



Project Squealer

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

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Summary

Feral pigs cause significant agricultural and environmental damage across the Herbert district in North Queensland. In 2009, annual sugarcane losses exceeded \$1 million, prompting formation of the Hinchinbrook Community Feral Pig Management Program (HCFMP). From 2022–2025, Project Squealer evaluated emerging technologies to improve pig detection, monitoring, and control — particularly during the wet season when traditional control methods are difficult.

The project assessed thermal drone surveillance, GPS tracking collars (“Judas pigs”), remote trail cameras, and AI-assisted monitoring, with the aim of improving population assessment, targeting control efforts, and increasing cost-effectiveness.

The Herbert region averages 2,160mm in annual rainfall, but the 2024/25 wet season exceeded 5,000mm – 7,000mm across parts of the district. Flooding and waterlogged terrain restricted vehicle access to many of the project sites, limited the delivery of baits to traps and to potential poisoning sites, submerged equipment, and severely limited management efforts across the district for a time.

Wet season conditions provide pigs with several months of minimal disturbance, enabling breeding and dispersal. Dense vegetation and wet season inaccessibility to many wetlands further complicates monitoring and control efforts.

Thermal imaging drones were tested to detect and count pigs.

Findings

- Thermal cameras detect pigs but struggle from high altitude where pigs are beneath dense vegetation such as sugarcane.
- Detection improves in cooler conditions (winter/night).
- Image resolution and canopy cover often fragment heat signatures.
- High altitude increases coverage but reduces identification accuracy.

Conclusion

Thermal drone surveys are not cost-effective for large-scale population counts, but are valuable for:

- targeted surveillance,
- estimating numbers before baiting.

Six pigs were collared to study movement patterns and assist control operations.

Key insights

- Home ranges were smaller than similar studies.
- Food availability and family group size strongly influences movement.
- Pigs may remain localised when resources are abundant.
- GPS accuracy decreased under dense canopy but remained adequate for movement analysis.

Collars successfully demonstrated movement patterns but more units (10–12) would improve data reliability and operational value.

Risks include equipment failure, collar loss, hunting losses, and recovery challenges.

Remote cameras with mobile telemetry and AI species recognition were trialled.

Benefits

- Real-time detection of pig activity
- Monitoring of bait sites and wetlands
- Reduced need for site visits
- Confirmation of group size and behaviour

Limitations

- Flood damage risk in wetlands
- Mobile network and subscription costs (~\$600/year per camera)
- Equipment lifespan ~2–3 years

Integration with drone surveillance and other bait deployment efforts showed promise but is conditional on weather and drone pilot costs and availability.

Management Implications

Project findings suggest effective feral pig management requires:

Improved targeting

- Use GPS collars and cameras to identify activity hotspots.
- Conduct drone surveys in high-risk areas.

Adaptive wet-season strategies

- Focus on accessible refuges and dry-season preparation.
- Improve equipment placement to avoid flood damage.

Technology integration

- Combine cameras, collars, and drones for coordinated control.
- Use targeted drone surveillance to inform bait quantities.

Operational improvements

- Increase number of GPS collars for better data.
- Consider in-house drone capability to improve response time.
- Deploy cameras strategically and elevate for flood protection.

Project Squealer demonstrated that while no single technology provides a complete solution, combining tools can significantly improve feral pig management.

Thermal drones are best suited to targeted detection rather than broad surveys. GPS collars provide valuable insights into pig behaviour and movement, challenging assumptions about range and crop impacts. Remote cameras and AI monitoring offer real-time intelligence but require strategic placement and ongoing investment.

An integrated, data-driven approach will enable more efficient control, better resource allocation, and improved protection of agricultural production and environmental assets in the Wet Tropics.

Introduction

In 2009, data indicated that feral pigs were causing more than \$1 million in sugarcane losses annually across the Herbert region^{1,2}. In response, the Hinchinbrook Community Feral Pig Management Program (HCFPMP) was established that same year to reduce the economic impact of feral pig damage in local sugarcane crops, and to reduce their impact to the broader environment. The original partners included the Hinchinbrook Shire Council, Herbert Cane Productivity Services, Terrain NRM, three Queensland Government departments (DERM, QPWS and FPQ), and two commercial MIS agribusiness and forestry companies (ITC Ltd. and Rewards Group). Over time, and in light of budgetary constraints within some organisations, the core participants have become the Hinchinbrook Shire Council, Herbert Cane Productivity Services, and Queensland Parks and Wildlife Service, with other groups contributing as resources allow.

From March 2022 to April 2025, Herbert Cane Productivity Services (HCPSSL) 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. The long-term goal is to equip the HCFPMP with more effective methods for evaluating feral pig numbers and identifying their locations, while developing cost-effective management solutions that maximise return on investment for participating partners.

Little is known locally about feral pig behaviour during the annual wet season, when traditional monitoring and control methods are hampered by flooding, soft/boggy terrain, and limited accessibility. This project aims to improve management outcomes by generating better data on population dynamics and movement patterns during the year.

Project Squealer 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.

Rainfall

Ingham sits at the southern end of Queensland's northern Wet Tropics, almost 1,000km south-east of the tip of Cape York and approximately 1,200km north-west of Brisbane as the crow flies. Generally speaking, Ingham has two seasons, wet and dry. 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 2015³. Figure 1 shows the seasonal change with the wet season beginning in January, but can begin in December the previous year, going through to

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 HCPSSL grower data collected via HCPSSL's annual "Green Sheet."

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.

April/May, and the dry season going from May/June through to October/November. This seasonal change in rainfall makes access to many coastal areas very difficult and invasive species management challenging.

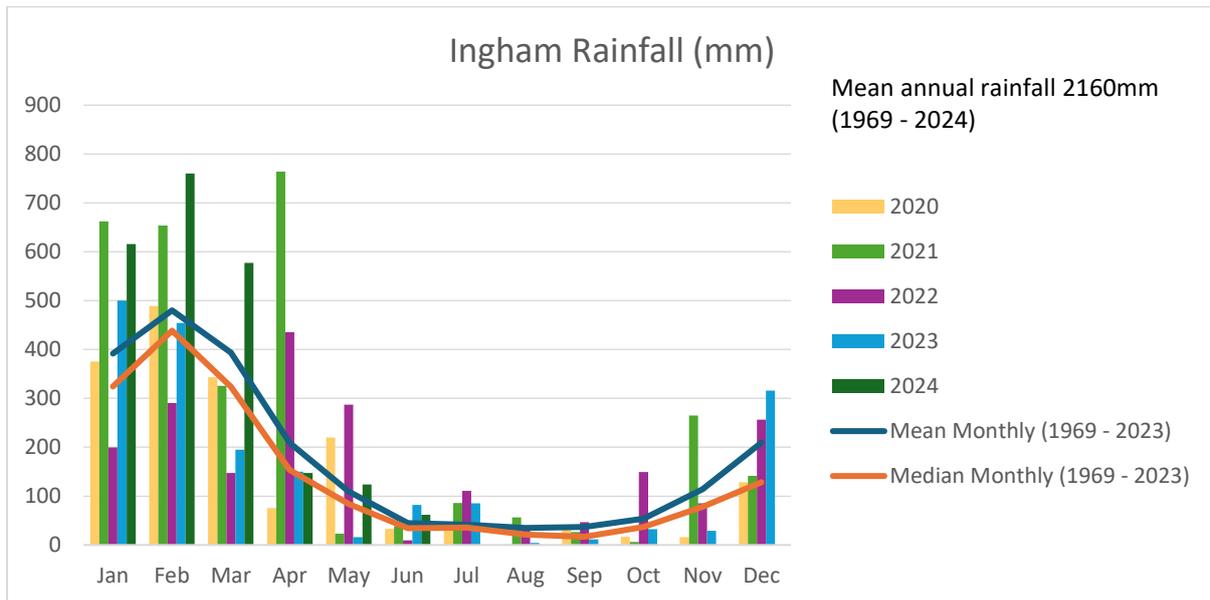


Figure 1. Monthly rainfall between January 2020 and June 2025, showing monthly mean and median. This chart demonstrates the distinction between the wet and dry seasons.

The northern wet season provides feral pigs a five-to-six-month timeframe, or an entire breeding cycle with very little harassment by land managers or hunters, with the exception of one of the two helicopter-based shooting activities, usually November or December, and any impact the local saltwater crocodile population can contribute. Limited access to many coastal wetland areas adversely affects trapping and hunting efforts. Traps become difficult to reach without specialised vehicles such as the amphibious Argo. Vehicle access is important because of the need to transport large amounts of bait to a trap⁴. In the Herbert district, fruit baits of bananas and/or mangos are used and vehicles are needed to carry sufficient fruit to the traps or to baiting sites.

The weather, particularly the 2023/24 and the 2024/25 wet seasons both created difficulties for this project. Both wet seasons were longer and wetter than average. According to the Bureau of Meteorology Ingham's annual rainfall between 1968 and 2025 is 2,160mm. Rainfall data collection from the 2nd of February⁵ to the 14th of February⁶ 2025 was interrupted across most of the Ingham district when the electricity was switched off to prevent damage to the Ingham substation, leaving the majority of weather stations, including the many of the official BoM recording stations showing incomplete data for February 2025.

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

⁵ Ergon de-energises flooded substations in North Queensland. URL: <https://esdnews.com.au/ergon-de-energises-flooded-substations-in-north-queensland>. Accessed: 22nd July 2025.

⁶ Flood lights: Ergon powers community recovery. URL: <https://www.ergon.com.au/network/news/2025/flood-lights-ergon-powers-community-recovery>. Accessed: 22nd July 2025.

Several private weather stations continued to run and did provide some data on the amount of rainfall received across parts of the Ingham District. This data is available on the Wundermaps website: <https://www.wunderground.com/wundermap>.

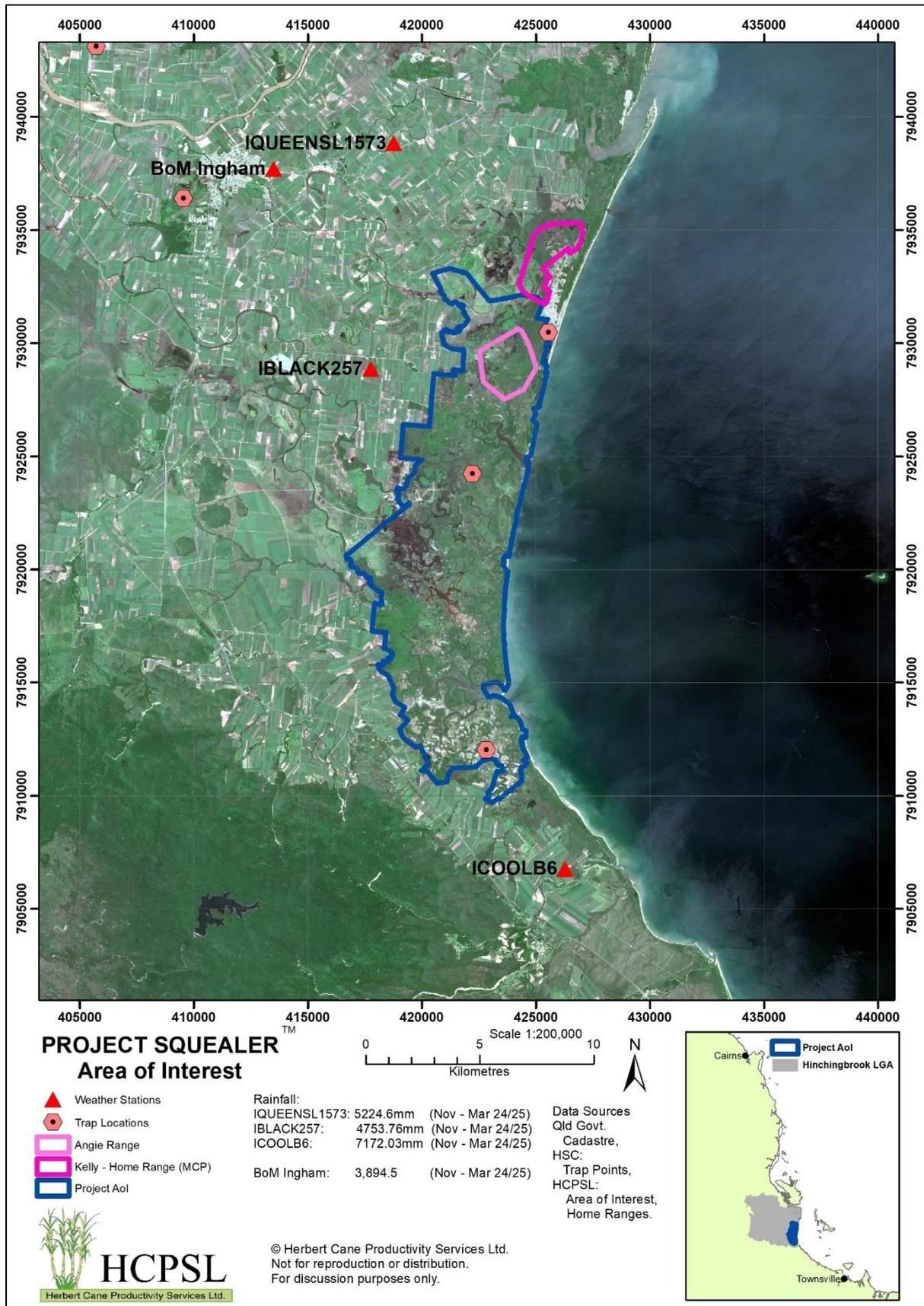
Table 1 below shows the rainfall for the 2023/24 and 2024/25 wet seasons, from November through to the 8th of April the following year and Map 1 shows the locations of the rainfall recording stations with regard to our project activity locations. With an average annual rainfall of 2,160mm both wet seasons exceeded the district average annual rainfall at each recording location by a considerable amount. The 2023/24 wet season was considered big, but 2024/25 broke records.

Recording Station	IQUEENSL1573 -18.64S, 146.23E		IBLACK257 -18.73S, 146.22E		ICOOLB6 -18.93S, 146.30E		Ingham Composite (BoM) -18.65S, 146.18E	
Month	2024/25	2023/24	2024/25	2023/24	2024/25	2023/24	2024/25	2023/24
November	158.4	49.9	202.19		333.62	101.82	158.2	29
December	585.67	212.14	579.85		757.97	215.16	362.2	316.3
January	774.57	837.14	837.6		981.17	594.66	521.2	615.8
February	2217.3	1220.75	1827.88		2865.15	1112.83	2049.4	760.5
March	1448.73	661.41	1251.65		2154.79	834.53	803.5	577.7
April (8 th)	81.03	328.05	54.59		79.33	228.31		123.8
Total	5265.7	3309.39	4753.76		7172.03	3087.31	3894.5	2423.1

Table 1 showing the rainfall figures in millimetres for the 2023/24 and 2024/25 wet seasons, from November through to April the following year. Station IBLACK257 was not in place for the 2023/24 wet season. April 2024/25 figures are up to the 8th of April.

Map 1 on the following page shows the initial area of interest (Aoi) for the project around the Halifax Bay Wetlands National Park along with three private weather stations that continued to record rainfall data through the period of the power outage. Rainfall has been a significant limiting factor for several of the activities in this project. Given the extent of flooding around the district, and in particular around the Halifax Bay Wetlands National Park, secondary sites around the Herbert district were used to complete several of the project activities.

Three of the four trail cameras purchased as part of the project were submerged during the February 2025 floods, and the length of the 2023/4 and 2024/5 wet seasons completely excluded many of our preferred activity sites. Trail cameras and other equipment weren't able to be recovered until August of 2025, and still took the use of an amphibious vehicle to access the camera sites.

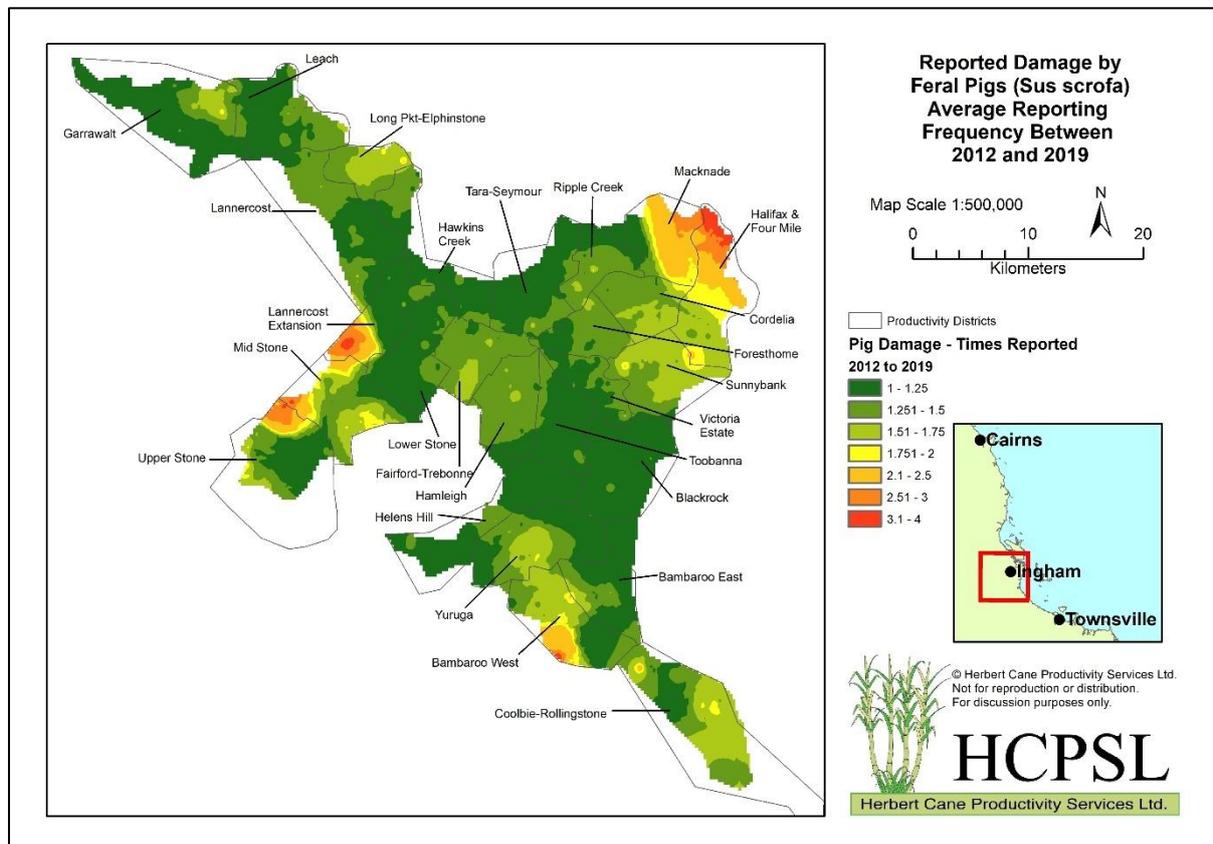


Map 1. Locations of private weather stations which continued to collect data during the Ergon electricity shutdown across the Hinchinbrook Shire Council area.

Hinchinbrook Feral Pigs

HCPSL collects information on sugarcane farming practices each year, to understand practice change, via what is known in the Herbert district as the ‘Greensheet’⁷. The information collected includes sugarcane lost due to pest animals including cane grubs, feral pigs, rats, cockatoos, coots, and wallabies, among others to a lesser extent. Tonnes lost is determined by the cane grower’s visual estimate.

The average annual cost of feral pigs to Australian agriculture is estimated at approximately \$156 million (five years to 2020–21), including both production losses and private management costs (Hafi, 2023). Within the sugar industry, Sugar Research Australia (SRA) estimates annual crop losses of around 20,000 tonnes of sugarcane (SRA, unpublished). This is likely an underestimate, as reported losses in the Herbert region alone have averaged 10,800 tonnes annually over the past four years. A 2002 study by Mitchell and Dorney found that sugarcane and banana farmers in North Queensland underestimated crop damage by an average of 37%⁸, suggesting that sugarcane losses may be significantly more than are being reported.



Map 2. The frequency of reported crop loss due to feral pigs from 2012 to 2019.

Map 2 is showing how often growers report cane loss to pigs, rather than tonnes. The more often damage is reported indicates that the battle against feral pigs is a greater, ongoing issue in some areas than others. The effectiveness of the HCFMP can be seen in figure 2, in the reduction of the

⁷ The Greensheet is an annual survey of sugarcane growers farming practices in the lower Herbert region.

