Summary of final report for Biosecurity R&D Fund[1] research project:

Reducing feral pig disease risks through the use of aerially deployed infrared sensors and habitat modelling

Proponent: Murdoch University

Compiled by Jenny Crisp (DPIRD Biosecurity R&D Fund manager) in February 2018[2]

Project information

Project manager and contact person	Name: Peter Adams Email: Peter.Adams@dpird.wa.gov.au
R&D Fund contribution	$470,700
Other contributions	$677,300
Total investment into project	$1,148,000
Start date	1st July 2015
Finish date	31st December 2017

Introduction and justification

Feral pigs (*Sus scrofa*) represent a serious threat to Australia's agricultural output and the environment through their highly destructive behaviour. Impacts include damage and/or loss of crops and livestock, destruction of agricultural infrastructure, degradation of natural ecosystems and predation of native wildlife. Feral pigs are also capable of harbouring a wide range of endemic and exotic diseases of significant importance e.g. Foot and mouth disease, classical swine fever and other vesicular diseases. In Western Australia (WA), feral pig populations are well established in the South-West Agricultural and Kimberley Regions, as well as along some of the major river systems in other regions. The remote nature of many of these populations, combined with the cryptic behaviour of feral pigs, makes population monitoring and control extremely difficult. Effective management of feral pigs requires knowledge of the species ecological preferences and movement patterns as well as the effectiveness of different management strategies.

Murdoch University and CSIRO recently completed a 2.5-year collaboration to enhance feral pig management in the South-West Agricultural Region of WA; working on developing a

[1] The Biosecurity R&D Fund is part of the Boosting Biosecurity Defences project, supported by Department of Primary Industries and Regional Development (DPIRD)
[2] This summary draws on information from the Feral pig final project report (Dec 2017), earlier milestone reports and further in-person clarification with Peter Adams (project manager).

broad-scale tracking tool (infra-red aerial detection of collared feral pigs) to estimate abundance and distribution, in conjunction with predictive risk mapping of feral pig distributions and their ecological and economic impacts. It is anticipated these tools will be directly applicable to ongoing management of feral pigs in WA on a regional scale, and also enhance targeted monitoring and risk assessment of feral pig populations in the event of a disease incursion.

Approach and key findings

Aerial surveillance for feral pigs

The aerial surveillance approach was to fly an aircraft with infrared thermal sensors attached across areas of the southern forest of the South-West Agricultural Regional of WA, aiming to detect and differentiate heat signals from free-ranging feral pigs in the forest below. Prior to the flights a number of feral pigs were trapped and fitted with GPS collars, so their location could be tracked and cross-referenced with the thermal data to validate the aerial thermal sensing technique.

Knowing the location of as many feral pigs as possible at the time of each flight is critical to assessment of the methodology. Unfortunately, there were major and ongoing problems throughout the project with deployed collars either failing or being lost or damaged, which meant that the number of pigs with known locations at the time of each flight was limited. The total number of different pigs collared during the project was 23, but the number of pigs with active collars at the time of each flight was at most 4.

Table 1 summarises the conditions and results for each flight. A summary of the events and challenges that impacted these results is presented below:

- The first 4 pigs were collared Nov-Dec 2014; Northcliffe wildfires in Jan 2015 swept the study area, killing pigs and destroying collars (1 collar had already failed and 1 collared pig died prior to fire).
- Another 11 pigs were collared Apr-Jun 2015; multiple collars began to fail around the time of Flight 1 in Jun 2015.
- Flight 1 was with a drone in June 2015, and was a non-event as the pigs were scattered and the drone could not fly far enough into the bush (restricted Visual Line of Sight); by July 2015 all remaining collars had failed).
- Another 8 pigs were collared in Feb-Mar 2016; these were fitted with version 2 (V2) collars which had external aerials to improve VHF signal distance and UHF download capability of stored location data; 3 collars failed prior to Flight 2.
- Flight 2 was in March 2016 with a light aircraft during the day (height 1000 ft AGL); weather conditions were warm with clear skies; number of pigs with active collars at the time of the flight was 5; this trial was unsuccessful as the clear skies and warm temps created too much thermal ‘noise’ to differentiate pig heat signatures from background environs.
- Flight 3 was in May 2016 with a light aircraft during the day (height 1,000 ft AGL); weather conditions were cool with patchy cloud; same 5 pigs with active collars; this trial had some success, with less thermal ‘noise’ and improved detection due the cloud cover (though patchy) and cooler temps; 1 collared pig detected.
- Meanwhile, multiple collars that had failed or were lost were recovered over time by trappers/shooters, and sent back to the manufacturer for diagnosis; a fault with internal wiring was identified; manufacturers fixed the identified fault and made other improvements around fit and upload capacity, creating version 3 (V3). In Dec 2016 new V3 collars were fitted to 4 (re-trapped) pigs, replacing the V2 collars.
- Flight 4 was in Feb 2017 with a light aircraft; this time at night, to try to manage the thermal ‘noise’ from reflected sunlight; 3 pigs with active collars; safety regulations required flight altitude at night to be 2,800 ft AGL, reducing image resolution by 2.8; this trial was successful, with detection rates of collared pigs consistent at 33.3% (4

of 12 possible detections) with repeat sampling of the area.

