Economic impact of feral pigs on agricultural production in North West NSW: 2021-22

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Economic impact of feral pigs on agricultural North West NSW: 2021-22

Client: **North West Local Land Services (NSW)**

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Executive Summary

The region of North West NSW with its vast areas of highly productive agricultural land adjoining national parks and natural waterways make an ideal habitat for feral pigs. This study estimated that during the period from July 2021 to June 2022, feral pigs cost the region an estimated $56 million in lost agricultural production, an increase of 19% from last season.

The study is the second in a series of three seasonal analyses that aim to build 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 2021 and Summer 2021-22 crops, this analysis used seasonal inputs including regional yields, commodity prices and estimated 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 (and change from previous years analysis)

Enterprise	Cost of feral pigs	Key mean inputs			Regional losses ($ million)
		Anticipated damage by feral pigs (% of yield)	Regional yields	Commodity prices	
Barley for grain	*$24 /ha* ↓	*2.30* ↓	*4.1 t/ha* ↑	$252/t ↑	6.32 ↑
Canola	*$32 /ha* ↑	*1.53* ↓	*2.5 t/ha* ↑	$841/t ↑	1.42 ↑
Chickpeas	*$28 /ha* ↓	*2.86* ↓	*2.1 t/ha* ↑	$467/t ↓	5.63 ↓
Cotton lint (irrigated)	*$61 /ha* ↓	*0.69* ↓	*11.6 bales/ha* ↑	$759/bale ↓	9.32 ↑
Cotton lint (dryland)	*$28 /ha* ↑	*0.69* ↓	*5.36 bales/ha* ↑	$759/bale ↓	3.48 ↑
Faba beans	*$22 /ha* ↑	*2.17* ↓	*3.0 t/ha* ↑	$340/t ↓	8.84 ↑
Grain in storage (bags & bunkers)	*$13 /ha*				6.99 .
Hay	*$29 /ha* ↑	*5.45* ↑	*3.5 t/ha* ↑	$151 /t ↓	0.43 ↑
Maize for grain	*$61 /ha* ↑	*1.8* ↑	*10.5 t/ha* ↑	$320/t ↑	0.18 ↑
Oats	*$10 /ha*	*2.62*	*1.38 t/ha*	$273	0.29 .
Sorghum for grain	*$36 /ha* ↑	*3.34* ↓	*4 t/ha* ↑	$271/t ↑	5.21 ↑
Wheat for grain	*$9 /ha* ↓	*0.92* ↓	*3.2 t/ha* ↑	$307/t ↑	9.56 ↓
Sheep and lambs		*7.7* ↑	94% weaning rate	$182 /hd ↑	6.21 ↑
Total regional losses Winter 2021 & Summer 2021-22					**55.92** ↑

The method considered 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 per hectare enterprise losses would be incurred for the Summer 2021-22 crop of irrigated crops of cotton and Maize both returning a loss of $61 /ha attributed to feral pigs, up to six times higher than the other crops. Cotton was estimated to sustain the lowest percentage yield losses by feral pigs, however this was offset by the high commodity value and high per hectare yields of the crop . Maize, also a high yielding irrigated crop, was modelled with higher yield losses, offsetting the lower commodity prices. The lowest per hectare losses was calculated for wheat. This result is attributed to the crop being modelled with the lowest yield damage, despite above average prices and yields for the season. However, on a regional scale, wheat experienced the highest enterprise losses of $9.56 million due to its dominance in the winter cropping landscape. Regionally, cotton, barley and Sorghum also experienced significant losses. 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 over $6 million. This was calculated using a 7.7% lamb loss rate from the farmer surveys and an opportunity cost of $182 /hd for each lamb lost. The regional loss was calculated using Australian Bureau of Statistics estimated lamb numbers for the region from the 2020-21 (ABS, 2022). Per hectare or individual enterprise losses vary depending on flock size and stocking rates, hence per hectare losses were not tabled.

Across all enterprises, the high per hectare and regional losses were influenced by the good agricultural seasons with generally higher than average yields and generally higher than average commodity prices, however feral pig losses were mixed. Lamb, maize and hay enterprises were all estimated to have experienced increased unit losses, with the remaining enterprises all estimated to experience lower losses than the previous study (Powell and Revell, 2021). For the NW NSW LLS region, this study estimated targeted, area wide control programs during the study period could have provided a net economic benefit of $20 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.

For two years in a row, the survey results indicated an increasing abundance of pigs in the region, despite 90% of survey respondents reporting to have actively implemented control measures for feral pigs using an increased range of control methods compared to the pervious study. On average respondents estimated that they had reduced feral pig numbers on their farms by 41%, with the consistent message that control would be most effective within a formal area wide program that was potentially mandatory.

Contents

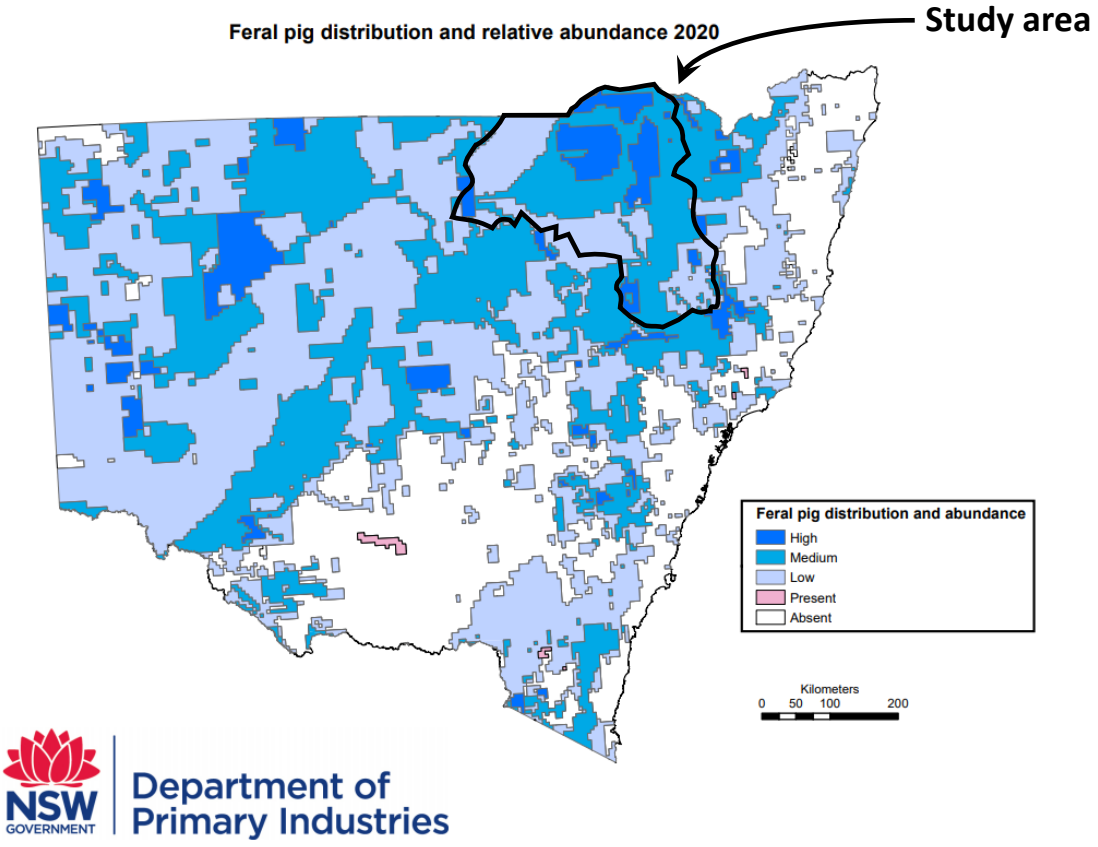
SECTION 1: Economic impact of feral pigs on agricultural production in North West NSW, Winter 2021 & Summer 2021-22.

