Net benefits from alternative feral goat management strategies in the western NSW rangelands

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Abstract: The western NSW rangeland is the pastoral zone of NSW, with increasing abundance and distribution of feral goats (*Capra hircus*). Feral goats are generally viewed as agricultural pests impacting on agricultural production and natural resources but they are also valuable economic resources that generate income for many pastoralists. This paper presents an economic analysis of alternative feral goat management strategies in the western NSW rangelands. We used benefit-cost analysis to evaluate the Net Present Value (NPV) and Benefit Cost Ratio (BCR) of feral goat management strategies including do-nothing, opportunistic harvesting, 'value added goats' and establishment of goat-proof fencing on representative properties in the Bourke, Cobar and Broken Hill districts. We found that the opportunistic harvesting and 'value added goats' strategies generate net benefits whereas do-nothing and goat-proof fencing strategies return net losses resulting mainly from the opportunity cost of lost income. The NPV of the management strategies examined ranged between -$383,577 and $855,836, with BCR between 0.34 and 3.77. NPVs were more sensitive to goat price than goat population. Establishment of goat-proof fencing could be justified only if increases in stocking rate could be achieved beyond those resulting from the replacement of feral goats by sheep. If achieved over the whole property, these increases are probably not beyond what might be expected from improved gazing management. The implications of the results for natural resource management policies in the region are briefly discussed.

Keywords: economics, feral goat, management, policy, NSW

Running title: Economic of feral goat management

Introduction

Feral goats (*Capra hircus*) are widely distributed in the arid and semi-arid regions of Australia including New South Wales, Queensland, South Australia and Western Australia (Freudenberger and Barber, 1996). Increases in the population and distribution of feral goats have been observed in the rangelands of western NSW (Holt and Pickles, 1996). Harrington (1982) and Gridd *et al.* (1992), cited by Parkes, Henzell and Pickles (1996), reported that the population of feral goats in NSW increased from 60,000, in 1982 to 1.2 million in 1993, with a corresponding increase in the area occupied from 255,000 to 330,000 km^2, representing an increase in average density from 0.23 goats/km^2 to 3.6 goats/km^2. In the most recent study, Ballard *et al.* (2011) estimated the population of feral goat in the region to be as high as 2.5 million with an average density of 2.8 goats per km^2.

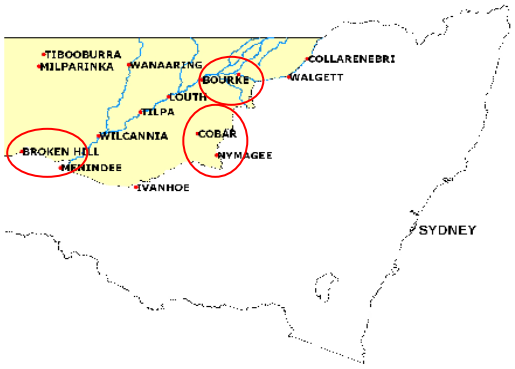
Feral goats are generally regarded as agricultural and environmental pests that increase total grazing pressure (TGP) and compete with domestic stock resulting in negative impacts on both agricultural production and natural resources (Parkes, Henzell and Pickles, 1996,). In spite of these negative attitudes, however, feral goats are also valuable economic resources that generate income for increasing numbers of pastoral producers and support the developing Australian goat industry. In 2010/11 total value of Australia's goat export was estimated at about $134.7 million, of which about 95% was produced by rangeland goats (Meat & Livestock Australia, 2011). The National Institute of Economic and Industry Research (2000) estimated that in 1999 pastoral producers in western NSW earned revenue ranging from $6,000 to $22,000 from the sale of feral goats.

Decisions by pastoral producers regarding the management of feral goats on their property will be determined by the financial returns expected from alternative strategies. This paper presents an economic analysis of several alternative strategies, including do-nothing, opportunistic harvesting, value added goats and goat-proof fencing, for representative properties in the western NSW rangelands. The implications of the findings for natural resource management policies in the region are also briefly discussed.

Methodology

This study covers the Bourke, Cobar and Broken Hill districts within the arid and semi-arid rangelands comprising the jurisdiction of the Western Catchment Management Authority (Western CMA, Figure 1).

Figure 1: Boundary of the Western Catchment Management Authority



The primary data used in the analysis were obtained from focus groups consultations in each district involving local pastoral producers, representatives of the Western CMA and Rangeland Livestock Officers of Industry & Investment NSW. Focus group members defined the economic and production parameters of a representative property in each district and the various costs and returns associated with a 'best practice' approach to the alternative feral goat management strategies outlined in Table 1.

