Northern Quoll Monitoring Report

Mount Emerald Wind Farm (2021)

4 elements

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Revision History

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1.0 Summary

The following report provides data from targeted Northern Quoll and BioCondition monitoring carried out on two sites at Mount Emerald Wind Farm (MEWF), and three control sites located on the Walsh River, Brooklyn Reserve and Davies creek. This monitoring program has been conducted to satisfy conditions of approval relating to Northern Quoll Management under Mount Emerald Wind Farm's Approval under the *Environmental Protection and Biodiversity Conservation Act 1999* (2011/6228). The methodology complies with the approved Mount Emerald Wind Farm, Northern Quoll Outcomes Strategy, December 2016, R76073/PR130417-2 (Quoll Outcome Strategy).

Non-target data on wild dog/dingo, feral cat, and toad were also captured on camera traps. Three sampling periods occurred in 2021 (March, July and October), with cameras deployed at each site for a minimum of 14 trap nights. Trapping grids at each site consisted of 36 camera survey points, encompassing 306.25 ha at each survey site, with 180 survey points overall (1,531.25 ha). This report follows prior monitoring by the University of the Sunshine Coast (Burnett et al. 2019) which investigated if a similar trajectory in number and occupancy of Northern Quoll were observed between MEWF and control sites during construction, and wind farm operations. BioCondition sampling occurred within each site, as per the sampling carried out by Burnett et al. (2019). If quoll numbers, or occupancy were to significantly differ between MEWF and control sites, the Quoll Outcome Strategy requires a management action by MEWF to reduce impact and to protect these populations.

Our data identifies a significant difference in estimated quoll populations amongst the samples during this study, which is likely to be a seasonality factor influencing quoll numbers at all sites. There was no interaction, and no effect of treatment on quoll numbers (impact or control sites). Occupancy data identified a similar trend, with no effect of treatment on quoll occupancy, however again there were an effect of season. Essentially, whatever patterns are seen at Mount Emerald in quoll numbers and occupancy is occurring across all sites, and therefore not an effect of wind farm operations.

Additionally, there was no overall effect of treatment (wind farm vs control) on feral animal numbers across the sites. Whilst not statistically significant, due to limited cat data, there did appear to be decline in quolls where cats were present. The methodology was not established to specifically target cats, however, as cats were only detected on the wind farm sites and Walsh River. Further monitoring and targeted control of feral animals is planned for MEWF in 2022, to mitigate future impacts on Northern Quoll populations.

There was no effect of vegetation based on the measured habitat metrics assessed, nor season on quoll populations across the sites from this study.

In summary, the data suggests Mount Emerald Wind Farm is not affecting number or occupancy of Northern Quoll during our study period.

2.0 Introduction

The Mount Emerald Wind Farm site is located approximately 20 km SSW of Mareeba on the Atherton Tablelands in North Queensland at the northern extent of the Herberton Range. Construction of the MEWF was completed in 2019 and now operates as a generator within the National Electricity Market.

The northern half of the project site has broad, rolling hills, with dissected areas found in ravines and gorges; whereas the land to the south of the existing 275 kV powerline is markedly rugged and steeply dissected, rendering the highest points a series of narrow ridges and rocky knolls with steep drop-offs on adjacent slope faces. A total of 53 individual wind turbine pads have been connected by a network of constructed access roads, some of which accommodate underground cabling. Further cleared areas, running parallel to this road infrastructure, were constructed for additional cabling requirements. A substation and contractors' compound have been constructed approximately central to the road network on the project site.

The project received approval under the *Environmental Protection and Biodiversity Conservation Act 1999* (2011/6228), which stipulated provisions for the management of construction and operational activities where the Northern Quoll is known to inhabit. Conditions 7 of the Approval requires that a viable population of the Northern Quoll be maintained at the wind farm site. The methodology for monitoring and developing adaptive management actions are described in the approved *Mount Emerald Wind Farm, Northern Quoll Outcomes Strategy, December 2016, R76073/PR130417-2 (Quoll Outcome Strategy)*. Monitoring has occurred through construction and operations through 2017-2019 by the University of the Sunshine Coast, which concluded no evidence of changes in the population of quolls across the survey period. This 2021 report follows the work completed by the University of the Sunshine Coast and satisfies the requirements of the Quoll Outcome Strategy.

The Northern Quoll, *Dasyurus hallucatus*, is listed by both the IUCN and Australian Federal Government as 'Endangered'. Large-scale population decline and numerous localised extinctions have occurred across most of north-eastern Australia (Covacevich and Archer 1975, Burnett 1997, Woinarski et al. 2008). This species is known to have declined due to the spread of Cane Toads which poisons quolls when predated upon. Cane Toads reached southern Cape York around 1980, and by 1995 had reached the tip of the Cape. Decline has occurred sequentially with toad incursion, from Queensland, west across the Top End of Australia towards Western Australia. The expiration of numerous populations has now been well documented in the Northern Territory (Woinarski et al. 2011). Woinarski et al. (2014) estimates the overall national population decline in the last decade to be >50%, with an estimated further >50% loss predicted for the remaining populations in the following decade . However, some populations are showing signs of toad avoidance in some limited areas of North Queensland, with documented field observations on camera traps from Brooklyn Station (Australian Wildlife Conservancy, unpublished data), South Endeavour Station (Starr et al. 2016) and Caloola Station (Starr and Waller 2017).

Additional known threats to the species are inappropriate fire regimes (Andersen. 2012), predation by feral cats and wild dogs (Hill and Ward 2010).

The national recovery plan recommends future emphasis on protecting key populations of Northern Quoll across its range (Hill and Ward 2010). The MEWF site consists of dry forests on the northern tablelands and the hills and slopes are identified by prior studies as important refugia for this species (Burnett et al. 2013). Prior monitoring at the Mount Emerald site monitored key vegetation attributes, as well as feral carnivores and cane toads (Burnett et al 2019), with the goal of better understanding any changes in quoll numbers. Data from this former study involved 6 survey periods, and provided assessment of trends in individuals, modelled population size and occupancy compared to control sites. Seasonal progress reports identified no obvious change in quoll numbers (however some change in occupancy), or the habitat metrics that were monitored. Data were further analysed in a comprehensive report, and this provided observations regarding variation in the quoll population through the survey period, when construction was occurring. The final report suggested a potential decline in juveniles and reduced breeding success in the time since construction-however this was not statistically conclusive. This study is a continuation of the earlier work, where similar data collection and analysis were carried out, to assess if populations and habitat variables have remained consistent in the years since construction, and with ongoing management at the site.