Introduction

In 2020, LLS commissioned a three-part series on the annual economic impact of feral pigs to agricultural production in North West NSW. This is the second report in the series that includes analysis considering economic losses specifically for the Winter 2021 and Summer 2021-22 seasons in the study area of 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). The most 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)



Agricultural enterprises in NW 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, including endemic and also exotic threats such as foot-and-mouth disease (if it were to reach Australia). ABARES has recently estimated the cost of a multi-state outbreak of the highly infectious disease (that affects cloven-hoofed animals such as cattle, sheep, pigs and goats) to be around $80 billion over 10 years (ABARES, 2022b). Within sheep enterprise, losses attributed to feral pigs come predominately in the form of lamb losses due to pig predation.

The NW NSW LLS engages in feral pig management through the provision of control 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 2021 and Summer 2021-22.

Method

The method used reflects that of *Cost benefit analysis of feral pig control in North West NSW* (Powell et al., 2020) and *Economic impact of feral pigs on Agriculture in North West NSW: 2020-21* (Powell and Revell, 2021). This analysis continues the study by focusing on the Winter 2021 and Summer 2020-22 timeframe.

The top agricultural enterprises in the study area by value (affected by feral pigs) in 2020-21 (the most recent available data) were wheat, cotton (irrigated and dryland), cattle, barley, chickpeas, sorghum, sheep (wool and meat), canola, hay, faba beans and oats (ABS, 2021). The largest threat of feral pigs to cattle enterprises is their potential to host and spread disease, however this complex issue has not been valued, so cattle enterprises were excluded from this analysis. 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. As this is the second analysis in a series of three, arrows indicate if the values are higher or lower than the first report (Powell and Revell, 2021).

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.

This report focuses retrospectively on the 12 months from July 2021 to June 2022. 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 2021, Summer 2021-22 (data sourced from local agronomists, Cotton Yearbook (Greenmount Press, 2022) and ABS data (ABS, 2022))
- NW NSW estimated pig damage Winter 2021, Summer 2021-22 (data sourced from the grower survey in Section 2 and local agronomist surveys)
- Commodity prices during the study period (data sources; barley, canola, chickpeas, faba beans, hay, maize, sorghum & wheat – *The Land commodity prices*. Cotton lint – *mixed cotton merchants,* lamb – MLA)
- Effectiveness of each control method (data from (Powell et al., 2020))
- Cost of each control method was increased by 18% - from the costs originally reported (Powell et al., 2020) to reflect the increase in farm costs over the two year period from 2020, as reported by (ABARES, 2022a)

Table 2: Analysis inputs: mean enterprise yield, price, regional ha's and estimated loss attributed to feral pigs. Arrows indicate increase or decrease compared to the previous year's analysis).

Enterprise	**Yield^**	**Estimated loss (% of yield)^**	**Commodity price****	**HA in NW NSW Region#**
Barley for grain	*4.1 t/ha* ↑	*2.30* ↓	$252/t ↑	266,000 ↑
Canola	*2.5 t/ha* ↑	*1.53* ↓	$841/t ↑	44,200 ↑
Chickpeas	*2.1 t/ha* ↑	*2.86* ↓	$467/t ↓	201,000 ↓
Cotton lint (irrigated)	*11.6 bales/ha* ↑	*0.69* ↓	$759/bale ↓	124,100 ↑
Cotton lint (dryland)	*5.36 bales/ha* ↑	*0.69* ↓	$759/bale ↓	153,400 ↑
Faba beans	*3.0 t/ha* ↑	*2.17* ↓	$340/t ↓	40,000 ↑
Hay	*3.5 t/ha* ↑	*5.45* ↑	$151 /t ↓	15,000 ↑
Maize for grain	*10.5 t/ha* ↑	*1.8* ↑	$320/t ↑	3,000 ↓
Sorghum for grain	*4 t/ha* ↑	*3.34* ↓	$271/t ↑	144,000 ↑
Oats*	*1.38 t/ha*	*2.62*	$273	29,900
Wheat for grain	*3.2 t/ha* ↑	*0.92* ↓	$307/t ↑	1,058,000 ↑
Sheep enterprises	94% weaning rate	*7.7* ↑	Lambs $182 /hd ↑	443,000 lambs ↑ marked in NW NSW

Grain storage (bags & bunkers)*	*2.93##*	$327 /t

Information source:
^Local agronomists and ABS Commodity statistics (ABS, 2022)
^^ Grower survey (Section 2)
***The Land commodity prices (accounting for freight differentials to NW NSW), MLA and mixed cotton merchants.*
 # Last reported SA4 (NW NSW) data was ABS Ag Commodities, 2020-21 (ABS, 2022). Applied the % change in NSW crop (ABARES Australian Crop report 22) to get indicative hectares for the region in 2021-22. No longer being able to access statistics specific to the region reduces the accuracy of the report.
**Enterprises included within analysis for the first time*
Information source, Grower survey. An average grain price of (wheat, barley, faba beans, chickpeas and sorghum) was used for stored grain.

Grain lost to feral pigs in temporary storage such as bags and bunkers was not considered in previous analyses. These losses are incurred when feral pigs chew holes in tarps and grain storage bags to eat the grain. Losses include the grain that is eaten, but more significantly the grain that is weather damaged (it becomes rotten when rain enters through the holes). Survey respondents (Section 2) reported the total tonnage of grain in storage and the estimated tonnage lost due to feral pig damage. Estimated losses were 2.93% of total grain stored. To value the stored grain, an average grain price was applied derived from; wheat, barley, faba beans, chickpeas and sorghum. The value of the stored grain losses was divided by the total cropped hectares of respondents within the survey that used grain bags to give an estimated per hectare value to stored grains losses.