Table 1 Feral goat management strategies and key assumptions

Strategies		Key assumptions
Do-nothing		Goats are a permanent component of TGP; livestock numbers are adjusted to maintain constant stocking rate in order to prevent resource degradation; strategy triggered by reduced feral goat price and/or other disincentives to harvesting (e.g. mandatory NLIS tagging); goat population increases at 0.057 exponential rate of growth with initial population at 50% of the potential population; 50% dietary overlap between sheep and goats; livestock number reduced by 0.4 DSE for each additional goat; livestock production parameters are the same as the representative property.
Opportunistic Harvesting	Current	Goats are a permanent component of TGP; goats are opportunistically harvested in conjunction with normal livestock operations; underweight feral goats are sold in Bourke and Cobar districts but released in Broken Hill district; livestock numbers are adjusted to maintain constant stocking rate in order to prevent resource degradation; no change in feral goat population; no change in domestic stocking rate, livestock production parameters are the same as the representative property.
	Maximum possible harvest	As above but with additional infrastructure investment to maximise feral goat turnoff; feral goat population reduced, domestic livestock population increased at the rate of 0.4 DSE for each additional goat removed; livestock production parameters are the same as the representative property.

Value added goats	Constant livestock	As for 'opportunistic harvest – current' but establish a goat (proof) paddock to grow out underweight feral goats captured; goat paddock also used as required for domestic livestock; no subdivision of goat paddock for grazing management purposes.
	Reduced livestock	As for 'value added goats – constant livestock' but goat paddock used only to grow out underweight feral goats; livestock population reduced by the carrying capacity of the goat paddock and turnoff of grown–out goats increased at the rate of 1 goat per 0.4 DSE removed.
Livestock with goat-proof fencing	Goat-proof paddock - goat country	Use the goat-proof paddock established under the 'value added' scenarios for livestock grazing only; paddock is established in country best suited to goats; total goat population is reduced by the number removed from the paddock and is harvested opportunistically on the remainder of the property; livestock population increased at the rate of 0.4 DSE for every goat removed from the paddock; 50% dietary overlap between sheep and goats; livestock production parameters are the same as the representative property; no subdivision of goat proof paddock for grazing management purposes.
	Goat proof paddock - good country	As above, but goat proof paddock established on better quality land that allows livestock population to be increased by an additional 0.3 DSE/ha over 10 years above the initial exchange of sheep for goats removed.
	Boundary fencing	Goat proof boundary fencing of all suitable land (see Table 2) ; opportunistic harvesting on the unfenced area; domestic livestock increased at the rate of 0.4 DSE for each goat removed from the fenced area; 50% dietary overlap between sheep and goats; livestock production parameters are the same as the representative property; no additional subdivision for grazing management purposes.

Key physical characteristics of the representative properties, and enterprise gross margins adapted from representative whole farm budgets developed by Khairo *et al.* (2008), are shown in Table 2.

Table 2: Key characteristics of the representative properties in Bourke, Cobar and Broken Hill

Description	Units	Bourke	Cobar	Broken Hill
Total land area	ha	24,000	20,000	50,000
Goat paddock (% of total area)	%	5	10	10
Land area suitable for boundary fencing (% of total area)	%	100	80%	60%
Enterprises		Sheep, cattle	Sheep, cropping	Sheep, cattle
Stocking rate	DSE/ha	0.20	0.25	0.25
Average annual feral goat population	no	1,920	4,000	1,500
Feral goats harvested annually (opportunistic harvest)	no/yr	960	2,000	1,670
Proportion of feral goats within boundary fence (% of total)	%	100	60	40
Feral goats held in goat paddock	no/yr	480	1,000	600
Sheep gross margin (21 micron)	$/DSE	31.05	32.00	30.70
Feral goat gross margin	$/goat	25.52	27.68	26.62

The decision by producers to manage feral goats is determined by the costs and benefits of the management strategy. The costs of feral goat management include the various expenses incurred for clearing, fencing, traps, yards, troughs, purchasing sheep (if goats are removed permanently), monitoring, repairs and maintenance, equipment and machinery use, labour, income forgone (if goats are removed permanently) and (unquantified) environmental damage. The benefits of feral goat management include revenue generated from sales, net gains from increased domestic livestock production (if goats are permanently removed) and (unquantified) improvement in natural resource condition.

