# Agriculture vs. the Environment on the Australian rangelands: The case for an alternative to competitive tenders for procuring environmental outcomes

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## Abstract:

Policy makers in Australia face challenges to manage rangelands in ways that will optimise both agricultural production and conservation outcomes. Public conservation is difficult because the extent of rangelands, a history of pastoral uses, and complexities in management mean that large areas remain used for private purposes. Over the last two decades there has been an increasing use of public money to directly fund private landholders to increase the output of environmental goods in order to improve conservation management on private lands. However, despite significant investments in purchasing environmental services from rangeland farmers there is little evidence which can show a net improvement in the environmental performance of the rangelands.

The lack of evidence for net environmental improvements may be due more to impacts on the decision function of producers than to a lack (due to the inherent difficulties) of monitoring. In this paper we show, using basic economic decision theory, why current grant-based financial incentive approaches may result in lower environmental outcomes than expected on the Australian rangelands. This is important as it suggests potential for, at least, poor value for money from such programs and, at worst, undermining of the extant duty of care and/or the natural incentives for the sustainable utilisation of natural resources on rangelands properties in Australia. We propose and describe an alternative approach which, in the long-run, is at least as efficient as competitive tenders. This alternative approach would reinforce existing duty of care clauses, personal conservation motivations, and potentially be self-funding.

The setting for this research was the Australia rangelands, however the results are potentially relevant across a greater scale (rangelands in other countries) and scope (other agricultural industries).

## 1. Introduction:

Policy makers in Australia face challenges to manage rangelands in ways that will optimise both agricultural production and conservation outcomes (Hajkowicz 2009; Greiner and Gregg, in press). The use of grant-based schemes in the rangelands has been suggested and trialled in Australia as a

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way to alleviate the private opportunity costs of investments in improving the provision of ecosystem services on the rangelands (Windle and Rolfe 2008). However there is little empirical evidence of improvements in environmental health for locations where these schemes have been implemented. It may be the case that difficulties in monitoring of environmental health variables on large-scale areas such as in the rangelands have restricted the observation of outcomes from conservation auctions. However, this justification is not satisfactory given the large investments in these programs made by the Australian public (Pannell *et al*. 2006; Hajkowicz 2009) and the increasing evidence of continued declines in environmental health across the Australian rangelands (Woinarski and Fisher 2003).

In response to efficiency concerns for grant-based conservation schemes there have been a number of trials of competitive processes for the allocation of public funds in order to procure conservation outcomes (Rolfe *et al.* 2009, Windle and Rolfe 2008, Windle *et al.* 2009). These competitive schemes have almost uniquely utilised an auction process to select conservation projects which provide the greatest level of environmental benefits or, increasingly, the greatest level of environmental benefits for the least cost (e.g. Windle and Rolfe 2008; Windle *et al*. 2009; Latacz-Lohmann and Schilizzi 2005). Although potentially leading to efficiency improvements in terms of procuring environmental outcomes on the rangelands, competitive tenders are not without their own problems. Previous research has shown that information asymmetries can lead to adverse selection issues and that contract monitoring issues can lead to problems of moral hazard (Latacz-Lohmann and Schilizzi 2005). Several researchers have shown that these problems may be resolved by, respectively, reducing the information asymmetry (most commonly 'disguising' the project selection mechanisms) and by including payments to landholders based purely on outcomes being achieved (i.e. compliance payments –Latacz-Lohmann and Schilizzi 2005).

However there remain some issues in that single round tenders generally do not achieve minimum willingness to accept bids from suppliers of environmental benefits and multiple round auctions allow suppliers to 'learn' the bid selection mechanism thereby reintroducing the issue of asymmetric information (Vukina *et al*. 2008). These problems have lead us to ask: From where do these strategic issues (i.e. adverse selection and moral hazard) arise and they a consequence of attempting to create a financial transaction mechanism for the purchase of non-market environmental benefits?; If they are a result of the mechanism then which sort of purchase mechanism may alleviate them?

In this paper we present theoretical research which attempts to answer these questions. We approach the issue utilising first principles of natural resource utilisation and output decisions for agricultural enterprises in the rangelands in order to avoid being constrained to attempting to understand the sources of strategic behaviour from within the competitive tender paradigm. This approach additionally allows us to consider an alternative approach to procuring environmental benefits on rangelands properties in Australia and present some hypothetical examples of their outcomes.

The remainder of this paper is set out as follows: A brief literature review on ecosystem function and decline in the rangelands is provided in the next section. In section three we review the potential impacts of competitive tenders on the *a priori* decision of graziers in the rangelands and propose an alternative approach. Section 4 contains a brief discussion of results and presents a hypothetical example application of our proposed alternative approach utilising actual data on ground cover. The final section presents conclusions and future research directions.

