Economic impact of feral pigs on agricultural production in North West NSW: 2020-21

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Client: North West Local Land Services (NSW)

Prepared by: Ag Econ

Janine Powell and George Revell

Namoi Valley, New South Wales

janine@agecon.com.au

Executive Summary

Feral pigs are a persistent problem for agricultural businesses in North West NSW. The region's vast areas of highly productive irrigated agriculture adjoining national parks and natural waterways make an ideal habitat for feral pigs. This study estimated that during the period from July 2020 to June 2021, feral pigs cost the region an estimated $47 million in lost agricultural production.

The study builds on findings from the 2020 analysis (Powell et al., 2020) that calculated a cost benefit analysis of feral pig control in North West NSW. Focusing specifically on a 12 month period that included the Winter 2020 and Summer 2020-21 crops, this analysis used seasonal inputs including regional yields, commodity prices and damage caused by feral pigs. The seasonal data was underpinned by a survey of landowners (see Section 2) and agronomists in the region. The enterprises included within the survey, the mean results and inputs are shown in in Table 1.

Table 1: Analysis results by enterprise and mean inputs

Enterprise	Cost of feral pigs	Key mean inputs			Regional losses
		Anticipated damage by feral pigs (% of yield)	Regional yields	Commodity prices	
Barley for grain	*$26 /ha*	*3.2%*	*3.75 t/ha*	*$215 /t*	$5,866,000
Canola	*$23 /ha*	*1.8%*	*2.2 t/ha*	*$571 /t*	$338,000
Chickpeas	*$30 /ha*	*3.5%*	*1.5 t/ha*	*$572 /t*	$6,073,000
Cotton lint (irrigated)	*$113 /ha*	*1.75%*	*11.5 bales/ha*	*$564 /bale*	$7,108,000
Cotton lint (dryland)	*$24 /ha*	*1.75%*	*2.4 bales/ha*	*$564 /bale*	$1,273,000
Faba beans	*$13 /ha*	*2.6%*	*1.5 t/ha*	*$345 /t*	$262,000
Hay	*$4 /ha*	*0.75%*	*3 t/ha*	*$190 /t*	$56,000
Maize for grain	*$24 /ha*	*1.5%*	*4.8 t/ha*	*$212 /t*	$127,000
Sorghum for grain	*$34 /ha*	*4.3%*	*3 t/ha*	*$262 /t*	$3,986,000
Wheat for grain	*$25 /ha*	*3.2%*	*3 t/ha*	*$265 /t*	$20,364,000
Sheep and lambs		*4.2%*	*251,000 lambs in the region*	*$169 /hd*	$1,778,000
Total regional losses Winter 2020 & Summer 2020-21					**$47,231,000**

The method considers the high level of variability by using @Risk where inputs used are a probability distribution rather than a fixed value. Appendix 1 outlines each input distribution.

The study's results indicated that the highest enterprise loss of $113 /ha was for the Summer 2020-21 crop of irrigated cotton. The enterprise was estimated to sustain low to moderate percentage yield losses by feral pigs, however the high commodity value and high per hectare yields of the crop resulted

in economic losses four times higher than the other crops. Sorghum (another summer crop) was estimated to experience the highest yield losses by feral pigs resulting in the second highest per hectare losses at $34 /ha. The lowest per hectare losses in terms of per cent yield loss and economic loss per hectare were calculated for hay that wasn't as prevalent in the regional given the reduced livestock feed demand associated with better seasonal conditions. The per hectare losses in wheat of $25 /ha were similar to barley, canola and maize, however on a regional scale due to the dominance of this enterprise in the winter cropping landscape just under half the seasonal regional losses were attributed to wheat at approximately $20 million. These results highlight that regionally feral pigs are causing large economic losses not just in high value crops.

Regionally, lamb losses in sheep enterprises were estimated at just under $2 million. This was calculated using a 4.2% lamb loss rate from the farmer surveys and an opportunity cost of $169 /hd for each lamb lost. The regional loss was calculated using Australian Bureau of Statistics estimated lamb numbers for the region from the 2015-16 census (ABS, 2017a). Per hectare or individual enterprise losses vary depending on flock size and stocking rates, hence per hectare losses were not tabled.

The high per hectare and regional losses were influenced by the good agricultural seasons with generally higher than average yields, commodity prices were also higher than average, however feral pig losses were mixed. Barley, cotton, maize, sorghum and wheat were estimated to have higher losses than average which were outlined in the original report, while chickpeas, faba beans, hay, and sheep enterprises were estimated to have lower than average losses. For the NW NSW LLS region, this study estimated targeted, area wide control programs during the study period could provide a net economic benefit of $26 million by reducing agricultural losses attributed to feral pigs. This finding highlights the value of ongoing control measures to suppress the feral pig population and the damage they can inflict.

The survey results indicated an increasing abundance of pigs in the summer cropping period. Informal farm networks were found to be the most frequently used and most relied upon resource of information for feral pig control followed by Government resources such as LLS. Every survey respondent agreed that feral pig control was important at both an individual farm level and area wide program level. Survey respondents also reported that they understood the economic benefits of control and most respondents agreed that the benefits outweighed the total cost of control.

Contents

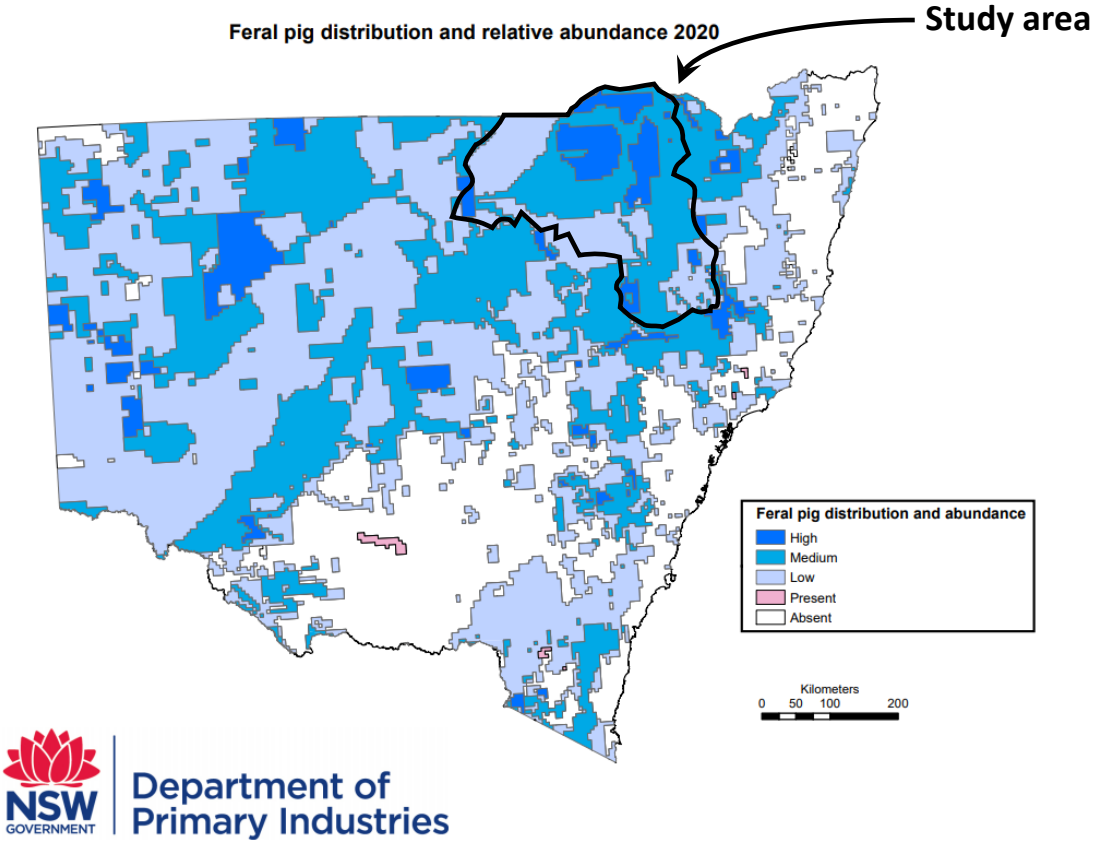
SECTION 1: Economic impact of feral pigs on agricultural production in North West NSW, Winter 2020 & Summer 2020-21.