⁸ Mitchell, JL & Dorney, W 2002, *Monitoring systems for feral pigs: monitoring the economic damage to agricultural industries and the population dynamics of feral pigs in the Wet Tropics of Queensland*, Final report, Queensland Department of Natural Resources & Mines and the Bureau of Rural Sciences, Queensland. Page 2.

estimated value of lost sugarcane from 2009 to 2017. The increase in loss post 2017 could be put down to one, or a combination of several possibilities:

1. A potential of reduced effort in feral pig management after several years of low impact.
2. 2018 and 2019 both had higher than average wet seasons which may have led to an increase in the survival in offspring, leading to greater sugarcane loss.
3. Not all damage is caused by feral pigs and the cause may not be immediately apparent.
4. Often damage can extend a considerable distance into the sugarcane field and seeing the whole extent of the damage isn't possible.
5. Damage isn't always just crop damage (although that is the premise of this study), but damage to headlands and infrastructure still incurs a cost in repairs (not considered in this report).

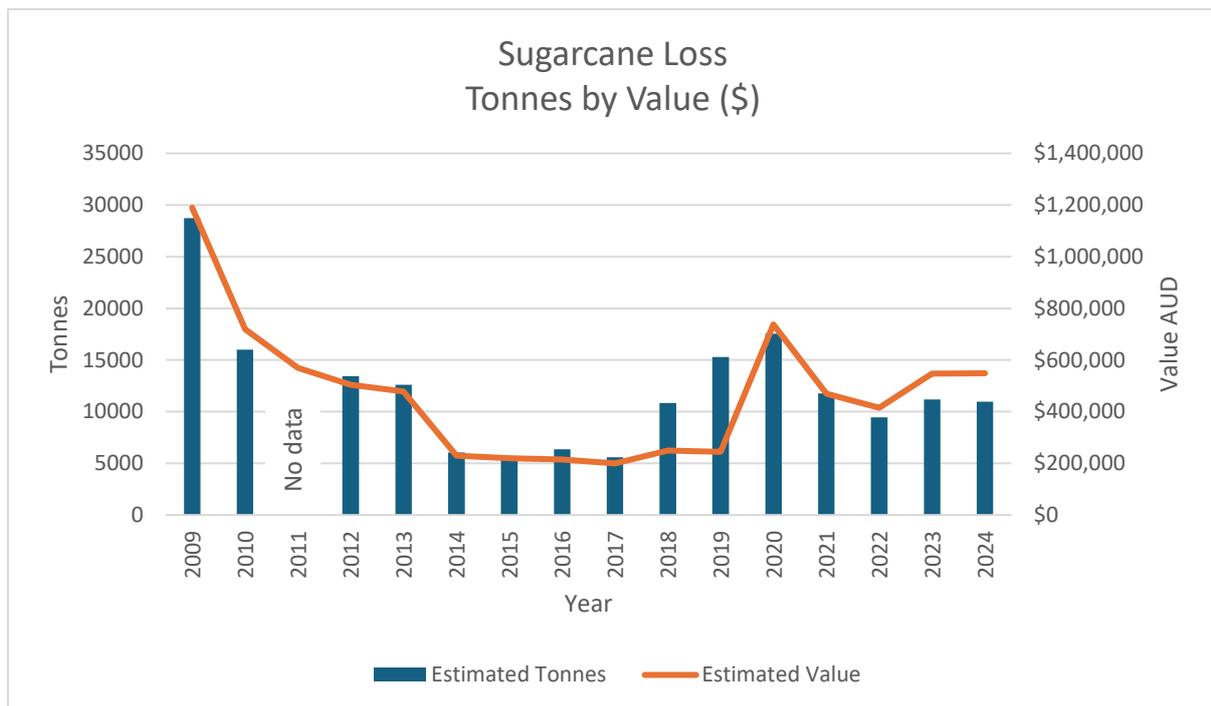


Figure 2. Estimated tonnes of sugarcane lost to feral pigs and estimated value, from 2009 when the Hinchinbrook Community Feral Pig Management Program commenced, until 2024. No data was recorded for 2011 because of tropical cyclone Yasi.

Surveillance Using a Drone-Mounted Thermal Camera

The project undertook an assessment of the effectiveness of DJI Matrice 300 (M300) with Zenmuse H20T (thermal) camera for identifying feral pigs in the bush. Project Squealer was devised to critically assess the use of various technologies in the population assessment and control of feral pigs (*Sus scrofa*).

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 a decreasing kill count indicates a reduction in population, then the numbers indicate no real change in population over the four-year period. Numbers of feral pigs destroyed fall between 52 (November 2022), and 113 (December 2021).

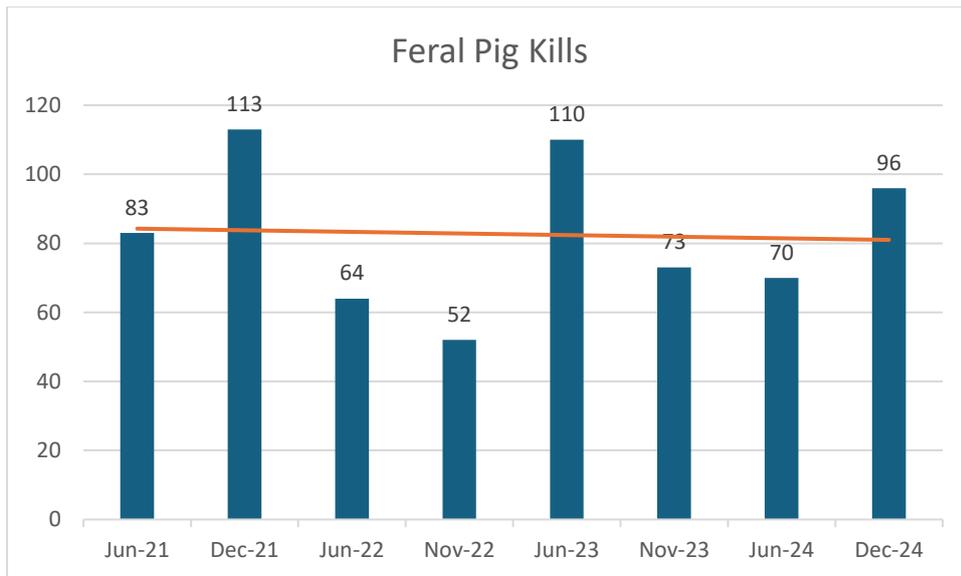


Figure 2. The chart shows a very slight downward trend in feral pigs destroyed over time from the aerial shooting activities, indicating no tangible reduction in the feral pig population.

Assessing Feral Pigs Populations Using Thermal Imagery

It was proposed to evaluate the viability of undertaking a feral pig population count using a drone-mounted thermal camera. The intent was to undertake pig counts before and after one of the aerial shooting activities to assess whether there had been a significant reduction in pig numbers in those areas.

In the Hinchinbrook Shire aerial shooting is currently carried out twice a year, once in winter and once in summer, along the coast in the Halifax Bay Wetlands National Park and in several of the surrounding cattle and sugarcane properties. These operations are conducted by the Hinchinbrook Shire Council in collaboration with QPWS and HCPSL as part of the Hinchinbrook Community Feral Pig Management Program (HCFPMP).



Image 1. DJI Matrice 300 (M300) with Zenmuse H20T (thermal) camera.

A local drone contractor conducted a demonstration of the DJI Matrice 300 RTK drone equipped with a Zenmuse H20T thermal imaging camera in February 2022 (image 2). While the technology successfully detected several pigs and demonstrated its potential, high summer evening temperatures limited its effectiveness early in the evening. The elevated ambient temperatures reduced the thermal contrast between animals and their surroundings, making detection more difficult. Based on this experience, the project team concluded that the method would be better suited to winter deployment, at night and into the early morning when the temperature differential between mammals and the environment is at its greatest.



Image 2. Initial drone with thermal flight – This flight was conducted inside the Halifax Bay Wetlands National Park with HCFPMP stakeholders in attendance. The drone was supplied and piloted by TravEarth Drone Services.

Method

Three areas of interest (Aol’s) were proposed, based on past aerial shooting and trapping efforts by the Hinchinbrook Community Feral Pig Management Program (HCFPMP). Site 1, to the north was 450Ha, site 2, centre, was 490Ha, and site 3, south, was 341Ha, shown in map 3 below.

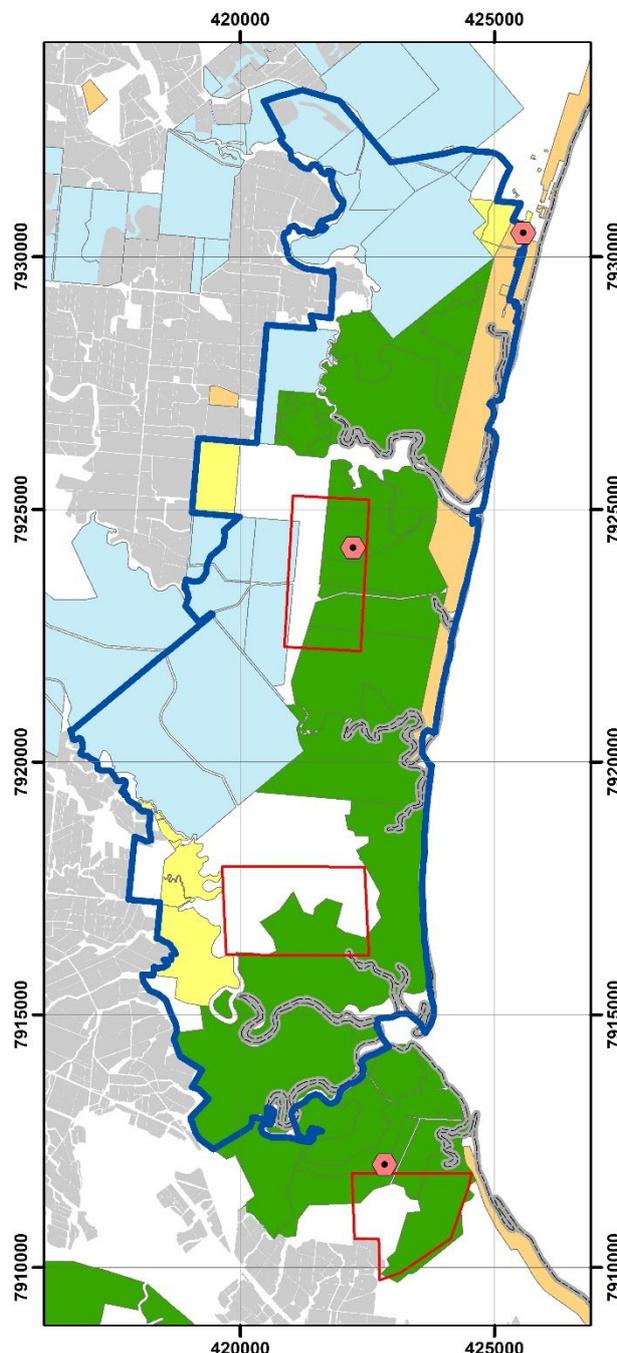
Equipment hired included a DJI Matrice 300 RTK (M300) drone with a Zenmuse H20T camera with thermal imaging capabilities (image 1 above). The image and video resolutions are in the table below.

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 μ m
Laser Range Finder			3 – 1200m

Table 2. Specifications of the H20T thermal camera.

It was proposed that flights be undertaken using gridded flight plans in order to cover the AoI's, moving to new take-off and landing locations as required. Unable to load the DroneDeploy app on the M300 controller, the pilot was required to quickly learn DJI's Pilot app for flight. Flight areas were recreated as .KML files and loaded into the M300 controller.

A pre-survey test flight grid of 1km x 1km (i.e. 100 hectares) was created over a cane farm, where it was possible to fly from the centre of the grid. Before flying however, it became apparent that this methodology would not be suitable for the project. The proposed test flight grid, flying at 120m with 10% image overlap (to allow the greatest ground area to be covered each pass), would require 17 passes, at approx. 3.4m/s (12.24km), would take approximately 1:42:00Hr flying time, requiring at least two battery changes and possibly a third change. The test flight was initiated and timed and was aborted after about five minutes when it was apparent that the flight time estimate from the DJI Pilot app 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.

- Trap_points
- Proposed Survey Area
- Project AoI
- Hinchinbrook LGA
- Cane Blocks 2021
- National Park
- Reserve
- State Forest
- State Land
- Grazing Lands

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 3. Tenure and area of land within the project area.

Site 1, north, was 450Ha,
 Site 2, centre, was 490Ha,
 Site 3, south, was 341Ha.

Map 3 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.

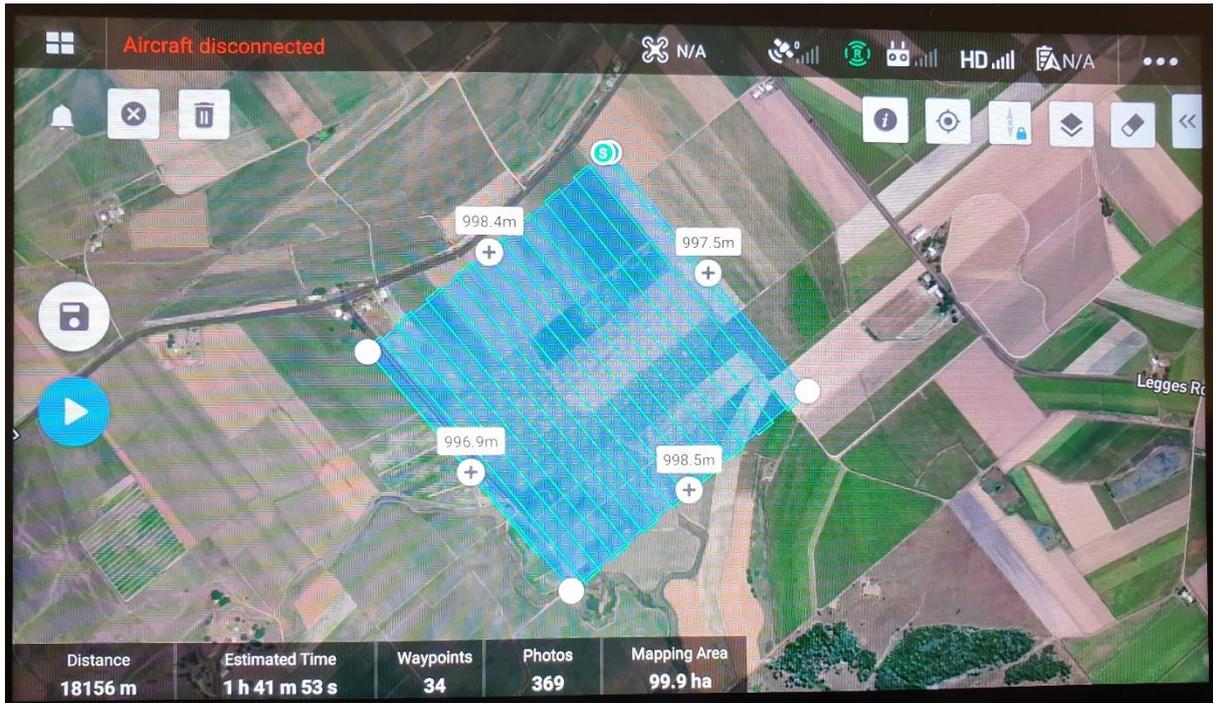


Image 3. The screen of the DJI M300 flight controller with the distance covered and the estimated flight time (bottom left).

On the morning of the 6th of June 2022, the planned flights were commenced in Halifax Bay Wetlands National Park at about 4:00am. A gridded flight plan was used for the first flight. After the first set of M300 batteries was depleted, only about 20% of the flight area had been completed. This confirmed the findings of the test flight plan from the previous evening. After this, 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.

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 and the image footprint became the main limiting factors for the project. 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, it quickly became apparent that too many passes would be required to undertake the survey mission.

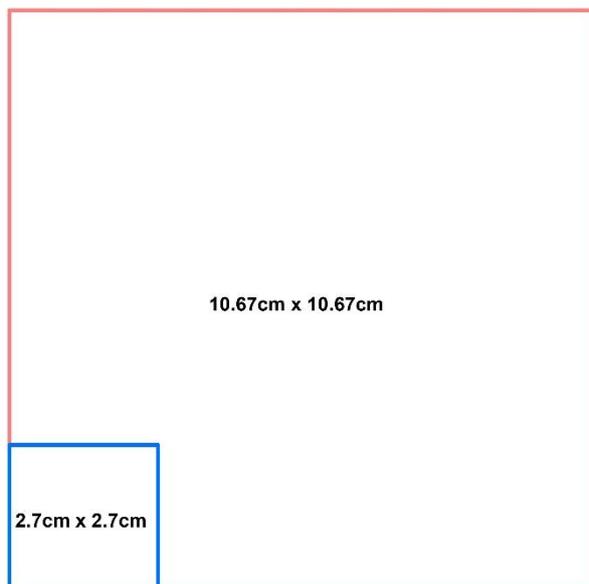


Image 4. A comparison of image pixel sizes. (Not to scale).

Image Resolution

Image 4 shows the size comparison between a 2.7cm image pixel from a 20MP RGB camera and a 10.67cm image pixel from the H20T thermal camera. 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 Footprint

Image 5 shows the difference between camera footprints between a 20MP camera (DJI Mavic 2 Pro) and the thermal camera on the H20T. It became apparent during the initial testing and familiarisation flights of the M300 by the pilot, that this camera system would not be suitable for the original objectives of this aspect of the overall project.

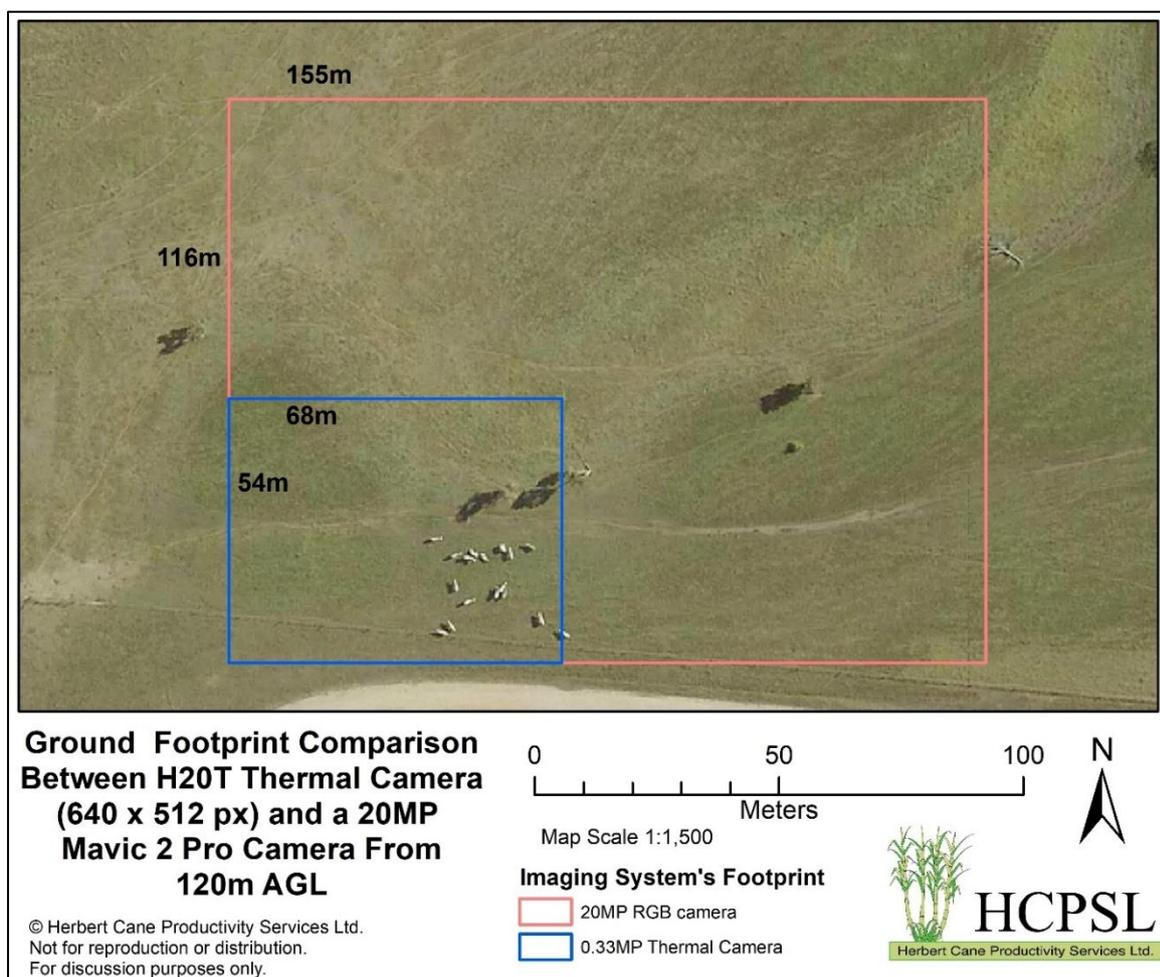


Image 5. Map showing the ground footprints of the H20T thermal camera and a 20MP DJI Mavic 2 Pro camera.

