Project Squealer - Assessing New Technologies in the Management of Feral Pigs (Sus scrofa) in the Queensland Wet Tropics.

Assessment of drone and thermal imagery technology

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Executive Summary

Feral pigs continue to impose significant costs on sugarcane growers in North Queensland's Herbert district. In 2009, crop losses were estimated at about $1.2 million, prompting the formation of a coordinated control effort through the Herbert Community Feral Pig Management Program. Damage declined for several years but rose again between 2018 and 2020 before stabilising at an estimated annual average of about $500,000 from 2021 to 2024. These ongoing losses highlight the need for more effective monitoring and control strategies.

In 2022, Herbert Cane Productivity Services Ltd received funding through the Queensland Feral Pest Initiative (Round 6) to trial and assess innovative approaches to feral pig management and to quantify their impacts. Among several options trialled, this study focused on the use of drones equipped with thermal imaging cameras to detect pigs and assess population changes.

The project area near Ingham experiences heavy seasonal rainfall, with most rain falling during the summer wet season. Flooded ground restricts access to traps and bait sites, allowing pigs an extended breeding period with minimal disturbance.

Initial drone trials confirmed that pigs can be detected using thermal imaging under suitable conditions. However, warm evening temperatures reduced thermal contrast, making animals difficult to distinguish from surrounding vegetation. Winter operations after sunset were considered more suitable.

Field testing revealed significant practical limitations. Systematic grid flights designed to cover large areas were too slow and required multiple battery changes, making full surveys impractical. The thermal camera's relatively low resolution also limited effectiveness. At higher flying altitudes needed for broad coverage, heat signatures became blurred and difficult to interpret. Dense vegetation, particularly sugarcane canopy, further obscured animals and fragmented their thermal signatures, increasing the risk of misidentification.

Manual flights over areas with known pig activity proved more useful because the pilot could reposition the drone to verify heat signatures. While unsuitable for large-scale population counts, thermal drones may still assist targeted control by locating pig activity in smaller areas, guiding baiting and trapping efforts, and improving understanding of pig behaviour.

Overall, drone-mounted thermal imaging is not a cost-effective method for estimating feral pig populations across large, densely vegetated landscapes. However, used strategically in smaller areas and alongside other control measures, the technology can support more effective feral pig management and help reduce ongoing crop losses.

Introduction

In 2009 the Herbert Community Feral Pig Management Program (HCFPMP) was established in response to feral pig damage estimated to be valued at $1.2 million to the sugarcane crop in the Herbert District[1], according to data collected by the Herbert Cane Productivity Services Ltd[2]. The HCFPMP coordinated the efforts of sugarcane growers and industry, and over the following years reported damage attributed to feral pigs fell to an average of 5,890 tonnes of sugarcane valued at $220,000 annually between 2014 and 2017. The years 2018 to 2020 again saw in increase in the feral pig damage being reported, peaking at an estimated 17,500 tonnes worth approximately $740,000 in 2020. Efforts from 2021 to 2024 have seen feral pig damage fall to an average of 10,800 tonnes worth an estimated $500,000 annually[2].

In 2022, Herbert Cane Productivity Services Ltd (HCPSL) in partnership with the HCFPMP received $200,000 through the Queensland Feral Pest Initiative (Round 6) to trial and assess innovative approaches to feral pig management and to quantify their utility. The project reviewed several emerging technologies, including aerial surveillance using thermal imagery, GPS tracking collars, and the potential use of unmanned aerial vehicles (UAVs or drones) to deploy baits (prefeed and potentially poisoned) into areas that are difficult to access during the north Queensland wet season. The project also explored the feasibility of applying AI to automate trap-gate closure once pigs have entered a trap.

The focus of this paper is on the use of drones (UAVs) mounted with thermal imaging sensors.

Ingham sits at the southern end of Queensland's Wet Tropics, almost 1,000km south-east of Cape York and approximately 1,200km north-west of Brisbane, as the crow flies. Australia's Bureau of Meteorology (BoM) rainfall records give Ingham an average annual rainfall of 2,160mm (1968 to 2024), with the range falling between 3,484mm in 2010 and 1,052mm in 2015[3]. Figure 1 shows the monthly rainfall range and visualises between the wet and dry seasons which are common across northern Australia. The northern wet season usually commences in December/January and goes through to March/April, with an average of 78% of the annual rainfall in occurring between these months (60.3% in 2022 and 94.2% in 2019)[3].

The northern wet season, provides the local feral pig population a five-to-six-month breeding window with little to no harassment from land managers or hunters, with the exception of one of two helicopter-based aerial shooting activities, usually held in late November or December, and any population reduction made by the local estuarine crocodile (*Crocodylus porosus*) population. Traps become very difficult to access without specialised vehicles like the amphibious Argo, due to inundated land or ground that will bog an ordinary four-wheel drive. Vehicle access is important because of the amount of bait required to bait a trap, or to pre-feed a site. In the Herbert district,

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[1] Kemp, I. Integrated feral pig management for the Herbert cane area.
URL: https://elibrary.sugarresearch.com.au/items/120d97b9-0011-4497-8723-eab0da8078f6
Accessed: 5th June 2023.

[2] Data collected by the Herbert cane Productivity Services Ltd. annually through their "Greensheet" – an annual district survey of farming practices in the Herbert District sugarcane growing area.

[3] Australian Bureau of Meteorology (2024). Ingham annual rainfall data. Station Number: 032078 - Ingham Composite QLD. Available at:
http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=136&p_display_type=dailyDataFile&p_startYear=&p_c=&p_stn_num=032078. Accessed: 7th May 2024.

fruit baits of bananas and/or mangos are used and vehicles are needed to carry sufficient fruit to the traps or to baiting sites[4].