Sinden and Thampapillai (1995) outlined the benefit-cost analysis method most commonly used by economists to evaluate alternative investment projects and make efficient decisions using Net Present Value (NPV), Benefit Cost Ratio (BCR) and Internal Rate of Return (IRR). Gong *et al.* (2009), for example, applied the benefit-cost analysis technique to assess the economic impacts of vertebrate pests in Australia and Drucker (2008) used the technique to analyse the economics of feral camel management in the Northern Territory. Khairo *et al.* (2009) and Trapnell *et al*. (2004) applied the method to evaluate the financial implications of liming acid soils. However, one of the limitations of the technique is that the method has limited capacity to evaluate non-priced goods and services and thus, in most cases, environmental changes resulting from investment decisions are ignored or described in qualitative terms.

We used the benefit-cost analysis method outlined by Sinden and Thampapillai to evaluate the alternative feral goat management strategies described in table 1. The specific equations for estimating the NPV and BCR are given in equation 1 and 2 below.

$$NPV = \sum_{t=1}^{T} \frac{B_t - C_t}{(1+r)^t} \quad (1)$$

$$BCR = \sum_{t=1}^{T} \frac{B_t}{(1+r)^t} \Big/ \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} \quad (2)$$

where B_t and C_t are benefits and costs in year *t,* respectively, *r* is the discount rate and *T* is the time frame of the investment in years. The decision rule is that the strategy with the highest NPV and BCR greater than one is economically desirable and ranked the highest whereas the strategy with negative NPV or BCR less than one is not desirable (Department of Finance, 2006).

We also used the @RISK software package to conduct sensitivity analysis to test the relationships between NPV and a number of key variables. The coefficients of the sensitivity analysis are the coefficients of the linear regression relationship between percentage change in NPV and percentage change in the variable of interest. They thus represent the percentage change in NPV for one per cent change in the variable. Negative values indicate inverse relationships whereas positive values indicate a direct relationship. Other general assumptions used in our analysis are provided in Table 3.

Table 3 General assumptions used in the analysis

Description	Units	Assumption used
Interest rate on loans	%	10
Discount rate	%	7
Inflation rate	%	5
Time frame of analysis	years	20
Time lag for the starting the benefits of reduced goats	years	3

Results and discussions

The pay-off matrix for the alternative feral goat management strategies is given in Tables 4, 5, and 6 for Bourke, Cobar and Broken Hill districts, respectively. The general characteristics of NPV and BCR for the alternative strategies in the three districts are similar and so the conclusions made here are applicable to all. The ranking of the management strategies on the BCR criterion is broadly similar to that given for NPV although some minor differences are apparent.

Table 4: The pay off matrix for alternative feral goat management strategies in Bourke district

Evaluation Criteria	Do nothing	Opportunistic harvest		Value added goats		Livestock with goat-proof fencing		
		Current	Max. harvest	Constant livestock	Reduced livestock	Goat country paddock	Good country paddock	Boundary fence
PVB	127,331	407,346	462,477	614,017	639,459	425,094	384,086	331,100
PVC	376,359	163,910	170,358	217,660	229,645	308,231	175,767	714,678
NPV	-249,029	243,436	292,119	396,357	409,815	116,863	208,319	-383,577
BCR	0.34	2.49	2.71	2.82	2.78	1.38	2.19	0.46
Ranking (NPV)	7	4	3	2	1	6	5	8
Desirability	x	√	√	√	√	√	√	x

Table 5: The pay off matrix for alternative feral goat management strategies in Cobar district

Evaluation Criteria	Do nothing	Opportunistic harvest		Value added goats		Livestock with goat-proof fencing		
		Current	Max. harvest	Constant livestock	Reduced livestock	Goat country paddock	Good Country paddock	Boundary fence
PVB	198,822	519,716	589,848	1,126,919	1,172,435	607,246	555,907	412,489
PVC	511,095	255,538	282,801	299,174	316,599	548,620	312,400	525,752
NPV	-312,273	264,177	307,047	827,745	855,836	58,626	243,506	-113,263
BCR	0.39	2.03	2.09	3.77	3.70	1.10	1.78	0.78
Ranking (NPV)	8	4	3	2	1	6	5	7
Desirability (NPV)	x	√	√	√	√	√	√	x

Table 6: The pay off matrix for alternative feral goat management strategies in Broken Hill district