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. A longer flight time also requires more battery changes.

Flight Passes

The test area grids measured 1km² 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.

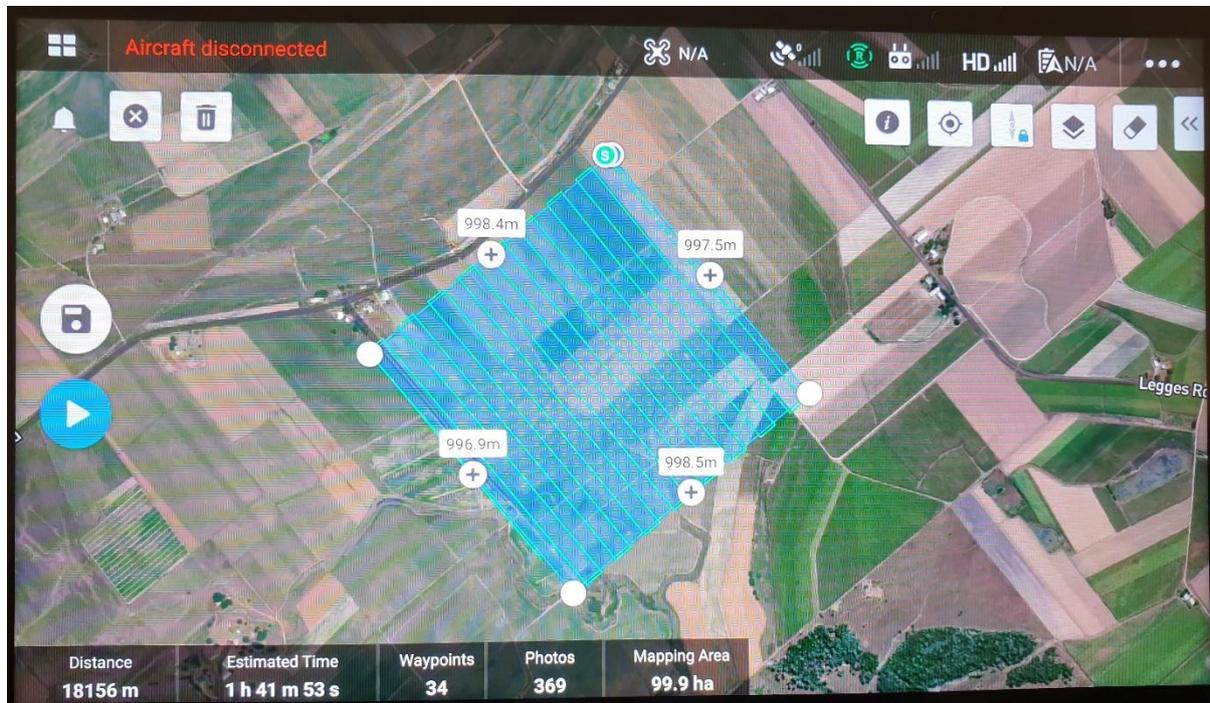


Image 6. The screen of the DJI M300 flight controller with the distance covered and the estimated flight time (bottom left).

The DroneDeploy app 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. (The M300 takes two batteries onboard for each flight).

Results

The methodology of using gridded flight plans was abandoned. Flights were instead undertaken by free flying over areas with a known history of feral pig activity, based on map 2, created from HCPSSL's Greensheet data of recorded sugarcane loss, and from advice from the Hinchinbrook Shire Council's Pest control operator.

Free-Flying and Visual Interpretation of Thermal Imagery

The series of images below illustrate two key challenges in using thermal imagery for feral pig detection:

1. The difficulty of identifying animals from altitude (e.g. 120 m), and
2. The difficulty of detecting pigs beneath a vegetation canopy—such as sugarcane.

Flying at higher altitudes increases ground coverage, enabling more area to be observed and photographed in less time. However, this benefit comes at the cost of reduced image resolution. For example, the Zenmuse H20T thermal camera delivers a ground sampling distance of approximately 10.6 cm per pixel at 120 m altitude. As pixel size increases, fine details are lost, making it harder to positively identify the heat signature, especially when partially obscured by vegetation. The larger the pixel footprint, the more the image becomes a generalised heat signature rather than a distinct shape.

Pigs have a core body temperature typically ranging from 38.7°C to 40°C⁹. While this is information that is critical for aerial surveys using thermal imaging equipment, temperature range data for feral pigs is very difficult to find in the scientific literature. Therefore, data for domestic pigs is used as a proxy.

For this survey, the thermal camera was configured to display a temperature range from 10°C to 48°C. This wider range allows for lower temperature readings to be visible on screen, which helps when flying at altitude where heat signatures become more diffuse and are represented by fewer pixels in the image.

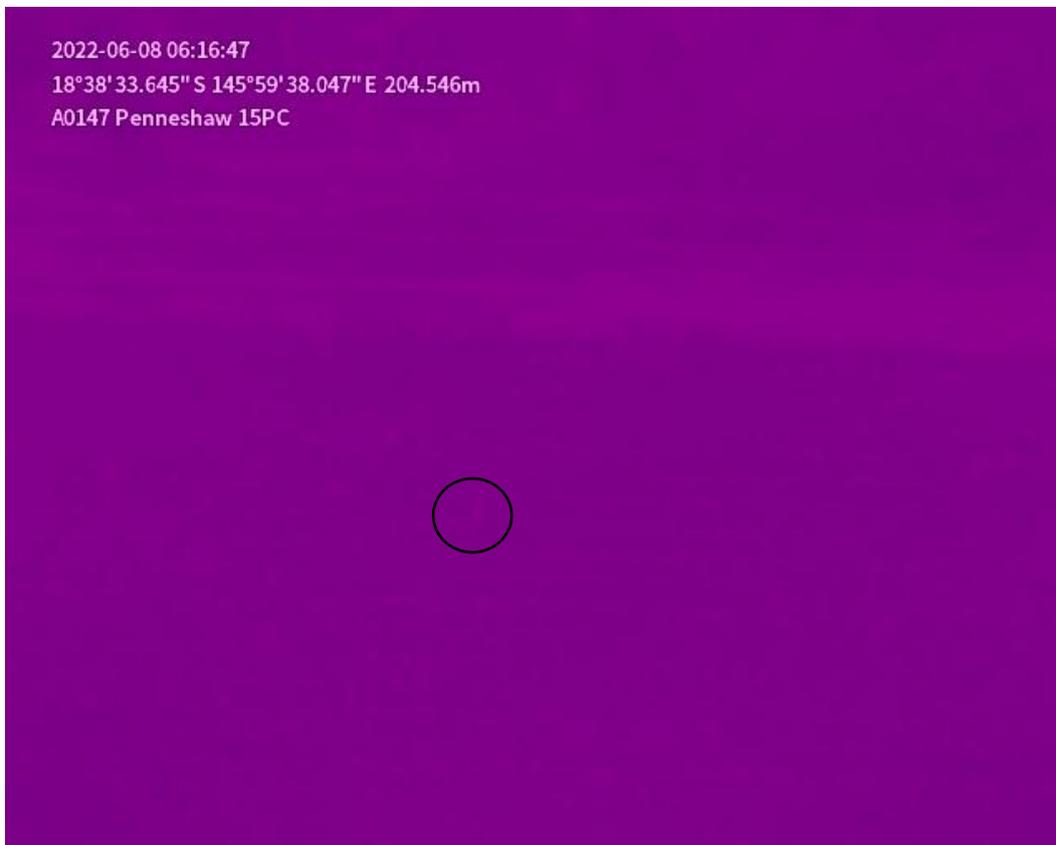


Image 7. Pigs in the cane from ~110m.

Image 7 highlights the difficulty of detecting a feral pig within a sugarcane paddock, partly concealed beneath the crop canopy. In this series of images, the drone initially flew at approximately 60 m above ground level (AGL) until a heat signature was detected. The drone was then flown vertically to 120m. From 120m an image was captured at 10m intervals from 120m AGL down to about 20m AGL.

⁹ 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.

The purpose was to compare the visibility and clarity of the thermal signature at varying altitudes. This test reflects a common challenge in the field: pigs often shelter under dense vegetation, such as sugarcane, which can obscure or fragment their heat signature, making identification more difficult. This is particularly important when counting pigs to establish accurate numbers. At flying heights above about 40 metres, it becomes difficult to determine whether there is one large pig, or several smaller pigs 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.

It should be noted that the thermal camera settings were being adjusted in real time by the drone pilot during the flights. Due to the short duration of aircraft hire, there was limited time for the pilot to become fully familiar with the optimal settings for maximising contrast between heat signatures and background thermal noise.

The Zenmuse H20T camera offers several colour palettes that assist in distinguishing heat signatures from background surfaces. In addition, the camera allows the user to define a temperature window, setting minimum and maximum thresholds, within which the colour ramp is most effective. Temperatures outside this defined range are treated as background, helping to enhance the visibility of target heat signatures such as those emitted by pigs.



Image 8. Pigs in the cane from ~100m.

Image 8 shows a barely perceptible signature of a pig in a cane field from 100m. Note that there needs to be some small gaps in the canopy or a heat signature will not be detected at all.

2022-06-08 06:16:28
18°38'33.637" S 145°59'38.042" E 176.478m
A0147 Penneshaw 15PC

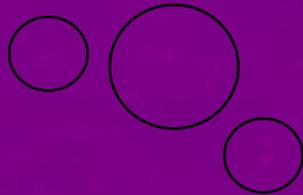


Image 9. Pigs in the cane from ~80m.

2022-06-08 06:16:12
18°38'33.635" S 145°59'38.039" E 149.836m
A0147 Penneshaw 15PC

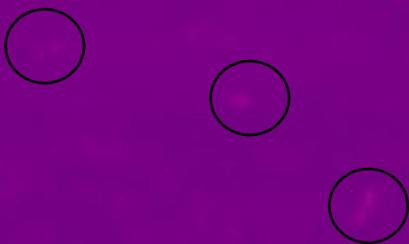


Image 10. Pigs in the cane from ~55m.

2022-06-08 06:28:06
18°38'34.542" S 145°59'37.086" E 134.438m
A0147 Penneshaw 15PC

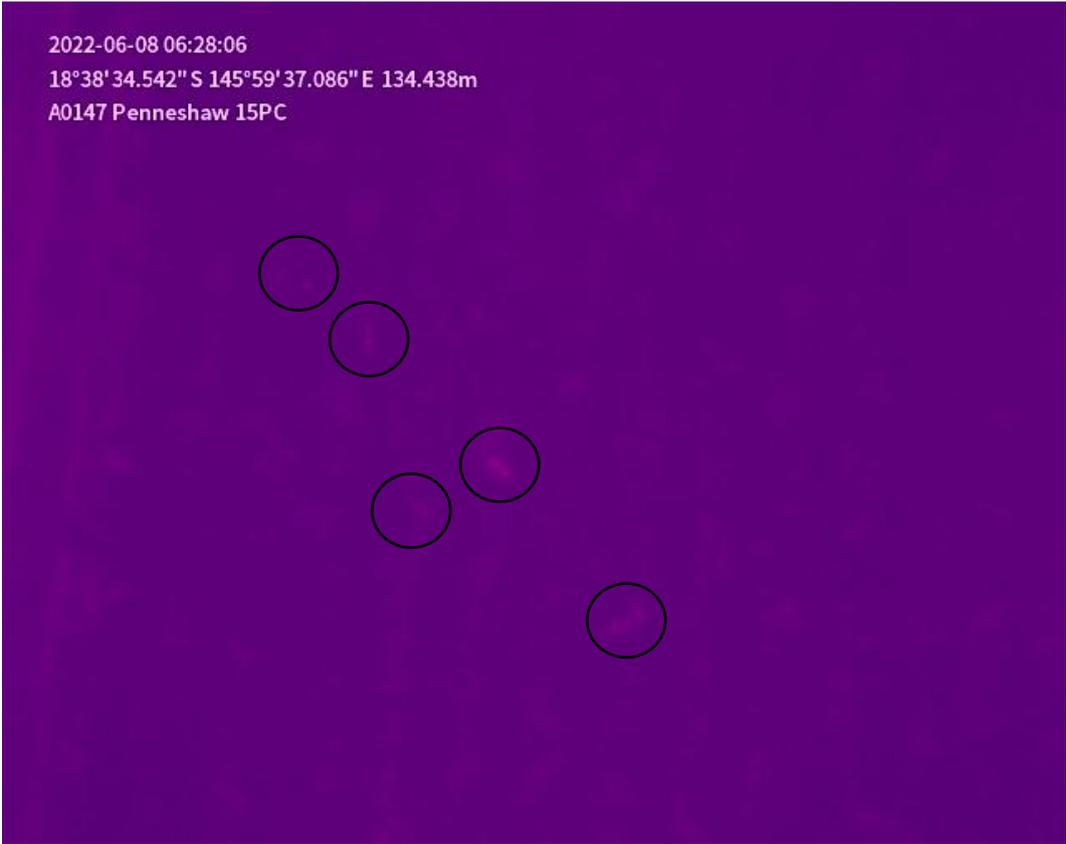


Image 11. Pigs in the cane from ~40m.

2022-06-08 06:27:44
18°38'34.541" S 145°59'37.087" E 124.715m
A0147 Penneshaw 15PC



Image 12. Pigs in the cane from ~30m.



Image 13. Pigs in the cane from ~20m.



Image 14. Pigs in the cane from ~20m. The dashed line shows a possible pig under the canopy.

During flights at night, heat signatures can be identified in the screen of the controller while animals are moving past openings in the vegetation canopy. At this time, the drone can be manoeuvred into a more favourable position to identify the signature. It may be advantageous to take video for animal counts rather than stills for reasons mentioned previously. Still images are still useful and some camera systems will allow still to be captured while the camera is taking video.

Consequently, any attempt to count feral pigs beneath a vegetation canopy should be regarded as an informed estimate rather than an exact figure. While clearings may occasionally allow for accurate counts, such instances are rare in sugarcane paddocks, where dense cover is the norm.

Image 14 below shows the thermal signatures of several cattle among trees and foliage. At this distance, the heat signatures lack sufficient detail for clear visual identification, making it difficult to distinguish the species based solely on the imagery. In this case, recognising the animals as cattle is aided more by prior knowledge of the property and its land use than by the thermal data itself. Familiarity with the area and its livestock is therefore an important factor in interpreting thermal imagery accurately.



Image 15. Heat signature of a pig in a small gap in the sugar cane from ~40m AGL.

Image 15 was captured using a different colour palette, with the minimum temperature threshold raised to 30 °C. As a result, heat signatures appear more distinct and intense—particularly evident is the large pig at the centre of the image. The image also illustrates the effect of the sugarcane canopy

on thermal detection: heat signatures can appear fragmented where sugarcane leaves intersect or obscure parts of the animal's body.



Image 16. The same pig in the small gap in the sugar cane shown in image 15.



Image 17. A closer image showing several cows including one larger cow.

The image above highlights the challenge posed by lower pixel resolution in images taken at higher altitude or greater distance when attempting to accurately identify animals in thermal imagery. Without contextual knowledge of the landscape, the potential for misidentification becomes higher, particularly when heat signatures are partially obscured by vegetation, as is the case here with animals behind tree cover. The combination of coarse resolution and visual obstruction significantly reduces confidence in species identification.

When identification is uncertain, the ability to reposition the drone and camera—flying closer or adjusting the angle as needed—is essential to increase the likelihood of a correct assessment.

Flying in close proximity to animals may or may not cause disturbance, depending on the species and context. In the case of domestic livestock, maintaining a greater distance is generally advisable once they have been identified, to avoid unnecessary stress. During the survey (below), feral pigs sheltering beneath a sugarcane canopy exhibited no signs of agitation or avoidance, even when the drone flew at low altitude - 20 metres, directly above the crop. Similarly, pigs observed in open areas showed little to no reaction to the presence of smaller drones, such as those from the DJI Mavic series. These observations suggest that under certain conditions, drone operations can be conducted at relatively close range without causing significant disturbance to feral pigs.

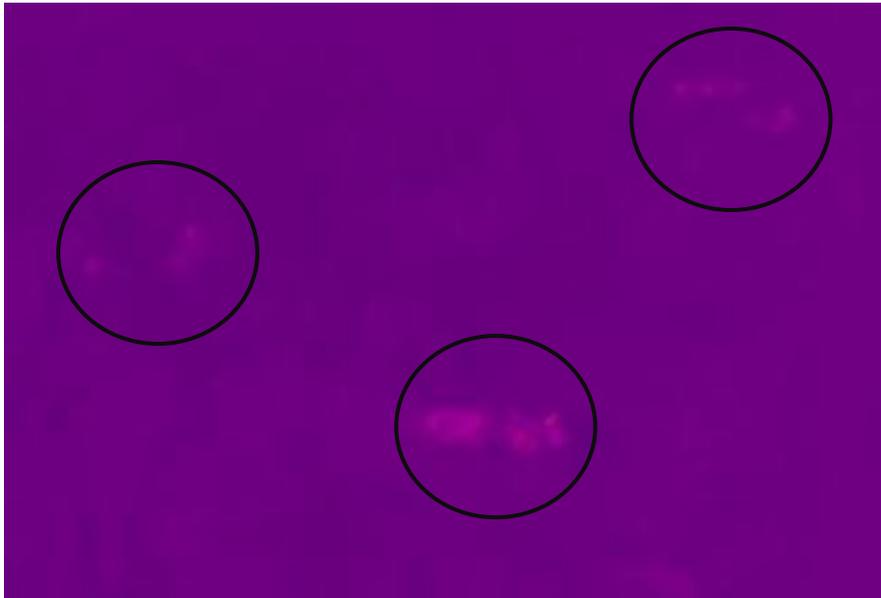


Image 18. Feral pigs in thermal imagery beneath a sugar cane canopy from ~20m at 6:14:59 am.

Image 18 above shows the thermal signatures of feral pigs beneath a sugarcane canopy. The effect of the canopy is evident - areas where the vegetation is denser partially obscure the pigs, resulting in fragmented or weakened heat signatures. Image 19 (below), captured in true colour just eight seconds later, shows the same area. While small gaps in the canopy are visible, the pigs themselves are entirely hidden in the shadows, illustrating the limitations of RGB imagery alone in detecting animals concealed beneath dense vegetation.



Image 19. The same area shown in Image 18, at 6:15:07am.

Conclusions

The use of drone-mounted thermal imaging cameras to blanket survey large, densely vegetated areas, such as large areas of bushlands like in many national parks, was found to be neither viable nor cost-effective for the purpose of assessing feral pig populations. Large areas require the drone to be flown at maximum height (120m) to cover the greatest possible area. This reduces the image pixel resolution which in turn make a positive identification of a heat source more difficult. This combined with the heat signature fragmentation caused by vegetation above the heat source, also increases the difficulty of identification.

Surveying large areas using preprogrammed flight lines, even at maximum flying height requires time and numerous battery changes. The project found that covering a 1km² area would take approximately 1 hour and 40 minutes, not including shifting to new take off and landing locations, and take two to three battery changes to cover the area. Estimated time with moving the take-off and landing locations would be approximately two hours per square kilometre. As a result, this method will not be pursued for future population assessments before and after aerial shooting operations.

However, there is potential to apply drone and thermal imaging technology in smaller areas and more selectively, such as sugarcane blocks, particularly during the harvest season when vegetation cover is reduced. Often growers see indications of feral pig activity around their cane blocks and, in the Herbert, call the Hinchinbrook Shire Council's pest management officer PMO. Part of the PMO's management strategy could include a nighttime flight with a drone with thermal camera, whether the PMO themselves or the use of a contractor, to count pigs present but outside of the view of the trail cameras. This would inform the PMO about how much bait will be needed to kill the entire mob.

The Use of GPS Tracking Collars and Judas Pigs

As part of Project Squealer, three medium-sized LITETRACK IR 750 PB+ GPS tracking collars were purchased from Lotek (Canada) in December 2022. These collars were acquired for the dual purposes of:

1. Collecting data on feral pig home ranges and movement patterns over time, and resource use, if any definite patterns could be identified, and
2. To make the wearers “Judas pigs” to assist with aerial shooting operations.

Included with the collars was a Biotracker 8 radio receiver and a folding Yagi antenna, used to detect the VHF radio signals emitted by the collars for ground-based tracking and retrieval. Each collar is equipped with satellite communication capability via the Iridium satellite constellation, enabling data transmission to Lotek’s servers in Canada. Data collected by the collars can be accessed through the Lotek web portal, where it can be viewed or downloaded for further mapping and analysis.

