Minjerribah (North Stradbroke Island) Drone Koala Surveys

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Introduction

Population distribution, size and density estimates are fundamental data requirement for informing conservation management initiatives (Caughley and Sinclair 1994). However, as a consequence of the koala being a cryptic species that often occurs at low and/or patchy densities within the landscape (that can also be difficult to access), accurate population estimates are difficult to obtain (Dique et al. 2001, Sullivan et al. 2002, Dique et al. 2003).

Various methods have been used in efforts to determine the distribution and abundance of koalas, including:

- community surveys (Lunney et al. 2009, Lunney et al. 2014, Flower et al. 2016, Dissanayake et al. 2017, Brown et al. 2018, Predavec et al. 2018),
- faecal pellet surveys (Ellis et al. 1998, Melzer et al. 2000, Sullivan et al. 2002, Phillips and Callaghan 2011, Cristescu et al. 2015),
- spotlighting (Smith and Andrews 1997, Wilmott et al. 2019),
- call playback (Jurskis et al. 2001),
- passive audio recorders (Law et al. 2018) and
- visual searches (Hasegawa 1995, Dique et al. 2001, Dique et al. 2003, Dique et al. 2004, Ashman et al. 2020).

While some methods are appropriate for efficiently generating a relative abundance index (e.g. relative comparison in space or times), these estimates are only valid if the proportionality constant that connects this index to the actual population size remains unchanged, and this crucial assumption is difficult to justify without robust testing (McCallum 2008). Estimating koala abundance from faecal pellet surveys, for example, requires prior establishment of the relationship at that particular study site between pellet occurrence and actual koala density (Sullivan et al. 2002, Rhodes et al. 2011). Genetic mark/recapture from scats can be successful (Wilson et al. 2003) but requires multiple surveys to be conducted in a short timeframe.

For these reasons, most koala researchers have attempted to estimate absolute abundance with direct animal counts, typically via systematic visual searches, for which the results are more easily interpreted (Dique et al. 2003). Visual searches typically involve teams of trained professionals systematically searching an area of potential habitat using line or strip transects or patches with defined boundaries to derive density estimates that can then be extrapolated to produce local population size estimates.

A common problem with animal count surveys, however, is imperfect and variable detection (MacKenzie et al. 2002, Gu and Swihart 2004, MacKenzie 2005, Wintle et al. 2005). The susceptibility of population estimates to koala detectability is exemplified by Dique et al. (2004) for the Koala Coast population of south-east Queensland. Their best population estimate of 6,246 (+/- 1,444 95% CI), would require a 20% change (or 1,450 individuals) to be detected as a "significant" change by subsequent monitoring surveys (Dique et al. 2004). However, due to their sparse distribution, this is equivalent to as few as two additional missed koala observations per survey site, highlighting the importance of robust calculations of both accuracy and precision for population estimates used for monitoring programs (Dique et al. 2001, Dique et al. 2004).

Vulnerability to missed observations and temporal variability in habitat use can be compensated for by intensifying sampling effort (e.g. spatial extent of area surveyed, number of sites surveyed, number of repeat surveys, number of observers) within a given study area, or the method of double count, where two independent teams survey each areas - but the required resources are often prohibitive. For this reason, alternative, more efficient methods of koala detection are required to enable accurate population estimates and ongoing monitoring (with enough statistical power to detect ecologically relevant change) across the koala's range to inform locally targeted and regionally relevant conservation management.

A new method revolutionising wildlife ecology is thermal imagery acquired through drones (Gonzalez et al. 2016). Especially, this method has been compared to alternatives including spotlighting and scat surveys and was more accurate and efficient at determining koala density (Witt et al. 2020). Here we propose to deploy this innovative technology to perform a large-scale survey of Minjerribah (North Stradbroke Island) bushland.

Methods

Survey sites, each of 25 ha in size, were selected to cover both known koala habitat and outside (based on detection dog scat surveys undertaken by Detection Dogs for Conservation in 2018), maintaining a minimum 1 km buffer between them (to ensure site independence), and achieve spatial spread over the entire island (selecting areas with trees, rather than heath or swamp). On two occasions, water bodies were present in the original polygons, and additional area was then surveyed to achieve a 25 ha of dry land survey. A minimum 100 m buffer from residential housing was also applied, which meant the township areas of Dunwich, Amity Point and Point Lookout were unable to be surveyed with the drone. Survey site shape was square by default but turned into rectangles as required due to landscape features and drone operation limitations. This was done to achieve unbiased survey sampling of areas with varying habitat types, land-use and fire histories surrounding the scat records. Proposed survey sites were sent to all landholders (RCC, QPWS, QYAC, Sibelco and SEQ Water) and sites with concerns were excluded (especially, where drone could be considered a nuisance).

A remotely piloted aircraft system (RPAS, or "drone", Figure 1), consisting of a DJI Matrice 100 or an Inspire quadcopter fitted with a thermal video camera on a stabilised gimbal with live image transmission (Zenmuse XT), was deployed between 12 October and 15 November 2020 to search for koalas across the island. This RPAS typically achieves 75% to 85% detection success of koalas within open sclerophyll forest (using GPS collared koalas of known locations, *unpublished data*).

Figure 1: Example of the drones used for this survey

The RPAS was flown slowly and systematically above the forest canopy in a search grid pattern at a height of 50 to 60 metres above ground level. The RPAS was paused and/or repositioned from multiple viewpoints until high confidence of koala detection was achieved (avoiding false positives, such as possums, flying foxes etc., see Figure 2-3). GPS coordinates of all thermal koala detections were recorded. If a koala was detected outside the search polygon, its position was recorded but not included in density estimates.

