Sunshine Coast Council Drone Survey

Thermal Drone Koala Survey | Technical Report May 2023

ENDEAVOUR VETERINARY ECOLOGY
Conservation through science, innovation & collaboration

Document control

Version	Date submitted	Authors	Approved
V1.1	16 May 2023	M. Harvey D. de Villiers	D. de Villiers J. Hanger

Introduction

Remotely Piloted Aircraft or 'drones', are increasingly being used for ecological applications such as population surveys of flora and fauna, habitat mapping and wildlife management activities (Linchant et al. 2015; Gonzalez et al. 2016; Hahn et al. 2017, Sudholz et al. 2022). Drones can facilitate the surveying of broad landscapes and access environments and situations that may be off-limits to, or difficult to access by humans on foot, and with somewhat unlimited applications and potential (Geoghegan et al. 2018; Hahn et al. 2017; Schofield et al. 2017, Wallace et al. 2018). Drone surveys have also been demonstrated to provide a more accurate, efficient and economical method of surveying large areas of habitat for some species (Burke et al. 2019; Hamilton et al. 2020, Hodgson et al. 2018; Muller et al 2019), although on occasion, drone surveys can also be less reliable and more costly than traditional methods (Gentle et al. 2018).

Surveys of koalas are ideally suited to thermal imaging drone methods: koalas can be cryptic, and the human detection rate of koalas using traditional on-foot transect surveys can vary widely. Factors such as the vegetation type and canopy cover, ambient temperature, terrain, the height of the koala in the tree, and the experience of the survey team may affect accuracy of detection (Beyer et al. 2018; Hanger et al. 2017; Dique et al. 2003). Additionally, traditional on-foot transect surveys can be labour intensive and limited by terrain or site accessibility issues (Corcoran et al. 2020). Night-time thermal drone surveys have an advantage over traditional surveys as: 1. Koalas are most active at the tops of tree canopies feeding during this time, improving detectability; and 2. Koalas are a relatively large animal (one of the largest arboreal animals in Australia) with a distinctive heat signature that can be detected well above the tree canopy by thermal cameras. Thus, thermal drone surveys have greater detection probabilities than traditional ground-based surveys (Beaver et al. 2020, Corcoran et al. 2020; Witt et al. 2020).

However, like other survey methods, thermal drone surveys have their limitations. The quality of the equipment and payload (cameras), flight speed, survey effort, flight elevation, vegetation cover, time of night and environmental conditions all influence the detection probability of the target species (Beaver et al. 2020; Beranek et al. 2021; Hamilton et al. 2020). Additionally, validation protocols can also influence the accuracy of surveys. Thermal drone detections can be validated *in situ*, during or shortly after the survey, or *ex situ*, at a later date by analysing or processing thermal drone imagery using people or machine-based algorithms (artificial intelligence or machine learning) to verify the thermal heat signature is coming from the target species, other animal or object (Beranek et al. 2021; Corcoran et al. 2019, Lyone et al. 2019; Sulholz et al. 2022).

It is important to understand and correct for any detection biases during the survey, and this is best achieved by mark-resight surveys where the number of animals are known or 'marked' in an area and drone surveys can be conducted to validate detection probabilities under various conditions (Corcoran et al. 2019; Witt et al. 2020). A sightability correction factor can then be applied to the survey result to more accurately reflect population abundance and correct for errors in drone detection and validation (Corcoran et al. 2021a; Corcoran et al. 2021b; Beaver et al. 2020). The reliability of population surveying methods to accurately determine distribution, abundance and trends in populations is critically important to inform the management of threatened wildlife and their conservation.

Methods

Site details

Endeavour Veterinary Ecology (EVE) was engaged by Sunshine Coast Council to conduct a drone survey to assess the presence of koalas in council managed reserves of Caloundra, and Caloundra West, Sunshine Coast. Historical records indicate a possible presence of koalas in the area and vegetation on site is mapped as koala habitat under the *Nature Conservation (Koala) Conservation Plan 2017*.

The survey was conducted over two nights running from the 2nd to the 4th May 2023. The first flight of night one commenced at 2251 hrs and the final flight of night one finished at 0223 hrs. Night two flights commenced at 0024 hrs and finished at 0312 hrs. Night-time flying provides the highest detection probability due to cooler temperatures and less reflectance of infra-red (IR) radiation – resulting in less IR noise and offers the greatest thermal difference in environmental and koala body temperatures. A daytime inspection of the site prior to the survey facilitated the selection of strategic launching spots to comply with CASA requirements.

The survey area was delineated into three polygons based on launch site, drone flight limitations and search area size. The total area surveyed on each night was determined by the vegetation cover and the number of wildlife detections found at the site, with possible koala detections temporarily halting the survey until the origin of the thermal heat signature was definitively identified. Operations were also to cease if manned aircraft entering the surrounding airspace, as instructed by CASA regulations, due to the survey area's proximity to Caloundra airport and the Caloundra Hospital helipad. Search polygon areas are described in Table 1 and displayed in Figures 1, 2, 3, and 4.