The total cost of the package, including three collars, Biotracker receiver, antenna, charging equipment, Iridium satellite data plan for twelve months, and international freight—was just under AUD \$16,000.

The collars arrived on the 6th of February 2023 and a Teams meeting with Lotek in Canada was arranged to set up the parameters in the collars. This involved late afternoon in Canada and 2:30am in north Queensland.

The collars were programmed to acquire a GPS coordinate every thirty minutes, i.e. 48 points per day. Data upload via the Iridium satellite network was programmed for four times a day, every six hours. The collars have a pre-programmed, 70 second time interval in which to connect to the GNSS (global navigation satellite system) satellites and acquire a location fix and create a record. Note that that is partially correct. The time between GPS point acquisition has been from 27 minutes to 32 minutes. So either the GPS has made several attempts to acquire a location, or the collar has kept the window open for longer than 70 seconds. A record is created at the beginning of the 70 second period, before the attempt to get a GPS fix.

From time to time a record appears in the data that has no GPS coordinates with it, that is, the GPS wasn’t able to get a fix within the 70 second period, and the process ends, to save battery.

Prior to deployment, collars were tested by attaching them to HCPSL vehicles operating in the field to confirm movement tracking. Stationary tests were then conducted in open areas to assess positional accuracy. According to the Lotek Collar User Manual (Lotek, 2020), horizontal error ranged between 5 and 7 metres. HCPSL field testing showed an average horizontal error of 7 metres in open areas, with outliers up to 28 metres. Under canopy cover, error increased to an average of 13 metres, with maximum deviations up to 69¹⁰ metres (Map 4).

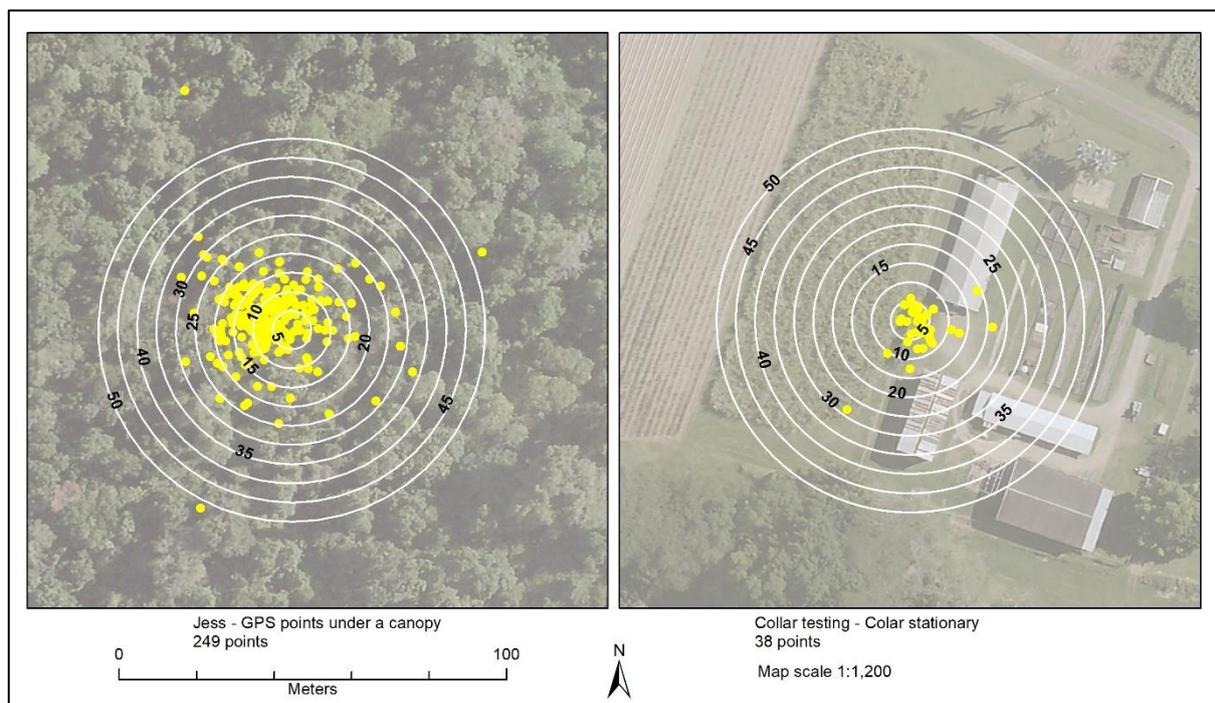
This variation in positional accuracy was considered when interpreting pig movement data. Where GPS points spanned an area with a radius greater than 30 metres, it was assumed the pig remained alive and mobile. Extended periods of apparent inactivity were not necessarily indicative of mortality; for example, one pig was believed to have died after bait consumption but was later

¹⁰ Based on data from a deceased animal (therefore not moving) located beneath a continuous tree canopy, with no visible sky.

confirmed alive through radio tracking. Review of trail camera footage from the bait site confirmed no collared pigs were present at that time¹¹.

The primary area of interest was within the Halifax Bay Wetlands National Park (HBWNP) and the adjacent cattle and sugarcane properties (map 1 & map 7). While this area has proved in the past, by aerial shooting records, to have plenty of feral pigs, trapping them is not always easy. Traps are out of the way and can take some time to get to, even in dry conditions. During the wet season these traps are inaccessible by motorised transport and are very difficult to access on foot.

During the collaring program, one unit was identified as defective after the pig wearing it died unexpectedly and could not be located using the VHF radio tracking beacon. The animal was eventually found near its release point; located by the smell of decomposition, and the collar was recovered, thoroughly cleaned, and returned to Lotek for analysis. Inspection revealed a short circuit in the internal components, which had caused premature battery depletion. The collar was subsequently replaced under warranty.



Map 4. shows the difference in the distribution of stationary GPS collar points from a deceased, collared feral pig located beneath a heavy forest canopy with no visible sky (left), and from initial collar testing when the collar was placed in the open with a clear view of the sky, overnight (right).

Each GPS record included a *dilution of precision* (DoP) value, indicating positional reliability. According to Lotek (2020), DoP values of <1 indicate ideal precision, 1–3 indicate good to moderate quality, and values >3 indicate poor quality (Table 1). Analysis of all collar data showed that more than 40% of recorded points had DoP values exceeding 3 (Table 4).

While reduced precision could be problematic when studying small species with limited home ranges, it was not a major limitation for feral pigs, given their size, mobility, and broad activity areas. The data adequately reflected the animals' general movements and spatial behaviour.

¹¹ Activities of feral pig baiting with fruit are required to be monitored for three days prior to the deployment of poisoned baits, to assess any danger to off-target species. This is often accomplished using trail cameras.

Name	Sex	Days	Total Points	DoP >3	% DoP > 3
Angie	Sow	347	16128	7345	45.54%
Jess	Sow	158	6436	2976	46.24%
Kelly	Sow	366	16825	10255	60.95%
Leroy	Boar	442	20713	10710	51.71%
Sabrina	Sow	76	3431	1392	40.75%

Table 4. Summary of GPS tracking data for five pigs, including duration of collaring, total recorded points, and the number and percentage of low-quality locations (DoP > 3). Note: Sabrina slipped her collar, which was later recovered.

Overall, collar performance was satisfactory in most conditions; however, limitations were noted under dense forest canopy, where GPS signal acquisition is more difficult.

GPS data were downloaded from the Lotek web service twice weekly—on Monday and Thursday mornings. New data for each period were extracted and appended to a master spreadsheet, which included additional fields for later mapping and analysis. Although collars were programmed to record a GPS position every 30 minutes, time intervals between points ranged from 27 to 32 minutes. Gaps in the data were not uncommon.

	A	B	C	D	E	F	G	H	I	J	K	L
1		Device ID	Date & Tir	Date & Time [Local]	Latitude	Longitude	Altitude	Fix Status	DOP	Temp [C]	Main [V]	Back [V]
176	15792	152304	#####	24/06/2024 3:32	-18.693	146.2931	72.07	3-D least-	2.2	26	3.8	0
177					38 hours							
178	15793	152304	#####	26/06/2024 17:30	-18.6841	146.2928	79.05	3-D least-	2.4	26	3.8	0
179	15794	152304	#####	26/06/2024 18:02	-18.6843	146.2927	101.56	3-D least-	3.6	26.5	3.8	0
180	15795	152304	#####	26/06/2024 18:30	-18.6841	146.2928	86.55	3-D least-	2.8	26	3.8	0
181	15796	152304	#####	26/06/2024 19:00	-18.6841	146.2927	70.41	3-D least-	3.4	25	3.8	0
182	15797	152304	#####	26/06/2024 19:30	-18.6841	146.2927	68.58	3-D least-	4	25.5	3.8	0
183	15798	152304	#####	26/06/2024 20:00	-18.6841	146.2927	56.26	3-D least-	3	25	3.8	0
184	15799	152304	#####	26/06/2024 20:30	-18.6841	146.2927	47.21	3-D least-	2.4	25	3.8	0
185	15800	152304	#####	26/06/2024 21:00	-18.684	146.2927	60.41	3-D least-	3.2	25	3.8	0
186	15801	152304	#####	26/06/2024 21:30	-18.6841	146.2927	81.44	3-D least-	2.8	25	3.8	0
187	15802	152304	#####	26/06/2024 22:01				0	17.8	27	3.8	0
188	15803	152304	#####	26/06/2024 22:31				0	17.8	27.5	3.8	0
189	15804	152304	#####	26/06/2024 23:01				0	17.8	28.5	3.8	0
190	15805	152304	#####	26/06/2024 23:31				0	17.8	29	3.8	0
191	15806	152304	#####	27/06/2024 0:01			4 hours	0	17.8	29	3.8	0
192	15807	152304	#####	27/06/2024 0:31				0	17.8	28.5	3.8	0
193	15808	152304	#####	27/06/2024 1:01				0	17.8	28.5	3.8	0
194	15809	152304	#####	27/06/2024 1:31				0	17.8	28.5	3.8	0
195	15810	152304	#####	27/06/2024 2:01	-18.684	146.2928	75.82	3-D least-	8.2	27	3.8	0
196	15811	152304	#####	27/06/2024 2:30	-18.684	146.2927	59.63	3-D least-	5	26	3.8	0
197	15812	152304	#####	27/06/2024 3:00	-18.6837	146.2928	110.17	3-D least-	3.6	25	3.8	0
198	15813	152304	#####	27/06/2024 3:30	-18.6841	146.2928	68.39	3-D least-	4.2	26	3.8	0
199	15814	152304	#####	27/06/2024 4:00	-18.6839	146.2927	91.62	3-D least-	2.6	26	3.8	0
200	15815	152304	#####	27/06/2024 4:30	-18.6842	146.2926	78.44	3-D least-	2.6	25.5	3.8	0
201	15816	152304	#####	27/06/2024 5:00	-18.6841	146.2927	53.26	3-D least-	1.8	26.5	3.8	0

Image 20 – Kelly: missing Data

Two distinct types of missing data were identified: (1) failed GPS fixes and (2) upload gaps (Image 20).

1. Failed GPS Fixes

Points 15802 to 15809 represent a four-hour period during which the collar attempted to acquire GPS locations but failed to obtain satellite fixes. These events are recorded in the dataset, but no coordinates are provided.

2. Upload Gaps

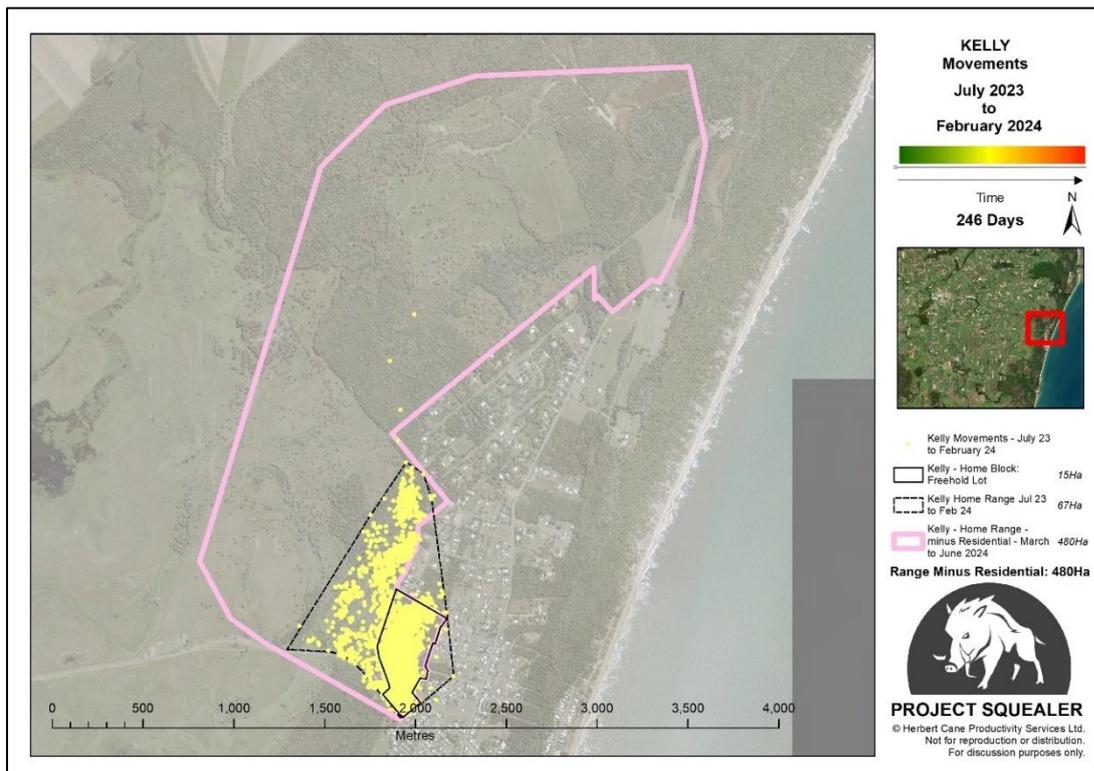
A 38-hour data gap is visible beginning at line 177, covering the period from 3:32 AM on 24 June to 5:30 PM on 26 June. This interruption is likely due to failed uploads via the Iridium satellite network, where the collar lost connection before completing the transmission of stored data.

It has been observed that data missing from a given day's download could sometimes appear in subsequent uploads, on later days. Therefore, it became standard practice to review the previous two months of data during each monthly data check. HCP SL staff began calculating the time intervals between GPS points using a formula in Excel, making anomalies and missing data easier to detect.

Tracking data has been used in presentations and discussions with land managers to demonstrate that some of the generally believed habits of feral pigs are inaccurate. Conventional opinion has long suggested that feral pigs have large home ranges and travel widely, especially when foraging in crop fields. However, data from the collaring program challenges this belief. Analysis has shown that food availability and mob size are more significant predictors of movement range.

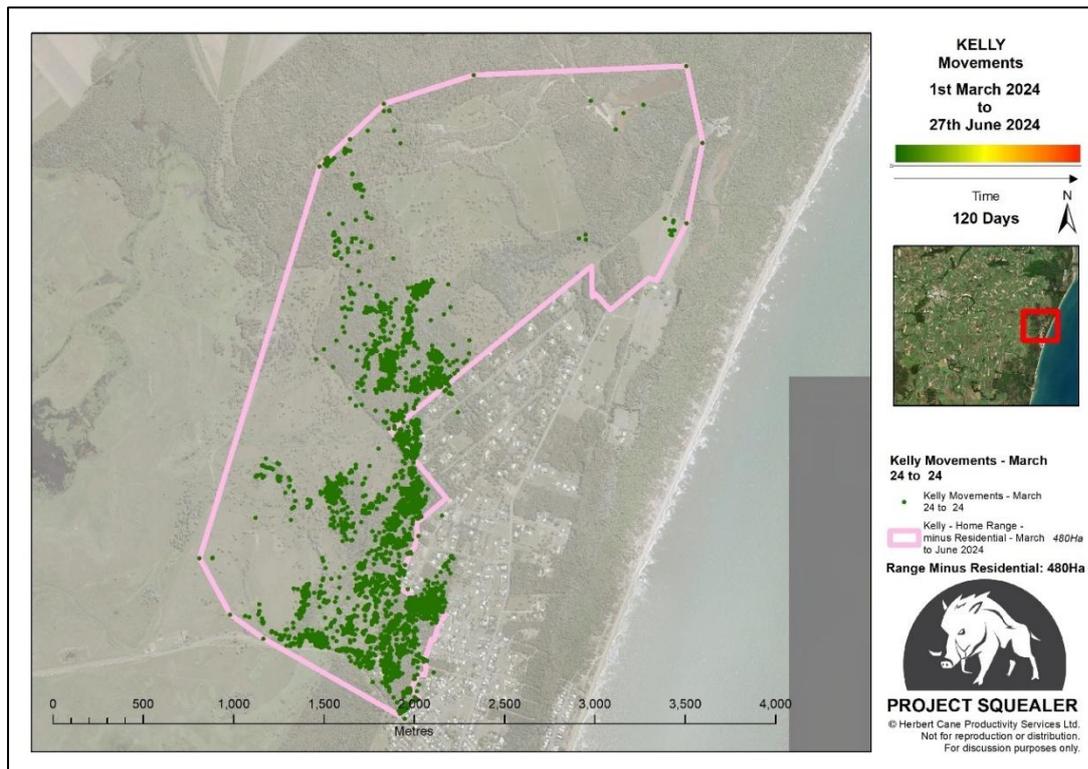
For instance, Kelly spent her first eight months travelling with just one other pig and occupied a home range of approximately 56 hectares. Remarkably, 80% of her activity occurred within just 15 hectares. After giving birth to a litter of seven piglets, her roaming range increased modestly as the piglets matured. GPS tracking later confirmed that she and her group were responsible for disturbances in several residential gardens.

Maps 5 and 6 show the change in Kelly's home range as her piglets began gaining size. Map 5 shows her home range between the time she was collared until the 29th of February 2024, and Map 6 shows her expanded home range from March to June 2024, when she was found deceased. Image 22 (page 31) shows Kelly and some of her litter on the 26th of February 2024, before she started roaming more widely (shown in map 6), it is assumed to access more food sources.



Map 5, Kelly's movements from July 2023 to February 2024.

Among all pigs collared in the region to date, only two have entered sugarcane fields. Even then, they primarily frequented a single field in each of their home ranges, with only brief and infrequent visits to others, despite the abundance of nearby cane fields.



Map 6 Kelly's movements from 1st March 2024 to 27th June 2024.

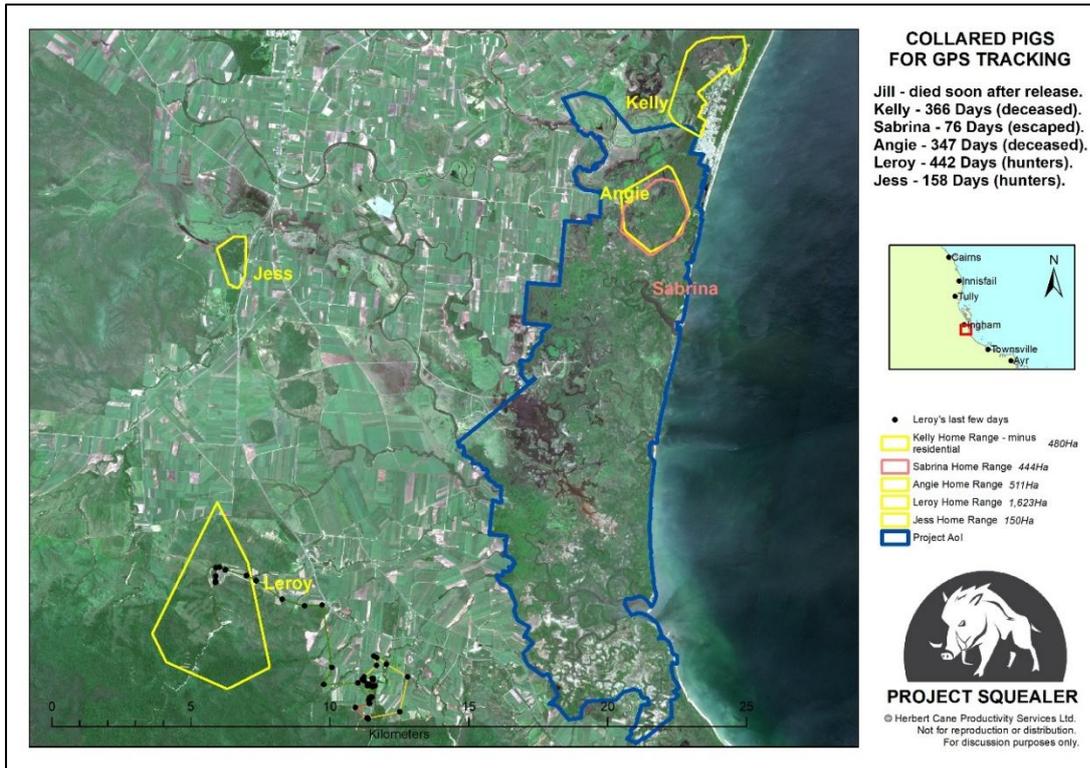
Collared Pigs

Over the course of the project six pigs have been collared: Jill and Sabrina (27th June 2023), Kelly (29th June 2023), Angie (6th October 2023), Leroy (9th March 2024), and Jess (23rd May 2025).

