetation (relative to baseline)

## Survey types and history

To report on the Biodiversity and Threat Indicators, our survey teams conduct a variety of surveys repeated on a schedule of 1–5 years, as required to obtain timely information on each indicator. These include:

For key threatened and iconic vertebrates, a range of targeted surveys including:

- Black-footed Tree-rat Targeted Survey
- Australian Palm Cockatoo Targeted Survey
- Magnificent Riflebird Targeted Survey
- Standard Trapping Survey
- Standard Camera Survey

For assemblages and surveillance species, these include:

- Spotlighting Survey
- Standard Trapping Survey
- Standard Camera Survey
- Rocky Outcrop Survey
- Red-backed Fairy-wren Playback Survey
- Golden-headed Cisticola Playback Survey
- Reed-warbler Survey Playback Survey
- Trumpet Manucode Playback Survey

To monitor threats, a range of surveys are used, including:

- Wetland Condition Assessment (aerial and on-ground)
- Feral Herbivore Survey
- Cat Targeted Survey

Five of these ecological surveys were conducted at Piccaninny Plains in 2021. Below is a list of surveys reported upon in this Ecohealth Report (Table 3). The Fire Scar Analysis has been completed using satellite data from 2000 (8 years prior to acquisition) to 2021. The methodology is described and results of these surveys and computations are reported on in this document.

**Table 3. Survey history and effort for Ecohealth surveys on Piccaninny Plains reported on in this report.**

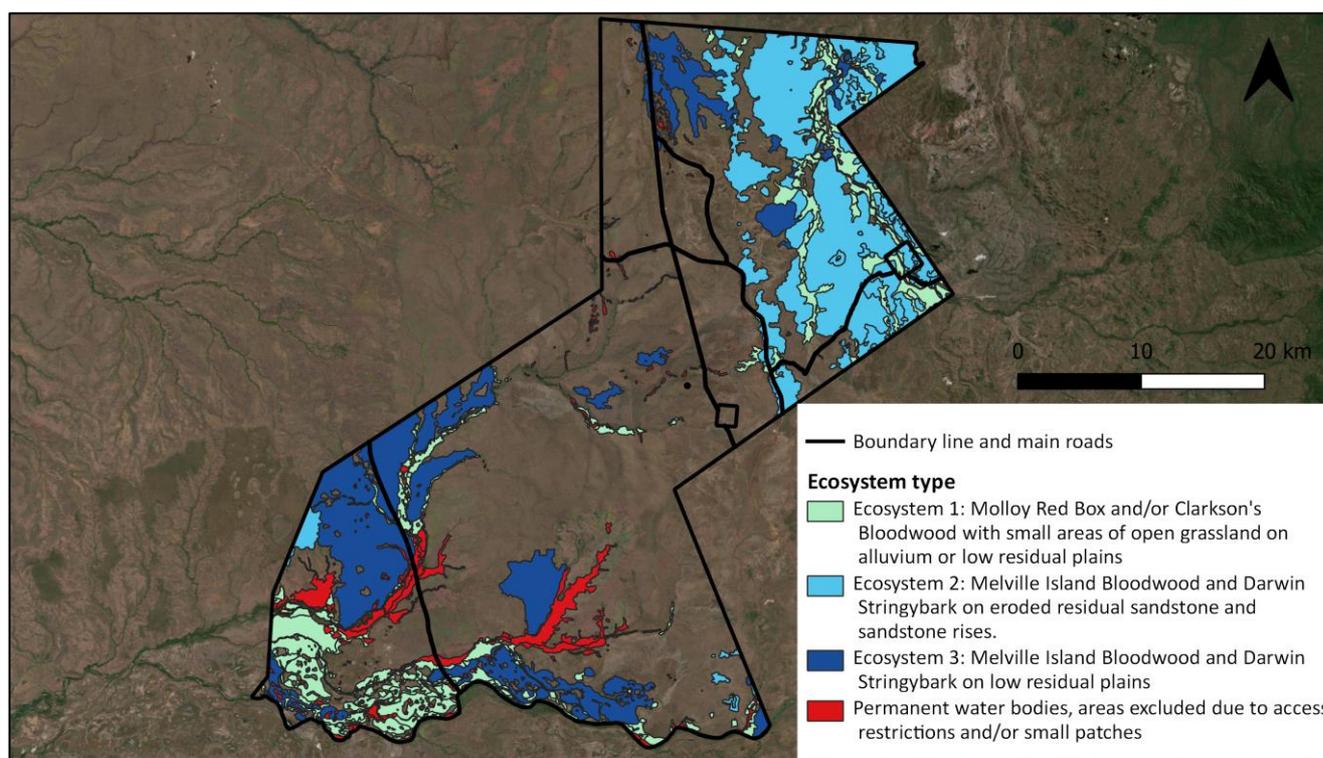
Survey name	Effort	Description/comment	Previous surveys
Black-footed Tree-rat Targeted Survey	1,876 camera trap nights	67 sites (North-east section), each containing 2 camera traps, set for 14 nights in 2021.	2020: 55 sites (Southern section), each containing 2 camera traps, set for 14 nights.
Rocky Outcrop Camera Survey	486 camera trap nights	Six sites, each site containing three camera traps set for 27 nights in 2021.	2015: 32 sites, each containing 1 camera trap set for 30 nights.
Spotlighting Survey	7 transects (2 replicates)	7 transects along river beds, 45 mins each	2014: 6 transects (surveyed once) 2015: 7 transects (surveyed once) 2016: 7 transects (surveyed once)
Wetland Condition Assessment	31 wetlands assessed (on ground)	The condition of 31 wetlands was scored in 2021.	2013: 26 wetlands scored 2014: 15 wetlands scored 2015: 25 wetlands scored 2016: 29 wetlands scored (13 on ground and 17 from a chopper) 2018: 38 wetlands scored 2019: 26 wetlands scored
Wetland Condition Assessment	7 sites of Green Swamp (aerial)	7 sites on Green Swamp, surveyed from the air in 2021.	2016: 1 site assessed (aerial) 2018: 6 sites assessed (on ground). 2019: 6 sites assessed (on ground). 2020: 7 sites assessed (aerial)
Feral Herbivore Survey	572 km of transect	Fixed aerial transect repeated in November 2021.	2016: 572 km 2017: 572 km 2019: 572 km

Survey name	Effort	Description/comment	Previous surveys
			2020: 572 km

## Survey design and methods

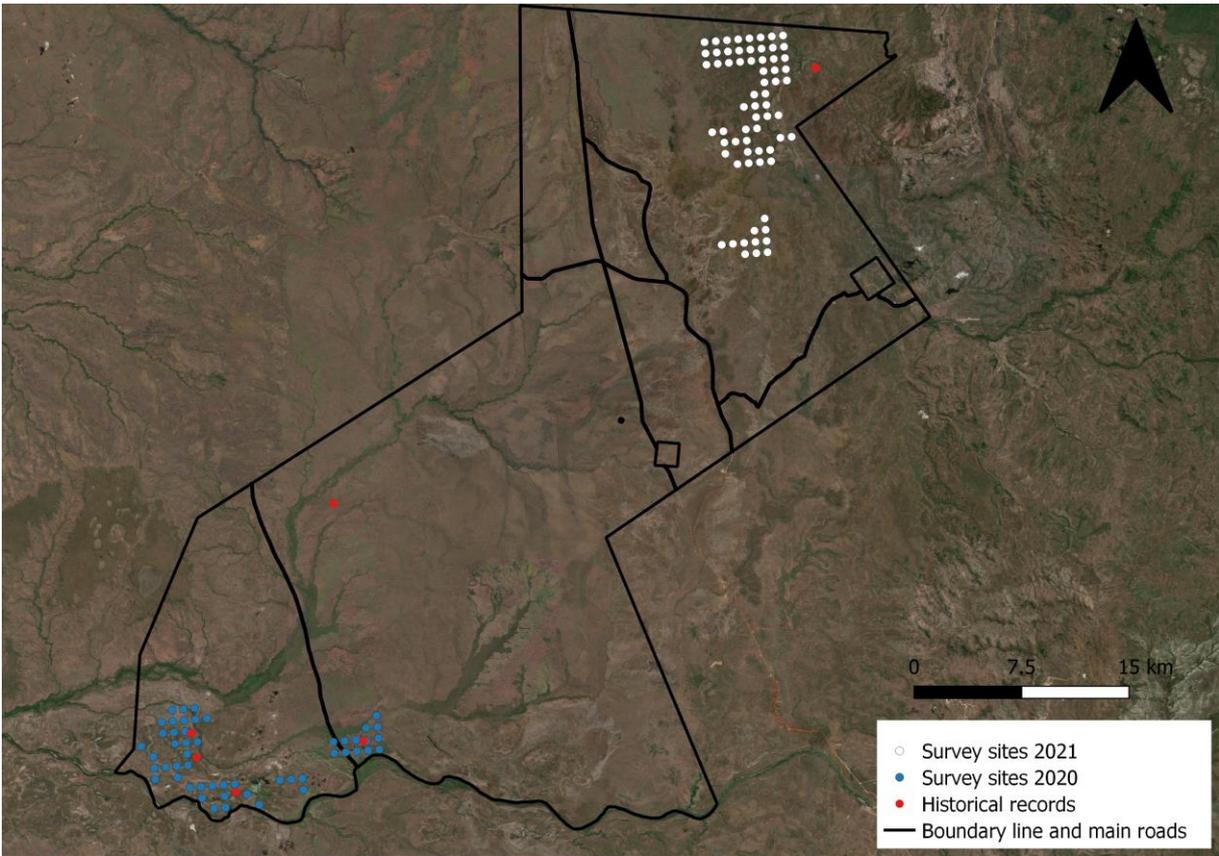
### Black-footed Tree-rat Targeted Survey