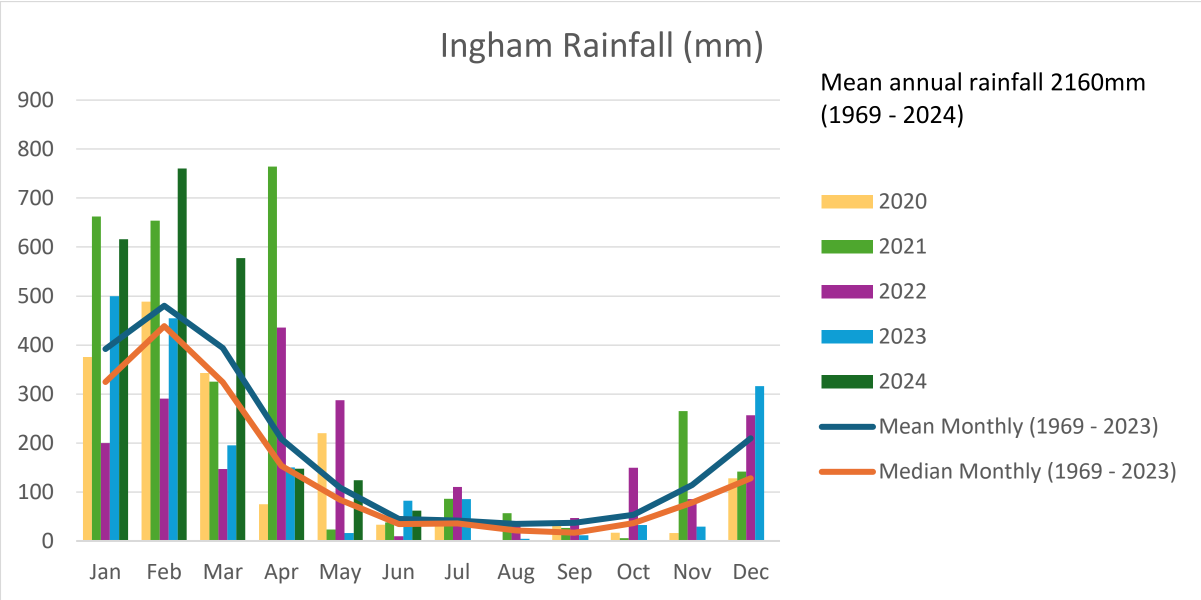


Figure 1. Monthly rainfall between January 2020 and June 2025, showing monthly mean and median. This chart demonstrates the distinction between the wet and dry seasons.

There is currently no way of determining whether the aerial shooting program is effectively reducing the feral pig population in the area of works, i.e. the Halifax Bay Wetlands National Park and several of the surrounding properties. The feral pig kill numbers shown in figure 2 indicate a slight decreasing trend in kills each year between 2021 and 2024, but the decrease is negligible. If anything, the kill numbers indicate no real change in overall population over the four-year period. Numbers of feral pigs destroyed fall between 52 (November 2022), and 113 (December 2021).

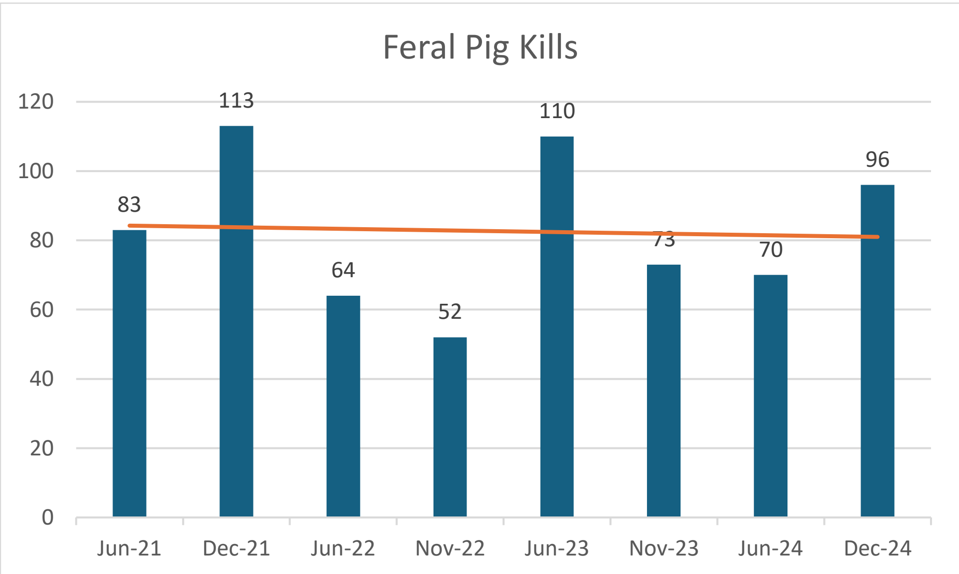
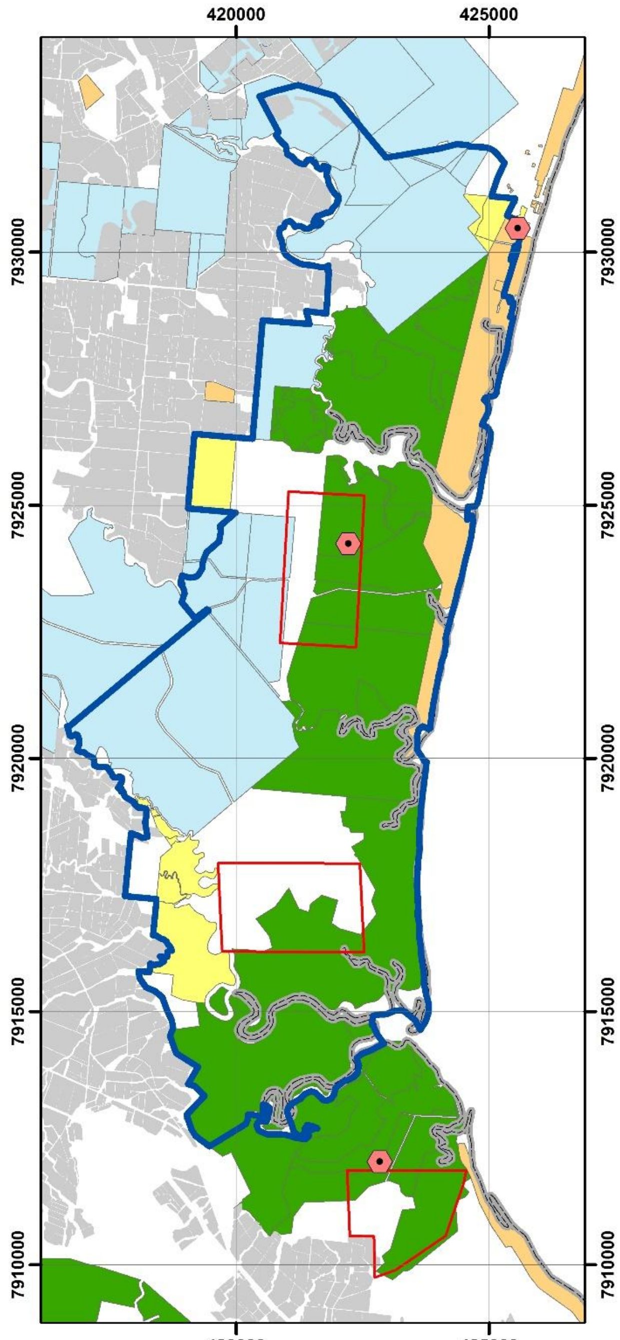
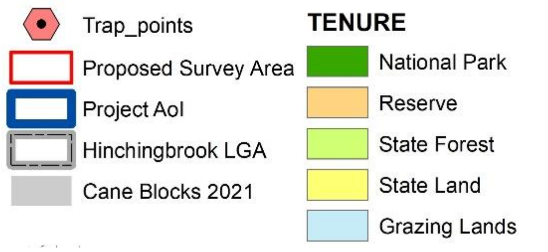


Figure 2. The chart shows a slight downward trend in feral pigs destroyed over time from the aerial shooting activities, indicating a growing feral pig population.