Drone pilot

All drone operations were conducted by pilot Matthew Harvey (ARN: 1126465), operating under EVE's Remote Operators Certificate (ReOC) 7571 in accordance with Civil Aviation Safety Authority (CASA) regulations.

Drone equipment

The DJI Matrice 300 quadcopter with the H20N dual thermal/optical zoom camera fitted with laser range finder and the GL-60 Zoom spotlight was the primary drone and payloads used during the survey (Image 1). A monitor connected to the controller mirrored the controller's display to allow the observer to assist with the detection of thermal heat signatures during the survey.

Image 1 The DJI Matrice 300 with H20N thermal/optical camera and GL60 Zoom spotlight was the primary drone and payload used to for the thermal drone survey.

Survey design

Systematic lawn-mower 'up-and-back' patterns were flown over the site at an average speed of 3-4 m/s and at a height of approximately 30 m above the tallest tree canopy. Each grid was spaced with a minimum 50% overlap between passes, ensuring tree canopies were surveyed obliquely two times, from two different angles, to maximise search effort and detections. Search polygons were delineated based on the regulatory conditions set out by CASA for drone operations requiring the pilot to maintain visual line of sight of the drone at all times. Figures 1, 2 and 3 and 4 illustrate the flight path/transects of the drone during the surveys.

Thermal heat signatures suggestive of koalas were investigated using the optical zoom camera of the drone with the surrounds illuminated by the drone's spotlight (see Images 1 and 2 as an example). The drone's laser rangefinder was used to determine the GPS location of detected wildlife, and pins were recorded on the pilot's controller display to ensure detections were not double counted at the next pass/transect search. Notes on each recorded detection were taken by the observer/support crew. Images and screen grabs were often recorded as reference data.
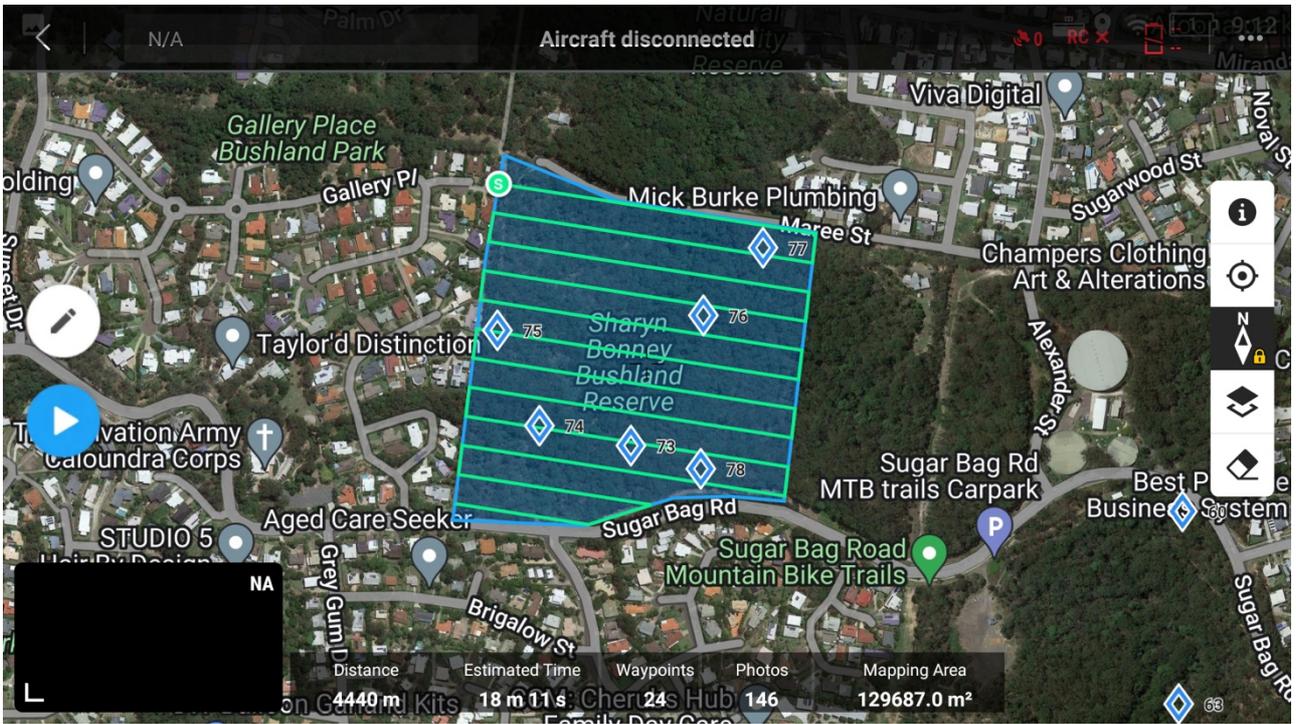
Figure 1. Search polygon 1 Sharyn Bonney Bushland Reserve in the north of Sugar Bag Rd
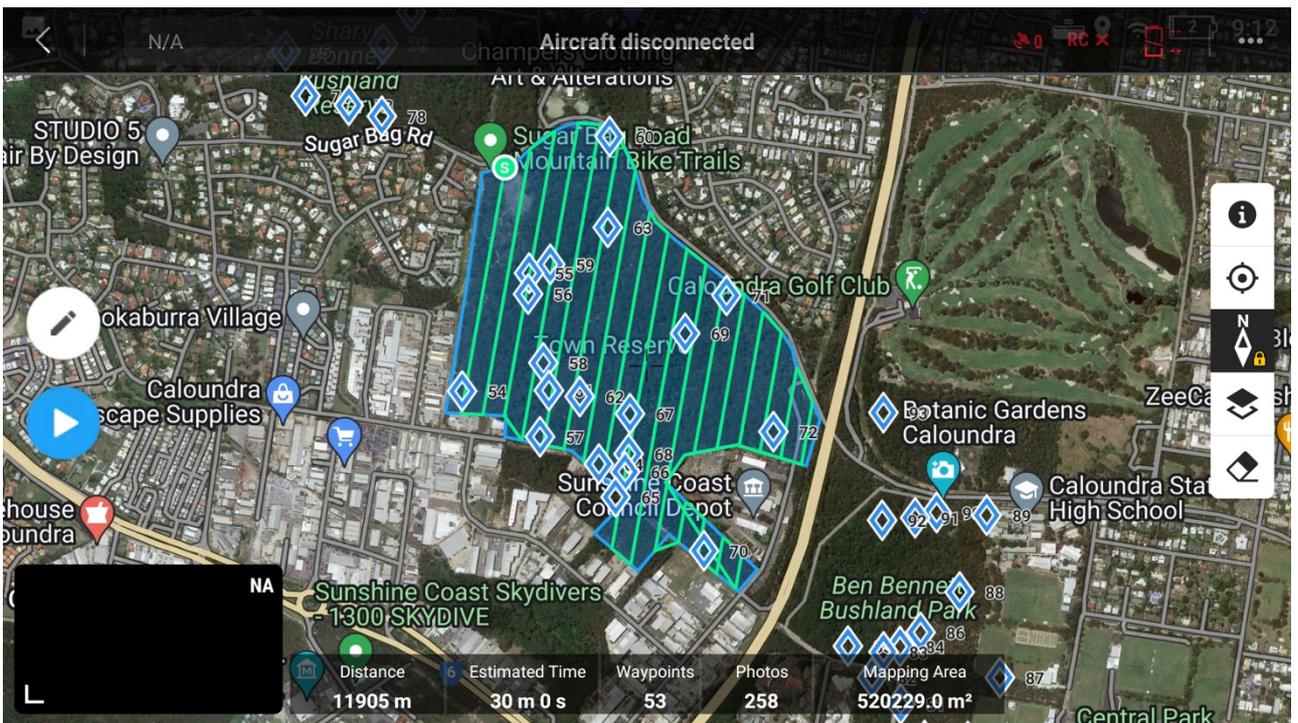