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) $= yield\ loss\ attributed\ to\ feral\ pigs\ x\ commodity\ price$

Grain storage loss (per ha) $= \frac{tonnage\ loss\ attributed\ to\ feral\ pigs\ x\ stored\ grain\ price}{total\ hectares\ of\ farms\ using\ temp\ grain\ storage}$

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

Where *sheep enterprise opportunity cost* $= lamb\ price\ x\ 23kg\ x\ lambs\ in\ the\ region$

Benefit of control (per ha)

Yield benefit

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

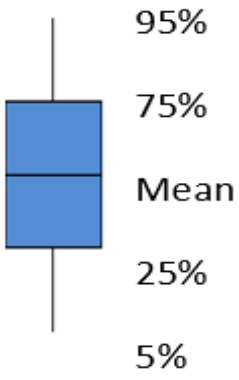
Economic benefit of control

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

To understand the potential regional economic losses, the enterprise economic losses were multiplied by the estimated hectares within the region for each enterprise found in Table 2. In the 2020 and 2021 impact reports (Powell and Revell, 2021, Powell et al., 2020) ABS cropping data was available at a *Statistical Area Level 2* (that closely reflected LGA level data), for the 2021-22 model ABS cropping data was only available at a state level, reducing the accuracy of the results. The region's hectares were estimated by applying the percentage change in hectares grown to each enterprise in NSW.

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 2) 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 75thand 25th percentiles, and the mean (average) result. Inputs and results displayed in the summary tables are the mean results.

Figure 2: Box whisker plot example



By considering the full range of potential values for each input variable, @RISK can clearly identify the extent to which the results are sensitive to each model variable.

Results

Modelling results indicated a range of estimated economic losses attributed to feral pig damage. Table 3 outlines by enterprise the mean economic losses per hectare and an estimated absolute regional economic loss by enterprise for winter 2021 and summer 2021-22 seasons.

Table 3: Mean economic losses by enterprise. Arrows indicate increase or decrease compared to the previous year's analysis.

Enterprise	Economic loss ($/ha)	Commodity loss (NW NSW Region)	Economic loss (NW NSW Region) ($ million)
Barley for grain	*24* ↓	25,000 t ↓	6.32 ↑
Canola	*32* ↑	2,000 t ↑	1.42 ↑
Chickpeas	*28* ↓	12,000 t ↑	5.63 ↓
Cotton lint (irrigated)	*61* ↓	12,000 bales ↓	9.32 ↑
Cotton lint (dryland)	*28* ↑	5,000 bales ↑	3.48 ↑
Faba beans	*22* ↑	3,000 t ↑	0.88 ↑
Grain in storage (bags & bunkers)	*13* *	27,000 t .	6.99 .
Hay	*29* ↑	3,000 t ↑	0.43 ↑
Maize for grain	*61* ↑	<1000 t ↑	0.18 ↑
Oats for grain	*10* *	1000 t .	0.29 .
Sorghum for grain	*36* ↑	19,000 t ↑	5.21 ↑
Sheep for meat & wool	-	34,000 lambs ↑	6.21 ↑
Wheat for grain	*9* ↓	31,000 t ↓	9.56 ↓
REGIONAL TOTAL			**$55.92 million**

**First time that Oats and stored grain has been included within analysis*

The 'in-crop' economic losses per hectare ranged from $9 to $61 and were influenced by a combination of the yield loss incurred due to feral pigs, the yield of the enterprise and the commodity price. Within the region, irrigated cotton is a high yielding, high value crop. Even as the crop with lowest per hectare yield losses attributed to feral pigs, the value of losses in irrigated cotton ($61 /ha) were up to 6 times that of other enterprise losses. Maize, also a high yielding irrigated crop, but with lower commodity prices than cotton, experienced similar per hectare losses as the yield loss from feral pigs was higher. The wheat enterprise had the lowest per hectare economic loss of $9. This is attributed to the relatively low yield loss associated with feral pigs, combined with wheat's moderate yield and commodity price.

Grain storage economic losses attributed to feral pigs were not quantified in previous analyses. This analysis indicated an estimated loss of $13 /ha to account for grain lost in temporary storage such as grain bags and bunkers.

Regional commodity losses are in terms of total tonnes estimated to be lost due to feral pig (except for cotton which is expressed as bales per hectare and sheep expressed as total number of lambs lost). Wheat production experienced the largest absolute commodity losses during the 2021-22 season. Building on the 'in-crop' losses, the regional commodity losses were also sensitive to the area planted to the crop during the study period. Wheat was estimated to be planted to just over 1 million ha during the season equating to 50% of land in the region used for cropping. Across the enterprises included within the study, regional commodity losses were calculated to be 95,000 tonnes of grain 'in crop' and 27,000 tonne of grain in storage plus, 15,000 bales of cotton and 34,000 lambs.

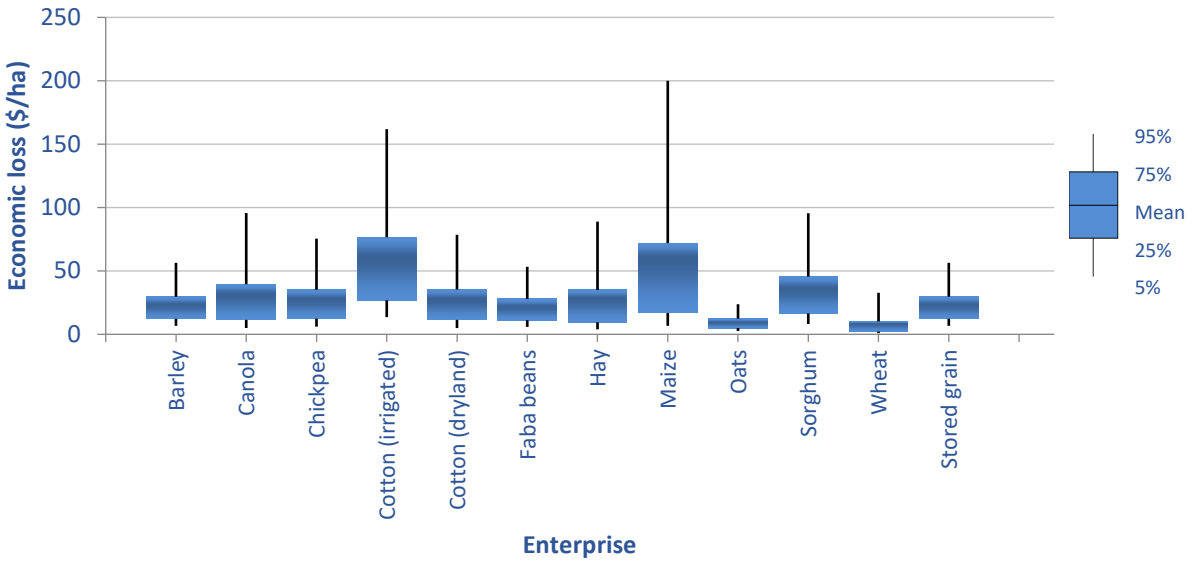
Economic losses at a regional level attributed to feral pig damage was calculated to be $56 million for NW NSW in the 12 months that included Winter 2021 and Summer 2021-22 cropping. During the analysis period, cotton (both irrigated and dryland) accounted for 23% of regional losses and wheat 17%. The regional losses by enterprise are most sensitive to the prevalence of the enterprise in the region and the value of the crop.