Map 7 shows the home ranges (with areas in hectares), and days collared of each of the pigs in the project. Jess was collared just after the project officially ended, but considering we had all of the equipment, and with an extension to our "Use of Animals for Scientific Purposes" permit, we chose to collar another pig in a location where feral pigs continue to be an ongoing problem. The information gained will help us demonstrate to land managers and other stakeholders, that where food, water and shelter are abundant, that feral pigs can remain very localised, with small home ranges.

The series of black dots identified in the legend as "Leroy's last few days" are from when Leroy, after 440 days within the yellow area, moved to a new area, and was caught by hunters within just a couple of days. It is unknown what made Leroy move on to a new area, but it has been speculated that he may have been chased by dingos, or he may have been looking for sows, and was forced out by other boars.

Female pigs were primarily targeted, as they were assumed more likely to associate with other pigs, including offspring and siblings. Three of the collared pigs produced one litter while monitored. Pigs were captured as part of the Hinchinbrook Shire Council's pest management program.



Map 7 showing collared pig home ranges and days collared.

Jill

Jill was collared at Mungala Station on 27 June 2023, between 2:00 pm and 3:00 pm. She was marked with ear-tag number 2.



Image 21: - Jill – recovering after collaring before she was to be released.

Upon release, an unexpected issue with data transmission was encountered. The GPS collar unit, which transmits location data via the Iridium satellite network, requires an unobstructed view of the sky for accurate GPS acquisition and reliable data upload. Following the absence of transmitted data, three possible causes were considered:

1. Obstruction of the satellite signal by dense vegetation,
2. Detachment or removal of the collar,
3. Mortality, with the animal lying on its side.

Three days post-release, a decision was made to use the radio-tracking equipment to locate the collar. Due to the challenging terrain, an aerial survey using a helicopter was planned, subject to weather conditions. However, before an aerial survey could be conducted, a ground team member returned to the site seven days after collaring. The remains of a collared feral pig were discovered in dense vegetation, near the original release point. An autopsy was not performed.

Initial examination of the collar revealed it was not functioning correctly. It had failed to acquire or transmit any GPS data, and the absence of a radio signal indicated a complete technical failure of the unit.

The collar was returned to the manufacturer, Lotek, in Canada. Upon inspection, it was found that a short circuit in the internal wiring had led to premature battery depletion. The unit was replaced under warranty and redeployed.

Sabrina

Sabrina was captured and collared on the same day as Jill (image 22). Her ear-tag was number 1. Although Sabrina recovered quickly from the collaring process, it is believed she remained stationary or sheltered for approximately 36 hours following release. Consequently, no GPS data was received during this period.



Image 22: - Sabrina with collar and ear tag - recovering before release. One of the collaring team remained behind with her to ensure she recovered sufficiently.

However, thanks to the collar's onboard data storage capability, the actual missing data was limited to only 4.5 hours immediately after collaring. Following this initial delay, data from Sabrina's collar was received consistently, including the infrequent data gaps. Data downloads from Lotek's web service are conducted several times per week, typically in the morning following the scheduled 8:00 AM data upload. Files are retrieved in .CSV format for mapping and analysis.

Sabrina's home range was approximately 450 hectares (4.5 km²). At around 6:00 PM on 9 September, her GPS data showed an abrupt halt in movement. The minimal displacement recorded was within the horizontal error margin established during February's testing. Most data points during this time were clustered within a 25-metre radius. Given prior instances—such as with Kelly—where pigs had shown limited movement temporarily, this initially did not raise concern.

After several days of continued inactivity, on 19 September, the project officer visited the last recorded location with the radio tracking equipment. At approximately 11:30 AM, Sabrina's collar was located on the ground, with no sign of Sabrina, at coordinates 146.267802 E, -18.728016 S. As shown in image 23, the collar was found near several sticks. Based on its position and orientation, it is believed that Sabrina may have slipped the collar off by rubbing against the sticks.

The collar was retrieved, deactivated, cleaned, and returned to the HCPSL office. It was subsequently reused for collaring another pig, named Angie.



Image 23: - Sabrina's collar lying on the ground – with no sign of Sabrina in sight, and no signs of misadventure. She was just gone. Someone with a sense of humour suggested a flesh-eating parasite.

Kelly

Kelly was captured and collared on 29 June 2023 (image 24). She was fitted with ear tag number 3. Kelly was monitored for 366 days, making her the second longest-tracked pig in the program.

Kelly was trapped by a local landholder, not a farmer or part of the feral pig management program, but a resident living on a one-hectare residential lot, beside the lot where Kelly initially spent much of her time. The yard was a typical 'lifestyle' block, with plenty of fruit trees, including cashews, mangos and bananas. The owner maintains three pig traps on this small area and catches 15 to 20 feral pigs each year, sometimes a few more. When made aware that the project was looking for pigs to collar in that area, the lot owner was happy to become involved with the project.

During the first six months post-collaring, Kelly's movements were highly localized. She remained within a 56-hectare area, with approximately 80% of her GPS points located within a single 15-hectare freehold lot adjacent to the lot she was captured in (maps 5 and 6 above). This area includes an abundance of fruit trees; particularly mangos, cashews and figs, which likely contributed to her continued presence in the region.



Image 24: - Kelly - collared and recovering – Kelly was kept in the trap by the landholder overnight and fed and watered until we were sure that the collar was working properly, then she was released.

Interestingly, the owner of the trap described the way that the feral pigs would eat the fruit from the cashew trees. The pigs would pick up the cashew apple and chew on that, while keeping the cashew seed, the part that humans roast and eat, on the outside of their mouths, letting the seed fall away to the ground, due to the toxicity of the cashew's shell and raw nut.



Image 25. Kelly caught on a trail camera travelling with a friend.

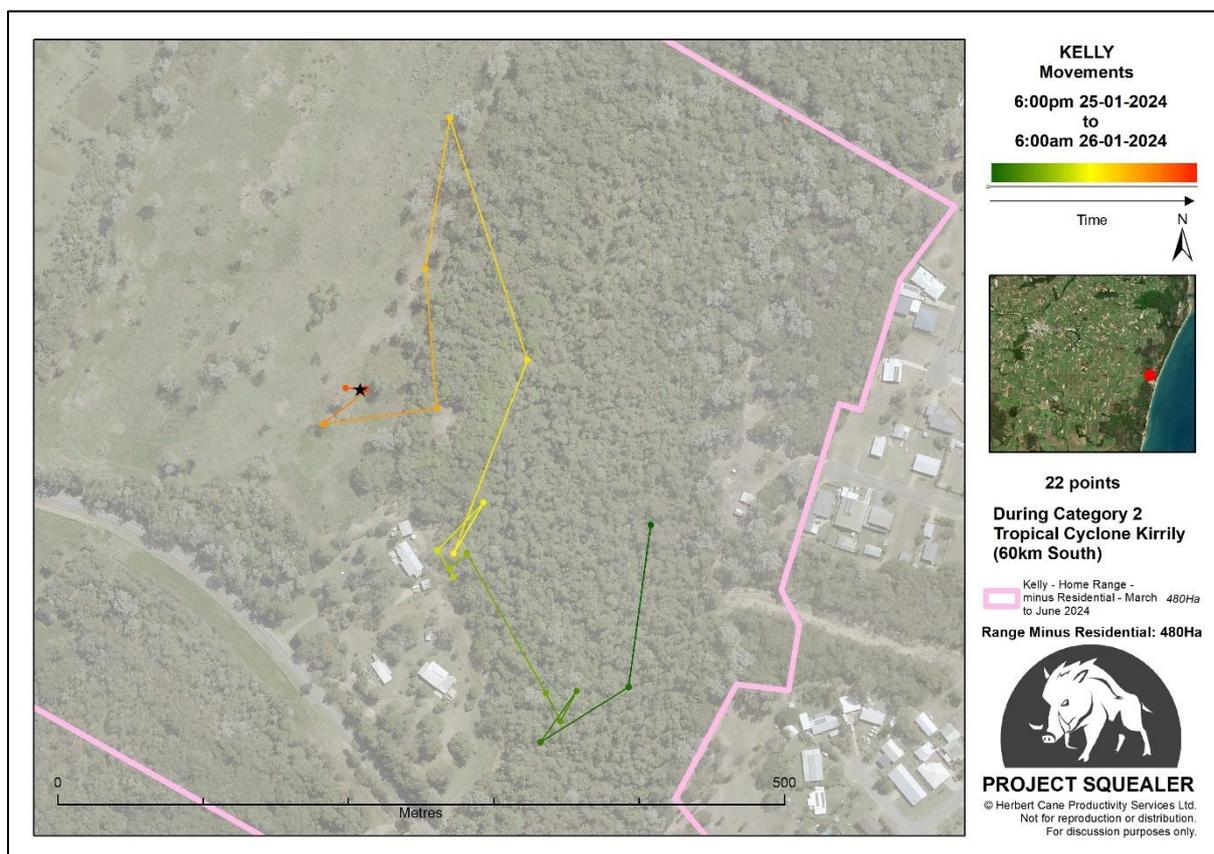


Image 26: - Kelly and some of her litter – at the property where Kelly was first captured. She continued to visit this property due to the food resources there including bananas, mangos and cashews.

Kelly was photographed by a trail camera on the 17th of August 2023. The image shows Kelly with the collar visible, travelling with another pig, on a game trail that goes under a fence into a cattle paddock.

In early 2024, Kelly was observed with a litter of piglets (image 26). On 30 April, one of her offspring was captured in a trap and humanely euthanised. Following the birth of her litter, Kelly’s home range expanded significantly to approximately 279 hectares (calculated using the Minimum Convex Polygon method). This increase is presumed to reflect both the presence of a growing family group and the associated pressure on local resources. This home range later grew to 480 hectares before she was found deceased.

Some interesting data was collected during the landfall of Tropical Cyclone Kirrily (Category 2) on the night of 25 January 2024. As the system crossed the coast north of Townsville, approximately 60 kilometres south of Kelly’s location, her GPS collar logged 22 points between 6:00 PM on 25 January and 6:00 AM on 26 January. These points spanned an area of only 10 hectares (approximately 450 metres north-south by 220 metres east-west), and the fact that she kept moving around the whole time, indicates that the storm had no noticeable impact on her movements within her typical range (map 7).



Map 7, Kelly’s movements in the 12 hours around TC Kirrily.

Beginning in June 2024, Kelly’s GPS activity became restricted to a much smaller area. Initially, this was not a cause for concern, as intermittent data loss had occurred previously—often for durations of six to twelve hours and occasionally up to four days—due to dense vegetation affecting GPS signal acquisition and satellite data transmission.

However, after several consecutive days of limited movement data, project staff sought and received permission from the landowner to investigate further. Upon reaching her last known location, Kelly was found deceased. There were no visible wounds or signs of injury, and the cause of death remains unknown.

Angie

Angie was collared at approximately 10:00 AM on Friday, 6 October 2023, at Mungalla Station, in the same trap used for Jill and Sabrina. She was assigned ear tag number 4. The collaring process went smoothly and relatively quickly, with Angie experiencing the least stress of all the pigs collared so far. Given the warm temperature, Angie was regularly sprayed with water to help keep her cool.

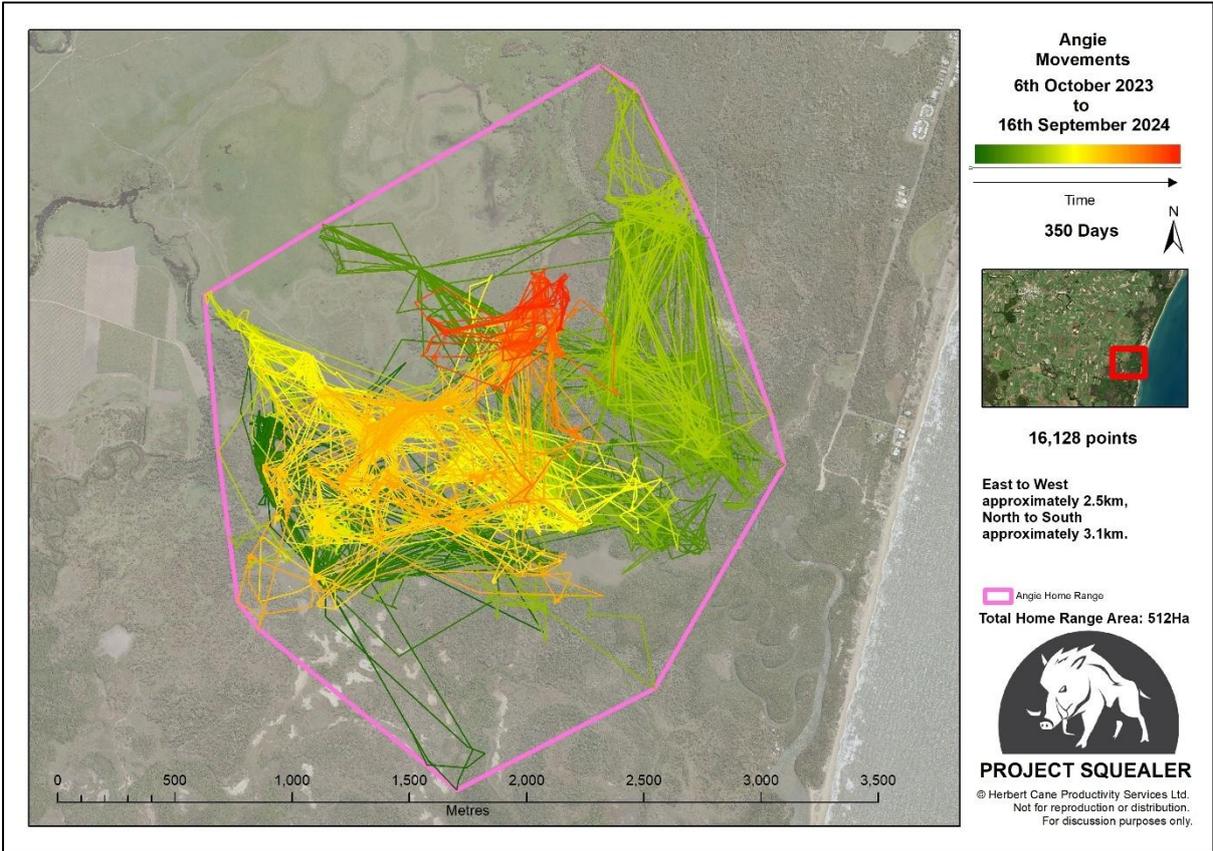


Image 27: - Angie – in the trap at Mungalla Station, before collaring.

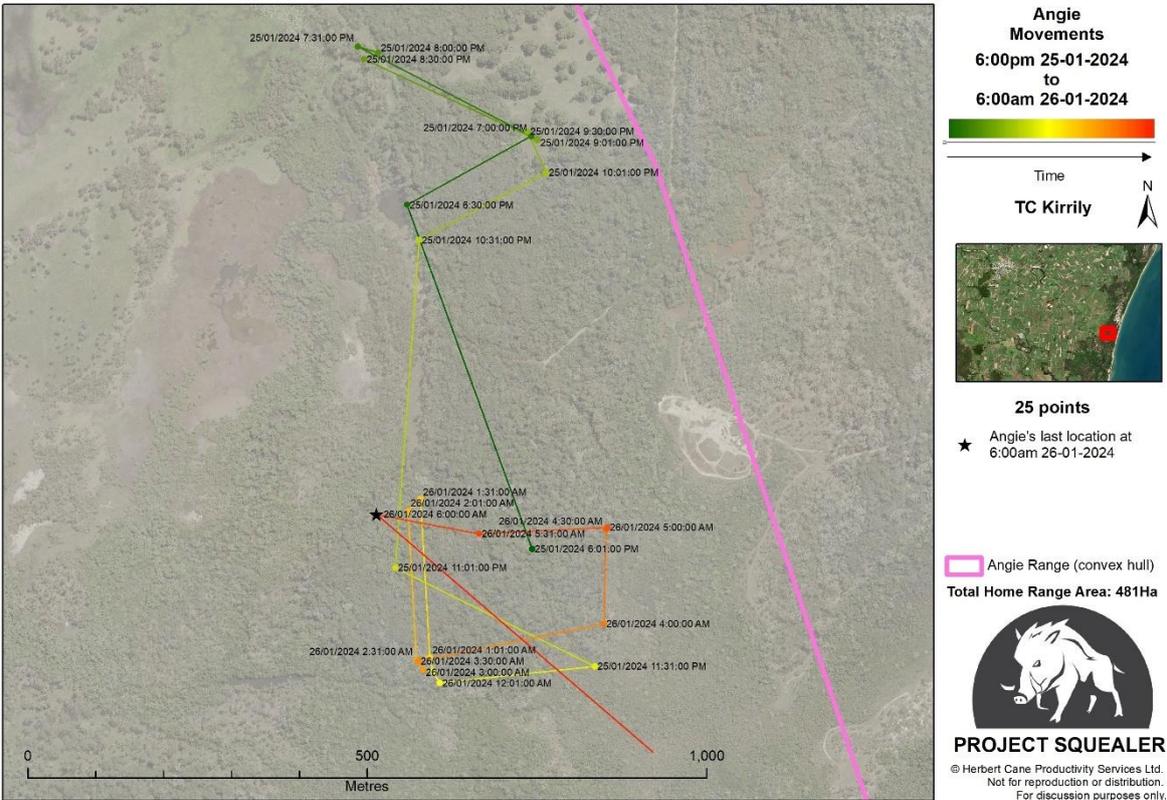
After the collaring, Angie showed positive signs of recovery, attempting to stand but still under the lingering effects of the tranquiliser. One team member remained on-site for an additional 20 minutes to ensure Angie was stable before leaving.

Map 8 illustrates Angie's movements over the 350 days she was tracked. The oldest tracks are shown in dark green progressing through to the latest tracks shown in red. Her total home range spanned 512 hectares (5.12 km²) and is almost identical to Sabrina's range (Map 7, p30), suggesting the possibility that Angie and Sabrina may have travelled together for a period, i.e. possibly being either siblings or at least close family.

Similar to Kelly, Angie also produced a litter of piglets while wearing the collar. These piglets were identified just prior to the June 2024 aerial shoot, during a helicopter flight, when the team attempted to track Angie from the air using radio tracking equipment. Although Angie and her piglets were briefly sighted running through a gap in the vegetation, only a short glimpse was captured. Her identification was confirmed through the radio tracker.



Map 8 showing Angie's movements over 350 days.



Map 9 showing Angie's movements during TC Kirrily.

Angie's movements are shown on Map 9 for a twelve-hour period during the passage of Category 2 Tropical Cyclone Kirrily, which crossed the coast just north of Townsville between approximately 8:00 PM and 12:00 AM on 25–26 January 2024. The map shows 25 GPS points for Angie between 6:00 PM on 25 January and 6:00 AM on 26 January. This data spanned an area of approximately 25 hectares (1 km north-south by 340 m east-west), indicating that the cyclone, some 60 km to the south, did not identifiably affect Angie's movements within her regular home range.

On 16 September 2024, Angie's GPS data revealed that she had become essentially stationary. While brief periods of inactivity (24–48 hours) were not unusual, after 48 hours of limited movement, project staff proceeded to investigate her location.

On 19 September, with permission from Mungalla Station, project staff ventured down a sand dune on the property, reaching a point approximately 1 kilometre from Angie's last known position. They followed a fence line to a location just above the swamp, then crossed the fence and navigated through the swamp. Unfortunately, Angie was found deceased. She had likely been dead for only a couple of days. The collar was recovered, cleaned, and prepared for redeployment.

During the search, a spent shotgun cartridge was discovered within 15 to 20 metres of Angie's location. Although there were no obvious wounds on the upward-facing side of the pig, the cartridge may have been linked to her death. However this is speculative.

Leroy

Leroy was collared between 8:00 AM and 9:00 AM on Saturday, 9 March 2024, at Jourama Falls National Park using the QPWS trap. The collar fitted to him had previously been worn by Sabrina (image 24 below). He was assigned ear tag number 5.