The RPAS was operated following strict CASA-approved procedures for night flights by Kye McDonald, an experienced operator with current Remote Pilot License (RePL) and Remote Operator's Certificate (ReOC). Approval of this methodology was provided by the University of the Sunshine Coast's Animal Ethics Committee, and scientific permits were secured with the Queensland Government.

Results

The RPAS surveys covered a total of 44 complete polygons (Figure 4-5) and 1100 ha (4% of the island). One polygon could not be completed due to a community complaint (Site near Dunwich). The time to survey a polygon was on average 1:42 h (SD = 36 minutes). Of the sites surveyed, 19 had koalas detected within the search polygon, two had koalas detected just outside the search polygon and 23 had no koala detection (Figures 6-9). A total of 117 koalas were detected, with 66 within the polygons, and the rest outside.

Figure 2: Example of a koala detected by thermal camera

Figure 3: Example of a koala and joey detected by thermal camera

In positive polygons, between one and 20 koalas were detected, transformed into densities, this amounts to 0.04 to 0.8 koala per hectare.

Regional ecosystem mapping was superimposed to the koala detections. The number of koalas per represented (in the polygons) regional ecosystem varied from zero to 17. Densities, calculated per regional ecosystem per site which allowed us to calculate standard deviation (SD), varied between 0.03 ±0.08 to 0.27 ±0.37 koala per hectare in regional ecosystems where koalas were detected (Table 1). Note that if a regional ecosystem representation in a site was < 1 ha, it was excluded from density calculation. The density of koalas between regional ecosystem at different sites was highly variable, and therefore density precision (i.e. SD) was low. Koala densities were higher in *Melaleuca* open forest (RE 12.2.7) and coastal swamps (RE 12.2.15).

We extrapolated these densities to the full extent of the regional ecosystems (Figure 10). However, there are obvious limitations to this. Most notably, highest densities in coastal swamps (RE 12.2.15) are linked to the presence, in the sites surveyed, of *Eucalyptus robusta*, whereas the same regional ecosystem (RE 12.2.15) in the eastern side of the island, at 18 Miles Swamp, does not present that species and koalas are not found there.

Table 1: Number of koalas detected in each regional ecosystem RE

RE	Koala Detected	Area surveyed (ha)	Percent of RE surveyed	Density	SD	Vegetation description
12.2.7	17	61	5.1%	0.27	0.37	*Melaleuca quinquenervia* or rarely *M. dealbata* open forest on sand plains
12.2.15	10	28	2.2%	0.24	0.38	*Gahnia sieberiana*, *Empodisma minus*, *Gleichenia spp*. closed sedgeland in coastal swamps
non-remnant	13	259	3.7%	0.05	0.10	Includes mine rehabilitation
12.2.6	19	446	7.6%	0.04	0.12	*Corymbia intermedia* +/- *Lophostemon confertus* +/- *Banksia spp.* +/- *Callitris columellaris* open forest on beach ridges usually in southern half of bioregion
12.2.5	6	158	9.8%	0.03	0.09	*Eucalyptus racemosa* subsp. *racemosa* open forest on dunes and sand plains. Usually deeply leached soils
12.2.8	1	99	6.6%	0.03	0.10	*Eucalyptus pilularis* open forest on parabolic high dunes
12.1.3	0	2	0.3%	0.00	0.00	Mangrove shrubland to low closed forest on marine clay plains and estuaries
12.2.10	0	41	1.0%	0.00	0.00	Mallee *Eucalyptus planchoniana* +/- *Corymbia gummifera*, *E. racemosa* subsp. *racemosa*, *Banksia aemula* woodland on dunes and sand plains, especially southern sand mass islands. Usually deeply leached soils

