Mt Emerald Wind Farm Fauna Monitoring

Final Report

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Dr Scott Burnett, Dr Carmen Piza-Roca and Daniel Nugent

University of the Sunshine Coast, 90 Sippy Downs Drive, Sippy Downs 4552

Final Report Mt Emerald quoll, other target fauna and habitat monitoring July 2017 – Feb 2019

Executive Summary

- Six, 306.25-ha camera trap monitoring plots, each consisting of 36 camera stations, were established on the northern Atherton Tablelands.
- We lost access to one of these sites and were unable to locate a replacement site, leaving five sites in operation during our six sampling sessions between July 2017 and March 2019.

- Camera traps recorded 712 independent detections of northern quolls over the two years at the five sites and 216 camera stations. Between 33 and 74 total individual quolls were detected during each of the six sampling sessions, and the numbers of individuals at any site ranged from 0 to 29 individuals in any single session.
- Quoll occupancy of the sites (i.e. proportion of camera stations detecting a quoll during any session) ranged from 0 (where no quolls were detected) to 0.818, with a mean 0.328 (SD=0.217). Modelled occupancy at each site ranged from 0 to 0.81201, with a mean 0.51037 (SD=0.192)
- Very low numbers of feral cats were recorded on three of the five sites (including the two Mt Emerald sites), very low numbers of dingoes were recorded on all sites and low numbers of pigs were recorded on 4 of the five sites (including the two Mt Emerald sites). Cane toads were recorded on all sites.
- **There is no statistical evidence that estimated population size of quolls changed in response to the construction works at Mt Emerald over the two-years of this project. However, the raw population counts hint that there may have been a decrease in breeding success leading to fewer juvenile quolls on the MEWF sites in Feb 2019. A similar pattern was observed at one of the control sites (Davies Creek), but wasn't observed at the other two control sites.**
- **There is strong statistical evidence that the distribution of quolls decreased on the MEWF site with each subsequent seasonal visit, particularly during the February 2019 juvenile pre-breeding season at ME1 indicating a decline in new recruits into the population following the July 2018 breeding season.**
- There is no evidence that populations of any of the non-quoll target species changed in response to the construction works at Mt Emerald over the two-years of this project.
- Given that the construction phase of MEWF works are now finalised, we would not expect to observe any ongoing direct effects on quoll or other fauna populations. However, our findings here cannot be used to imply that there will be no ongoing impact on quoll populations resulting from altered habitats, population dynamics or medium to long-term effects on habitat quality resulting from landscape changes arising from the MEWF project.

- Quoll habitat was assessed at 108 camera stations. This monitoring program was designed to detect pervasive landscape-level habitat changes arising from the MEWF project, in the event that a change in quoll populations was detected and putative drivers of that change needed to be identified.

- Although we detected some changes in the quoll habitat directly surrounding the camera trap stations, these changes did not significantly differ from control sites.
- **There is no qualitative or statistical evidence that there has been a change in quoll habitat at the camera trap stations as a result of the MEWF project over the two years of this project. However, it is noted that this monitoring is spatially very localised, as are the impacts of the MEWF construction works, and, therefore, we haven't directly monitored those impacts.**

- We make several recommendations designed to assist the continued presence and health of the northern quoll population at the MEWF site;
  - A 3-season 2020 monitoring session is recommended to assess whether there has been a continued decline in breeding success of quoll on the Mt Emerald sites and to establish whether quoll occupancy has stabilised. This should follow the protocols used here in order to render data comparable with that collected here.
  - Conduct early wet season acoustic surveys for artificial cane toad breeding sites and decommission where possible. The spike in toad numbers at the ME1 site in February 2019 may indicate the inadvertent creation of artificial toad breeding ponds. A survey of these sites to identify any such locations and allow their decommissioning would be a technically simple operation with potentially important positive ecological outcomes for quolls and the entire ecosystem at the MEWF site.
  - Maintain a healthy dingo population at MEWF. The two MEWF sites had the highest incidence of cats of any of the five sites monitored (though still low). Cats are a known predator of northern quolls and the best option for keeping them in low numbers is helping to maintain a healthy Dingo population at these sites by not undertaking poisoning or shooting campaigns against the species there.
  - Full BioCondition should be repeated whenever quoll monitoring is repeated in order to detect pervasive vegetative habitat changes (such as intrusion of weeds or deleterious changes in fire frequency and intensity).

Introduction

The northern quoll is a small carnivorous marsupial which occurs patchily across northern Australia (Woinarski *et al*. 2012). Within this range, it inhabits dry sclerophyll forest on rocky landscapes ranging from sea-level to 1300-m altitude. Northern quoll populations have suffered a catastrophic range decline, which has been attributed to cane toads *Rhinella marina* (Burnett *et al*. 1996), altered fire regimes (Woinarski *et al.* 2012) and predation by feral cats *Felis catus* and dingoes/wild dogs *Canis familiaris/dingo*. The decline in northern quolls appears to have started in eastern Australia in the early-mid 1900's, and has spread to the north and west (Woinarski *et al.* 2012). Dry forests on the hills and slopes associated with the northern Atherton Tablelands have been identified as a key refuge for the species in north-eastern Australia (Burnett *et al.* 2013). The Mt Emerald Windfarm (MEWF) site has been identified as a potentially important part of that refuge, both in terms of the numbers of northern quolls which occur there, and the role of the mountain ranges on which the MEWF is located, as a corridor for gene flow between the Lamb Range population and the Herberton Range population of the species (Conroy *et al.* 2013).

The construction of the MEWF at Mt Emerald, far north Queensland, received approval from the Australian Commonwealth Government in 2015 conditional upon implementation of an ongoing monitoring program of the population of northern quolls, *Dasyurus hallucatus*, within the project area and at a number of "control" sites in the immediate vicinity of the MEWF. Given the possibility of a quoll decline being detected at MEWF, we also collected quantitative data on key habitat attributes and the presence of feral carnivores and cane toads at our camera trapping stations in order to be able to better disentangle the drivers of any such decline.

The monitoring program, conducted over 6 sessions, has been reported as each session was completed (http://mtemeraldwindfarm.com.au/compliance/), and provides a qualitative assessment of the trends in individuals detected, modelled population size and site occupancy of northern quolls at the MEWF sites compared to a set of regional control sites. The timing of this monitoring coincides with three stages in the life of northern quoll populations in far north Queensland (S. Burnett unpubl. data). These stages cover the period immediately prior to and during the breeding season (July-August each year), the post breeding period (October-November each year), and the juvenile pre-breeding phase (February-March each year). This allows us to explore at which stage any observed population changes are occurring. The seasonal progress reports produced to date indicated no obvious change in the quoll population (measured by any of the three metrics listed above), nor in the habitat parameters measured (including vegetative and predators or cane toads).

This final report consolidates the data from each survey into a single data set, presents detailed methods and a new analysis using quantitative models and plots aimed at detecting statistically significant changes in the abundance and occupancy of the quoll populations at the five monitoring sites. We similarly explore whether the MEWF project has resulted in increases in feral animals at those sites, and whether there is any impact on habitat attributes at our monitoring sites. Our key finding is that, with the data collected during the two-year period, there is inconclusive evidence on whether the MEWF has had an impact on quolls. While there is no discernible impact on population size, there is some indication of a decline in juveniles which may hint at lowered breeding success in the 2018 breeding season. We have also identify a statistically significant decrease in quoll occupancy in MEWF sites relative to the control sites.

Methods

This project utilised repeated plot-based camera trapping of target fauna and transect-based habitat monitoring on two impact sites within the MEWF footprint, and four control sites in the surrounding region (Fig. 1). Each of the six sites consisted of a 6 x 6 station grid with each station spaced 350m apart. This gave 36 survey points encompassing 306.25 ha at each survey site.

Northern quoll and other fauna species monitoring

Baited trail cameras were used to collect capture-recapture and site occupancy data on northern quoll *Dasyurus hallucatus.* Wild dogs/dingo*, Canis familiaris/dingo,* feral cat *Felis catus,* feral domestic pig, *Sus scrofa* and cane toads *Rhinella marina* relative abundance (number of detections) was also monitored using this method.

At each site (with the exception of site Tinaroo – see Table 1), fauna monitoring occurred during six, 14-day deployments between July 2017 and March 2019 (Fig. 1, Table 1). We lost access to site Tinaroo after two rounds of monitoring (i.e. from February 2018 onwards) due to veto of our Scientific Purposes Permit renewal application by the Native Title holders of that area. We therefore only surveyed five of the original six sites for the full duration of the proposed monitoring term (Table 1).

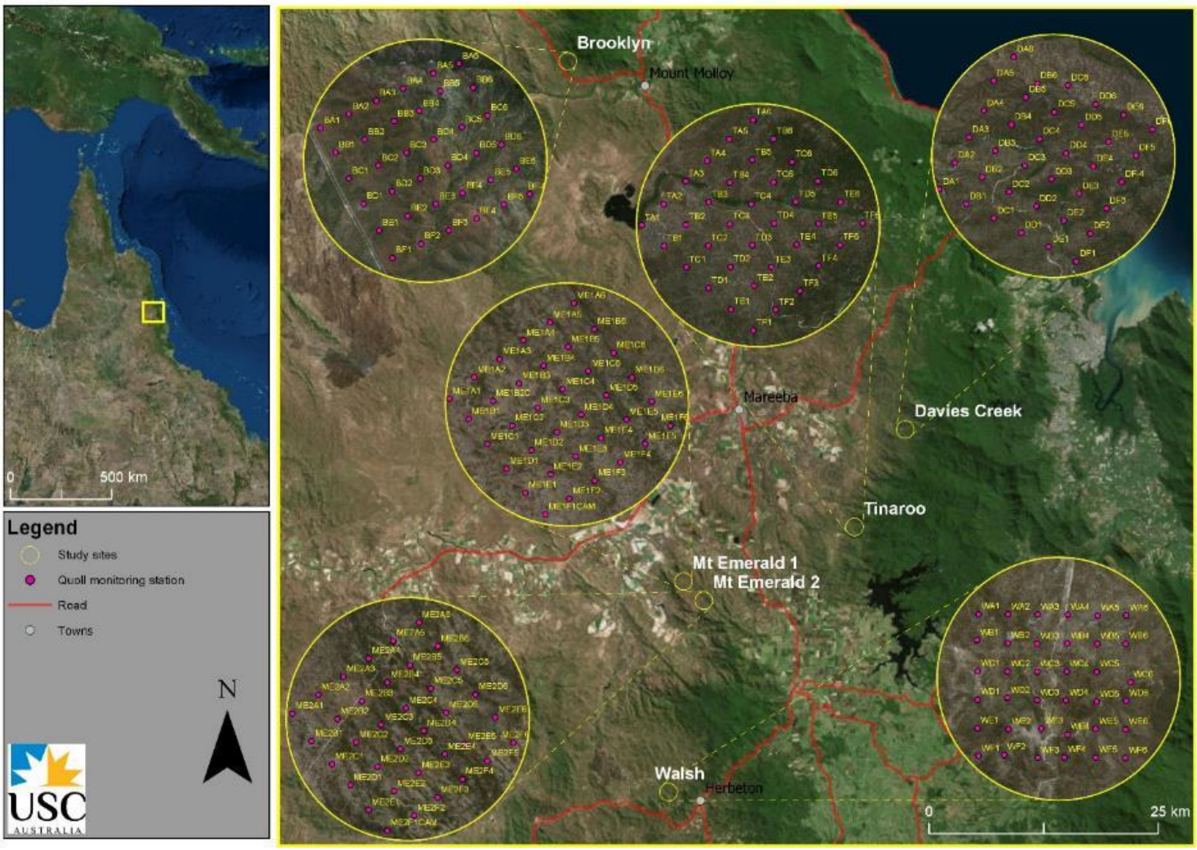

Fig. 1. Indicative locations of the camera trapping stations (purple circles) at the six monitoring sites used to monitor northern quoll populations in the northern Atherton Tablelands from July 2017 onwards. Monitoring site names are displayed in white text. Local place names are in black text. The exploded views (large yellow circles) show the orientation and placement of the camera trap stations within each site. Note that site "Tinaroo" was not utilised from February 2018 due to permits being denied for this area from that point onwards. Basemap: GoogleEarth Pro 9 December 2017.

Camera trapping entailed the use of a single Bestguarder Trail Camera Model SG990v (www.faunatech.com.au) at each station, mounted horizontally onto a tree trunk, 150 cm above and aimed perpendicularly to the ground (Fig. 2). In the centre of the target area, a PVC bait cannister loaded with five chicken necks was pegged to the ground. The bait cannister consisted of a 10-cm-long, 50-mm-diameter PVC pipe capped at both ends. At one end the cap was a vented cowling, which would allow the scent of the lure to disperse, but which prevented animals from consuming the bait. Trail cameras were deployed for a minimum 14 nights and programmed for 24-hour operation, to take three photographs per detection event, and to continue to capture photo bursts for as long as an animal remained within the detection area. The flash setting was set to incandescent flash for all night time image capture. Bait cannisters and cameras were not reloaded during the 14 days when they were deployed.

Table 1. Site location, survey timing and effort at each of the survey sites. "Type" refers to whether the site was a control or an impact site. "Coords" refers to the central coordinate (Station C3– refer Fig. 1) of each site (in decimal degrees), "Monitoring Session." refers to each of the six repeat surveys at each site.

			Monitoring Session					
Site	Type	Coords	1	2	3	4	5	6
Brooklyn Sanctuary	**Control**	-16.65, 145.2538	**10/07/17 – 25/07/17**	**4/10/17 – 18/10/17**	**23/2/18 – 11/03/18**	**18/2/19 – 02/08/18**	**2/10/18 – 17/10/18**	**19/2/19 – 11/03/19**
Davies Creek (Danbulla NP)	**Control**	-17.01, 145.5818	**04/07/17 – 19/07/17**	**6/10/17 - 20/10/17**	**20/2/18 – 06/03/18**	**17/7/18 – 31/07/18**	**1/10/18 – 15/10/18**	**18/2/19 – 04/03/19**
Mt Emerald 1	**Impact**	-17.1603, 145.3671	**31/07/17 – 15/08/17**	**23/10/17 – 6/11/17**	**13/3/18 - 19/04/18**	**02/8/18 – 16/08/18**	**18/10/18 – 1/11/18**	**12/3/19 – 27/03/19**
Mt Emerald 2	**Impact**	-17.1793, 145.3872	**01/08/17 – 16/08/17**	**24/10/17 – 7/11/17**	**12/3/18 – 10/4/18**	**03/8/18 – 17/08/18**	**18/10/18 – 2/11/18**	**13/3/19 - 28/03/19**
Tinaroo (Dinden NP)	**Control**	-17.1046, 145.5324	**20/07/17 – 04/08/17**	**5/10/17 - 20/10/17**	**NA**	**NA**	**NA**	**NA**
Walsh	**Control**	-17.3637, 145.3524	**12/07/17 – 27/07/17**	**25/10/17 – 11/10/17**	**24/2/18 – 10/03/18**	**19/7/18 – 08/08/18**	**10/10/18 – 24/11/18**	**25/2/19 – 22/03/19**

Fig. 2. Trail camera deployment (left) and bait presentation (right). The camera on the left is facing directly down at the bait cannister (Source: N. Foster). The bait cannister method used in this project has the upwards end of the cannister capped with a vented cowling to allow scent to disperse (right).

Habitat Monitoring

Habitat monitoring utilised a modified BioCondition monitoring method (Eyre *et al.* 2015). The standard BioCondition Monitoring protocol was modified by increasing the course woody debris plot from 50 x 20m to 100 x 20m. Habitat monitoring was undertaken at half of the camera trapping stations, and repeated during each quoll monitoring session (Fig. 3). In keeping with standard BioCondition monitoring protocols (Eyre *et al.* 2015), if there were no obvious signs of disturbance such as storm, fire or construction damage observed at a site, then measures of tree and course woody debris abundance were not recorded again between sessions. All measures were however recorded on the last survey (February 2019) regardless of whether a disturbance was detected. The BioCondition plots were typically situated so that the camera station was the centre point of the BioCondition transect but in some instances, the landscape dictated that the camera station was at one end of the transect.

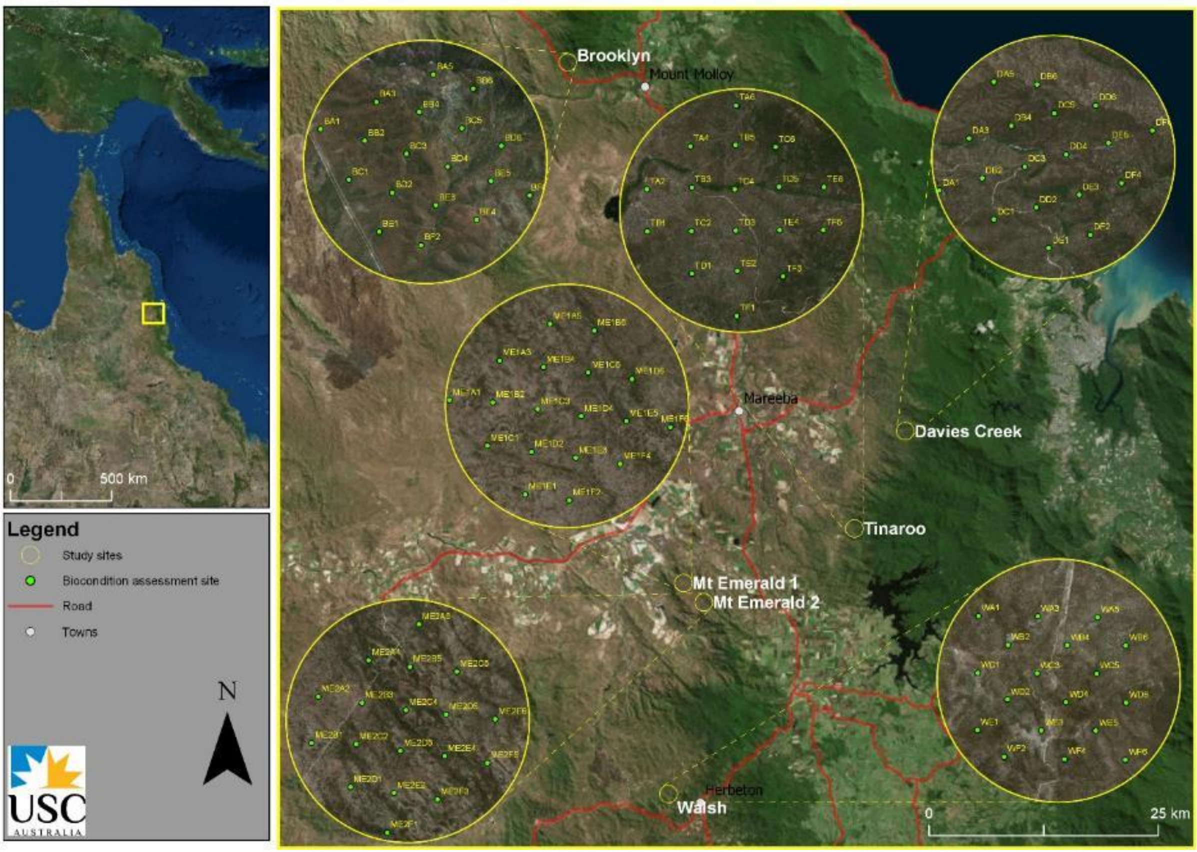

Fig. 3. Locations of the 108 BioCondition monitoring plots (green dots) which were used to monitor quoll habitat on our camera trapping sites in the northern Atherton Tablelands from July 2017 onwards. Monitoring site names appear in white text. Local place names appear in black text. The exploded views (large yellow circles) show the orientation and placement of the BioCondition monitoring plots within each site. Note that site Tinaroo was not utilised from February 2018 onwards due to permits being denied for this area. Basemap: GoogleEarth Pro 9 December 2017.

Data analyses

Fauna data

The species captured by each trail-camera image were tagged with species and individual (in the case of quoll) tags using the software program *digiKam* (digikam.org). These tagged pictures were summarised and prepared for further analyses using the package *camtrapR* (Niedballa *et al.* 2016) within the R statistical environment (R Core Team, 2016). Prior to compiling species and individual summary data, we checked that the photo creation date and time of each picture were accurate. This was achieved by comparing the *dateTimeOriginal* metadata of the photos captured at camera set-up against our field notes. Where discrepancies were identified, these were corrected using the *timeshift()* function in *camtrapR*. We then compiled species record tables for each site and session using a 15-minute rule to distinguish independent detections of any species/individual (i.e. if images of a single species or individual were detected within 15 minutes of one another, they were not counted as separate detections). Quolls and cats were able to be identified to individual level by their unique coat markings. All other target and non-target fauna were identified to species only.

Northern quoll populations at each site and session were quantified using a number of population metrics including, (i) minimum number known to be alive (KTBA) (i.e., minimum number of individuals which were photographed and identified during each monitoring session), (ii) a population size estimate generated by the R-package *RMark* (Laake 2013), and (iii) a naïve occupancy (i.e. the number of camera stations at which quolls were detected, expressed as a proportion of all stations), and, (iv) an occupancy estimate generated using the R-package *unmarked* (Fiske and Chandler 2011).

R-package *RMark* (Laake 2013), an interface of the program MARK (White, G. C., & Burnham, K. P. (1999)), was used to build and implement capture–recapture models for closed populations (Otis *et al.* 1978). Closed-population models assume that a population remains unchanged during the sampling period (i.e., that there are no gains or losses of individual quolls during the 14 nights). *RMark* utilizes individual capture histories to estimate the number of quolls within the area covered by the camera traps. The capture-recapture models account for imperfect detection rates to estimate the numbers of individuals likely to be present but which were not detected. These are added to the individuals that were detected to estimate total population size.

RMark input files were generated using *camtrapR*. We built three closed-capture models: the null model (where probability of capture and recapture are constant and the same), the behavioural model (where probability of capture and recapture are constant but different) and the time-varying model (where probability of capture and recapture over with time). Goodness of fit was assessed using AIC_c. When more than one model seemed plausible, model averaging was performed (White *et al.* 2001).

Model averaging entails a weighted average of the estimates of a parameter for several models, including model selection uncertainty in the estimate of precision of the parameter, and thus producing unconditional estimates of sampling variances and covariances and standard errors.

Site occupancy was estimated using the R package *unmarked* (Fiske and Chandler 2011) using occupancy models. These models are hierarchical, in that the ecological process that influences occupancy is modelled separately from the detection process. The models produce estimates for the state variable occupancy (*psi*) and detection probability (*p*), therefore accounting for imperfect detection (MacKenzie *et al.* 2017). Input files for *unmarked* were also generated within *camtrapR* and a simple null occupancy model was run. This produced estimates of *psi* (occupancy) and *p* (detection) probability for each site at which enough data were obtained to do so.

To assess the impacts of MEWF project on quolls, trends in quoll population size and site occupancy over time were modelled. Population size estimates (as calculated using capture-recapture models in *Rmark*) were modelled using general linear modelling. Due to seasonal changes in quoll populations, the natural variation across the three life-stage seasons (surveys in February, July and October) needed to be considered. To do so, we assessed whether population of quolls had changed from the same season to the next one (July 2017 vs July 2018, October 2017 vs October 2018 and February 2018 vs February 2019). In other words, we modelled the differences in population size between first and second visit for a particular time of the year. To determine a potentially different impact in MEWF sites compared to other monitoring sites we also included the site type (impact vs control sites) as a predictor. Finally, to account for natural differences across sites and seasons, we included both variables as predictors in the model. To allow time trends and impact to differ depending on site, all interactions between predictors were included, except with time of the year. The model was simplified using single-term deletions and subsequent assessment of changes in AIC, and further tests of significance of model fit deterioration using a Fisher-test. See Table xxx for more information on model structure. Occupancy was modelled in the same way. However, because not enough data were available to obtain sufficient occupancy estimates in *unmarked* for construction of robust models, we used naïve occupancy. Because occupancy is a proportion (proportion of the site inhabited by quolls), generalised linear modelling was used, with the family structure Binomial. Model simplification was conducted by single-term deletions and subsequent assessment of AIC, with further testing of significance of model fit deterioration using χ^2-tests. See Table 3 for more information on model structure.

Cat, dingo/dog, feral pig and cane toad populations were assessed using the number of independent detections and naïve occupancy, as data for these species were too sparse for effective model-building approaches to population estimation.

Habitat data

Key habitat data were summarised at each station by taking; (1) the number of fire events detected, (2) the total length of coarse woody debris at 20 x 100 plots, (3) species richness of trees, shrubs, grasses and forbs, (4) the average percent bare ground cover across nine 1-m^2 quadrats separated by 10 m along a 100 m transect, (5) and the length of canopy cover and (6) shrub cover along the same 100 m transect.

Changes in key habitat variables were modelled using generalised linear modelling. Canopy and shrub cover, coarse woody debris and percent bare ground were modelled as a function of survey number to investigate any trends over the two-year period in which surveys were conducted. Similar to quoll models, we also included the site type (impact vs control sites) as a predictor to quantify differences between MEWF sites and other monitoring sites. Also, to account for natural differences across sites and seasons, we included both variables as predictors in the model. To allow trends to differ depending on sites, all interactions between predictors were included, except with time of the year. The model was simplified using single-term deletions and subsequent assessment of changes in AIC, and further tests of significance of model fit deterioration using a Fisher-test.

Results

Quoll populations

Across the two-year project, camera trapping resulted in 712 independent detections of northern quolls (Fig. 4). Between 33 and 74 total individual quolls (mean = 56.5, SD = 14.77) were detected across the five sites during any session, and the numbers of individuals detected at any site varied from 0 to 29 individuals (mean = 11.3 individuals, SD = 1.47) (Fig. 4, Appendix A & B).