Evaluation Criteria	Do nothing	Opportunistic harvest		Value added goats		Livestock with goat-proof fencing		
		Current	Max. harvest	Constant livestock	Reduced livestock	Goat country paddock	Good country paddock	Boundary fence
PVB	281,144	520,597	580,311	847,732	879,006	692,575	710,541	353,488
PVC	443,082	233,004	239,905	318,424	343,574	555,392	327,171	368,247
NPV	-161,939	287,593	340,406	529,307	535,432	137,183	383,370	-14,759
BCR	0.63	2.23	2.42	2.66	2.56	1.25	2.17	0.96
Ranking (NPV)	8	5	4	2	1	6	3	7
Desirability (NPV)	x	√	√	√	√	√	√	x

Judged by the NPV criterion the 'value added with reduced livestock' strategy is the most attractive for producers in all districts but it is only marginally superior to 'value added with constant livestock'. Both are substantially superior to either of the opportunistic harvest scenarios which, in turn, are superior to use of the 'goat paddock' for livestock grazing only. However, the NPV for goat-proof fencing of a paddock used for livestock in good country is comparable, or even superior at Broken Hill, to the opportunistic harvest scenarios though still substantially lower than the 'value added' scenarios. The result at Broken Hill reflects the larger size of the representative property and therefore the greater increase in the livestock population and sheep income produced from the fenced paddock. The do-nothing and boundary fencing scenarios return negative NPV in all districts.

None of the goat-proof fencing scenarios for livestock grazing described above resulted in a NPV or BCR equal to or better than the 'value added with reduced livestock' scenario for feral goats. Nevertheless, in all districts goat-proof fencing of a single paddock for livestock grazing, either in good country or goat country, returns a positive NPV and BCR greater than 1 and so the investment could be justified even if the return is lower than would be achieved by investment in a goat paddock to grow out captured feral goats. Fencing of good quality country is always the better option, because it is assumed to achieve an improvement in resource condition and the opportunity cost of foregone goat income is reduced.

Goat-proof boundary fencing of as much of the property as feasible returns negative NPV and BCR less than 1 in all districts. However, differences between the districts reflect the extent of boundary fencing feasible and thus the opportunity cost of feral goat income foregone. At Broken Hill, where only 60% of the property can be fenced and the unfenced area allows 60% of the normal level of opportunistic goat harvesting to be maintained (Table 2), the BCR is only slightly less than 1. BCR is lowest at Bourke where the whole property can be fenced and all feral goat income is foregone, and intermediate at Cobar where 80% of the property can be fenced.

Regression coefficients from the @RISK analysis (Table 7) indicate that all scenarios are more sensitive (positively or negatively) to goat price than to the goat population with NVP changing by 0.87-0.99% for every 1% change in price but by only 0.10-0.36% for every 1% change in population. Goat price rather than goat population is thus expected to be the primary driver of producers' decisions to harvest feral goats. The negative regression coefficients for both the boundary fence and do nothing strategies mean that NPV declines with both increasing goat price and goat population due to the income forgone from sale of goats.

Table 7: Regression coefficients for sensitivity analysis

District	Variables	Do nothing	Opportunistic harvest		Value added goats		Livestock with goat-proof fencing		
			Current	Max. harvest	Constant livestock	Reduced livestock	Goat country paddock	Good country paddock	Boundary fence
Bourke	price	-0.90	0.93	0.93	0.93	0.93	0.92	0.92	-0.87
	pop.	-0.34	0.29	0.28	0.28	0.29	0.22	0.34	-0.32
Cobar	price	-0.92	0.95	0.95	0.94	0.94	0.99	0.72	-0.94
	pop.	-0.36	0.29	0.29	0.32	0.32	0.10	0.26	-0.19
Broken Hill	price	-0.93	0.94	0.93	0.93	0.93	0.99	0.92	-0.97
	pop.	-0.30	0.28	0.29	0.32	0.32	0.25	0.29	-0.29

Stocking rates required for economic goat-proof fencing

Increasing the stocking rate of domestic livestock beyond what can be achieved simply by the substitution of livestock for feral goats removed is required to allow the boundary fencing option to compensate for the opportunity cost of goat income forgone and break even (Table 8). Further increases in stocking rate will be required to allow this or other 'livestock with goat-proof fencing' strategies to return a NPV equal to the best feral goat management option (value added with reduced livestock). The required increases (Table 8) may be sought either within the fenced area itself or more broadly over the whole property. These increases will need to be achieved by the application of improved grazing management practices (e.g. some form of non-

continuous grazing) but the cost of infrastructure that may be required to allow implementation of these practices has not been considered in determining the stocking rate increases required.

Table 8: Increases in stocking rate required for 'livestock with goat-proof fencing' strategies to breakeven or produce NPV equal to the best feral goat management strategy. (Increases are additional to those achieved by the substitution of sheep for feral goats removed).