3.0 Methods

Plot based camera trapping and BioCondition transect assessments were carried out on two impact sites (Mt Emerald 1 and 2) located on Mount Emerald Wind Farm, and three nearby control sites (Walsh River, Brooklyn Sanctuary and Davies Creek). Each site had a 6 x 6 station grid, with each trap placed 350 m apart, as specified in the Quoll Outcome Strategy. This gave 36 survey points, encompassing 306.25 ha at each survey site, and 180 survey points overall (1,531.25 ha).

3.1 Camera trapping

Camera traps were baited at each survey point to collect data on Northern Quoll which were used to carry out capture-recapture and site occupancy analysis. Data on Dingo/ild dog *Canis familiaris/Dingo*, feral cat *Felis catus*, feral pig *Sus scrofa* and Cane Toad *Rhinella marina* were also collected to record relative abundance of these species; however, we note this is not considered an ideal monitoring tool to accurately monitor some of these species. Three samples were recorded at each site in 2021. Cameras were deployed for 14 days at each sampling period. Figure 1 and Table 1 identify the location of survey sites for this study.

RECONYX Hyperfire® (HC550 and HP2W) and Bolyguard® (SG 562-C and 2060-D) camera traps were placed at each sample location (**Plate 1**). Cameras were mounted horizontally on a picket or tree trunk, 150 cm above the bait station, aimed perpendicularly to the ground as per former sampling periods (Burnett et al 2019). The bait cannister consisted of a PVC plumbing cowl secured at each end with a plumbing cap and ventilation cowl. These contained chicken necks to lure quolls to the camera station. Reconyx camera traps were deployed for a minimum of 14 trap nights, operating for 24 hours, taking three images per event.

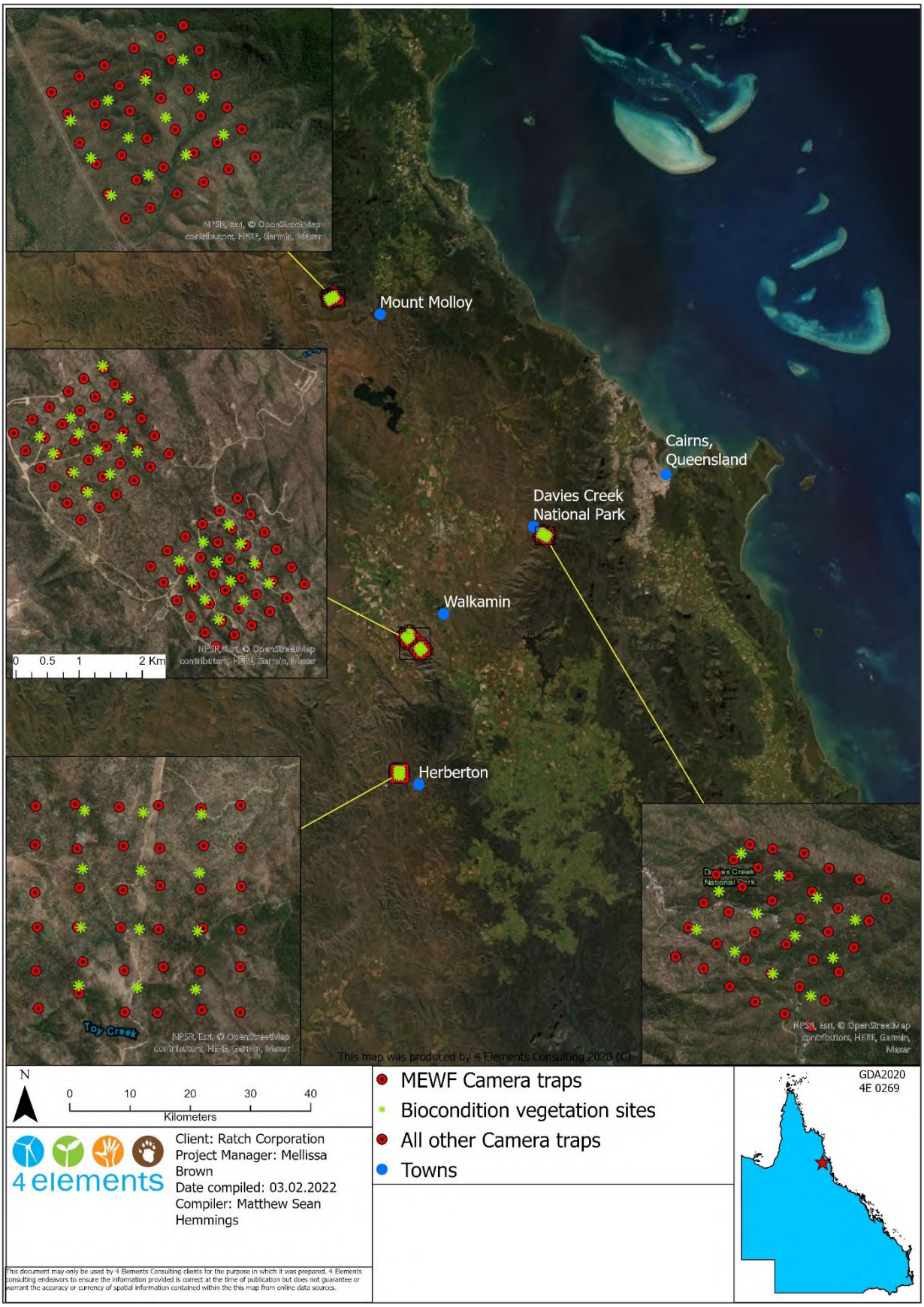

Figure 1. Location of the camera trapping stations, and BioCondition locations surveyed during this study.