Introduction

A study commissioned by the NW LLS (Powell et al., 2020) to understand the benefits of feral pig control suggested that feral pigs could cause up to $100 /ha in agricultural cropping enterprises. This report furthers that analysis by considering economic losses specifically for the Winter 2020 and Summer 2020-21 seasons in the same study area, the North West New South Wales Natural Resource Management Region (NW NSW).

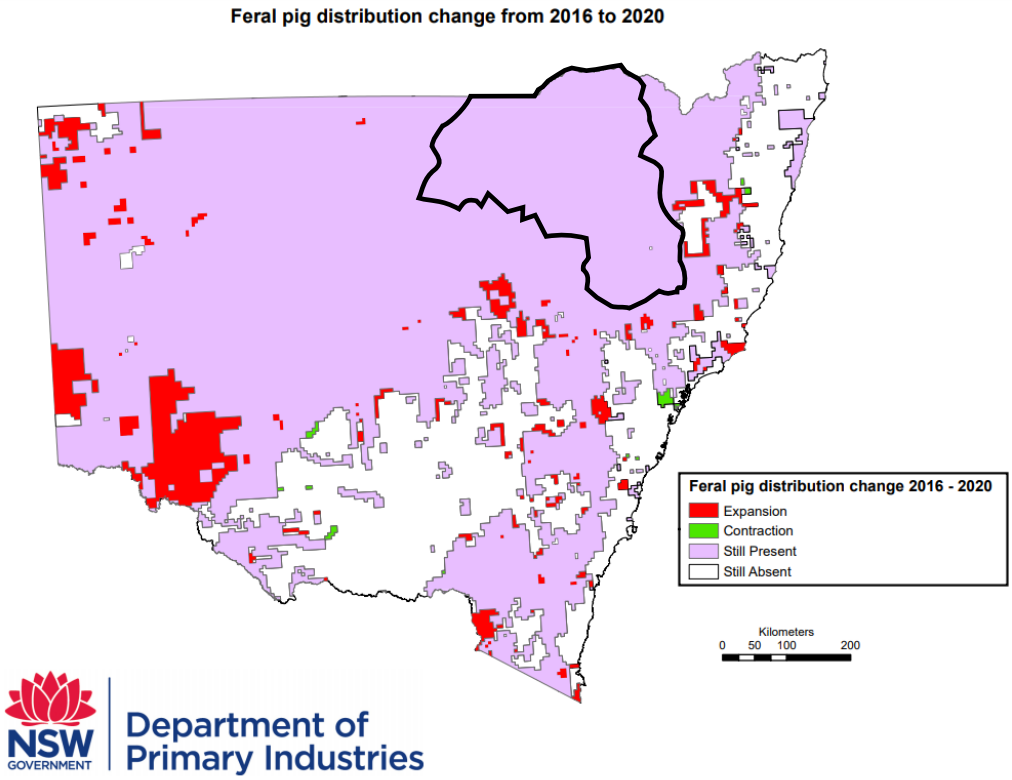
NSW DPI periodically creates maps for key vertebrate pests including feral pigs (DPI, 2020). Recent mapping (see Figure 1) indicated that in 2020, for the study area pigs were generally present in a medium to high abundance, with some of the southern area experiencing low feral pig abundance.

Figure 1:Feral pig distribution and relative abundance (DPI, 2020)



Mapping also indicated (Figure 2) that feral pigs remained present in a large part of NSW with the areas of expansion (red) larger than the areas of contraction (green). Within the entire study area feral pigs were classed as 'still present'.

Figure 2: Feral pig distribution change from 2016 to 2020 (DPI, 2020)



Agricultural enterprises in North West NSW are dominated by broadacre cropping of cereal, pulse and lint as well as grazing enterprises. Feral pigs cause yield loss in both winter and summer crops by consuming the crop itself or by using the crop as a habitat, where they often root, trample and wallow, destroying the plants. Within livestock enterprises, feral pigs compete for food sources such as hay, pastures and grains and also pose a biosecurity threat as a host and carrier of disease. Within sheep enterprise, losses attributed to feral pigs come predominately in the form of lamb losses due to pig predation.

While it is generally known that feral pigs cause agricultural economic losses, farm and regional scale losses have not been well documented. In their recent *National Feral Pig Management Report* (APL, 2020) Australia Pork limited cited (McLeod, 2004) who had calculated an estimated annual $106.5 million of direct economic cost to the agricultural industry, 16 years previously. Australia Pork Limited also noted this could be a conservative figure.

The improved seasonal conditions across NSW over the past 12 months have triggered increased breeding in feral pig populations. Population increases and concerns of farmers have been reflected in rural media. ABC Central West (2021) reported an individual farmer near Bathurst in the Central Tablelands had estimated his sheep enterprise losses at $300,000 for the 2020-21 period.

The North West NSW LLS engages in feral pig management through the provision of information, subsidisation of 1080 poison for feral pig baiting and the coordination of aerial shooting for feral pig management.

Using survey data from primary producers and their agronomists, this analysis aims to quantify economic losses attributed to feral pigs for NW NSW in the period of Winter 2020 and Summer 2020-21.

Method

The method used reflects that of *Cost benefit analysis of feral pig control in North West NSW* (Powell et al., 2020). This analysis furthers the study by focusing on the Winter 2020 and Summer 2020-21 timeframe.

The top ten agricultural enterprises in the study area by value (affected by feral pigs) in 2015-16 were wheat, chickpeas, cotton (irrigated and dryland), barley, cattle, sorghum, faba beans, canola, hay, sheep (wool and meat) (ABS, 2017b). Table 2 outlines the enterprises included in the analysis, average regional yields, commodity price, hectares estimated within NW NSW and the subsequent losses associated with feral pigs. The largest threat of feral pigs to cattle enterprises is their potential to host and spread disease, however this complex issue has not been included, so cattle enterprises were excluded from this analysis.

The modelling approach incorporated @RISK (a risk analysis package for excel), that captures the high level of potential variation in underlying inputs by using a distribution in place of a static value. The distribution reflects the range of possible values and the probability of them occurring. @Risk uses Monte Carlo stochastic simulation which allows the model to sample random numbers from the distribution to generate results. The model repeated this process twenty thousand times to create a probability distribution for each result that displays the range of possible values and the probability of them occurring.

Unlike the original report which looked at variability over a 10 year period, this report focuses retrospectively on the 12 months from July 2020 to June 2021. The variables modelled (and their data sources) are listed below, their distribution graphs and statistics can be found in *Appendix 1: @RISK model input distributions.*

- NW NSW regional yields Winter 2020, Summer 2020-21 (data sourced from local agronomists)
- NW NSW estimated pig damage Winter 2020, Summer 2020-21 (data sourced from the grower survey in Section 2)
- Commodity prices during the study period (data sources; barley, wheat, sorghum, chickpeas, faba beans & maize – *The Land commodity prices*. Cotton lint – *mixed cotton merchants*)
- Effectiveness and cost of each control method (data from (Powell et al., 2020))

Table 2: Analysis inputs: mean enterprise yield, price, regional ha's and estimated loss attributed to feral pigs

Enterprise	Yield	Estimated loss (% of yield)^	Commodity price**	HA in NW NSW Region#
Barley for grain	*3.75 t/ha*	*3.2*	$216/t	226,750
Canola	*2.2 t/ha*	*1.8*	$570 /t	14,900
Chickpeas	*1.5 t/ha*	*3.5*	$372/t	202,350
Cotton lint (dryland)	*11.5 bales/ha*	*1.75*	$564/bale	62,700
Cotton lint (irrigated)	*2.4 bales/ha*	*1.75*	$564/bale	53,700
Faba beans	*1.5 t/ha*	*2.6*	$345/t	19,400
Hay	*3 t/ha **	*0.75*	$190 /t	13,000
Maize for grain	*4.8 t/ha*	*1.5*	$212/t	5,350
Sorghum for grain	*3 t/ha*	*4.3*	$262/t	117,800
Wheat for grain	*3 t/ha*	*3.2*	$266/t	800,850
Sheep enterprises	94% weaning rate	*4.2*	Lambs $169 /hd	251,000 lambs* under 1 year

 # Information source: ABS Crop Statistics (Kynetec, 2021)
**Information source: ABS Commodity statistics (ABS, 2017a)*
^Information source: Grower service (Section 2)
***Information source: The Land commodity prices*

The calculations in this study are based on information (regional yields and estimated pig damage) obtained from agricultural businesses that responded to the survey. However, since not all businesses in the region provided data, the estimates are subject to sampling variability; that is, they may differ from the figures that would have been produced if information had been collected from all operating businesses.