The collaring process was swift and caused minimal stress to Leroy. He was in excellent condition at the time, though he was the smallest pig collared to date. Despite the warmth of the March morning, the trap site remained shaded under the dense rainforest canopy, providing a relatively cool environment. By the time the team departed, Leroy had begun moving about the trap, though still recovering from the procedure. The trap gate was open allowing him to leave.

A check of the Lotek portal after 2:00 PM on Saturday showed no uploaded data, likely due to Leroy remaining beneath the canopy. However, by 7:30 AM Sunday, 43 data points had uploaded, indicating he had moved to an area where the collar could establish contact with the Iridium satellite network.

In early April 2024, Leroy ventured into a neighbouring cane paddock. From that point onward, he regularly returned to the area, often spending extended periods there. Of the four pigs being tracked by this time, Leroy was the only one to enter a sugarcane block. Ironically, his behaviour mirrored the local farmers' beliefs: moving into the cane fields during the night and returning to the national park before sunrise. However, contrary to common assumptions, his movements were not over particularly long distances.

To access the cane, Leroy typically travelled between 350 and 1,500 metres. On one occasion, he crossed over a hill and travelled approximately 2.5 kilometres to reach a separate cane block, but returned to his more familiar territory after one hour, and never went back to that particular sugarcane block.



Image 28: - Leroy – recovering in the trap after being collared. Note, in the background the gate to the trap is open.

Unfortunately, Leroy was shot by hunters on the morning of Saturday, 24 May 2024. He had recently begun venturing well beyond his established home range, and we were hopeful he might settle in a new area. Unfortunately, this exploratory move became his undoing; something we hadn't anticipated, especially given that he had remained around Jourama Falls for more than 14 months.

The collar was recovered by the hunters and returned to the HCPSL office over the weekend. Thankfully, the cleaning process was far easier than retrieving a unit from an animal several days post-mortem.

Leroy may have done well to heed Bilbo's warning to Frodo:

"It's a dangerous business, Frodo, going out your door. You step onto the road, and if you don't keep your feet, there's no knowing where you might be swept off to."

Jess

Jess was collared on Thursday, the 23rd of May 2025, at a cane farm, adjacent to Francis Creek, at about 8:30am. Her ear-tag number is 6 (six). The trap is located at -18.7485594 (S), 146.1344222 (E), on the northern fence-line, roughly 100m west of Francis Creek .



Jess was the first pig captured for collaring in this area and the only one captured on a sugarcane farm. She was accompanied by eight suckers, all of which were euthanised prior to her being tranquilised. The attending veterinarian noted that she was in excellent condition. The morning was cool and dry, and the collaring process was completed quickly to minimise stress. Jess recovered well and was making her way back into the adjacent cane paddock as the team departed.

There has been a lot of interest in monitoring pig movements in this area, due to high pig activity - both from visual sightings and increasing losses of sugarcane in recent years. In June 2023, a drone equipped with a Zenmuse H20T thermal camera was flown over the farm and detected numerous pigs, particularly concentrated at the western end of the farm and none at this eastern end.

Image 29 on the 4th of June 2024, Jess was caught in the same trap again, two weeks after her initial capture.



Image 30 – Jess with at least thirteen other pigs back at the site of the trap.

On 2 June, shortly before 4:00 AM, Jess was captured on a trail camera near the original trap site. Just two days later, on 4 June, she was re-captured in the same trap along with several other pigs (image 29). Jess was released, while the other pigs were euthanised. GPS data showed that she immediately returned to cover in the sugarcane. Again, on 24 June at 11:30 AM, she was recorded on a trail camera (image 30 above) near the trap, this time in the company of at least 13 other pigs.

On the 19th of September, a Friday, a baiting activity was undertaken at Jess's home farm. Jess's locations remained in a confined area inside one of the cane paddocks over the weekend. On Monday the 22nd of September project staff went to the farm expecting to recover the collar from a deceased pig. After setting up the radio tracking equipment and walking into what was a badly lodged field of sugarcane for about 8 to 10 rows (~20m), the sound of something large moving in the cane was heard. The project staff exited the cane paddock as quickly as the lodged cane would allow. A later review of Jess's GPS data showed that, at the time project staff entered the cane paddock, and the next point 30 minutes later, showed that she had moved to the north by approximately 80 metres. A further review of the monitoring photos of the baiting activity failed to provide any evidence of a collared pig consuming any poisoned baits.

On the 24th of October Jess stopped moving and remained in an area of the cattle paddock under the tree canopy. On the 30th of October project staff went out into the scrub to locate Jess using the radio tracking equipment to investigate her lack of movement. When she was found she was deceased. Her last movements were on Friday the 24th and early on Saturday the 25th of October. It is assumed that she succumbed to hunters some time on the morning of Saturday the 25th of October.

The collar was recovered and cleaned and was left out in the sunshine and rain to de-stink. The collar was deactivated on Monday the 3rd of November by taking a laptop to the collar, so the collar wouldn't have to come into the office.

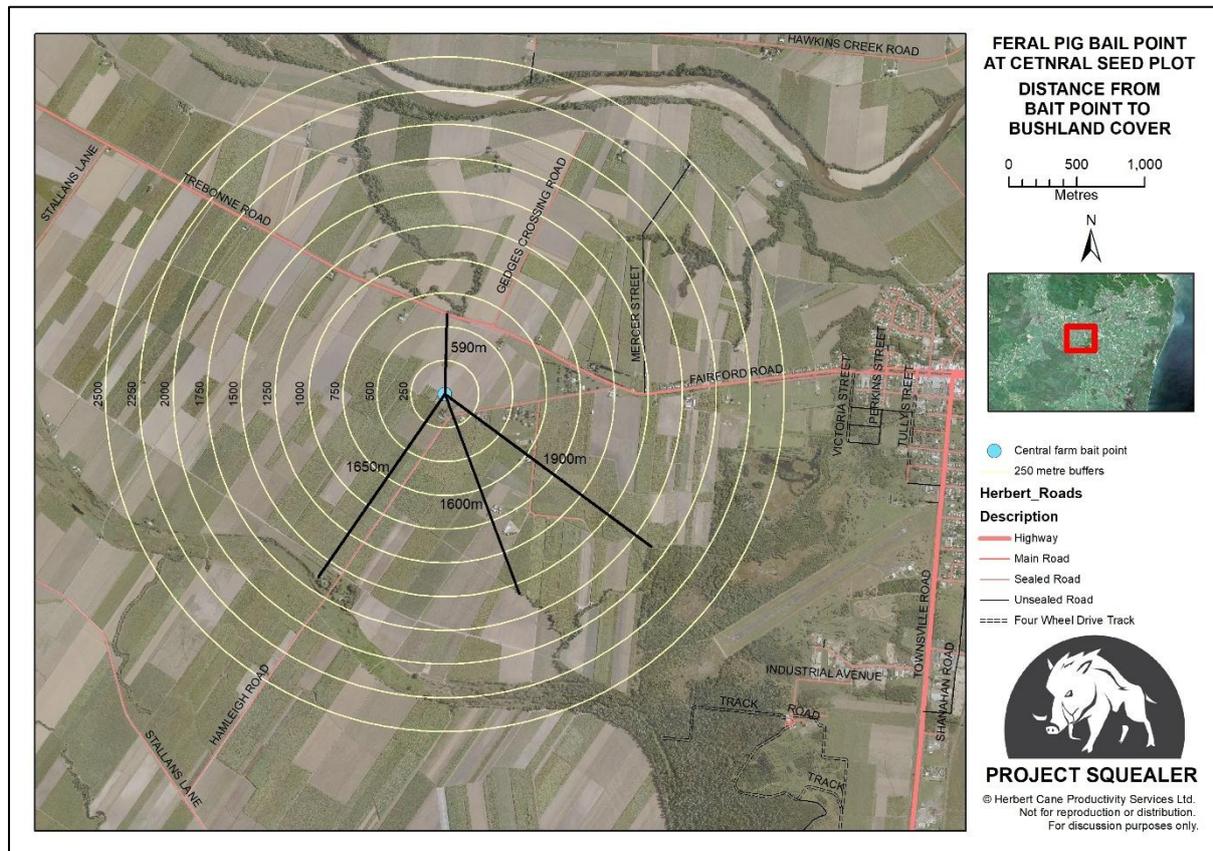
The GPS data showed that Jess spent ~67% of her time in the sugarcane paddocks (~28 hectares), and she had the smallest home range of all the pigs being tracked, at 151 hectares.

Discussion of GPS Tracking of Feral Pigs

It was found that three collars are perhaps too few to get sufficient data that would be helpful and convincing to farmers and land managers. Ten to twelve would have been better. More collars would have allowed the use of Judas pigs to be trialled over a greater area and would have provided the opportunity to study other parts of the district that have feral pig problems. For example, during 2024 at least two mobs of feral pigs began frequenting one of HCPSL's clean seed plots. Drone imagery shows one group of nine adult pigs, while trail camera images show a mob of several adults along with suckers. Map 10 shows 250m buffer rings around the pre-bait deployment site at the seed plot. Four lines denoting distance to the nearest wooded areas are also shown. The shortest distance is ~590m to a culvert underneath Abergowrie Road to a small riparian area around a creek line. The next shortest distance is ~1,600m to the end of a small tributary of Trebonne Creek. Feral pigs have been controlled near the longest distance shown, which is a forested area connecting to the Tyto Wetlands.

To have been able to collar a pig where there is little else but sugarcane would have provided a useful insight into how they move around, and where they go to find water and shelter when they are not adjacent to wooded areas and creeks. If the project had a longer timeframe this would have been

one of the more useful pieces of information for discussions with sugarcane growers all over north Queensland.



Map 10 showing 250m buffer rings from a point in HCPSSL's central seed plot where pre-feed baits were set.

One of the risks of releasing collared pigs back into the wild is losing them to hunters. This may have been the downfall of Angie as when her collar was recovered, a spent shotgun shell was found very close to her body. All of the collars have the phone number of the Hinchinbrook Shire Council on them if hunters or growers kill a collared pig. But there being a collar on the pig may also make people reluctant to admit to killing one, making the recovery effort more difficult as it takes several days to determine that the pig is definitely not moving.

One proposal which was not trialled is the thought that locations of the collared pigs could be given to landholders when they're on privately managed land, and the landholders could hunt the pigs themselves, or let their preferred hunters know where they are likely to be. While studies have shown recreational hunting is one of the most popular forms of feral pig control, it has been found to be one of the least effective forms of management control. Perhaps providing landholders with locations, hunters, approved by the landholders may have greater success. However, this idea is not popular with those who are employed to control feral pigs using the more effective methods, such as aerial shooting, trapping and baiting.

Remote Trail Camera Systems

Four trail cameras were acquired to assist in capturing images of GPS-collared feral pigs and monitoring various field sites, and monitoring wetlands for feral pig activity. Two of the cameras were equipped with external 3G/4G Antenna 6.2dBi antennas and SIM cards, enabling remote data transfer via the mobile phone network. The remaining two cameras were designed for ad hoc monitoring and were deployed flexibly throughout the district.

Images and video can be transferred via email or SMS to a computer or a mobile device in real time, or at periodic intervals for review. An alternative now it is possible to transfer the images to a third-party server such as eVorta, which has AI-based, analytical software to identify any (or at least most) of the species in the image, including feral pigs, birds, livestock, humans, and vehicles. eVorta was used during Project Squealer to assess its utility and cost. eVorta requires a \$20 per month mobile data sim and a \$30 per month subscription for eVorta, for each camera.

Item	Cost	+ Data Plan	+ eVorta
Swift Enduro G4 camera	\$470.00		
32GB SD Card	\$ 14.00		
Solar panel Swift	\$102.00		
AA Jujitsu rechargeable batteries (12 per camera)	\$ 58.80		
3G/4G Antenna 6.2dBi	\$175.00		
Sim card (12 month)		\$20/month	
eVorta subscription (12 month)			\$30/month
Total (initial setup)	\$819.80	\$1,059.80	\$1,419.80
Ongoing		\$240/year	\$360/year

Table 5. Showing the setup and ongoing costs for one remote trail camera setup with ongoing annual costs.

To breakdown the costs per camera for a stand-alone remote camera setup with a mobile data plan and a subscription for an analytical platform such as eVorta includes: a camera, an SD card (memory), a solar panel for ongoing power, twelve rechargeable batteries (required for the functioning of the camera – these run the cameras at night and assist on cloudy days, of which there are a lot during the wet season), an external high power antenna (required for better reception to mobile phone towers, particularly for more remote cameras), mobile data subscription and eVorta (or analytical server). Table 5 (above) shows the cost for a system which will serve as an on-site, remote, baiting site monitoring camera, or for long-term site monitoring. The analytics server is an option, but the rest will cost \$1060.00 (2023 pricing) with ongoing costs of \$240 per year. Note that cameras permanently onsite may only last for two or three years before needing to be replaced.

The two network-enabled cameras were integrated with *eVorta*¹², a web-based platform designed to automatically identify, curate, and provide real-time alerts from camera trap data. Images captured were transmitted to a server in Melbourne, where species were identified using an AI-based recognition process. Access to the platform is secured by user login, ensuring only authorized users can view their respective data. The system also offers the capability to continue to train its algorithms for new species identification.

¹² eVorta. URL: <https://web.evorta.com/>



Image 31 showing a remote trail camera setup with high power antenna and solar panel.

Image 1 shows one of the wetland monitoring cameras. An extra board was used to lift the height of the antenna to the top of the foliage for better connectivity with the mobile network. The solar panel was placed facing north for the best exposure to the sun.

The camera was placed about one metre from the ground for image acquisition. With hindsight, the camera would have been better placed higher up the pole, for better ground coverage and for flood protection. This camera was submerged during the extensive flooding in February 2025. The water levels and ongoing rain was such that the equipment wasn't recoverable until August 2025. The recovery still required the use of the Hinchinbrook Shire Council's amphibious Argo, at a

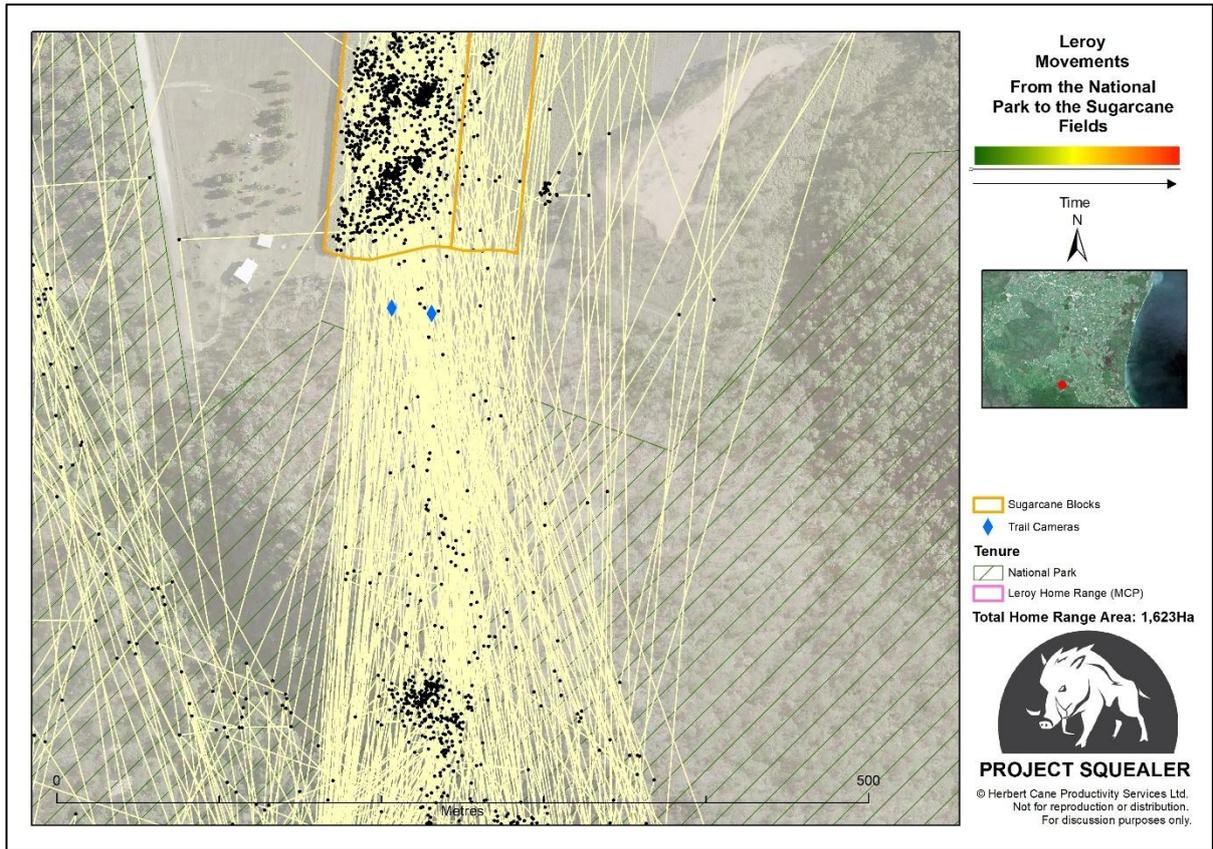
time when, in previous years, access was possible with a four-wheel drive vehicle.

The manually monitored cameras were deployed in areas frequently visited by feral pigs, as indicated by GPS collar data (Map 11). These cameras successfully captured images of the collared pigs, including evidence of breeding activity. The cameras were rotated between various reported hotspots to gather information on population numbers and group sizes. Additionally, they were used to monitor pre-feed and poisoned bait deployments.

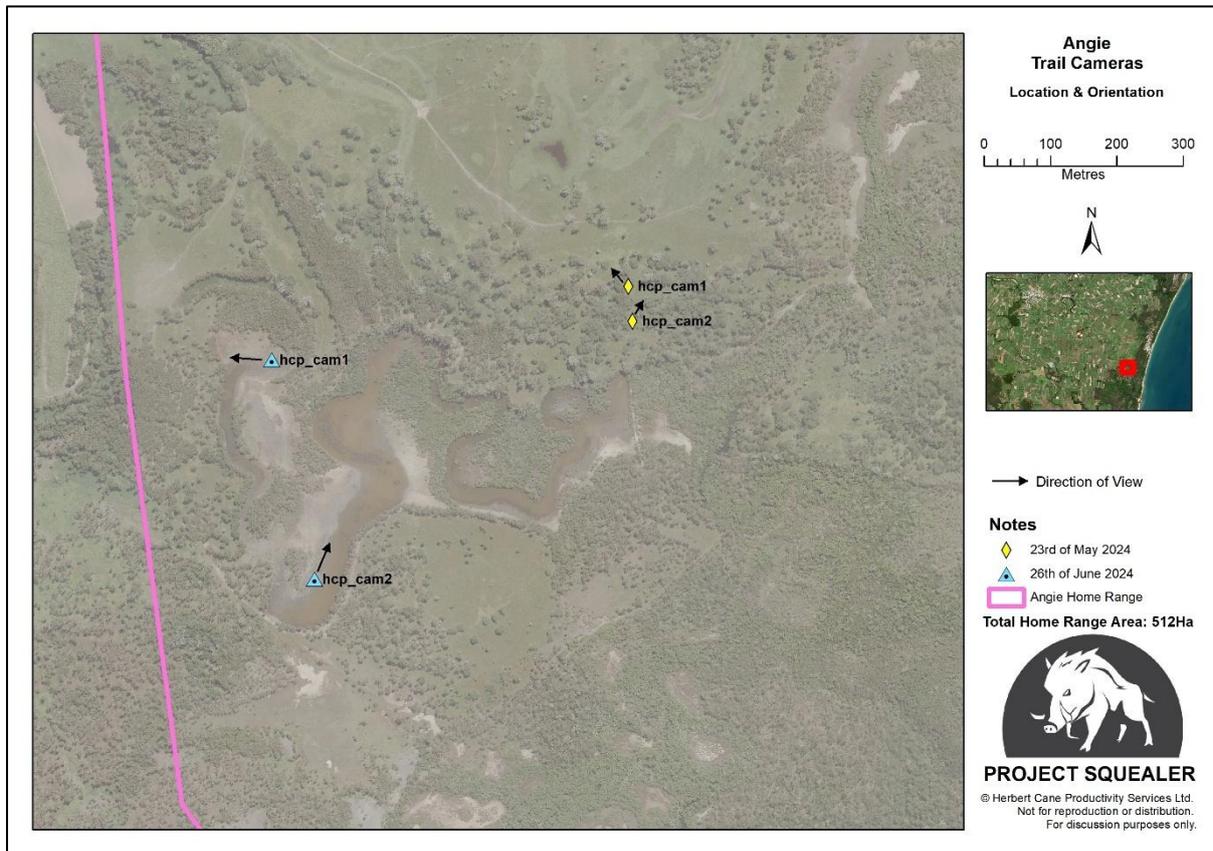
After testing, the mobile network enabled cameras were strategically placed at two wetlands known for feral pig activity. These units were powered by compact solar panels included in the purchase package. Their remote monitoring capability proved especially valuable in these hard-to-access locations, enabling real-time observation without requiring physical site visits. Map 12 shows the locations of these automated camera systems on Mungalla Station.