Figure 4: Location of the 41 sites

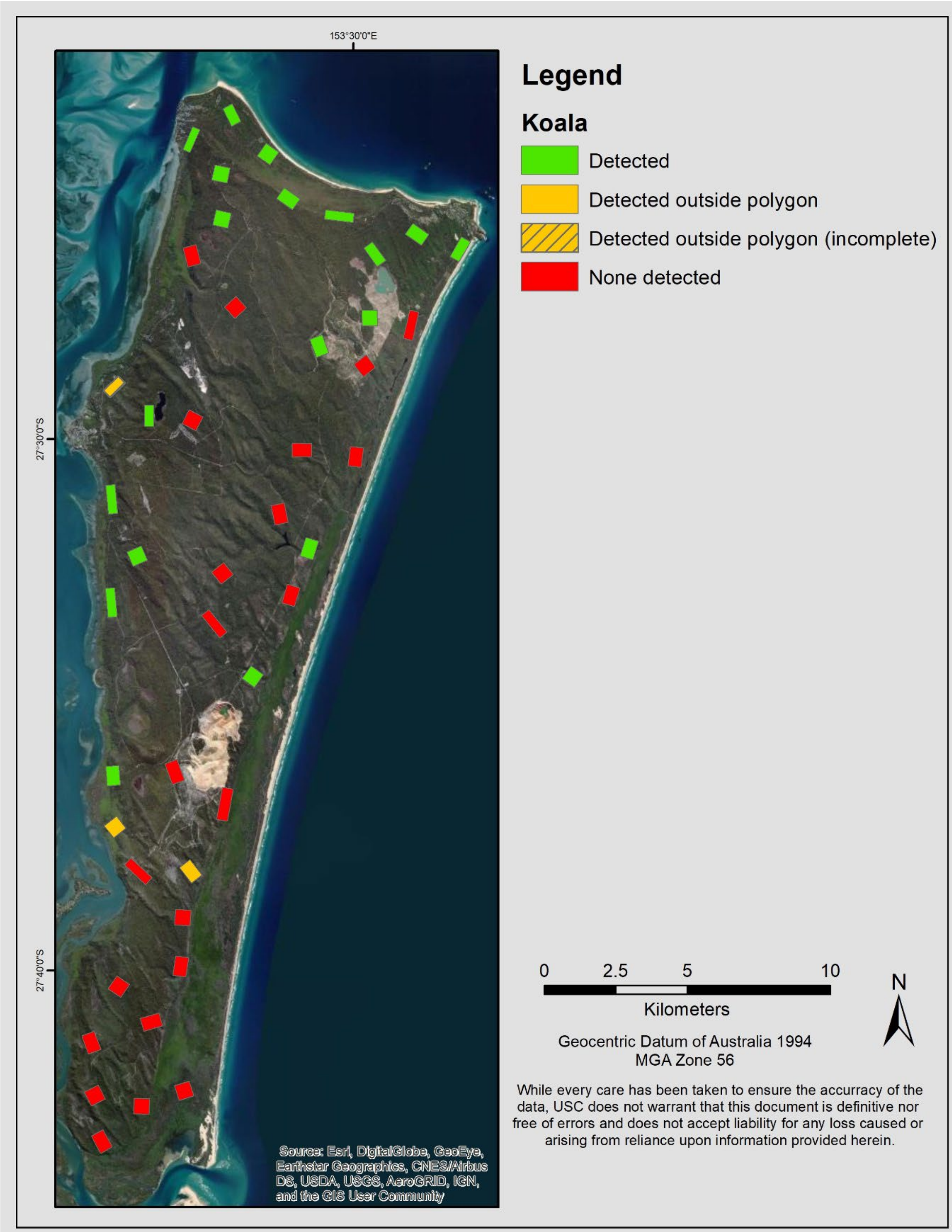

Figure 5: Sites where koalas were detected, not detected or detected just outside the site