AWC has identified three woodland ecosystems as suitable habitat for the Black-footed Tree Rat (*Mesembriomys gouldii*; Figure 5). Potential sites for Targeted Surveys were stratified by habitat type based on the literature (Friend and Taylor 1985; Friend 1987; Risler 2017). Survey sites were generated by overlaying an 800 m x 800 m grid across the sanctuary. Sites were then stratified to > 1 ha patch size, within 1.5 km of a road, and accessible on foot. Sites that required traversing vine thickets or water bodies were removed. In 2021, 67 sites were established for a Black-footed Tree-rat Targeted Survey in areas with suitable habitat in the north-eastern part of the property (Figure 6). This survey was designed to complement the targeted survey undertaken in 2020 which focused on the southern end of the sanctuary near the Archer River (n=55 sites). These and past data will inform the development of future surveys to assess species status and trends to guide ongoing management decisions and ensure early detection of any serious issues that arise and to trigger timely responses.



**Figure 5. Ecosystem types identified as suitable habitat for the Black-footed Tree-rat on Piccaninny Plains.**

At each site, the data collected from two Reconyx Whiteflash cameras for a period of 14 nights was used. The cameras were placed 50 m to 80m apart, at a height of 50 cm, facing north or south, and angled down towards the bait container placed 1.5 m away (Figure 7). Bait comprised peanut butter, oats, sardines and vanilla. Cameras were set to take three consecutive photos, one second apart, with no delay between triggers.



**Figure 6. Selected sites for the Black-footed Tree-rat Targeted Surveys.** White dots represent selected survey sites in 2021, blue dots represent selected survey sites in 2020 and red dots represent historical records for the species.