[4] Mitchell, J 2011, Trapping of Feral Pigs, NQ Dry Tropics, Townsville, page 7.

It was proposed to evaluate the viability of undertaking a population count using a drone-mounted thermal camera. The intent was that two flights be made, one flight just before an aerial shooting activity and one flight several days after the activity to attempt to quantify any reduction in population in the project area.





Tenure	Area (Ha)
Easement	11.18
Freehold	3865.09
Lease Lands	206.28
National Park	3895.65
Reserve	564.27
State Land	498.35
No Tenure	705.68
Total	9746.49

Table 1. Tenure and area of land within the project area.

Map 1. The Project area of interest is made up of the tenures shown in the table above, with sugar cane and cattle farming the main adjacent land use.

A demonstration of a DJI Matrice 300 RTK with a Zenmuse H20T thermal camera was conducted in February 2022. While the demonstration proved effective, showing several pigs in one of the test areas, the summer evening temperatures proved to be a drawback to this method at this time of the year. Heat absorbed by trees and termite mounds, etc. during the day radiated back in the early evening made interpretation difficult from maximum flying height. The Project team thought it better to use this method in winter, beginning several hours after sunset when the differential between the ambient atmospheric temperature and mammals would be at its greatest.

Method

Three areas of interest (AoI's) were proposed, based on past aerial shooting and trapping efforts by the Hinchinbrook Shire Council's pest management program. Site 1, to the north was 450Ha, site 2, centre, was 490Ha, and site 3, south, was 341Ha, shown in Map 1, above.

The project hired a DJI Matrice 300 RTK (M300) drone with a Zenmuse H20T camera with thermal imaging capabilities from Drone Hire Adelaide. The image and video resolutions are in the table 2, below.

Sensor	Photo Resolution	Video Resolution	
Zoom Camera	20MP	4K video	
Wide Camera	12MP	1080p video	
Thermal	0.33MP (640 x 512)	640 x 512 video	Spectral bands: 8-14 µm
Laser Range Finder			3 – 1200m

Table 2. Image and video resolution for the Zenmuse H20T.

The intention was to create a gridded flight plan over the AoI's to ensure total coverage of the area, moving to new take-off and landing sites as required. Unable to load the desired flight app onto the M300 controller, the remote pilot had to quickly learn DJI's Pilot app for the flights. The Proposed flight areas were created as .kml files and loaded into the M300 controller.

Image 1. DJI Matrice 300 RTK drone with H20T camera system.

A pre-survey test flight of 1km x 1km was made over a farm where it was possible to fly the whole area without the need to move to remain in visual line of sight (VLOS) of the drone. Before commencing this test flight, it became apparent that this method would not be suitable for purpose. The test flight grid, flying at the maximum height of 120 metres, with a 10% image overlap (allowing the greatest ground area to be covered each pass), would require seventeen passes, at 3.4m/s (12.24km/h), would take approximately 1:42:00 hours of flying time, at least two battery changes, and possibly a third, to complete (image 2 below). The test flight was aborted when it became apparent that the estimated flight time was proving to be accurate.

Extrapolating this to the proposed survey areas, flight times would be - Site 1: 7 hours & 40 minutes; Site 2: 8 hours & 20 minutes; Site 3: 5 hours & 48 minutes, not including time for battery changes and take-off and landing location changes.

These estimates were confirmed on the morning of the 6th of June 2022 when the planned survey flights were commenced. At the first battery change it was apparent that the time required to complete one survey area would be too long, ending well after sunrise. After abandoning this method, manual flights were undertaken over the wetlands and surrounds in an attempt to maximise the flight time over areas where feral pigs might be seen.

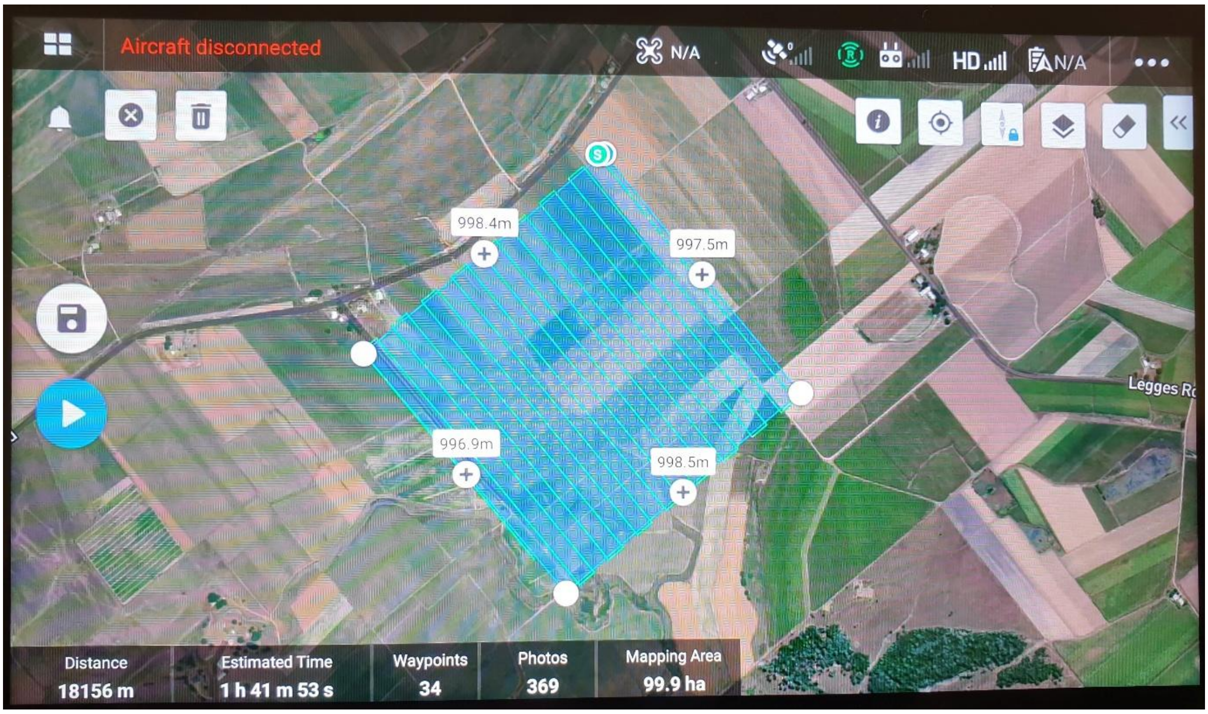


Image 2. The screen of the DJI M300 flight controller with the distance covered and the estimated flight time (bottom left).

Limitations of the DJI Matrice 300 RTK Drone with Zenmuse H20T Camera

While the Zenmuse H20T thermal camera is one of the better thermal camera packages available for medium sized drones, the image resolution of the thermal camera became the main limiting factor in Project Squealer. The need to cover the greatest area requires the drone to be flown at its maximum allowed height, 120m (400 feet). Given the resolution of the thermal camera, 640 x 512 pixels, and the image footprint, it quickly became apparent that too many passes would be required to undertake the survey mission.