Table 1. Site locations and survey periods across the three census periods.

Site	Type	Monitoring dates		
		Survey 1	Survey 2	Survey 3
Mt Emerald 1	Impact	22/02-21-08/03-21	12/7/21-26/7/21	5/10/21-19/10/21
Mt Emerald 2	Impact	24/02/21-10/03/21	14/7/21-29/7/21	6/10/21-22/10/21
Brooklyn Sanctuary	Reference	15/03/21-1/04/21	16/7/21-3/8/21	28/10/21-17/11/21
Davies Creek	Reference	30/03/21-13/04/21	4/8/21-18/8/21	25/10/21-8/11/21
Walsh River	Reference	22/03/21-7/04/21	6/8/21-20/8/21	3/11/21-18/11/2021

Plate 1. The camera facing the bait station, allowing for a horizontal image of the quolls and their individual markings.

3.2 BioCondition Assessments

Habitat census involved a modified BioCondition method (Burnett et al. 2019), originally developed by Eyre et al. (2011). The modification involved an increase to the woody debris plot to 100 x 200 m (originally 50 x 20 m). Surveys were carried out at half of the trapping locations at each quoll monitoring census (Figure 1). BioCondition

plots were located so that the camera point was the centre point of the transect, except where the terrain meant this was not possible.

3.3 Data Analysis

3.3.1 Fauna data

All images were tagged in EXIF PRO® by species and individual, with the data used for further analysis in *camptrapR* (Niedballa et al. 2017) within the R statistical environment (R core Team 2016). Data was first checked to ensure the time and date were correct in each of the images to allow for correction prior to analysis. This species-specific interval was determined with photographic data of known individuals identified by natural marking to be 15 minutes for the Northern Quoll (Diete, Meek et al. 2016), and this were used for analysis. Non-target species were not able to be identified down to the individual.

As per prior monitoring by Burnett et al. (2019) Northern Quolls were assessed at each site and session using the following analysis:

- Minimum number known to be alive (KTBA)- this is the number of unique individuals photographed and identified in each of the sampling sessions;
- Estimate of population size using R-package *RMARK* ;
- A Naïve occupancy- the number of camera trap stations where quolls were detected, and expressed as a proportion of all those stations;
- Occupancy estimate generated using the R-package *unmarked* (Fiske 2011)

3.3.2 Habitat metrics

Vegetation sampling followed the prior methodology which used a modified BioCondition assessment at the site by Burnett et al. (2019), which recorded:

- Recent fire history;
- Woody debris at 20 m x 100 m plots;
- Species richness of trees, shrubs, grasses and forbs;
- Average percent of bare ground cover across five $1m^2$ quadrats separated by 10 m along a 100 m transect. Data were recorded on native perennial and annual grass cover, native forbs, native shrubs (‹1 m height), non-native grasses, non-native forbs, litter, rocks and cryptograms;
- Length of canopy cover; and
- Shrub cover along the same 100 m transect.

4.0 Results

4.1 Quoll populations

There were 422 distinct quoll observations during this sampling period. This ranged from 0 to 30 individuals per site sampled (mean = 11.3 individuals, SD=8.1), with the highest estimates identified on Brooklyn Reserve, and lowest in the Walsh River control site (Figure 2).

There was a significant difference in estimated quoll populations amongst the samples (p=<0.01), however, no interaction and no effect of treatment (impact or control site) (Table 2).

Table 2. Mixed effects linear model testing effect of treatment and season on estimated population size of Northern quoll.

	Num DF	Den DF	F-value	P-value
Intercept	1	531	7.52	0.006
Treatment	1	3	0.06	0.81
Sample	2	531	10.12	<0.01
Treatment: Sample	2	531	0.70	0.49