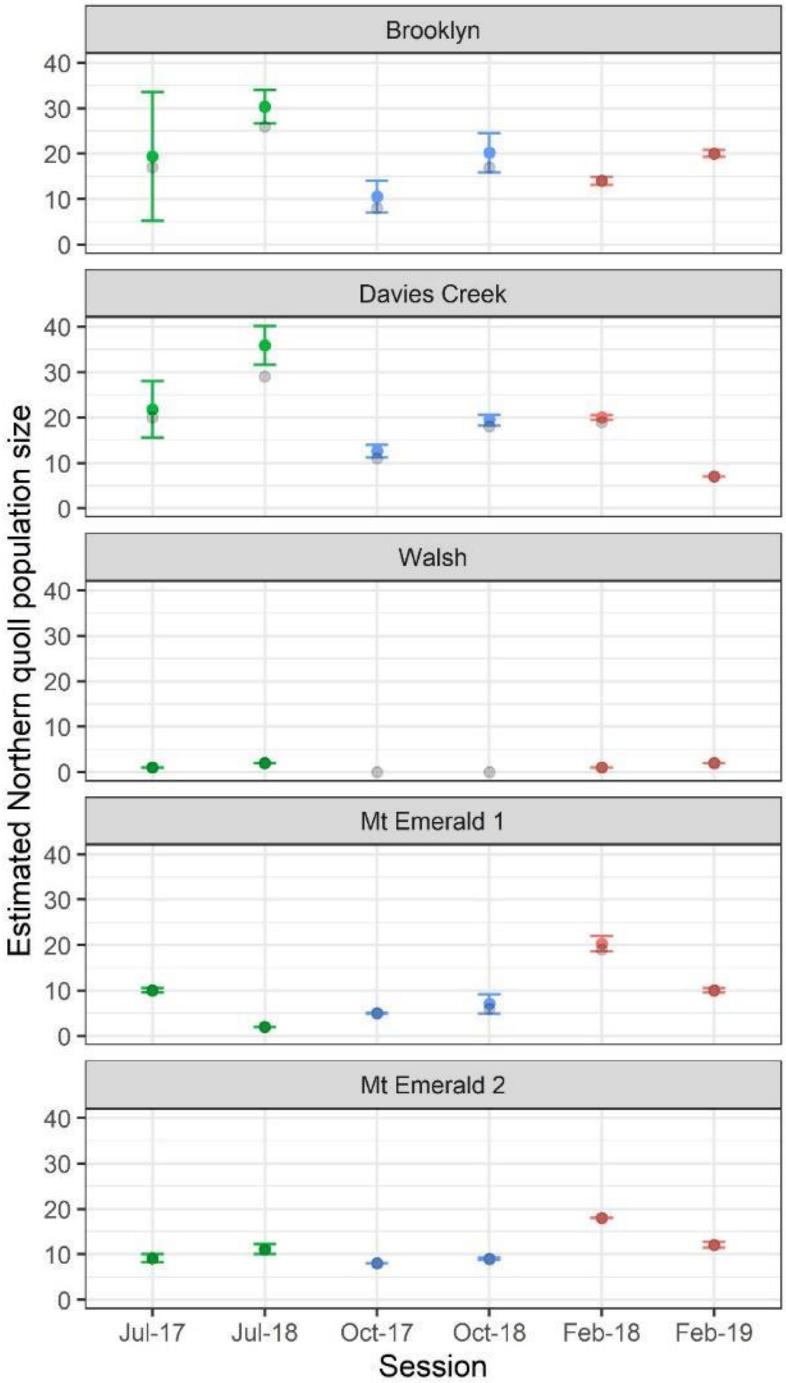

Fig. 4. The number of individuals detected (grey dots) and the estimated population size with standard errors (coloured symbols), as produced by *RMark*, at each of the five sites during each monitoring session. Where only the coloured symbol is visible this is because minimum observed and estimated population size are the same. Because of the highly seasonal changes in quoll populations, the x-axis is arranged to display comparable seasons adjacent to one another. Green symbols (July) represent the quoll breeding season, blue symbols (October) represent the post-breeding season, and red symbols (February) represent the juvenile pre-breeding season. Both Mt Emerald sites and Davies Creek show a decrease in juvenile quolls.

The proportion of stations at which quolls were detected at any site varied from 0 – 0.818 (mean = 0.328, SD = 0.217) (Fig. 5). Where it could be modelled using an occupancy modelling approach, the occupancy at each site ranged 0 to 0.81201 (mean = 0.51037, SD = 0.19168) (Fig. 5).

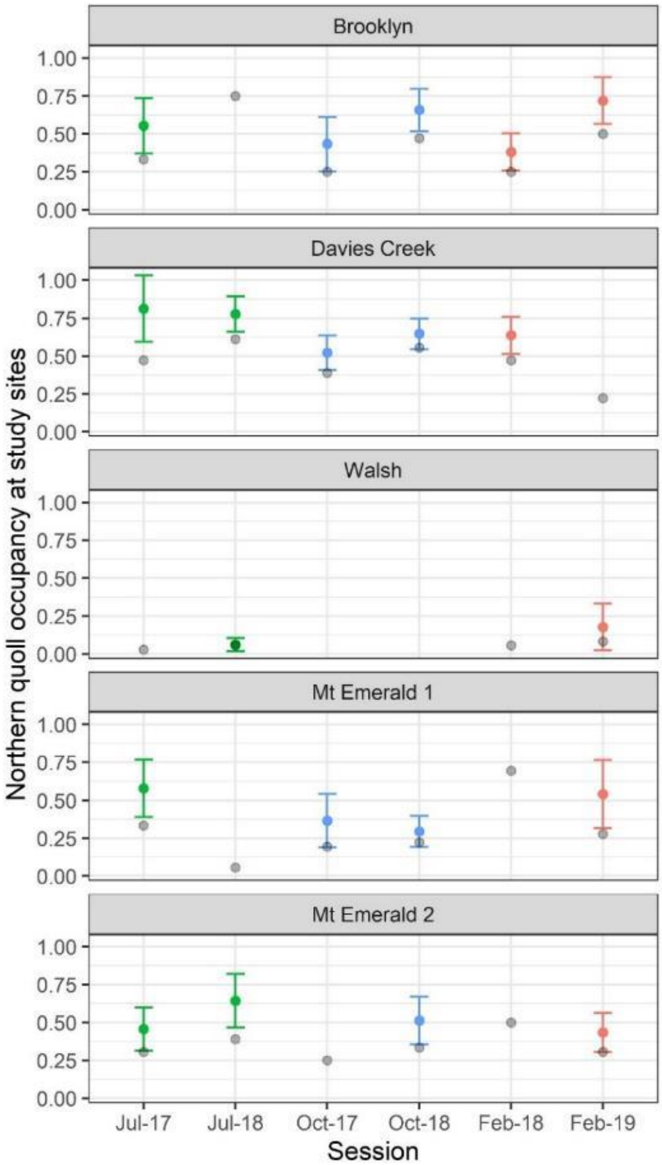

Fig. 5. The naive occupancy (grey dots) and the modelled population size with standard error bars (coloured symbols) of northern quolls at each of the five sites during each monitoring session. Because of the highly seasonal changes in quoll populations, the x-axis is arranged to display comparable seasons adjacent to one another. At some sites where occupancy couldn't be modelled due to the small number of detections, we display naive occupancy only. Green symbols (July) is the quoll breeding season, blue symbols (October) is the post-breeding season, and red symbols (Feb) the juvenile pre-breeding season. Mt Emerald sites and Davies Creek show a decrease in occupancy during the juvenile pre-breeding season.

When seasonal variation is considered, there is no statistical evidence for an impact of the MEWF activities on the number of northern quolls on the Mt Emerald monitoring sites (Table 2). However, there is a strong significant effect of time on occupancy at one Mt Emerald site (ME1) (Fig. 6, Table 3). In effect, this shows that the distribution of quolls across the Mt Emerald site was significantly less at each seasonal resampling time than during the first sample. We also note that at both MEWF sites, the observed abundance breeding age adults in July 2018 and juveniles in the subsequent pre-breeding phase (February 2019) is lower (though not statisticaly significantly so) compared to the first round of sampling in these months in the previous years (Figs. 4 & 5). The implications of this are explored in the Discussion below.

Table 2: Outputs of quoll population models (N = 28). Population size (as calculated using *RMark* models, see Methods section) was modelled as a function of time (visit number: first or second visit for a particular time of the year) and site type (control vs impact sites) while considering the effects of seasonality (time of the year) and site using a general linear model. The only significant predictors of population size in our data were monitoring site (Site) and time of the year (Month). Both Mt Emerald sites and Walsh show smaller estimated quoll populations.

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept (Brooklyn in February)	19.80368	3.059293	6.473286	2.05E-06
Site = Davies Creek	0.343104	3.624338	0.094667	0.925477
Site = Mt Emerald 1	-10.0456	3.624338	-2.77171	0.011431
Site = Mt Emerald 2	-7.86523	3.624338	-2.17012	0.041615
Site = Walsh	-19.2246	4.1522	-4.62998	0.000144
Month = July	1.841883	2.8074	0.656082	0.518896
Month = October	-3.91962	3.059293	-1.28122	0.214085

The model included 28 observations (6 sessions over 5 sites, except Walsh which had only 4 observations due to no quoll detections on October 2017 and 2018 sessions). The model equation is N ~ Site + Month, where N is population size (continuous variable), Site is the monitoring site (discrete variable: Brooklyn, Davies Creek, Walsh, Mt Emerald 1, Mt Emerald 2) and Month is the time of the year in which the surveys were conducted (discrete variable: February, July, October). Initially, also the variables for time (continuous variable: field session number), and type of site (discrete variable: control, impact) were included, as well as the interactions between all variables except with Month. However, time and type of site, as well as interactions, were dropped due to non-significant contribution to model fit.

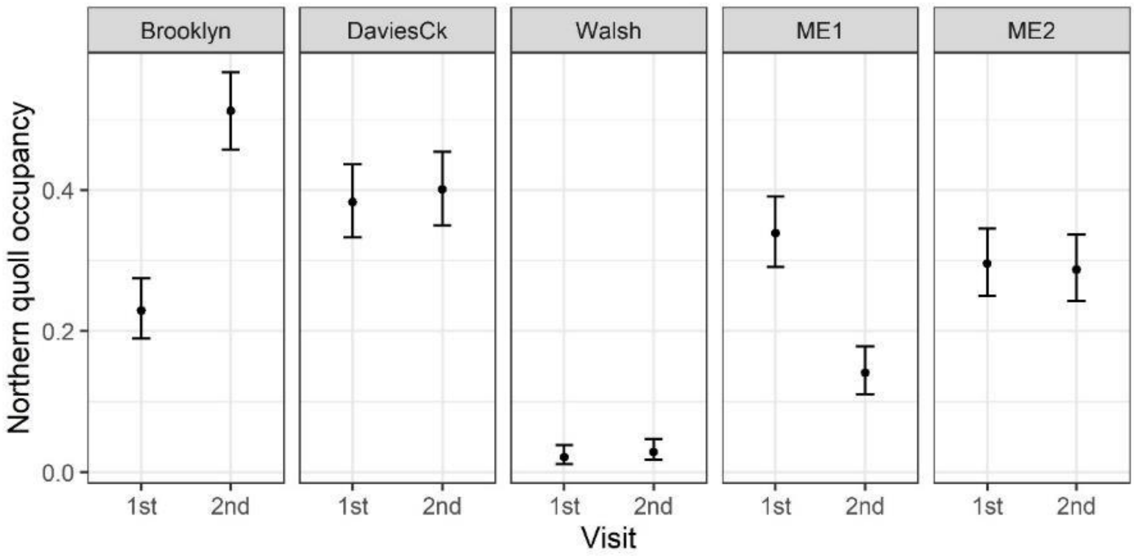

Fig. 6. Pooled estimated (modelled) occupancy (and standard error) of northern quolls at each visit at each site. 1st visit refers to the July 2017, October 2017, February 2018 surveys; 2nd visit refers to the July 2017, October 2017, February 2018 surveys at each site. Mt Emerald sites show a decrease in quoll occupancy from the first to the second visit.

Table 3: Outputs of quoll occupancy models (N = 30). Observed site occupancy was modelled as a function of time (visit number: first or second visit for a particular time of the year) and site type (control vs impact sites) while considering the effects of seasonality (time of the year) and site using a Binomial generalised linear model. The only significant predictors of population size in our data were monitoring site (Site) and time of the year (Month). Mt Emerald sites, especially site 1, show less occupancy on the second visit compared to the first.

Variable	Estimate	Std. Error	z value	Pr(>|z|)
Intercept (Brooklyn in February on the first visit)	-0.82968	0.236238	-3.51204	0.000445
Second visit	1.263187	0.290948	4.34163	1.41E-05
Site = Davies Creek	0.737445	0.290232	2.540885	0.011057
Site = Walsh	-2.60701	0.624145	-4.17693	2.95E-05
Site = Mt Emerald 1	0.545968	0.29217	1.868666	0.061669
Site = Mt emerald 2	0.34683	0.295492	1.173739	0.2405
Month = July	-0.01471	0.171534	-0.08577	0.931652
Month = October	-0.38424	0.176003	-2.18312	0.029027
Second visit : Site = Davies Creek	-1.18789	0.399954	-2.97005	0.002977
Second visit : Site = Walsh	-0.96568	0.829208	-1.16458	0.244189
Second visit : Site = Mt Emerald 1	-2.40083	0.433377	-5.53982	3.03E-08
Second visit : Site = Mt Emerald 2	-1.30432	0.408569	-3.19241	0.001411

The model included 30 observations (6 sessions over 5 sites). The response variable was modelled as the proportion of detectors with quoll sightings (naïve occupancy: proportion of sites occupied) using the binomial family structure (bound between 0 and 1). Note, therefore, that the estimates are in the *logit link space. The model equation is cbind(Sites occupied, sites not occupied) ~ Visit number + Site + Month + Visit number:Site, where Visit number represents time (discrete variable: first or second visit), Site is the monitoring site (discrete variable: Brooklyn, Davies Creek, Walsh, Mt Emerald 1, Mt Emerald 2) and Month is the time of the year in which the surveys were conducted (discrete variable: February, July, October). Initially, also the variable for type of site (discrete variable: control, impact) was included, as well as the interactions between all variables except with Month. However, type of site, as well as all interactions except that between Visit number and Site, were dropped due to non-significant contribution to model fit.*

Dingo/wild dog, cat and cane toad populations

There is no evidence for any change in populations of any of these species at the two MEWF sites beyond that which was observed at the control sites (Figs. 7 & 8).

The numbers of feral domestic cats and dingoes/wild dogs detected during these surveys was consistently very low, ranging from a total of 0 to 2 detections at any site in any one session (Fig. 7). Further, there was no indication of any change in occurrence on the sites during this project (Fig. 8, Appendix C).

Detections of feral pigs were variable across the sites and surveys, and there was no pattern of increasing pig detections or occupancy in response to MEWF (Fig. 7 & 8).

Cane toads were the most frequently detected of the four non-quoll target species, but generally occurred as low numbers of detections at each site and time. There was a sharp increase in cane toad detections at several sites Brooklyn, Davies Ck and Mt Emerald 1 sites during the last sampling occasion (February 2019). This was matched by increases in the observed (naïve) occupancy of cane toads at these sites (Fig. 8).

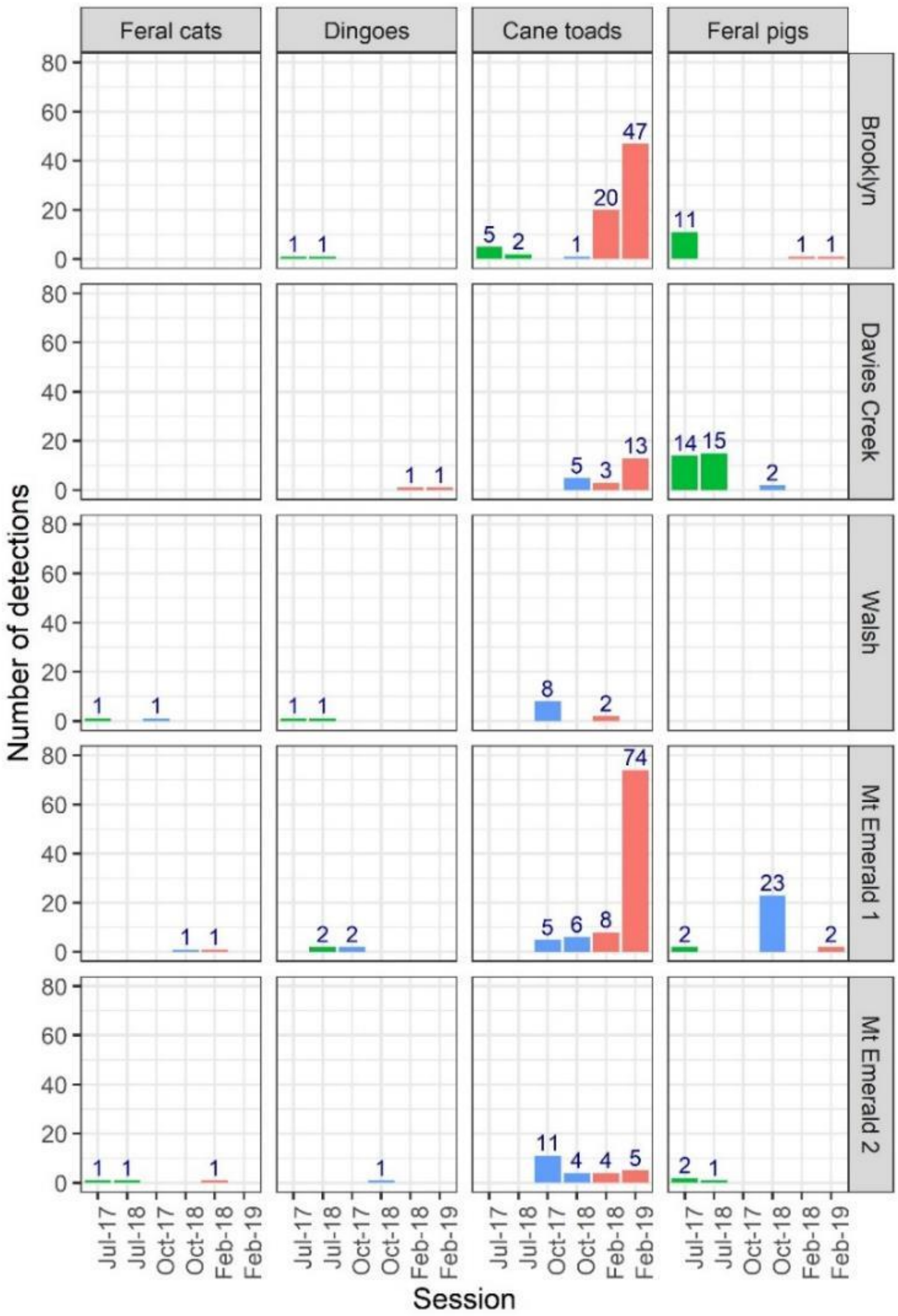

Fig. 7. The number of detections of the four non-quoll target species at each of the five sites during each monitoring session. The x-axis is arranged to display comparable seasons adjacent to one another for easy comparison. Numbers above each bar are the number of detections of each species at that site and Session.

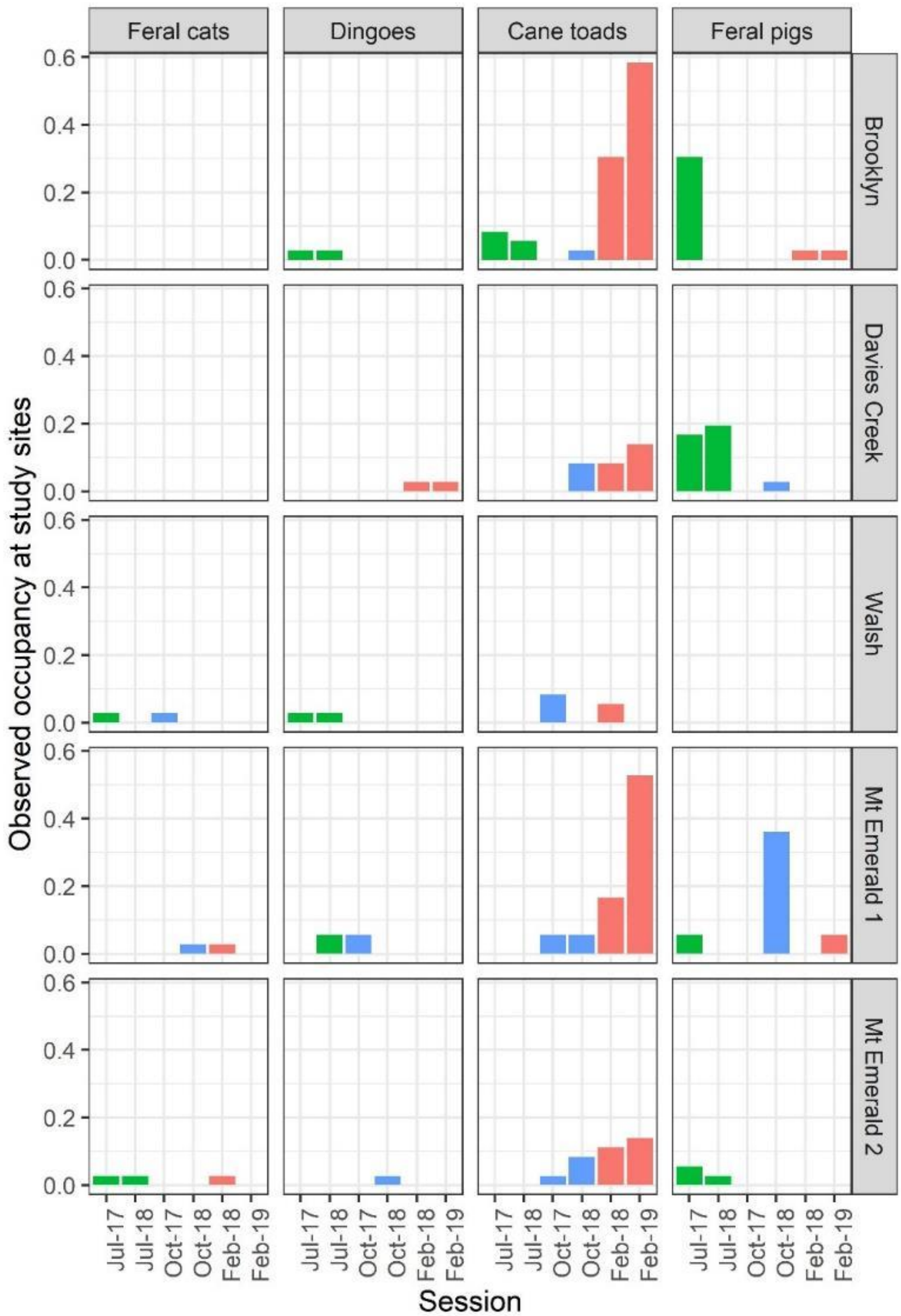

Fig. 8. The proportion of camera stations at which each non-quoll target species was detected at each site (observed or naïve occupancy) during each monitoring session. The x-axis is arranged to display comparable seasons adjacent to one another for easy comparison.

Changes in quoll habitat associated with the MEWF project

There were no changes in vegetative habitat on the quoll monitoring sites during the construction phase of the MEWF. Canopy cover remained relatively constant across the two-year monitoring program in all sites (Figs 7 and 8, Table 4). Shrub cover increased in all sites except Brooklyn, a control site (Figs 7 and 9, Table 5).

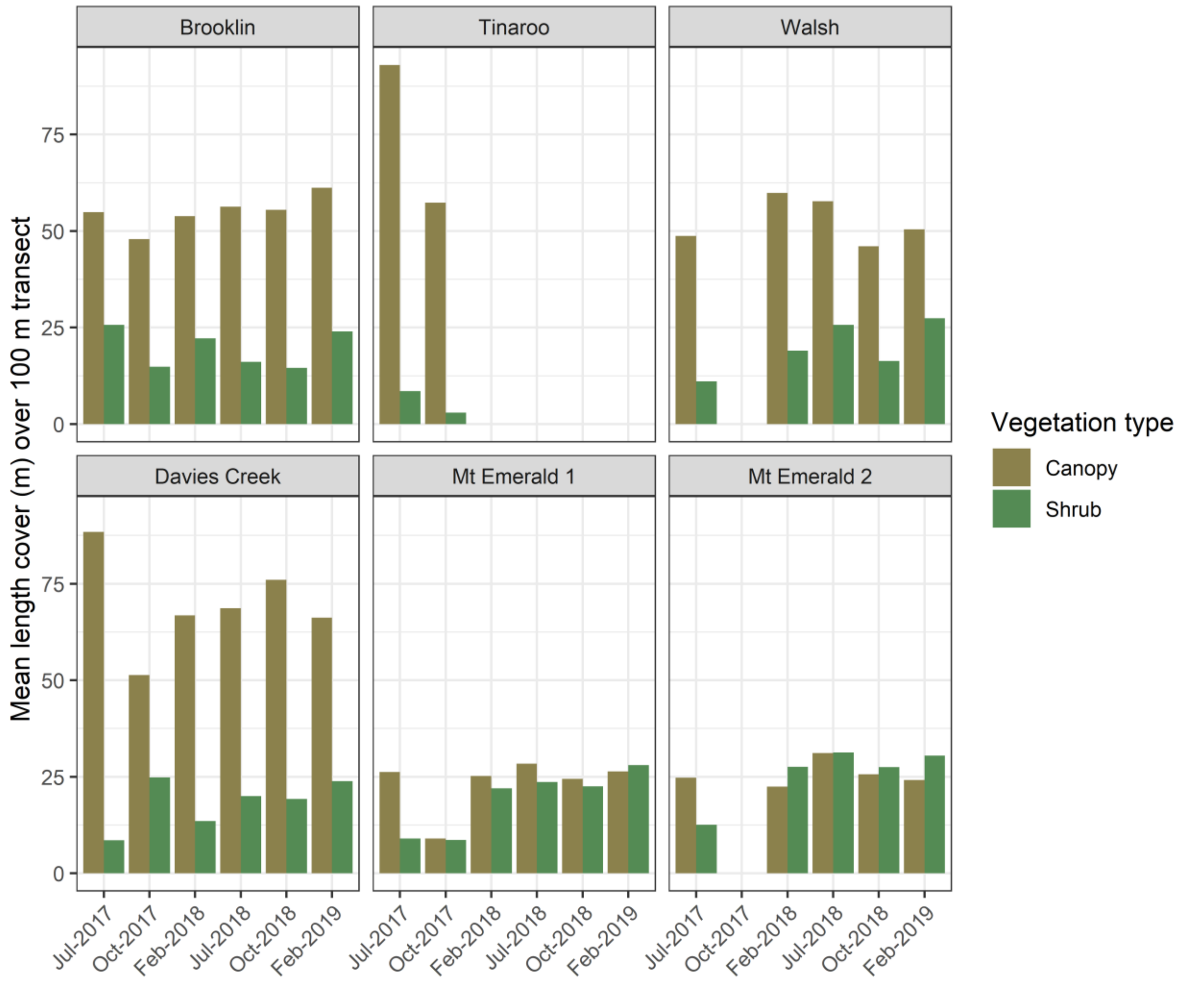

Fig. 7. Canopy and shrub cover on the 18 BioCondition plots at each of the six quoll monitoring sites surveyed between July 2017 and February 2019. Data was not collected from sites on some occasions due to site access or other logistic issues. Note that site Tinaroo has been unavailable from February 2018.