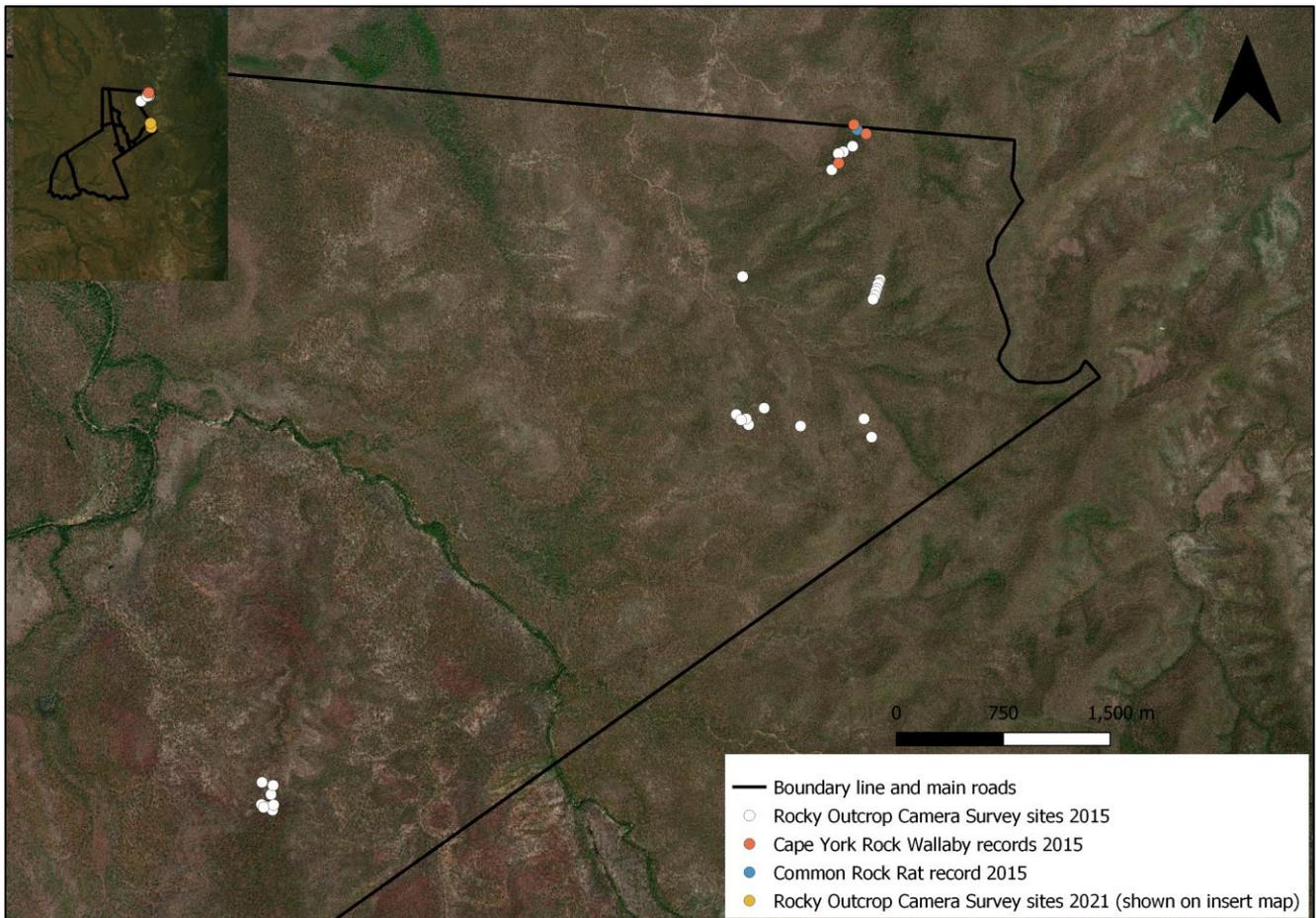


**Figure 7. Camera trap and bait set up for the Black-footed Tree-rat Targeted Survey at Piccaninny Plains.**

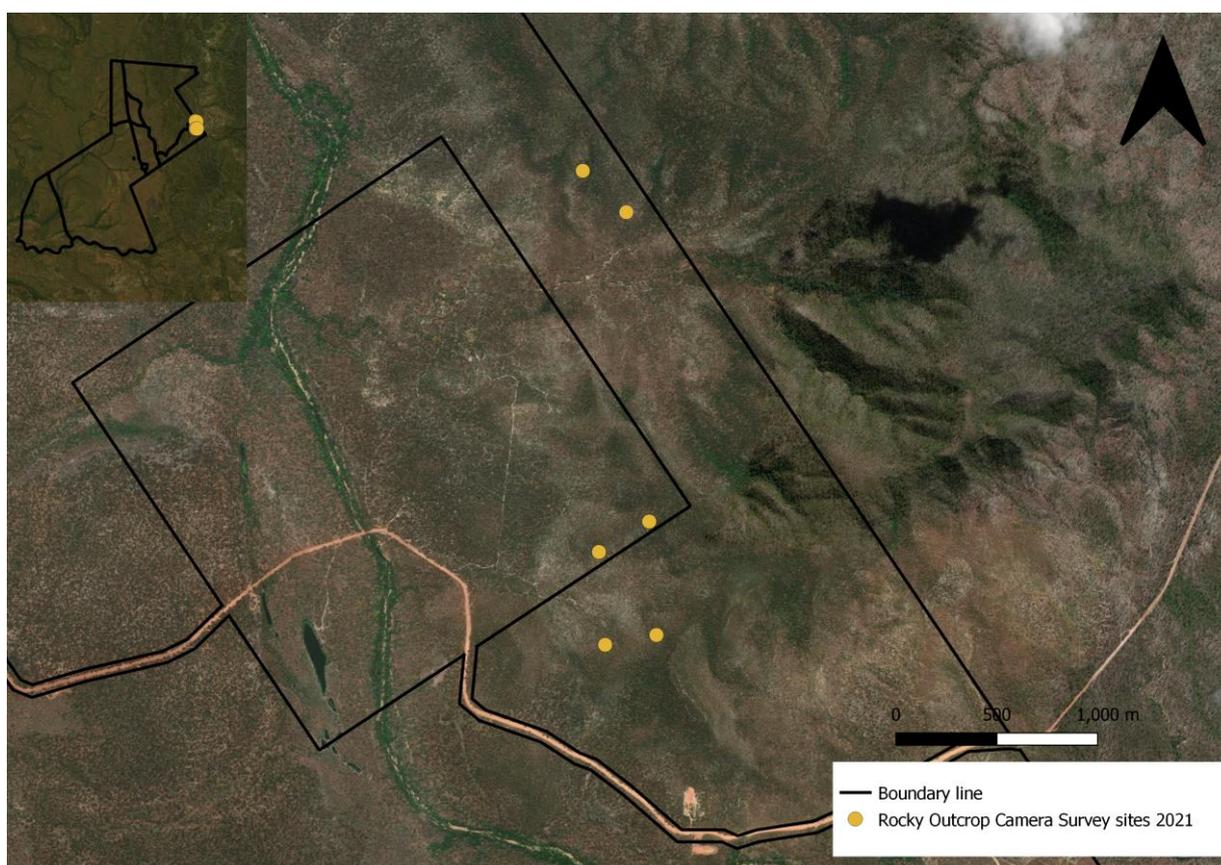
### Rocky Outcrop Camera Survey

The first Rocky Outcrop Camera Survey was undertaken in the north-east corner of Piccaninny Plains in 2015 to obtain baseline occupancy and distribution data on the Cape York Rock-wallaby, Northern Quoll (*Dasyurus hallucatus*) and Common Rock Rat (*Zyomys argurus*). In 2015, 32 sites were surveyed each with a Reconyx Whiteflash camera deployed for 30 nights in the north-eastern corner of the Sanctuary (Figure 8).

In 2021, due to access issues to survey previous sites (no landing sites for the helicopter), a new area was surveyed. In this area, six new sites were established (Figure 9), with each site being at least 250m apart. At each site, three cameras were placed at a minimum of 50 m apart. The two external cameras were baited to attract Cape York Rock-wallaby, while the middle camera was baited for Northern Quoll. All cameras were centred on a bait holder containing a bait ball comprised of either, a mixture of peanut butter, oats, vanilla and Dairy Krave to attract Cape York Rock-wallaby, or a mixture of peanut butter, oats, vanilla and sardines to attract Northern Quoll.



**Figure 8. Location of Rocky Outcrop Camera Survey Sites in 2015 and Cape York Rock-wallaby and Common Rock Rat detections.**



**Figure 9. Location of Rocky Outcrop Camera Survey Sites in 2021.**

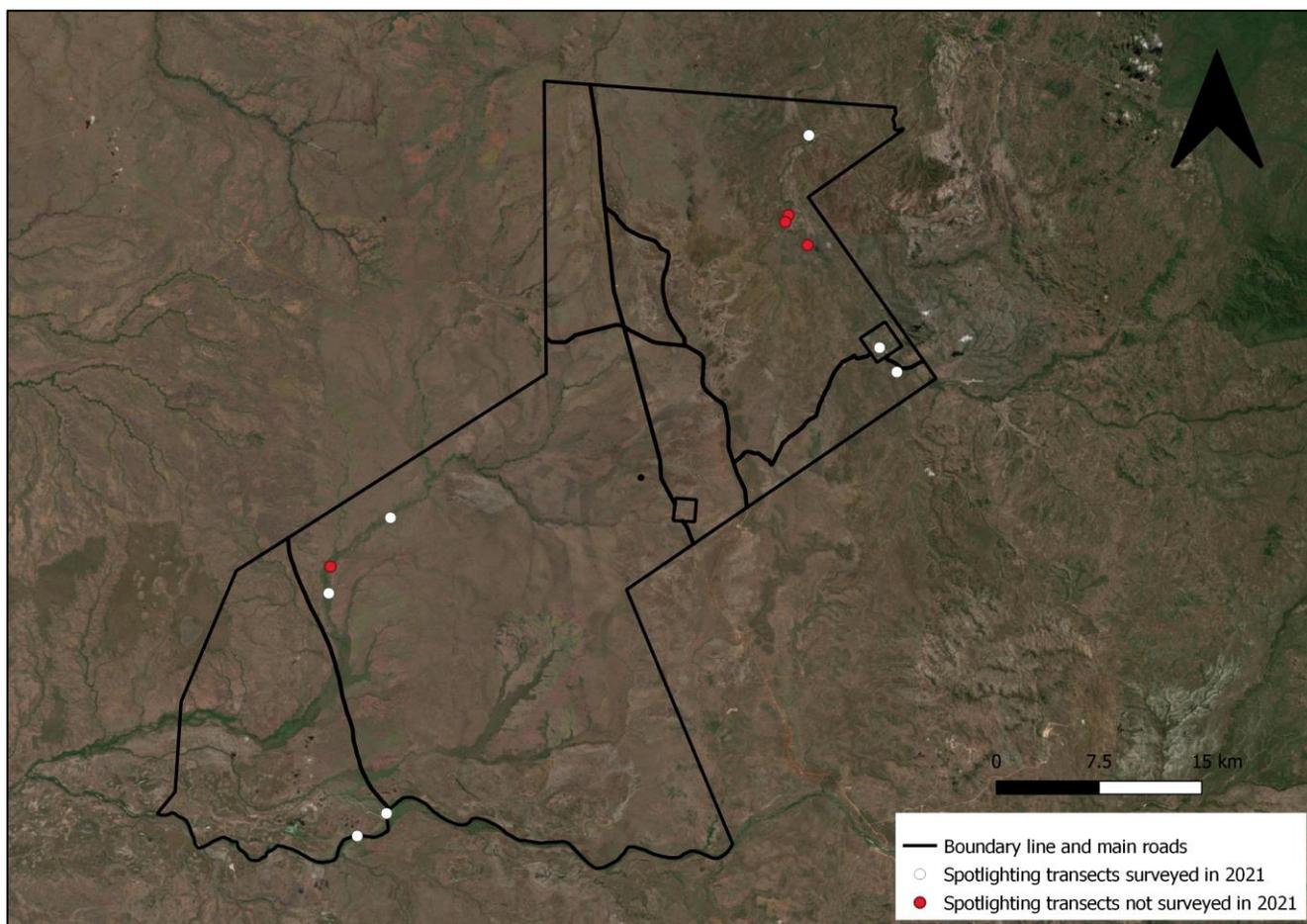
### Spotlighting Survey

To conduct Spotlighting Surveys, AWC has established 11 transects along the Archer River, Piccaninny Creek and the Wenlock River (comprising 2, 3 and 6 transects respectively; Figure 10). Transects have been conducted when access conditions and water-level allowed and usually in conjunction with the Standard Trapping Survey; as such not all of the 11 transects have been surveyed each year. Of the 11 transects, 6 transects were established and surveyed in 2014, 4 additional transect were established in 2015 and 8 transects were surveyed (4 repeated from 2014 surveys and 4 new). In 2016, 7 transect were surveyed (2 and 4 repeated transects surveyed in 2014 and 2015, respectively and 1 was new). In the years 2014-2016, transects were surveyed once. In 2021, 7 transects were surveyed with each surveyed twice (all were surveyed in previous years; Table 4).

**Table 4. Spotlighting transects location and years surveyed.**

Transect name	Location	Years surveyed
PIC_ArcherSpot01	Archer River	2015, 2016, 2021
PIC_ArcherSpot02	Archer River	2015, 2021
PIC_PCK01	Piccaninny Creek	2015, 2016, 2021
PIC_PCK06	Piccaninny Creek	2015, 2016
PIC_PCK07	Piccaninny Creek	2016, 2021
PIC_WenSpot01	Wenlock River	2014, 2015, 2016
PIC_WenSpot02	Wenlock River	2014, 2015, 2016
PIC_WenSpot03	Wenlock River	2014, 2015
PIC_WenSpot04	Wenlock River	2014, 2021
PIC_WenSpot05	Wenlock River	2014, 2021
PIC_WenSpot06	Wenlock River	2014, 2015, 2016, 2021

During these surveys, observers used 200 lumen LED head-torches to search the gallery rainforest on either side of the watercourse for nocturnal fauna. Each transect took approximately 45 minutes to complete. In 2021, transect length fluctuated between 450 and 750 m due to deep water pools persisting in some watercourses as a result of an extended wet season that reduced accessibility.