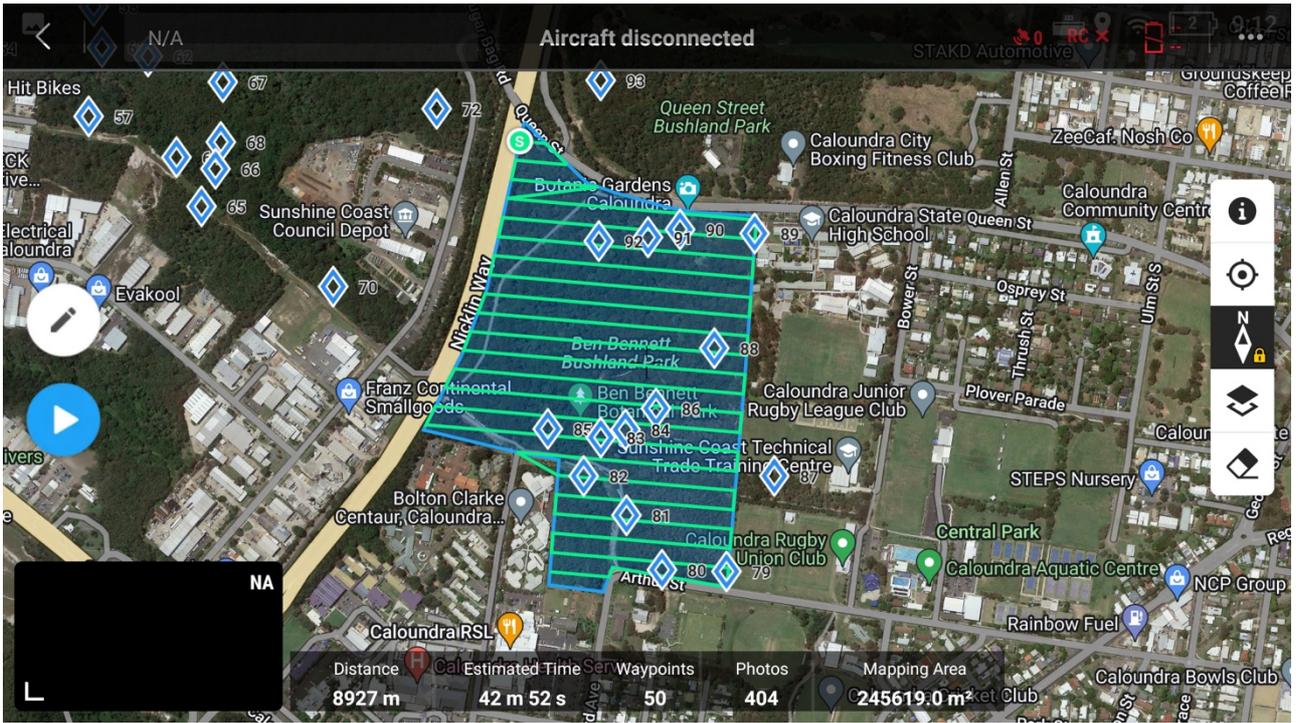Figure 2. Search polygon 2 Town Reserve & Sugar Bag road Bike trails.