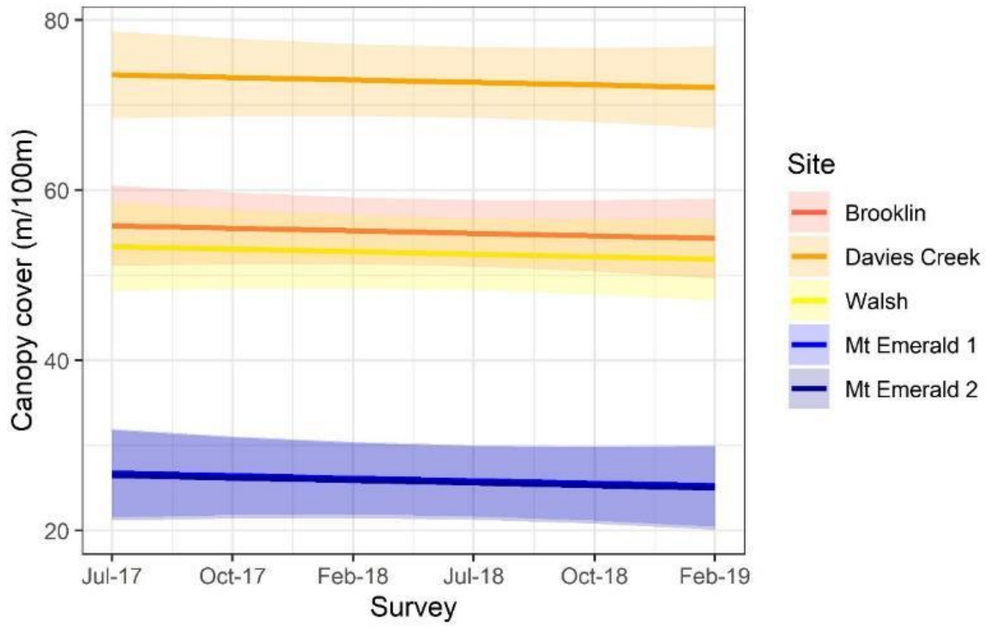

Fig. 8. Outputs of general linear model to predict canopy cover over time at the five monitoring sites. No time trend was detected at any site.

Table 4: Outputs of canopy cover models (N = 460). Canopy cover (m/100m) was modelled as a function of time (survey number) and treatment type (control vs treatment sites) while considering the effects of seasonality (time of the year) and site using a general linear model. The only significant predictor of canopy cover was study site (Site). There were no changes over time in any of the study sites.

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	55.07229	1.969923	27.95657	########
Site = Davies Creek	17.67	2.882626	6.129826	1.91E-09
Site = Mt Emerald 1	-29.1458	2.899647	-10.0515	1.34E-21
Site = Mt Emerald 2	-29.4288	2.945212	-9.99207	2.19E-21
Site = Walsh	-2.53672	2.917336	-0.86953	0.385015

The model included 460 observations (6 surveys over 18 stations in 5 sites, minus 80 instances when canopy cover not recorded). The model equation is Canopy cover ~ Site, where Site is the study site (discrete variable: Brooklyn, Davies Creek, Walsh, Mt Emerald 1, Mt Emerald 2). Initially, also the variables for time (continuous variable, survey number starting July 17 and finishing February 19), type of site (discrete variable: control, treatment) and time of the year in which the surveys were conducted (discrete variable: February, July, October) were included, as well as the interactions between all variables except with time of year. However, all variables and interactions except for the variable Site, were dropped due to non-significant contribution to model fit.

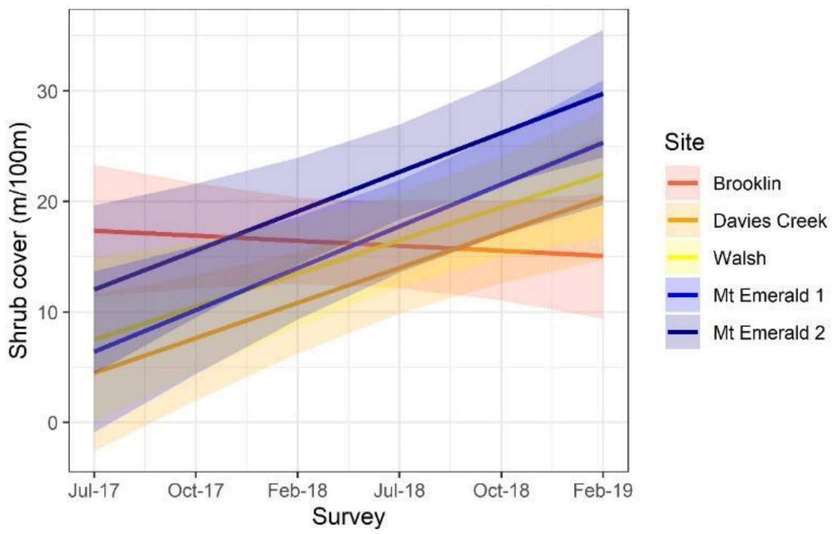

Fig. 8. Outputs of general linear model to predict shrub cover over time at the five monitoring sites. Shrub cover increased in all sites except Brooklyn, a control site.

Table 5: Outputs of shrub cover models (N = 460). Shrub cover (m/100m) was modelled as a function of time (survey number) and treatment type (control vs treatment sites) while considering the effects of seasonality (time of the year) and site using a general linear model. Significant predictors of shrub cover in our data were survey number (SurveyN), study site (Site) and time of the year (Month). Shrub cover similarly increased in all sites over time, except in Brooklyn.

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	22.92777	3.858197	5.942612	5.64E-09
SurveyN	-0.45393	0.903769	-0.50226	0.615728
Site = Davies Creek	-16.5079	5.201062	-3.17395	0.001607
Site = Mt Emerald 1	-15.2066	5.294832	-2.87197	0.004273
Site = Mt Emerald 2	-9.3253	5.46902	-1.70511	0.088866
Site = Walsh	-13.3178	5.34953	-2.48952	0.013153
Month = July	-0.14169	1.905334	-0.07436	0.940754
Month = October	-5.11411	1.88828	-2.70834	0.007021
SurveyN : Site = Davies Creek	3.630685	1.281238	2.833732	0.004809
SurveyN : Site = Mt Emerald 1	4.242049	1.296201	3.272679	0.001148
SurveyN : Site = Mt Emerald 2	3.9995	1.327864	3.011981	0.002742
SurveyN : Site = Walsh	3.45294	1.303019	2.649954	0.008335

The model included 460 observations (6 surveys over 18 stations in 5 sites, minus 80 instances when shrub cover was not recorded). The model equation is Shrub cover ~ SurveyN + Site + Month + SurveyN:Site, where SurveyN represents time (continuous variable, survey number starting July 17 and finishing February 19), Site is the study site (discrete variable: Brooklyn, Davies Creek, Walsh, Mt Emerald 1, Mt Emerald 2) and Month is the time of the year in which the surveys were conducted (discrete variable: February, July, October). Initially, also the variable for type of site (discrete variable: control, treatment) was included, as well as the interactions between all variables except with Month. However, type of site, as well as all interactions except between SurveyN and Site, were dropped due to non-significant contribution to model fit.

There were no changes in coarse woody debris in any sites except Walsh, where debris decreased substantially, and Mt Emerald site 2, where debris increased (Figs 10 and 11, Table 5). The decrease in Walsh coincided with intense fire events, which may have burnt the woody debris down. The increase in Mt Emerald may be attributed to construction of mill pads and roads, in which cut-down and grounded trees were pushed to the side to form mounts of debris.

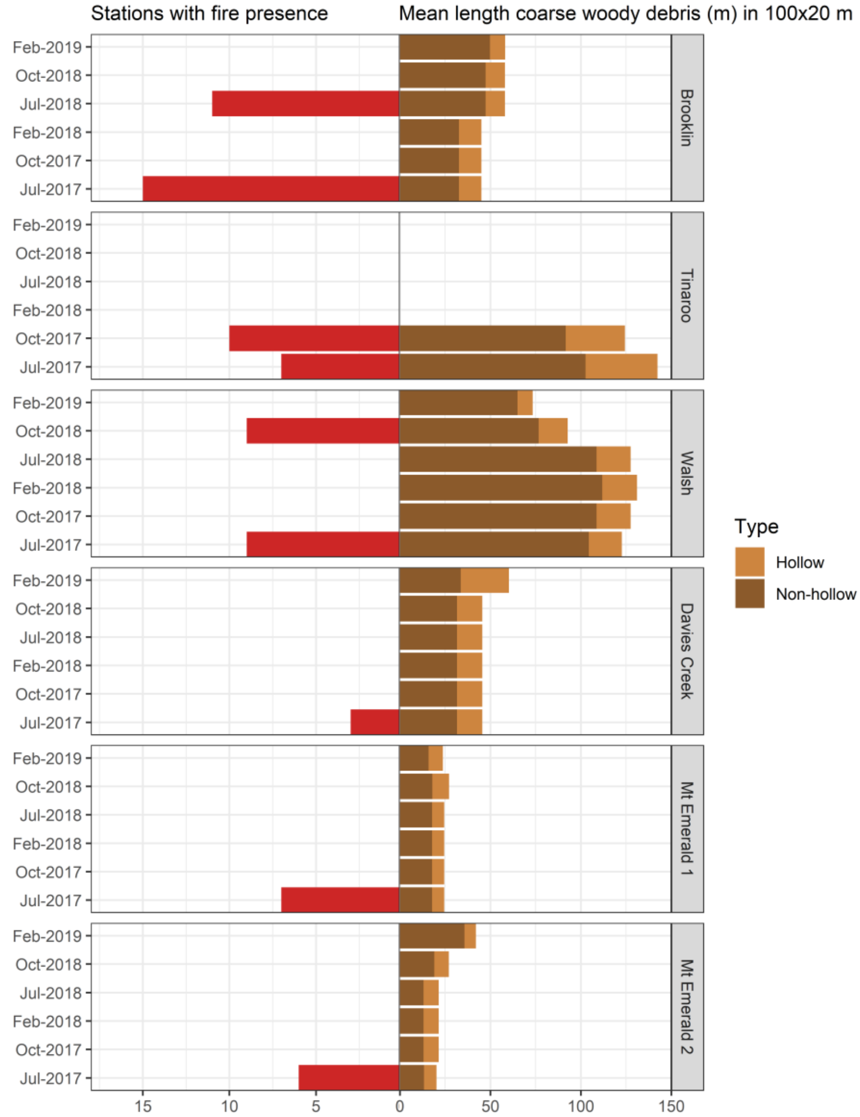

Fig. 10. Number of stations (out of 18 at each site) on which there was evidence of recent fire and mean length of hollow and non-hollow course woody debris at each site between July 2017 and February 2019. Note that site “Tinaroo” has been unavailable from February 2018.

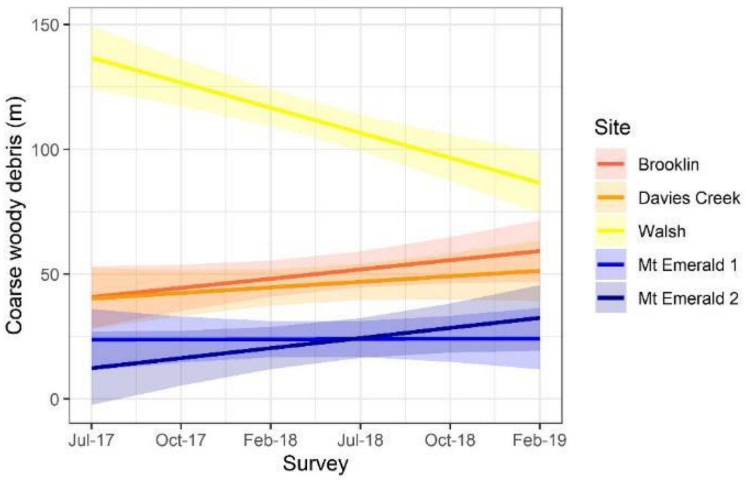

Fig. 11. Outputs of general linear model to predict coarse woody debris over time at the five monitoring sites. Coarse woody debris remained unchanged in all sites except Walsh, where it decreased and Mt Emerald 2, where it increased.

Table 5: Outputs of coarse woody debris models (N = 515). The total length of coarse woody debris found on a 100 x 20 m area surrounding each detector was modelled as a function of time (survey number) and treatment type (control vs treatment sites) while considering the effects of seasonality (time of the year) and site using a general linear model. Significant predictors of coarse woody debris in our data were survey number (SurveyN) and study site (Site). Coarse woody debris remained unchanged in all sites except Walsh, where it decreased and Mt Emerald 2, where it increased.

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept (time zero in Brooklyn)	37.10264	8.033169	4.61868	4.91E-06
SurveyN	3.69286	2.062727	1.79028	0.074008
Site = Davies Creek	0.864585	11.36062	0.076104	0.939367
Site = Mt Emerald 1	-13.4412	11.36062	-1.18314	0.237312
Site = Mt Emerald 2	-28.8127	12.45972	-2.31247	0.021153
Site = Walsh	109.6605	11.45753	9.571037	4.70E-20
SurveyN : Site = Davies Creek	-1.46167	2.917137	-0.50106	0.616545
SurveyN : Site = Mt Emerald 1	-3.6054	2.917137	-1.23594	0.217056
SurveyN : Site = Mt Emerald 2	0.339633	3.121974	0.108788	0.913414
SurveyN : Site = Walsh	-13.7328	2.932666	-4.68271	3.64E-06

The model included 515 observations (6 surveys over 18 stations in 5 sites, minus 25 instances when coarse woody debris were not recorded). The model equation is CWD ~ SurveyN + Site + SurveyN:Site, where SurveyN represents time (continuous variable, survey number starting July 17 and finishing February 19) and Site is the study site (discrete variable: Brooklyn, Davies Creek, Walsh, Mt Emerald 1, Mt Emerald 2). Initially, also the variables for time of the year in which the surveys were conducted (discrete variable: February, July, October) and type of site (discrete variable: control, treatment) were included, as well as the interactions between all variables except with time of year. However, time of year and type of site, as well as all interactions except between SurveyN and Site, were dropped due to non-significant contribution to model fit.

The percent vegetative ground cover decreased in all five sites across the two-year monitoring period. However, the decrease was less prominent in Mt Emerald sites and Davies Creek (Figs 12 and 13, Table 6).

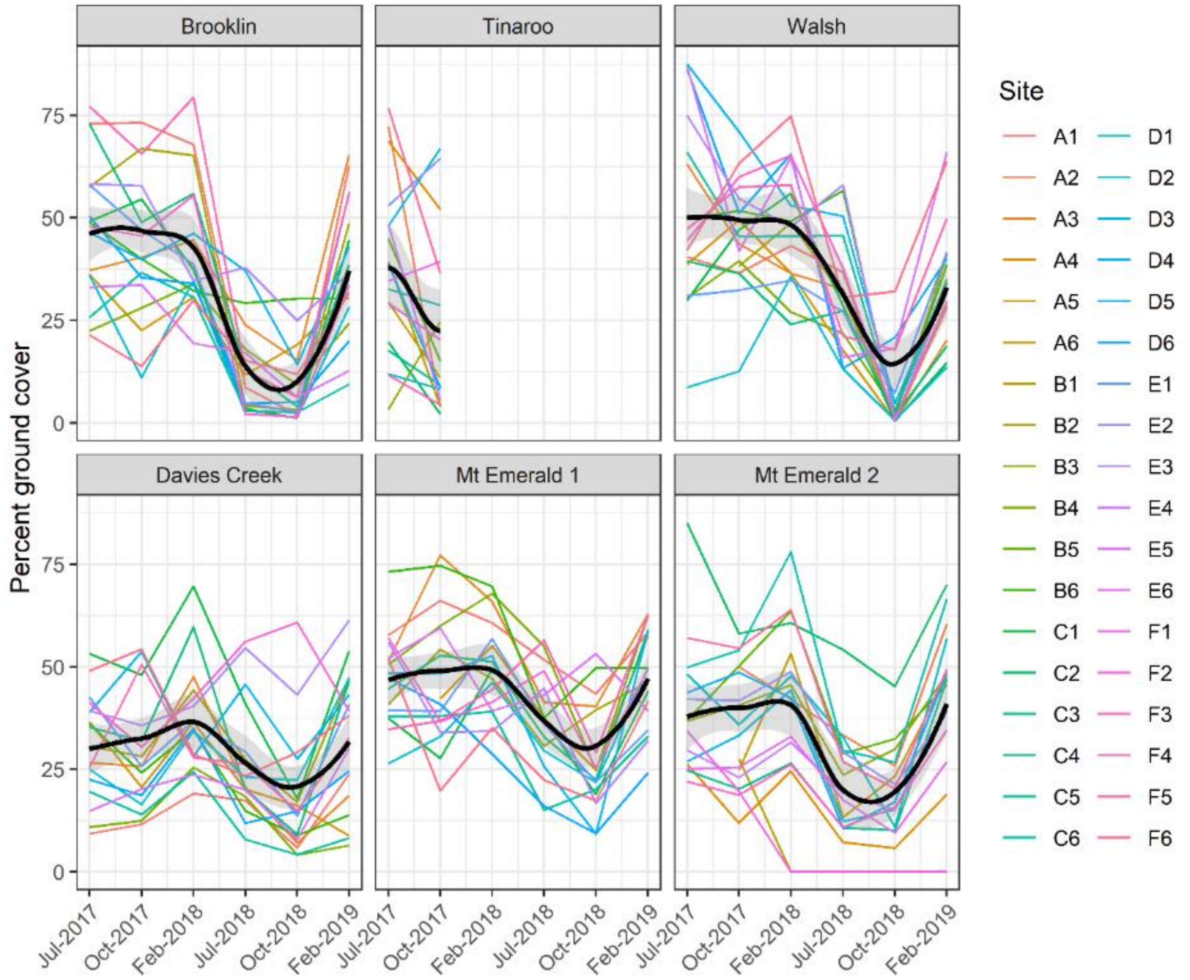

Fig. 12. The percentage of vegetative ground cover at each BioCondition station at each quoll monitoring site between July 2017 and February 2019. Individual plot measurements at each site are individually labelled for each site. Alphanumeric site numbers relate to the labelled stations in Fig 2. The thick black line represents an average value for each site, and the grey margin the standard error of that mean. Note that site “Tinaroo” has been unavailable from February 2018.

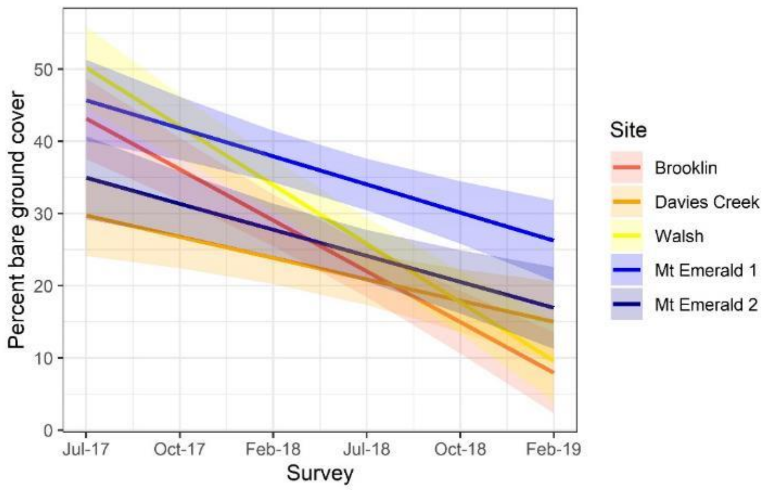

Fig. 13. Outputs of general linear model to predict shrub cover over time at the five monitoring sites. Shrub cover increased in all sites except Brooklyn, a control site. Percent bare ground cover decreased in all sites, but less so in Mt Emerald sites and Davies Creek.

Table 6: Outputs of bare ground cover models (N = 533). The percent cover of bare ground in 1 m^2 plots was modelled as a function of time (survey number) and treatment type (control vs treatment sites) while considering the effects of seasonality (time of the year) and site using a general linear model. Significant predictors of percent bare ground in our data were survey number (SurveyN), study site (Site) and time of the year (Month). Percent bare ground cover decreased in all sites, but less so in Mt Emerald sites and Davies Creek.

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept (time zero in Brooklyn in February)	68.55356	3.797852	18.05061	6.24E-57
SurveyN	-7.04231	0.89306	-7.8856	1.85E-14
Site = Davies Creek	-17.5041	4.777893	-3.66356	0.000274
Site = Mt Emerald 1	-0.6197	4.812874	-0.12876	0.897598
Site = Mt Emerald 2	-11.6296	4.890588	-2.37795	0.017769
Site = Walsh	8.111173	4.818719	1.683263	0.092923
Month = July	-17.0104	1.855669	-9.1667	1.12E-18
Month = October	-18.3646	1.68924	-10.8715	5.97E-25
SurveyN : Site = Davies Creek	4.092762	1.22685	3.335993	0.000911
SurveyN : Site = Mt Emerald 1	3.157849	1.233112	2.560878	0.010721
SurveyN : Site = Mt Emerald 2	3.438911	1.249092	2.753128	0.006109
SurveyN : Site = Walsh	-1.07932	1.233391	-0.87509	0.38193

The model included 533 observations (6 surveys over 18 stations in 5 sites, minus 7 instances when percent bare ground was not recorded). The model equation is Percent ground ~ SurveyN + Site + Month + SurveyN:Site, where SurveyN represents time (continuous variable, survey number starting July 17 and finishing February 19), Site is the study site (discrete variable: Brooklyn, Davies Creek, Walsh, Mt Emerald 1, Mt Emerald 2) and Month is the time of the year in which the surveys were conducted (discrete variable: February, July, October). Initially, also the variable for type of site (discrete variable: control, treatment) was included, as well as the interactions between all variables except with Month. However, type of site, as well as all interactions except between SurveyN and Site, were dropped due to non-significant contribution to model fit.

These habitat monitoring plots do not suggest any disproportionate change in key vegetation parameters at the Mt Emerald sites (although there would obviously have been localised impacts from construction of wind turbines and road infrastructure through the site), other than a modest increase in CWD and percent bare ground cover. Otherwise, the temporal trends observed in vegetative variables are generally similar between Mt Emerald and control sites, so likely represent broadscale weather patterns rather than any site-specific process.

Discussion/Conclusion

The analyses presented above produced no unambiguous evidence for a negative impact of the MEWF project on the number of individual northern quolls; however, we did detect a statistically significant decline in site occupancy on the MEWF sites between the first and second surveys (especially between February 2018 and 2019).

Our data also hint at a decline in the number of individual northern quolls on both MEWF monitoring sites (and the Davies Creek site) between the 2018 and 2019 juvenile pre-breeding phase and a a possible increase in cane toads at one MEWF site (ME1), an increase in course woody debris at the MEWF site ME2, and a relative increase of bare ground cover at both MEWF sites (and the Davies Creek site) were also detected.

No changes in populations or occupancy of the other target fauna species were detected.

The decline in quoll occupancy observed at both MEWF project sites cannot be directly attributed to MEWF works given that the decline was statistically significant in one MEWF site, but statistical significance could not be inferred for the decline in the other MEWF site. However, this combined with the indication of a drop in the number of juveniles between the 2018 and the 2019 juvenile pre-breeding season should be the cause of some concern. The fact that this same pattern was also observed at one of the three control sites (Davies Creek) is somewhat ambiguous evidence that these changes are not caused by MEWF activities, especially given that a strong reverse trend was observed at the Brooklyn control site. Unfortunately, another of our control sites (Walsh) experienced an unexplained crash in quoll numbers at the July 2017 breeding season when our project started and so, although it also demonstrated an increase in numbers counter to that observed at the two MEWF sites, the numbers there are so low as to make any statistical trend impossible to identify. It must be noted that the models utilized are very conservative due to the low sample size. The strong seasonality in quoll numbers means that the population can only be compared between the same season (i.e., same time of year) across years. This, in turn, means that each year only one sample can be collected each breading season, resulting in a sample size of two for the two-year monitoring period. With such low sample size, it is very difficult to infer statistical significance on trends over time. Yet, we were able to infer significance on the decrease in quoll occupancy at one MEWF sites, which indicates a strong decline. The collection of more samples in the coming years may allow the identification of population trends that are too early to be inferred with the present data.

It is reasonable to expect that local construction activity could have caused temporary (or longer term) shifts in the activity patterns of quolls at the MEWF sites, which may not necessarily lead to a longer-term decline in the species there. Moreover, the hinted decline in juvenile quolls during the last survey could affect population dynamics of quolls in the coming years. But this is speculation until further monitoring is undertaken during the post-construction phase of windfarm operation.

We identified no trend in cat, dingo/wild dog or pig abundance (number of detections) or occupancy (number of stations). The presence of all of these species was generally very low on the sites, and there is no reason to expect any changes arising from the MEWF project. They were included here because our method detected them without any extra effort and it was decided, *a priori*, that it would be useful to know how their populations had trended in the event that an unambiguous change in quoll populations had been detected. The camera trapping method used here has not been calibrated for any of these species, and there is reason to suspect that it underestimates cat abundance (cats are not normally thought to be particularly attracted to carrion-baits (e.g. Clapperton *et al.* 1994). On the other hand, we would expect dingoes/wild dogs and feral pigs to be attracted to these lures, and our unpublished data from several years of similar field work support this (S. Burnett unpubl. data). Of these species, the feral cat is likely the most serious threat to individuals and populations of the northern quoll (e.g. Woinarski et al. 2012). Therefore, it is perhaps relevant that at these sites where quolls are abundant, cats are seemingly scarce. An increasing body of research suggest that dingoes/wild dog play an important role in limiting feral cat abundance, and dingoes should be treated as an important part of the ecology of the MEWF sites. For that reason, it would be inappropriate to undertake any dingo or wild dog control on the MEWF site.