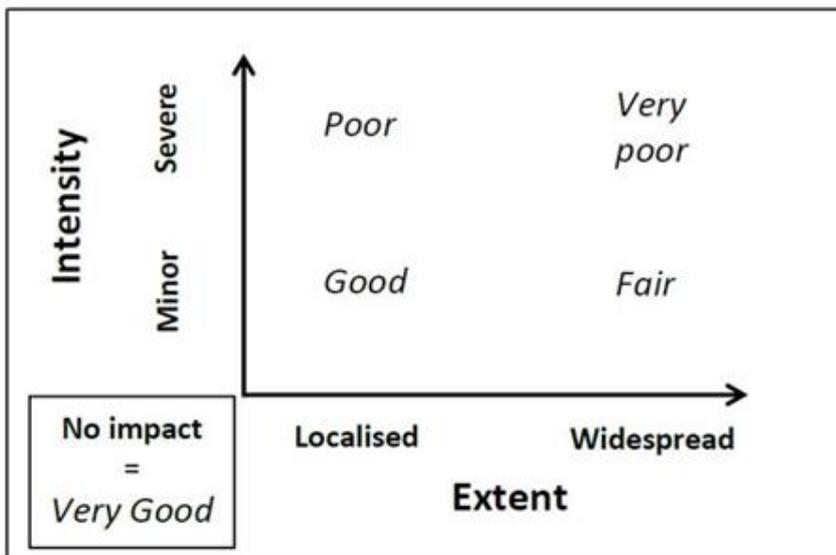


**Figure 10. Location of all spotlighting transects established at Piccaninny Plains.**

### **Wetland Condition Assessment (on-ground)**

Wetland surveys commenced in 2013 when 26 wetlands were assessed. Now, 39 individual wetland sites exist, but the total number of sites surveyed in a given year depends on access and water levels following the wet season (e.g., nine sites in the Wenlock River floodplain were inaccessible following cyclone damage in 2019).

The ‘Wetland Assessment Index Score’ is the ecological process metric for assessing the health of wetland habitats at Piccaninny Plains. It provides a rapid and repeatable metric by which damage from feral animals to these sensitive habitats can be monitored over time. This metric is based on the classification developed by Russell-Smith and Bowman (1992), which considered the intensity and the extent of the impacts of fires on vegetation (Figure 11). Based on this classification system, for the Wetland Assessment Index Score, each wetland surveyed was given an overall rating of ‘very good’, ‘good’, ‘fair’, ‘poor’ or ‘very poor’.



**Figure 11. Point assessment ratings for impacts of feral animals at wetlands.**

During the on-ground wetland surveys, an observer was located at the exact point where the assessment for each wetland had been undertaken in previous years. However, this depends on the preceding wet season, since at some sites the observation point had been underwater, or previously separated wetlands had joined. In these cases, an assessment was made at only one of the two pre-existing sites, or at the nearest location to the previous observation point. After assessing the wetland's condition, the observer gave the wetland a score of 'very good' to 'very poor' (Figure 11).

When assessing the intensity of damage, the following aspects were considered: visible water quality, health and occurrence of aquatic vegetation, bank erosion, health of surrounding vegetation, and impacts of feral animal disturbance from wallows, footprints and diggings.

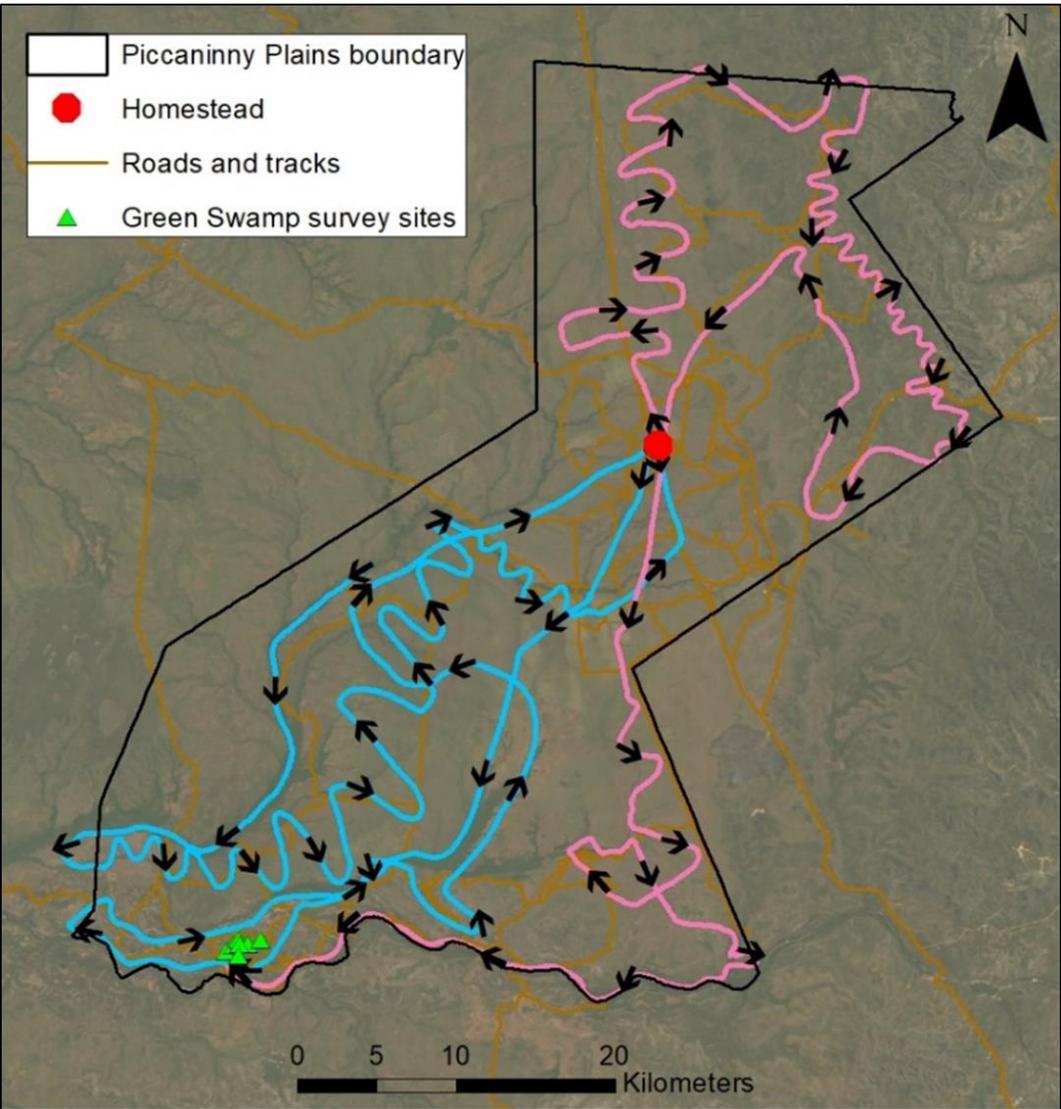
### **Wetland Condition Assessment (aerial)**

Since 2019 the condition of seven sites at Green Swamp (a subset of the existing monitoring sites) has been re-assessed during the Feral Herbivore Survey in November (Figure 12). These additional surveys provide a late dry-season assessment of condition at this important wetland (the largest on Piccaninny Plains) following the muster activities taking place in August and September.

### **Feral Herbivore Survey**

Since 2016, a fixed aerial transect covering the north and south of Piccaninny Plains has been used to survey feral herbivores (Figure 12). The survey comprises two separate aerial runs, with half of the sanctuary covered in each run. The route is flown at 300 feet above ground level and at a steady 60 knots. Depending on weather conditions, this survey is usually completed in the early morning just after sunrise, or in the early morning and late afternoon, when cattle (*Bos taurus*) are likely to be visible.

During the survey, two spotters counted the number of feral cattle (*Bos taurus*), horses (*Equus caballus*) and pigs. When one or more animals were observed, a waypoint was taken on a handheld GPS unit and the number and species were recorded. The flight path was tracked during the survey.



**Figure 12. The aerial feral herbivore survey route.** South-west of the homestead (blue) and south-east and north of the homestead (pink). At the conclusion of the survey, seven wetland sites on Green Swamp were assessed (green triangles).

## Analysis methods

Most Ecohealth metrics are common across the indicator species for Piccaninny Plains. Unless noted otherwise, the metrics are calculated as set out in Table 5 below.

As there are diverse ecosystems on Piccaninny Plains ranging from riparian rainforest to open grassland, species are assigned to a 'guild' prior to survey and analysis.