## 2. The Rangelands:

The rangelands are a vast land type covering approximately 70% of the global (excluding Antarctica) land mass (Ash and Stafford Smith 1996). It is generally thought that many of the landscapes within the rangelands can produce commercial levels of agricultural production, usually in the form of broad-acre grazing operations whilst simultaneously providing substantial and measurable levels of ecosystem services (Ash *et al*. 1995; Fargher *et al*. 2003; Bjorkhaug and Richards 2008; House *et al*. 2008; Greiner *et al*. 2009). In addition to ecosystem services (such as water retention and filtration, soil erosion mitigation, carbon capture, etc) the rangelands support a wide array of biodiversity and include 'hotspots' of biodiversity and areas of high endemism (Jones and Dowling 2005; Woinarski and Fisher 2003).

Ecosystem health has been declining on the rangelands for at least half a century (Watson *et al*. 2007; Woinarski and Fisher 2003). The most important anthropogenic driver of biodiversity change on the rangelands has been Land-use change (Sala and Jackson 2006) and since grazing is the dominant land use in rangeland ecosystems, many issues of environmental pressure and decline can be related to grazing pressures (Woinarksi and Fisher 2003; Watson *et al*. 2007; Ash and Stafford Smith 1996; Madany and West 1983). However there are other factors (such as invasive species) that cause environmental pressures, and grazing management may also be important in protecting and enhancing rangelands conditions (Farmar-Bowers and Lane 2009; Reeson 2008; Greiner and Gregg, in press). Indeed, in the face of existing environmental threats – beyond controlled grazing pressure – (e.g. pest animals, invasive weeds, biosecurity, etc), grazing in the rangelands may enhance environmental values in some instances rather than detract from them uniformly across the grazing-intensity gradient (Woinarski and Fisher 2003).

While public ownership and conservation is one strategy for environmental protection, the extent of rangelands, a history of pastoral uses, and complexities in management mean that large areas remain used for private purposes. The sustained interest in conservation and the environment has driven governments and conservationists to find alternative methods of achieving conservation aims on agricultural properties. Hajkowicz (2009) provides a review of the progression in Australian Government conservation efforts: (1) extension and attitude change in the 1990s via the National Landcare Scheme; (2) financial assistance/payments for conservation mainly distributed via devolved grants schemes in the mid 1990s to mid 2000s (Natural Heritage Trust 1 and 2), and; (3) the current approach using Market Based Instruments to finance farm management changes, more environmentally friendly farm infrastructure, and land set-asides (Caring for Our Country). These programs have involved increasing amounts of funding from approximately $360 million in 1990-91 (landcare) to over $2.2 billion in 2007-08 (Caring for Our Country program). Given the large and growing amount of funding for conservation on agricultural areas it is important that the public achieves value for money and that the money spent does not encourage poorer agricultural practices than those already extant and considered standard practice.

## 3. Production decisions in the Australian rangelands: with and without the presence of grant-based incentive schemes:

In order to understand properly the incentives that landholders may face to provide ecosystem services on the rangelands it is important to first understand their opportunity costs. In this paper we consider environmental services as a product of rangeland ecosystems i.e. the rangelands areas may produce a combination of agricultural commodities (henceforth referred to simply as commodities) and environmental benefits. By taking first principles we may consider the influence that competitive tenders and grant-based approaches in general have on the decisions of graziers on the rangelands with respect to the supply of environmental benefits relative to agricultural commodities.

Agricultural systems are typically annual systems relying largely on a combination of seasonal rainfall and temperature variations and existing characteristics of the locality's soil and climate (Rodriguez and Jameson 1988). Grazing systems in the rangelands in particular can be characterised as relying almost completely on natural factors (rainfall and soil nutrients) influencing ecosystem structure and pasture growth/ground cover (Pandey and Singh 1992; Ward and Kutt 2009; Langevelde *et al*. 2003). Rangelands grazing systems can thus be examined from the traditional bio-economic perspective of a 'population' growth curve (i.e. assume a logistic growth function incorporating recruitment and crowding-out effects) with several optimal harvest levels depending upon the economic prerogative: (1) Maximum Sustainable Yield (MSY) maximising revenue; (2) Maximum (private) Economic Yield (MEY) maximising net private benefits, and; (3) Maximum Social Economic Yield (MSEY) maximising social net benefits. It is the third of these, MSEY, which is of concern in this paper.