The original objective for these cameras was to detect the presence of feral pigs in real time. Upon detection, pre-feed baits could be delivered via drone to retain the pigs in the area, followed by the delivery of poisoned baits by vehicle - minimizing repeated vehicular access and reducing environmental impact.

However, wet season conditions affected drone availability. Also, increased demand for aerial operators - due to farmers being unable to access wet fields with tractors - delayed our ability to deploy baits in a timely manner. By the time a pilot was available, the camera footage showed that the pigs had moved away from the monitored area.



Map 11. Showing the placement of trail cameras in high activity areas.



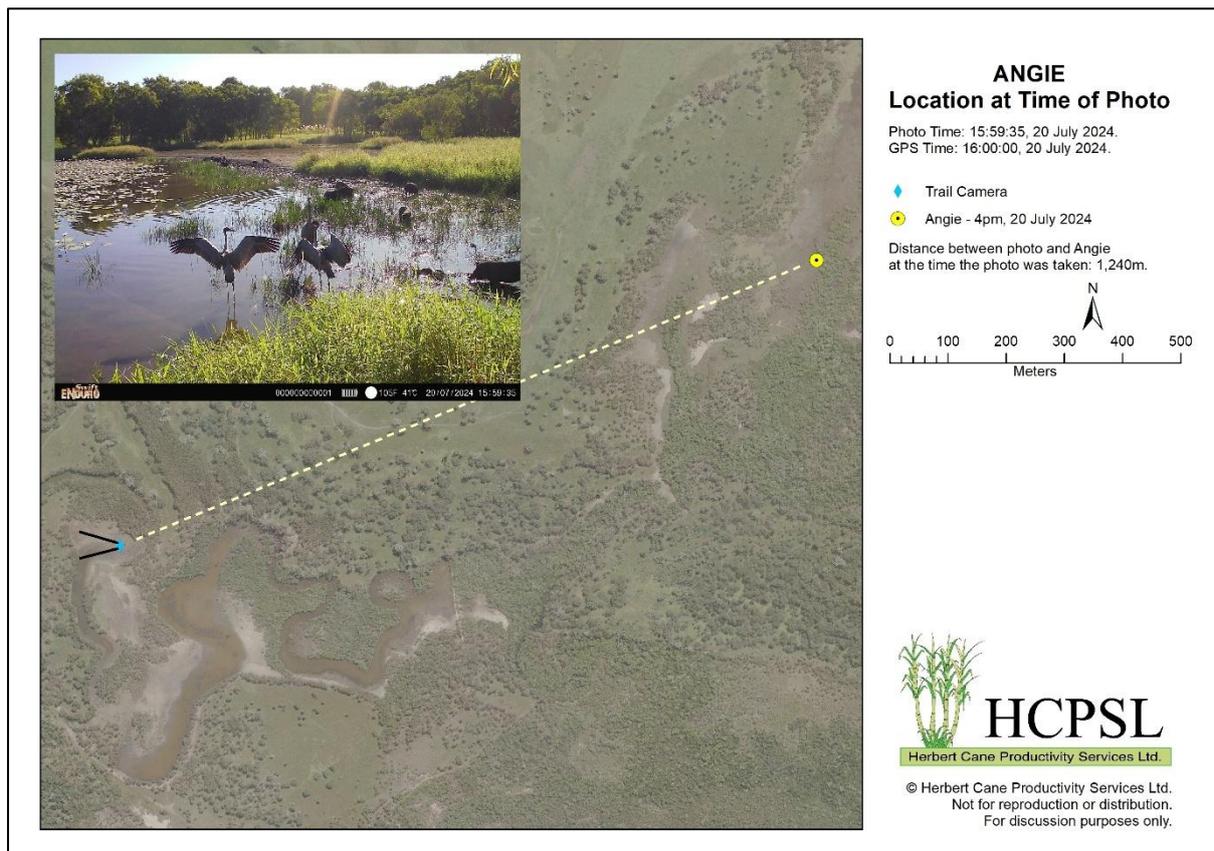
Map 12. Position of trail cameras for testing, from the 23rd of May to the 26th of June 2024, and for wetland monitoring, from the 26th of June 2024 to August 2025.

While this method of integrating camera surveillance with drone-based bait delivery has potential, it highlights the desire for drone operations to be internally managed by the agencies responsible for pest control. This would necessitate significant investment in suitable drone equipment (e.g., the DJI FlyCart 30 at approximately \$27,000, excluding batteries, training for Remote Pilot Licence [RePL], and Remote Operator Certificate [ReOC] requirements).

Additionally, cameras with mobile telemetry incur recurring costs such as mobile data plans and, when used with third-party platforms like eVorta, platform fees, which apply on a per-camera basis. At a minimum these have cost this project \$20/mth for mobile telephony and \$30/mth for eVorta access, totalling \$600 per year for each camera set up this way. This significantly increases the cost of the system but can provide real-time information on what is happening in the location the camera is monitoring.

Despite these considerations, trail cameras, whether used for mobile, short-term deployments or fixed, long-term monitoring, offer substantial benefits, provided they are deployed in sufficient numbers to effectively cover target areas.

Again, it was the rain during the 2023/24 and 2024/25 wet seasons which caused problems for this aspect of Project Squealer. They are problems because cameras that become submerged in crocodile infested wetlands is not a challenge. The challenge is to take the lessons learned and make strategies that will avoid the problem from occurring again.



Map 13. Shows the view from hcp_cam1 monitoring a wetland with feral pigs that were not part of Angie's immediate family, but obviously did have overlapping home ranges, and resource use.

Used in conjunction with other technologies, such as the GPS collars, trail camera photo of feral pigs in a wetland can confirm use of the same areas by different feral pig family groups at different times.

Map 13 shows an image of feral pigs with broilgas from the trail camera (lower left in the map), and the location of the collared pig (Angie) and where her immediate family would be. The photo time and the GPS time is 25 seconds apart, and the distance is 1240 metres – too far to travel in 25 seconds. Such information becomes useful population dynamics and resource use, and for future planning control activities.

The cameras overlooking the wetlands suffered somewhat from a lack of rigidity of the trees they were mounted in, although there wasn't a lot of choice in the area. While this didn't affect the performance of the camera, the swaying of the tree is visible between the photos. A bigger issue was the wind moving the surrounding trees and vegetation, which would set off the camera.

The cameras captured a variety of species during their months of deployment, including feral pigs, cattle, jabirus (black necked storks), broilgas, egrets, magpie geese, several unidentified waders, and a small crocodile. The cameras were programmed to send two photos of each burst of five photos, to eVorta for species identification and to aid in their machine learning.

Unfortunately, both cameras ceased operation during the 2024/25 floods. One was submerged and stopped working, and the other had the solar panel break away from its mount and stopped working after the backup batteries went flat. These cameras were not able to be recovered until mid-August 2025 due to continued wet conditions.

The collared pig Angie was only seen once by these trail cameras. GPS tracking showed that she moved to a different part of the national park and adjacent cattle property. Hence the rest of the pigs photographed are assumed to be from different family groups inhabiting the same area, but still possibly related.

One camera was destroyed flood waters when it was placed to monitor a sugarcane clean seed plot as evidence of feral pigs had been seen. Not only did this camera get submerged by the floodwaters, the memory card, when recovered and found to be still working, held 42 hours of sugarcane swaying in the breeze.

The mobile data enabled cameras were found to be very useful while they remained functioning. However no-one could have predicted the level of flooding during the 2024/25 wet season. Stiffer trees and more elevation off the ground would have been better in hindsight. In addition, the wind created its own problems, with the cameras being frequently set off simply from the surrounding vegetation blowing in the breeze, even after the near branches were trimmed from the trees.

The project would have benefited from more cameras, both as mobile cameras and long-term stationary cameras. With few cameras more effort goes in to determining where the best place to position a camera will be. Mobile cameras always require onsite visitation to change batteries and swap out memory cards, which add to the cost, i.e. cost of staff, and a risk to the staff of having to work remotely to service the cameras. Mobile cameras are opportunistic and can be moved around when required, particularly when used in conjunction with pigs (or other target species) wearing GPS tracking collars. If feral animals are habitually moving between areas, then cameras can be deployed for a time, e.g. for a fruiting season, to capture groups of pigs, deer or goats, etc for the identification of individuals and counting numbers. This would have been an ideal situation during the mango season in the Ingham district. Angie was seen to travel between the mangos at night and to Cassidy's creek during the day.

Use of Animals in Scientific Research

To undertake GPS collaring and tracking of feral pigs, Project Squealer was required to acquire an approval from the Department of Primary Industries Animal Ethics Committee, for the use of an animal for scientific purposes. The use of live animals for scientific purposes has provided many benefits for both animals and humans. However, this use has also been an area of public concern because of the potential for suffering or negative effects on the animals' welfare¹³.

According to the Business Queensland website, an animal is used for scientific purposes if it is used in activity to acquire, demonstrate or develop knowledge or a technique in any field of science.

Examples of an activity include:

- diagnosis
- environmental studies
- field trials
- producing biological products
- product testing
- research, including for example, creating or
- breeding a new line of animal
- teaching

Scientific purposes also include using any animal, or the remains of an animal that was killed, for any of the above purposes. Anyone using animals for scientific purposes must be registered with Biosecurity Queensland and obtain approval from an animal ethics committee (AEC).

In this situation, 'use' generally means to cause or permit to be used.

This includes to:

- acquire or purchase an animal
- accommodate, provide for, or care for an animal
- breed with an animal
- identify the animal (e.g. microchip, ear tag, brand)
- dispose of an animal
- drive, load ride, transport or work an animal.

The use of animals for scientific purposes is governed by the principles and ethical framework outlined in the Australian code for the care and use of animals for scientific purposes¹⁴, known as the scientific use code (refer to section 1 of the scientific use code).

¹³ Business Queensland website. URL: <https://www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/animal/health/welfare/science/use>

¹⁴ Australian code for the care and use of animals for scientific purposes.
URL: <https://www.nhmrc.gov.au/about-us/publications/australian-code-care-and-use-animals-scientific-purposes>

Project Squealer’s use of GPS tracking collars to understand home range and resource, and to also use the collared pigs as Judas pigs, therefore triggered the requirement for the “scientific use” permit. Four of the project staff were required to successfully complete an online training course with regards to “Using Animals in Science.”

In addition to the acquisition of this permit, the Centre for Invasive Species Solutions (CISS), via the Pestsmart website¹⁵, provides resources (toolkits) for the management of feral species, including activities like: the use of Judas pigs, monitoring techniques, baiting (with poisons), trapping, shooting (aerial shooting and ground shooting), and euthanising under field conditions, to name a few. These toolkits are available for many feral species in the Pestsmart website.

¹⁵ Pestsmart Website. <https://pestsmart.org.au>

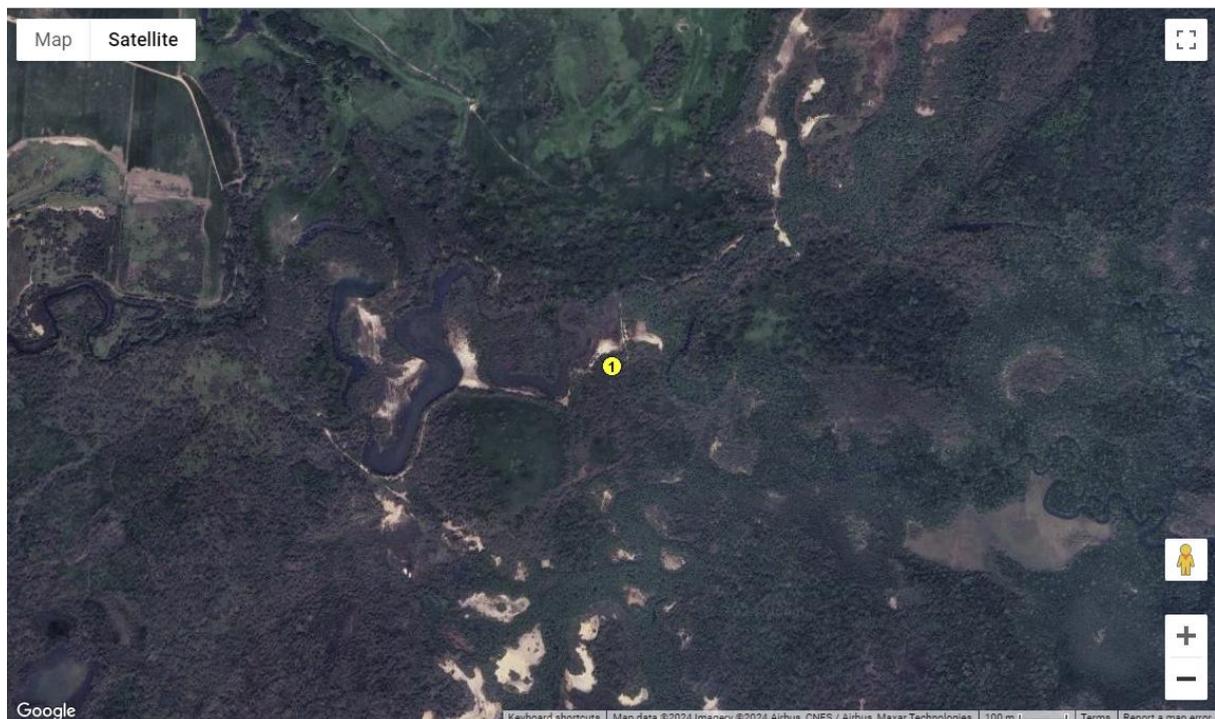
Judas Pigs

A Judas pig is one that has been captured, fitted with a GPS or radio-tracking collar, and then released back into the wild, with the purpose of betraying the location of other feral pigs to land managers. Because pigs are social animals, the collared pig will usually rejoin other pigs. By tracking the "Judas pig," wildlife managers can locate and eliminate the rest of the group mob.

This technique is used to efficiently find and cull otherwise hard-to-locate animals. Once the rest of the group is removed, the Judas pig is often left alive to find another group, effectively "betraying" multiple groups over time. The name is an analogy to the biblical figure Judas Iscariot, who betrayed Jesus for thirty pieces of silver.

The Hinchinbrook Shire Council conducts two aerial shooting operations annually—in May/June and again in November/December—in collaboration with the Queensland Parks and Wildlife Service. These operations focus primarily on the Halifax Bay Wetlands National Park and surrounding farmland. GPS data from two collared feral pigs along this coastal section was provided to the aerial shooting team to help reduce the time required to initially locate target animals.

As noted earlier, GPS data is transmitted from the collars to a Lotek server every six hours, depending on signal availability. This introduces a delay between the time a coordinate is recorded and when it becomes accessible to the aerial team. In optimal conditions, this delay may be as short as 30 minutes, but it may be 12 hours or more. Dense vegetation canopy in many areas interferes with both GPS satellite reception and data transmission, further impacting the timeliness and accuracy of the information.



Angie: Collar 150.250 146.27285 E; -18.73047 S

14th June 2024, 2:30am

Been in this vicinity since 6:30pm, 13th June.

Image 32. One of the maps supplied to the helicopter pilot for one of the aerial shoots. Information includes the date, time and coordinates of the latest known point, plus any other information that may be useful.

While GPS data can aid in locating feral pigs, it does not guarantee that a collared animal will be spotted—especially under dense canopy cover. Even with the use of thermal imaging telescopic sights, visibility remains limited. Feedback from the aerial shooting team indicated that no pigs wearing collars were observed during their operations. Most feral pigs were encountered and culled in open areas—bare flats between forested zones—rather than within the heavily canopied regions.

Attempts to locate collared pigs using a helicopter and the radio receiver, prior to the aerial shoot also met with limited success. Despite receiving strong signals indicating close proximity to a collared pig, visual confirmation was often impossible due to the dense foliage. On only one occasion, was a fleeting glimpse of a collared pig obtained as it ran through a clearing into mangroves, closely followed by seven or eight suckers.

This method of integrating GPS tracking with aerial shooting may prove more effective in areas with sparser vegetation and a less dense canopy.

The Potential Use of Drones to Deploy Baits

The north Queensland wet season, lasting usually four to five months from November/December through to March/April, provides almost an entire breeding cycle for feral pigs with very little harassment from land managers, with the exception of shooting from helicopters, and crocodiles. Many coastal areas where pig control activities occur, become inaccessible by vehicle due to high water levels in creeks and drains. Additionally, in many areas the ground just remains too wet for extended time periods to drive even four-wheel drives through. Vehicle access is necessary to carry in the amount of fruit required for pre-feeding and baiting traps.

The Hinchinbrook Shire Council maintains several pig traps on cattle properties adjacent to the Halifax Bay Wetlands National Park. These are only accessible during the dry season, April/May through to November/December. For example, one trap location used in this project was inaccessible by mid-December 2024 and was still inaccessible by regular four-wheel drive vehicle in August 2025. Even through most of the 2024 dry season this site was only accessible using Council's Argo amphibious vehicle.

Feral pigs in the Hinchinbrook Shire along with other norther local government areas (LGAs), won't eat grain baits, preferring fruit baits, specifically mangos and bananas. In Queensland, meat baits are only allowed in western and northern grazing areas (Pestsmart 2014) and are therefore not available in the agricultural districts along the coast¹⁶. Working under a permit held by Biosecurity Queensland, the Hinchinbrook Shire is authorised to use, bananas and mangos as both prefeed and poison baits. An APVMA (Australian Pesticides and Veterinary Medicines Authority) permit acquired by Biosecurity Queensland allows the use of fruit baits in the Burdekin, Cairns, Cassowary Coast, Cook, Douglas, Hinchinbrook, Mareeba and Tablelands local government areas, only.

According to the APVMA permit, prefeed baits need to be monitored for three days to assess any visitation by non-target species before poisoned baits are set. At remote sites, monitoring can be done using trail cameras equipped with mobile telephony to transfer images at the trap to the land manager or agency. Sites can be reached using amphibious, all-terrain vehicles such as an Argo, outside of the peak of the wet season, to recover any unconsumed baits and carcasses when able to be found.

Drone Delivery

The Brisbane Times, on the 9th of March 2014, ran an article suggesting that drones could deliver poisoned baits for feral pigs¹⁷. The following ten years have provided very few examples of drones actually being used to carry baits, pre-feed or poisoned, for any species. Two exceptions include an article from The Drive (a U.S. online publication) on the 16th of August 2018 stating that the Native American Choctaw Nation in Oklahoma State, had FAA approval to use drones to bait traps for feral

¹⁶ Pestsmart (2014). Poison baiting for feral pig control in Australia. Pestsmart. Available at: <https://cwba.org.au/wp-content/uploads/2024/05/Poison-baiting-for-feral-pig-control-in-Australia.pdf>. Accessed: 15th July 2024.

¹⁷ Cairns G (2014). Drones carrying poison baits may be used to cull feral pigs. Brisbane Times. March 9, 2014. Available at: <https://www.brisbanetimes.com.au/national/queensland/drones-carrying-poison-baits-may-be-used-to-cull-feral-pigs-20140309-34fem.html>. Accessed: 22nd May 2024.

pigs¹⁸, and a 2022 article on the Beef Central website showing a drone-based, poison bait delivery system for feral dogs in Western Australia¹⁹. As a result of standover sugarcane after the 2022 harvest, rat numbers exploded across the Herbert sugarcane growing district, within the Hinchinbrook Local Government Area. Travearth Drone Services developed a drone-mounted rat-bait dispenser able to dispense Ratoff sachets into sugarcane fields²⁰.

In January 2023, a controlled trial was conducted to evaluate the feasibility of using unmanned aerial vehicles (UAVs) to transport non-toxic, pre-feed fruit baits, specifically bananas and/or mangos, to predetermined ground locations. The objective was to assess whether UAVs could reliably lift and deliver attractant food items as a potential alternative delivery method. While current regulations prohibit the aerial delivery of poisoned baits via drone, the transport of non-poisoned attractant food is permitted.



Image 33: - Drone delivery - DJI T40 drone with bananas and mangos – This is a medium sized drone. These and large drones are needed to carry the weight of fruit to make effective prefeed baits, i.e. to keep the feral pigs returning to the baiting site.

Flight Trials

¹⁸ Margaritoff M (2018). The Choctaw Nation in Oklahoma is using drones to trap feral pigs. The Drive. August 16, 2018.