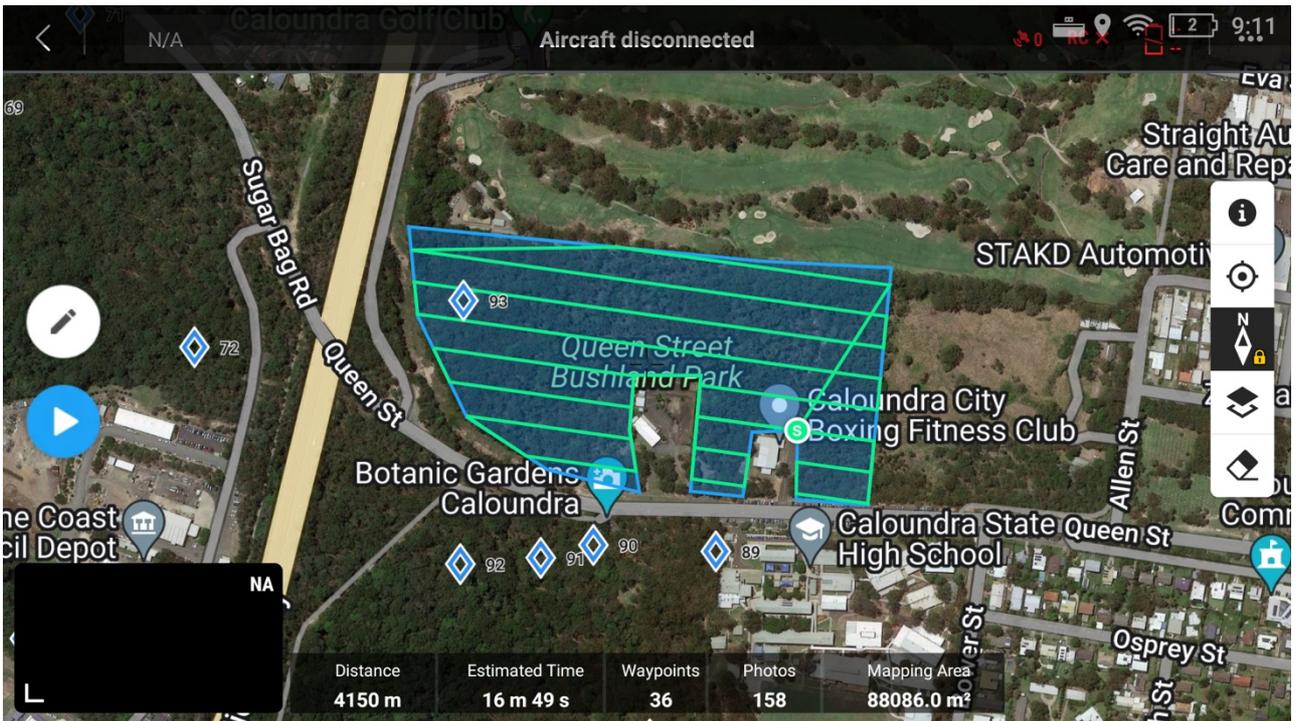Figure 3. Polygon 3 Part A. Polygon 3 is split into Part A & B. Part A located below Queen St.

Figure 4. Polygon 3 Part B. Polygon 3 is split into Part A & B. Part B located below Queen St.

Data collection

The following data were collected for each drone flight:
- Drone flight path and flight details, as per CASA regulatory requirements.
- Drone-derived GPS locations of detections of koalas or other fauna species of note (latitude, longitude).