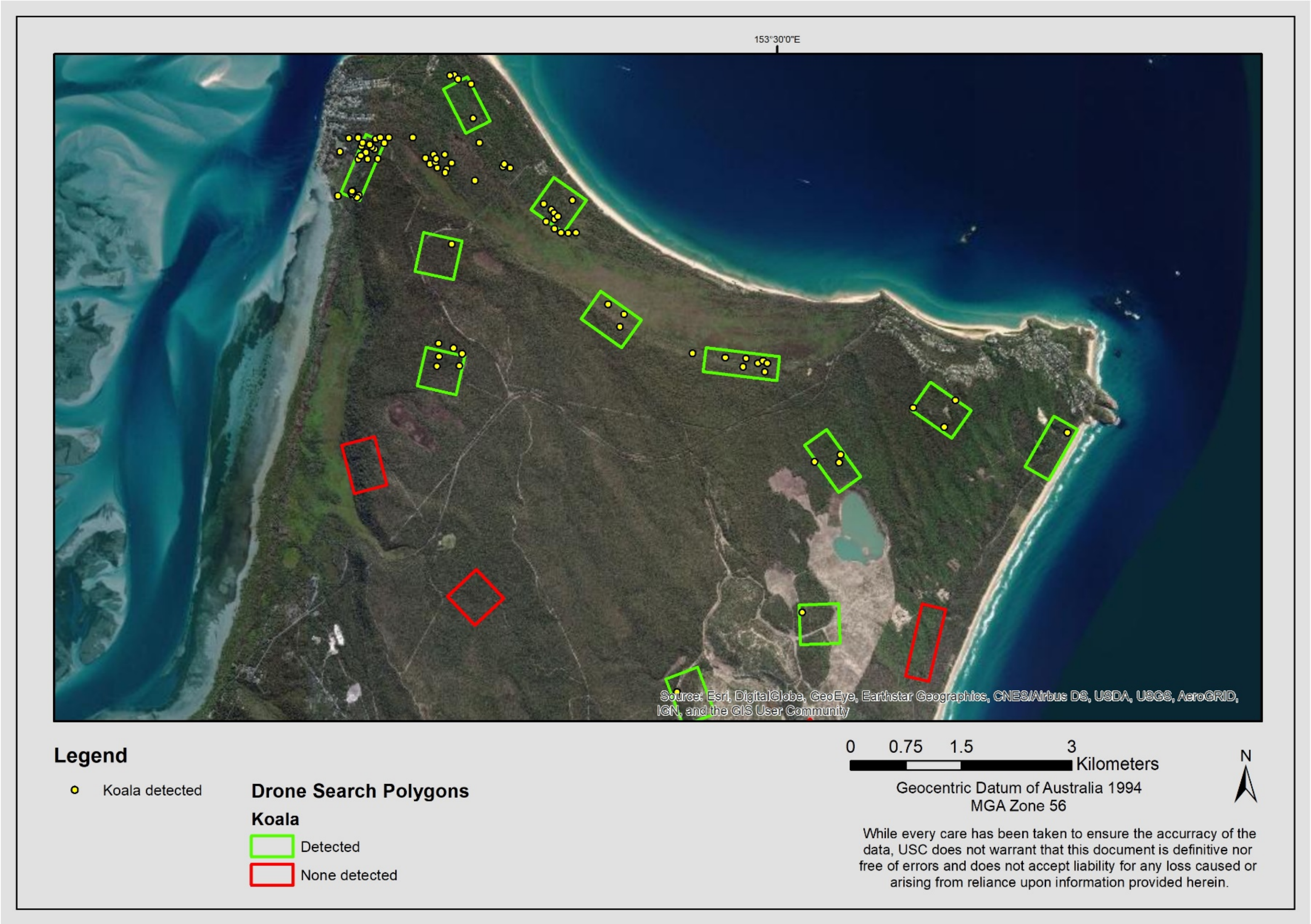

Figure 6: Koala detections 1

USC Detection Dogs for Conservation

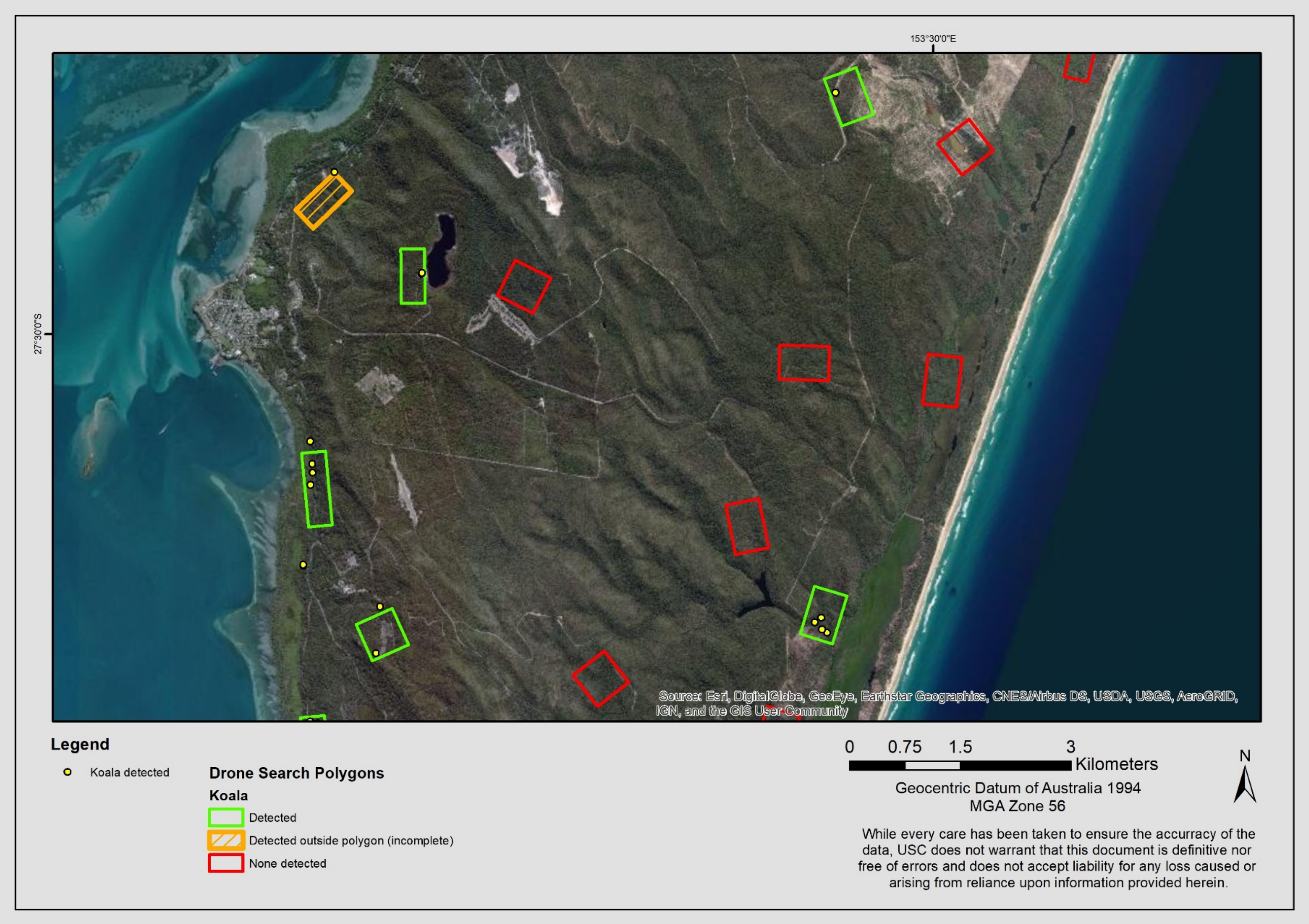

Figure 7: Koala detections 2

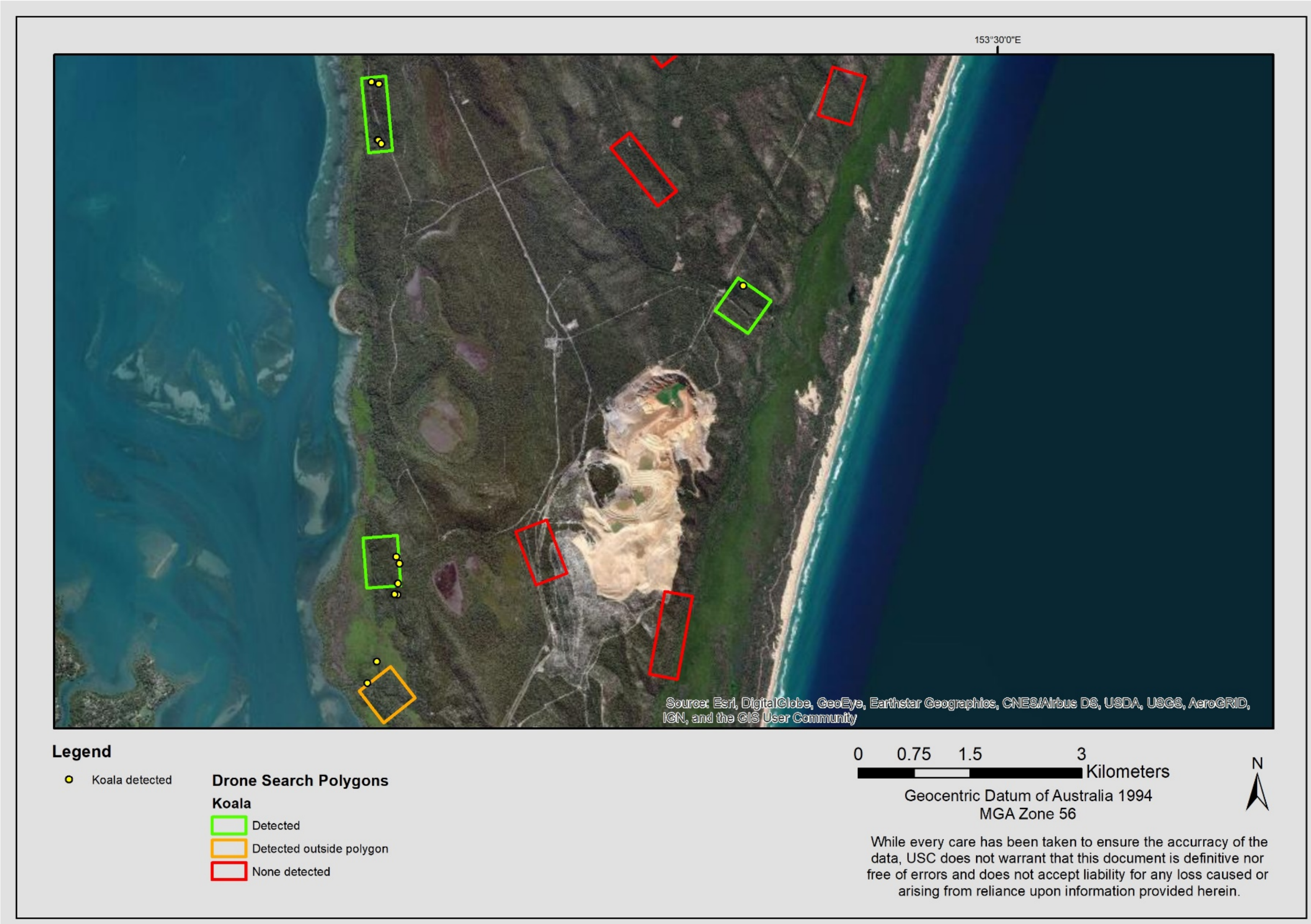

Figure 8: Koala detections 3

Figure 9: Koala detections 4

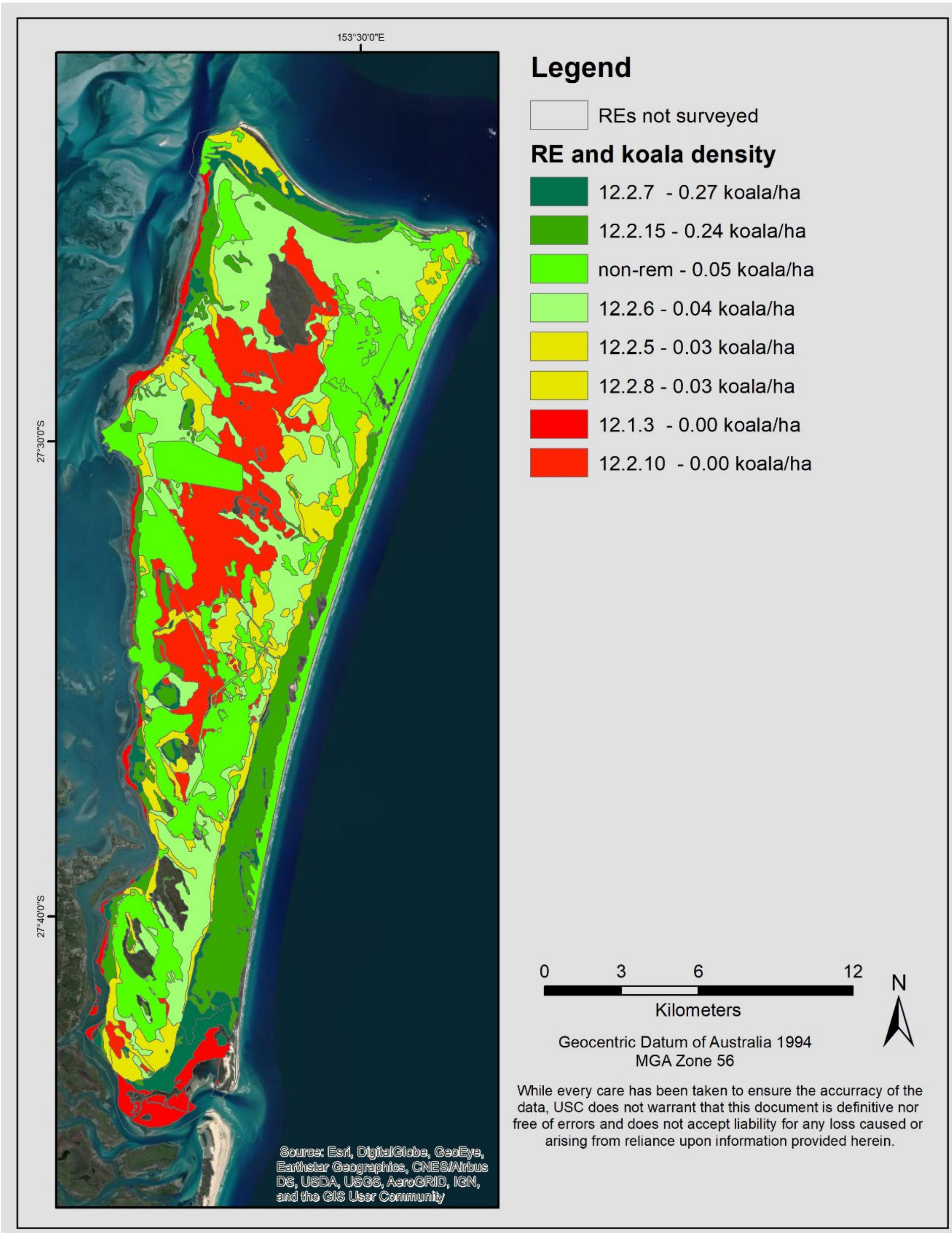

Figure 10: Koala densities in each regional ecosystem, extrapolated from the densities calculated at the site level

Discussion

This report presents the first large scale attempt at a drone koala survey on Minjerribah, and the first attempt at calculating koala density across a whole bushland population using heat-seeking drone. More than a 1000 ha was surveyed, 66 koalas (117 in total, including outside polygons) were detected within 44 sites, and densities varied between 0.03 ±0.08 to 0.27 ±0.37 koala per hectare in regional ecosystems where koalas were detected. It has to be noted that due to CASA regulations, the urban areas of Minjerribah were not part of the survey, and it is well known that these areas contain an important part of the koala population on Minjerribah (with 77 koalas found during the 2019 annual Council led urban koala count). The urban count could not, in 2020, target the entire urban area due to restriction from COVID.