The most widespread of the non-quoll target species on the sites was the cane toad. No doubt cane toad detections are inflated compared to those of other species by the toad's habitat of remaining almost motionless beside the bait cannister (where they feed on insects attracted by the bait) for extended periods. All other animals whose primary focus is the bait itself, tend to give up after relatively few detections, after they fail to extract it from the cannister. The spike in cane toad numbers at one of the MEWF sites (ME1) in February 2019 has a parallel at the Brooklyn and, to a lesser extent, the Davies Creek sites at the same time. This suggests that it is a seasonal effect being the result of the hot and humid weather at this time compared to the previous February and other survey sessions which were much drier when cameras where set. Although there are parallels between the sites, the spike in numbers at the ME1 sites may indicate that earthworks have created better toad habitat, i.e. bare ground and possibly artificial breeding sites. As toads are already present at the MEWF sites, and quolls have coexisted with them here for many generations, it is unlikely that an increase in toad numbers will directly affect quolls via poisoning, as happens when naïve quolls interact with toads (e.g. Burnett 1997)(and see cover image for an example of quoll habituation to cane toads at ME1), but they could represent a competition for invertebrate prey if their numbers boom. We point out that ME1 is the site from which quolls unambiguously decreased in distribution and so an impact of high-density toad populations on naïve young quolls can't be ruled out as a driver from this apparent contraction of quoll range on this site.

Finally, given the spatial scale of the habitat monitoring which we conducted (confined to a 100 x 20m plot centred on every second camera station) it is not surprising that we didn't detect any pervasive habitat changes at the Mt Emerald sites indicative of project works. At all sites, ground cover decreased each year from the February late wet season survey to the October late dry season survey as a function of the seasonal changes that typify the northern Australian annual wet-dry seasons. Other changes at various sites could be attributed to wildfires at these sites. The only habitat change that we detected which could be attributed to MEWF project works was an increase in course woody debris on our plots. As noted at the time, this was a function of clearing for access roads and turbine pads leading to trees being felled into our monitoring plots. Perversely (and not withstanding deleterious impacts on other species), this may benefit quolls by providing denning habitat and nocturnal shelter sites from predators on the MEWF sites. The strength of our habitat monitoring lies in its baseline nature, which includes visual observations and a photographic record of ground cover and ground layer species samples, and will be useful for detecting pervasive changes to the sites due to the spread of weeds and possibly changed fire regimes.

Recommendations

Recommendations arising from this work are designed to clear up ambiguities in the data and to facilitate the continued presence and health of the northern quoll population at the MEWF site;

- A 3-season 2020 monitoring session is recommended to assess whether there has been a continued decline in breeding success of quoll on the Mt Emerald sites and to establish whether quoll occupancy has stabilised. This should follow the protocols used here in order to render data comparable with that collected here.

- Conduct early wet season acoustic surveys for artificial cane toad breeding sites and decommission where possible. The spike in toad numbers at the ME1 site in February 2019 may indicate the inadvertent creation of artificial toad breeding ponds. A survey of these sites to identify any such sites, and their decommissioning would be a technically simple operation with potentially great ecological outcomes for quolls and the entire MEWF site.
- Maintain a healthy dingo population at MEWF. The two MEWF sites had the highest incidence of cats of any of the five sites monitored (though still low). Cats are a known predator of northern quolls and the best option for keeping them in low numbers is helping to maintain a healthy Dingo population at these sites.
- Full BioCondition should be repeated whenever quoll monitoring is repeated in order to detect pervasive vegetative habitat changes (such as intrusion of weeds or deleterious changes in fire frequency and intensity).

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References

Burnett S. 1997. Colonising Cane Toads cause population declines in native predators: reliable anecdotal evidence and management implications. *Pacific Conservation Biology*. 3: 65-72.

Burnett, S. 2012. Northern quoll *D. hallucatus* pp 340-341 in Curtis LK, Dennis AJ, McDonald KR, Kyne PM and Debus SJS (editors). *Queensland's Threatened Animals*. CSIRO Publishing, Melbourne.

Burnett, S., Shimizu, Y and Middleton, J. 2013. *Distribution and abundance of the northern quoll (Dasyurus hallucatus) in far north Queensland.* Unpublished Report to Ratch Australasia.

Clapperton, BK., Eason, CT., Weston, RJ., Woolhouse, AD, and Morgan, DR. 1994. Development and testing of attractants for feral cats, Felis catus L. *Wildlife Research*, 21(4): 389-399.

Conroy, G., Lamont, R and Burnett, S 2013. *Dasyurus hallucatus Population Genetics: Final Report*. Unpublished report to Ratch Australasia.

Eyre, T.J., Kelly, A.L, Neldner, V.J., Wilson, B.A., Ferguson, D.J., Laidlaw, M.J. and Franks, A.J. 2015. *BioCondition: A Condition Assessment Framework for Terrestrial Biodiversity in Queensland. Assessment Manual. Version 2.2.* Queensland Herbarium, Department of Science, Information Technology, Innovation and Arts, Brisbane.

Fiske, I., and Chandler, R. 2011. unmarked: An R Package for Fitting Hierarchical Models of Wildlife Occurrence and Abundance. *Journal of Statistical Software*, 43(10), 1-23. URL http://www.jstatsoft.org/v43/i10/.

Laake, J.L. 2013. *RMark: An R Interface for Analysis of Capture-Recapture Data with MARK*. AFSC Processed Rep 2013-01, 25p. Alaska Fish. Sci.

MacKenzie, D. I., Nichols, J. D., Royle, J. A., Pollock, K. H., Bailey, L., & Hines, J. E. (2017). *Occupancy estimation and modelling: inferring patterns and dynamics of species occurrence.* Elsevier

Niedballa, J., Courtiol, A., and Sollmann, R. 2017. *camtrapR: Camera Trap Data Management and Preparation of Occupancy and Spatial Capture-Recapture Analyses.* R package version 0.99.9. https://CRAN.R-project.org/package=camtrapR.

Otis, D.L., Burnham, K.P., White, G.C., and Anderson, D. 1978. Statistical Inference from Capture Data on Closed Animal Populations. Wildlife Monographs, No. 62, Statistical Inference from Capture Data on Closed Animal Populations (Oct., 1978), pp. 3-135.

R Core Team, 2016. R: *A language and environment for statistical computing*. R foundation for statistical computing, Vienna, Austria. URL https://www.R-project.org.

White, G. C., & Burnham, K. P. (1999). Program MARK: survival estimation from populations of marked animals. *Bird study*, 46(sup1), S120-S139.

White, G. C., Burnham, K. P., & Anderson, D. R. (2001, June). Advanced features of program MARK. In *Wildlife, land, and people: priorities for the 21st century*. Proceedings of the second international wildlife management congress. The Wildlife Society, Bethesda, Maryland, USA (pp. 368-377).

Woinarski, J., Oakwood, M., Winter, J., Burnett, S., Milne, D., Foster, P., Myles, H. and Holmes, B. *Surviving the toads: Patterns of persistence of the northern quoll,* Dasyurus hallucatus in Queensland. Report submitted to the Natural Heritage Trust Strategic Reserve Program, as a component of project 2005/162: Monitoring & Management of Cane Toad Impact in the Northern Territory.

Woinarski, J., Burbidge, A., and Harrison, P., 2012. *The Action Plan for Australian Mammals*. CSIRO Publishing, Melbourne.

APPENDICES

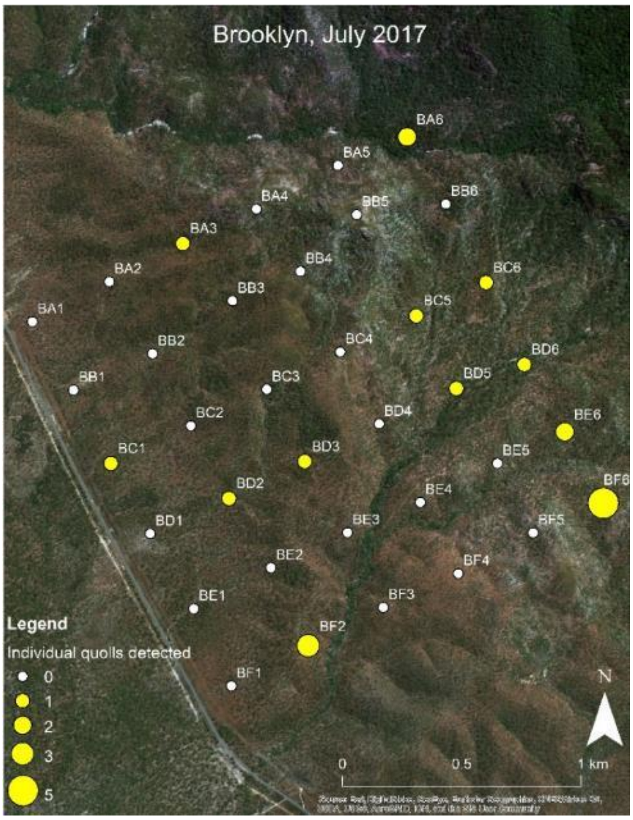
Appendix A. Summarised northern quoll detection data from this project.

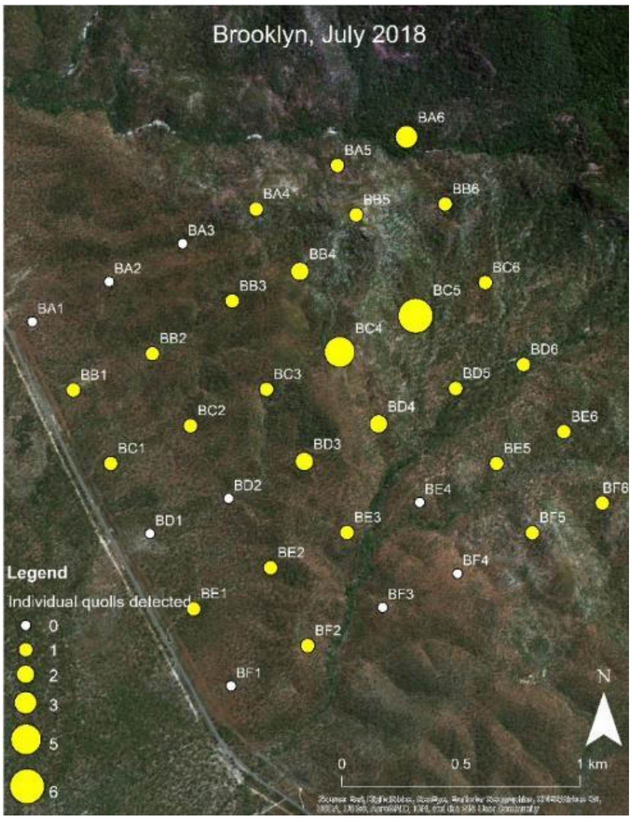
“Site” refers to the monitoring site in question (refer to Fig. 1, Table 1 for details). “Revisit” refers to whether it was the first or second sample made for each site. “Nmark” and “SE(Nmark)” refer to population estimates generated using the r- package RMark and the standard error of those estimates. “Psi” and “P” and “SE(psi)” and “SE(p)” refer to the estimates and their standard errors of occupancy and detection probability calculated using r-package unmarked. “Naïve” refers to the naïve or observed occupancy of quolls on each site. “Events” refers to the number of independent detection events, “Stations” refers to the number if camera stations at which quolls were detected and “N-ind” refers to the number of individual quolls captured for each Site and session.

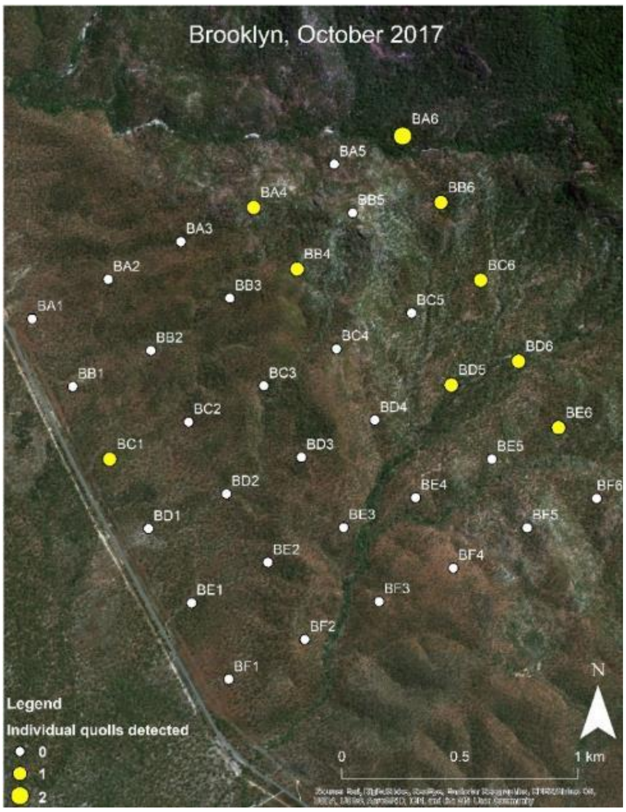
Site	Session	Nsession	Month	Revisit	Type	Nmark	SE(Nmark)	Psi	SE(psi)	P	SE(p)	Naive	Events	Stations
Brooklyn	Jul-17	1	Jul	0	Control	19.44413	14.17536	0.553582	0.182015	0.065492	0.024157	0.333333	25	12
DaviesCk	Jul-17	1	Jul	0	Control	21.78095	6.194638	0.81201	0.219681	0.061991	0.019916	0.472222	33	17
ME1	Jul-17	1	Jul	0	Treatment	10.04315	0.552512	0.579008	0.189644	0.065398	0.024172	0.333333	21	12
ME2	Jul-17	1	Jul	0	Treatment	9.172597	0.847394	0.456505	0.141951	0.080593	0.027036	0.305556	26	11
Walsh	Jul-17	1	Jul	0	Control	1	3.07E-11	NA	NA	0.002037	0.002035	0.027778	1	1
Brooklyn	Oct-17	2	Oct	0	Control	10.59584	3.478958	0.434279	0.179859	0.059394	0.027068	0.25	17	9
DaviesCk	Oct-17	2	Oct	0	Control	12.588	1.371354	0.522901	0.114794	0.111078	0.025455	0.388889	32	14
ME1	Oct-17	2	Oct	0	Treatment	5.002425	0.115888	0.365276	0.177158	0.057514	0.030344	0.194444	13	7
ME2	Oct-17	2	Oct	0	Treatment	8	4.36E-07	NA	NA	0.018336	0.006062	0.25	10	9
Walsh	Oct-17	2	Oct	0	Control	NA	NA	NA	NA	NA	NA	0	0	0
Brooklyn	Feb-18	3	Feb	0	Control	14.01325	0.833022	0.380695	0.123328	0.095535	0.031482	0.25	18	9
DaviesCk	Feb-18	3	Feb	0	Control	20.02896	0.50929	0.63714	0.122318	0.111855	0.024586	0.472222	39	17
ME1	Feb-18	3	Feb	0	Treatment	20.2647	1.681446	NA	NA	0.087432	0.013038	0.666667	49	24
ME2	Feb-18	3	Feb	0	Treatment	18.00013	0.049557	NA	NA	0.054063	0.010099	0.5	30	18
Walsh	Feb-18	3	Feb	0	Control	1	5.53E-06	NA	NA	0.004462	0.003344	0.055556	3	2
Brooklyn	Jul-18	4	Jul	1	Control	30.35751	3.7036	NA	NA	0.095219	0.013656	0.75	59	27
DaviesCk	Jul-18	4	Jul	1	Control	35.8674	4.260872	0.77774	0.116527	0.123554	0.023276	0.611111	69	22
ME1	Jul-18	4	Jul	1	Treatment	2	6.62E-07	NA	NA	0.004636	0.003562	0.055556	2	2
ME2	Jul-18	4	Jul	1	Treatment	11.20513	1.111279	0.641837	0.176944	0.073453	0.023286	0.388889	27	14
Walsh	Jul-18	4	Jul	1	Control	2	0.000429	0.061764	0.042498	0.238781	0.115224	0.027778	5	1

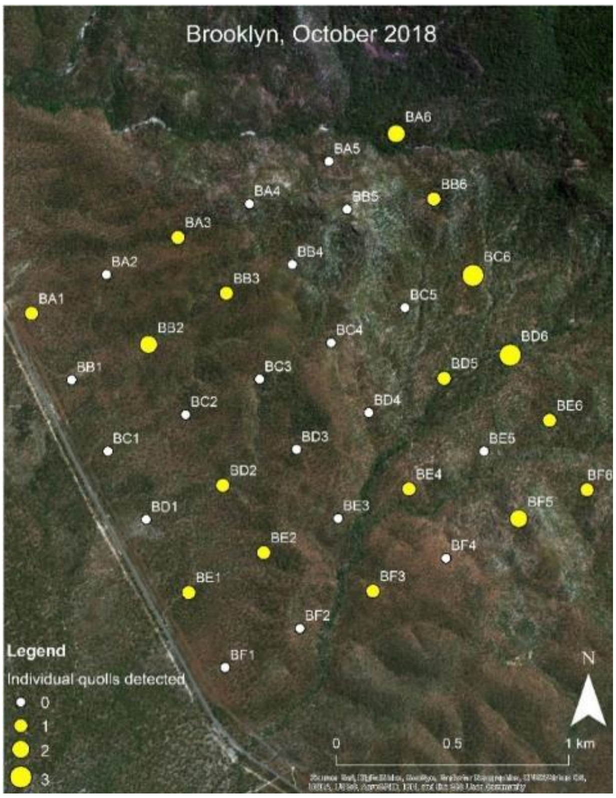
Site	Session	Nsession	Month	Revisit	Type	Nmark	SE(Nmark)	Psi	SE(psi)	P	SE(p)	Naive	Events	Stations
Brooklyn	Oct-18	5	Oct	1	Control	20.22236	4.36571	0.658151	0.140504	0.09355	0.023452	0.472222	39	17
DaviesCk	Oct-18	5	Oct	1	Control	19.45991	1.198917	0.646489	0.100585	0.141559	0.023507	0.555556	60	20
ME1	Oct-18	5	Oct	1	Treatment	7.065426	2.14994	0.295176	0.103624	0.101414	0.035518	0.194444	19	7
ME2	Oct-18	5	Oct	1	Treatment	9.002987	0.207405	0.512131	0.156339	0.074872	0.025276	0.333333	19	12
Walsh	Oct-18	5	Oct	1	Control	NA	NA	NA	NA	NA	NA	0	0	0
Brooklyn	Feb-19	6	Feb	1	Control	20.03351	0.785339	0.719544	0.154821	0.085411	0.02251	0.5	35	18
DaviesCk	Feb-19	6	Feb	1	Control	7	8.14E-06	NA	NA	0.016925	0.005946	0.222222	11	8
ME1	Feb-19	6	Feb	1	Treatment	10.01713	0.494882	0.54078	0.224186	0.053343	0.024546	0.277778	15	10
ME2	Feb-19	6	Feb	1	Treatment	12.09436	0.66156	0.43458	0.128307	0.090149	0.027946	0.305556	25	11
Walsh	Feb-19	6	Feb	1	Control	2	2.13E-05	0.177755	0.154625	0.045924	0.042664	0.083333	7	3

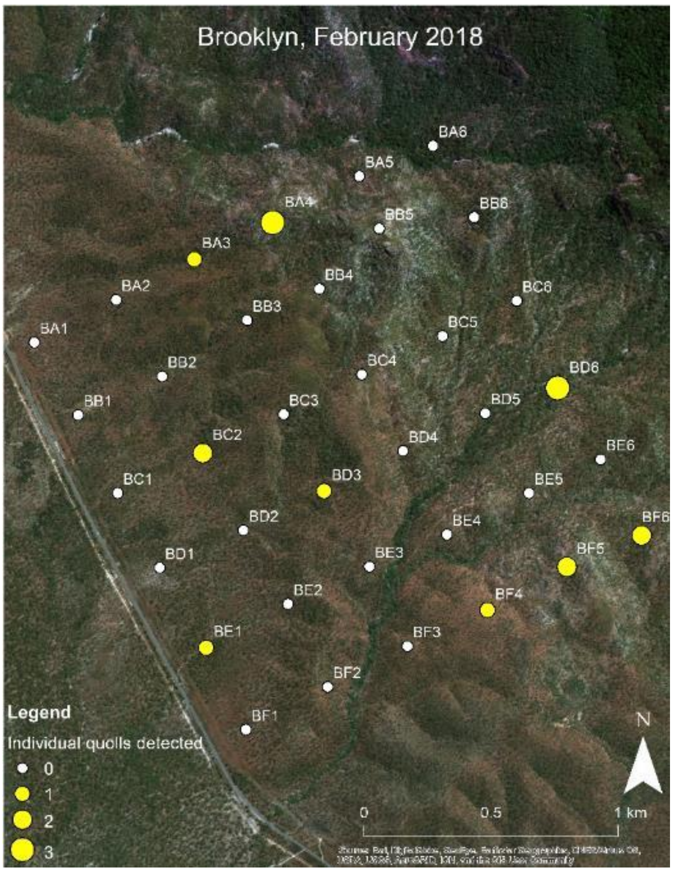
Appendix B. Quoll detections at each of the six monitoring sites during each survey period. Maps are arranged on the page to allow direct comparison between comparable seasonal surveys.