The perpetual benefits from use of the natural resources in a rangelands grazing system (conditional on use ≤ MSY) can be considered to have the characteristics of a perpetual annuity (Clarke 1990; Rodriguez and Jameson 1988): i.e. an annual flow of benefits which can be realised indefinitely conditional on the maintenance of an underlying (natural) capital resource. This suggests that the net present value of benefit flows from the pasture resource can be obtained from the formula for a perpetual annuity:

$$NPV_{Annuity} = \frac{\alpha A}{d}$$

Where:

$\alpha$ = Elasticity of profit with respect to pasture

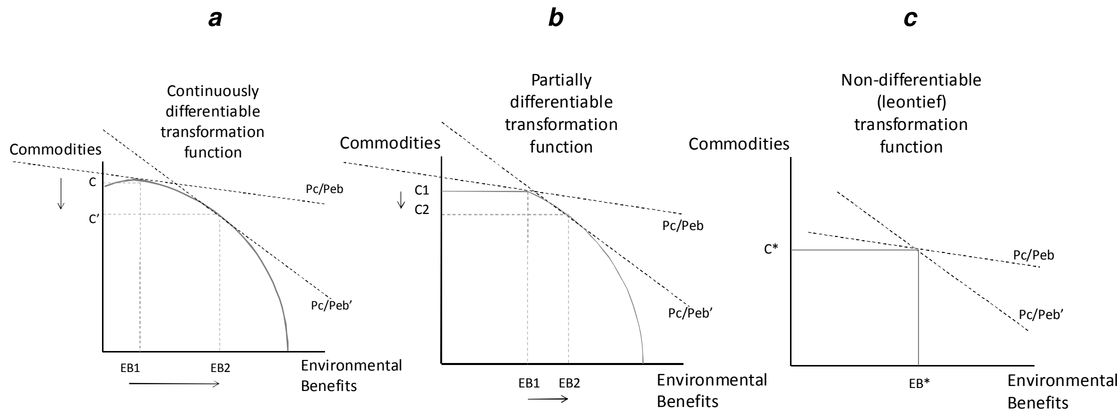
$A$ = Annual sustainable harvest of pasture (related to stocking rate, average rainfall, etc)

$d$ = Discount rate

The relationships between the production of environmental benefits and agricultural commodities from rangeland ecosystems can be described by product transformation curves (see Figure 1). Previous research (e.g. Ash *et al*. 1995; Fargher *et al*. 2003; Bjorkhaug and Richards 2008; House *et al*. 2008; Greiner *et al*. 2009) suggests that the transformation curve is subject to the standard economic assumption of a diminishing Marginal Rate of Transformation (MRT) between agricultural commodities and environmental services. The diminishing MRT is shown as a concave product transformation curve and has the implication that progressive shifts toward increasing the output of one product involves an increasing loss in the other output (holding inputs fixed and for a two-product example). The potential for changes in the ratio of provision of ecosystem services and agricultural commodities on the rangelands depends on the form of the product transformation curve between these two potential outputs. If the transformation curve is differentiable across some of the output space (Figure 1*a* and 1*b*) a shift in the relative price for output of environmental benefits can change the ratio of commodities-environmental benefits produced by owners of rangelands properties. For Figure 1a and 1b there is a diminishing marginal rate of transformation (MRT) between the two outputs, commodities and environmental benefits – the optimal point of production is located at the point where the slope of the price ratios is equal to the slope of the product transformation curve ($P_{EB}/P_C$ =MRT). A non-differentiable product transformation curve is shown in Figure 1c as an example of a Leontief production technology – the optimal point of production, regardless of the price ratio of the outputs is at the outermost vertex. When the production technology is not Leontief, in order to increase the provision of environmental benefits it is sufficient only to increase the price of these relative to those of agricultural commodities. When no environmental benefit-purchase mechanism is present the opportunity costs for depletion of ecosystem services (i.e. the annuity) is equal only to the net present value of profit from production losses in the future (and possibly a premium for environmentally conscious producers).

It is the aim of this section to consider whether competitive tenders do in fact increase the price for environmental benefits relative to that of agricultural commodities on the rangelands.

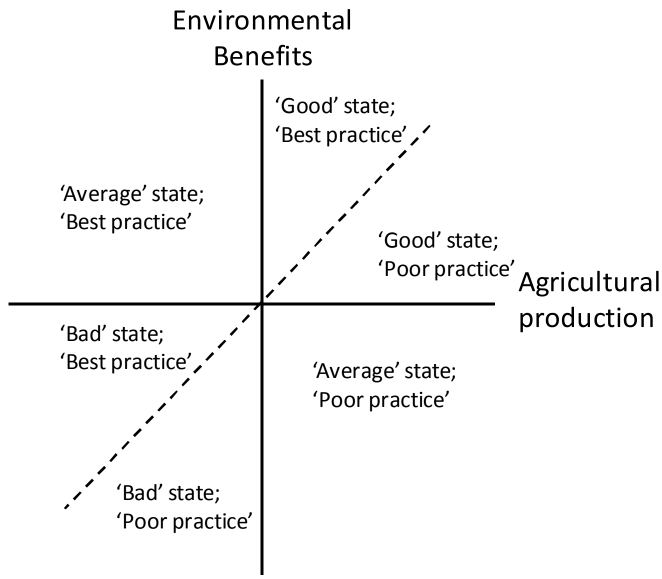
**Figure 1: Product transformation curve for environmental benefits and agricultural commodities**