A large-scale scat survey using detection dogs was conducted in 2018 by the Detection Dogs for Conservation. Although the scat survey was performed for the collection of genetic samples, the large area covered by the survey allowed us to gain some information on where koalas were detected (Figure 11). In comparing the 2018 and the 2020 surveys (Figure 12), some areas were confirmed as used (most of the western and northern coastal edge of the island) or not used (interior of the island, south-east coastal edge) by koalas – but the picture of the south of the island appears very different. A wildfire impacted the southern end of the island in January 2019. Scat surveys conducted after this fire confirmed some koala presence, however some sites with scats prior to the fire had none post fire (Figure 13). The nine most southern drone survey sites with no koala detections may be due to a lower koala density in that area that was decreased further post fire, combined with unfortunate location of koalas outside the survey areas on the night of survey.

The surveys detected koalas in post mining rehabilitation in Amity, Ibis, Bayside and Yarraman mine sites (the age of rehabilitation on the island ranges from a year old to 60+ years old and the koala detections were not superimposed with mining rehabilitation age in this study). Detections of koalas in mining rehabilitation is in line with previous work which established that koalas used mining rehabilitation as early as six years post rehabilitation (Cristescu 2011). More work is needed to determine how much the mining rehabilitation can support a koala: from movement data in particular, we could establish whether koalas are fully supported by the mining rehabilitation (i.e. spend most of their time) or whether they are using mining rehabilitation part of the time (part of the year, or only at night for feeding while moving back to undisturbed areas to shelter during hot days, etc.).

Repeat drone surveys would help elucidate areas that have koala presence in very low densities compared to no koala, as one off survey is not robust to establish true absence. Repeat surveys would also provide more robust mean density estimates and tighten confidence intervals, this would inform whether the method is appropriate for an island-wide population estimate. Additionally, a selection of key sentinel survey sites, surveyed with a thermal drone several times per year, could enable cost-effective long-term monitoring of Minjerribah's koala densities at specific locations, with more sensitivity to provide an early warning to population decline (regardless of cause) than many other survey methods (i.e. scat presence / absence surveys).