Calculations used

The following formulas were applied to the analysis to derive economic loss and benefits of control outcomes:

Cropping economic loss (per ha) $= yield\ loss\ attributed\ to\ feral\ pigs\ x\ commodity\ price$

Sheep enterprise regional economic loss $= yield\ loss\ attributed\ to\ feral\ pigs\ x\ opportunity\ cost$

Where ***sheep enterprise opportunity cost*** $=\ lamb\ price\ x\ 21kg\ x\ lambs\ in\ the\ region$

Benefit of control (per ha)

Yield benefit

$$= enterprise\ yield\ x\ (losses\ attributed\ to\ feral\ pigs\ x\ control\ method\ effectiveness)$$

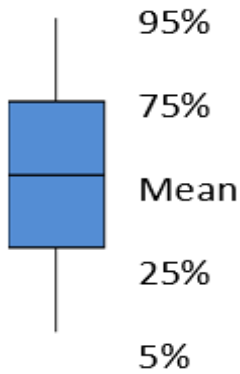
Economic benefit of control

$$= (Yield\ benefit\ x\ commodity\ price) - cost\ of\ control\ method$$

To understand the potential regional economic regional losses, the enterprise economic losses were multiplied by the estimated hectares within the region for each enterprise found in Table 2.

The analysis results are displayed in box and whisker plots to reflect the reality of variable results between farms; these graphs highlight the range and probability of a result occurring. The box and whisker plot (Figure 3) displays the results that fall between the 5th and 95th percentile. These plots exclude the upper and lower "tails" which are more likely to contain outliers (i.e. there is a 90% probability that the result will occur within this range). The box and whisker plots also show the 75th, 50th (mean / average), and 25th percentiles and the mean which is the average result. Inputs and results displayed in the summary tables are the mean results.

Figure 3: Box whisker plot example



Results

The analysis found that feral pigs caused a range of estimated economic loss per hectare which varied depending on the damage done to the enterprise, the potential yield of the enterprise and the value

of the commodity. Table 3 outlines by enterprise the mean economic losses per hectare and an estimated absolute and economic loss by enterprise for the 2020-21 winter and summer seasons.

Table 3: Mean economic losses by enterprise

Enterprise	Economic loss ($/ha)	Commodity loss (NW NSW Region)	Economic loss (NW NSW Region)
Barley for grain	*26*	27,000 t	$5,866,000
Canola	*23*	<1000 t	$338,000
Chickpeas	*30*	11,000 t	$6,073,000
Cotton lint (irrigated)	*113*	13,000 bales	$7,108,000
Cotton lint (dryland)	*24*	2,000 bales	$1,273,000
Faba beans	*13*	<1000 t	$262,000
Hay	*4*	<1000 t	$56,000
Maize for grain	*24*	<1000 t	$127,000
Sorghum for grain	*34*	15,000 t	$3,986,000
Sheep for meat & wool	-	11,000 lambs	$1,778,000
Wheat for grain	*25*	77,000 t	$20,364,000
REGIONAL TOTAL			**$47,231,000**

The economic losses per hectare are influenced typically by the value of production. Within the region, irrigated cotton is a high yielding crop and within the analysis period had higher than average commodity prices. Even as a crop with lower per hectare yield losses attributed to feral pigs, the value of losses in irrigated cotton were three to four times that of other enterprise losses. Hay also had relatively low yield loss attributed to feral pigs and was the lowest per hectare economic loss. This can be attributed to the moderate yields for the season and the relatively low commodity price (good seasonal conditions resulted in reduced supplementary requirements of hay).

Regional commodity losses are in terms of tonnes per hectare (except for cotton which is expressed as bales per hectare and sheep expressed as total number of lambs lost). The wheat enterprise was calculated to experience the largest absolute agricultural losses during the 2020-21 season. The key factor contributing to the relative size of the regional commodity losses was the area planted to each crop during the study period. Wheat was reported to be planted on 800,863 ha during the season equating to 32% of land in the region used for cropping. Across the enterprises included within the study, regional commodity losses were calculated to be 132,000 tonne of grain, 15,000 bales of cotton and 11,000 lambs.

Economic losses at a regional level attributed to feral pig damage was calculated to be $47,231,000 for NW NSW in the 12 months that included Winter 2020 and Summer 2020-21 cropping. During the

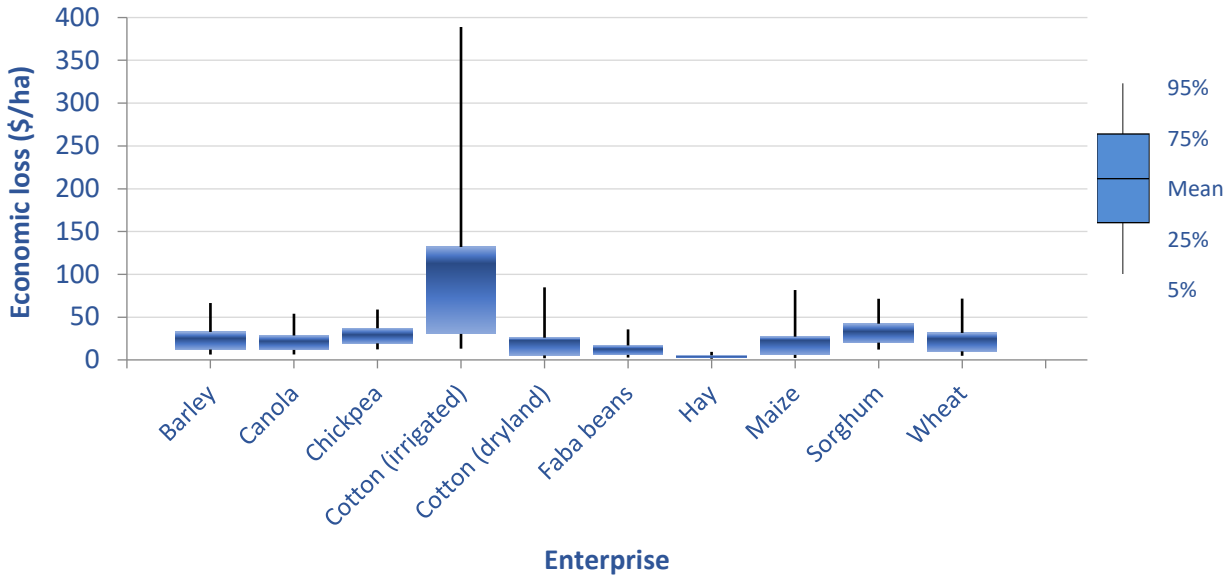
analysis period, wheat contributed to 43% of the total regional losses at $20,364,000. The regional losses by enterprise are most sensitive to the prevalence of the enterprise in the region.

The distribution of the per hectare economic loss (Figure 4) are influenced by the ranges of the variables within the analysis. Commodity prices during the analysis season had a relatively tight range (or distribution), the key variability is within the actual yields achieved in the region and the estimated losses attributed to feral pigs. A wide range is expected in both of these variables due to differing environmental aspects of each farm. These include soil types, farming rotations, rainfall, disease pressures and abundance of feral pigs. Economic losses are lowest (along the lower tail) when crops with poor yields or prices experience low levels of feral pig damage. Economic losses are highest (along the upper tail) when crops achieve above average yields and commodity prices experience high damage from feral pigs.