Note: The backward-bending (non-concave) portion of the product transformation curve in Figure 1(a) reflects the point at which a decline in environmental benefits leads to a decline in future pasture productivity and hence commodities (meat, fibre) production. This reflects the complex dependence of sustainable rangelands grazing systems on maintenance of a minimum level of environmental benefits.
The linear component of the transformation curve in Figure 1(b) suggests a point where a rangelands producer cannot increase commodities production regardless of the trade-off of environmental benefits – this is clearly a weaker physical relationship than in Figure 1(a).
In Figure 1(c) there is only one efficient point of production and hence ratio of outputs. The producer cannot trade-off production of one output for another – this is a very restrictive form of production relationships.

Figure 2 represents a conceptual view of the possible outcomes of two possible management approaches across three categories of possible states of nature – ‘good’, ‘bad’, and ‘average’: ‘best practice’ referring to management which represents the frontier of sustainable grazing management, and; ‘poor practice’ which represents grazing management which is more focused on commodity production and may incorporate such management actions as ‘set stocking rates’.

**Figure 2: Possible outcomes from state and action combinations**




Although Figure 2 is a good representation of the state-outcome space we instead utilise a continuous representation of actions aligned with stocking rates (and thus pasture utilisation) and we present expected profit as simply the expectation of a function with respect to pasture utilisation – states of nature and their respective profit potentials are implicit but not considered directly:

$$E(\pi_m) = \max\left[f\left(PU_m\right)\right]$$

Where:

$f(.)$ = Profit/utility function for production of commodities

$PU_m$ = Level of pasture utilisation for management type $m$

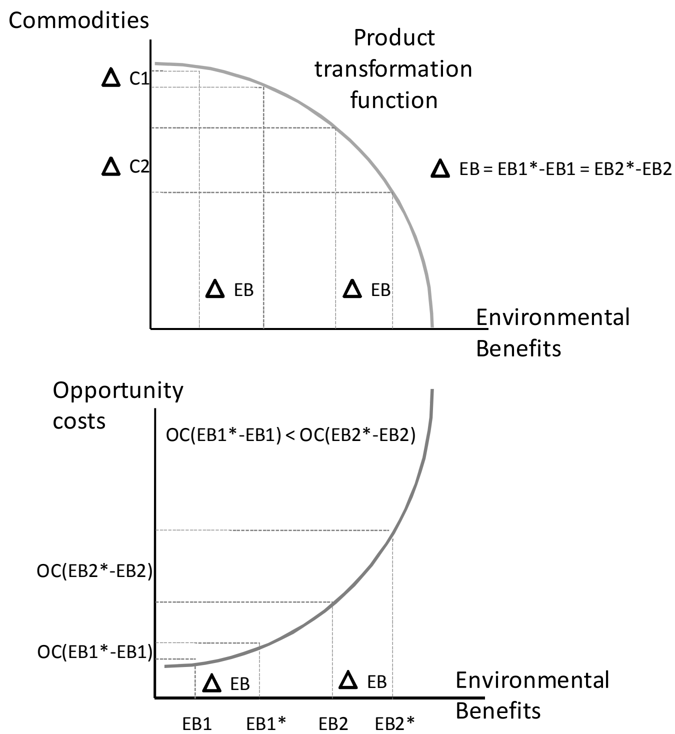
In the context of this paper we consider profit in terms of the net benefits over time and assume that graziers' are profit maximisers. This allows incorporation of the opportunity costs of depletion of ecosystem services directly in the profit function as the declining future levels of profit arising from a lower stock of natural capital – i.e. profit is a function of the maximum possible net benefits from the pasture annuity:

$$E(\pi_m) = \max\left[f\left(\frac{\alpha A}{d}\right)\right]$$ (using the NPV formula from earlier)

The costs associated with expanding the output of ecosystem services within a particular grazing enterprise on the rangelands can be considered as the costs of foregone agricultural production. Assuming a monotonically increasing supply curve for environmental benefits on a given property the costs of provision of environmental services are increasing as provision of environmental benefits increases (Figure 3). The monotonically increasing supply curve arises here from our specification of cost of environmental benefit provision as the opportunity costs of foregone agricultural production.

An example of empirical results supporting this functional form for provision of environmental benefits can be found in Rolfe *et al*. 2008.