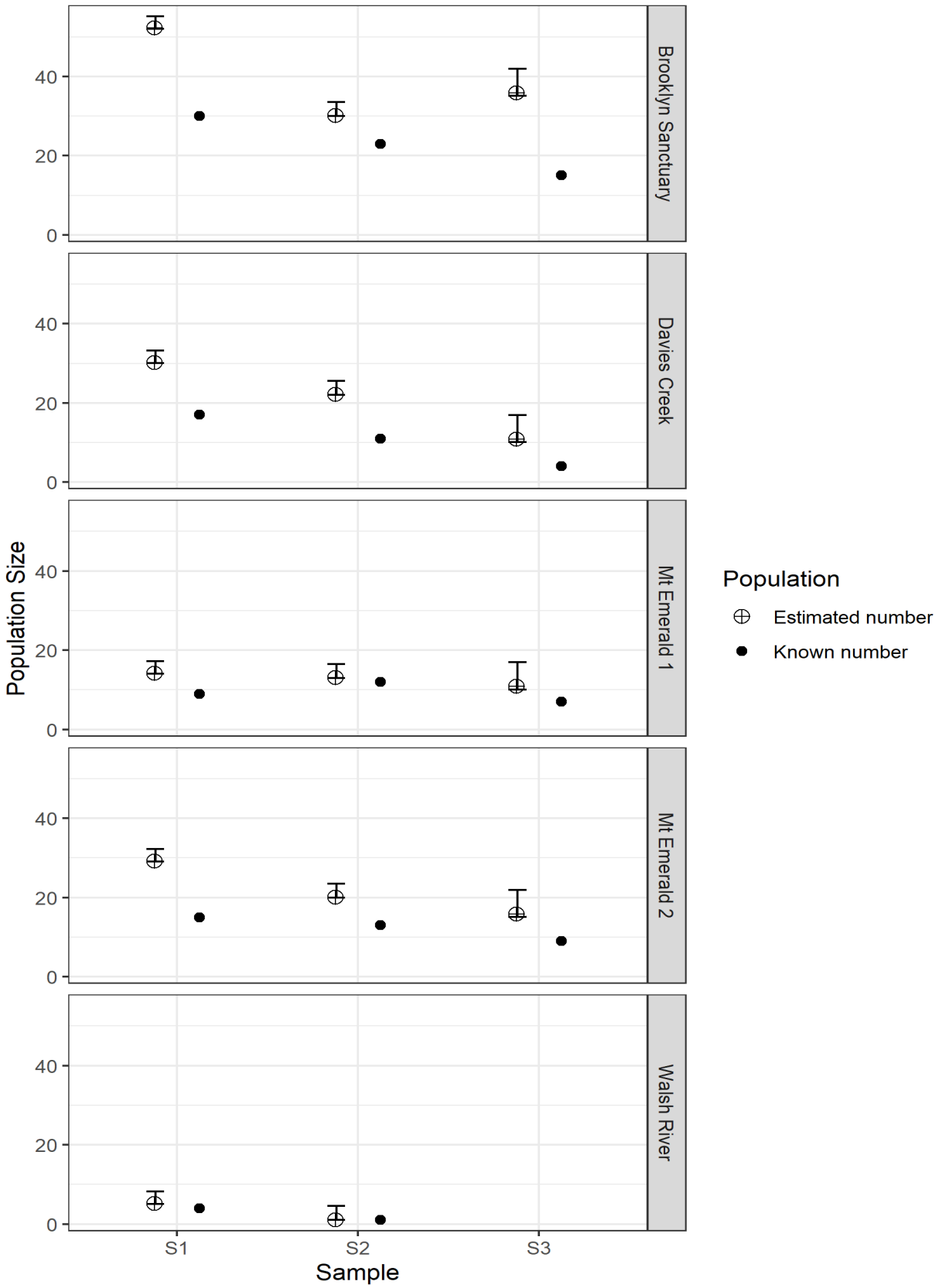

Figure 2. Estimated population size with asymmetric SD estimates using Bayesian estimation, and minimum number of quolls known to be alive (camera) at each site at each season. (mark-recap-daily-camtrap.R)

The proportion of stations where quolls were detected varied from 0 to 0.75 across the sampling periods at the sampling sites (Figure 3). There was an overall decline in occupancy across both control and treatment sites, except for Brooklyn Reserve where 60-75% of cameras detected quolls across the study period (Figure 3). There is an evident seasonal effect, with fewer quolls in S3.

There was no effect of treatment on quoll occupancy, however, as with the estimated populations there was an effect of season (p=0.02 and p=0.01) (Table 3). Figure 4 provides the Bayesian occupancy method accounting for error in quolls potentially missed by the total observed (Figure 3).

Table 3. GLMM testing the effect of treatment on quoll occupancy.

	Estimate	Standard Error	Z value	P-value
Intercept	-0.31	0.80	-0.38	0.70
Treatment Impact	0.13	1.24	0.11	0.91
Sample2	-0.78	0.34	-2.31	0.02
Sample3	-0.84	0.34	-2.47	0.01
TreatmentImpact:Sample2	0.43	0.48	0.89	0.37
TreatmentImpact:Sample3	0.03	0.49	0.07	0.94

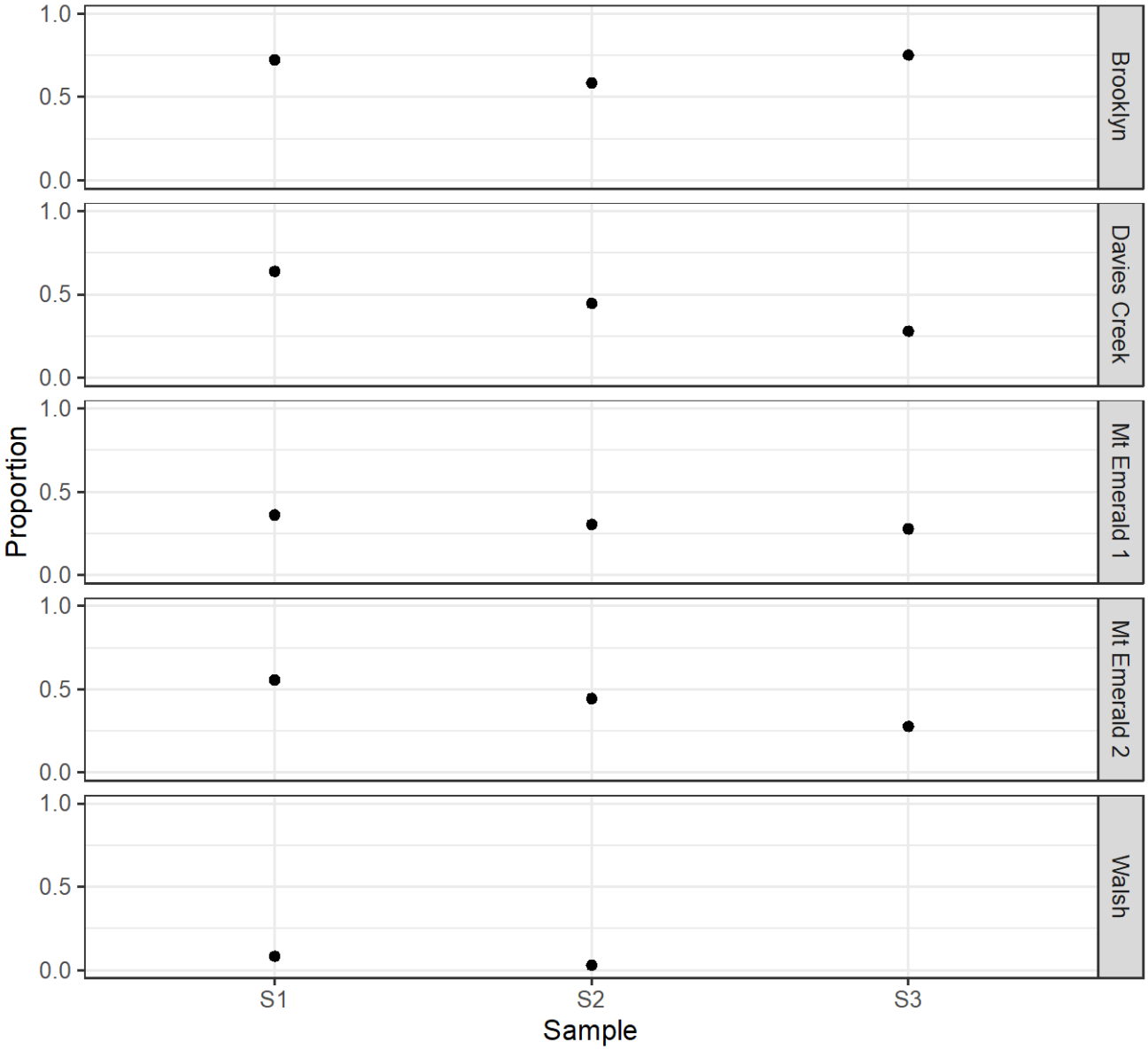

Figure 3. **Site occupancy rate by Northern Quoll. Observed proportion of sites occupied by at least one quoll at each site, broken into seasons.**