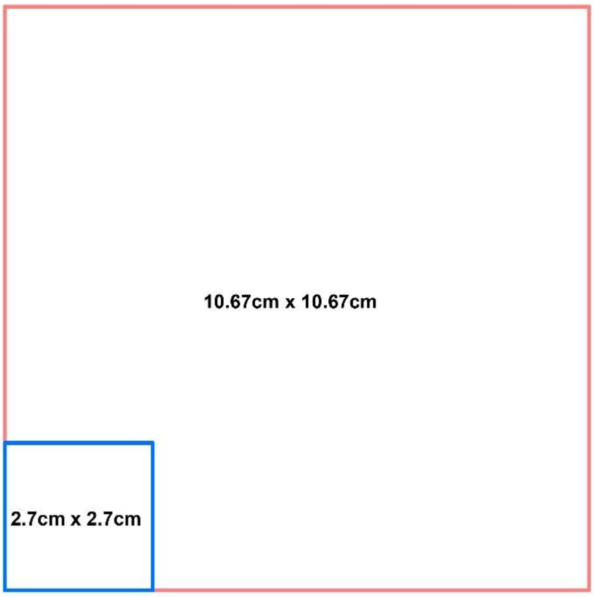


Image 3. A comparison of image pixel sizes. Not to scale.

Image 3 shows the size comparison between a 2.7cm image pixel and a 10.67cm image pixel. The effect of the larger image pixel size is a loss of image sharpness, clarity and detail. The image looks blocky instead of crisp and sharp. Also, when looking at a heat source, the larger the pixel, the more information from a larger area needs to be generalised for the camera to give a pixel value. This tends to dilute information. This will be demonstrated later.

Image Resolution

Image 4 compares the footprints of an image from a 20MP camera (Mavic 2 Pro) with that of the thermal camera on the H20T camera (640 x 512 = 0.33MP). The approximate footprint of the 20MP image is 155m x 116m (4 x 3 image) while the thermal image footprint is approximately 68m x 54m. The comparative areas covered is 17980m^2 (20MP) against 3708m^2 (thermal) meaning that up to five times the number of thermal images would need to be reviewed compared to an RGB image. Image pixel size was 2.7cm (20MP) against 10.67cm (thermal – 0.33MP). It became apparent during the initial testing and familiarisation flights of the M300 by the pilot, that this thermal camera system would not be suitable for the original objectives of this aspect of the overall project.

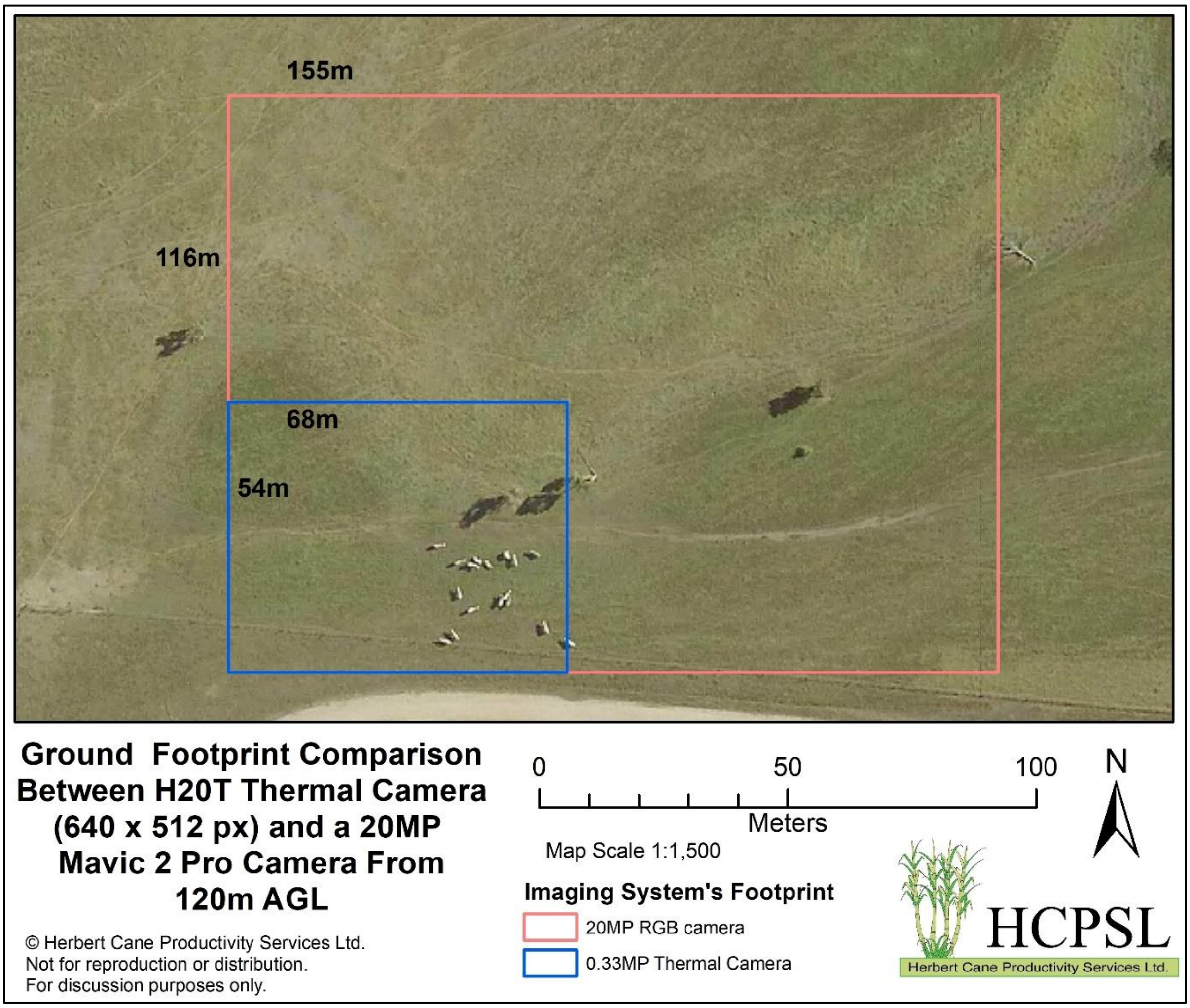


Image 4. Map showing the ground footprints of the H20T thermal camera and a 20MP DJI Mavic 2 Pro camera.

Ground Speed

A comparison of flight grids created by DroneDeploy (Mavic 2 Pro) and DJI's Pilot app (M300) over the test area estimated the Mavic's flight speed as ~15m/s while the M300 with the thermal camera at 3.4m/s. Thus, it takes about four times as long to cover the same distance.