When the range of inputs are considered, results are displayed as a probability distribution. The distribution of the per hectare economic loss are displayed in Figure 3. On a per hectare basis, the results are most sensitive to changes in the actual yields achieved in the region and the estimated losses attributed to feral pigs. A wide range is expected in both variables due to differing environmental aspects across farms. These include farming rotations, rainfall, disease pressures and abundance of feral pigs. Economic losses are lowest (along the lower tail) when crops achieving poor yields or prices experience low levels of feral pig damage. Economic losses are highest (along the upper tail) when crops achieving above average yields and commodity prices experience high damage from feral pigs.

The high yielding irrigated cotton and maize were the standout enterprises with the largest range of per hectare estimated losses and 90% of results between $14 to $163 and $7 to $203 /ha, respectively. Experiencing the next largest ranges were the enterprises of barley, canola, chickpea, dryland cotton, hay and sorghum with 90% of results between $4 and $96 /ha economic loss. The lowest per hectare economic losses were for oats and wheat with 90% of results between $1 and $32 /ha.

With stored grain, 90% of estimated losses were between $5 to $26 /ha. There is a higher degree of uncertainty for this part of the analysis as several assumptions were made based on the survey data that may not accurately reflect the regional average. For example, the number of hectares associated with each stored tonne of grain and the number of hectares that would utilise grain bags or bunkers.

Figure 3: @RISK results. Agricultural losses ($/ha), box whisker chart

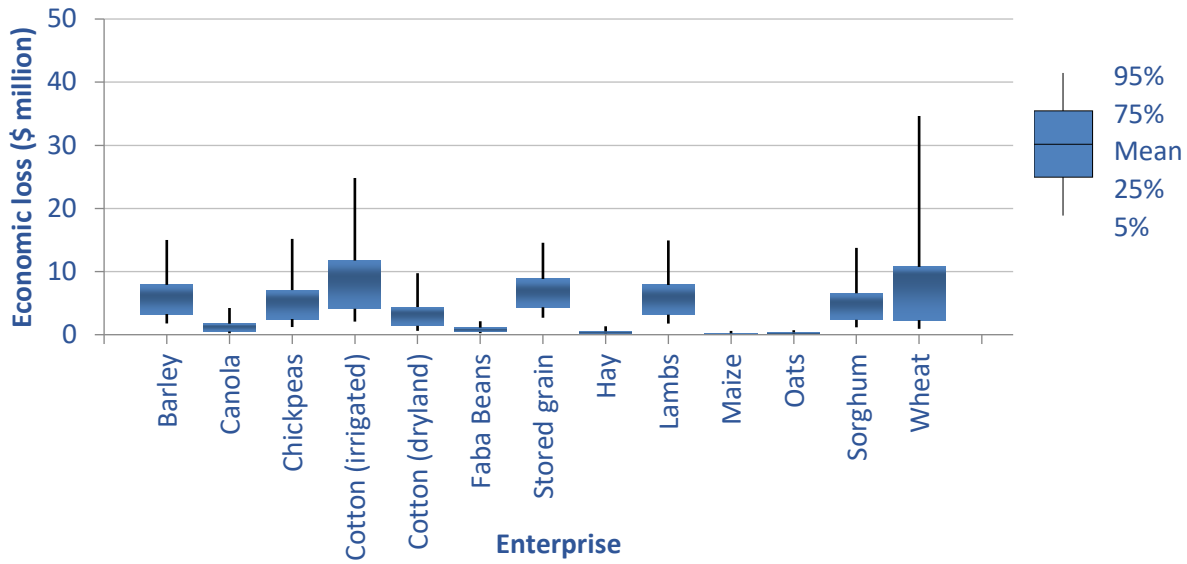


Total economic losses at a regional level (Figure 4) were calculated combining the per hectare losses with the area planted to an enterprise during the study period. In the case of lambs, it was the number of marked lambs for the year. Wheat experienced low per hectare losses, however due to its dominance in the cropping landscape (50% of cropping ha's), in terms of regional losses wheat was calculated to have the highest loss and the highest range of losses, with 90% of results falling between $0.9 to $34 million. Irrigated cotton which was planted to 7% of the region's cropping area had the next largest range of total regional economic losses with 90% of results falling between $2 to $25 million. As expected, the enterprises with the lowest total planted hectares (canola, faba beans, hay, maize and oats) had the lowest regional losses.

Regional losses of lambs in sheep (wool and meat) enterprises were estimated at $6 million. This loss was calculated using a 7.7% lamb loss rate from the farmer surveys and an opportunity cost of $182 /hd for each lamb lost, using estimated marked lamb numbers for the region (ABS, 2022). Per hectare or individual enterprise losses would vary depending on flock size and stocking rates.

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 2021 survey (Powell and Revell, 2021), with 100% of respondents agreeing that area wide management of feral pigs resulted in larger and longer-term benefits than individual farm programs.

Figure 4: @RISK results (regional economic losses), box whisker chart



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 and their effectiveness in this study reflect those in Powell et al. (2020). 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.

The benefit of regional control across NW LLS, was considered by applying the average cost of control ($5.17 /ha) across 2,000,000 ha. With an effectiveness of 50%, the resulting net economic benefit was $14 million. 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 $20 million. These findings highlight the potential avoided losses on a regional scale if strategically selected control measures were implemented across the NW LLS region.

Discussion

Enterprise losses attributed to feral pigs were both lower and higher in 2021-22, compared to the previous year. The region experienced another good season with yields in the study period higher across all enterprises. Feral pig losses were estimated lower for most enterprises and higher in just three enterprises (hay, maize and lamb losses). Commodity prices remained higher than average, however compared to the previous 12 months, some were lower and some higher. Combined, these

inputs resulted in higher per hectare losses compared to 2020-21 for all enterprises except barley, chickpeas, irrigated cotton and wheat. Oats and temporary grain storage were not included within last years report. At t a regional level, losses would have been similar to 2020-21, however by including an estimated value for stored grain losses attributed to feral pigs, total regional losses are up 19% to $56 million. These results suggest that by focusing on field losses only, the value of losses previously reported was likely to be underestimated.

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. To combat this bias, additional questions were asked around yield loss, with the resulting estimates thought to be more accurate. This slight change in survey method (and noting the survey sample is not consistent every year), resulted in lower estimated yield losses across most enterprises despite the feral pig population increasing in abundance across the region. However, improving the method by including stored grains and more accurately estimating loss estimates ensures 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 with 50% of results falling between $42 and $65.

Losses associated with cattle enterprises and infrastructure losses were collected within the survey, however the value of these losses were not included within the analysis due to the lack of regional data.

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 with two respondents specifically noting the severity of the problem.