**Figure 3: Costs of expansion in the provision of environmental benefits (no environmental benefits purchase scheme)**




The objective function of the allocation of funds in a competitive tender scheme is usually to maximise the environmental benefits purchased given a budget constraint (Latacz-Lohmann 2005; Rolfe, McCosker and Windle 2008). In order to do this, competitive tenders incorporate an auction mechanism to encourage competitive bidding thus obtaining the greatest environmental benefits for the least cost in each auction round. Formally, we may write the objective function of competitive tender schemes as:

$$\max(EB)$$
$$s.t. \quad \sum_{X} B_x \le Y$$

Where:

*EB* = Environmental Benefits (expected conditional on state of nature)

$B_x$ = Bid/payment amount for Environmental Benefits from action or outcome *x*

*Y* = Budget constraint

Figure 3 shows that the marginal opportunity costs of the supply of environmental benefits are lower for an enterprise producing a relatively greater proportion of commodities to environmental benefits *ceteris paribus*. That is, landholders who can produce more environmental services for limited opportunity costs (those close to EB1 in Figure 3) are likely to submit cost-effective proposals in a tender system. This result is supported in the literature and is linked to the notion that information asymmetry will lead to adverse selection where high opportunity cost suppliers of environmental benefits will falsely portray the impression that they are actually low opportunity cost suppliers – i.e. they will state or imply they are producing at EB1 rather than at EB2 in Figure 3 (Latacz-Lohmann 2005). The net result of the implementation of a competitive tender can be considered from the perspective of the marginal impact on the expected profit for the landowner. We utilise a two-period model to highlight the behavioural shift here and assume that the landowner in question has knowledge of an impending conservation auction in time *t+1* and considers his/her actions in time *t*.

The landowner first assesses the prospects in time *t+1*. Two possible outcomes are (1) Be funded for actions under the conservation auction, and; (2) do not get funded and continue as normal. The two outcomes have expected profit:

$E(\pi_{CT}) = \sum_{J} \max\left[f\left(PU_{CT}\right)\right]$ for (1), and;

$E(\pi_{m}) = \sum_{J} \max\left[f\left(PU_{m}\right)\right]$ for (2)

Where:

$PU_{CT}$ = the level of pasture utilisation which maximises net present benefits in time *t+1* if the landholder engages in the competitive tender

$PU_{m}$ = the level of pasture utilisation under the status quo

If the expected profit from winning a contract in the competitive tender is greater than under the status quo (in time *t+1*):

$$\sum_{J} \max\left[f\left(PU_{CT}\right)\right] > \sum_{J} \max\left[f\left(PU_{m}\right)\right]$$

Then the landowner will act to jointly maximise expected profit in time *t* and that in time *t+1* by maximising the sum of expected profit in time *t* and expected profit in time *t+1*:

$$\begin{aligned} E(\pi_{T}) = & \sum_{J} \left[f\left(PU_{m,t}\right)\right] \\ & + \lambda \sum_{J} \max\left[f\left(PU_{CT,t+1}\right)\right] \\ & + (1-\lambda) \sum_{J} \left[f\left(PU_{m,t+1}\right)\right] \end{aligned}$$

Where:

$\lambda$ = Probability of proposed *CT* bid being successful

Since the objective function of a competitive tender is to maximise environmental benefits per dollar spent (from earlier) and since the supply function for environmental benefits is monotonically increasing, then lambda is inversely related to current (time *t*) environmental benefits. Then if expected profit from a successful competitive tender bid is greater than the status quo, the landowner will reduce provision of environmental benefits in time *t* to some extent in order to equalise the marginal net present value of expected profit in time *t* and that in time *t+1* (since production of beef in time *t* directly affects production in time *t+1* – i.e. it is an inter-temporal consumption problem):

$$\max[\pi_T] = \frac{\partial E[\pi_t]}{\partial E[\pi_{t+1}]} = 0$$

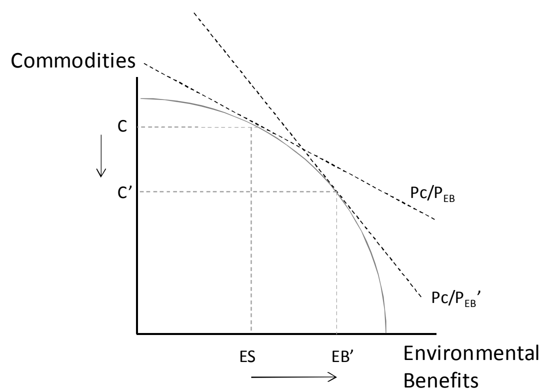
Given our assumption of diminishing MRT (or alternatively: a monotonically increasing supply function for environmental benefits), the above results suggest that in the case where participation in the competitive tender is beneficial to the landowner (i.e. higher expected profit) the provision of environmental benefits relative to commodities will inadvertently be reduced in time *t*. The amount of reduction in production of environmental benefits in time *t* depends on two main factors: (1) the (positive) difference between profit under the competitive tender and under the status quo, and; (2) Lambda – the probability function for success in the competitive tender. This result is not so surprising as may seem – Latacz-Lohmann and Schilizzi (2005) show that adverse selection in competitive tenders is the occurrence of bidders making false claims that they are 'low-cost' suppliers – i.e. making claims that they are not supplying environmental benefits which they are in fact already providing. The result above shows that they may not only make false claims but actually change their behaviour to become, temporarily, low cost producers when they have knowledge over an impending competitive tender. This behaviour would maximise expected profits when the profit arising from success in the competitive tender is greater than continuing commodity production in the same manner as the status quo.