Irrigated cotton was the standout enterprise with the largest range of estimated losses and 90% of results between $13 to $389 /ha. Experiencing the next largest ranges were the enterprises of barley, dryland cotton, maize, sorghum and wheat with 90% of results between $2 and $85 /ha economic loss. Canola, chickpeas and faba beans experienced similar ranges of economic loss with 90% of results between approximately $6 to $59 /ha. The lowest economic losses were for hay with 90% of results between $1 and $9 /ha.

Cotton was reported as experiencing relatively lower damage from feral pigs compared to the other enterprises, with only maize reported to experience lower yield losses. The mean economic loss and potential per hectare losses for cotton can be attributed to the large gross margin per hectare for this crop during the season (due to higher than average prices and consistently high yields).

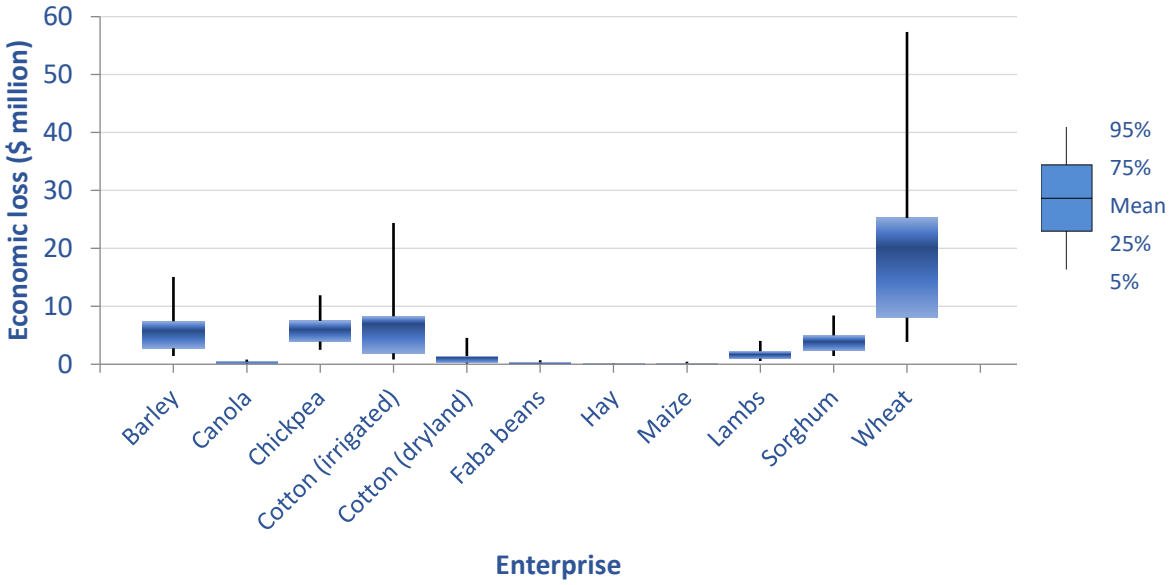
Figure 4: @RISK results. Agricultural losses ($/ha), box whisker chart



Total economic losses at a regional level (Figure 5) were calculated combining the per hectare losses with the area dedicated to an enterprise during the study period. Wheat experienced moderate per hectare losses, however due to its dominance in the cropping landscape, in terms of regional losses wheat was calculated to have the highest losses and the highest range of losses, with 90% of results falling between $4 to $57 million. Irrigated cotton which was planted to 5% of the region's cropping area had the next largest range of total regional economic losses with 90% of results falling between $0.8 to $24 million. As expected, the enterprises with the lowest total planted hectares (canola, faba beans, hay and maize) had the lowest regional losses.

Regional losses of lambs in sheep (wool and meat) enterprises were estimated at $1.7 million. This loss was calculated using a 4.2% lamb loss rate from the farmer surveys and an opportunity cost of $169 /hd for each lamb lost, using estimated lamb numbers (ABS, 2017a) for the region. Per hectare or individual enterprise losses would vary depending on flock size and stocking rates.

Figure 5: @RISK results (regional economic losses), box whisker chart



Benefits of feral pig control vary depending on the control method (or methods) used and the scope of the control program. A long-term, routine control program implemented strategically, using varied methods across an area wide landscape has the highest effectiveness. This was acknowledged in the survey (Section 2), with 100% of respondents agreeing that area wide management of feral pigs resulted in larger and longer-term benefits than individual farm programs.

No control method is 100% effective. The cost of control also needs to be considered; therefore the net benefit of control will never equal the economic losses. As the 2020 study found, the economic benefits per hectare of feral pig control varied depending on the effectiveness and cost of control. The feral pig control methods, costs and their effectiveness in this study reflect those in (Powell et al., 2020) and the input distributions for control method effectiveness and cost can be found in Appendix 1. Aerial shooting and 1080 baiting were found to be the most cost-effective methods across all enterprises, with ground shooting and exclusion fencing broadly the least cost-effective (Powell et al., 2020). However, each control method when used in a strategic targeted approach can be highly effective.

For the NW LLS region, this study found that 36% of economic losses ($17 million) attributed to feral pigs could be avoided by applying the average effectiveness of all control methods across the total area for each enterprise (resulting in 51% of the feral pig population controlled). When a lower range of effectiveness is applied, such as that associated with ground shooting (20% of feral pig population controlled), the net benefit of control could be as low as $1.5 million or 3% of regional economic losses. However, when the effectiveness of control is increased to 60%, which is the estimated effectiveness of both 1080 baiting and aerial shooting (but also potentially achievable on an area wide scale by using

a range of strategically targeted measures in a long-term control program) the net benefit of control increases to $26 million or 55% of regional losses. These findings highlight the potential avoided losses on a regional scale if strategically selected control measures were implemented across the entire region.

Discussion

Compared to the average per hectare losses calculated in the original study (Powell et al., 2020), enterprise losses attributed to feral pigs were both lower and higher in 2020-21 – depending on commodity. Yields in the study period were generally higher than average reflecting the good season, commodity prices were also higher than average, feral pig losses were estimated higher for some enterprises (cotton, wheat, barley, sorghum and maize) and lower in other enterprises (faba beans, chickpeas, hay and lamb losses) compared to enterprise losses in the original study. These inputs resulted in barley, cotton, maize, sorghum and wheat losses attributed to feral pigs to be higher than average, while chickpeas, faba beans and hay were lower due to the significantly lower yield loss estimates. Canola was not included within the original report.

Yield losses were based on the results of the farmer and agronomist survey (Section 2). As discussed in the method, survey results can be influenced by the survey sample, and farmer-estimates when not specifically measured may result in overstated losses due to the cognitive bias towards loss aversion. However, repeating the same process over three years should still highlight trends and provide meaningful results. Also, outputs as distributions still highlight the potential range of results. For example, total economic regional losses attributed to feral pigs remained high as $32 million in the bottom quartile of results.

In addition to informing the analysis, the survey results (Section 2) also provided insight into the practices and attitudes of respondents towards feral pig management. Respondents reported an increasing abundance of pigs in the summer cropping period and noted that the recent drought had helped to suppress feral pig numbers. 93% of respondents attempted to control feral pigs during the study period and every respondent agreed that on farm feral pig management was important to them.

Favourable seasonal conditions for the 2021-22 season would suggest that feral pig numbers if left unmanaged could quickly balloon, thereby increasing agricultural losses at both a farm and regional scale. This is the first annual report of a three year study; patterns of abundance, loss and control may become evident across the three year study period.

From the survey, informal farm networks were found to be the most used and most relied upon resource for information on feral pig control followed by Government resources such as LLS. The highest utilised LLS feral pig management resources were the fact sheets outlining the benefits of

control. Survey respondents also reported that they understood the economic benefits of control and most respondents agreed that the benefits outweighed the total cost of control – even if the control cost was not subsidised. 20% of respondents answered they were either unsure or unwilling to maintain aerial shooting control programs without subsidisation, suggesting a potential change in the mix of utilised control methods should subsidies be reduced. A more detailed study would be required to understand the economic impact of feral pig control subsidisation.

Conclusion

Understanding how economic losses attributed to feral pigs varies between seasons can be helpful in planning and promoting control programs for the highest economic benefit. This is the first of three consecutive seasonal reports to estimate agricultural economic losses attributed to feral pigs in the North West NSW LLS region. The report found that between the ten enterprises included within the analysis, regional losses for the Winter 2020 and Summer 2020-21 seasons were estimated at $47 million.