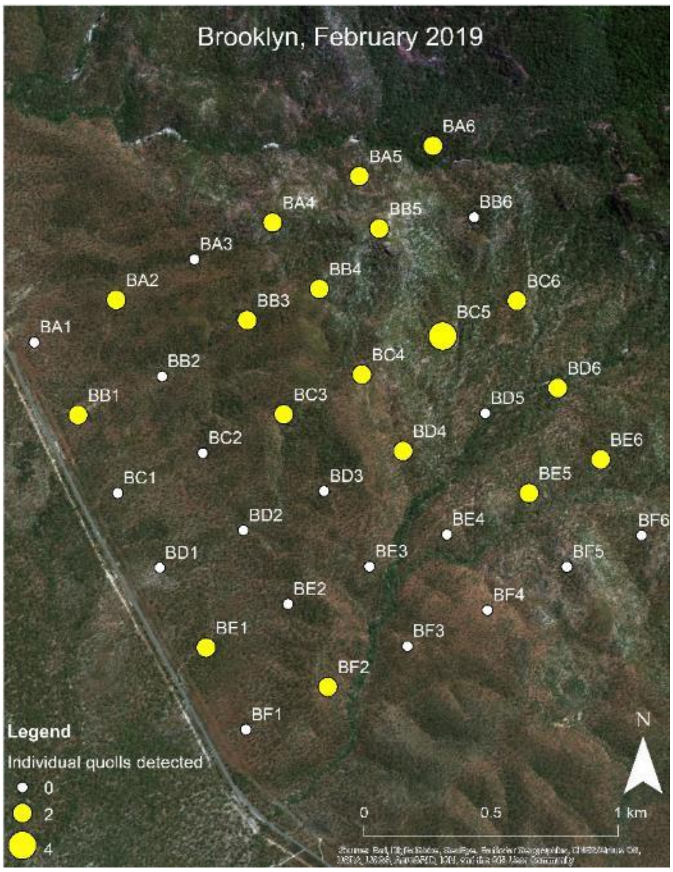




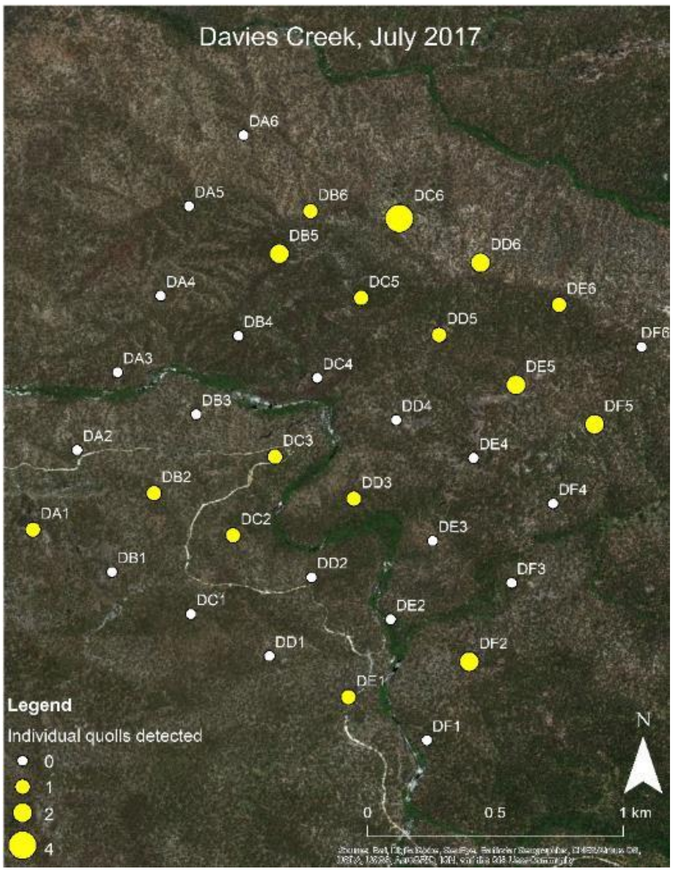


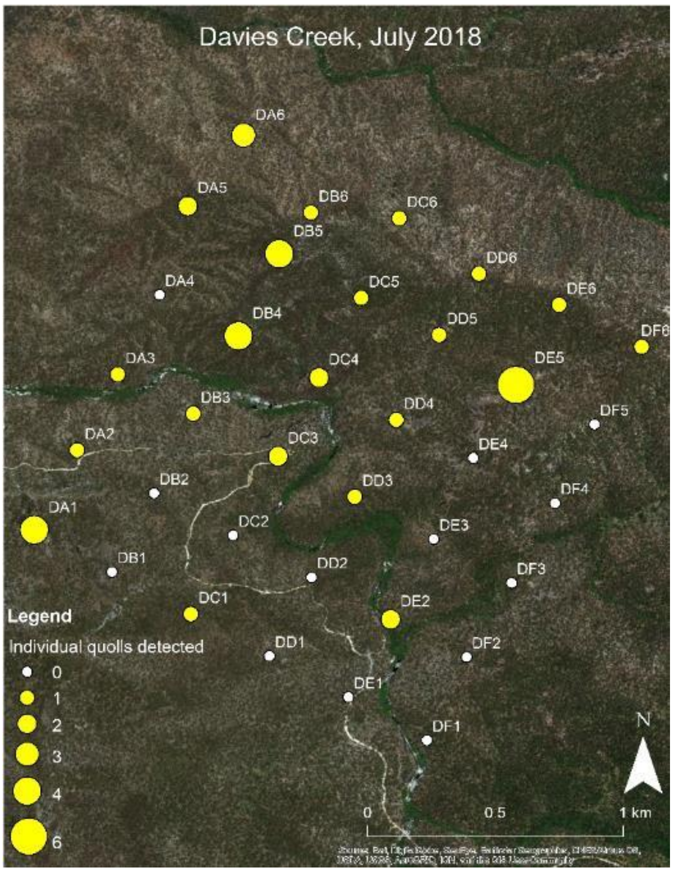


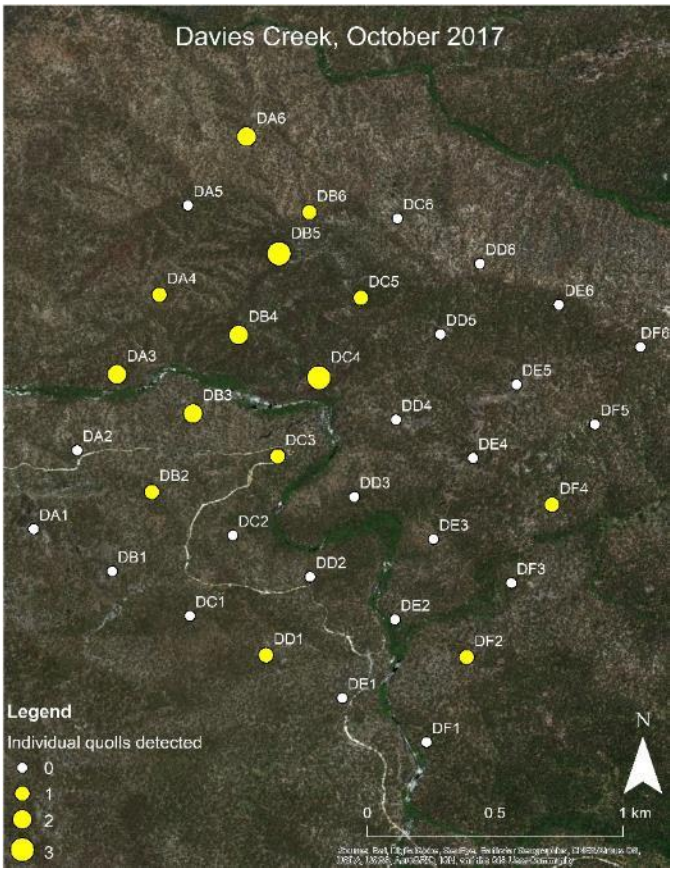


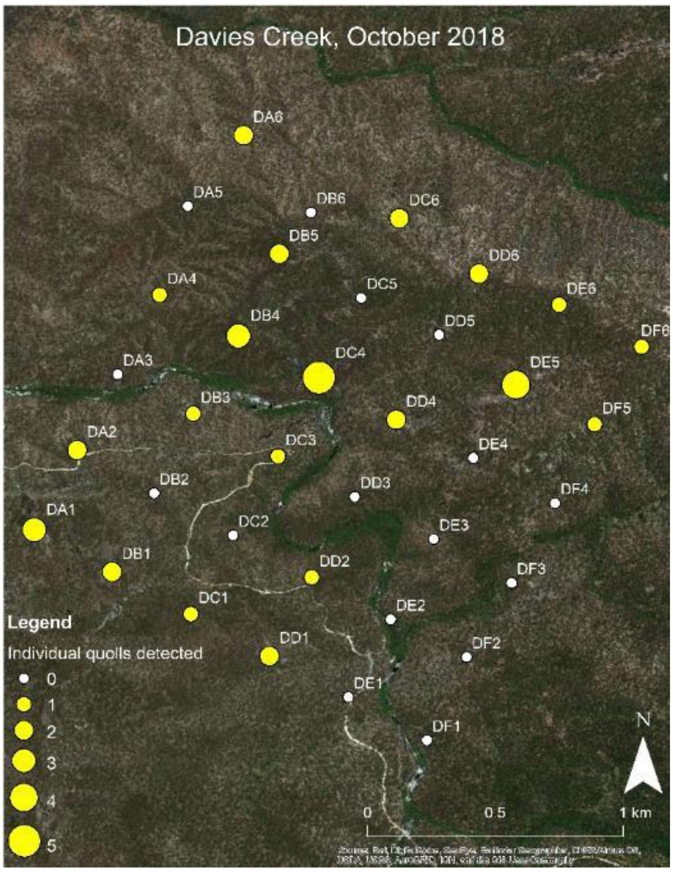


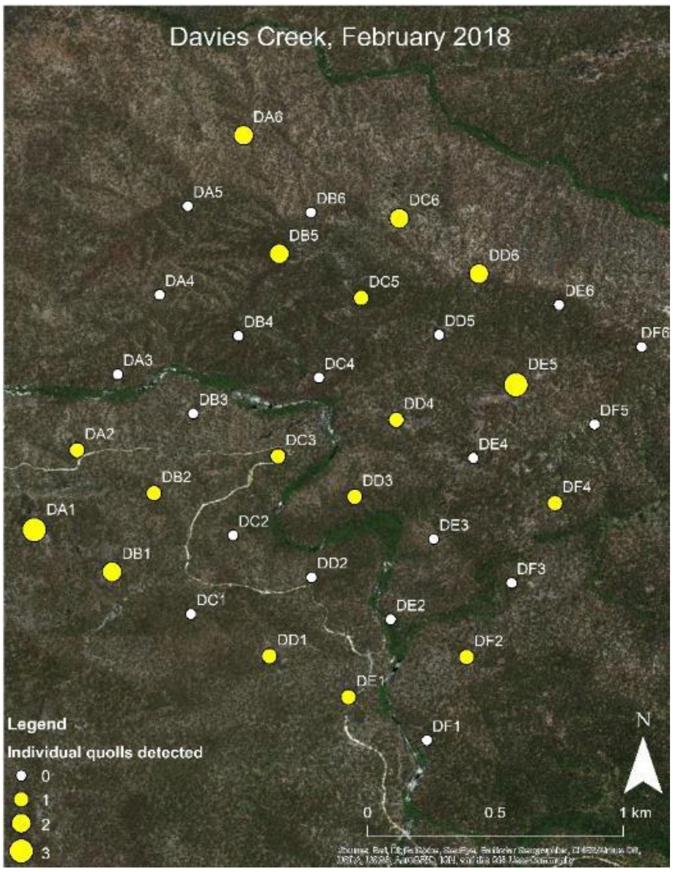
Appendix B1. The distribution of quolls, and the number of individuals detected at each camera trap station during comparable monitoring times. July 2017 and July 2018 (top row previous page), October 2017 and 2018 (bottom row previous page) and February 2018 and February 2019 (this page) at Site "Brooklyn".

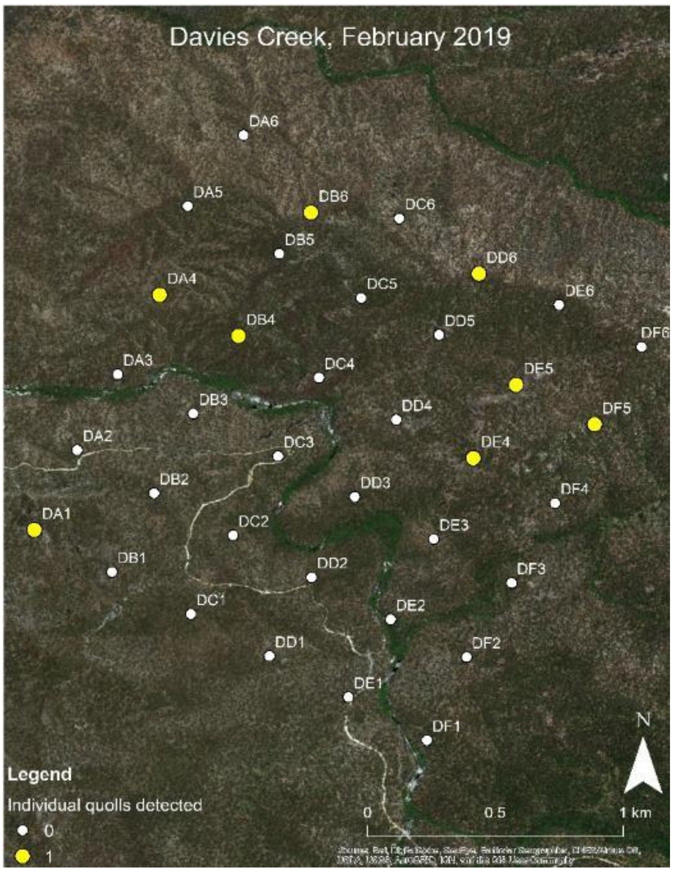

Davies Creek, July 2017
DA6
DA5
DB6
DC6
DB5
DD6
DA4
DC5
DE6
DB4
DD5
DF6
DA3
DC4
DE5
DB3
DD4
DF5
DA2
DC3
DE4
DB2
DD3
DF4
DA1
DC2
DE3
DB1
DD2
DF3
DC1
DE2
DD1
DF2
DE1
DF1
Legend
Individual quolls detected
0
1
2
4
N
0
0.5
1 km


Davies Creek, July 2018
DA6
DA5
DB6
DC6
DB5
DD6
DA4
DC5
DE6
DB4
DD5
DF6
DA3
DC4
DE5
DB3
DD4
DF5
DA2
DC3
DE4
DB2
DD3
DF4
DA1
DC2
DE3
DB1
DD2
DF3
DC1
DE2
DD1
DF2
DE1
DF1
Legend
Individual quolls detected
0
1
2
3
4
6
N
0
0.5
1 km

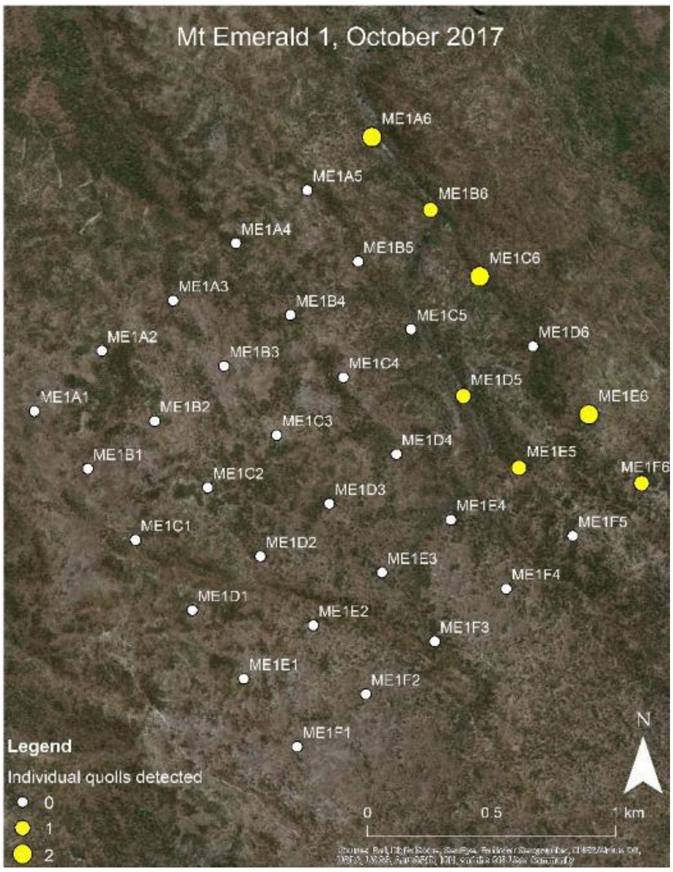

Davies Creek, October 2017
DA6
DA5
DB6
DC6
DB5
DD6
DA4
DC5
DE6
DB4
DD5
DF6
DA3
DC4
DE5
DB3
DD4
DF5
DA2
DC3
DE4
DB2
DD3
DF4
DA1
DC2
DE3
DB1
DD2
DF3
DC1
DE2
DD1
DF2
DE1
DF1
Legend
Individual quolls detected
0
1
2
3
N
0
0.5
1 km

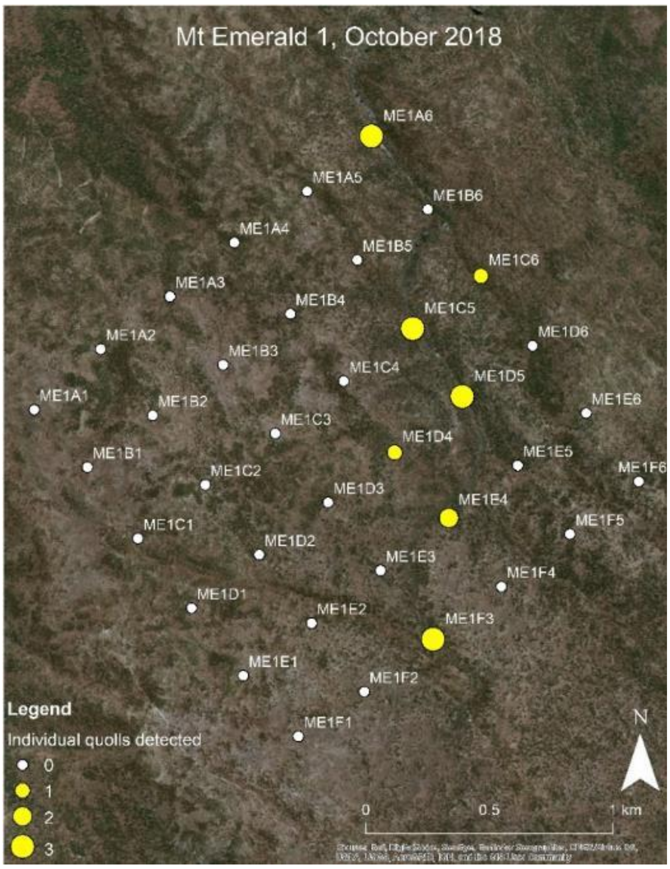

Davies Creek, October 2018
DA6
DA5
DB6
DC6
DB5
DD6
DA4
DC5
DE6
DB4
DD5
DF6
DA3
DC4
DE5
DB3
DD4
DF5
DA2
DC3
DE4
DB2
DD3
DF4
DA1
DC2
DE3
DB1
DD2
DF3
DC1
DE2
DD1
DF2
DE1
DF1
Legend
Individual quolls detected
0
1
2
3
4
5
N
0
0.5
1 km

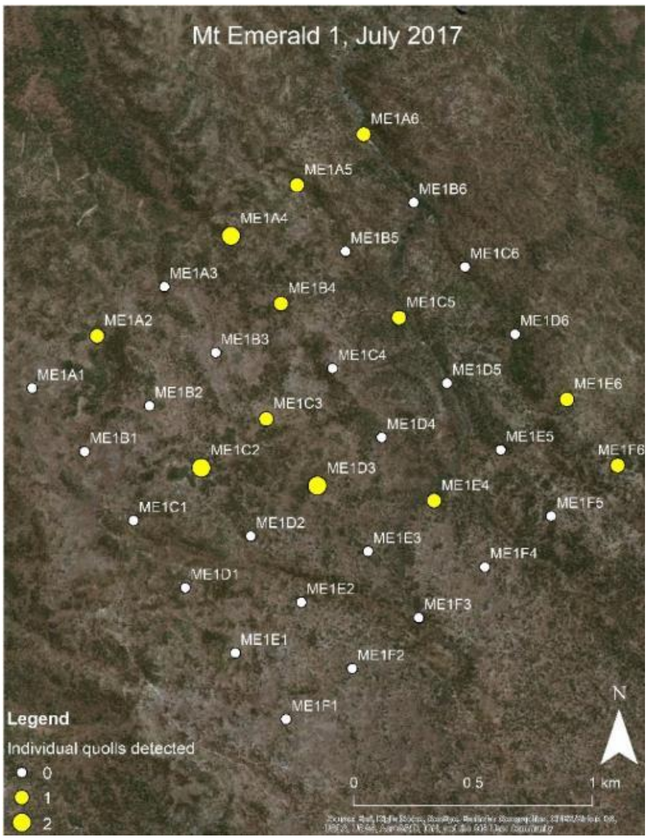


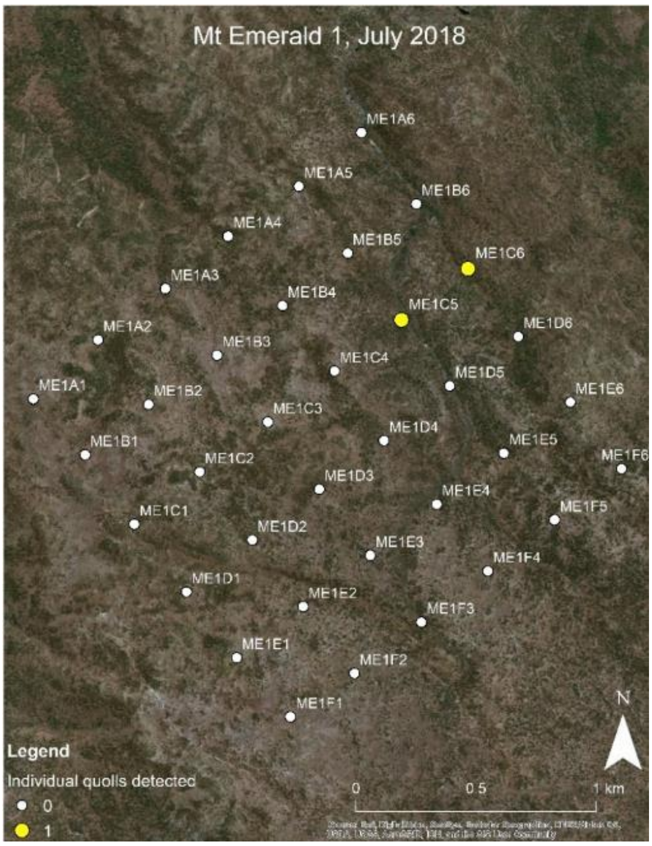


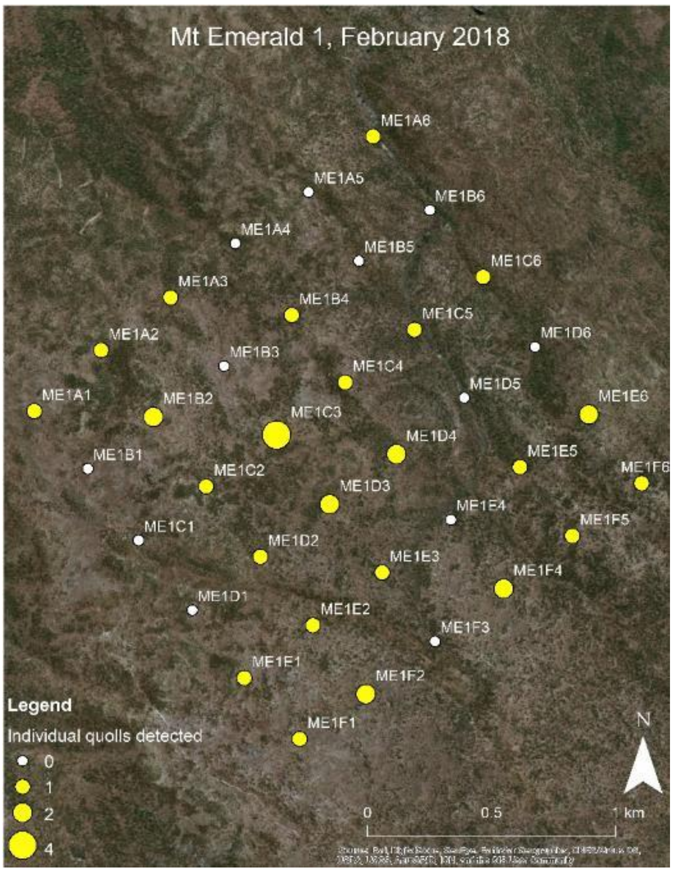
Appendix B2. The distribution of quolls, and the number of individuals detected at each camera trap station during comparable monitoring times. July 2017 and July 2018 (top row previous page), October 2017 and 2018 (bottom row previous page) and February 2018 and February 2019 (this page) at Site "Davies Creek".

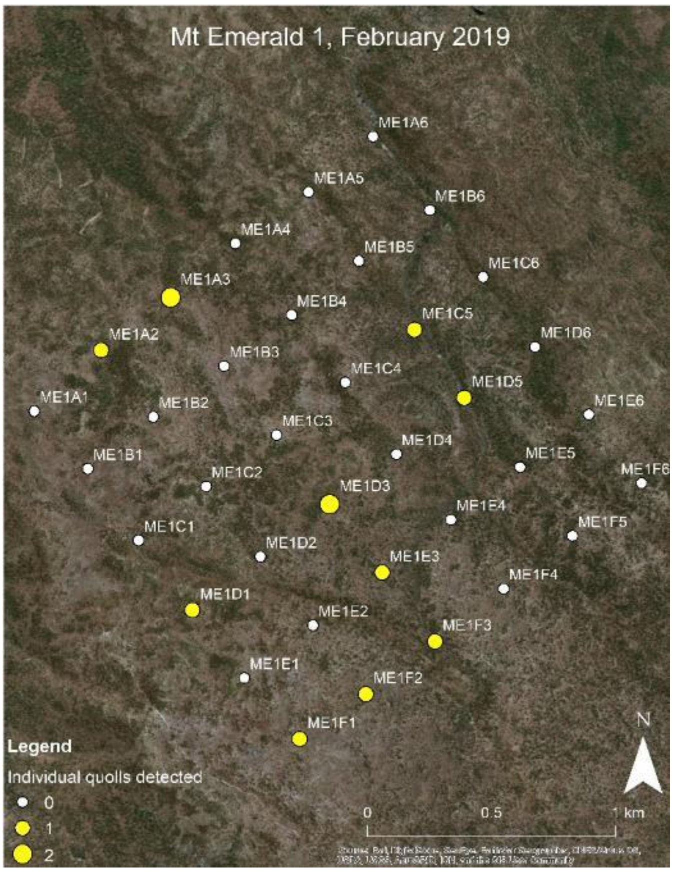

Mt Emerald 1, October 2017
Legend
Individual quolls detected
0
1
2
0 0.5 1 km
N


Mt Emerald 1, October 2018
Legend
Individual quolls detected
0
1
2
3
0 0.5 1 km
N