Flight Passes

The test area grids measured 1km^2 for both DroneDeploy and the DJI Pilot app, to allow each flight app to make comparable estimates for flight times, passes, etc. Not that the flights were undertaken, but to simply compare the estimated times and battery swaps between the different drone and camera systems.

The DroneDeploy created grid for the Mavic drone with 30% image overlap (the minimum available in DroneDeploy) would require 10 passes, flying at approximately 15m/s (54km/h, taking about 16:09 minutes, using one battery. The DJI Pilot app used with the M300 drone and the H20T thermal camera with 10% image overlap, would require 17 passes, flying at approximately 3.4m/s (12.24km/h), taking almost 1 hour & 42 minutes, using 3 sets of batteries, maybe 4 sets.

Result

The methodology of using gridded flight plans was abandoned. Flights were instead undertaken manually over areas with a known history of feral pig activity.

Visual Interpretation of Thermal Imagery

The series of images below demonstrate two important issues, 1) the difficulty of identification of an animal from altitude (e.g. 120m) using thermal imagery, and 2) the difficulty of identifying a pig under a vegetation canopy. In this case the canopy is sugarcane.

The higher the altitude the more ground is traversed in a given time. This allows more ground to be observed and photographed. The advantage of ground covered, however is lost by low image pixel resolution, i.e. 10.67cm for the H20T thermal camera at 120m. The larger the image pixel, the greater the difficulty in positively identifying a pig as opposed to another species, particularly under a vegetation canopy. The reason being that the greater the area coverage of the pixel, the more detail is generalised in the image.

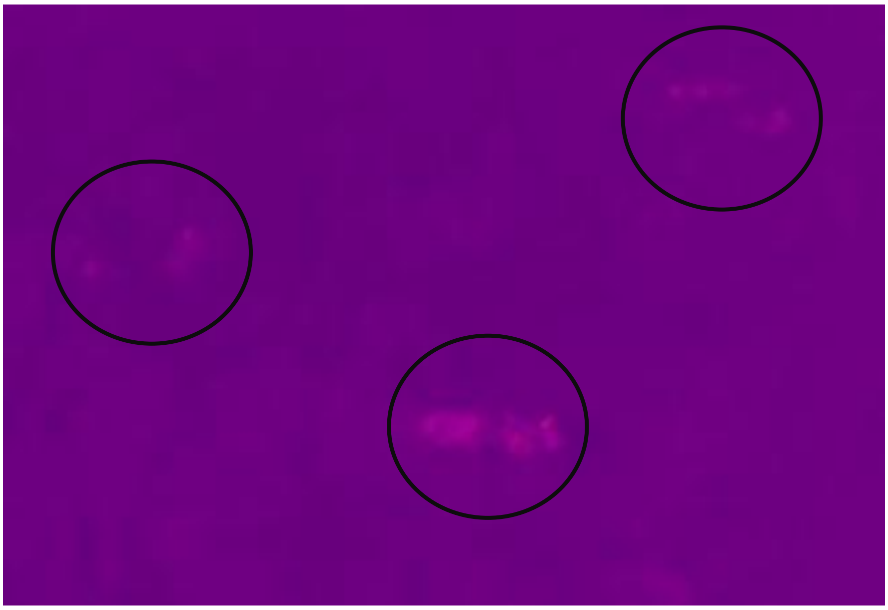


Image 5. Feral pigs in thermal imagery beneath a sugar cane canopy from ~20m at 6:14:59 am.

Image 5 shows the thermal signature of pig beneath a sugarcane canopy. In each case sugarcane leaves can be seen to cover the pig, segmenting the heat signature. At flying heights above about 40 metres, it becomes difficult to determine whether is one large pig, and several smaller ones beside each other. Video taken during the project, several times shows large heat masses breaking into two or three smaller heat masses and moving away from each other. The implication is that when using still imagery, an incorrect feral animal count is not unlikely.

The core body temperature of a pig is stated as 38.7°C to 40°C[5]. The parameters on the thermal camera were set to display the colour ramp from 10°C to 48°C. This lower temperature allows lower temperatures to show in the screen. This helps when flying at altitude, when the temperature of a mammal is more diffuse and is recognised by less pixels in the image. Note that the operator at this time had had little time to become familiar with the nuances of the camera app on the M300 controller.

Image 5 above, is thermal signature of feral pigs in a cane field being beneath the sugarcane canopy. Image 6 below, shows the same area, in true colour (RGB), eight seconds after the thermal image. The true colour image shows some small gaps in the canopy, but the shadow beneath the canopy hides the pigs completely.

Image 6. The same area shown in the above image at 6:15:07am.

[5] [5] North American Pet Pig Association. URL: https://petpigs.com/education/farec-forgotten-angels-rescue-education-center/pig-education/swine-temperatures/ Accessed on 5th of June 2023.

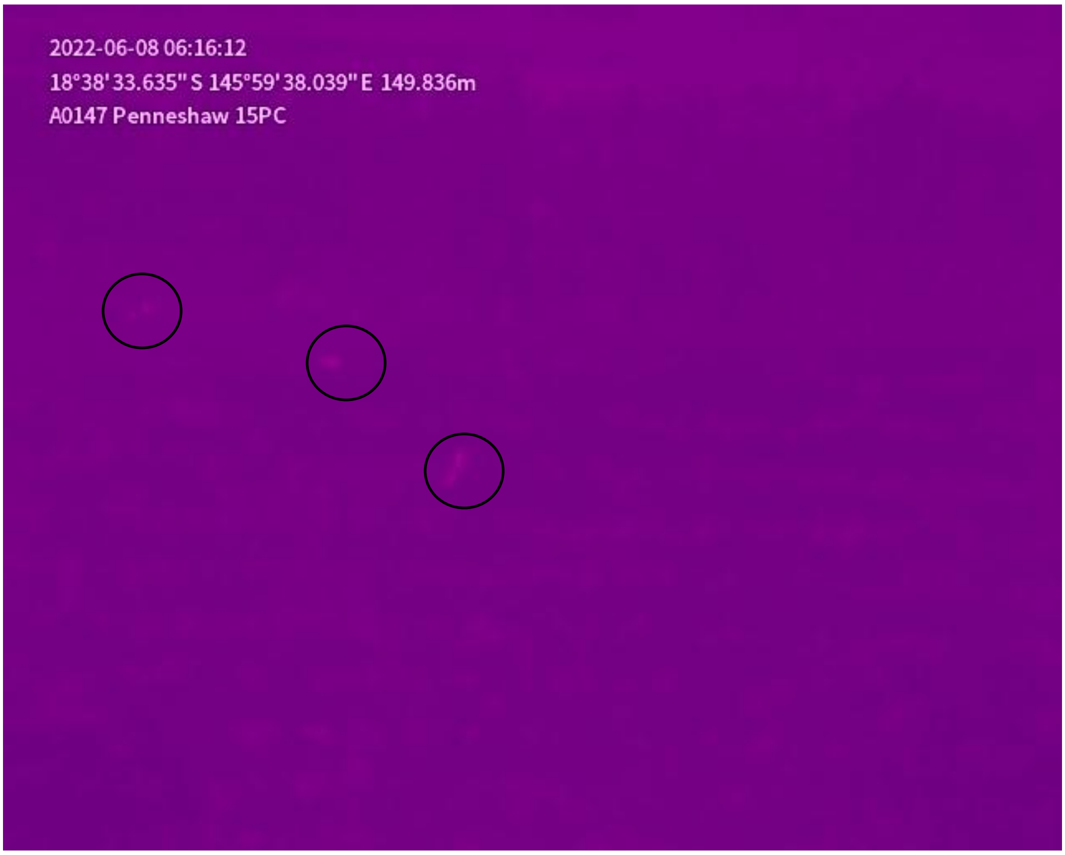


Image 7. Pigs in the cane from ~55m above ground level (AGL).