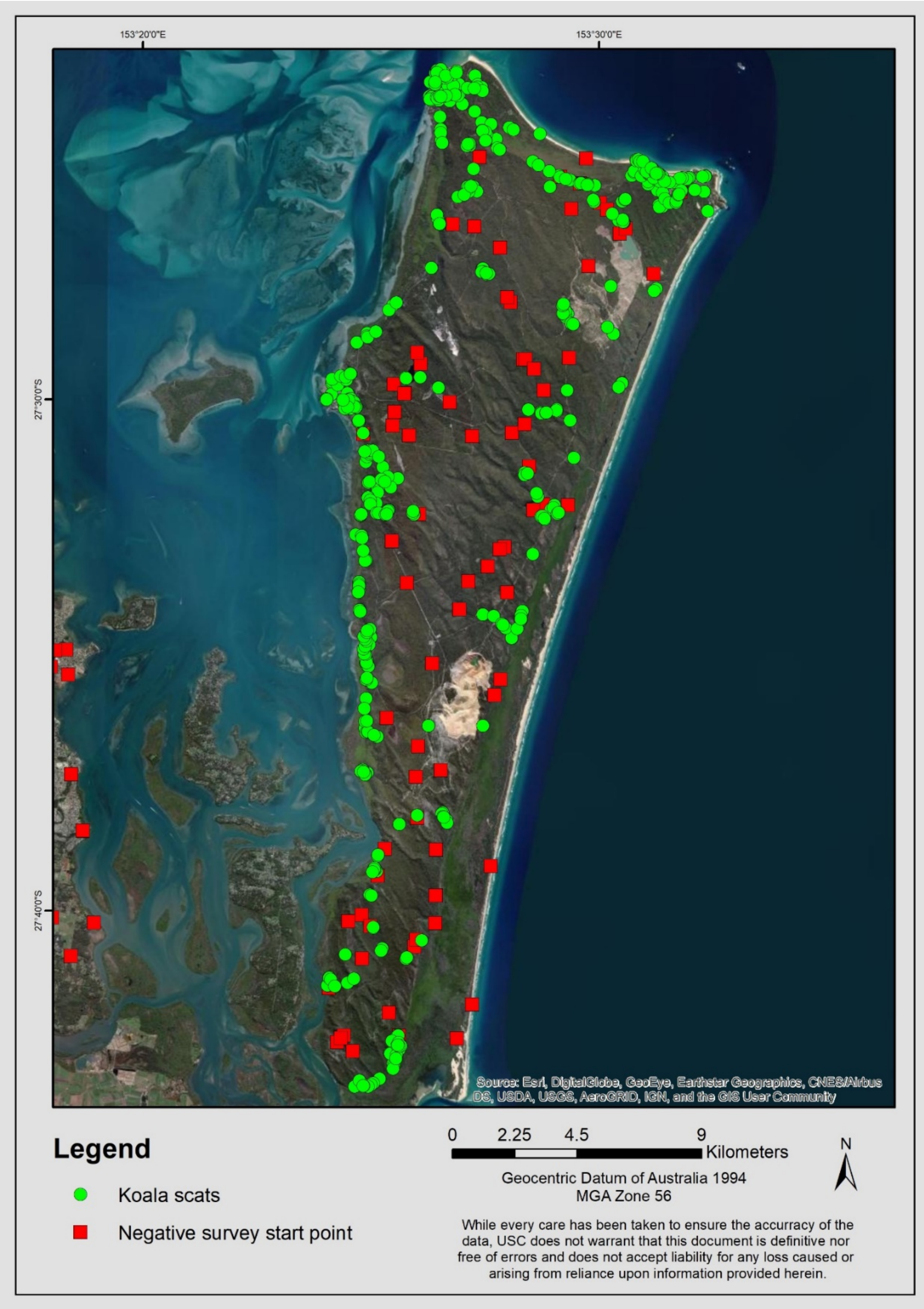

Figure 11: Results of the 2018 Detection Dogs for Conservation scat surveys

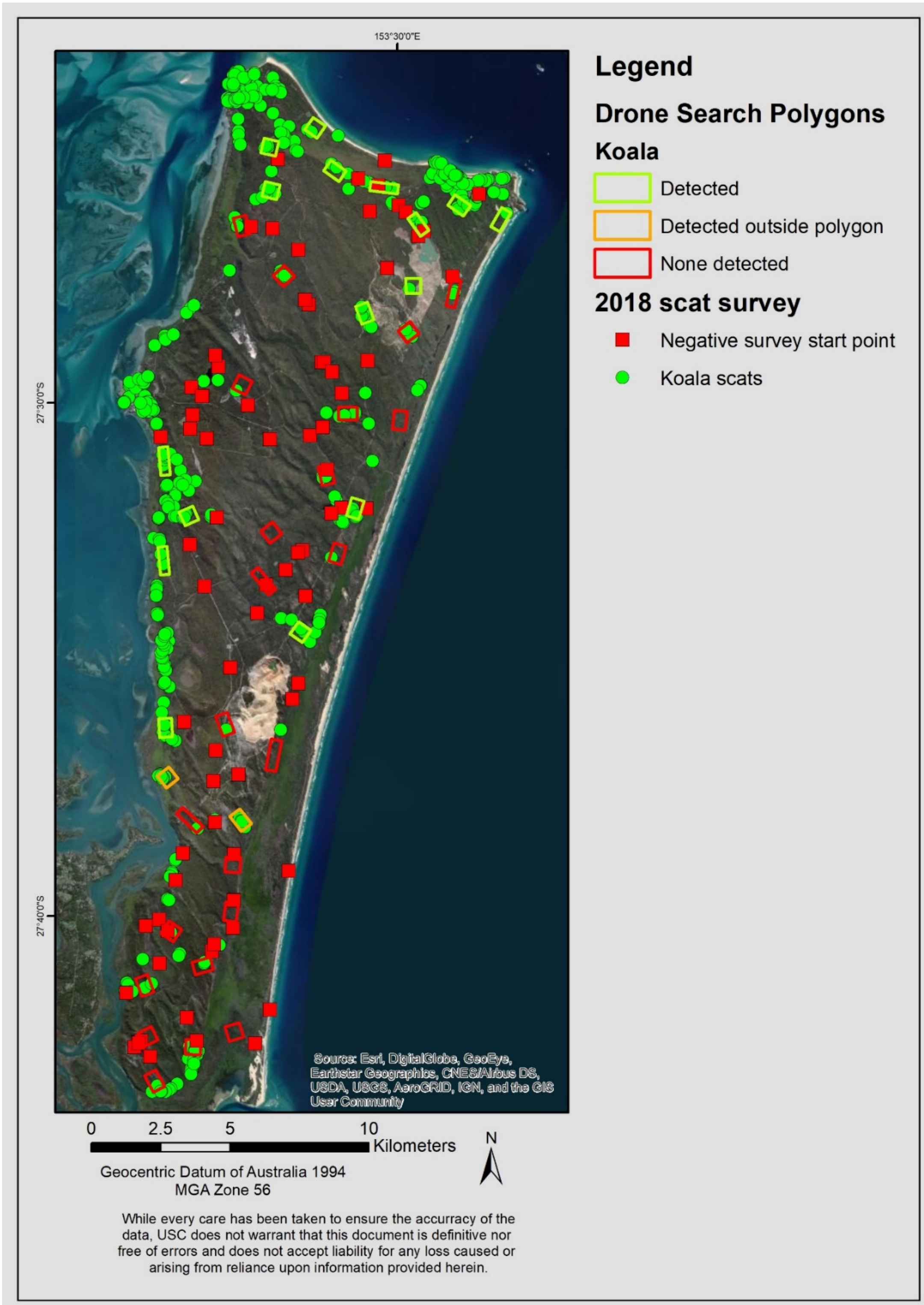

Figure 12: Comparison of 2018 scat survey