Much has been said of the strategic behaviour of landowners participating in competitive tenders when there is information asymmetry (e.g. Ferraro 2008; Arredondo 2008; Latacz-Lohmann and Schilizzi 2005) or where initial actions are necessary but not sufficient to achieve the 'purchased' environmental benefits – i.e. ongoing monitoring and enforcement is required. In general the conclusion has been to increase complexity (e.g. Vukina *et al*. 2008) via disguising of the proposal selection mechanism as much as possible – such as in the Conservation Reserve Program in the United States (Vukina *et al*. 2008), or respectively; by including an outcome oriented component in the contract payment schedule. Both of these offer only partial solutions to the problem outlined above: (1) Hiding the selection mechanism in an attempt to equalise information asymmetry also confuses the objective function of landowners – i.e. they must conduct a search informed largely by innuendo and guesswork over the true preferences of the 'consumer' (the government) to whom they are selling their 'product' (the environmental benefits), and; (2) including a partial outcome-based selection mechanism deals well with ex-post moral hazard (Ferarro 2008) but does not deal with the *a priori* moral hazard impacts on the landowners objective function. Alternatively, the prior analysis suggests that the inclusion of an appropriately set and apparent minimum standard for inclusion in the competitive tender mechanism will minimise adverse impacts on *a priori* provision of environmental benefits despite failing to directly address the moral hazard issue. This is a similar result as that arising from including a bid ceiling above which bids are not funded in order to restrict rent seeking (Latacz-Lohmann and Schilizzi 2005). Many competitive tenders have included such a benchmark as a minimum standard. The result is that a floor on *ex ante* strategic behaviour (to maximise the probability of success in a competitive tender) is set. It does not however remove the incentive to strategic behaviour and thus the potential remains for strategic behaviour to reduce or make negligible the possible improvements from implementations of competitive tenders. .

The issue highlighted in the preceding material signals that issues with information asymmetry or moral hazard are not intrinsically associated with public purchases of environmental benefits – rather it is the design of the purchase mechanism which leads to problems with adverse selection and moral hazard. It raises the question of whether there may be a better approach to funding (additional) environmental services on rangelands grazing enterprises. We review an obvious alternative in the following.

From the principles outlined above it is clear that the main effect of a mechanism to purchase environmental benefits should be to increase the 'price' (opportunity cost) for environmental benefits relative to that of commodities (Figure 5).

**Figure 5: Effect of increasing the relative price for output of environmental benefits**




This may occur simply by applying a payment schedule for marginal additions to the output of environmental benefits for any group of enterprises (ideally the universal set of suppliers) – let us refer to such an approach as a marginal rewards scheme. In terms of the expected profit/utility function this can be shown as:

$$E(\pi_m) = \max[g(PU_{MR})]$$

Where:

*g(.)* is differentiated from *f(.)* earlier by the inclusion of an additional payment schedule for environmental benefits

$PU_{MR}$ = the level of pasture utilisation which maximises net present benefits for the case where a marginal rewards scheme is implemented

And assuming the product transformation curve between commodities and environmental benefits is not Leontief (i.e. is of the form shown in Figure 1a or 1b):

$$g(PU_{MR}) = E(\pi_{MR}) \succ E(\pi_m) = f(PU_m)$$

Where:

$E(\pi_{MR})$ = Expected profit/utility with the marginal rewards scheme for the pasture utilisation level which maximises the function *g(.)*

$E(\pi_m)$ = Expected profit/utility with the marginal rewards scheme for the pasture utilisation level which maximises the function *f(.)*

The terms above are exactly the same as the original profit function term because they do not change the structure of the grazing enterprise's objective function – the only change is to the ratio of prices for outputs. Originally the 'price' for environmental benefits was a function only of the opportunity cost of foregone commodity production at that point:

$$P_{MR} = \Delta \frac{\alpha H}{d}$$

Where:

$\Delta$ = Represents the change in NPV of the pasture annuity from a unit change in H