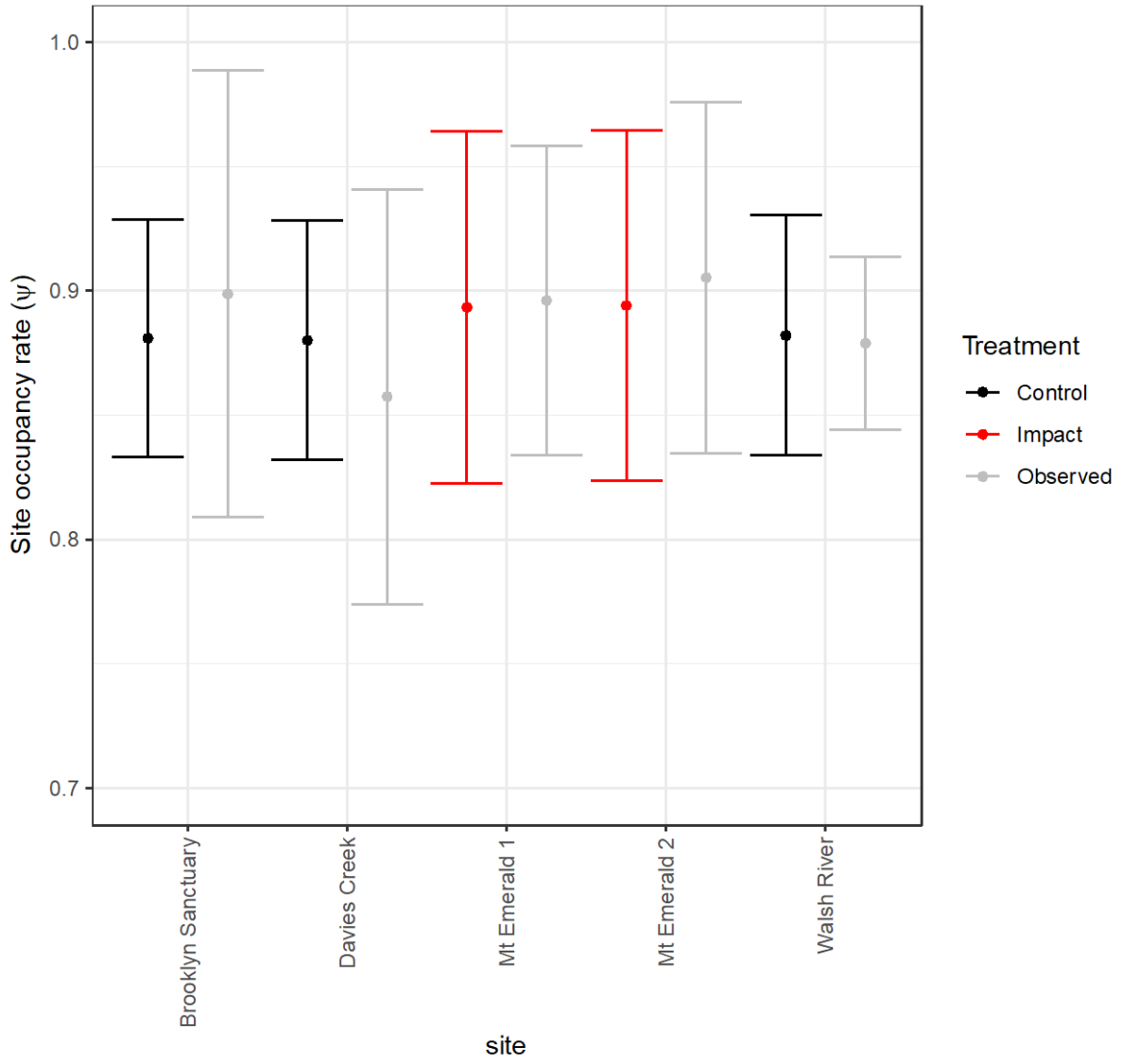

Figure 4. Observed (grey) and predicted (Bayesian method, black/red) site occupancy rate: the proportion of sites where quolls were observed to occur or predicted to occur using package unmarked. This is not by sample (S1, S2, S3), as the data were too scarce to construct meaningful error bars at that resolution.

4.2 Feral animals

There was no effect of treatment on feral animal populations (combined data) identified in this study (i.e., feral animal numbers did not differ between wind farm and control sites). Figure 5 provides the numbers of each pest species recorded during the study.