**Table 5. Metrics and associated calculations for Piccaninny Plains.**

Indicator	Metric	Survey data sources	Description	Analysis summary/calculation
Assemblage richness	Number of species	All surveys and incidental records	A measure of intactness for the whole sanctuary	The number of species detected on the sanctuary within the last 2–5 years is compared to the number of species listed as 'confirmed', 'very likely' or 'likely' on the sanctuary species list.
Various	Abundance	Black-footed Tree Rat Targeted Survey  Rocky Outcrop Camera Survey  Spotlighting Survey	A measure of activity, either number of detections per 100 trap nights, or per site  Where, 'number of detections' is captures for live trapping data; and independent 'visits' for camera traps.  In a sequence of images of a single species, a single camera 'visit' is defined as occurring when there is at least a 15 min period between the species' first capture and subsequent image.	<b>Per 100 trap nights:</b> For individual species: Calculate the average over all survey sites of: $((\text{No. individuals of that species recorded at survey site} / \text{total number of trap night at survey site}) \times 100)$  For guilds: Calculate the average of: $((\text{Total no. individuals of the guild recorded at each survey site} / \text{total number of trap night at each survey site}) \times 100)$  <b>Per site:</b> For individual species: Calculate the average over all survey sites of: $(\text{No. individuals of that species recorded at survey site} / \text{total number nights})$  For guilds: Calculate the average over all survey sites of: $(\text{No. individuals of that guild recorded at survey site} / \text{total number nights})$
Mammals, reptiles, birds	Occupancy	Black-footed Tree Rat Targeted Survey  Rocky Outcrop Camera Survey  Spotlighting Survey	A measure of distribution; the proportion of sites where the species was recorded using a particular technique	For individual species: $(\text{number of sites at which the species was recorded} / \text{number of sites surveyed}) \times 100$ if reporting as a %  For guilds: $(\text{number of sites at which any species within the relevant guild was recorded} / \text{number of sites surveyed}) \times 100$ if reporting as a %
Arboreal mammals, nocturnal birds	Richness	Spotlighting Survey	Richness: A measure of diversity; average number of species per site	Average over all sites of: $(\text{No. species of that guild recorded at survey site} / \text{total number nights})$

Indicator	Metric	Survey data sources	Description	Analysis summary/calculation
Wetlands	Wetland Assessment Index Score		A measure of wetland health	A rating of 0–4 assigned to each wetland, where: 0 = Very Good, 1 = Good, 2 = Fair, 3 = Poor and 4 = Very Poor. Mode of each year is calculated.

### Camera surveys – Black-footed Tree-rat and Rocky Outcrop Targeted Surveys

Camera data were downloaded and categorised as “animal present” or “animal absent” using the Artificial Intelligence (AI) software (Microsoft Azure and Postman). Once categorised, images with animals present were uploaded into the program ‘Timelapse’ (Greenberg et al. 2019) and animals were identified to species level where possible. A file containing all species captures was exported from Timelapse.

A 15-minute event interval was chosen for the analyses based on the use of this interval for species of a similar size and in similar habitats (e.g. Diete et al. 2016). A measure of relative abundance (abundance per 100 camera trap nights) and occupancy (percentage of sites occupied) were then calculated as per Table 4.

### Fire scar analysis

Fire scar data were derived from Landsat satellite imagery, and in later years supplemented by Sentinel-2 satellite imagery. ‘Hotspot’ data from the North Australian Fire Information (NAFI) website were used to help identify the month of the fire when the Landsat satellite imagery interval extended across two months. Each scar was attributed by year, month and season. Fire scars detected from January to July (inclusive) were attributed as ‘Early’, whereas those detected August to December were attributed as ‘Late’. For each year, unburnt areas were created by erasing the recorded fires from the entire boundary area. The maps and statistics for the analyses were created using ArcGIS (Environmental System Research Institute Inc., Redlands, CA, USA) with Spatial Analyst, and were semi-automated using Python scripting. Detailed methods are provided in Webb et al. (2022).

## Results

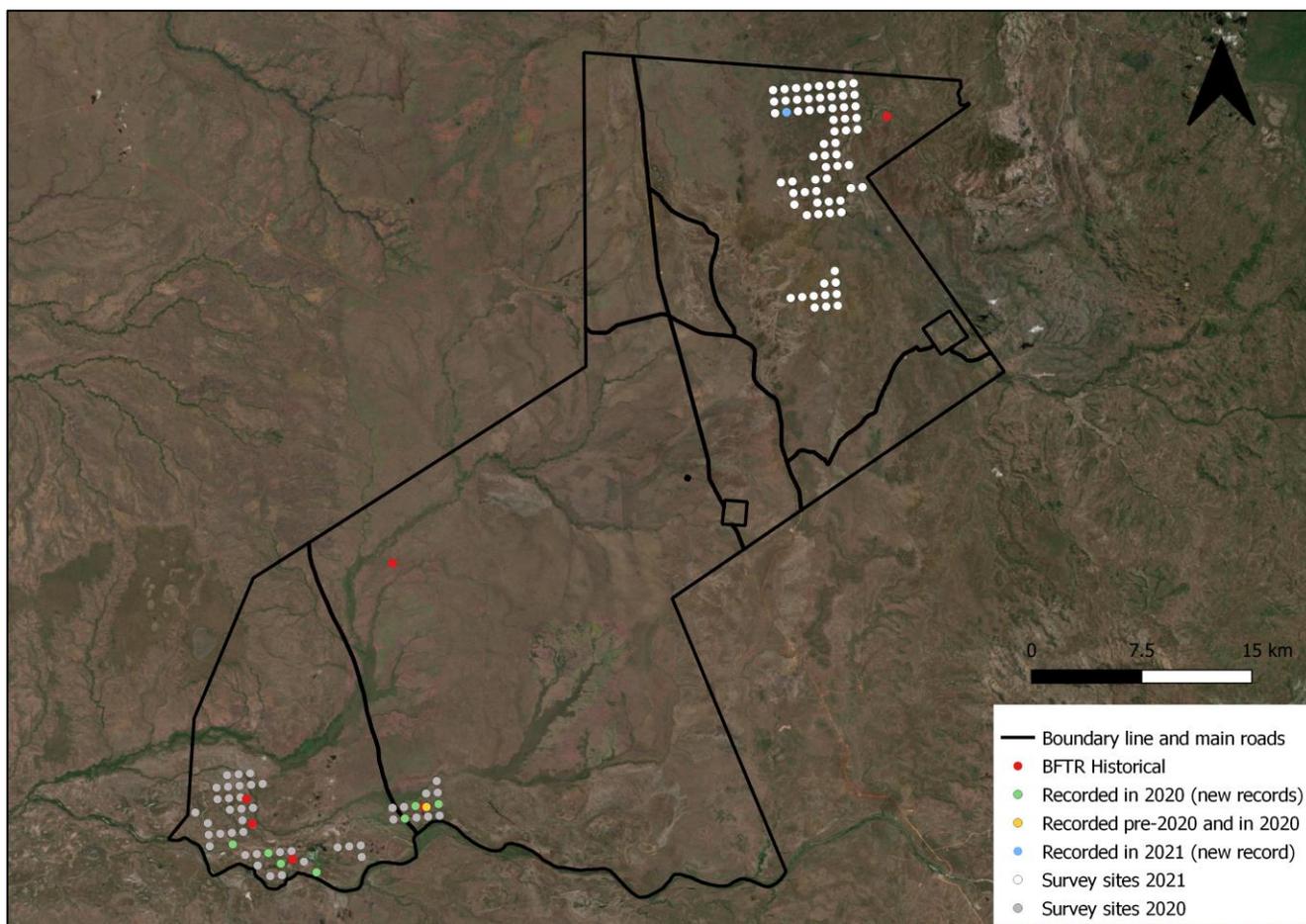
### Key threatened and iconic vertebrates

#### Black-footed Tree-rat

In total, 15 images of Black-footed Tree-rats were captured in 2021, all from a single site on a single night during the 14-day deployment period in the north-east (Figure 13). A further 25 species were detected during this camera survey (Appendix 1). Due to the small number and highly clustered (spatially and temporally) images of this species collected during the survey, and that all images were of an adult male, it was presumed that only one individual was detected. Therefore, images were not grouped to independent detections and abundance was calculated as 1 detection from 1,876 camera trap nights. Based on these results, Black-footed Tree-rat estimated abundance was 0.05 animals per 100 trap nights and occupancy was 1.5% across 66 sites.

In 2020, at the Southern edge of Piccaninny Plains, the Black-footed Tree-rat was detected on 8 of 54 sites and 20 independent detection events were recorded (Figure 13). In 2020, abundance was estimated at  $1.3 \pm 0.5$  individuals per 100 camera trap nights and an occupancy of 15% across 54 sites. In 2020 seven of the eight site records were new locations for the species, however, the species was not detected at three previously known locations. The site where the Black-footed Tree-rat was detected in 2021 is a new location for the species on Piccaninny Plains.

Including historical records, Black-footed Tree-rats have been recorded on 14 different locations on Piccaninny Plains. Out of these records, eight have occurred in ecosystem 1 (Molloy Red Box, *Eucalyptus leptophleba*, and/or Clarkson’s Bloodwood, *Corymbia clarkinsonia*, with small areas of open grassland, on alluvium or low residual plains); four in ecosystem 3 (Melville Island Bloodwood, *Corymbia nesophila* and Darwin Stringybark, *Eucalyptus tetrodonta*, on low residual plains) and two in ecosystem 2 (Melville Island Bloodwood and Darwin Stringybark on eroded residual sandstone and sandstone rises; Figure 5).