and 2020 drone surveys of Minjerribah

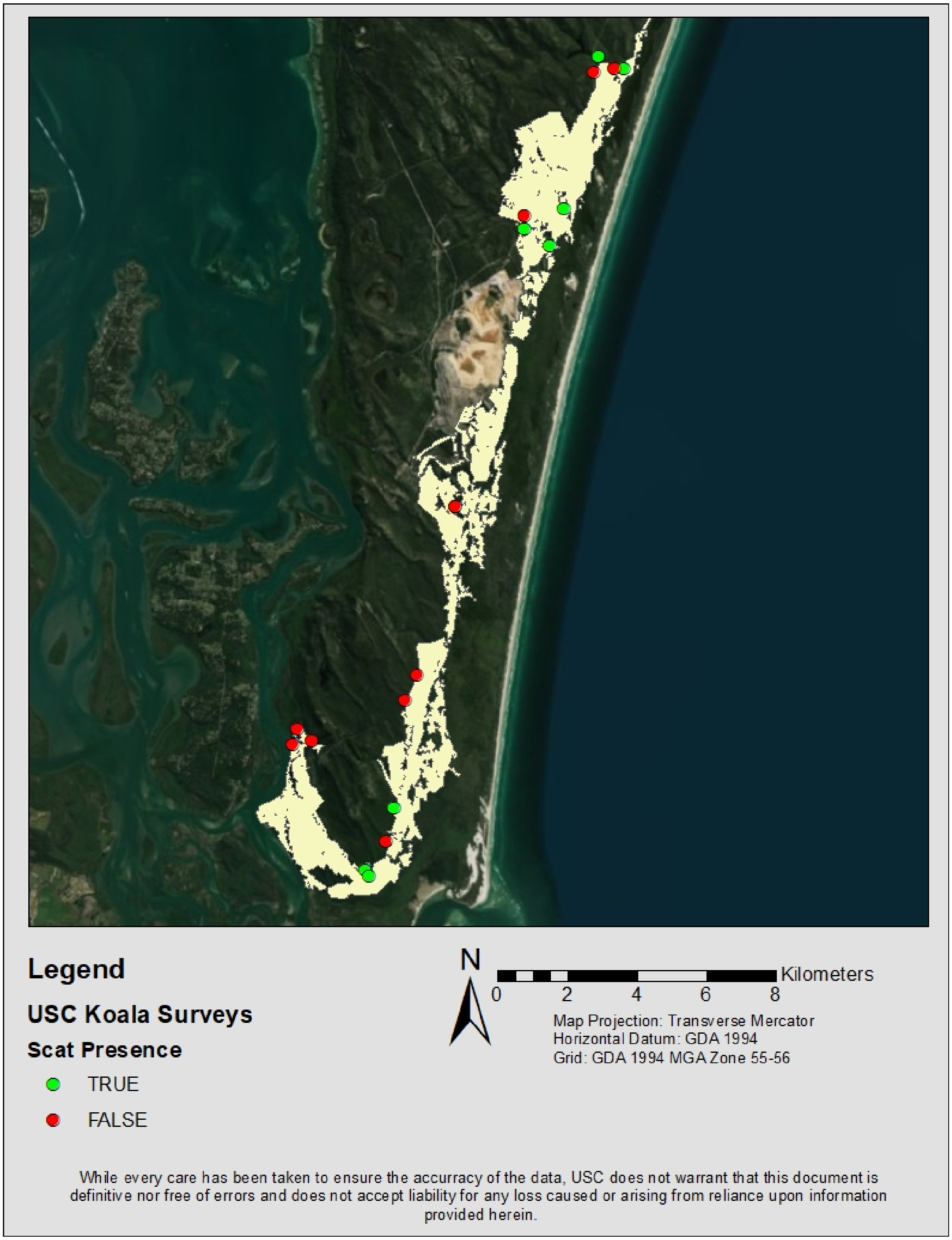

Figure 13: Scat survey post 2019 fire showing the extent of the fire

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