Several pigs were identified while flying at ~55m above the ground, shown in image 7. While hovering in place, the drone was raised to 80m, 100m, 110m and 120m to show how difficult it would be to identify a pig beneath a vegetation canopy. Appendix 1 shows a series of photos taken at 110m, 100m, 80m, 55m, 40m, 30m, and 20m and shows how difficult it can be to identify feral pigs beneath a sugarcane canopy. Other thick vegetation canopies would produce the same problems.

In this case, the drone was manually flown over a sugarcane field at 55m until an anomaly appeared in the screen on the controller. The drone was then repositioned to gain a better view of the anomaly to determine whether it was a feral pig. The advantage of free-flying in this way over a gridded mapping flight plan, is the ability to quickly stop and reposition the drone to obtain a better view of the target in the screen.

Image 8. Pigs in the cane from ~100m above ground level (AGL).

Image 8 shows a barely perceptible signature of a pig in a cane field. Note though that there needs to be some small gaps in the canopy or a heat signature will not be detected at all.

The heat signature of a large pig in a small gap in the sugar cane was detected from about 60m AGL. Images 9 and 10 were taken from 40m AGL. Image 9 also shows the heat signatures of at least seven pigs, partly obscured by the sugarcane foliage. This sugar cane field experiences more than average pig damage so the expectation of finding heat signatures was high.

In image 9, the background (minimum) temperature had been increased to 30 degrees to reduce some of the noise seen in the other images. The heat signatures are more pronounced but are harder to identify unless pigs are already known to be in the vicinity. Video of these pigs showed ten other pigs moving through the sugarcane, although only seven other pigs can be identified from this distance.

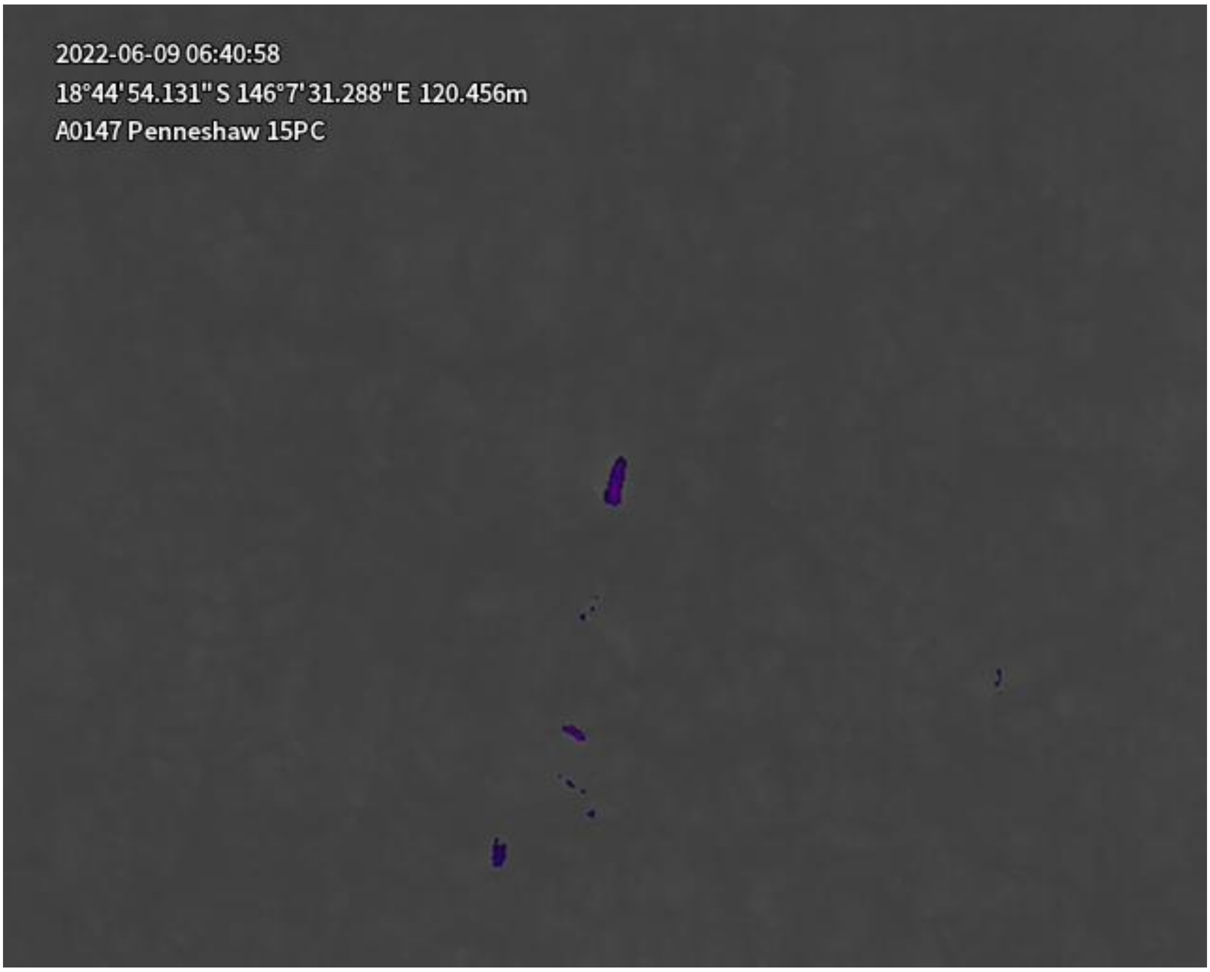


Image 9. Heat signature of a pig in a small gap in the sugar cane from ~40m AGL.


Image 10. The same pig in the small gap in the sugar cane shown in image 9.

Image 11. This image shows the outlines of several objects in grey scale because they are below the minimum value of the colour ramp range.

The temperature range settings for the thermal camera help to distinguish a heat source from the background. The H20T has ten colour ramps used to display heat signatures. The Pilot app allows the user to set a minimum and maximum value range to use the colour ramp's range to effect. Temperatures outside of the set range show in grey.