"Past years have seen us destroy up to 400 pigs. This year we will exceed that probably by a factor of two !!"

90% of respondents attempted to control feral pigs during the study period using a broader range of control methods. On average respondents estimated that they had reduced feral pig numbers on their farms by 41%. The consistent message from respondents was that more needed to be done, and that it would be most effective within a formal area wide program that was potentially mandatory.

Conclusion

This is the second of three consecutive seasonal reports to estimate agricultural economic losses attributed to feral pigs in the North West NSW LLS region. The report estimated that regional in-crop

and storage losses across 12 enterprises for the Winter 2021 and Summer 2021-22 seasons were $56 million.

As part of the analysis 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 $61 /ha for irrigated cotton and corn down to $9 /ha for wheat enterprises.

At a regional level, economic losses attributed to feral pigs in wheat and barley contributed to 28% of regional losses respectively due to the large proportion of cropping area dedicated to these enterprises. Cotton (including dryland and irrigated enterprises) contributed to 23% of regional losses, an increase from last season due to the significantly larger cotton crop. The regional economic losses for sheep attributed to feral pigs was valued at $6 million (about 11% of total regional losses). This enterprise had the highest increase in estimated regional losses compared to the last analysis (Powell and Revell, 2021) due to both an increase in estimated lambs within the region and an increased unit loss (from 4.2% to 7.7%). The total regional economic losses of each enterprise was most sensitive to the area dedicated to the enterprise.

Compared to the last analysis (Powell and Revell, 2021), yield loss attributed to feral pigs was lower in most enterprises however this was largely a result of the improved survey data collection. During the analysis period most enterprises experienced higher than average yields and commodity prices. On a per hectare basis, economic losses attributed to feral pigs were both lower and higher than the last analysis, depending on the enterprise. In general, despite the more conservative unit loss estimates, the higher yields, cropping area and flock, higher commodity prices and inclusion of storage losses means that total economic losses across the region by enterprise were higher in 2021-22.

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.

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 NW NSW LLS region.

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.

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 2021 and Summer 2021-22 timeframes.

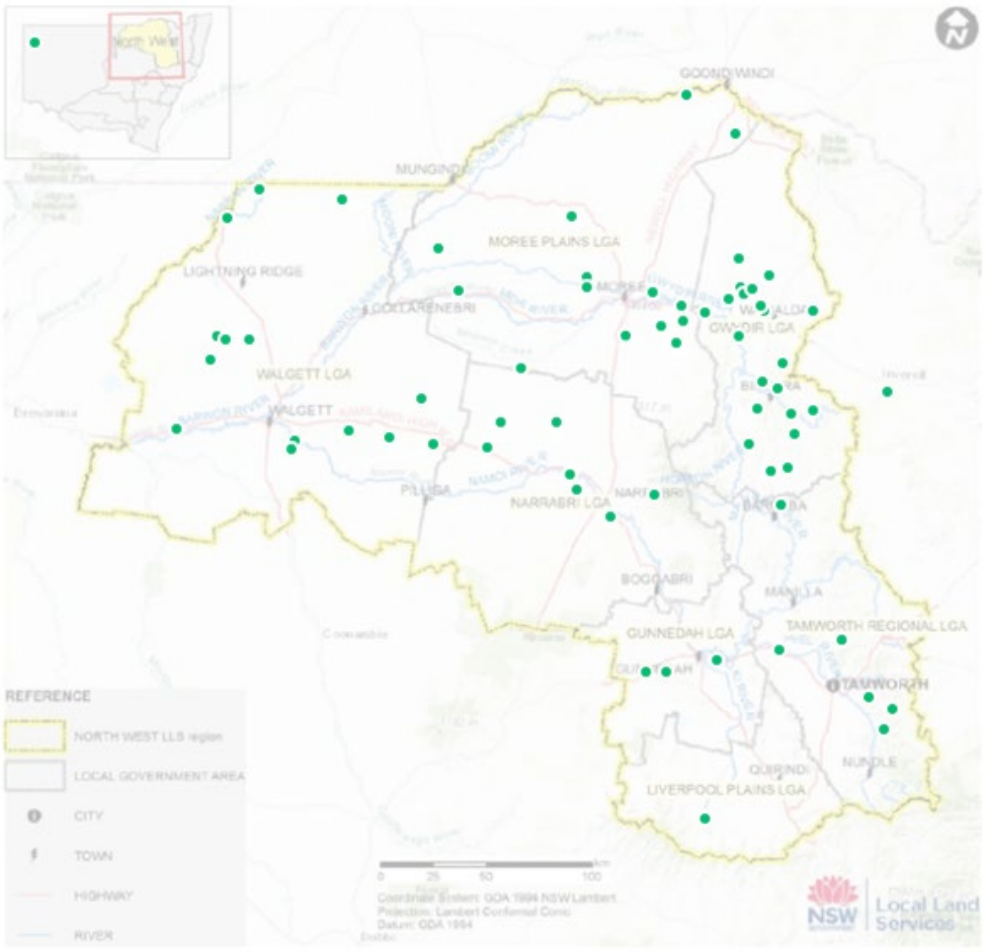
Survey distribution

This year, the survey distributed in May 2022 covered livestock and both the Winter 2021 and the Summer 2021-22 cropping periods.

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

The survey had 69 responses covering a total of 282,259 ha in the NW LLS area. 30 of these respondents also completed the 2021 surveys. The location of respondents within the study region can be seen in Figure 5.

Figure 5 : Maps indicating the location of survey respondents.



Feral pig presence and abundance

Respondents were asked if pigs were present on their properties. The survey found **pigs were present on 96% of properties surveyed.** This result was up 6% from last season, an expected result considering the ideal pig breeding conditions of above normal rainfall and abundant food and shelter.

Those with pig presence were asked about the abundance of feral pigs on their farms during each period. The response categories were based on the DPI abundance mapping (Figure 1, Section 1). Table 4 and Figure 6 present these results.

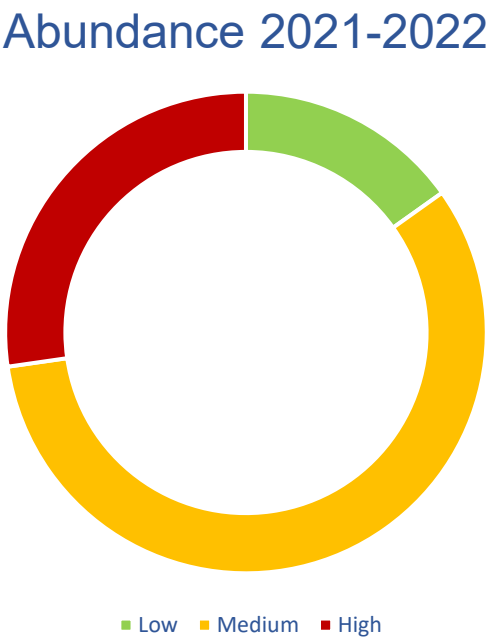
80% of respondents observed increased feral pig abundance on their farms. 17% of respondents stated that pig abundance stayed the same and 3% responded that feral pig pressure had decreased. Although the respondents and their location within the NW LLS area changes from survey to survey, these results indicate a strong trend in higher abundance of feral pigs across the region.