Estimation of detection probability

An estimate of the probability of detecting koalas was also recorded, with a very experienced drone pilot and observer basing the estimate on the ease of detecting koalas under the prevailing environmental conditions and the degree of vegetation cover during the flight. A key factor informing the estimate of detection is the temperature during the survey, and the amount of thermal 'noise' in the environment (e.g. warm tree trunks, water bodies retaining heat, artificial light sources) that can mask or diminish thermal heat signatures of the target species. Based on prior survey work conducted by EVE, detection probabilities during thermal drone surveys of koalas with monitoring tags (know locations) range from 0.65, where 1 in every 3 koalas is missed, to 90%, where as few as 1 in every 10 koalas is not detected, and is comparable to other studies reported in the literature (e.g. Corcoran et al. 2019). These probabilities can be used to calculate a 'corrected' koala total abundance and density estimates for each search polygon where koalas are detected.

Permits to conduct the work

Endeavour Veterinary Ecology conducted the work under Department of Agriculture and Fisheries *Animal Ethics Committee* approval CA2022/03/1595 and Department of Environment and Science *Research Permit* WA20210702-1. Drone operations were also conducted under a Civil Aviation Safety Authority (CASA) Remotely-piloted aircraft Operator's Certificate (ReOC) 7571 held by EVE.

Results

No koalas were detected during the surveys (Table 1). The estimated detection probability for each polygon was relatively high, with cold nights contributing to optimal conditions for the detection of faunal heat signatures. Drone flight paths reflected the proposed lawnmower 'up and back' survey method, ensuring sites were comprehensively surveyed for the target species, the koala (Figure 5).

The survey detected a range of mammal species, both arboreal and terrestrial, including all three local species of possum, gliders, macropods and echidnas (see Figure 6 and Images 2-9) . No threatened species were detected, however, thermally-identified flying foxes were not spotlighted to confirm species due to drone staff previously identifying the disturbance the spotlight can have on foraging bats. Therefore, some of the many flying foxes observed were possibly Grey-headed flying-foxes listed as vulnerable nationally (*Environment Protection and Biodiversity Conservation Act 1999*).

Survey	Area (ha)	Koalas	Detection probability	Corrected abundance	Density koalas/ha	Comment
Polygon 1	13	0	0.80	0	0.00	Warm days and cold nights, 8-25 ºC
Polygon 2	53	0	0.76	0	0.00	Warm days and cold nights, 8-25 ºC
Polygon 3 (A&B)	34	0	0.78	0	0.00	Warm days and cold nights, 9-25 ºC
TOTAL	100					

Table 1. Thermal drone survey results for each polygon
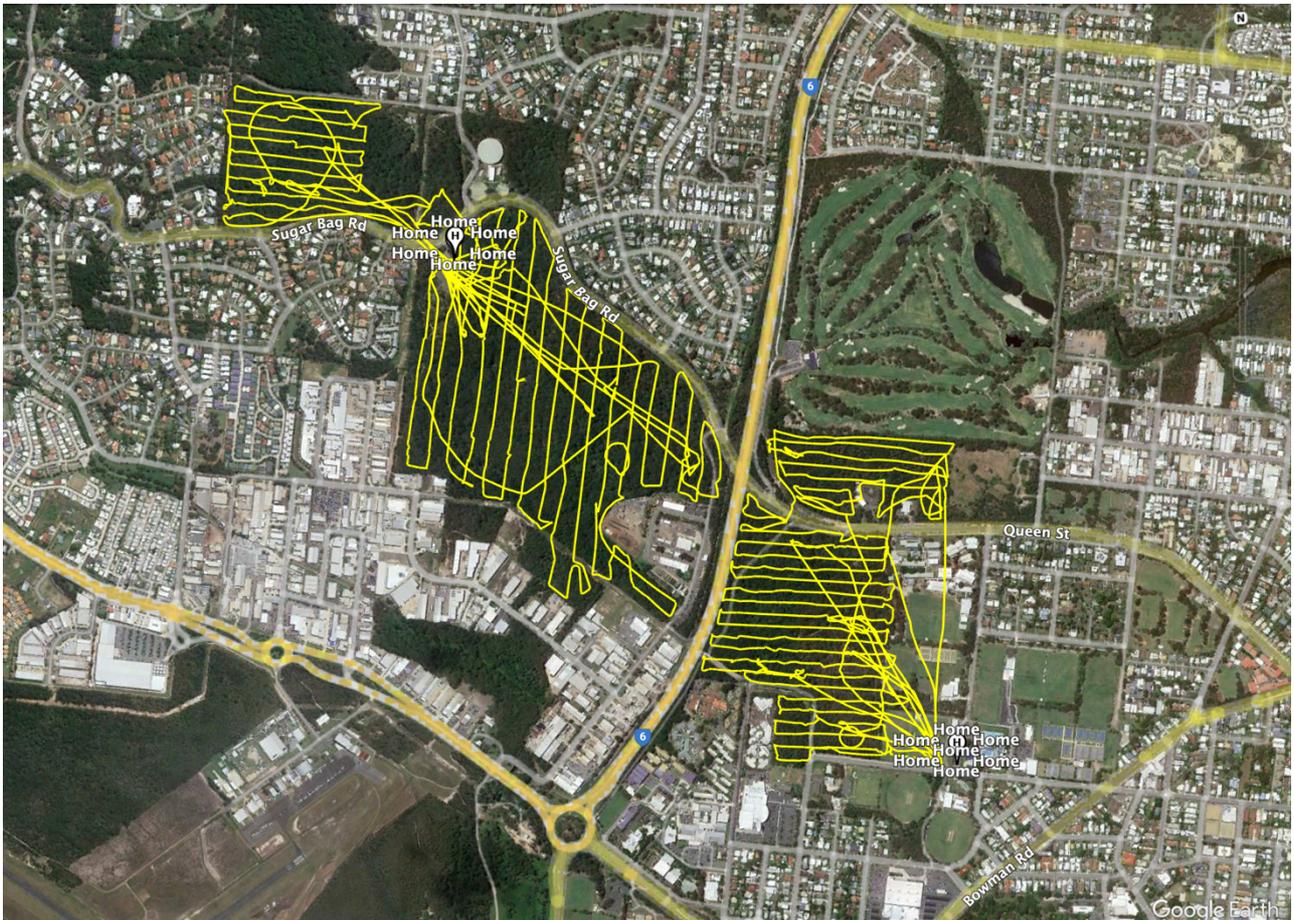
Figure 5 Drone flight paths recorded during the survey.