In image 11 several trees can be made out along with some cattle and cow trails. Foliage and non-foliage artifacts show up due to their slight temperature difference. Of the four cattle in the image, only one, the largest (in the blue circle), gives any positive signature to the thermal camera. From a distance the heat signature is being diffused by the area of pixel size related to the distance from the camera (further away, the larger the area covered by each pixel).

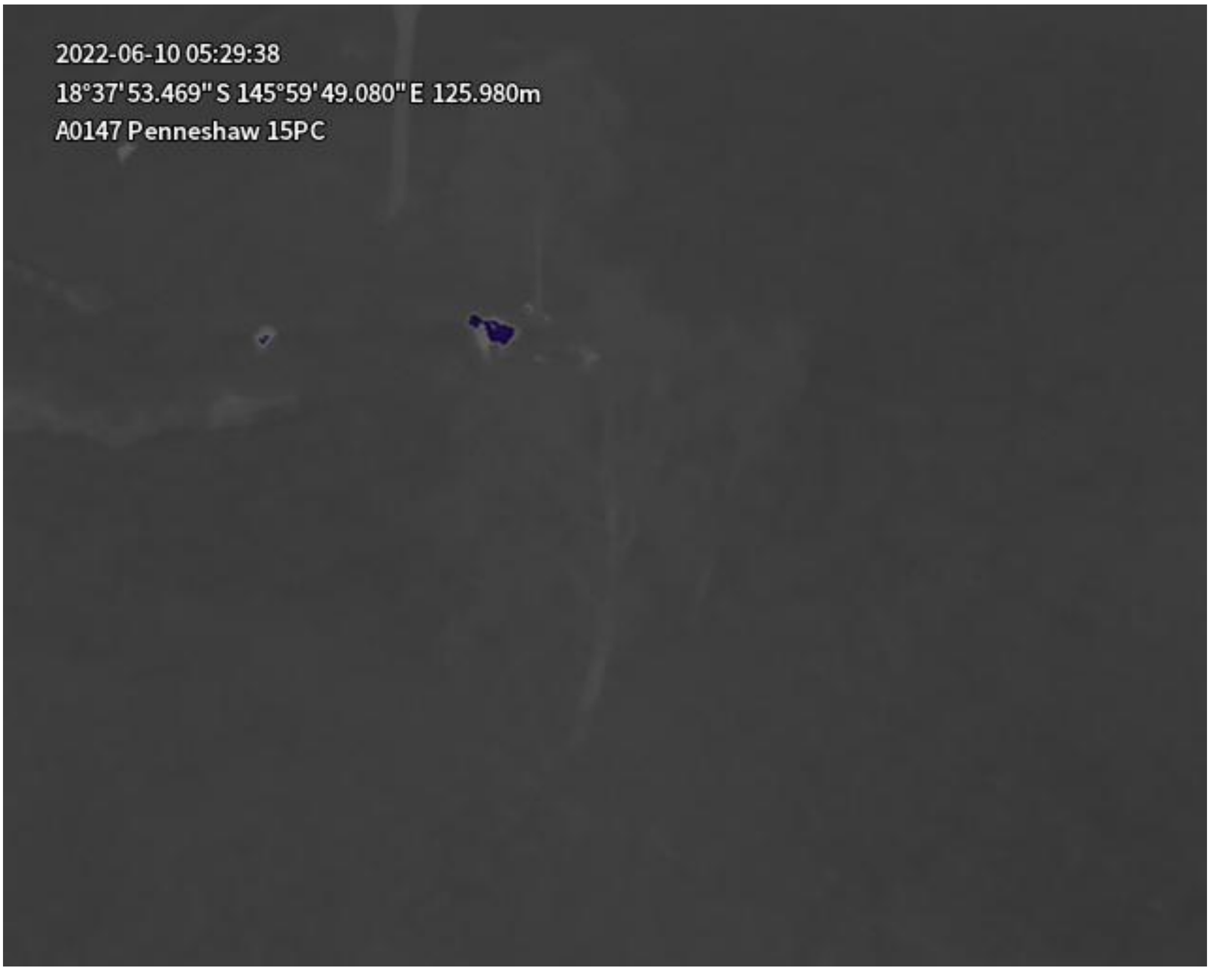


Image 12. A closer image showing several cows including one larger cow.

Image 12 shows the heat signature of the larger cow from a closer distance (the distance was not too close as to not stress the cattle). Understanding that these are cattle is more from knowing that it is a cattle property than just interpreting the imagery.

This demonstrates the issue of lower pixel resolution and the ability to accurately determine what is being seen in the image, at distance. Without an understanding of the landscape, mistakes in identification are possible. The combination of the low pixel resolution and that the animal is somewhat obscured behind the tree, exacerbates the issue of misidentification.

When identification is unsure, the ability to fly closer, or as close as needs be, i.e. to reposition the drone and camera is required to have a higher probability of correct identification.

Image 13. Shows the heat signatures of cattle in the open and under a shed.

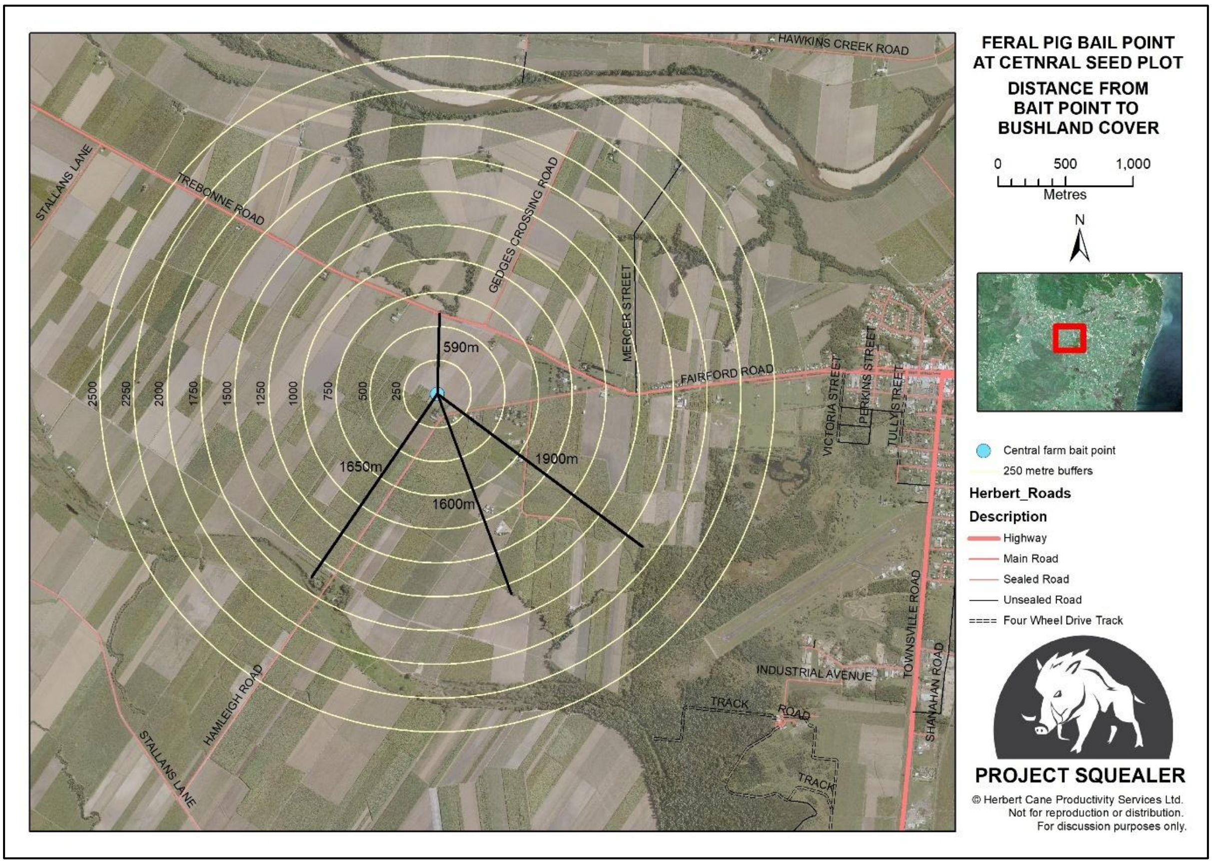
Image 13 has a group of cattle around a shed showing as a large blob near the top of the image. Again, from a distance and making out shapes is difficult. Some of the heat signatures closer to the drone, although still at a distance, can be interpreted as cattle.