**Figure 13. Records of Black-footed Tree-rat and sites monitored during the Targeted Surveys in 2020 and 2021.**

## Vertebrate assemblages and surveillance species

### Mammals

Since 2019, 18 mammal species have been recorded at Piccaninny from 67 known, likely or very likely to occur. Undetected species were mostly bats (29 species) and other small-medium nocturnal mammals (13 species).

#### **Rocky outcrop small mammal guild**

During the 2021 Rocky Outcrop Camera Survey, AWC did not detect the Northern Quoll, the Cape York Rock-wallaby or Common Rock Rat at any of the six sites. The cameras detected seven other species (Appendix 1). The 2015 Rocky Outcrop Camera Survey was successful in detecting the Cape York Rock-wallaby. It was recorded at 3 of the 32 cameras (9% occupancy) with an average abundance of  $0.3 \pm 0.2$  individuals per 100 trap nights across the 32 sites. The Common Rock-rat was also detected at 1 site (3% occupancy) with an average abundance of  $0.1 \pm 0.1$  per 100 trap nights across the 32 sites. No Northern Quolls were detected in 2015.

#### **Arboreal mammals**

Three arboreal mammal species from 38 known or likely to occur were detected during the Spotlighting Surveys in 2021: Common Spotted Cuscus (*Spiloglossus maculatus*), Striped Possum (*Dactylopsila trivirgata*) and unidentified flying foxes. Undetected species were mostly microbats (29 out of 35) which are difficult to detect spotlighting.

In 2021, 11 Common Spotted Cuscus were detected, 1 Stripped Possum and 2 unidentified flying fox that may have been either Black Flying-fox (*Pteropus alecto*) and/or a Spectacled Flying-fox (*Pteropus conspicillatus*). Detailed metrics for this and past Spotlighting Surveys undertaken at Piccaninny Plains since 2014 can be found below in Table 6.

**Table 6. Arboreal mammal metrics derived from Spotlighting Surveys.**

Indicator	Metric*	2014	2015	2016	2021
Common Spotted Cuscus	Abundance	0.67±0.42	0.87±0.35	0.85±0.40	0.79±0.3
	Occupancy	33%	50%	57%	85%
Arboreal mammal guild	Abundance	4.5±3.9	3.63±2.6	1±0.44	1±0.24
	Richness	0.83±0.48	0.88±0.35	0.7±0.29	0.71±0.15

\*Calculations based on the following data: 2014: 6 transects (surveyed once); 2015: 8 transects (surveyed once); 2016: 7 transects (surveyed once); 2021: 7 transects (surveyed twice= 14 transects).

The Common Spotted Cuscus is the only species that has been detected every year that was surveyed. Its occupancy has increased from 33 to 85% across the four surveys, noting that survey effort has doubled between 2014 and 2021. The Striped Possum was a new detection for this survey in 2021. Arboreal mammals are detected in at least half on the transects surveyed in all years with richness per site remaining relatively stable since 2014, while the abundance has declined from 4.5 individuals per site to 1 individual per site since 2014. In the 2021 survey, the two flying foxes observed could not be identified to species level. In previous years they have been the most recorded mammal during the Spotlighting Surveys at Piccaninny Plains.

### Reptiles

Since 2019, 21 reptile species have been recorded at Piccaninny from 80 known, likely or very likely to occur. Missing species were mostly skinks and geckos (37 species) that are picked up in our Standard Trapping Surveys, which we haven't conducted within the time period; the next surveys will be in 2023. No reptile surveys were conducted in 2021.

### Birds

Since 2019, 212 bird species have been recorded at Piccaninny from 265 known, likely or very likely to occur. Missing species were largely irruptive/nomadic or cryptic species. No diurnal terrestrial bird surveys were undertaken in 2021.

#### Nocturnal birds

Five species of nocturnal birds were detected during the Spotlighting Surveys in 2021: two Australian Boobook (*Ninox boobook*), six Large-tailed Nightjar (*Caprimulgus macrurus*), six Nankeen Night Heron (*Nycticorax caledonicus*), 16 Papuan Frogmouth (*Podargus papuensis*) and Tawny Frogmouth (*Podargus strigoides*). Although known to occur on the Sanctuary, three of these species were detected by the Spotlighting Survey for the first time: Australian Boobook, Large-tailed Nightjar and Tawny Frogmouth, with 2021 recording the highest species richness (1.5 per site) since surveys began (Table 7).

Papuan Frogmouth is the only nocturnal bird species that has been detected across all years during Spotlighting Surveys, its occupancy ranges from 25 to 71%. The Nankeen Night Heron is the second most detected species (three out of four survey periods) with a slightly lower occupancy ranging from 33 to 57%.

**Table 7. Nocturnal bird metrics derived from Spotlighting Surveys.**

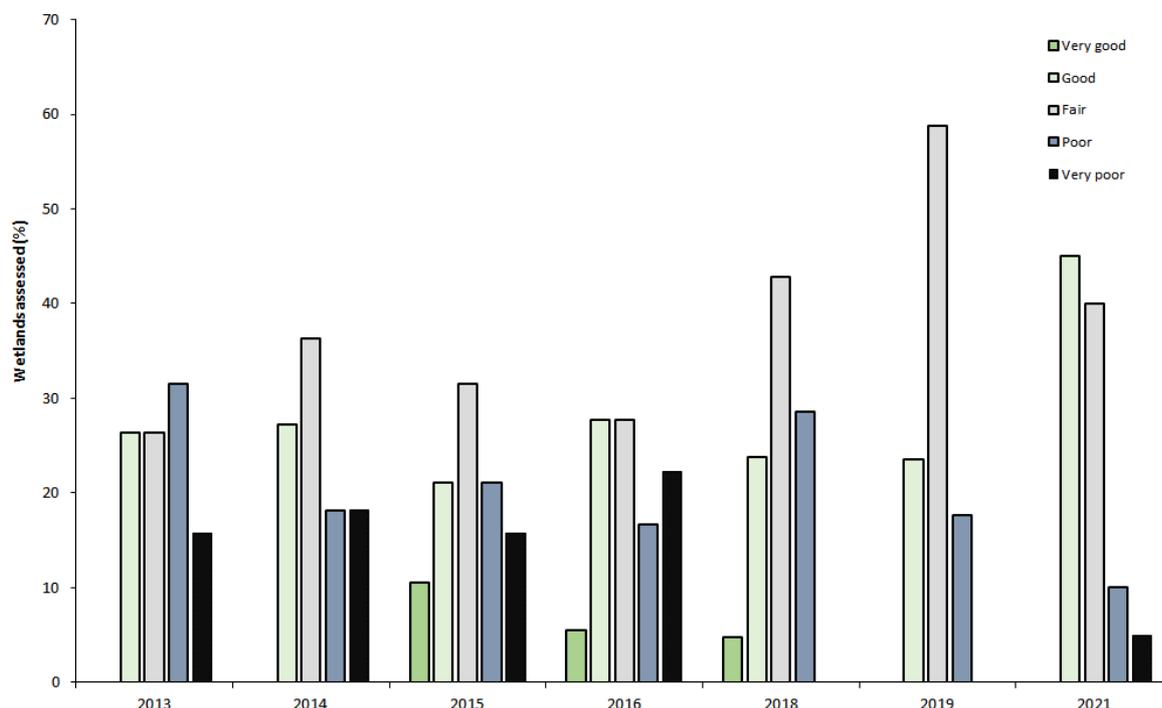
Species	Metric*	2014	2015	2016	2021
Nocturnal bird guild	Abundance	3.00 ± 1.0	0.75 ± 0.25	1.14± 0.34	2.14±0.44
	Richness	1±0.52	0.63±0.18	0.71±0.18	1.5±0.24

\*Calculations based on the following data: 2014: 6 transects (surveyed once); 2015: 8 transects (surveyed once); 2016: 7 transects (surveyed once); 2021: 7 transects (surveyed twice = fourteen transects).

### Wetland Condition Assessments

In 2021 the condition of 31 wetlands was assessed from the ground. Overall, most wetlands were in 'good' or 'fair' condition (77%, 12 in each category). Six wetlands (19%) were in 'poor' condition, and one was in 'very poor' condition (3%). Although the number of wetlands assessed each year varies due to changing weather and access conditions, 21 wetlands have been assessed at Piccaninny Plains for five to seven consecutive years. These long-term data indicate that the condition of wetlands at Piccaninny Plains has improved, with more wetlands reported in 'good' condition over the years (Figure 14). Out of these 21 long-term monitored

wetlands, 11 have improved their condition since monitoring at Piccaninny Plains started in 2013, and 10 have maintained their original condition.



**Figure 14. Wetland Condition Assessment for 21 long-term monitored sites.** This graph includes data from 2016 when most Wetland Condition Assessments were done from a helicopter (18 out of 29) and does not include data collected for Green Swamp. Data for Green Swamp is presented in the following section.

All data from the Wetland Condition Assessment for 2021 and previous years can be found on Table 8 below.