URL: <https://www.thedrive.com/tech/22944/the-choctaw-nation-in-oklahoma-is-using-drones-to-trap-feral-pigs>. Accessed 22nd May 2024.

¹⁹ Beef Central (2024). Drone mounted bait delivery system managing wild dogs in remote terrain. Available at: URL: <https://www.beefcentral.com/news/drone-mounted-bait-delivery-system-managing-wild-dogs-in-remote-terrain/>. Accessed: 13th June 2024.

²⁰ The development of this delivery system was undertaken at the suggestion of HCPSL. While the system has been used in the Herbert, the Author is not aware of any publication documenting its use. The Author however was on-site during its actual use to dispense Ratoff baits in sugarcane.



Image 34: - Drone delivery - carrying a hessian bag containing mangos – Shows the drone carrying a bag of mangos during the first proof-of-concept trial in January 2023.

A licensed operator, certified to fly ‘medium’ UAVs (defined as aircraft with a gross weight between 25 kg and 150 kg), was engaged to conduct the trial using a DJI T40 agricultural drone. This model, capable of lifting payloads up to 50 kg, was selected for its large size and ability to remain compliant with Visual Line of Sight (VLOS) regulations at operational distances. Beyond Visual Line of Sight (BVLOS) operations were not pursued due to the need for additional pilot certification and formal approvals from the Civil Aviation Safety Authority (CASA), which involve significant administrative overhead and cost.

For the test, the fruit baits were placed in a hessian bag (made from natural hemp fibre) and successfully transported to a ground target positioned beyond a low dirt mound (images 34, 35 and 36). Although the target was not directly visible from the take-off point, an observer maintained visual contact with the UAV throughout the flight and while pilot used the drone’s downward-facing camera to accurately position the payload. The trial demonstrated the practicality and effectiveness of using UAVs to deliver non-poisoned bait to specific locations under controlled conditions.



Image 35: - T40 drone showing the earthen mound hiding the delivery point – There is an earthen bank infested with guinea grass behind the tree in the foreground of the photo. Behind this mound was a target for the drone pilot to place the bag of mangos on to prove that the pilot could place the bag on the target while an observer watches the drone.



Image 36. Shows the ground target behind the earthen berm and the baits being placed on the target.



A follow up test was conducted on the 15th of April 2025. Prefeed baits were lowered into a gap in a sugarcane crop. Bananas were again used in the trial and carried to the site in a hessian bag. The drone used was a DJI T50 drone which has a greater carrying capacity than the T40 drone from the original test. The same pilot, from TravEarth Drone Services²¹, was used for the second trial flight (images 37, and 38).

Image 37. Shows the T50 drone carrying banana baits in a hessian bag during the field test for placing prefeed baits in a real scenario.

²¹ TravEarth Drone Services. URL: <https://travearth.com.au/>



Image 38. Shows the hessian bag of banana baits being lowered to the ground in a gap in a sugarcane field during the second field trial.

The initial trial was undertaken on the 25th of January 2023 to assess the potential that fruit a hessian bag, or bananas woven into a hessian strap could be picked up, carried and placed on the ground, onto a target which could not be seen by the drone operator due to an obstruction between the drone operator and the target. A local agricultural drone contractor with a DJI T40 drone was engaged for the trial. Approximately 20Kg of mangos and about 10kg of bananas were used with a hessian sandbag and an 25mm hessian strap for transport containers. These were carried beneath the drone on 10m of rope and a spring-loaded release hook. The length of rope is determined by the height of the trees around the baiting sight, so the drone remains visible to the operator and/or an observer while the baits are being lowered to the ground. At the test site, ten metres of rope was sufficient. As the weight of the payload came to rest on the ground, the hook released from the bag or the strap, leaving the baits on the ground.

The trial area included a low berm of soil covered by guinea grass, making a 4m high obstacle between the drone operator and a 1.8m by 2.4m tarp on the ground as a target, approximately 90m from the drone's launch point. Using an observer to watch the drone, the pilot was able to successfully guide the payload onto the target using the drone's downward-facing camera.

The fruits in the trial were later used as pre-feed baits at an actual baiting site to test whether the pigs could successfully assess the fruit inside the bag. This test proved successful. A second flight trial was undertaken at an accessible field site on the 15th of April 2025 with bags of bananas delivered into a gap within a sugarcane crop (image 38).

These trials were both conducted within the conditions for a “normal” flight, e.g. in daylight, within visual line of sight (VLOS), below 120m, with no person not involved in the flight within 30m of the operation.

The 2023/24 wet season lasted longer than usual and the proposed take-off and landing areas remained too wet for use. The proposed test site was close enough to the take-off and landing site as to not require BVLOS (beyond visual line of sight) certification for the pilot, leading to the postponement of the trial several times.

One unforeseen issue was that as ground conditions improved, the project was then competing with farmers for the attention of agricultural drone pilots, because farmers were still unable to drive tractors into their fields to spray weeds. Understandably the farmers and the primary local agricultural crop, sugarcane, became the main focus for the drone pilots for a time.

BVLOS (beyond visual line of sight)

Deploying pre-feed and poisoned baits via drone typically requires medium or large UAVs (drones), as effective programs often demand 30–50 kg or more of bait, depending on the size of the feral pig population (mob) being targeted. Drones of different sizes fall under varying licensing requirements (table 6), and certain operations may require additional authorisations based on the activity type and location.

A Remote Pilot Licence (RePL), similar to a driver’s licence, remains valid indefinitely unless surrendered or revoked by the Civil Aviation Safety Authority (CASA). In contrast, operational approvals, such as the Remote Operator’s Certificate (ReOC), must be renewed every three years. Additional authorisations are essential for specific activities, such as flying beyond visual line of sight (BVLOS), which also requires the pilot to hold an IREX or OCTA²² certification.

Class	Gross Take-off Weight	License
Micro	<250g	Excluded
Very Small	250g to 2kg	
Small	2kg to 25kg	<7kg <25kg
Medium	25kg to 150kg	<150kg (type specific ratings only)
Large	>150kg	>150kg (type specific ratings only)

Table 6 Showing the different drone size categories and different licensing requirements.

Despite planning efforts, the preferred test site, equipped with cameras capable of mobile data transmission, was often inaccessible due to flooding or overly saturated ground conditions. During the limited windows of accessibility, the drone pilot was unavailable due to existing crop-spraying commitments. Furthermore, as the pilot has not yet completed the IREX certification, operations are restricted to within visual line of sight (VLOS), significantly limiting potential trial sites. Under more typical seasonal conditions, this restriction would be less prohibitive, but in recent years it has posed a significant challenge.

The number of pilots qualified for BVLOS operations remains low, although it is expected to increase over time. Currently, most certified pilots are engaged in sectors such as mining, construction and

²² IREX – Instrument rating exam. OCTA – Outside of Controlled Airspace.

infrastructure maintenance. Additionally, the large size and high cost of drones suitable for baiting applications restricts access to a small but growing group of operators.

Gaining authorisation for BVLOS operations is both time-consuming and costly. The minimum application fee is currently \$2,880, with approvals potentially taking several months, and may not be approved. These authorisations are valid only until the associated ReOC expires²³. While this process may be justifiable as part of a long-term operational strategy, it presents a substantial barrier during the trial phase. Consequently, all test activities were confined to areas where VLOS operations were possible.

The unpredictable and transient presence of feral pigs further complicates drone-based bait deployment. Camera data shows that pigs may only frequent a specific site for a few days before moving on, making rapid response critical. Moreover, the cost of hiring a drone and certified pilot for even a few hours can run into several hundred dollars per delivery.

Beyond the logistical and regulatory challenges, compliance with the APVMA permit for fruit baiting requires that cameras be installed and monitored in real time to track both target and non-target species' interactions with the bait.

Bait Delivery

Baiting feral pigs with tropical fruit baits requires the delivery of 30kg to 50kg of fruit, usually bananas or mangos, to a location small enough to be monitored by a remote camera system. Given the disparate size and shape of mangos and bananas the systems used to deliver baits for wild dogs in western Australia and those used for incendiary purposes are not appropriate. Also, baits need to be placed on the ground rather than being dropped from height in a dispersal method. There is also a need to limit the ability of off target species from accessing the baits.

In the trials the project utilised hessian sandbags to carry up to 20kg of fruit for each drop. Hessian sandbags have the strength to carry 20kg of fruit and the hessian bag provides limited access to the fruit by off target species. The coarse weave of the hessian used to make the bags makes them relatively easy to tear apart or dragged around by feral pigs. A handle of 25mm hessian strap was sewed into the bag to facilitate carrying. Hessian fabrics, often referred to as burlap, are made out of natural fibres such as sisal or jute²⁴, and will do less harm to the environment if unable to be recovered quickly after deployment. The hessian bag option was seen as reasonable as uneaten poison baits need to be removed from the site after 24 hours according to the APVMA permit. Any remains of the bags or straps can be collected at that time.

Work is currently being undertaken on a delivery bag which will empty the fruits on to the ground, rather than leaving the bag.

Discussion

With the exception of the two referenced articles above, very little information exists on the use of drones to deliver baits for feral animal control—successful or otherwise. While this study has

²³ CASA – Regulatory Oversight Division. Pers comm by email – 28th May 2024.

²⁴ EU Fabrics (2024). Origin of Hessian fabrics and its uses. Available at: URL: <https://www.eufabrics.com/content/23-origin-of-hessian-fabrics-and-its-uses#:~:text=Hessian%20fabrics%20are%20coarse%2C%20woven,tight%20to%20very%20visibly%20open>. Accessed: 07/05/2024.

confirmed that the concept is feasible, it also highlights several operational challenges that limit broader adoption.



Figure 39. Shows approximately 15kg of mangos in a hessian sandbag with a sewn in carrying strap, and several hands of bananas wound into a loop made from a 25mm hessian strap. The coarse weave of the hessian bag allows pigs to tear open the bag or swing it around until the mangos roll out.

Key Operational Challenges Identified:

- Limited availability of qualified pilots with appropriately sized UAVs
- Competing demands on pilot availability due to commercial commitments
- Additional certification requirements for BVLOS operations
- High cost and lengthy approval process for BVLOS authorisations
- Cost of contracting UAV operators for field deployment
- Need for camera-equipped sites with mobile connectivity

The number of pilots licensed to fly medium and large drones is slowly increasing, particularly in cropping regions. As competition among these operators grows, opportunities to use drones for alternative purposes are likely to be welcomed. Many pilots who purchase medium drones do so primarily for use on their own property, which requires slightly less stringent licensing than operating commercially. However, some choose to obtain commercial licences to offset the cost of the drone and associated equipment, such as certification for aerial application of agricultural chemicals.

Following the 2023/24 and 2024/25 wet seasons, saturated ground prevented farmers from using machinery to spray weeds, making aerial application the only practical option. During this period, drone pilots were in high demand, which delayed Project Squealer’s feral pig bait delivery trials. Local primary production needs understandably took precedence over the project’s flight schedule.

In many areas—particularly during the wet season—operations would inevitably require flying beyond visual line of sight (BVLOS), which demands an additional level of pilot certification. The initial proposed field site could have been accessed for trials if the pilot had BVLOS certification and the project had secured the necessary authorisation for that location. As more pilots obtain BVLOS certification, hire costs are likely to rise due to the higher qualification level. At present, BVLOS-

certified pilots are in demand in industries such as mining, meaning it will take time before their numbers increase enough to reduce costs.

BVLOS flights require not only a certified pilot but also CASA approval for the operational area. This process can take several months and has a minimum cost of \$2,880. While this may be justifiable for long-term, multi-year programs, it poses challenges for feral animal control where target species are transient and follow resource availability. In such cases, long-term camera data and GPS tracking over multiple years would be needed to identify sites with consistent pig activity before committing to BVLOS application areas.

A single baiting activity will require at least four drone operations: three flights to deploy pre-feed baits and monitor for off-target species, and one return operation to confirm activity by the target species which could be undertaken using a drone with a thermal camera. Using an estimated operational cost of \$250 per hour, and allowing two hours per day for travel and bait deployment, the total cost for the four-day activity is approximately \$2,000.

Multiple flights per day may be required to transport the total quantity of baits, depending on the capacity of the bait-carrying system. Alternative bait-carrying options have been discussed since the trial flights conducted for this project, but nothing past the hessian bags has yet been developed.

Beyond Visual Line of Sight (BVLOS) authorisation is expected to add almost \$3,000 to the overall cost of the activity.

Component	Times	Cost
Monitoring (trail camera)	Once (initially)	\$1,060
Drone and Operator	4 times x 2 hours	\$2,000
BVLOS	Once	\$2,880

Table 7 listing the main costs involved with delivering fruit baits for feral pigs by drone.

Hiring an appropriately licensed and certified drone operator is expensive, and employing such a pilot in-house would still incur high costs. A local government with an in-house operator could also undertake weed management in inaccessible or hazardous areas, but pilot rates may exceed \$250 per hour. When adding the cost of three days of pre-feed bait monitoring and one day of poisoned baiting, expenses escalate quickly.

Under the APVMA permit for fruit baits targeting feral pigs, sites must be monitored for three days before deploying poisoned baits. This requires at least one camera per site, along with purchase, setup, and maintenance. In February 2024, a Swift Enduro 4G camera with a solar panel, 32GB SD card, 3G/4G antenna (6.2dBi), 24 AA rechargeable batteries, and a 12-month prepaid SIM card cost \$1,079.80. Cameras must be installed in the dry season and, if located near wetlands, positioned high enough to remain above floodwaters in the wet season. An eVorta subscription was an extra \$600 per camera per year.

Project Squealer purchased four cameras—two with the accessories listed above and eVorta subscriptions, and two without SIM cards, additional antennas and eVorta subscriptions. Two cameras were submerged during the peak of the 2024/25 wet season floods. One, positioned one metre above ground at a HCPSL clean seed cane plot, was completely submerged. The depth of water at that site remains unknown. Another, located at a wetland frequented by pigs and mounted 1.2 metres above ground, was partially submerged, with damage to the lower half of its battery case.

To be effective, cameras must be installed early enough to allow for testing and adjustment of their field of view before the wet season renders sites inaccessible.

Even if the cost of the operator and drone were halved, and Beyond Visual Line of Sight (BVLOS) authorisation were not required, the cost of a single drone-based baiting activity would still remain high. At a minimum cost of \$2,000 or more for an initial activity, it is doubtful whether drone baiting is economically viable when a substantial proportion of the work is outsourced. If an organisation were to have its own suitably licensed operators and equipment, the economic outcome may differ. Reducing costs to the initial outlay for monitoring cameras and the wages of an operator may improve viability.

On 10 January 2024, DJI released the FlyCart 30, a new UAV platform equipped with an optional winch system. This system offers enhanced suitability for bait deployment by eliminating the need for a long lowering rope. With the winch, payloads can be lowered to the ground while the drone remains above the canopy and within VLOS constraints, representing a significant improvement in operational efficiency and safety for future applications.

Automated trap closure systems

The project team engaged Dr Carlo Mattone and his research group at James Cook University (JCU) to develop artificial intelligence (AI) technology capable of distinguishing feral pigs from non-target animal species. This initiative builds upon existing work by JCU's TropWATER team, which has successfully developed and deployed AI systems for fish species identification. The underlying technology will be adapted to suit terrestrial applications in feral animal management. This software will not only be able to identify feral pigs and to discriminate between target and non-target species but will also be able to count the number of the target species in the camera view.

The initial phase of the project involved collecting and collating video footage and still images of feral pigs and non-target species to support algorithm development and machine learning model training. The Hinchinbrook Community Feral Pig Management Program has provided JCU with access to its private library of relevant footage and imagery. Work undertaken included sending images and video to James Cook University, which then needed to be annotated to allow the neural network being developed to recognize what a pig is. This data will form the foundation for developing an accurate and reliable identification system. This initial stage of the AI development is scheduled for completion by late March 2023.

In the longer term, it is proposed that this AI system could be integrated with automated trapping infrastructure, enabling smart trap doors to open and close in response to the presence of target species (feral pigs) while excluding non-target animals. Achieving this functionality will require significant ongoing research and development.

There are several groups doing this sort of work at this time, including eVorta which was used with the trail camera component of the project. These groups have made considerable progress in the identification of different species within camera images. Groups such as eVorta are a viable alternative to university-based groups for any future work in taking this technology through to the automated trap gate release mechanisms.

This activity was completed in December 2023. A report was completed by James Cook University staff in December 2023 and forwarded to DFPI committee in June 2024.

Extension and Communication

7 national and regional conferences.

- FunGIS is a regional GIS user group with members from Townsville to Cairns and the Atherton Tablelands.
- The Combined Productivity Services Conferences is for the sugar industry productivity services from Mossman to northern NSW.
- Australasian Vertebrate Pest Conference is mostly Australia and New Zealand, with some interest from other countries.
- Australian Society of Sugar Cane Technologists Limited is mostly Queensland and northern New South Wales, with some interest from overseas sugar producing countries.

3 published peer reviewed papers.

11 presentations at conferences workshops and meetings.

HCPSL shed meetings in 2022 and 2023 - >100 people each year.

Extension of project outcomes

2022

The following activities occurred during the reporting period:

- 30th of June 2022- "Update on technologies for controlling rats and pigs, applying ripening products and soil mapping workshop". Twelve attended the workshop.
- 15th and 16th of September 2022. Presentation at the FunGIS (Far North Queensland GIS Group inc.) annual conference in Cairns: Use of Thermal Imaging Systems to Help Manage Feral Pig Populations. Approximately 40 people in attendance (Lower numbers due to the effect of CoVid).
- 10th, 11th and 12th of October 2022. HCPSL shed meetings with 120 growers attending the meetings.
- 6th of December 2022. Combined Productivity Services conference, with 65 agricultural advisors attended the conference.

2023

- Online presentation to the National Feral Pig Action Plan stakeholder forum on the 7th of March 2023.
- Presentation and paper to the Australian Society of Sugarcane Technologists (ASSCT) conference in Cairns from the 18th to the 21st of April 2023.
Di Bella L. et al. (2023). Learnings from the Hinchinbrook Community Feral Pig Management Program. Proceedings of the Australian Society of Sugar Cane Technologists, volume 44, 65-72, 2023.

- Presentation at the SRA (Sugar Research Australia) Herbert Field day on the 4th of May 2023. 56 growers and agricultural advisors attended from the Herbert, Tully and South Johnstone sugar cane growing areas (photo 7).
- Attended the National Feral Pig Conference in Cairns from the 20th to the 21st of June 2023, as a delegate. The conference proceedings can be found online at: <https://feralpigs.com.au/wp-content/uploads/2023/06/National-Feral-Pig-Conference-2023-proceedings-final.pdf>.
- 24th and 25th of August 2023. Presentation at the FunGIS (Far North Queensland GIS Group inc.) annual conference in Cairns: The Next Chapter: GPS Tracking of Feral Pigs - Where do they go when no-one's looking ... Approximately 70 in attendance.
- Presentation of Project Squealer progress so far, at the Herbert Cane Productivity Services Ltd. Annual General Meeting on the 24th of October 2023

2024

- A pig management workshop was held with growers on the 12th of March 2024, with 8 affected attendees.
- The use of GPS tracking Collars within Project Squealer was given at the Hinchinbrook Local Government Area Biosecurity Plan Review, on the 1st of May 2024.
- Elements of this project will be presented at the Australasian Vertebrate Pest Conference in Sydney, from the 29th of July to the 1st of August with over 300 attendees. The draft paper is Attachment 5, The written proceedings are still a work in progress, and a recording of the presentation is available online at: <https://www.youtube.com/watch?v=eZP7NG8HEZ8&list=PLvvZSynxYkKe4wi9GI9PO9DMAR-R01JL8&index=2>



Image 40. Presentation at the Australasian Vertebrate Pest Conference in Sydney on the 1st of August 2024.

2025

- A presentation of Project Squealer's assessment of new technologies was given at the Grazing Connect workshop in Ingham on the 4th and 5th of April 2025. Approximately 40 people from the grazing industry were in attendance.
- The GPS tracking and remote camera systems component of Project Squealer was presented at the Hinchinbrook Biosecurity Plan Review 2025, on the 23rd of April 2025.



Image 41. Presenting the work of Project Squealer at the Grazing Connect Workshop at Ingham on the 5th of April 2025.



Image 42. Grazing Connect Workshop – Ingham, on the 5th of April 2025.

2026

Presentation and paper to the Australian Society of Sugarcane Technologists (ASSCT) conference in Cairns from the 21st to the 24th of April 2026.

Nielson R. et al. (2026). Project Squealer: observations from GPS collaring and tracking. Proceedings of the Australian Society of Sugar Cane Technologists, Volume 47, 2025

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