District	Current stocking rate (DSE/ha)	Increase in stocking rate[1] necessary for boundary fencing strategy to breakeven (%)	Increase in stocking rate required to equal best feral goat management strategy (%)					
			Within the fenced area			Over the whole property		
			Goat country paddock	Good country paddock	Boundary fence	Goat country paddock	Good country paddock	Boundary fence
Bourke	0.20	10	290	124	43	14	6	43
Cobar	0.25	4	640	220	63	59	20	51
Broken Hill	0.25	0.2	102	21	14	10	2	8

[1] Within the fenced area

The relative increase in stocking rate (within the boundary fence) necessary for the boundary fencing strategy to breakeven is modest in all districts, the differences reflecting the extent to which feral goat harvesting opportunities remain outside the boundary fence. Furthermore, the increases required for boundary fencing to provide NPV equal to the best feral goat management option are not considered beyond the range that could be expected from improved resource management.

However, when goat-proof fencing is confined to a single paddock used for livestock grazing, that investment will generally only be competitive with the best feral goat management option if improvements in carrying capacity can be realised over the whole property, through the combination of goat exclusion in the fenced area, opportunistic harvest in the unfenced area and improved grazing management overall. Under these circumstances the required improvements in carrying capacity might be feasible. Otherwise, with the possible exception of the Broken Hill district, the improvements required within the fenced paddock alone would probably not be achievable.

Anecdotal evidence in the Western Catchment (P. Theakston, pers. comm.) suggests that a doubling of carrying capacity over several years might be feasible with exclusion of feral goats and the introduction of rotational grazing. Certainly, differences of this magnitude in the estimated carrying capacity of areas in poor versus good range condition would not be exceptional so that opportunities for substantial improvement in carrying capacity with establishment of goat-proof fencing and improved grazing management should be expected. However, if land is already overstocked in the presence of feral goats, so that no increase in livestock carrying capacity can be expected simply from their removal, the increases shown in Table 8 will underestimate the improvements required.

Policy implications

Both the opportunistic harvesting and value added goats strategies are profitable for landholders in all districts and so there would appear to be no justification for public subsidisation of this form of investment. Public financial support would be better directed towards improving grazing management and encouraging improvement in natural resource condition.

The feral goat management strategies evaluated here probably result in different natural resource management outcomes expressed in the form of environmental spillovers (positive and negative externalities). With the exception of the do-nothing strategy, all strategies are likely result in improved natural resource condition at the property scale but the level of improvement achieved may well be lower

than that required by the public. The difference between the optimal levels of private and public natural resource condition resulting from feral goat management is a potential source of market failure. Public intervention may be justified to compensate for lost income in the interests of further improved natural resource outcomes.

Producers' decisions to harvest feral goats are largely driven by the goat price rather than the goat population. Further development of the rangeland goat industry may thus contribute to both the economic viability of rangeland enterprises and to improved natural resource condition.

Conclusions

Both opportunistic harvesting and value added goats strategies generate positive NPVs and BCRs greater than 1 whereas goat-proof fencing of the property boundary, to the extent permitted by local topography, returns negative NPV and BCR less that 1 in all districts unless increases in stocking rate beyond the substitution of sheep for feral goats can be achieved. Increases in stocking rate within the fenced area need only be modest, and probably within the range achievable by improved grazing management, to allow the boundary fencing strategy to breakeven or generate a NPV equal to that of the best feral goat harvesting strategy. However, the cost of any additional infrastructure require to facilitate improved grazing management has not been included in the analysis.

Investment in a single goat-proof paddock for livestock grazing is best directed to better quality land rather than land more suited to a goat paddock. Such investment provides positive NPV and BCR in all districts, and is economically justifiable, but returns a lower NPV than the best of the feral goat harvesting scenarios unless associated with increases in carrying capacity beyond the substitution of sheep for feral goats. If these increases can be achieved across the whole property then only modest improvements, within the range probably achievable by grazing management techniques, are required. However, if improvements are limited to the fenced area then the increases required are unlikely to be achievable except perhaps in the Broken Hill district, and this option will remain less attractive than investment in value adding to harvested feral goats.

Any cessation of feral goat harvesting due to low prices or other impediments is likely to seriously reduce the profitability of livestock enterprises, and will probably also reduce natural resource condition as pastoralists seek to maintain incomes in the absence of an alternative income stream.

Since different natural resource outcomes can be expected from the different management strategies, any public investment may be best directed at encouraging improved resource condition directly (e.g. through incentives for ground cover) rather than at infrastructure for feral goat harvesting which is generally profitable for pastoralists.

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