**Table 8. The number of sites in each condition at on-ground wetland monitoring sites 2013–2021.**

Condition score	2013	2014	2015	2016*	2018	2019	2021
Very good	0	0	2	1	2	1	0
Good	6	5	5	8	7	6	12
Fair	8	6	8	11	16	14	12
Poor	8	2	7	3	11	4	6
Very poor	4	2	3	6	2	1	1
<b>Mode</b>	<b>Fair/Poor</b>	<b>Fair</b>	<b>Fair</b>	<b>Fair</b>	<b>Fair</b>	<b>Fair</b>	<b>Good/Fair</b>
<b>Wetlands Assessed<sup>1</sup></b>	<b>26</b>	<b>15</b>	<b>25</b>	<b>29</b>	<b>38</b>	<b>26</b>	<b>31</b>

\*includes data from 18 sites that were assessed from a helicopter.

<sup>1</sup> Although between 5 and 7 sites of Green Swamp are assessed from the ground each year, these data were excluded from this table. Data for Green Swamp is presented in the following section.

In November 2021, the Green Swamp wetland condition assessments had a mode of ‘good’. Comparisons of condition scores pre- and post-2019 show an improvement in wetland health (mode condition scores post-2019 have been ‘fair’ to ‘good’, while the pre-2019 condition scores, which were all undertaken on-ground, and in August, had a mode of ‘fair’/‘very poor’). Although these results should be interpreted with caution, given possible subjective differences between observers and in comparing August to November assessments; the condition of the large wetland improved in November following the removal of feral cattle and pigs. Repeating assessments in both August and November in coming years will help to clarify this pattern.

**Table 9. Wetland Condition Assessment at Green Swamp 2013–2021.**

Wetland site	2013	2014	2015	2018	2019		2020	2021	
	August	August	August	August	August	November	August	August	November
Green Swamp 1	Poor	Fair	Fair	Fair	Fair	Good	Good	Fair	Good
Green Swamp 2	Fair	Fair	Fair	Good	Fair	Fair	Good	Fair	Good
Green Swamp 3	Very poor	Very poor	Poor	Fair	Fair	Good	Good	Poor	Fair
Green Swamp 4	Very poor	Poor	Very poor	Fair	Fair	Good	Good	Fair	Good
Green Swamp 5	Very poor	N.A*	Very Poor	Poor	Poor	Fair	Poor	Fair	Fair
Green Swamp 6	Very poor	Very poor	N.A*	N.A*	N.A*	Good	Poor	N.A*	Fair
Green Swamp 7	Fair	Good	N.A*	Good	Good	Good	Good	N.A*	Good
<b>Mode</b>	<b>Very poor</b>	<b>Fair/ Very poor</b>	<b>Fair/ Very poor</b>	<b>Fair</b>	<b>Fair</b>	<b>Good</b>	<b>Good</b>	<b>Fair</b>	<b>Good</b>

\*N.A = Data Not Available, site not assessed.

## Threat indicators

### Feral animals

In November 2021, 269 feral cattle and seven horses were recorded during the Feral Herbivore Survey. Numbers of feral cattle increase at Piccaninny Plains later in the dry season, when water bodies dry out in the region, and feral cattle move towards the permanent lagoons on Piccaninny Plains. Undertaking the Feral Herbivore Survey in November helps AWC assess the number of feral cattle, horses and pigs when their numbers should be highest. Current and historical data from the Feral Herbivore Survey is shown in Table 10 and Figure 15.

**Table 10. Results of the 2020 Feral Herbivore Survey.**

Year	Cattle	Horses	Pigs
2016	442	75	91
2017	329	51	8
2018	376	27	0
2019	275	7	1
2020	185	17	0
2021	269	7	0

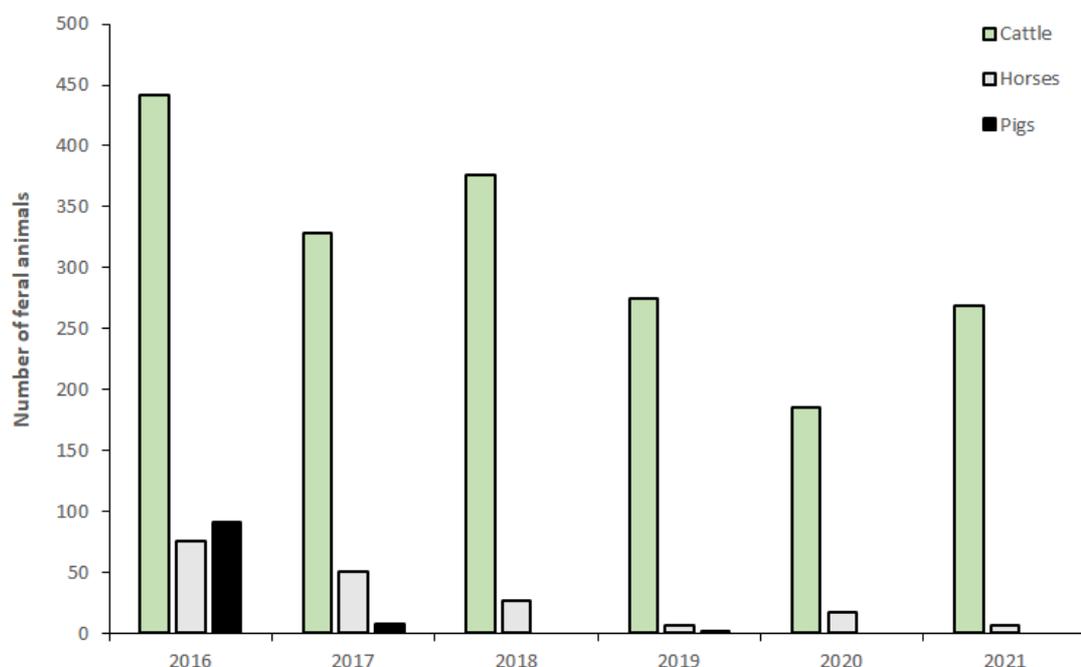


Figure 15. Number of feral animals recorded on Piccaninny Plains from 2016 to 2021.

### Fire

Active fire management began in 2009. AWC implements fire management on Piccaninny Plains in accordance with strategies developed in partnership with TLLF-WildlifeLink.

All key fire metrics on Piccaninny Plains have improved since implementation of active fire management in 2009 (Table 11). The extent and frequency of late dry season fires have been substantially reduced since 2009 and the cumulative area burnt by late dry season fire has been reduced. Fire management has also reduced distances to unburnt vegetation from within fire scars. Despite a large increase in the area of early dry season prescribed fire, the total area burnt annually on Piccaninny Plains has declined since 2009, reflecting the improved and strategic fire management.

Table 11. Fire metrics for Piccaninny Plains for 2021.

Metric	Baseline average 2000/02–2008	AWC Management average	2021 result	Trend (AWC vs baseline)	Trend (2021 vs baseline)
Area burnt by early dry season (EDS) fire (%)	22	37	27	↑	↑
Area burnt by late dry season (LDS) fire (%)	54	18	16	↓	↓
Cumulative extent burnt by LDS fire in past 3 years (%)	90	42	32	↓	↓
Mean distance to unburnt vegetation (km)	1.8	1.0	0.8	↓	↓
Mean distance to vegetation unburnt by LDS fire for 3 or more years (km)	2.7	1.1	0.9	↓	↓

**Notes:**

Area-base metrics are expressed as % of the 164,862 ha sanctuary.

**Baseline** values for metrics are the average for the years immediately prior to acquisition of Piccaninny Plains by AWC: i.e., 2000–2008, the years immediately prior to acquisition of Piccaninny Plains by AWC and TLLF-WildlifeLink.

**AWC management** values for metrics are the average for the years following acquisition of Piccaninny Plains by AWC: i.e., 2009 onwards, for annual metrics, and 2002 onwards, for 3 year metrics.

**Trend:** change in metric compared with baseline, considering (i) average across AWC management; (ii) current year. Change in magnitude shown by arrows: increase ↑, no change ↔, reduction ↓.

Inferred consequences for ecological health depicted by colour: improving in green (e.g., ↑ or ↓, depending on the metric); deteriorating in red (e.g., ↑ or ↓); no change, or if the change cannot be interpreted in terms of ecological health, in black. (↔, ↑ or ↓).

## Discussion

This Ecohealth report summarises the results of the 2021 surveys conducted under the Ecohealth Monitoring Program. In implementing the Ecohealth program at Piccaninny Plains in 2021, AWC conducted 2,362 camera trap nights, 32 wetland condition assessments, 572 km of aerial feral herbivore survey and 14 transects surveying arboreal mammals and nocturnal birds. These surveys detected 16 mammals, 18 birds, 2 reptiles and 1 amphibian species. Where available, results from surveys conducted in previous years (2013-2020) provided baseline numbers for comparison.