Figure 6 Thermal detections of recorded fauna during the survey.

Image 2: A thermal heat signature is detected (waypoint 55)

Image 3: The optical camera and spotlight is used to identify the detection as a Swamp wallaby.

Image 4: A red fox's thermal heat signature glows bright (waypoint 87)

Images 5 and 6: Another red fox detected (waypoint 69) via the thermal camera shown *left*, is verified by the optical camera and spotlight shown *right*.

Images 7: An Echidna is first detected thermally then observed by the team active on the ground using the spotlight.

Images 8 and 9: A Brushtail possum is detected (waypoint 86) on a lateral branch shown *left*. Large possums can at times portray a thermal signature like that of a koala. On the *right* a short-eared possum is observed seemingly unperturbed feeding on a flowering tree.

Drone Detections

Date and time	Creature	Certainty	Latitude (decimal °)	Longitude (decimal °)	Comment/activity
2022-05-02 22:59:00	Echidna	Positive	-26.791329	153.112497	WP54. Active
2023-05-02 23:11:00	Swamp Wallaby	Positive	-26.788119	153.114104	WP55
2023-05-02 23:17:16	Ringtail possum	Positive	-26.789232	153.114078	WP56
2023-05-02 23:22:34	Ringtail possums X 2	Postive	-26.792316	153.114364	WP57
2023-05-02 23:26:44	Brush tail possum	Positive	-26.790719	153.114443	WP58
2023-05-02 23:41:46	Feathertail glider	Unconfirmed	-26.78859	153.11461	WP59. Feeding in Bloodwood blossoms.
2023-05-02 23:45:53	Brushtail possum	Positive	-26.785823	153.116034	WP60
2023-05-02 23:51:39	Black flying fox	Positive	-26.791315	153.114578	WP61
2023-05-02 23:55:07	Sugar/squirrel glider	Confirmed glider	-26.791447	153.115318	WP62
2023-05-02 23:59:26	Echidna	Positive	-26.78779	153.115991	WP63
2023-05-03 0:08:52	Flying fox	Species not confirmed	-26.792907	153.115778	WP64. Feeding species unconfirmed.
2023-05-03 0:09:56	Black flying fox	Positive	-26.793619	153.116179	WP65
2023-05-03 0:12:12	Swamp wallaby X2	Positive	-26.793075	153.116405	WP66
2023-05-03 0:16:43	Possum	Unidentified	-26.791818	153.116522	WP67
2023-05-03 0:19:52	Ring tail possum	Positive	-26.792686	153.11649	WP68
2023-05-03 0:33:54	Red fox	Positive	-26.790082	153.117847	WP69
2023-05-03 0:41:59	Squirrel/ Sugar gliders X2	Confirmed gliders	-26.79478	153.118298	WP70
2023-05-03 0:48:38	Brush tail possum	Positive	-26.78926	153.118839	WP71. Carrying drey material in tail
2023-05-03 1:11:56	Possum box giving off heat		-26.792206	153.119963	WP72
2023-05-03 1:33:20	Ring tail possum with Joey	Positive	-26.785152	153.109778	WP.73 back riding Joey on Mum
2023-05-03 1:35:20	Short eared possum	Unconfirmed	-26.78495	153.10874	WP74
2023-05-03 1:43:10	Echidna	Positive	-26.783977	153.108263	WP75
2023-05-03 1:47:13	Short eared possum	Positive	-26.783824	153.1106	WP76
2023-05-03 2:00:07	Short eared possum	Positive	-26.783134	153.111276	WP77
2023-05-03 2:11:52	Ring tail possum	Positive	-26.78539	153.11057	WP78
2023-05-04 0:26:57	Flying fox	Positive. Species unconfirmed	-26.798905	153.224627	WP79
2023-05-04 0:28:51	Flying fox X 9	Positive. Species unconfirmed	-26.798881	153.12359	WP80. Multiple flying fox feeding
2023-05-04 0:45:49	Short eared possum	Positive	-26.798089	153.123019	WP81. Feeding
2023-05-04 1:00:29	Brush tail possum	Positive	-26.797523	153.122329	WP82. Feeding in paper bark
2023-05-04 1:12:48	Sugar/squirrel Glider	Species unconfirmed	-26.796966	153.122604	WP83
2023-05-04 1:22:13	Ring tail possum	Positive	-26.79685	153.123003	WP84
2023-05-04 1:29:51	Swamp Wallaby x2	Positive	-26.796839	153.121753	WP85
2023-05-04 1:35:16	Brush tail possum	Positive	-26.796543	153.123492	Positive
2023-05-04 1:36:48	Red fox	Positive	-26.797519	153.125397	WP87
2023-05-04 1:56:07	Bandicoot	Species unconfirmed	-26.795671	153.124433	WP88
2023-05-04 2:19:16	Ring tail possum	Positive	-26.79401	153.125082	WP89
2023-05-04 2:20:58	Ring tail possum	Positive	-26.793952	153.12388	WP90