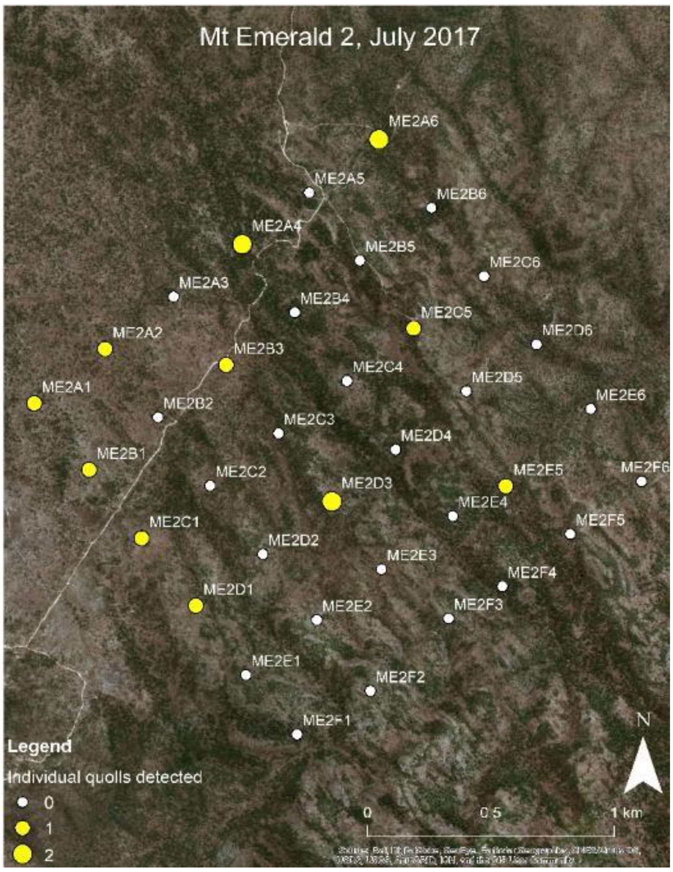

Mt Emerald 1, July 2017
Legend
Individual quolls detected
0
1
2
0 0.5 1 km
N

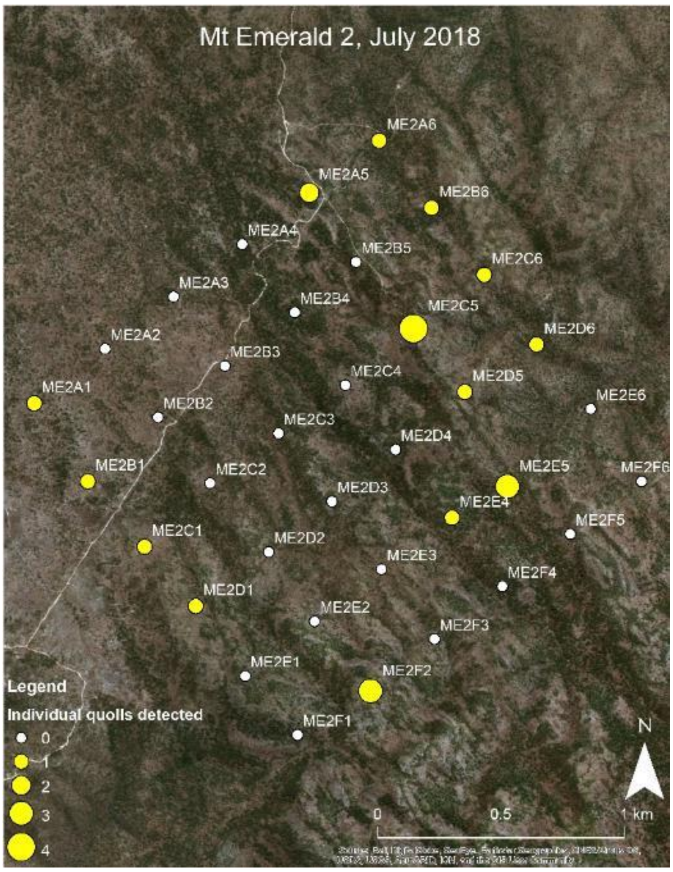

Mt Emerald 1, July 2018
Legend
Individual quolls detected
0
1
0 0.5 1 km
N

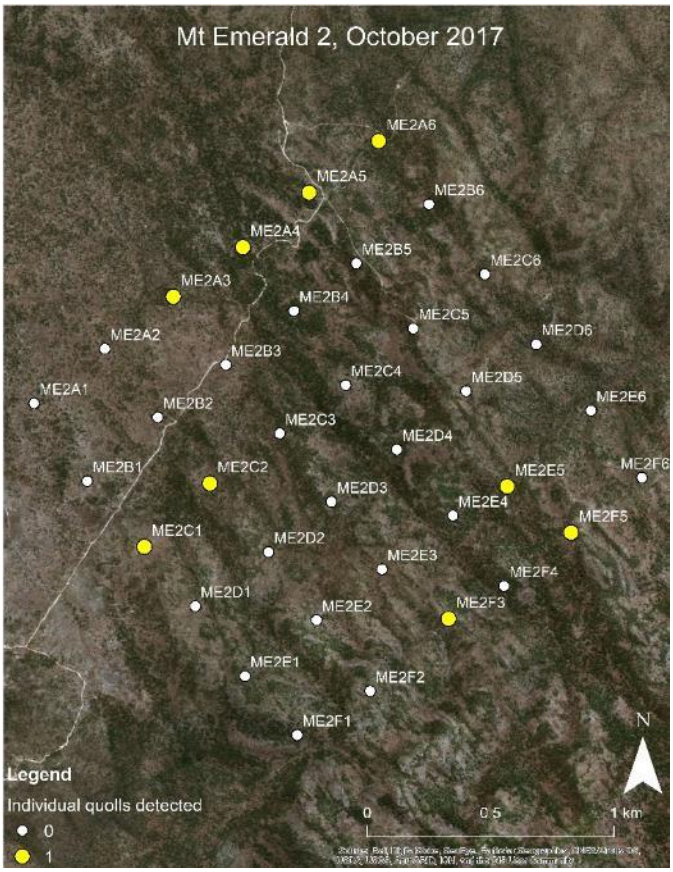


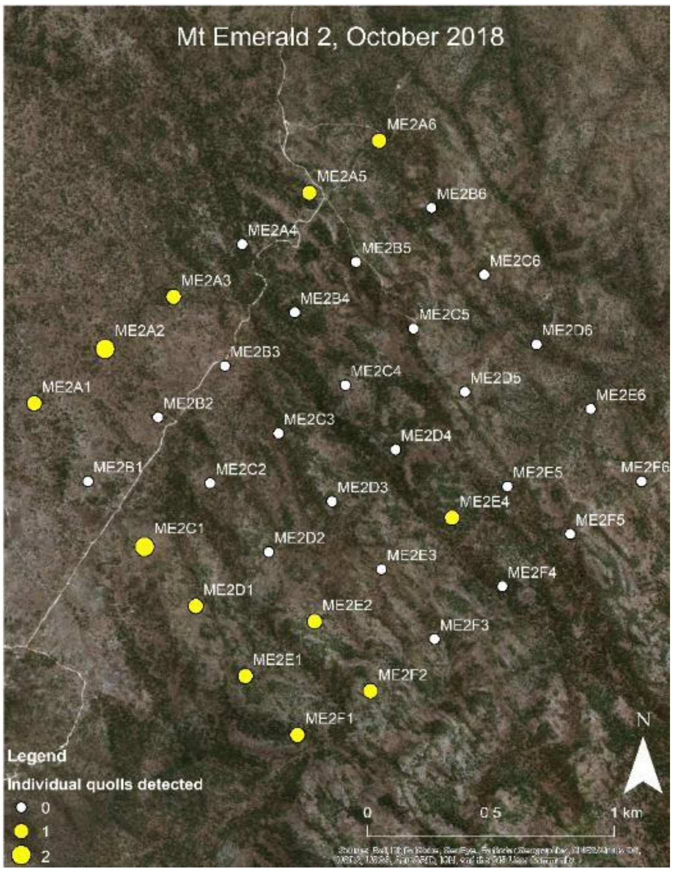


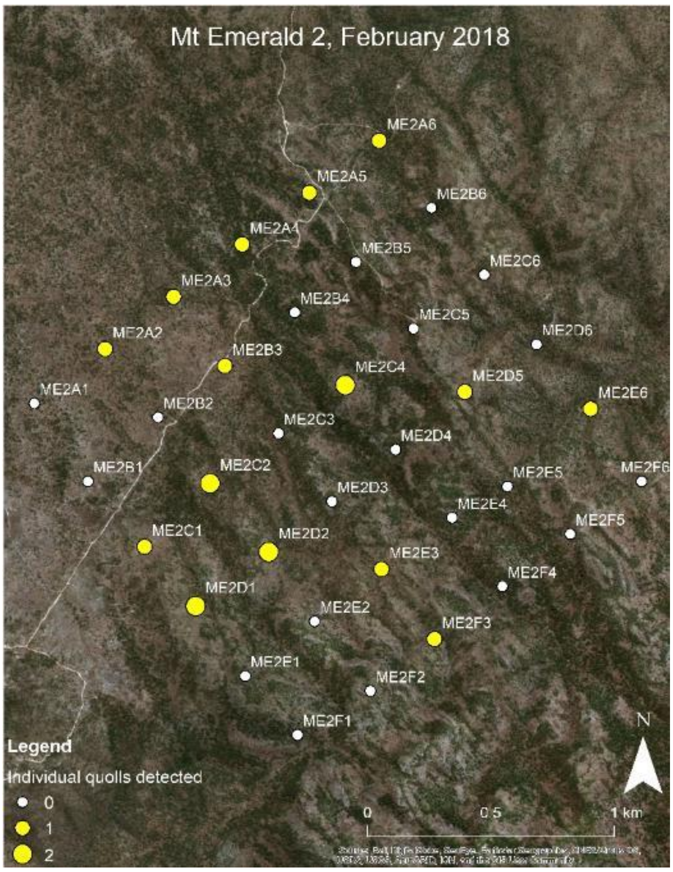
Appendix B3. The distribution of quolls, and the number of individuals detected at each camera trap station during comparable monitoring times. July 2017 and July 2018 (top row previous page), October 2017 and 2018 (bottom row previous page) and February 2018 and February 2019 (this page) at Site "Mt Emerald 1".

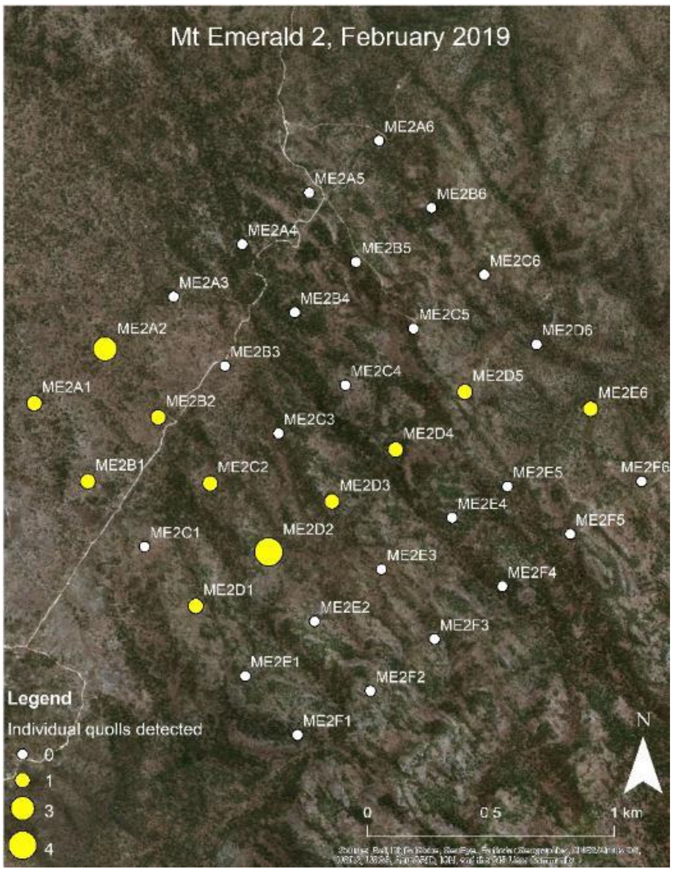

Mt Emerald 2, July 2017
ME2A6
ME2A5
ME2B6
ME2A4
ME2B5
ME2C6
ME2A3
ME2B4
ME2C5
ME2A2
ME2B3
ME2D6
ME2C4
ME2D5
ME2A1
ME2B2
ME2E6
ME2C3
ME2D4
ME2B1
ME2C2
ME2D3
ME2E5
ME2F6
ME2E4
ME2C1
ME2F5
ME2D2
ME2E3
ME2F4
ME2D1
ME2E2
ME2F3
ME2E1
ME2F2
ME2F1
N
Legend
Individual quolls detected
0
1
2
0
0.5
1 km


Mt Emerald 2, July 2018
ME2A6
ME2A5
ME2B6
ME2A4
ME2B5
ME2C6
ME2A3
ME2B4
ME2C5
ME2D6
ME2A2
ME2B3
ME2C4
ME2D5
ME2A1
ME2B2
ME2E6
ME2C3
ME2D4
ME2B1
ME2C2
ME2E5
ME2F6
ME2D3
ME2E4
ME2F5
ME2C1
ME2D2
ME2E3
ME2F4
ME2D1
ME2E2
ME2F3
ME2E1
ME2F2
ME2F1
Legend
Individual quolls detected
0
1
2
3
4
N
0
0.5
1 km

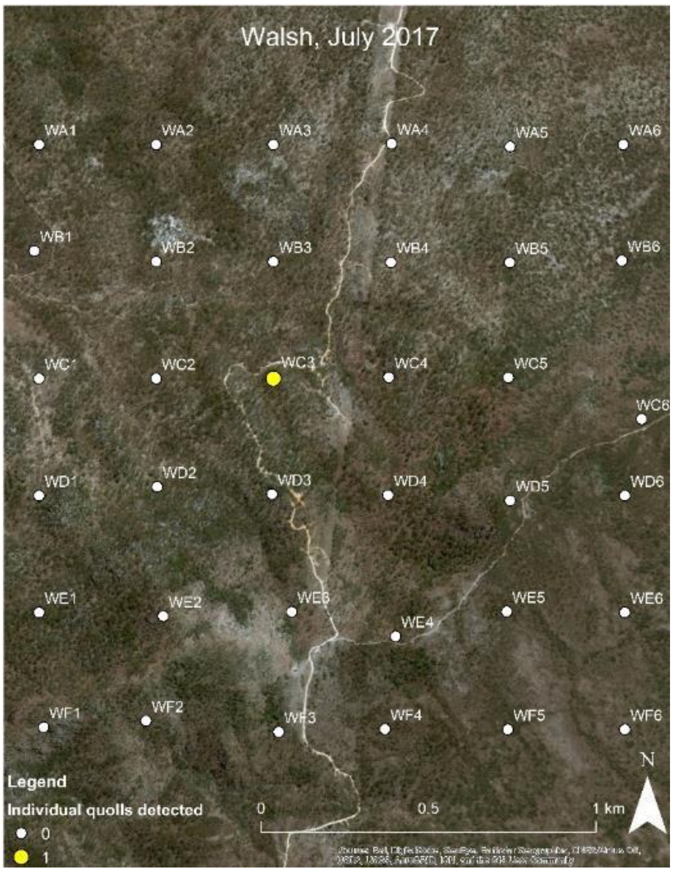

Mt Emerald 2, October 2017
ME2A6
ME2A5
ME2B6
ME2A4
ME2B5
ME2C6
ME2A3
ME2B4
ME2C5
ME2A2
ME2D6
ME2B3
ME2C4
ME2D5
ME2A1
ME2B2
ME2E6
ME2C3
ME2D4
ME2B1
ME2C2
ME2E5
ME2F6
ME2D3
ME2E4
ME2F5
ME2C1
ME2D2
ME2E3
ME2F4
ME2D1
ME2F3
ME2E2
ME2E1
ME2F2
ME2F1
N
Legend
Individual quolls detected
0
1
0
0.5
1 km

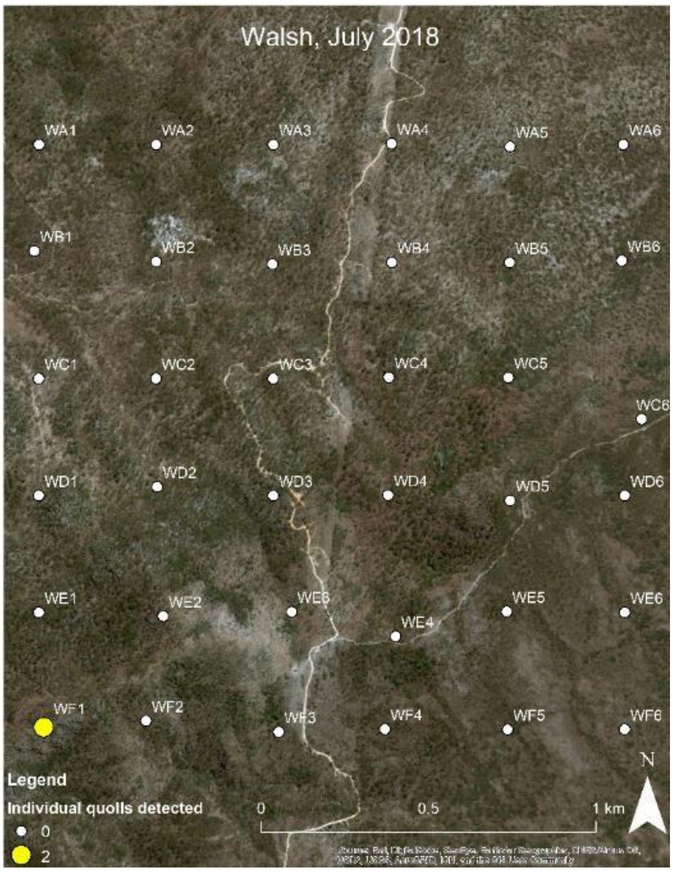

Mt Emerald 2, October 2018
ME2A6
ME2A5
ME2B6
ME2A4
ME2B5
ME2C6
ME2A3
ME2B4
ME2C5
ME2A2
ME2D6
ME2B3
ME2C4
ME2A1
ME2D5
ME2B2
ME2E6
ME2C3
ME2D4
ME2B1
ME2C2
ME2E5
ME2F6
ME2D3
ME2E4
ME2F5
ME2C1
ME2D2
ME2E3
ME2F4
ME2D1
ME2E2
ME2F3
ME2E1
ME2F2
ME2F1
N
Legend
Individual quolls detected
0
1
2
0
0.5
1 km

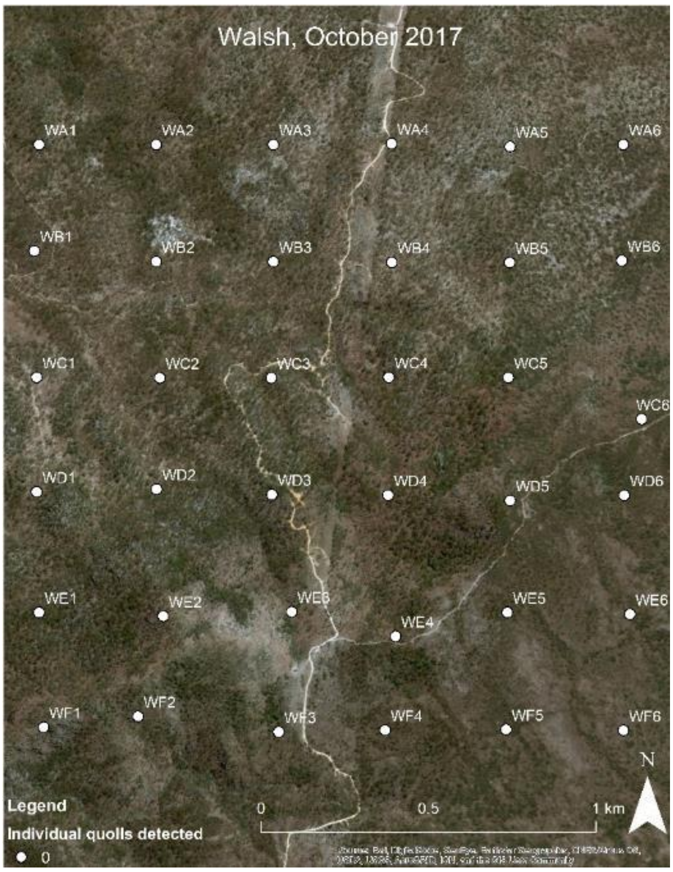


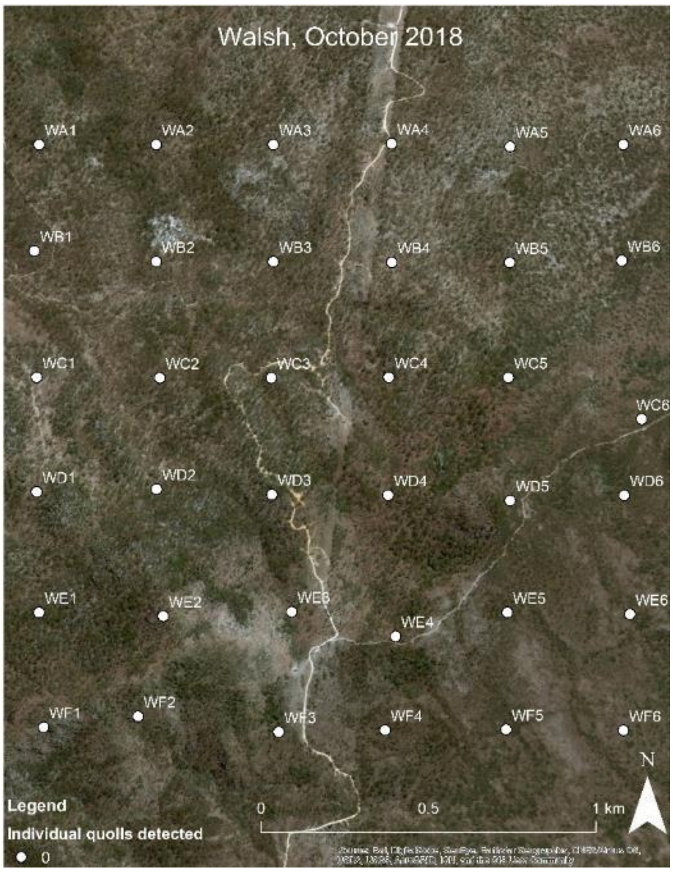


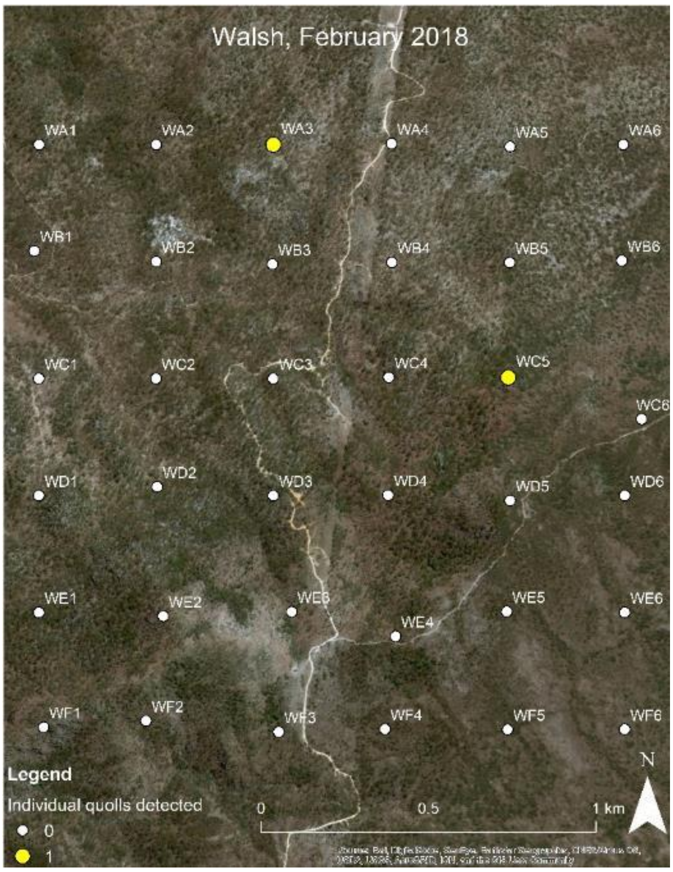
Appendix B4. The distribution of quolls, and the number of individuals detected at each camera trap station during comparable monitoring times. July 2017 and July 2018 (top row previous page), October 2017 and 2018 (bottom row previous page) and February 2018 and February 2019 (this page) at Site "Mt Emerald 2".

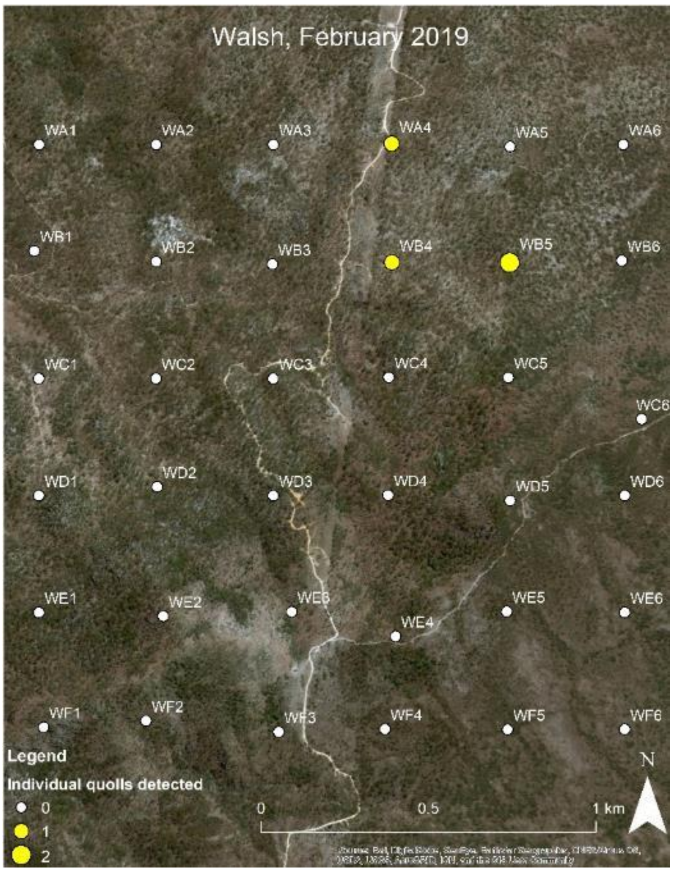

Walsh, July 2017
WA1 WA2 WA3 WA4 WA5 WA6
WB1 WB2 WB3 WB4 WB5 WB6
WC1 WC2 WC3 WC4 WC5 WC6
WD1 WD2 WD3 WD4 WD5 WD6
WE1 WE2 WE3 WE4 WE5 WE6
WF1 WF2 WF3 WF4 WF5 WF6
N
Legend
Individual quolls detected
0
1
0 0.5 1 km


Walsh, July 2018
WA1 WA2 WA3 WA4 WA5 WA6
WB1 WB2 WB3 WB4 WB5 WB6
WC1 WC2 WC3 WC4 WC5 WC6
WD1 WD2 WD3 WD4 WD5 WD6
WE1 WE2 WE3 WE4 WE5 WE6
WF1 WF2 WF3 WF4 WF5 WF6
N
Legend
Individual quolls detected
0
2
0 0.5 1 km

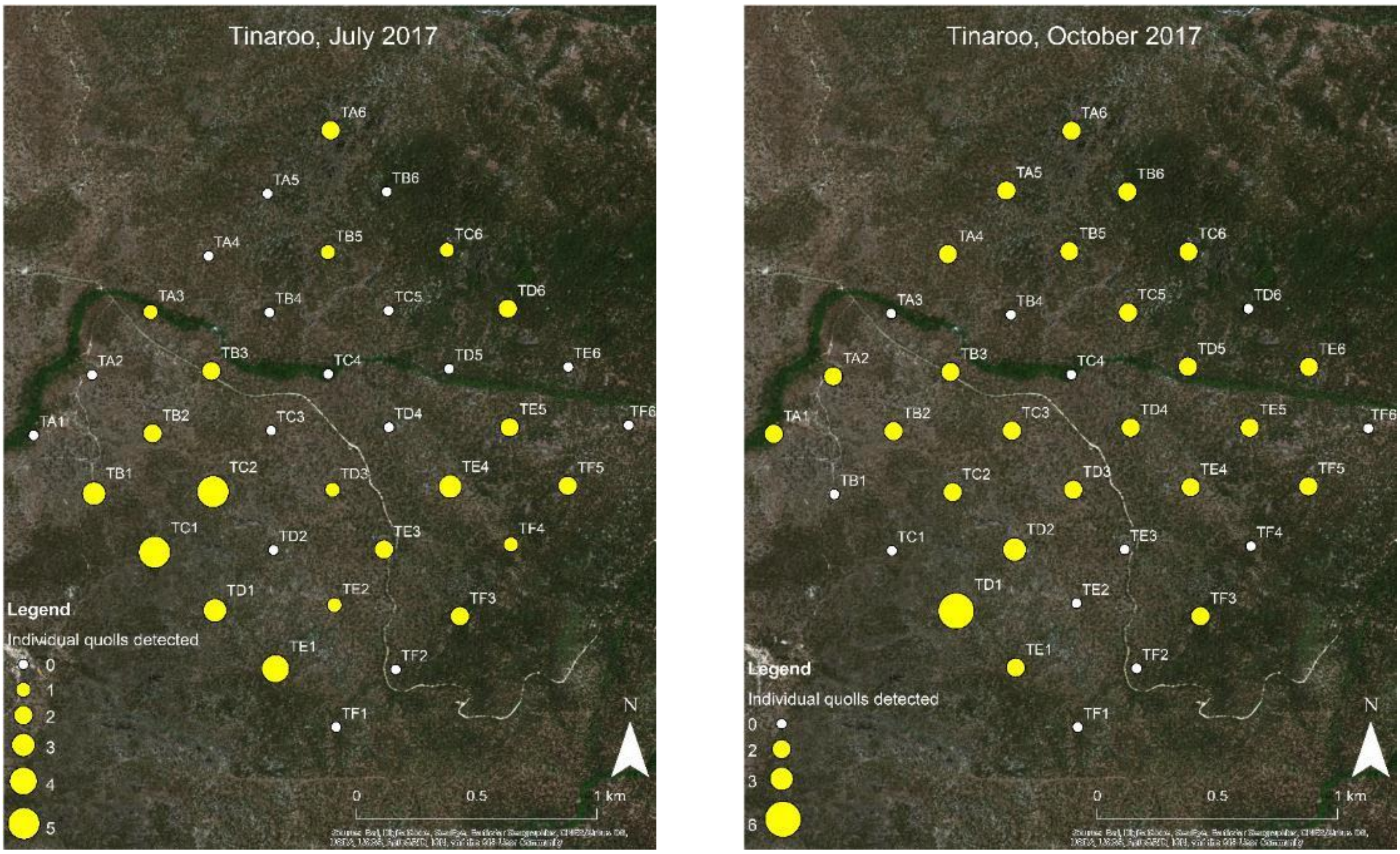

Walsh, October 2017
WA1 WA2 WA3 WA4 WA5 WA6
WB1 WB2 WB3 WB4 WB5 WB6
WC1 WC2 WC3 WC4 WC5 WC6
WD1 WD2 WD3 WD4 WD5 WD6
WE1 WE2 WE3 WE4 WE5 WE6
WF1 WF2 WF3 WF4 WF5 WF6
N
Legend
Individual quolls detected
0
0 0.5 1 km


Walsh, October 2018
WA1 WA2 WA3 WA4 WA5 WA6
WB1 WB2 WB3 WB4 WB5 WB6
WC1 WC2 WC3 WC4 WC5 WC6
WD1 WD2 WD3 WD4 WD5 WD6
WE1 WE2 WE3 WE4 WE5 WE6
WF1 WF2 WF3 WF4 WF5 WF6
N
Legend
Individual quolls detected
0
0 0.5 1 km





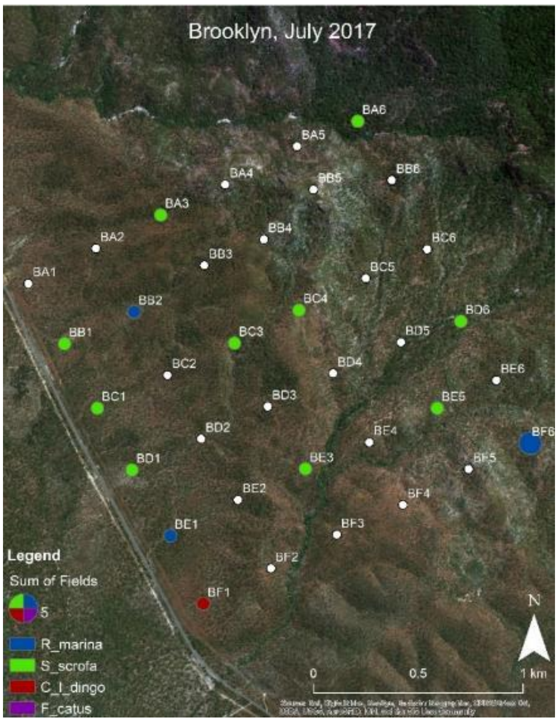
Appendix B5. The distribution of quolls, and the number of individuals detected at each camera trap station during comparable monitoring times. July 2017 and July 2018 (top row previous page), October 2017 and 2018 (bottom row previous page) and February 2018 and February 2019 (this page) at Site “Walsh”.