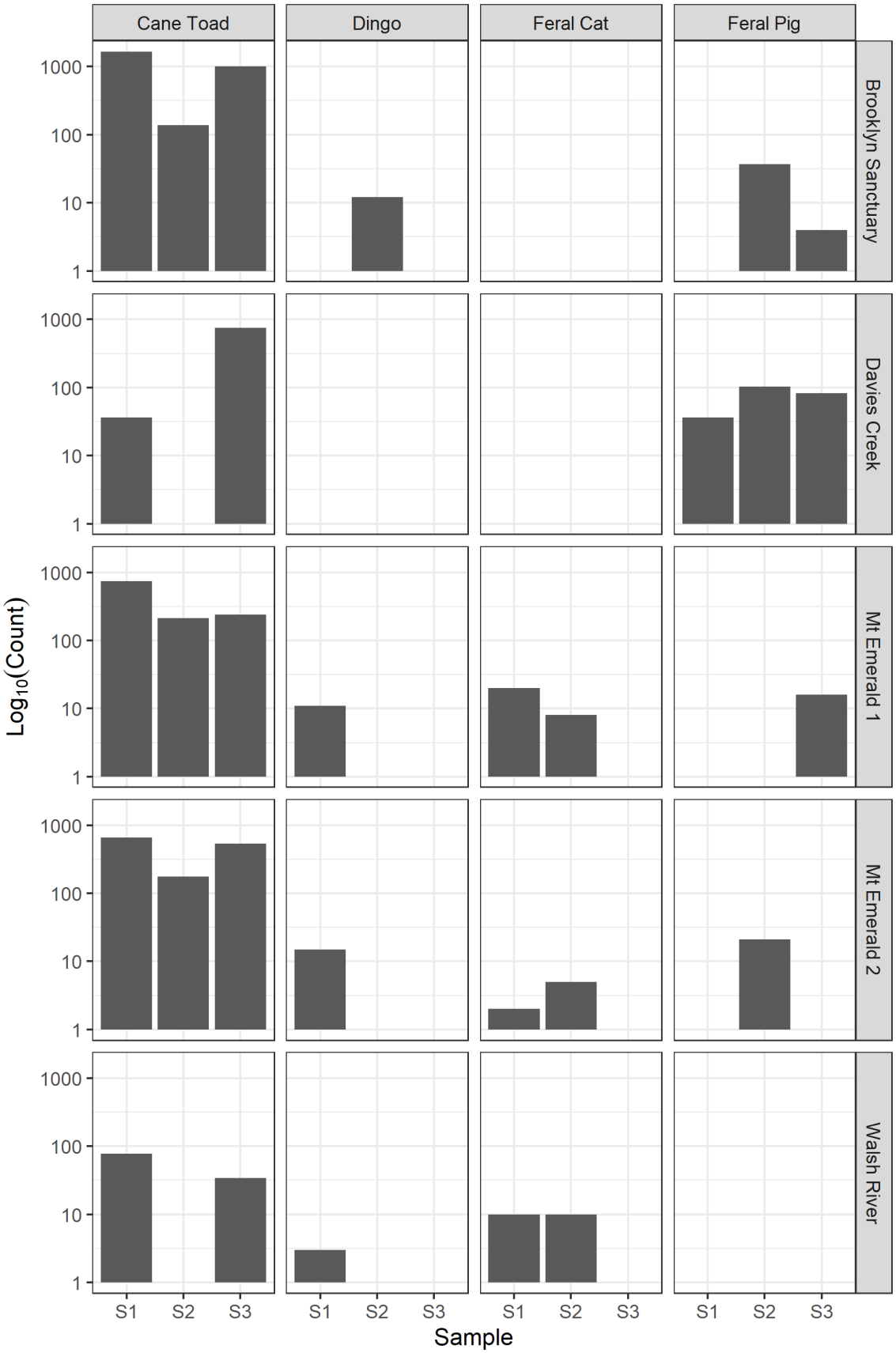

Figure 5. **Feral animals recorded across the sites. Note the log-scale on the y axis. This is presented to improve visibility of rare events (e.g. 2 cats, S1, ME2).**

Feral cats were only detected at the Walsh control site and two treatment sites on Mount Emerald during the study, and there was no significant difference between number of cats between treatments ($F_{1,13}$=1.3, p= 0.27). There was no significant effect on feral cats on Northern Quoll ($F_{1,13}$=1.86, p=0.20), however, the data did show a decline in quolls where cats were present (Figure 5). The methodology was not specifically established to measure cats, and this may change with more targeted feral cat monitoring.

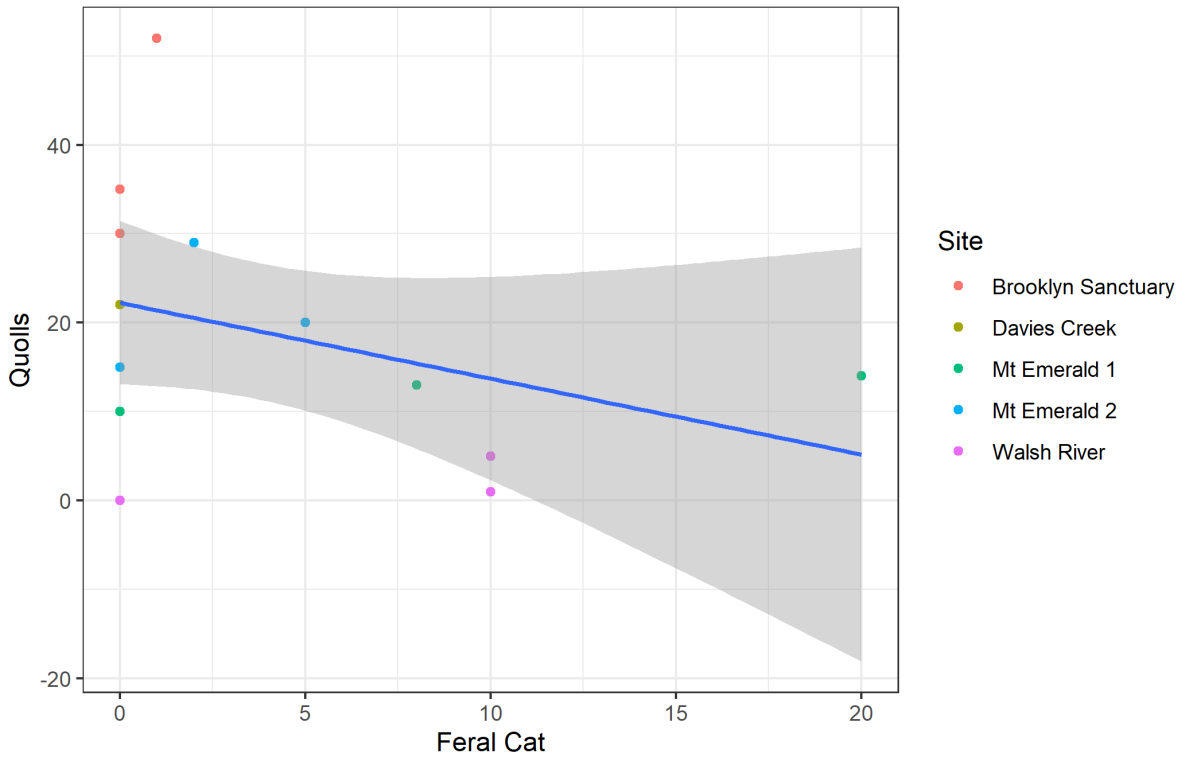

Figure 6. Number of quolls (predicted) vs number of qat observations. We assumed an independent detection time for cats as 15 minutes, as used for Northern Quoll. The smooth line is the linear model fit, with 95% confidence interval.