To examine this regional result, firstly per hectare losses were calculated for each cropping enterprise by multiplying regional yields by losses attributed to feral pigs and the value of each commodity. Mean per hectare losses ranged from $113 /ha for irrigated cotton down to $4 /ha for hay enterprises.

At a regional level, economic losses attributed to feral pigs in wheat and barley contributed to 43% and 12% of regional losses respectively due to the large proportion of cropping area dedicated to these enterprises. Cotton (including dryland and irrigated enterprises) contributed to 18% of regional losses. The regional economic losses for sheep attributed to feral pigs was valued at $1.7 million (about 4% of total regional losses). The total regional economic losses of each enterprise was most sensitive to the area dedicated to the enterprise, or in the case of the sheep enterprises the estimated number of lambs in the region.

The analysis found that the increased control effectiveness of areawide strategic feral pig control programs could reduce agricultural losses by an estimated 55% with an associated net economic benefit valued at $26 million.

Compared to the 2020 report, yield loss attributed to feral pigs was higher in some enterprises and lower in others. During the analysis period most enterprises experienced higher than average yields and higher commodity prices. In general, economic losses per hectare were higher in 2020-21.

The survey highlighted the fact that most farmers understood the benefits and were willing to implement feral pig control programs both at a farm and area wide scale. The mix of control methods could potentially change should existing subsidies by reduced. Further research into the effectiveness and impact of subsidisation is recommended.

This study could be improved by valuing other costs of feral pigs to livestock enterprises such as losses from pigs eating grain out of feeders, reduced breeder productivity from disease or reducing pasture yield of grazing areas. Further studies are also required to value the economic losses attributed to feral pigs to agricultural infrastructure such as fencing and irrigation channels and environmental assets in the North West NSW LLS region.

SECTION 2: Survey results

A primary survey was conducted to understand the experience farmers within the North West LLS region had with feral pigs during the Winter 2020 and Summer 2020-21 timeframes.

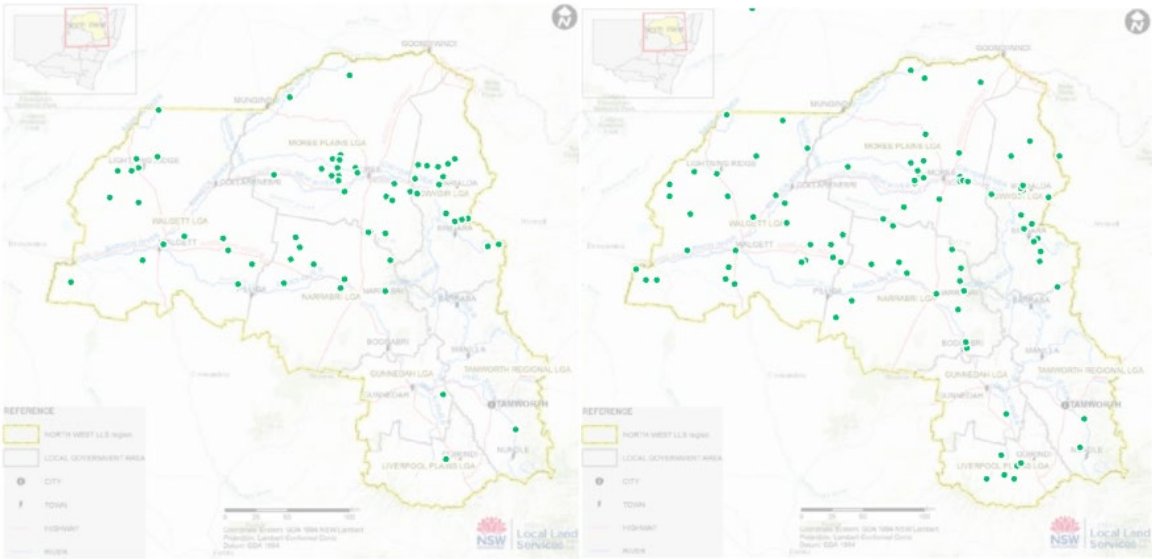
Survey distribution

A survey on feral pig impact and management during the Winter 2020 cropping period was distributed in February 2021. And a survey focusing on the 2020-21 summer cropping and livestock was distributed in May 2021.

The surveys were distributed via social media, direct e-mails (Ag Econ and LLS) and e-mails via a number of third-party agricultural organisations. Additionally, farmers were contacted directly via telephone. The survey was targeted at farm owners or managers.

The winter 2020 survey had 67 responses covering a total of 204,102 ha in the NW LLS area. The summer 2020-21 survey had 91 responses covering area 543,644 ha in the NW LLS. Some respondents completed both surveys, however most completed one only. The location of respondents within the study region can be seen in Figures 6 & 8.

Figures 6 & 7: Maps indicating (within blue ring) the location of survey respondents. LHS: Winter 2020 survey. RHS: Summer 2020-21 survey.



Feral pig presence and abundance

Respondents were asked if pigs were present on their properties. The survey responses from Winter to Summer remained consistent with **pigs present on 90% of properties surveyed – Summer**.

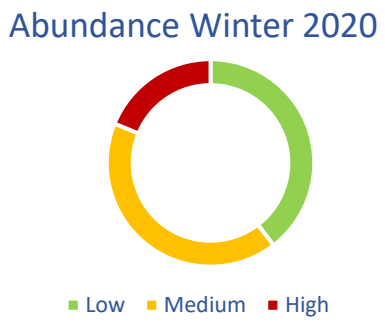
Those with pig presence were asked about the abundance of feral pigs on their farms during each period. Table 4 and Figures 8 & 10 present these results. The response categories were based on the DPI abundance mapping (Figure 1, Section 1).

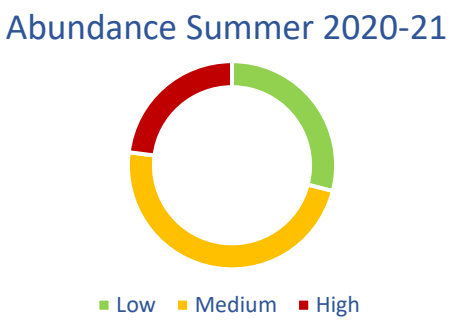
Table 4: Survey responses on Feral pig presence in the North West LLS

Feral pig presence	Winter 2020	Summer 2020/21
Low *(Few sightings, little active sign)*	40%	29%
Medium *(Some animals seen at almost any one time, much active sign - significant sign of animals 50-80% of the time)*	42%	48%
High *(Many animals seen at any time and much sign of activity - significant sign of animals on more than 80% of occasions)*	19%	23%

The results indicated that from the winter to summer periods, pigs had increased in intensity where they were present – potentially indicating that the improved seasonal conditions throughout 2020 triggered breeding and by Summer 2020-21 an increased population was evident.

Figures 8 & 9: Abundance of feral pigs on respondent farms. LHS Winter 2020. RHS Summer 2020-21.





Many respondents chose to leave optional comments about pig presence and abundance. The main response themes were that the prolonged drought had resulted in lower pig presence in the region, but with the improved seasonal conditions in 2020 numbers had started to increase. Also in relation to the good seasons was the increase in vegetation matter that made the pigs difficult to sight. Another key theme in the comments was the attribution of a reduction in pig presence due to active feral pig management. Comments were also made about the higher presence of feral pigs along water ways and adjacent to heavily timbered areas such as National Parks.

Table 5: Survey comments, grouped by theme

Theme	Sample comment	Respondents
Lower numbers attributed to the drought	*"The recent drought had a big impact on pig numbers in this region."*	8
Increase in pressure	*"Around our lambing ewes there was obvious increase in numbers."* *"We trapped 108 pigs in the last three months."*	5
Increase in vegetation made the pigs more difficult to sight	*"Due to the height of the vegetation due to the good season, sightings were few although I knew that they were present due to tracks."*	3
Active management has reduced pig presence	*"Probably a little bit better this year because we joined with National Parks to do some control methods."*	3
Higher presence near timbered areas and waterways	*"They migrate between wetlands to the West and gingham channel / thick timber to the East."*	5

Enterprise damage attributed to feral pigs

Respondents were asked for their best estimate of feral pig damage to select agricultural enterprises (barley, wheat, faba beans, chickpeas, pastures/fodder, hay, cotton, maize, sorghum and lamb losses), see Figure 10. Most losses were reported at less than 1% of yield loss. The lowest losses were reported in hay, maize and cotton. The highest losses were reported for lambs, sorghum, barley and wheat. Respondents were invited to comment on yield loss caused by feral pigs. Some of their comments can be seen in Table 6.