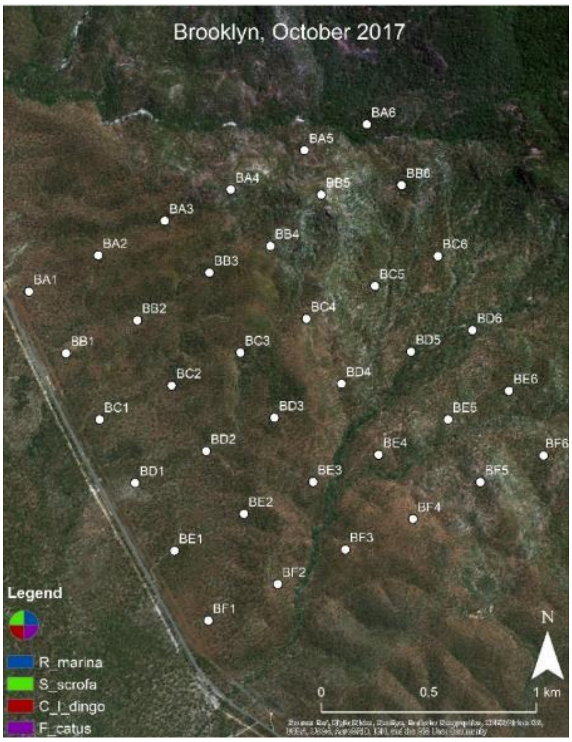


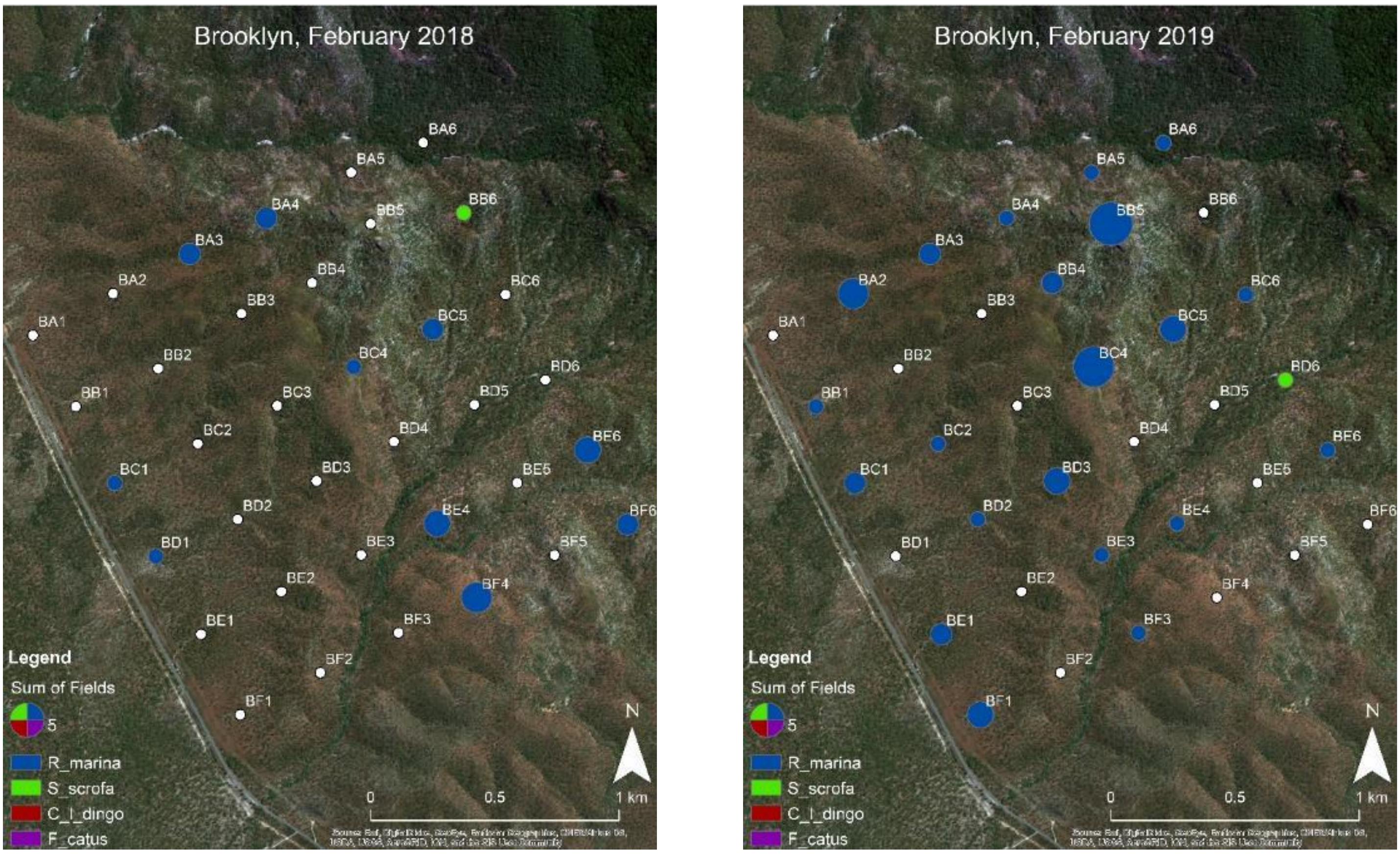
Appendix B6. The distribution of quolls, and the number of individuals detected at each camera trap station during July 2017 and October 2017 at Site "Tinaroo". Sampling at this site was discontinued after October 2017 due to our inability to obtain research permits due to Native Title considerations.

Appendix C. Detections of non-quoll target species (cat, dingo/dog, feral pig and cane toad) at each of the six monitoring sites during each survey period.

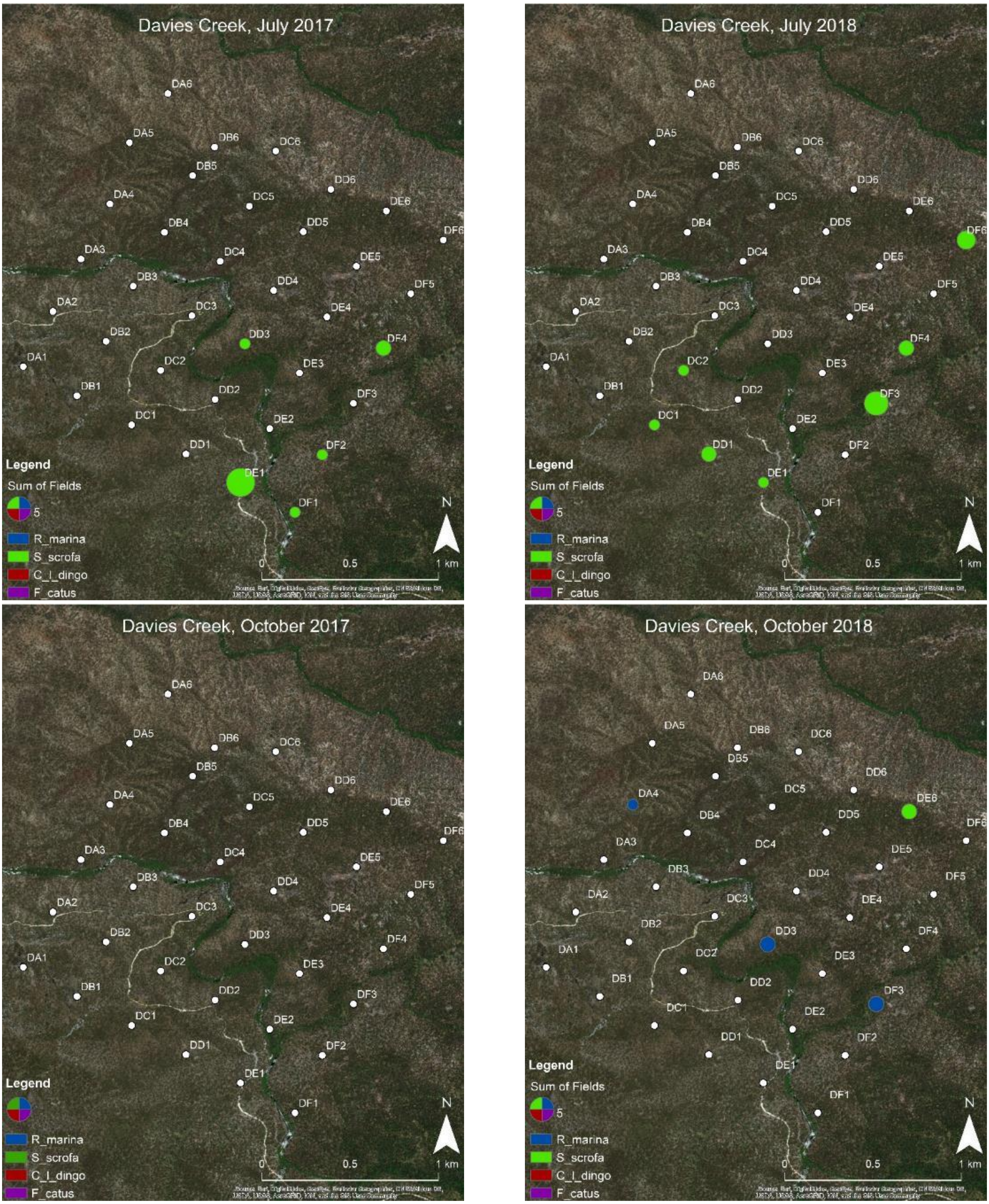
Maps are arranged on the page to allow direct comparison between comparable seasonal surveys. Refer to Fig. 7 for the absolute no. of detections of each species per site and time.

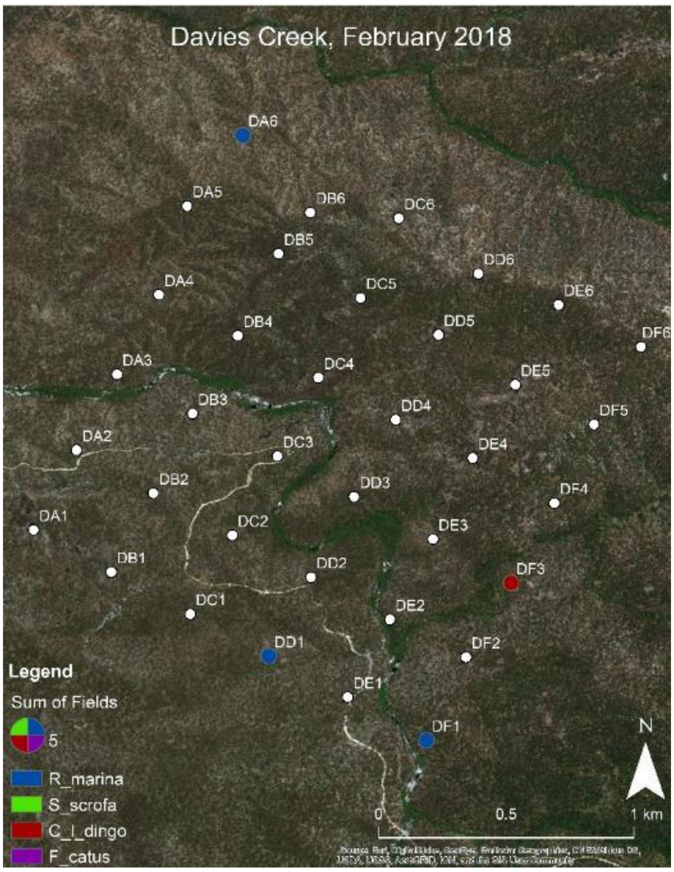


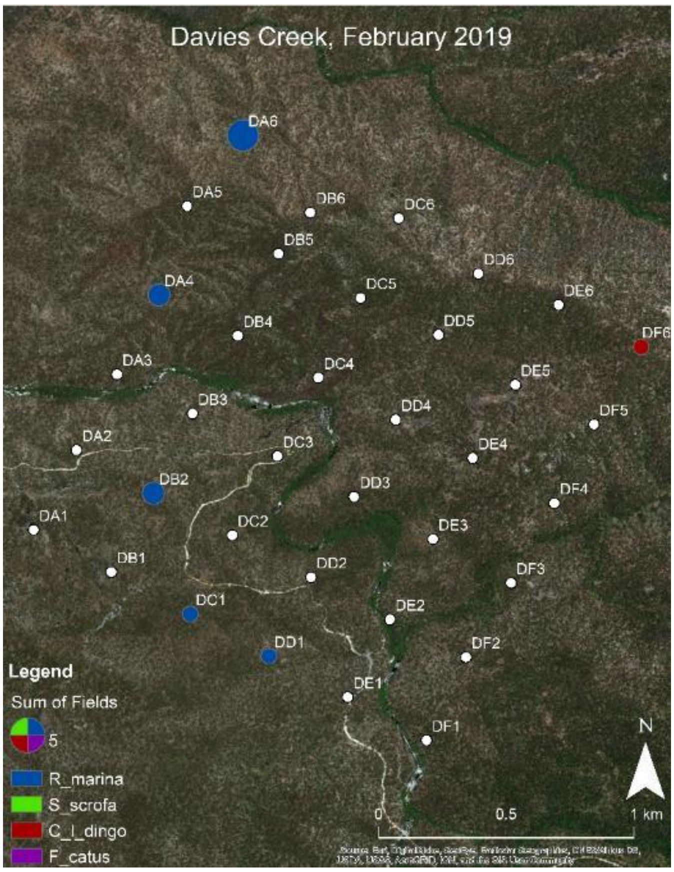




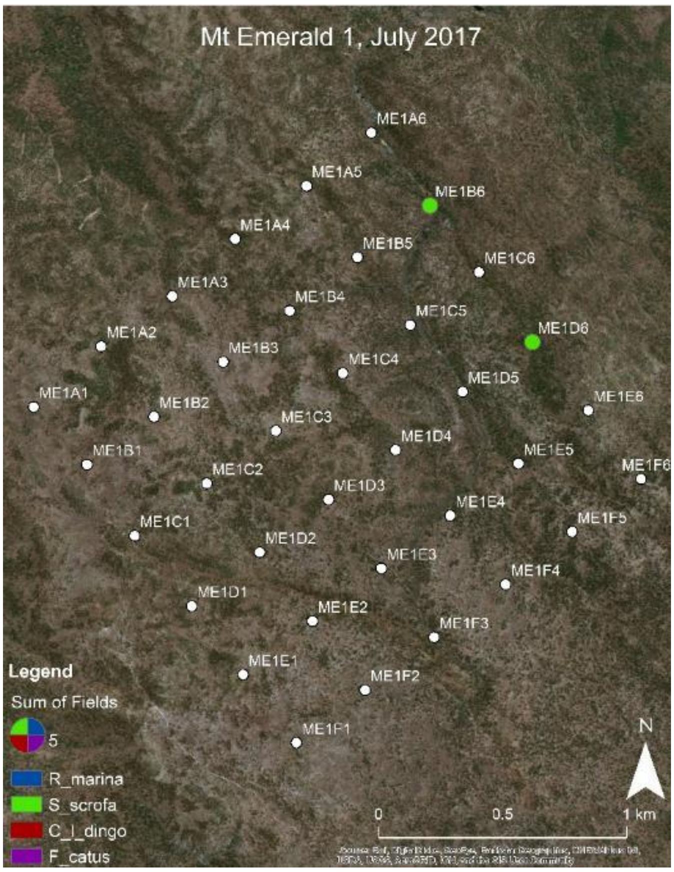
Appendix C1. The distribution of cane toads, feral pigs, dingoes/wild dogs and feral cats, and the proportional number of detections of each species at each camera trap station during comparable monitoring times. July 2017 and July 2018 (top row previous page), October 2017 and 2018 (bottom row previous page) and February 2018 and February 2019 (this page) at Site "Brooklyn".

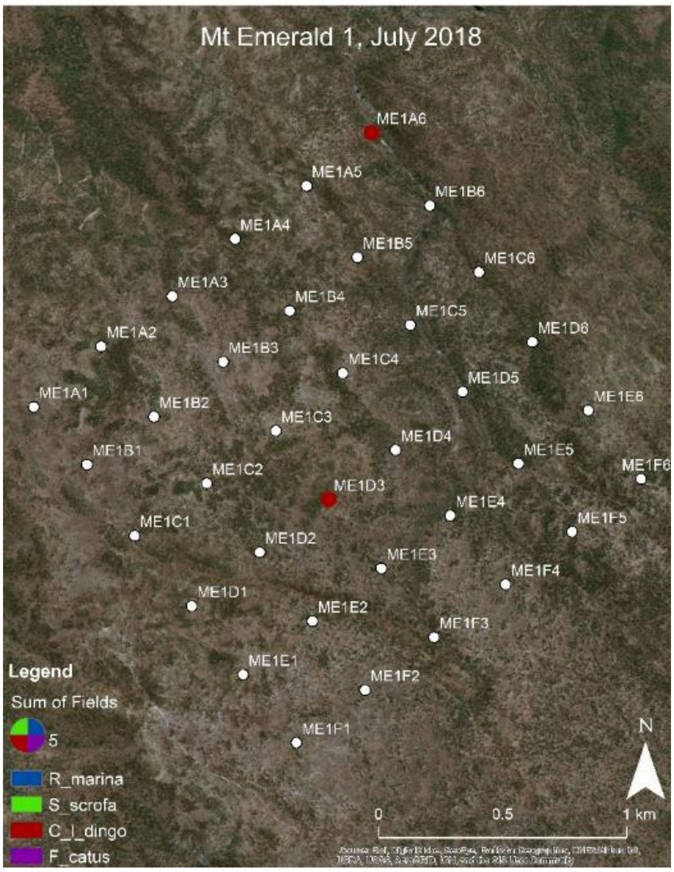

Davies Creek, July 2017
Davies Creek, July 2018
Davies Creek, October 2017
Davies Creek, October 2018
Legend
Sum of Fields
5
R_marina
S_scrofa
C_l_dingo
F_catus
N
0
0.5
1 km

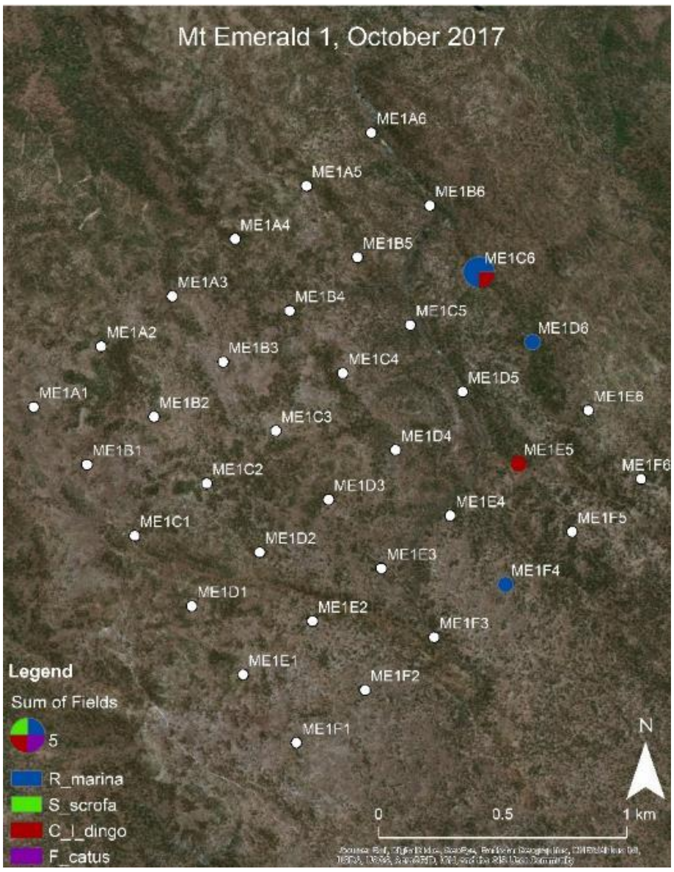


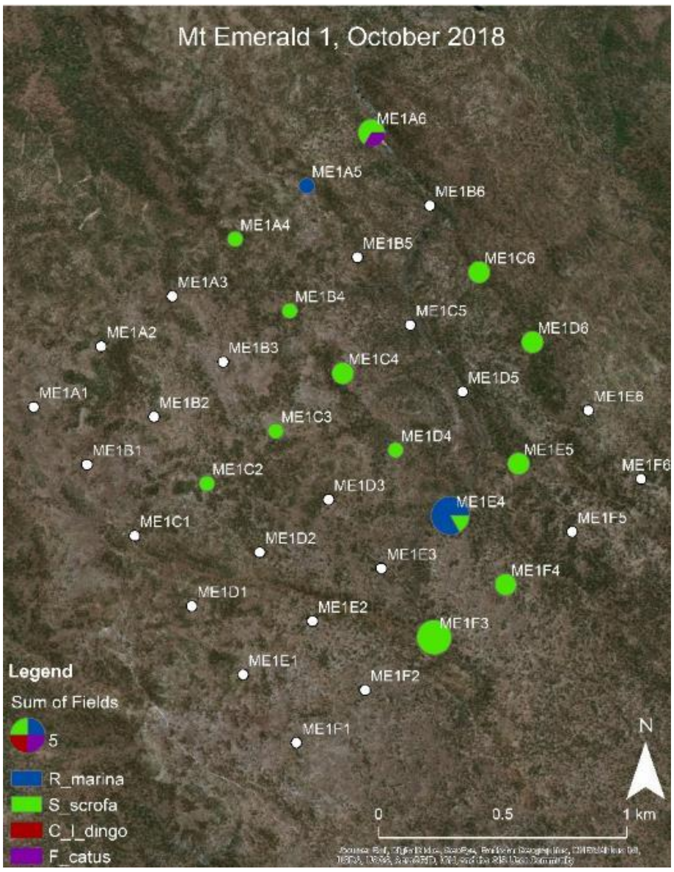


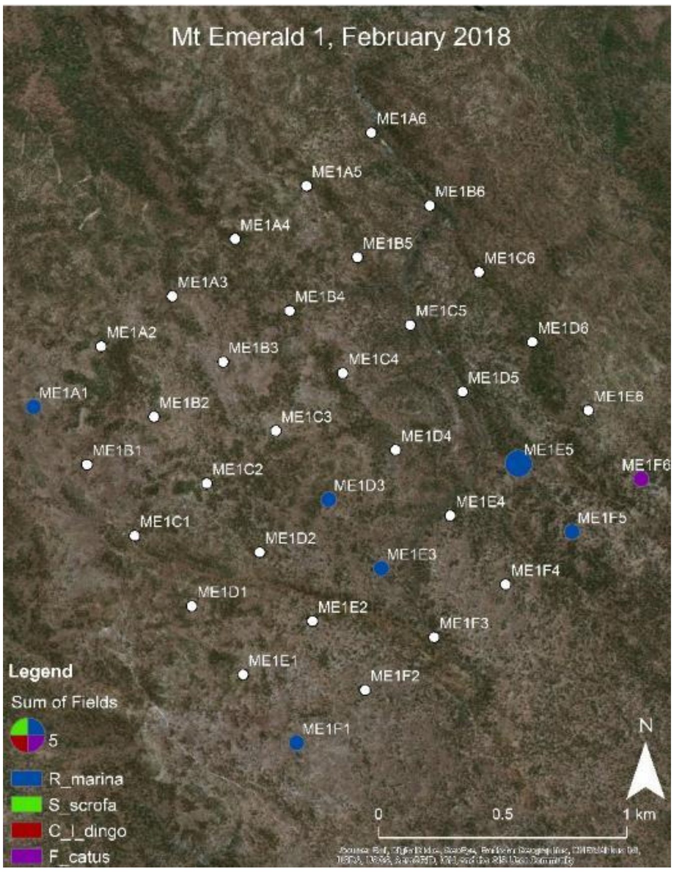
Appendix C2. The distribution of cane toads, feral pigs, dingoes/wild dogs and feral cats, and the proportional number of detections of each species at each camera trap station during comparable monitoring times. July 2017 and July 2018 (top row previous page), October 2017 and 2018 (bottom row previous page) and February 2018 and February 2019 (this page) at Site "Davies Creek".