Date and time	Creature	Certainty	Latitude (decimal °)	Longitude (decimal °)	Comment/activity	
2023-05-04 2:22:29	Ringtail possum	Positive	-26.794067	153.123363	WP91	
2023-05-04 2:25:27	Echidna	Positive	-26.794121	153.122573	WP92	
2023-05-04 2:47:01	Possum	Unidentified	-26.791793	153.122604	WP93	
			2			
Date and time	Creature	Certainty	Latitude (decimal °)	Longitude (decimal °)	Comment/activity	
2023-05-04 2:22:29			-26.794067	153.123363	WP91	
2023-05-04 2:25:27			-26.794121	153.122573	WP92	

Discussion

This survey represents a snapshot of koala presence on site at a moment in time, and the results do not account for seasonal variations in the movements (e.g. breeding season dispersals) and occupancy of the sites by koalas. Additionally, we acknowledge that 100% detection rates of koalas are not realistic, even with the experience of the drone pilot and observer using thermal-imaging drones. A conservative estimate is that 65% - 90% of koalas are detected, with the higher estimate achieved under favourable environmental conditions.

As with traditional surveys, thermal drone detections of koalas are impeded by factors including vegetation type/canopy density, the experience of the observers, and day and night temperatures, where warm tree trunks, ground and water bodies can mask heat signatures by creating background 'IR noise', and the thermal differential between the environment and the koala is reduced. Also, a single layer of vegetation is sufficient to mask a koala's thermal signature – so a koala's position in a tree can significantly affect detection probability, and in warm weather koalas tend to seek refuge in dense, cool understory vegetation.

As discussed above, thermal drone surveys have inherent limitations, but can provide a robust method of efficiently assessing the distribution and abundance of koalas over large areas. Along with koalas, other mammalian wildlife can be successfully identified if fauna are of sufficient body mass (small birds, squirrel gliders and larger) to produce a thermal heat signature that can be detected by the drone's thermal camera. While the target species (koala) was not detected, this survey has provided valuable data on the distribution and abundance of the wildlife communities occupying Council's reserves.

For enquiries about this report, please contact:
Matthew Harvey
M: 0434 928 188
E: matt@endeavourvet.com.au
or
Dr Deidré de Villiers at Endeavour Veterinary Ecology on:
M: 0419 995 399 or
E: deidre@endeavourvet.com.au

References

Beaver JT, Messenger M, Newbolt CH and Silman MR. 2020. Evaluating the use of drones equipped with thermal sensors as an effective method for estimating wildlife
Wildlife. Society Bulletin 44(2) 434–443; doi: 10.1002/wsb.1090

Beranek CT, Roff A, Denholm B, Howell LG and Witt RR. 2021. Trialing a real-time drone detection and validation protocol for the koala (*Phascolarctos cinereus*). Australian Mammalogy 43, 260–264; doi.org/10.1071/AM20043

Beyer HL, de Villiers D, Loader J, Robbins A, Stigner M, Forbes N and Hanger J. 2018. Management of multiple threats achieves meaningful koala conservation outcomes. Journal of Applied Ecology 55, 1966–1975; doi:10.1111/1365-2664.13127

Burke C, Rashman M, Wich S, Symons A, Theron C and Longmore S. 2019. Optimizing observing strategies for monitoring animals using drone-mounted thermal infrared cameras International Journal of Remote Sensing 40 (2), 439–467; doi.org/10.1080/01431161.2018.1558372

Corcoran E, Winsen M, Sudholz A and Hamilton G. 2021b. Automated detection of wildlife using drones: synthesis, opportunities and constraints. Methods Ecol Evol. 12:1103–1114; doi: 10.1111/2041-210X.13581