- Flight 5 was in Jun 2017 with a light aircraft at night (height 2,800 ft AGL); 2 pigs with active collars (V3); this trial had success with night detection rates consistent at 30% (6 of 20 possible detections) with repeat sampling of the area. An additional 4-5 heat signatures strongly suspected of being un-collared feral pigs were detected during the flight; supported by remote camera monitoring of the study area.

Table 1: Summary table of thermal detection trial conditions and results

Flight	Date & conditions	Collar version	Number active collars	Number pigs detected	Result
1	Jun 2015, day, drone	V1	1	0	Unsuccessful – drone couldn't fly far enough
2	Mar 2016, day, warm, clear skies, light aircraft	V2	4	0	Unsuccessful - clear skies and warm temps created too much thermal 'noise' to differentiate pig heat signatures from environs.
3	May 2016, day, cool, patchy cloud, light aircraft	V2	4	1	Limited success - improved detection due to patchy cloud and cooler temps; conditions difficult to plan for logistically.
4	Jun 2016, night, light aircraft	V2	3	2*	Successful - detection rates consistent at 33.3% with repeat sampling (4 out of 12 possible detections).
5	Feb 2017, night, light aircraft	V3	2	2*	Successful - detection rates consistent at 30% with repeat sampling (6 out of 20 possible detections).

*While there were only 3 pigs with active collars at the time of the flight, the aircraft made multiple crossings of the area, and an overall 30% detection rate was achieved over multiple crossings.

In summary, the low number of active collars at the time of each flight was a major limiting factor to trialling the thermal detection approach. Within this context, the thermal detection results at night were most successful with detection rates consistent around 30% with multiple crossings of area, even with reduced target size due to the requirement to fly higher at night. It is important to note that thermal detection can only take place with direct line of 'sight' of the target, and in thick karri forest with significant canopy cover, 100% detection is not to be expected. The plan for this project was to investigate the detection rate of feral pigs in this type of habitat, using the GPS-locatable pigs to verify detection or non-detection of pigs. Having a better understanding of the likely detection rate enables the extrapolation of observed detections to relative abundance of feral pigs when the technique is applied over much greater areas; multiplying the result by the consistent percentage to estimate abundance and distribution.

So the initial aim of undertaking a regional-scale preliminary assessment of feral pig abundance in the southwest was not achieved due to the identified unexpected challenges. However, the project did generate important knowledge on tracking collar technology and factors impacting aerial detection of feral pigs by thermal sensing.

Habitat suitability modelling for feral pigs

The habitat suitability modelling part of the research used a participatory modelling approach to develop risk maps of feral pig distributions and their ecological and economic impacts for the South-West agricultural Region of WA. A workshop was held in November 2015 to pool expert knowledge about feral pig establishment and persistence. Invited participants had experience in managing feral pigs within the study area and/or were involved in feral pig ecology research. Information gathered during the workshop, with some additional expert interviews, was used to build a modelling framework (Bayesian network) representing the environmental system for feral pig persistence. The model integrated causal relationships between the climatic, environmental and management variables influencing habitat suitability for feral pigs. The model was then used to generate spatial risk maps by linking it to relevant environmental layers within a Geographic Information System (GIS).

Model predictions showed the area of land suitable for pigs varied significantly across four season scenarios. Feral pig density and distribution during hot-dry periods (summer-dry scenario) was highly constrained by resource availability, especially water. During wet and cool periods (winter-wet scenario) resource availability was rarely limiting and there was a much greater area of suitable habitat available to support increased pig density and distribution. It was intended that the habitat suitability models would be validated with the expected aerial surveillance data but as the aerial surveillance approach did not achieve broad-scale application, this was not possible. The habitat suitability model was instead tested using trap capture records of feral pigs collected by community feral pig control programs.

An economic impact model was also developed within the project, which combined habitat suitability, agricultural commodities, land use and relevant pest management strategies to determine potential economic loss under different management scenarios. Commonly used and current best management strategies were identified by experts, and new management strategies are easily incorporated as relevant.

Model predictions are used to spatially represent the expected outcome of changes to resource availability and management, which in turn can guide where and how management resources should be best directed, particularly on a regional scale. It is anticipated the models will be used by community groups, government and researchers to evaluate scale of feral pig management, estimate economics of feral pig management, explore implications of temporal variation in habitat suitability, inform operational plans and guide policy and management. Model predictions could also be of value in the event of a disease incursion to highlight areas of greatest risk and determine where to focus available resources to limit the potential spread and maximise control efficacy.