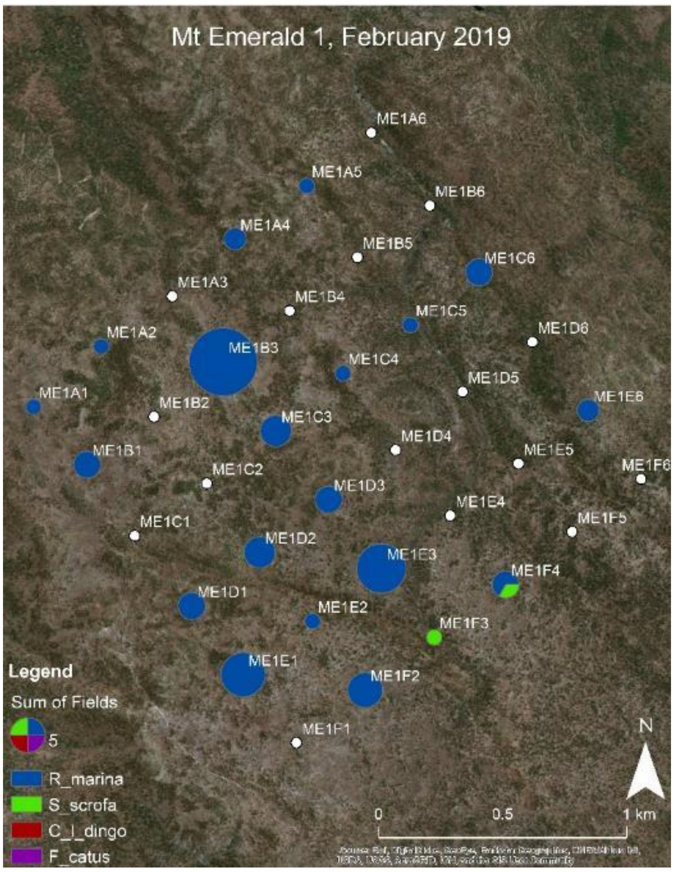

Mt Emerald 1, July 2017
ME1A6
ME1A5
ME1B6
ME1A4
ME1B5
ME1C6
ME1A3
ME1B4
ME1C5
ME1D6
ME1A2
ME1B3
ME1C4
ME1D5
ME1A1
ME1B2
ME1C3
ME1E6
ME1D4
ME1B1
ME1E5
ME1F6
ME1C2
ME1D3
ME1E4
ME1C1
ME1F5
ME1D2
ME1E3
ME1F4
ME1D1
ME1E2
ME1F3
ME1E1
ME1F2
ME1F1
Legend
Sum of Fields
5
R_marina
S_scrofa
C_l_dingo
F_catus
N
0
0.5
1 km


Mt Emerald 1, July 2018
ME1A6
ME1A5
ME1B6
ME1A4
ME1B5
ME1C6
ME1A3
ME1B4
ME1C5
ME1D6
ME1A2
ME1B3
ME1C4
ME1D5
ME1A1
ME1B2
ME1C3
ME1E6
ME1D4
ME1B1
ME1E5
ME1F6
ME1C2
ME1D3
ME1E4
ME1C1
ME1F5
ME1D2
ME1E3
ME1F4
ME1D1
ME1E2
ME1F3
ME1E1
ME1F2
ME1F1
Legend
Sum of Fields
5
R_marina
S_scrofa
C_l_dingo
F_catus
N
0
0.5
1 km

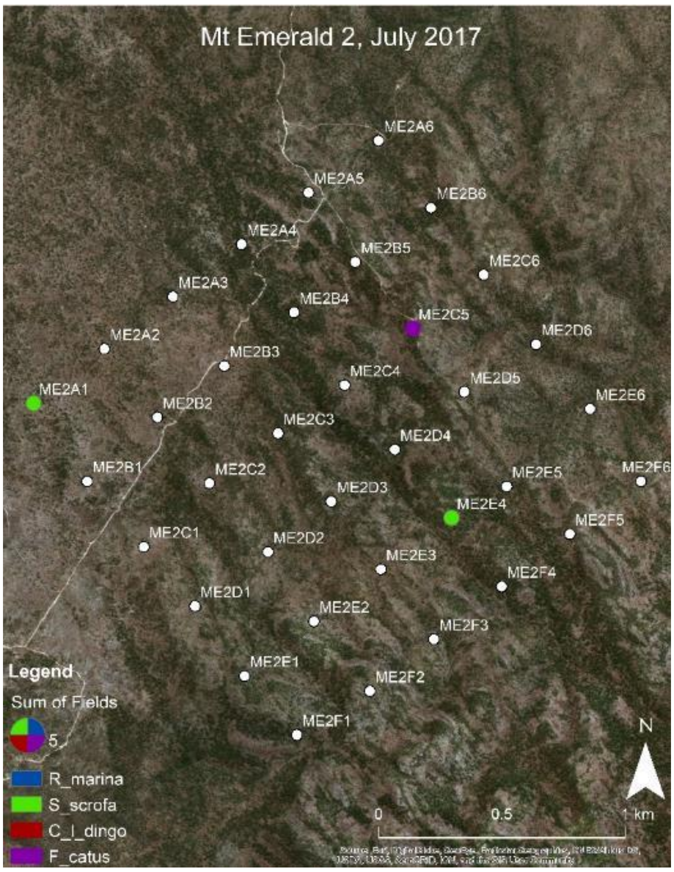

Mt Emerald 1, October 2017
ME1A6
ME1A5
ME1B6
ME1A4
ME1B5
ME1C6
ME1A3
ME1B4
ME1C5
ME1D6
ME1A2
ME1B3
ME1C4
ME1D5
ME1A1
ME1B2
ME1C3
ME1E6
ME1D4
ME1B1
ME1E5
ME1F6
ME1C2
ME1D3
ME1E4
ME1C1
ME1F5
ME1D2
ME1E3
ME1F4
ME1D1
ME1E2
ME1F3
ME1E1
ME1F2
ME1F1
Legend
Sum of Fields
5
R_marina
S_scrofa
C_l_dingo
F_catus
N
0
0.5
1 km

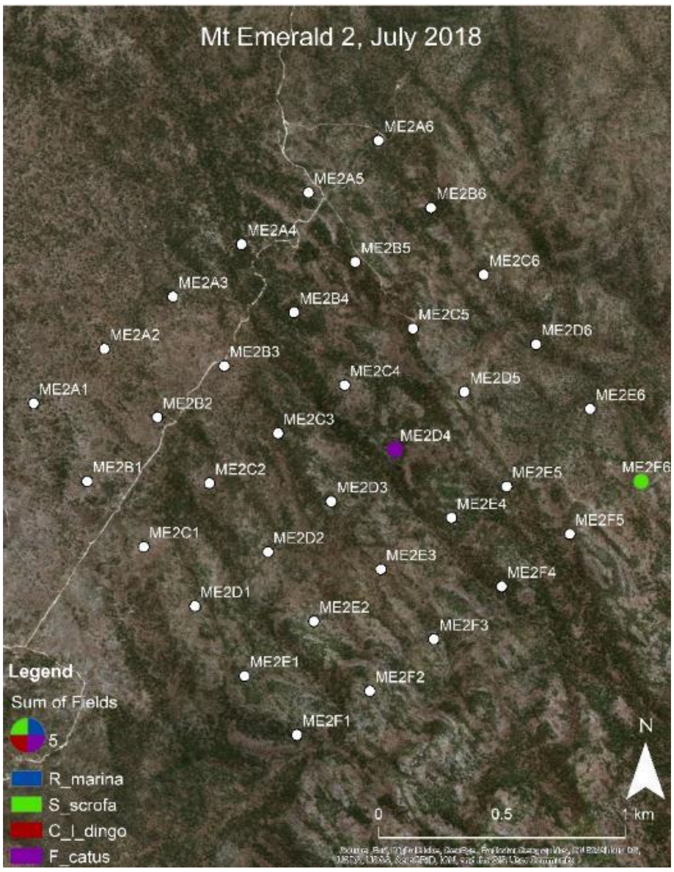

Mt Emerald 1, October 2018
ME1A6
ME1A5
ME1B6
ME1A4
ME1B5
ME1C6
ME1A3
ME1B4
ME1C5
ME1D6
ME1A2
ME1B3
ME1C4
ME1D5
ME1A1
ME1B2
ME1C3
ME1E6
ME1D4
ME1B1
ME1E5
ME1F6
ME1C2
ME1D3
ME1E4
ME1C1
ME1F5
ME1D2
ME1E3
ME1F4
ME1D1
ME1E2
ME1F3
ME1E1
ME1F2
ME1F1
Legend
Sum of Fields
5
R_marina
S_scrofa
C_l_dingo
F_catus
N
0
0.5
1 km

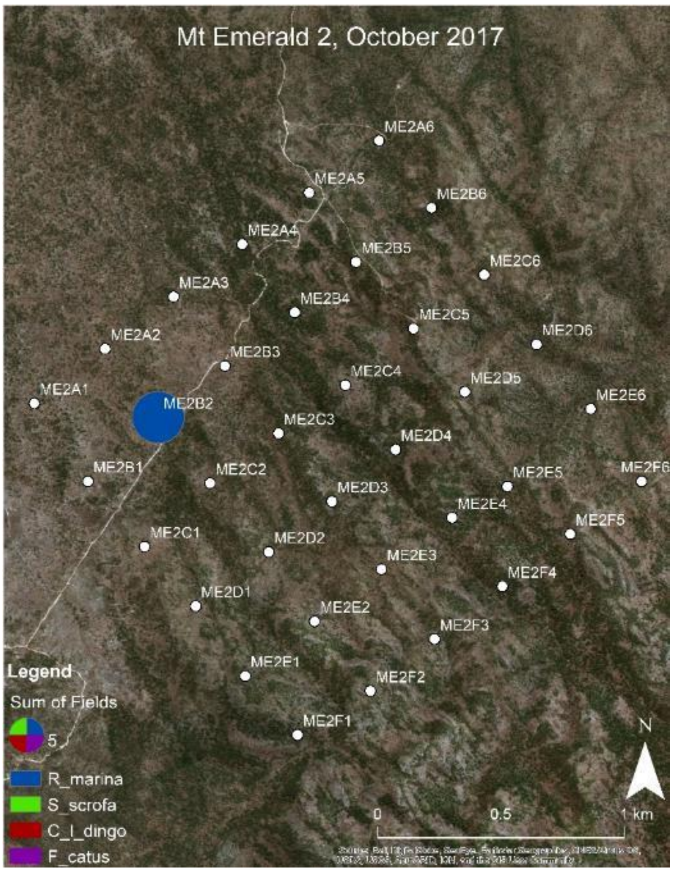


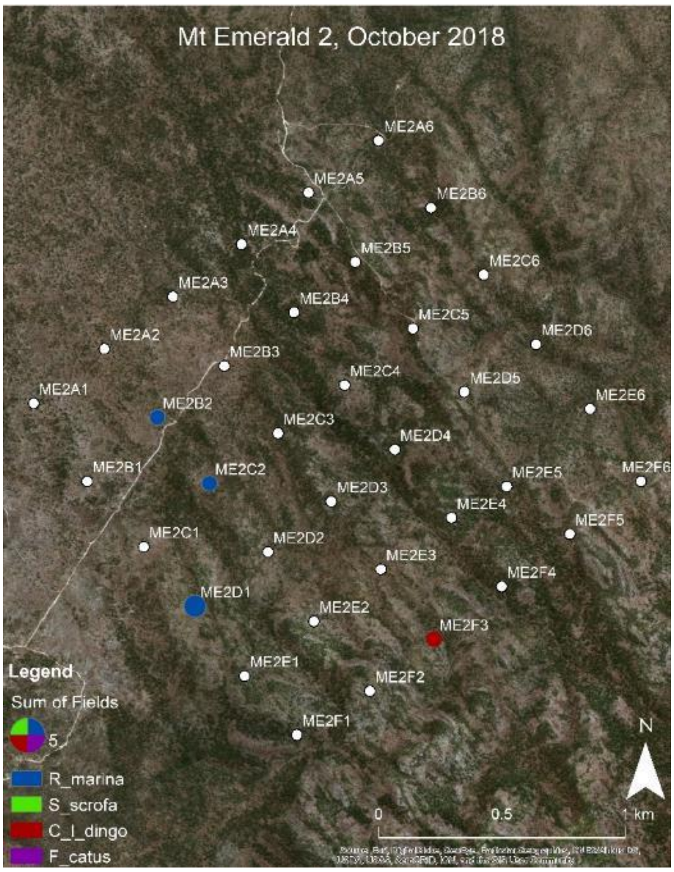


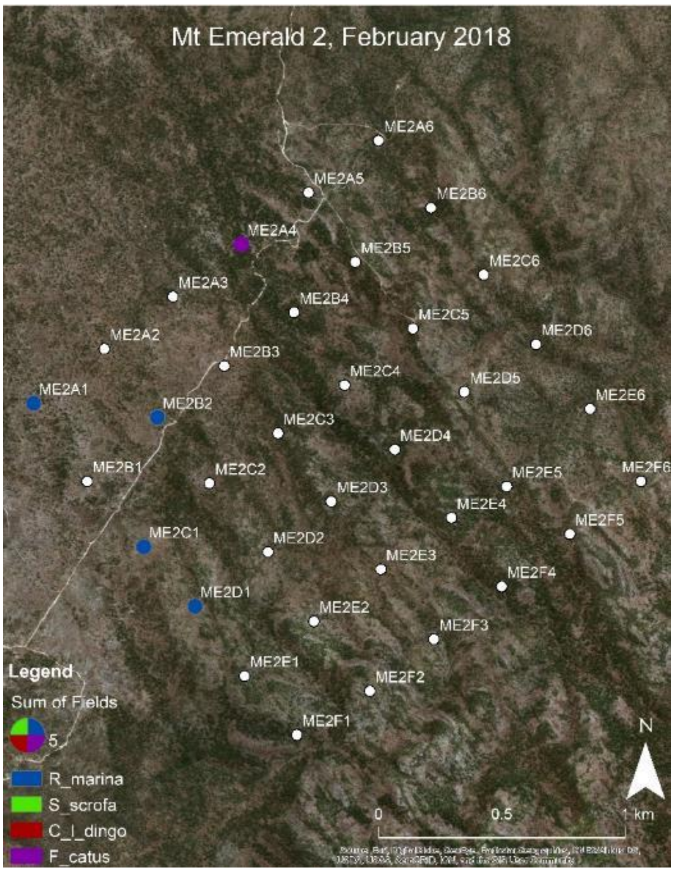
Appendix C3. The distribution of cane toads, feral pigs, dingoes/wild dogs and feral cats, and the proportional number of detections of each species at each camera trap station during comparable monitoring times. July 2017 and July 2018 (top row previous page), October 2017 and 2018 (bottom row previous page) and February 2018 and February 2019 (this page) at Site "ME1".

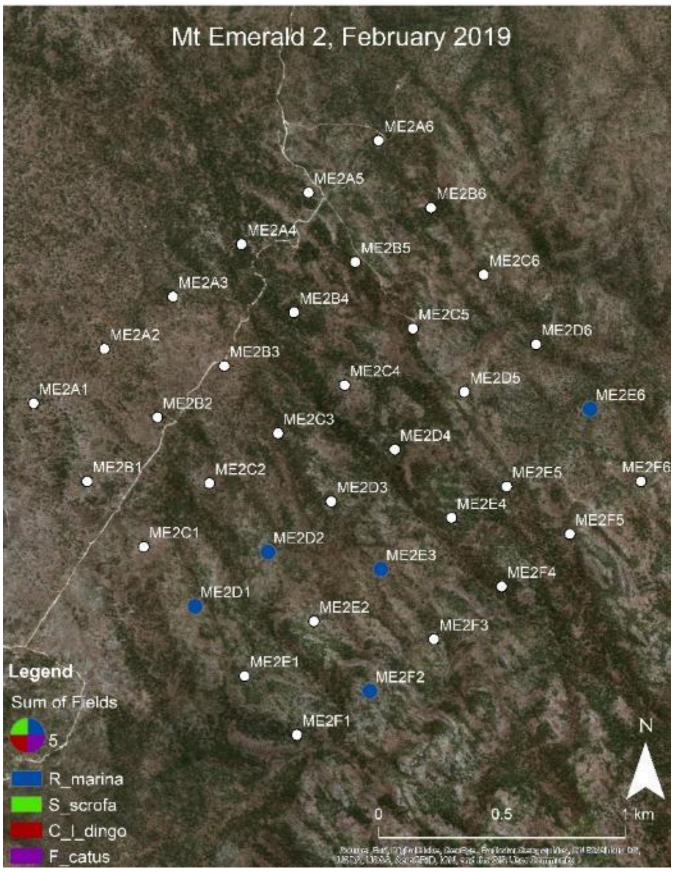

Mt Emerald 2, July 2017
ME2A6
ME2A5
ME2B6
ME2A4
ME2B5
ME2C6
ME2A3
ME2B4
ME2C5
ME2A2
ME2B3
ME2D6
ME2A1
ME2C4
ME2D5
ME2B2
ME2E6
ME2C3
ME2D4
ME2B1
ME2C2
ME2E5
ME2F6
ME2D3
ME2E4
ME2C1
ME2D2
ME2F5
ME2E3
ME2F4
ME2D1
ME2E2
ME2F3
ME2E1
ME2F2
ME2F1
Legend
Sum of Fields
5
R_marina
S_scrofa
C_l_dingo
F_catus
N
0
0.5
1 km


Mt Emerald 2, July 2018
ME2A6
ME2A5
ME2B6
ME2A4
ME2B5
ME2C6
ME2A3
ME2B4
ME2C5
ME2A2
ME2B3
ME2D6
ME2A1
ME2C4
ME2D5
ME2B2
ME2E6
ME2C3
ME2D4
ME2B1
ME2C2
ME2E5
ME2F6
ME2D3
ME2E4
ME2C1
ME2D2
ME2F5
ME2E3
ME2F4
ME2D1
ME2E2
ME2F3
ME2E1
ME2F2
ME2F1
Legend
Sum of Fields
5
R_marina
S_scrofa
C_l_dingo
F_catus
N
0
0.5
1 km


Mt Emerald 2, October 2017
ME2A6
ME2A5
ME2B6
ME2A4
ME2B5
ME2C6
ME2A3
ME2B4
ME2C5
ME2A2
ME2B3
ME2D6
ME2A1
ME2C4
ME2D5
ME2B2
ME2E6
ME2C3
ME2D4
ME2B1
ME2C2
ME2E5
ME2F6
ME2D3
ME2E4
ME2C1
ME2D2
ME2F5
ME2E3
ME2F4
ME2D1
ME2E2
ME2F3
ME2E1
ME2F2
ME2F1
Legend
Sum of Fields
5
R_marina
S_scrofa
C_l_dingo
F_catus
N
0
0.5
1 km


Mt Emerald 2, October 2018
ME2A6
ME2A5
ME2B6
ME2A4
ME2B5
ME2C6
ME2A3
ME2B4
ME2C5
ME2A2
ME2B3
ME2D6
ME2A1
ME2C4
ME2D5
ME2B2
ME2E6
ME2C3
ME2D4
ME2B1
ME2C2
ME2E5
ME2F6
ME2D3
ME2E4
ME2C1
ME2D2
ME2F5
ME2E3
ME2F4
ME2D1
ME2E2
ME2F3
ME2E1
ME2F2
ME2F1
Legend
Sum of Fields
5
R_marina
S_scrofa
C_l_dingo
F_catus
N
0
0.5
1 km





Appendix C4. The distribution of cane toads, feral pigs, dingoes/wild dogs and feral cats, and the proportional number of detections of each species at each camera trap station during comparable monitoring times. July 2017 and July 2018 (top row previous page), October 2017 and 2018 (bottom row previous page) and February 2018 and February 2019 (this page) at Site "ME1".

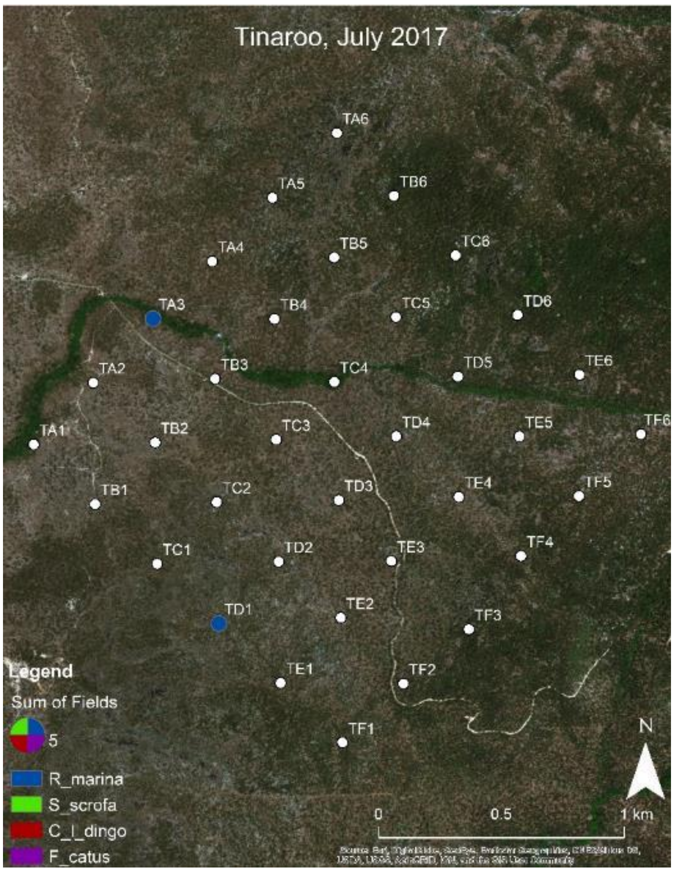

Walsh, July 2017
WA1 WA2 WA3 WA4 WA5 WA6
WB1 WB2 WB3 WB4 WB5 WB6
WC1 WC2 WC3 WC4 WC5 WC6
WD1 WD2 WD3 WD4 WD5 WD6
WE1 WE2 WE3 WE4 WE5 WE6
WF1 WF2 WF3 WF4 WF5 WF6
Legend
Sum of Fields
5
R_marina
S_scrofa
C_l_dingo
F_catus
0 0.5 1 km
N

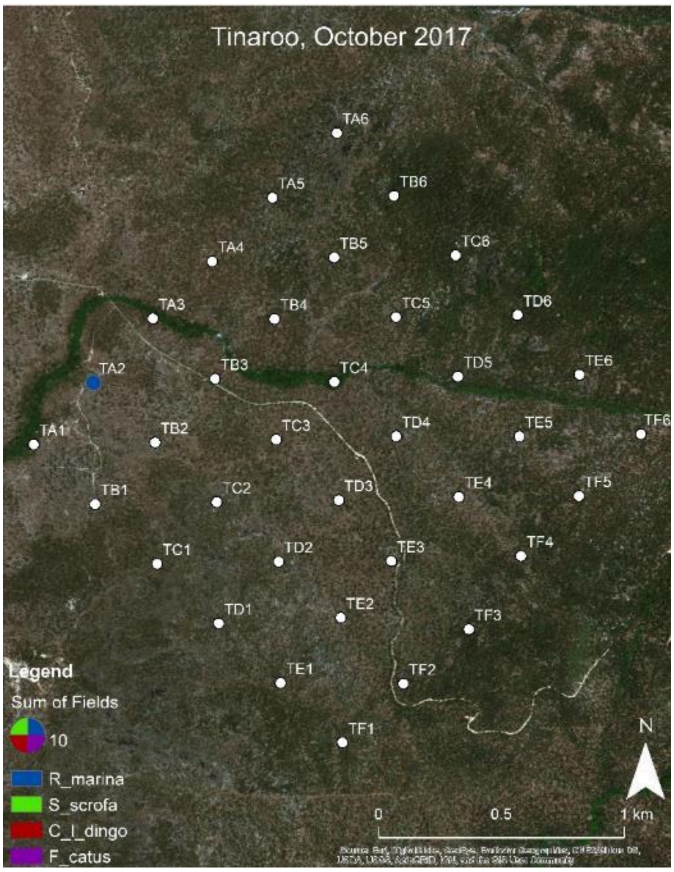

Walsh, July 2018
WA1 WA2 WA3 WA4 WA5 WA6
WB1 WB2 WB3 WB4 WB5 WB6
WC1 WC2 WC3 WC4 WC5 WC6
WD1 WD2 WD3 WD4 WD5 WD6
WE1 WE2 WE3 WE4 WE5 WE6
WF1 WF2 WF3 WF4 WF5 WF6
Legend
Sum of Fields
5
R_marina
S_scrofa
C_l_dingo
F_catus
0 0.5 1 km
N


Walsh, October 2017
WA1 WA2 WA3 WA4 WA5 WA6
WB1 WB2 WB3 WB4 WB5 WB6
WC1 WC2 WC3 WC4 WC5 WC6
WD1 WD2 WD3 WD4 WD5 WD6
WE1 WE2 WE3 WE4 WE5 WE6
WF1 WF2 WF3 WF4 WF5 WF6
Legend
Sum of Fields
5
R_marina
S_scrofa
C_l_dingo
F_catus
0 0.5 1 km
N


Walsh, October 2018
WA1 WA2 WA3 WA4 WA5 WA6
WB1 WB2 WB3 WB4 WB5 WB6
WC1 WC2 WC3 WC4 WC5 WC6
WD1 WD2 WD3 WD4 WD5 WD6
WE1 WE2 WE3 WE4 WE5 WE6
WF1 WF2 WF3 WF4 WF5 WF6
Legend
R_marina
S_scrofa
C_l_dingo
F_catus
FezWalshOct17
0 0.5 1 km
N

Appendix C5. The distribution of cane toads, feral pigs, dingoes/wild dogs and feral cats, and the proportional number of detections of each species at each camera trap station during comparable monitoring times. July 2017 and July 2018 (top row previous page), October 2017 and 2018 (bottom row previous page) and February 2018 and February 2019 (this page) at Site "Walsh".





Appendix C6. The distribution of cane toads, feral pigs, dingoes/wild dogs and feral cats, and the proportional number of detections of each species at each camera trap station during July 2017 and October 2017 at Site "Tinaroo". Sampling at this site was discontinued after October 2017 due to our inability to obtain research permits due to Native Title holder veto of permits.