Figure 10: Estimated yield loss (%) caused by feral pigs in select agricultural enterprises

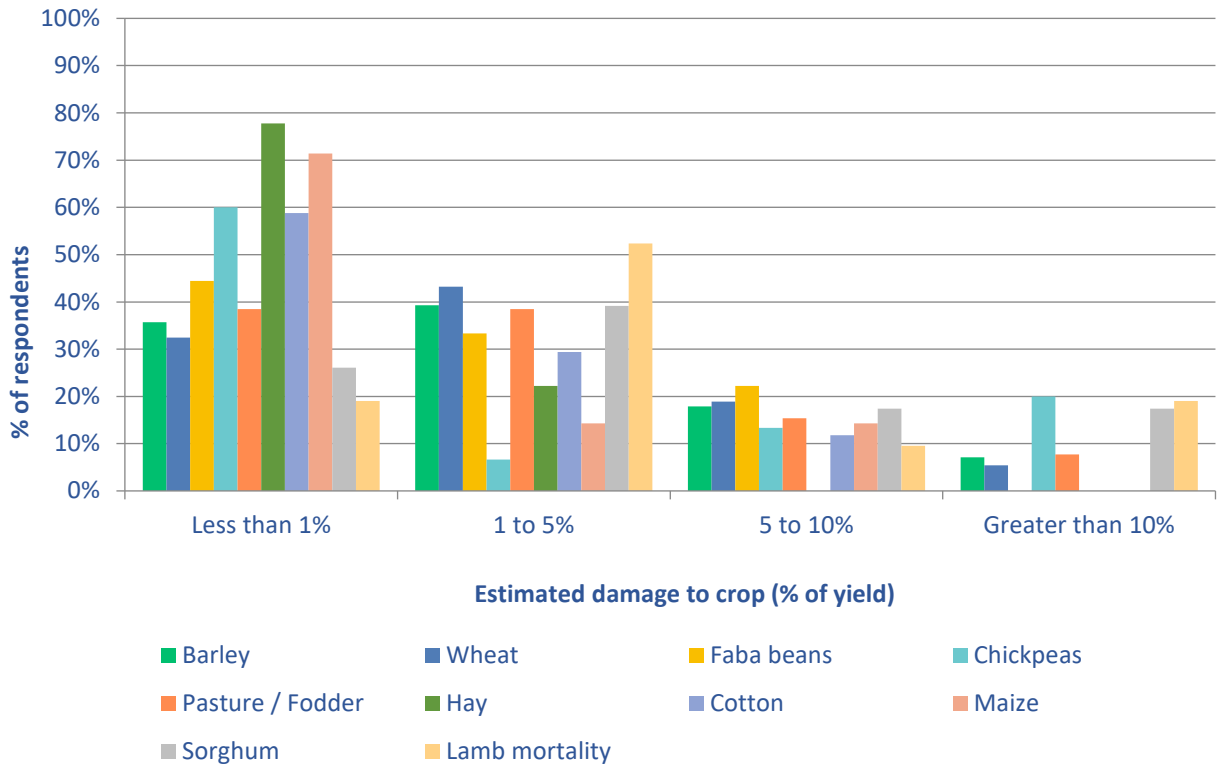


Table 6: Respondent comments on yield loss attributed to feral pigs

Theme	Sample comment	Respondents
Highest pressure near waterways and timber belts	*"Main losses in grazing country near water ways"*	4
Lower losses this year	*"Previous years have been worse"*	1
Active management has reduced yield loss	*"Very little yield loss due to exclusion fencing"*	1
Other or excessive crop losses	*"Estimated 50% loss on oats crop for seed production"*	17

Feral pig control

93% of respondents attempted to control feral pigs during the study period.

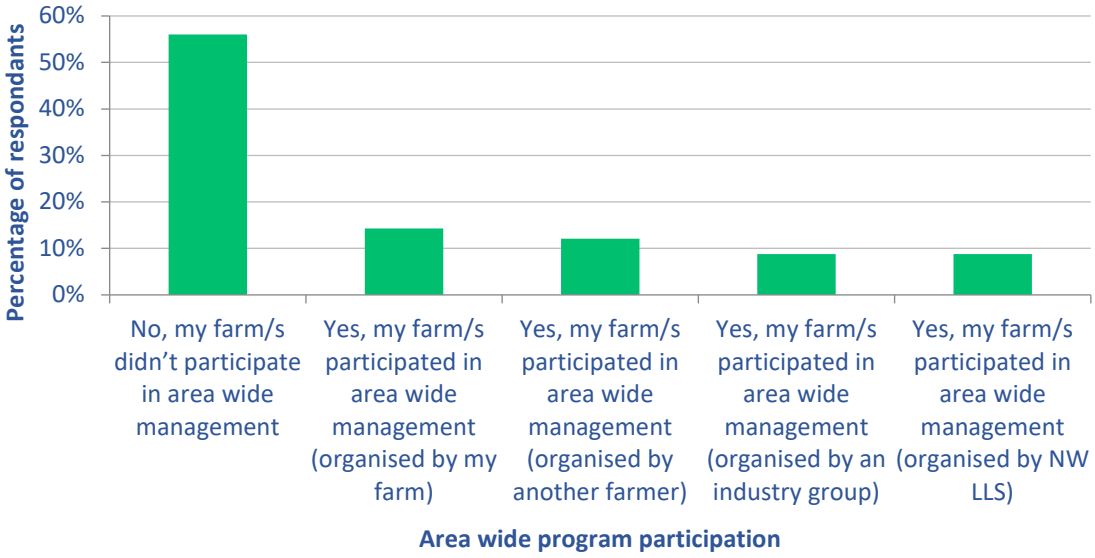
The number of respondents actively controlling feral pigs stayed consistently high at 93% in both the winter and summer cropping periods. This high participation in control indicates the extent of the feral pig problem and that farmers understand the general benefits of control.

Respondents were surveyed on the feral pig control methods they relied on most for their farms. The answer to this question indicates which methods farmers are prepared to use and how effective they believe each method to be. Ground shooting was reported as the most used control method and the most relied upon, followed by trapping (Figure 11). These two methods have been found to be the least effective feral pig control measures (Powell et al., 2020). Aerial shooting was the next most relied upon control measure, followed by 1080 baiting and lastly exclusion fencing was the least relied upon for feral pig control. The average number of control methods relied upon was 2.5, with most relying upon at least two control methods and many relying on up to four methods. The more methods a respondent utilised may indicate that they understand that different methods provide the highest benefits in varied situations.

Figure 11: Control methods most relied on in Winter 2020 & Summer 2020-21.

49% of respondents participated in area wide management programs for feral pigs in Winter and 41% Summer 2020-21. The area wide programs were mostly organised by the individual farmers or their neighbours (see Figure 12).