$\alpha$ = Elasticity of profit with respect to pasture

*H* = Annual harvest of pasture (related to stocking rate, average rainfall, etc)

*d* = Discount rate

This is the annuity formula from earlier which is used to calculate the NPV (Net Present Value) of resource (pasture) usage. The implementation of a marginal rewards scheme which provides payments for unit additions to the stock of ecosystem services amends this formula with an additional term:

$$P_{EB} = \Delta \frac{\alpha H + \partial EB}{d}$$

Where:

$\partial$ = Payment amount per unit of environmental services (+ve)

EB = Quantity of environmental benefits supplied

Thus such a scheme achieves the aim of increasing the ratio of prices paid for environmental benefits to those for agricultural commodities. However it is apparent that the public should not carry the full burden of payments for environmental benefits due to complimentarity between commodities and environmental health and questions of distributional efficiency (i.e. payment for outputs below those occurring under an expected duty of care). These issues may be dealt with via inclusion of a benchmark (e.g. duty of care or best practice) under which no payments are made (i.e. a 'benchmark marginal rewards scheme') or, in the case where a duty of care is extant; a dual sided payment schedule with 'output' of environmental benefits above the duty of care receiving a payment and 'consumption' of environmental benefits below the duty of care subject to a fee (i.e. a 'marginal pricing scheme'):

$$P_{EB} = \Delta\frac{\alpha H}{d} + \partial\left(EB - \overline{EB}\right)$$

OR

$$P_{EB} = \Delta\frac{\alpha H}{d} + if\begin{cases} EB < \overline{EB}, & \varepsilon EB \\ EB > \overline{EB}, & \partial EB \end{cases}$$

Where:

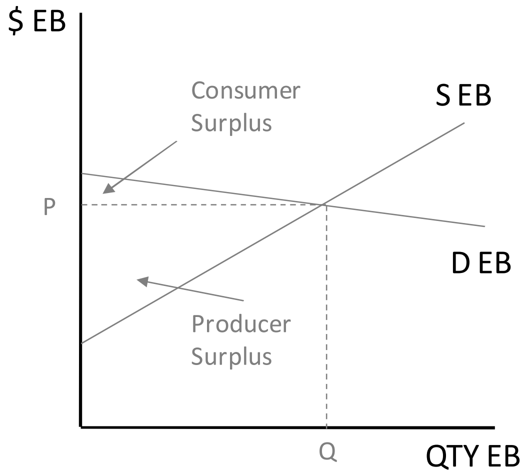
$\overline{EB}$ = Duty of care quantity of environmental benefits

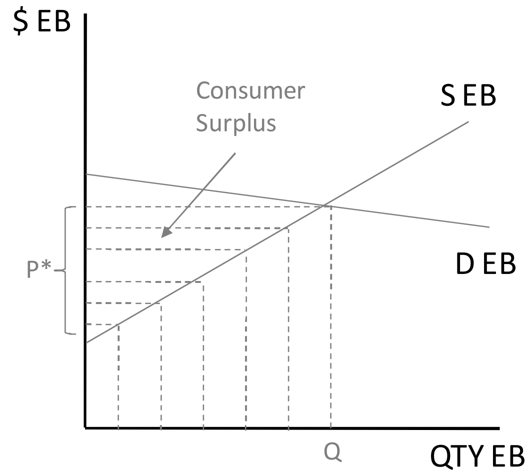
In the above the first equation suggests an equal reward/penalty schedule for provision of environmental benefits above or below the duty of care benchmark – this is the payment rule for the 'marginal pricing scheme'. The second suggests an unequal payment schedule which may incorporate other social goals (such as having a financially secure rangelands grazing industry with $\varepsilon < \partial$ ; or when distributional goals weight environmental values more highly than agricultural values with $\varepsilon > \partial$ ) and may reflect the 'benchmark marginal reward scheme' when $\varepsilon$ is equal to zero and the 'marginal pricing scheme' when $\varepsilon$ is greater than zero.

Although the marginal reward scheme is simple and apparently addresses issues with strategic behaviour it is not necessarily cheaper than competitive tenders. Competitive tenders have a distinct advantage over set-price schemes in that, due to the sealed-bid characteristic of their implementation, they are potentially able to capture producer surplus and thus purchase environmental benefits at lower prices than in the case of an open market purchase such as in the marginal pricing scheme above. This can be clearly shown using simple supply and demand diagrams. Figure 6 shows the relative advantage a competitive tender may have in terms of the costs to the Government of purchases of environmental benefits from grazing properties on the rangelands.