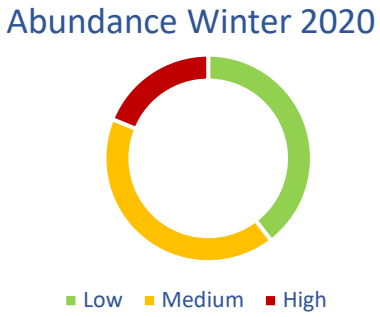
Table 4: Survey responses on Feral pig presence in the NW LLS

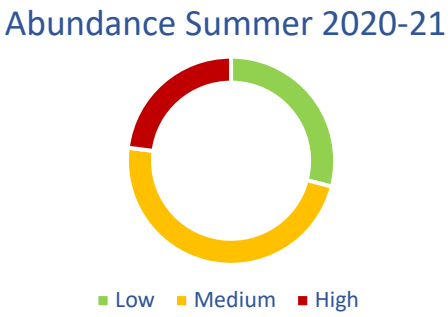
Feral pig presence	Responses (change from last survey)
Low *(Few sightings, little active sign)*	**15%** (-14%)
Medium *(Some animals seen at almost any one time, much active sign - significant sign of animals 50-80% of the time)*	**58%** (+10%)
High *(Many animals seen at any time and much sign of activity - significant sign of animals on more than 80% of occasions)*	**27%** (+4%)

The results indicate that feral pigs have increased in intensity where they were present. Figure 6 gives a visual depiction of the decreasing 'low abundance' and increasing 'high abundance' compared to the survey 12 months pervious.

Figure 6: Abundance of feral pigs on respondent farms.



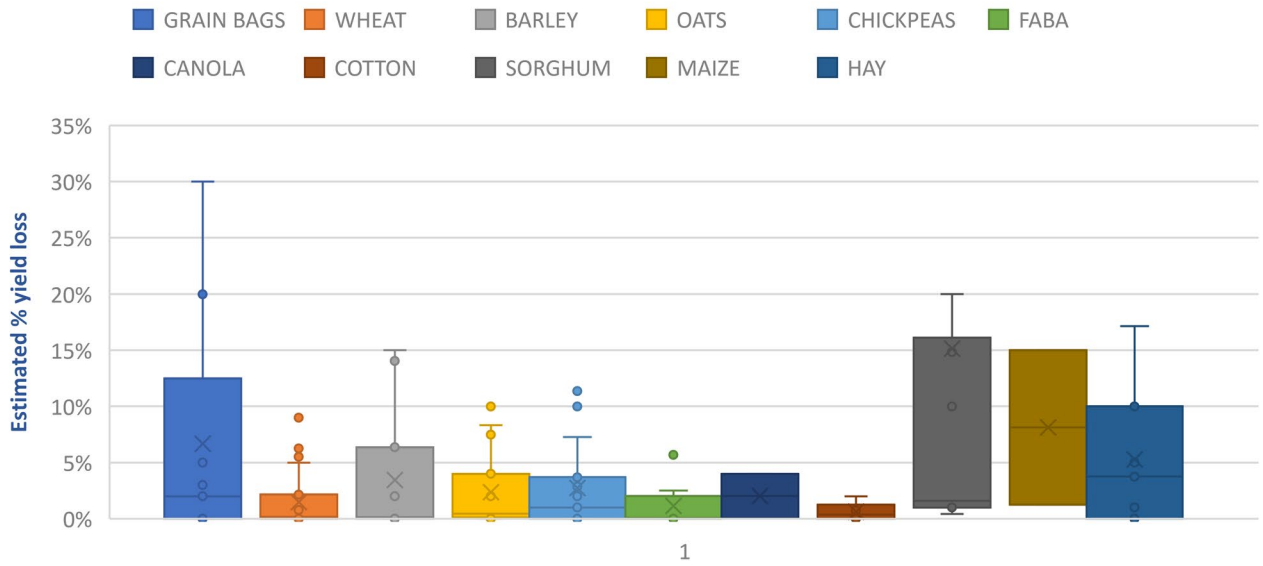




Enterprise damage attributed to feral pigs

Respondents were asked for their best estimate of feral pig damage to specific agricultural enterprises including damage to infrastructure and crops see Figure 7. The lowest losses were reported in cotton, wheat and faba beans. The highest losses were reported for sorghum, maize, grain storage and hay. Maize, hay and sheep enterprises were reported as higher estimated losses than last year, with all other enterprises reporting lower losses.

Figure 7: Grower estimated yield loss as a result of feral pig damage



Cattle enterprises

16 respondents reported a loss within their cattle enterprises as a direct result of feral pigs. The most commented on damage was pasture damage (digging up roots resulting in yield loss). Additionally, the potential of disease (leptospirosis) being spread by feral pigs and the resulting requirement for vaccination was also a common theme. Also noted was the goring of bulls (resulting in fatal injuries) at a total cost of $40,000. The range in estimated reduction of enterprise income ranged from 0 to 70%.

Infrastructure losses

28 respondents outlined infrastructure losses as a result of feral pig damage. Fences were the most damaged infrastructure at an estimated damage value of $102,000. An estimated $32,000 for land formation and $24,500 for water or irrigation infrastructure.

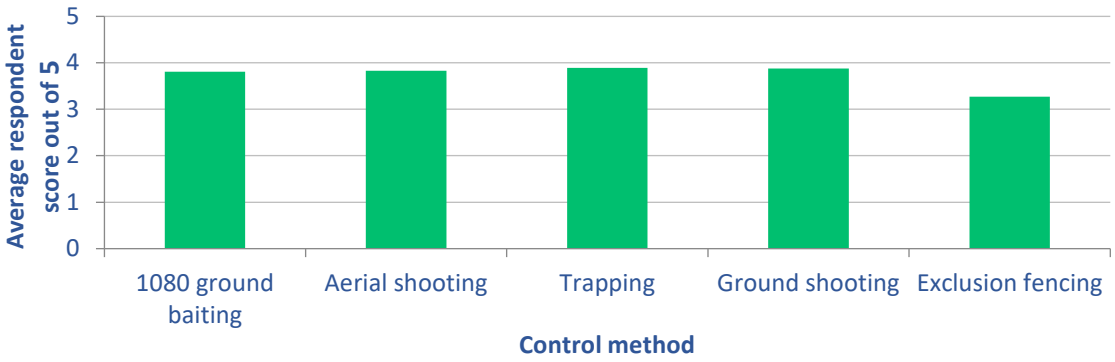
Feral pig control

90% of respondents attempted to control feral pigs during the study period.

This high participation in control indicates the extent of the feral pig problem and that farmers understand the general benefits of control.