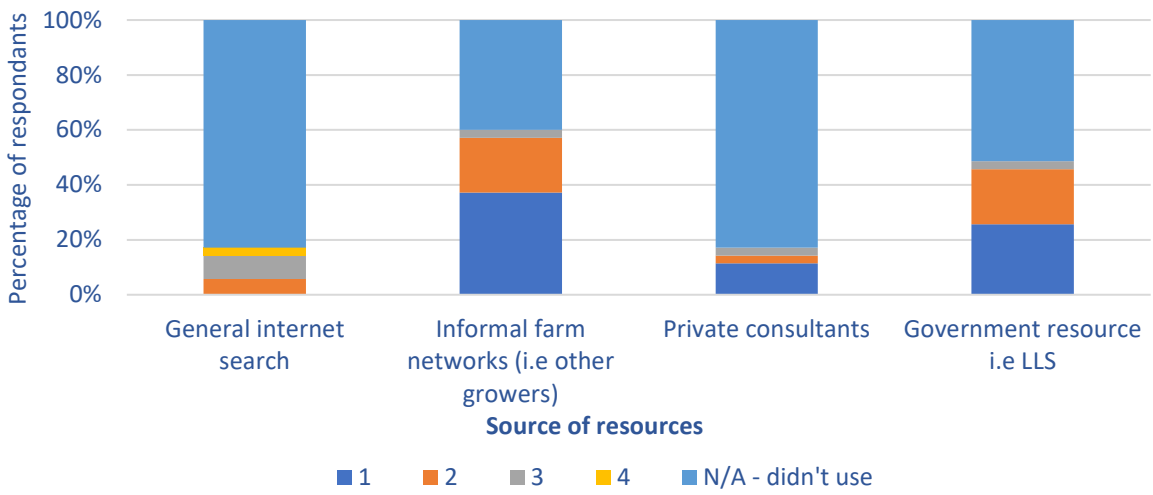
Figure 12: Did your farm participate in area wide management of feral pig control?



Information sources used by farmers

Respondents were asked to rank the usefulness of resources used to inform feral pig management (1 = most useful and 4 = least useful) (Figure 13). Informal farm networks was the most used resource and the resource that was thought to be most useful. Government resources such as LLS was the second most useful resource followed by private consultants and general internet searches.

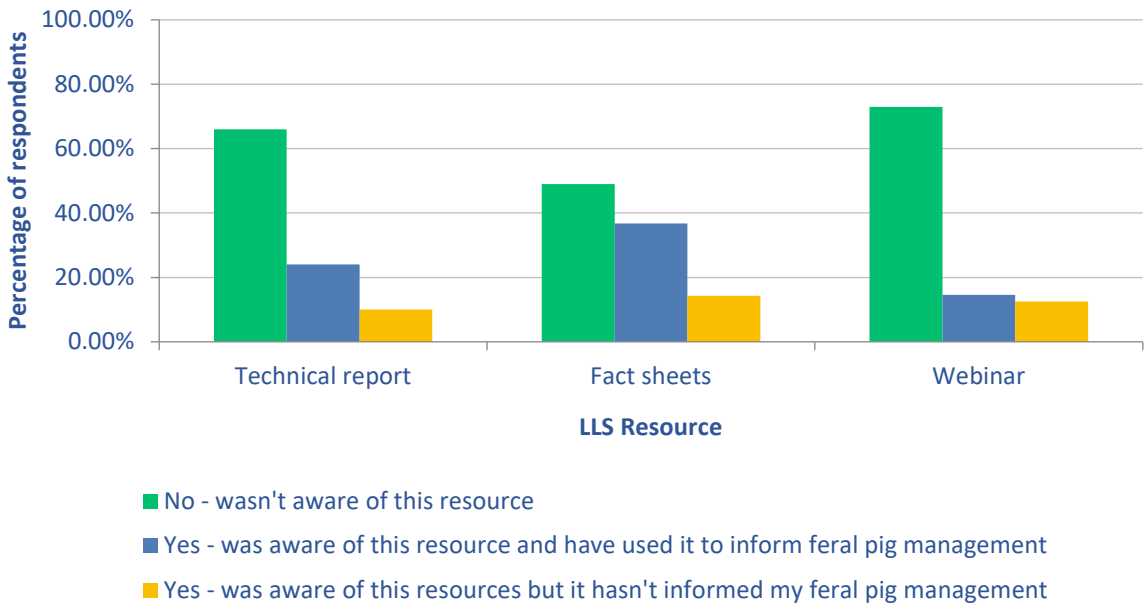
Figure 13: Source of resources, ranked by usefulness to inform feral pig management (1 = most useful, 4 = least useful)



LLS information resources for feral pig control

Respondents were asked about their awareness and use of a selection of LLS resources. The fact sheets were the resource that had the highest awareness (at 51%) and the highest use with 37% of respondents reporting to have used these resources to inform their feral pig management. While the overall awareness was lower for the technical report "*Cost benefit analysis of feral pig control in North West NSW",* however 24% of all respondents reported to have used this resource. The *Damage feral pigs do to your hip pocket WEBINAR* had the lowest awareness and use.

Figure 14: Awareness and utilisation of LLS resources on feral pig control



Attitudes to feral pig management

The last survey question attempted to gauge the attitude of respondents around various aspects of feral pig management. The questions asked and a summary of attitudes are found in Figure 15. **Every respondent agreed that on farm feral pig management was important** (75% strongly agreed, 25% agreed). Similarly, every respondent reported to understand the economic benefits of feral pig control (70% strongly agreed and 30% agreed). **All respondents agreed that the benefits of participating in area wide management programs were larger and longer than individual farm programs** (72% strongly agreed, 28% agreed).

When asked if they would continue feral pig control without subsidisation, 42% of respondents strongly agreed and 38% agreed, while 17% remained neutral and 3% disagreed. When asked if they would continue to control feral pigs with unsubsidised aerial shooting, 25% strongly agreed, 28%

agreed, 28% were neutral or unsure, 13% disagreed and 6% strongly disagreed. These answers suggest that **without subsidisation most farms would continue with feral pig management, however the mix of control methods may be adjusted to cheaper less efficient methods.**

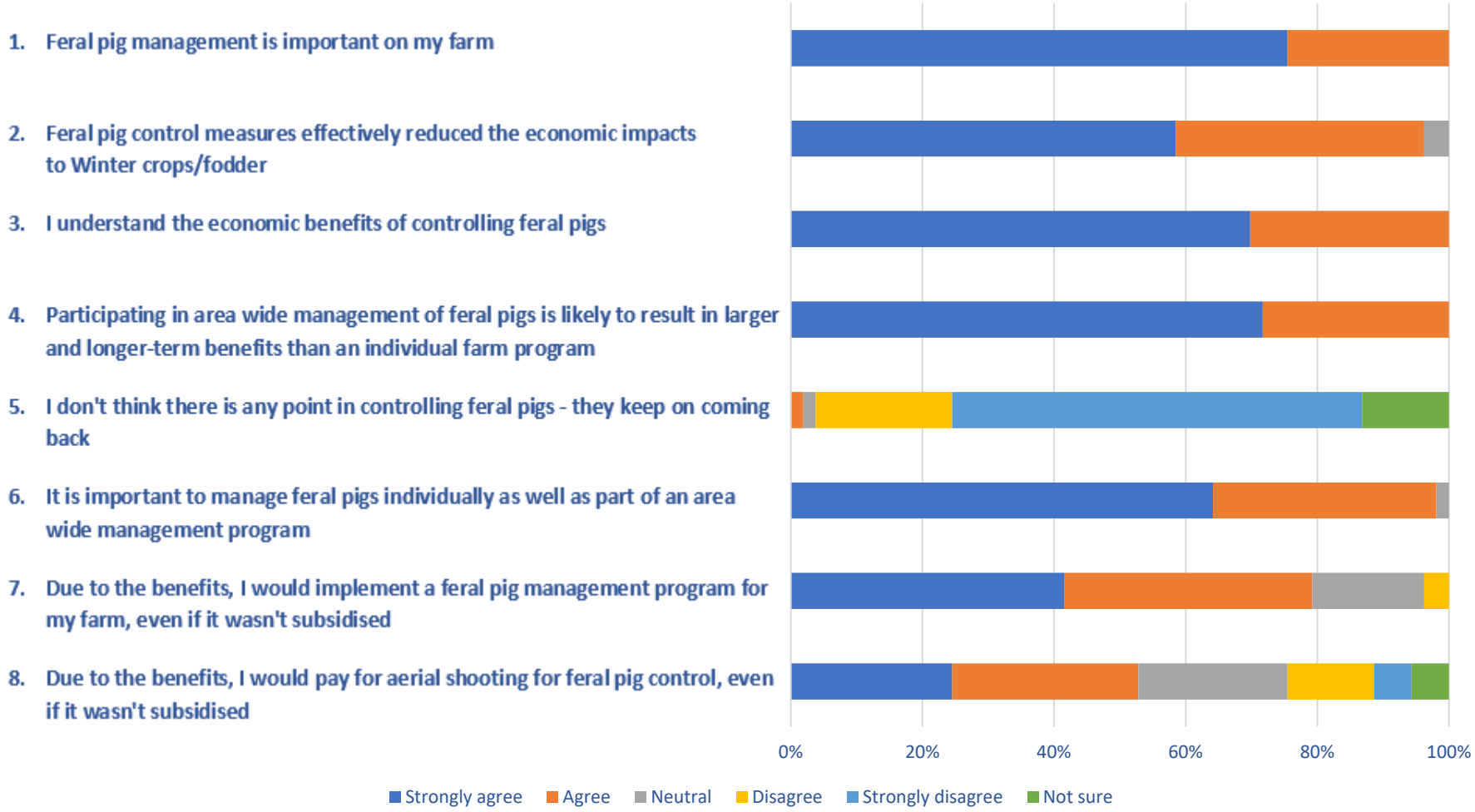
Some survey respondents used the final chance to comment (see Table 7) to make suggestions for area wide management programs, such as the development of 1080 meat baits that were pig strength so that wild dogs and pigs could be targeted at the same time. Comments were also made about the willingness to participate in aerial shooting programs, the importance of control and control timing. The final survey comments were generally in line with the attitudinal findings that feral pig control is important and that respondents are motivated to continue control programs.