4.3 Changes in habitat

Our data collection followed the methodology established at the commencement of Northern Quoll monitoring at the site, which involved targeted BioCondition sampling. We initially constructed a multi-factor-analysis to determine if any of these variables allowed for site separation, and to look at how different the sites may be. MFA reduced the 19-dimensions to a more plottable, and easy to visualise 6 dimensions. The first two dimensions explained most of the variation (Figure 7 and Figure 8). There was a qualitative difference among sites, with ME2 being distinct in vegetation from the other sites, seen by the separation of ME1 (Figure 7). This was primarily driven by the abundance of large eucalypt trees (more at ME1), and the leaf litter (less at ME2, figure 8). There was some separation among the other sites due to canopy cover: more at Davies, Walsh River, and Brooklyn in order, and less at ME2, and grass cover: more at ME1 and ME2, less at Brooklyn, Walsh and Davies, in order (Figure 7, 8).

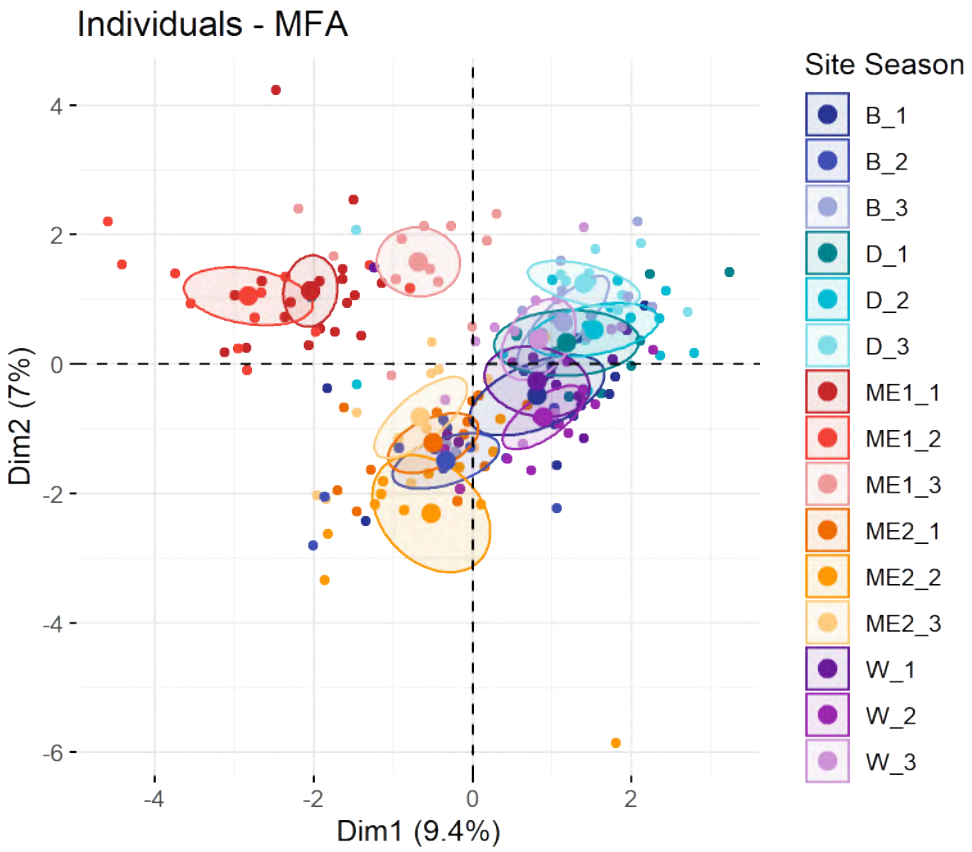

Figure 7. First two dimensions of MFA of 19 vegetation variables measured at each site at 3 seasons. Each point represents one vegetation survey. Warm colours (red, orange) are Control, cool colours (Blues) are Control, colour density represents season. One 95% confidence ellipse was constructed per season per site. ME1 separates from the other sites which cluster very heavily. There was no consistent pattern due to seasonality