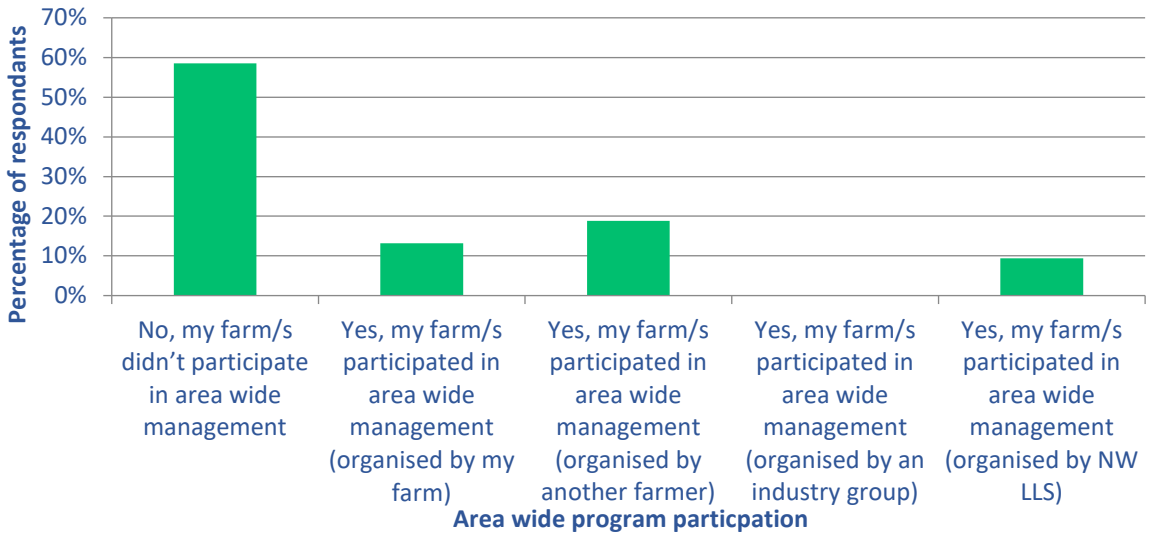
Respondents were surveyed on the feral pig control methods they relied on most for their farms. Figure 8 indicates that farmers were essentially equally reliant on all methods. The average number of control methods relied upon was 3 (an increase from 2.5 last year), with most relying upon at least three control methods and some relying on up to five methods. The more methods a respondent utilised may indicate that they understand that different methods provide the highest benefits in varied situations, the increase in using varied methods of control may also reflect the increasing abundance of feral pigs in the area.

Figure 8: Control methods most relied on in Winter 2021 & Summer 2021-2022



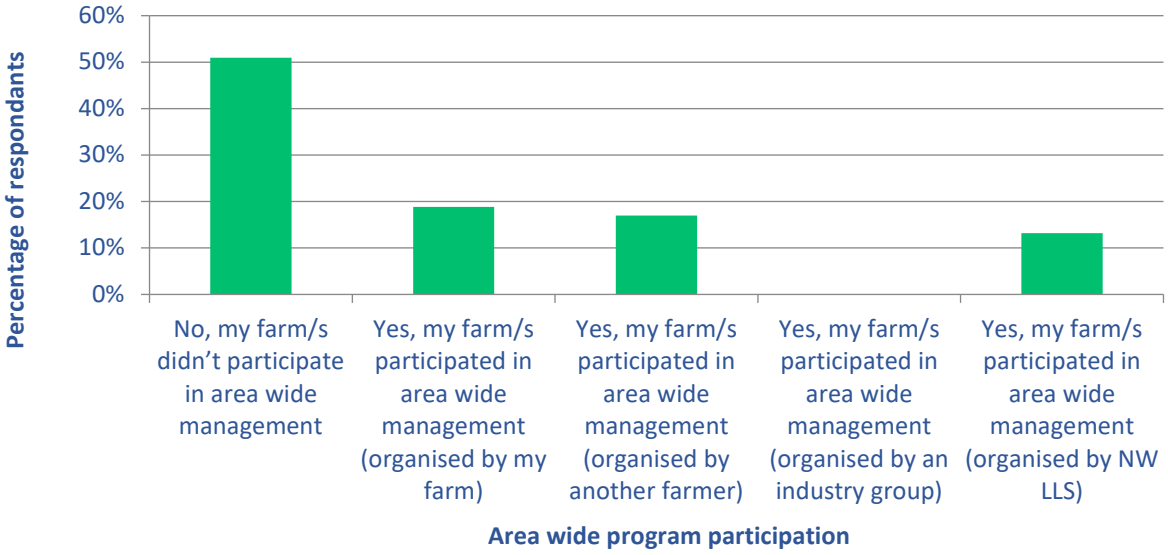
42% of respondents participated in area wide management programs for feral pigs during Winter 2021. The area wide programs were mostly organised by the individual farmers or their neighbours Figure 9.

Figure 9: Did your farm participate in area wide management of feral pig control, Winter 2021?



49% of respondents participated in area wide management programs for feral pigs during Summer 2021-2 The area wide programs were mostly organised by the individual farmers or their neighbours Figure 10.

Figure 10: Did your farm participate in area wide management of feral pig control, Summer 2022?

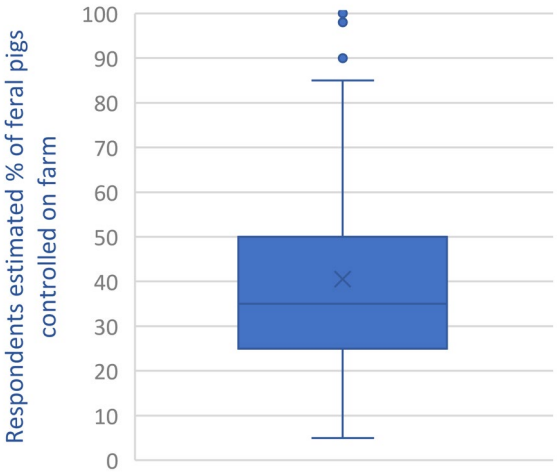


Estimated % of feral pigs controlled

Respondents were asked to estimate the percentage of feral pigs they have controlled on their farm in the last 12 months. On average respondents estimated they had controlled 41% of pigs on their

farms. The box whisker plot in Figure 10 outlines the respondents estimates. The responses ranged from just 5% of feral pigs controlled to

Figure 11: Box whisker plot of respondents estimated % of feral pigs on their farm that were controlled



Attitudes on how to improve feral pig control

Respondents were given an opportunity to comment on their ideas on how to improve feral pig control. 17 of the respondents left comments with most of the comments centred around the themes of co-ordinated area wide control. Many of the comments centred around co-ordinated area wide control.