The survey provided a strong insight into the effect of feral pigs and the effectiveness of control options utilised by land managers in the North West LLS region of New South Wales.

Table 7: Respondents final survey comments

Theme	Sample comment	Respondents
Benefits of aerial shooting	*"Currently we have neighbours that are shooting the feral pigs and letting us know so we can participate."*	3
Area wide program suggestions	*"Need pig strength meat 1080 baits, it would help with dog baiting programs and may control both pests at once."*	3
	"I would like to see an aerial shoot every twelve months with all parties involved not just one farmer to wear the cost. Make the aircraft available before sowing each year. Phone number to contact who is authorised to do the shooting with the aircraft."	
	"We think all means of pig control should be subsidised"	
Increased pressure	*"In the last few weeks, we have noticed a lot of pig diggings in the cultivation, due to the lush season."*	1
Control timing is key	*"Would only pay for aerial shooting at specific times e.g. calving"*	3
Importance of control	*"Pig control in lambs and sheep are very important"*	2

Figure 15: Survey results for attitudinal questions on feral pigs



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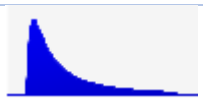
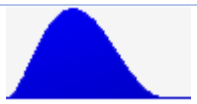
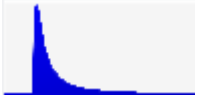
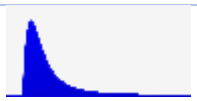
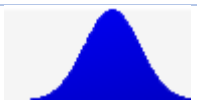
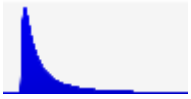
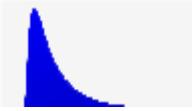
Appendix 1: @RISK model input distributions

Cropping Enterprises					
Input	**Data distribution graph**	**Mean**	**5%**	**95%**	**Data sources**
Barley price		$216 /t	$195 /t	$244 /t	The Land
Barley yield		3.75 t/ha	2.3 t/ha	5.6 t/ha	Agronomist survey[1]
Barley yield loss from pigs		3.2%	.9%	7.8%	Survey (Section 2)
Canola price		$571 /t	$529 /t	$668 /t	The Land
Canola yield		2.2 t/ha	1.5 t/ha	3.0 t/ha	Agronomist survey[2]
Canola yield loss from pigs		1.8%	.6%	1.2%	Agronomist survey[1]
Chickpea price		$572 /t	$496 /t	$635 /t	The Land
Chickpea yield		1.5 t/ha	1.0 t/ha	2.2 t/ha	Agronomist survey[1]
Chickpea yield loss from pigs		3.5%	1.7%	6.3%	Survey (Section 2)
Cotton price		$564 /bale	$492/bale	$643 /bale	Mixed cotton merchants
Cotton (irrigated) yield		11.5 bales/ha	8.7 bales/ha	14.2 bales/ha	Agronomist survey[1]

[1] Five independent agronomists across NW NSW, emails and phone communication, July 2021

[2] Five independent agronomists across NW NSW, emails and phone communication, July 2021

Cotton (dryland) yield		2.4 bales/ha	0.8 bales/ha	5 bales/ha	Agronomist survey[1]
Cotton yield loss from pigs		1.75%	0.2%	6%	Survey (Section 2)
Faba bean price		$345 /t	$293 /t	$457 /t	The Land
Faba bean yield		1.5 t/ha	0.7 t/ha	2.3 t/ha	Agronomist survey[1]
Faba bean yield loss from pigs		2.6%	0.7%	6.2%	Survey (Section 2)
Hay price		$190 /t	$174 /t	$206 /t	The Land
Hay yield		3.0 t/ha	1.1 t/ha	6.2 t/ha	Agronomist survey[1]
Hay yield loss from pigs		0.75%	0.5%	1.1%	Survey (Section 2)
Maize price		$330 /t	$234 /t	$396 /t	The Land
Maize yield		4.8 t/ha	2.0 t/ha	9.3 t/ha	Agronomist survey[1]
Maize yield loss from pigs		1.5%	0.2%	4.9%	Survey (Section 2)
Sorghum price		$262 /t	$251 /t	$273 /t	The Land
Sorghum yield		3.0 t/ha	1.7 t/ha	4.8 t/ha	Agronomist survey[1]
Sorghum yield loss from pigs		4.3%	1.9%	8.1%	Survey (Section 2)
Wheat price (H2)		$266 /t	$245 /t	$294 /t	The Land

Wheat yield		3.0 t/ha	1.8 t/ha	4.6 t/ha	Agronomist survey[1]
Wheat yield loss from feral pigs		3.2%	0.7%	8.7%	Survey (Section 2)
Sheep: lamb price		$168 /hd	$151 /hd	$183 /hd	The Land
Sheep: lamb losses		4.2%	1.3%	9.5%	Survey (Section 2)
Control methods					
Input	**Data distribution graph**	**Mean**	**10%**	**90%**	**Data sources**
Aerial shoot cost		$1.19 /ha	$0.37 /ha	$2.09 /ha	(Lockrey and Marshall, 2019, Saunders, 1993, Cowled et al., 2006) (Personal Communication, GVIA[3])
Aerial shoot effectiveness		59%	37%	81%	(Lockrey and Marshall, 2019, Cowled et al., 2006, Saunders, 1993) (Personal Communication[4])
Baiting cost		$1.17 /ha	$0.38 /ha	$2.09 /ha	(Lockrey and Marshall, 2019)
Baiting effectiveness		59%	37%	82%	(Lapidge, 2003, Saunders et al., 1993, Twigg et al., 2005, Hone and Pedersen, 1980) (Personal Communication[4])

[3] Gwidir Valley Irrigator's Association, emails and phone communication, May 2020

[4] Dave Lindsay, Local Land Services, emails and phone communication, June 2020

Exclusion fence cost		$12.81 /ha	$7.92 /ha	$18.01 /ha	(Hone and Atkinson, 1983, Lockrey and Marshall, 2019)
Exclusion fence effectiveness		70%	55%	85%	(Hone and Atkinson, 1983, Lockrey and Marshall, 2019) (Personal Communication[4])
Ground shoot cost		$5.18 /ha	$2.80 /ha	$7.61 /ha	(Lockrey and Marshall, 2019)
Ground shoot effectiveness		20%	10%	30%	(McLeod and Norris, 2004, Gentle and Pople, 2013, Lockrey and Marshall, 2019) (Personal Communication[5])
Trapping cost		$1.30 /ha	$0.44 /ha	$2.57 /ha	(Lockrey and Marshall, 2019)
Trapping effectiveness		45%	25%	65%	(Lockrey and Marshall, 2019, Saunders, 1993, Lapidge, 2003) (Personal Communication[5])

[5] Dave Lindsay, Local Land Services, emails and phone communication, June 2020