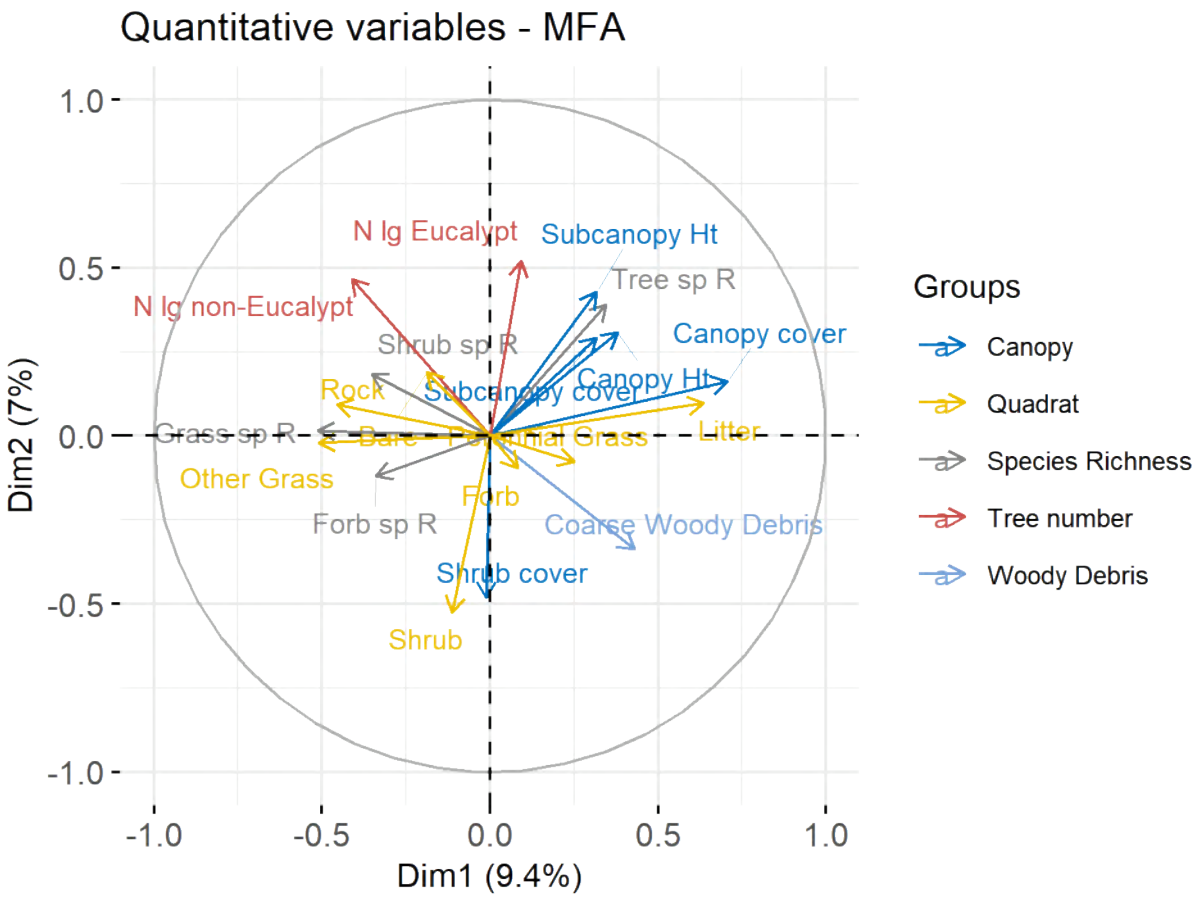

Figure 8. Vegetation shifts in various directions on the MFA plot, i.e., which qualities of vegetation drive the patterns visible in Figure 8. ME1 is up and right from the rest of the sites, driven by increase in the N lg non-Eucalypt, and a decrease in Coarse Woody Debris. Davies has increased subcanopy height compared to other sites, ME1 has more shrubs and grasses, but overall, ME1, D, B, W are clustered and strongly overlapping.

We used the dimension 1 and 2 scores as predictors to determine if vegetation and season influenced quoll population size. The predictors were the covariance of leaf litter, canopy cover, and N lg Eucalypt and non-Eucalypt. There were no effect of vegetation nor season on quoll population size based on these assessed metrics (**Table 4**).

Table 4. Vegetation attributes and quoll populations

	DF	Sum of Squares	Mean Squares	F value	p-value
Season	2	238.13	193.1	0.66	0.55
PCA1	1	27	27	0.09	0.77
PCA2	1	0.95	0.95	0.003	0.96
Season:PCA1	2	378.4	189.2	0.65	0.56
Season:PCA2	2	272.3	136.1	0.47	0.65
Residuals	6	1752.2	292.0		

5.0 Discussion

The data presented here shows no significant difference between quoll populations or site occupancy across impact and control sites. As this study only occurred over a year, we did not measure any longerterm temporal change in quolls at MEWF, which were captured in prior reports by Burnett et al. (2019). The population numbers or occupancy of quolls in this study do not appear to have declined at Mount Emerald 1 or 2 based on studies in 2017, 2018 and 2019 (Burnett et al, 2019), however, our analysis varied slightly and a re-run of all data would be required to quantify any statistical change from 2017 to 2021. Change in occupancy may have occurred in prior study years (Burnett et al., 2019), however there does not appear to be any further decline in 2021. This earlier find by Burnett et al. (2019) is not surprising, and it is plausible initial construction activity influenced the way in which quolls utilised the sites. Season did significantly affect number and occupancy of quoll across the year; however, this was also observed in the control sites and likely to be a natural fluctuation in this species populations.

Feral animals (cats, toads, dogs, and pigs) did not significantly differ in their numbers across the Wind Farm and control sites. The data collected on these species, however, was opportunistic with camera traps, and not species specific in method. Feral cats were detected at the Walsh and the Mount Emerald sites, as per prior studies (Burnett et al., 2019). Whilst there were limited data on cats, there did appear to be fewer quolls where cats were present. Camera traps are known to underestimate feral cat abundance, as they are not as attracted to carrion-based bait (Clapperton 1994). In consultation with the approval holder, targeted cat monitoring and control efforts are planned for 2022 to mitigate impacts on the Northern Quoll population.

Toads were abundant during this survey and are known to stay near cannisters consuming insects which account for in part, so many detections. This species has co-habited with Northern Quoll for many generations in this region and are unlikely to have a negative impact on the species. Images are often collected where toads are near the bait cannister hunting for insects and a quoll will come up to the cannister, smell the bait and then leave the camera frame. Further studies where toads are marked for individual identification would be required to understand the time frame for discrete detections in this species.

The parameters assessed for vegetation did not indicate any disparity in condition or structure across control and wind farm sites and it is unlikely the vegetation differs sufficiently (based on the BioCondition parameters) to result in altering population estimates of Northern Quoll.

Overall, the data showed Northern Quoll number and occupancy to be consistent across all sites, with feral cats likely to be the biggest threat at the wind farm to these populations. Further control and monitoring of this pest species may further protect the Mount Emerald Northern quoll population.

As required by the Quoll Outcome Strategy, further monitoring is scheduled for 2023 and 2028.

6.0 Acknowledgements

Thank you to the Australian Wildlife Conservancy (notably Andrew Francis) for allowing continued use of Brooklyn Station as a control site for this study. We acknowledge Willie Brim, Buluwai elder and Jo Martin for their guidance and assistance in organising cadet rangers who assisted on the project.

This work was carried out under Scientific Purposes Permit number SPP-100071533P, PTC-100071531 and Animal Ethics CA 2020/01/1339.

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