Table 5: Respondents final survey comments

Theme	Sample comment	Respondents
Area wide control	***"Area wide baiting was most efficient in the 1980's were had feral animal control groups organised by the PP board ranger"***	**9**
Increased baiting	***"I believe that baiting, then trapping and finally aerial shooting should all be undertaken in order by every farmer in the district at a set time each year. I think it should be mandatory. Farmers should be trained on how to get the best outcome and be reimbursed for their time."***	**5**
Meat baits	***The use of meat baits for pigs allows 1080 baiting in stocked paddocks. It is allowed to do it further west so why not further East ?***	**2**
Allowing farmers to assist with aerial shooting	***"Cut red tape for landholders both for cat D firearms and access to Arial shooting for themselves, so they can get more involved in eradicating feral pigs."***	**1**

Other	*"Investigate generic sterilisation"*	**1**

Final comments

Respondents were given an opportunity to make final comments. 7 respondents left comments which are listed below.

"In the last 6 months of extended wet periods and flooding, pig numbers have exploded to some of the worst numbers seen in the last 50 years on our farms."

"Due to the outbreak of FMD in Indonesia government funded aerial shooting should be mandatory."

"There needs to be a co ordinated regional response to the problem"

"Past years have seen us destroy up to 400pigs this year we will exceed that probably by a factor of two !!"

"LHPA are the best vehicle to deliver multi farm eradication programs."

"We are willing to participate in trials, area groups or any other programs available"

"More assistance for smaller property owners not just big company's and land holders who receive more government assistance."

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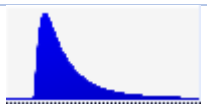
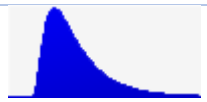
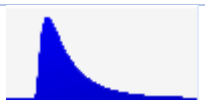
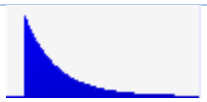
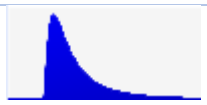
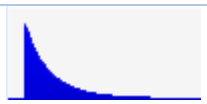
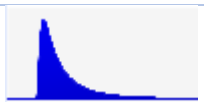
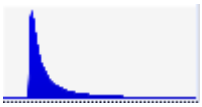
Appendix 1: @RISK model input distributions

Cropping Enterprises					
Input	**Data distribution graph**	**Mean**	**10%**	**90%**	**Data sources**
Barley price		$252 /t	$205 /t	$311 /t	The Land
Barley yield		4.1 t/ha	2.5 t/ha	6 t/ha	ABS 2022 & Agronomist survey[1]
Barley yield loss from pigs		2.3%	1%	4%	Survey (Section 2)
Canola price		$841 /t	$762 /t	$191 /t	The Land
Canola yield		2.5 t/ha	1.2 t/ha	4.1 t/ha	ABS 2022 & Agronomist survey[1]
Canola yield loss from pigs		1.5%	.4%	3.1%	Survey (Section 2)
Chickpea price		$467 /t	$434 /t	$495 /t	The Land
Chickpea yield		2.1 t/ha	1.0 t/ha	3.5 t/ha	ABS 2022 & Agronomist survey[1]
Chickpea yield loss from pigs		2.9%	1.1%	5.2%	Survey (Section 2)
Cotton price		$759 /bale	$657/bale	$889 /bale	Mixed cotton merchants
Cotton (irrigated) yield		11.6 bales/ha	9.6 bales/ha	13.6 bales/ha	Cotton Yearbook 2022 & Agronomist survey[1]
Cotton (dryland) yield		5.4 bales/ha	3 bales/ha	7.7 bales/ha	Cotton Yearbook 2022 & Agronomist survey[1]

[1] Five independent agronomists across NW NSW, emails and phone communication, December 2022

Cotton yield loss from pigs		0.7%	0.2%	1.4%	Survey (Section 2)
Faba bean price		$340 /t	$322 /t	$365 /t	The Land
Faba bean yield		3 t/ha	1.6 t/ha	4.7 t/ha	ABS 2022 & Agronomist survey[1]
Faba bean yield loss from pigs		2.2%	1%	3.7%	Survey (Section 2)
Hay price		$151 /t	$141 /t	$166 /t	The Land
Hay yield		3.5 t/ha	1.5 t/ha	6.2 t/ha	ABS 2022 & Agronomist survey[1]
Hay yield loss from pigs		5.45%	1.5%	11.2%	Survey (Section 2)
Maize price		$320 /t	$279 /t	$381 /t	The Land
Maize yield		10.5 t/ha	2.4 t/ha	13 t/ha	ABS 2022 & Agronomist survey[1]
Maize yield loss from pigs		1.8%	0.8%	3.2%	Survey (Section 2) & Agronomist survey[1]
Sorghum price		$271 /t	$240 /t	$308 /t	The Land
Sorghum yield		4.0 t/ha	2.26 t/ha	6.1 t/ha	ABS 2022 & Agronomist survey[1]
Sorghum yield loss from pigs		3.3%	1.2%	6.2%	Survey (Section 2)
Wheat price (H2)		$307 /t	$276 /t	$346 /t	The Land
Wheat yield		3.2 t/ha	1.9 t/ha	4.7 t/ha	ABS 2022 & Agronomist survey[1]

Wheat yield loss from feral pigs		**0.9%**	**0.1%**	**2.2%**	**Survey (Section 2)**
Sheep: lamb price		**791 c/kg**	**741 c/kg**	**854 c/kg**	**MLA**
Sheep: lamb losses		**7.7%**	**2.7%**	**14.6%**	**Survey (Section 2)**
Control methods					
Input	**Data distribution graph**	**Mean**	**10%**	**90%**	**Data sources**
Aerial shoot cost		**$1.71 /ha**	**$1.20 /ha**	**$2.36 /ha**	**(Lockrey and Marshall, 2019, Saunders, 1993, Cowled et al., 2006) (Personal Communication, GVIA[2])**
Aerial shoot effectiveness		**59%**	**37%**	**81%**	**(Lockrey and Marshall, 2019, Cowled et al., 2006, Saunders, 1993) (Personal Communication[3])**
Baiting cost		**$1.38 /ha**	**$0.65 /ha**	**$2.32 /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])**
Exclusion fence cost		**$15.12 /ha**	**$8.27 /ha**	**$23.53 /ha**	**(Hone and Atkinson, 1983, Lockrey and Marshall, 2019)**

[2] Gwydir Valley Irrigator's Association, emails and phone communication, May 2020

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

Exclusion fence effectiveness		**70%**	**55%**	**85%**	**(Hone and Atkinson, 1983, Lockrey and Marshall, 2019)** **(Personal Communication[4])**
Ground shoot cost		**$6.11 /ha**	**$3.97 /ha**	**$8.60 /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[4])**
Trapping cost		**$1.53 /ha**	**$0.69 /ha**	**$2.63 /ha**	**(Lockrey and Marshall, 2019)**
Trapping effectiveness		**45%**	**25%**	**65%**	**(Lockrey and Marshall, 2019, Saunders, 1993, Lapidge, 2003)** **(Personal Communication[5])**

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