Conclusions of the study

The use of drone equipment fitted with thermal imagery cameras to undertake a feral pig population assessment in large densely vegetated areas proved to be unviable or cost effective. Free flying the drone proved to be quite valuable due to the pilot's ability to reposition the drone once a heat signature had been discovered, to make a better interpretation of what was producing the heat signature.

During 2024, a small mob of pigs began frequenting one of HCPSL's clean seed plots. Map 2 (below) has a blue point where pre-feed baits were placed in an attempt to poison the mob, and four lines radiate out from the point showing distanced to forested cover. GPS tracking showed that feral sows in the Herbert region had a home range of about 5km^2. That means the mob was possibly within a 1.25 km radius of the blue dot on the map. It is known that for several months they spent time in the sugarcane blocks within 750m to the east of the blue dot.

An attempt was made to hire a drone with a thermal camera again, but the weather at the time was not conducing to flights. The ability to have flown a drone around this area at night would have provided good information for discussion with growers regarding feral pig habits, and management options. GPS tracking would have also provided a lot of information. GPS tracking would have been preferable at the time, but traps were not available at that time for the effort.



Map 2 showing 250m buffer rings from a point in HCPSL's central seed plot where pre-feed baits were set.

No further assessments using drone technology and thermal imagery cameras to determine population numbers before and after aerial shoots will be undertaken. The use drones and thermal imagery camera technology to locate and determine feral pig activity and numbers in smaller sugarcane blocks during the sugarcane harvest season would benefit baiting and trapping activities, ensuring sufficient baits are set, and that traps are big enough for the number of feral pigs present.

DJI's Mavic 3T would be a useful acquisition to the HCFPMP's or to a farmer's toolkit for feral pig management. Night flying however come with the requirement for licensed pilots and remote operator's certificates (ReOCs). Anyone wanting to fly at night needs to have this reason written into their Procedures Library and their Operations Manual.

Appendix 1

Image 12. Pigs in the cane from ~110m.

Image 13. Pigs in the cane from ~100m.

Image 14. Pigs in the cane from ~80m.

Image 15. Pigs in the cane from ~55m.

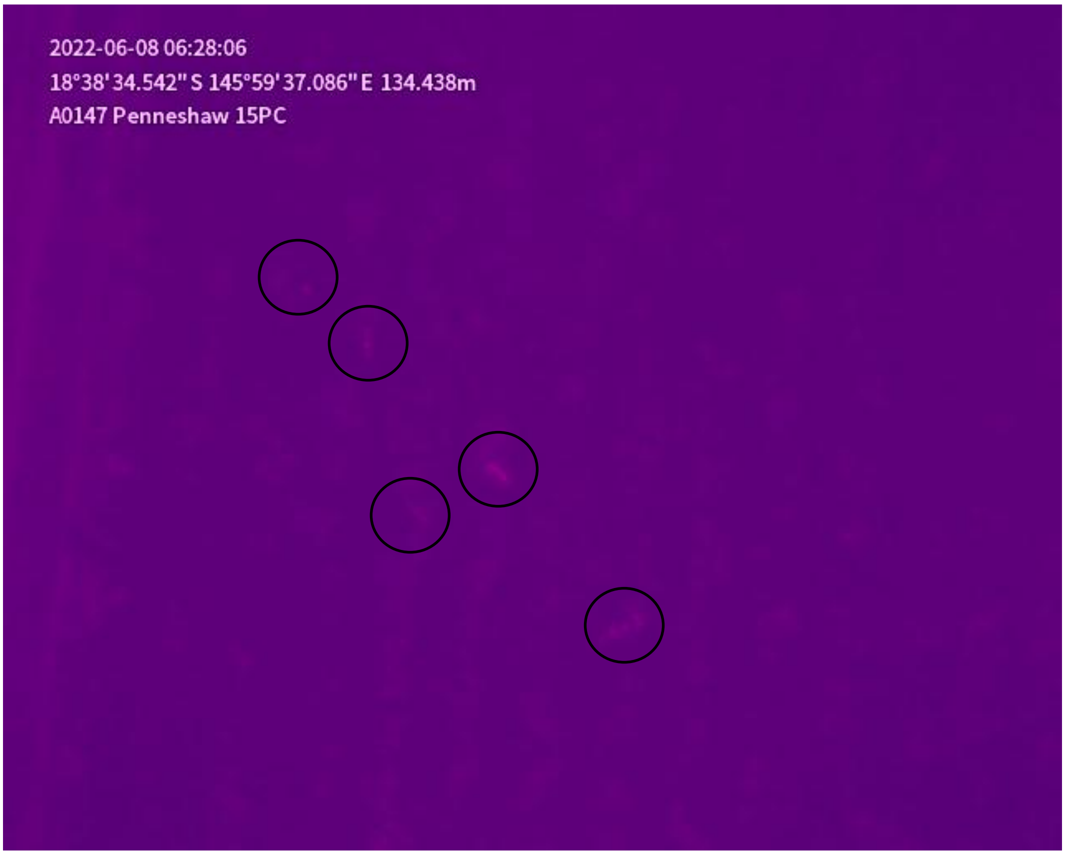


Image 16. Pigs in the cane from ~40m.

Image 17. Pigs in the cane from ~30m.

Image 18. Pigs in the cane from ~20m.

Image 19. Pigs in the cane from ~20m.