Feral pig diet

In response to the technical and logistical issues encountered in the aerial surveillance research, it was decided to augment project outcomes with an additional component - feral pig stomach analysis. Stomachs from 44 free-ranging feral pigs in the southern forests of the South-West Agricultural Region were collected during the summer of 2015-16 (n=8), autumn 2016 (n=12), winter of 2016 (n=7) and summer 2016-17 (n=17), and contents analysed to provide insight into their diet and impact on agriculture and biodiversity in the area.

Previous diet analysis studies in the South-West Agricultural Region relied primarily on feral pig stomachs collected from trapped animals baited with food, which obviously impacts on stomach contents at time of collection. The work conducted in this project used stomachs opportunistically collected by established community group trappers from free-ranging feral pigs not relying on bait stations as a supplementary food source.

Results showed stomach contents were highly macerated, making it difficult to identify food items to species level. The ratio of broad food type found in the stomachs by volume was (on average) 93.3% plant material, 3.4% vertebrates (typically consumed as carrion), 1.3% invertebrates and 2% fungi. The percentage of the 44 animal stomachs these materials were found in was 100% for plant material, 70.5% for vertebrates, 88.6% for invertebrates and 16% for fungi. There were significant seasonal differences in the consumption of reptiles, fungi and above ground plant material; gender and age (young/juvenile/adult) did not influence diet composition. Feral pigs were shown to be both opportunistic and selective in the food that they consume.

Samples of stomach contents from 22 animals were retained for further analysis. DNA extraction has been completed for these samples, and deep sequencing DNA analysis will take place[3] mid-2018 (post-project) to identify the major food items to genus level.

[3] Deep sequencing DNA analysis to be conducted under the supervision of Dr Charlotte Oskam at the Vector and Waterborne Pathogens Research Group (CrypTick Laboratory), Murdoch University WA.

Engagement and communications

Project implementation has involved stakeholders from community, government and research in project activities and outcomes to a high degree throughout implementation.

- Feral pig trapping and collaring work was with assistance from DPaW, DPIRD, Murdoch University, Lake Muir/Denbarker Community Feral Pig Eradication Group and the Northcliffe Feral Pig Control Group.
- Expert panel modelling workshop participants included DPaW, DPIRD, Perth NRM, Murdoch University, Water Corporation, Blackwood Biosecurity Group, Donnelly Vertebrate pest Group, Chittering Landcare, and the Lake Muir/Denbarker Community Feral Pig Eradication Group and the Northcliffe Feral Pig Control Group.
- Further clarification with some expert panel members took place post-habitat suitability workshop (including those unable to attend initial workshop).
- Habitat suitability modelling results were presented to stakeholders and management options and impacts further discussed in mid-2017.

The project approach and results have also been opportunistically promoted to community, industry, government and researchers; within WA, nationally and internationally.

Next steps

Aerial surveillance for feral pigs

A recommended next step for the aerial thermal surveillance approach is to source/develop a more reliable GPS collar for the southern forest habitat, as knowing the location of as many of the target animals as possible at the time of aerial surveillance is critical to improving the accuracy of the approach.

With more reliable collars for the habitat, it is recommended to continue to trial the aerial thermal detection approach to the point where regional-scale abundance and distribution of feral pigs can be estimated and validated for different habitat conditions. This would benefit from the manipulation of closed populations feral pigs to assess the sensitivity of the technique to detect density change within a population. GPS collars may need to be tailored to suit different habitats.

Once the approach has been validated for feral pigs in the South-West Agricultural Region, applying the approach to feral pig populations in the Kimberley Region is recommended, as well as evaluating application to other target species such as deer, goats, horses, donkeys, kangaroos, sheep and cattle.

Habitat suitability modelling for feral pigs

The recommended next steps for the habitat suitability modelling include improving economic impact estimates for feral pigs in the South-West Agricultural Region by sourcing more accurate impact data for a broader range of commodities. Expansion/development of habitat suitability and economic impact models to other areas of WA where feral pig populations are an issue (e.g. the Kimberley Region), and for additional pest species (e.g. deer in the South-West Agricultural Region) is also recommended.

Feral pig diet

The areas of southern forest where feral pig stomach contents were sourced for analysis as part of this project have had well established community groups controlling pigs in and out of the forests for many years, and there are substantial areas of forest habitat in the area for the pigs to roam and source food. It is considered possible that the impact of feral pigs on agriculture in these areas could be less than in other areas of the South-West Agricultural Region where there has been less focus on feral pig management and/or where there is less area of alternative habitat to agriculture. The next step in this area of research (from an agricultural perspective) would be to expand stomach analysis to other areas of the South-West Agricultural Region where feral pigs are considered to be an issue.