Corcoran E, Denman S and Hamilton G. 2021a. Evaluating new technology for biodiversity monitoring: Are drone surveys biased? Ecology and Evolution 11:6649 – 6656; doi: 10.1002/ece3.7518

Corcoran E, Denman S, Hanger J, Wilson B and Hamilton G. 2019. Automated detection of koalas using low-level aerial surveillance and machine learning. Scientific Reports 9:3208; doi.org/10.1038/s41598-019-39917-5

de Villiers DL. 2015. The role of urban koalas in maintaining regional population dynamics of koalas in the Koala Coast. PhD thesis, The University of Queensland; doi.org/10.14264/uql.2015.498

Dique DS, de Villiers DL and Preece HJ. 2003. Evaluation of line transect sampling for estimating koala abundance in the Pine Rivers Shire, south-east Queensland. Wildlife Research 30, 127–133; doi:10.1071/WR02042

EVE (Endeavour Veterinary Ecology). 2020. Coomera Connector Stage One Comprehensive Koala Survey Report. Technical report for the Department of Transport and Main Roads, Queensland.

Gentle M, Finch N, Speed J and Pople A. 2018. A comparison of unmanned aerial vehicles (drones) and manned helicopters for monitoring macropod populations. Wildlife Research 45, 586–594; doi.org/10.1071/WR18034

Geoghegan JL, Pirotta V, Harvey E, Smith A, Buchmann JP, Ostrowski M, Eden JS, Harcourt R and Holmes EC. 2018. Virological sampling of inaccessible wildlife with drones. Viruses 10, 300; doi:10.3390/v10060300

Gonzalez LF, Montes GA, Puid E, Johnson S, Mengersen K and Gaston KJ. 2016. Unmanned Aerial Vehicles (UAVs) and Artificial Intelligence revolutionizing wildlife monitoring and conservation. Sensors 16, 97; doi:10.3390/s16010097

Hahn N, Mwakatobe A, Konuche J, de Souza N, Keyyu J, Goss M, Chang's A, Palminteri S, Dinerstein E and Olson D. 2017. Unmanned aerial vehicles mitigate human-elephant conflict on the borders of Tanzanian Parks: a case study. Oryx 51(3), 513–516; doi:10.1017/S0030605316000946

Hamilton G, Corcoran E, Denman D, Hennekam ME and Koh LP. 2020. When you can't see the koalas for the trees: Using drones and machine learning in complex environments. Biological Conservation 247 108598; doi.org/10.1016/j.biocon.2020.108598

Hodgson J, Mott R, Baylis SM, Pham TT, Wotherspoon S, Kilpatrick AD, Segaran RR, Reid I, Terauds A and Koh LP. 2017. Drones count wildlife more accurately and precisely than humans. Methods Ecol Evol. 9:1160–1167; doi: 10.1111/2041-210X.12974

Linchant J, Lisein J, Semeki J, Lejeune P, Vermeulen C. 2015. Are unmanned aircraft systems (UASs) the future of wildlife monitoring? A review of accomplishments and challenges. Mammal Review 45; 239–252; doi:10.1111/mam.12046

Lyons M, Brandis KJ, Murray NJ, Wilshire JH, McCann JA, Kingsford RT and Callaghan CT. 2019. Monitoring large and complex wildlife aggregations with drones. Methods Ecol Evol. 10:1024–1035; doi: 10.1111/2041-210X.13194

Muller CG, Chilvers BL, Barker Z, Barnsdale KP, Battley PR, French RK, MCCullough J and Samandari F. 2019. Aerial VHF tracking of wildlife using an unmanned aerial vehicle (UAV): comparing efficiency of yellow-eyed penguin (*Megadyptes antipodes*) nest location methods. Wildlife Research 46, 145–153; doi.org/10.1071/WR17147

Rhodes JR, Beyer HL, Preece H and McAlpine C. 2015. South East Queensland Koala Population Modelling Study. Technical Report, UniQuest, Brisbane, Australia.

Schofield G, Katselidis KA, Lilley MKS, Reina RD and Hays GC. 2017. Detecting elusive aspects of wildlife ecology using drones: New insights on the mating dynamics and

operational sex ratios of sea turtles. Functional Ecology 31:2310–2319; doi: 10.1111/1365-2435.12930

Sudholz A, Denman S, People A, Brennan M, Amos M and Hamilton G. 2022. A comparison of manual and automated detection of rusa deer (*Rusa timorensis*) from RPAS-derived thermal imagery. Wildlife Research 2022, 49, 46–53; doi.org/10.1071/WR20169

Wallace P, Martin R and White I. 2018. Keeping pace with technology: drones, disturbance and policy deficiency. Journal of Environmental Planning and Management 61(7) 1271–1288; doi.org/10.1080/09640568.2017.1353957

Witt RR, Beranek CT, Howell LG, Ryan SA, Clulow J, Jordan NR, Denholm B and Roff A. 2020. Real-time drone derived thermal imagery outperforms traditional survey methods for an arboreal forest mammal. PLOS ONE; doi.org/10.1371/journal.pone.0242204