The results of the two targeted Black-footed Tree-rat surveys are positive: the combined results have increased the number of sites where the species has been detected on Piccaninny Plains to 14. Further surveys are needed across Piccaninny Plains to determine distribution and habitat requirements for the species before a long-term ecological survey is established. Like most Australian mammals, it is likely the species experience intrinsic population fluctuations that align with environmental variables, such as resource availability, rainfall and fire.

During the 2021 Rocky Outcrop Camera Survey, AWC did not detect the Northern Quoll, the Cape York Rock-wallaby, or Common Rock Rat. The most suitable habitat for these species is the remote outcrops in the North-east of Piccaninny Plains. AWC were not able to access this area in 2021 due to lack of landing spots for a helicopter.

The Spotighting Surveys in 2021 resulted in the highest richness for nocturnal birds since the surveys began in 2014 and almost twice the abundance compared to 2016. Arboreal mammals were found at a similar abundance and richness in 2021 compared to 2016, but both of these metrics have decreased since 2014 and 2015.

The number of feral herbivores at Piccaninny Plains continues to decrease since surveys began in 2016. The mode of the wetland condition at Green Swamp has remained stable, in 'good' condition, since 2019, suggesting that the continued removal of feral cattle and pigs from Piccaninny Plains benefits the sensitive wetland ecosystems. Historical data shows that the condition of long-term monitored wetlands is also improving, highlighting the importance of the on-going management efforts. AWC undertake different strategies to reduce the number of feral animals in the Sanctuary including mustering of feral cattle and shooting of horses and pigs. The results of these efforts are reflected not only in the lower number of feral herbivores, but also in the good condition of the wetlands across Piccaninny Plains.

Since active fire management began in 2009 the extent of late dry season fires has been substantially reduced, with only 16% of the sanctuary being affected by late dry season fires in 2021. The fire management program has also reduced distances to unburnt vegetation from within fire scars (1.8 km before fire management vs 0.8 km in 2021). Despite a large increase in the area of early dry season prescribed fire, the total area burnt annually on Piccaninny Plains has declined since 2009, reflecting the improved and strategic fire management (76 % before 2009 vs 42% in 2021). These results highlight the effectiveness of AWC's fire management approach.

## Acknowledgments

AWC acknowledges the Wik and Wik Way people, the Traditional Custodians, of Wik and Wik Way Country on which Piccaninny Plains resides. We also acknowledge their continuing connection to land, culture and community. We pay our respects to Wik and Wik Way Elders past present and emerging.

AWC's Ecohealth Program on Piccaninny Plains is only possible because of the generosity of AWC's supporters and the partnership with the Tony and Lisette Lewis Foundation.

The North-east Science team is grateful for the assistance from the Piccaninny Plains Sanctuary Managers, Graham Woods and Sally Gray, during the 2021 surveys and for undertaking the 2021 aerial feral survey and wetland assessment.

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## Appendices

### Appendix 1. List of species detected at Piccaninny Plains in 2021.

Complete list of species detected at Piccaninny Plains during the 2021 field season.

Incidental Record: Refers to species detected while in the field that are not part of a particular survey and are recorded in Fulcrum.

Scientific Name	Common name	Detection method
<i>Aegotheles cristatus</i>	Australian Owlet-nightjar	BFTR Targeted Survey
<i>Alectura lathami</i>	Australian Brushturkey	BFTR Targeted Survey/Incidental Record
<i>Anhinga novaehollandiae</i>	Australasian Darter	Incidental Record
<i>Antaresia maculosa</i>	Spotted python	Incidental Record
<i>Boiga irregularis</i>	Brown tree snake	Incidental Record
<i>Bos taurus</i>	European Cattle	BFTR Targeted Survey/Incidental Record
<i>Burhinus grallarius</i>	Bush Stone-curlew	Incidental Record
<i>Canis dingo</i>	Dingo	BFTR Targeted Survey/Incidental Record
<i>Caprimulgus macrurus</i>	Large-tailed Nightjar	Spotlighting Survey
<i>Centropus phasianinus</i>	Pheasant Coucal	BFTR Targeted Survey
<i>Chlamydera nuchalis</i>	Great bowerbird	BFTR Targeted Survey
<i>Chlamydosaurus kingii</i>	Frilled-neck lizard	Incidental Record
<i>Corvus orru</i>	Torresian Crow	BFTR Targeted Survey
<i>Cracticus mentalis</i>	Black-backed butcherbird	BFTR Targeted Survey
<i>Cracticus quoyi</i>	Black butcherbird	Rocky-outcrop Camera Survey
<i>Crinia deserticola</i>	Desert Froglet	Incidental Record
<i>Dacelo leachii</i>	Blue-winged Kookaburra	BFTR Targeted Survey
<i>Dacelo novaeguineae</i>	Laughing kookaburra	BFTR Targeted Survey
<i>Dactylopsila trivirgata</i>	Striped Possum	Spotlighting Survey
<i>Dendrocygna guttata</i>	Spotted Whistling Duck	Incidental Record
<i>Diporiphora jugularis</i>	Black-throated Two-pored Dragon	Incidental Record
<i>Dromaius novaehollandiae</i>	Emu	BFTR Targeted Survey
<i>Equus caballus</i>	Horse	BFTR Targeted Survey/Incidental Record
<i>Felis catus</i>	Feral cat	BFTR Targeted Survey
<i>Furina tristis</i>	Brown-headed snake	Incidental Record
<i>Geopelia humeralis</i>	Bar-shouldered Dove	BFTR Targeted Survey
<i>Geopelia placida</i>	Peaceful Dove	BFTR Targeted Survey
<i>Grus antigone</i>	Sarus Crane	Incidental Record
<i>Hydromys chrysogaster</i>	Water rat	Incidental Record
<i>Isodon</i> sp.	northern brown bandicoot or Short-nosed bandicoot	BFTR Targeted Survey
<i>Lialis burtonis</i>	Burton's legless lizard	Incidental Record
<i>Liasis fuscus</i>	water python	Incidental Record
<i>Litoria bella</i>	Cape York Graceful Tree Frog	Incidental Record

Scientific Name	Common name	Detection method
<i>Lophoictinia isura</i>	Square-tailed kite	Incidental Record
<i>Macropus agilis</i>	Agile Wallaby	BFTR Targeted Survey/Incidental Record
<i>Macropus antilopinus</i>	Antilopine Wallaroo	BFTR Targeted Survey/Rocky-outcrop Camera Survey/Incidental Record
<i>Macropus robustus</i>	Common wallaroo	Rocky-outcrop Camera Survey
<i>Mesembriomys gouldii rattoides</i>	Black-footed Tree-rat (north Queensland)	BFTR Targeted Survey
<i>Morelia amethystina</i>	Amethystine python	Incidental Record
<i>Morelia</i> sp.	Python	Incidental Record
<i>Ninox boobook</i>	Australian Boobook	BFTR Targeted Survey/Spotlighting Survey/Incidental Record
<i>Nycticorax calidonicus</i>	Nankeen Night Heron	Spotlighting Survey/Incidental Record
<i>Oxyuranus scutellatus</i>	Coastal taipan	Incidental Record
<i>Podargus papuensis</i>	Papuan frogmouth	Spotlighting Survey/Incidental Record
<i>Podargus strigoides</i>	Tawny Frogmouth	Spotlighting Survey/Incidental Record
<i>Pteropus alecto</i>	Black Flying-fox	Incidental Record
<i>Pteropus scapulatus</i>	Little Red Flying-fox	Incidental Record
<i>Pteropus</i> sp.	Flying-fox	Spotlighting Survey
<i>Ptiloris magnificus</i>	Magnificent Riflebird	Incidental Record
<i>Rhinella marina</i>	Cane Toad	BFTR Targeted Survey/Rocky-outcrop Camera Survey/Incidental Record
<i>Sminthopsis virginiae</i>	Red-cheeked dunnart	BFTR Targeted Survey
<i>Spilocuscus maculatus</i>	Common Spotted Cuscus	Spotlighting Survey
<i>Stegonotus australis</i>	Slatey-grey Snake	Incidental Record
<i>Strepera graculina</i>	Pied currawong	Rocky-outcrop Camera Survey
<i>Sus scrofa</i>	Feral pig	BFTR Targeted Survey/Incidental Record
<i>Tachyglossus aculeatus</i>	Short-beaked Echidna	Rocky-outcrop Camera Survey
<i>Trichosurus vulpecula</i>	Common Brushtail Possum	BFTR Targeted Survey/Incidental Record
<i>Tropicagama temporalis</i>	Northern Water Dragon	Incidental Record
<i>Tyto javanica</i>	Eastern Barn Owl	Incidental Record
<i>Tyto novaehollandiae kimberli</i>	Northern masked owl	Incidental Record
<i>Varanus panoptes</i>	Yellow-spotted Monitor	BFTR Targeted Survey/Incidental Record
<i>Varanus</i> sp.	Monitor	Rocky-outcrop Camera Survey

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