**Figure 6: competitive tender vs. Marginal reward scheme – capturing producer surplus**

**a. Marginal reward** **b. Competitive tender**



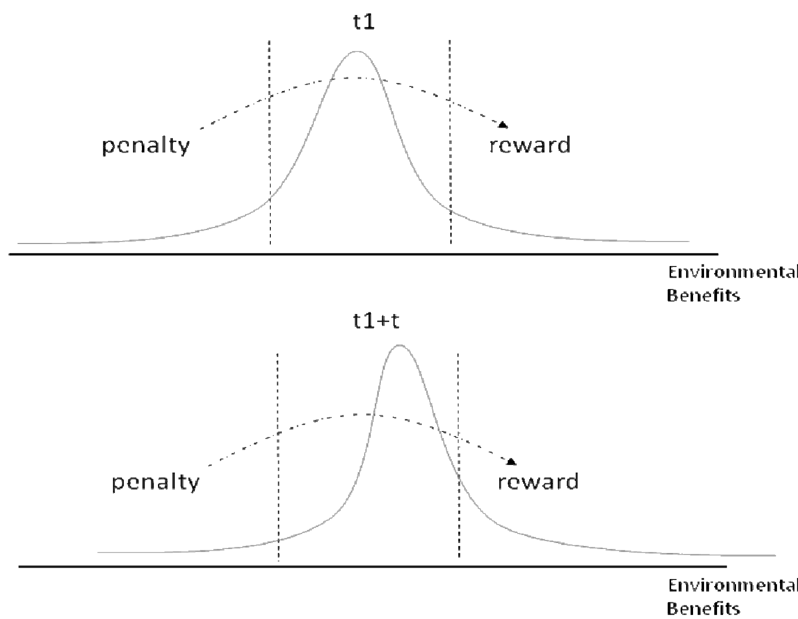

The competitive tender approach is able to purchase environmental benefits from landowners at their individual willingness to accept, rather than at a given 'market' price under which producers able to supply environmental benefits at lower cost are able to obtain a surplus. This is similar to the case where a monopoly consumer has the ability to segment their supply market and purchase quantities of inputs at the respective suppliers' marginal willingness to accept. In the long-run however, under a traditional market price transaction arrangement, the supply curve would be expected to be flat (Pindyck and Rubinfeld 1997). Thus there would be no advantage of a competitive tender program over a marginal reward program. This may occur (in the case of the marginal reward scheme) as land/labour prices increased for those properties/managers better able to procure joint environmental benefits and beef from rangelands properties thus leading to a flatter supply curve over time. In contrast, the competitive tender-type program would lead to greater wages for those managers able to capture greater surplus via strategic behaviour reinforcing the returns to such behaviour.

## 4. Discussion and an empirical example:

The preceding analysis is not conclusive on the net impact of competitive tenders on provision of environmental benefits. In the short term competitive tenders may dominate traditional market interactions (where a single price is paid to all suppliers) by placing purchasing power firmly in the hands of the auctioneer via the sealed bid mechanism. This theoretically allows the auctioneer to obtain environmental benefits from landowners at different prices which are reflective of their marginal costs of supply/willingness to accept. However the capture of such surplus generally only occurs over multiple bidding rounds which allow bidders to learn the bid selection mechanism and thus potentially generates strategic behaviour (Latacz-Lohmann 2005). These issues raise questions over possible alternatives which may prove to be (more) effective with negligible or no losses in efficiency in the long-term – one such alternative was reviewed in the previous section of this paper.

The alternative approach to competitive tenders suggested in this paper – the marginal reward/penalty approach – alleviates these perverse outcomes but may, in the short run, involve greater public outlays per unit of environmental benefits purchased due to inelasticity of the short run supply curve. However, there is potential for this type of approach to place the funding burden (partially) on industry by applying penalties to significantly under-performing properties which are then redistributed to significantly over-performing. Conceptually this approach would involve some benchmark (i.e. of ground cover in the rangelands) with lower and upper bounds within which the difference between environmental benefits provided and the benchmark remain un-priced. Below the lower bound landowners would be levied by some price multiplied by the difference between their level of environmental benefits and the benchmark or the lower bound. Revenues from these levies would then be distributed to landowners on the basis of their provision of environmental benefits above the benchmark or upper bound for the benchmark, possibly with top-up funds from the Government. Figure 7 shows a simple conceptual model of this type of scheme. Those producers in the 'penalty' portion of the distribution may be those with relatively poor lands for dual production of agricultural and environmental outputs use or have low management skill/preferences with respect to provision of environmental benefits – and vice versa for those in the 'reward' portion. Over time it would be expected that the distribution of environmental benefits supply would shift right, whilst those lands/managers with lower dual production potential/skills would experience declines in their value/salary relative to those lands/managers with high dual production potential/skills. The relative decline in value/salary is part of the supply adjustment leading to an elastic long-run supply curve.

**Figure 7: Marginal penalty-reward scheme using redistribution of penalties**




The rangelands presents as an ideal area in which to observe the true impacts of schemes ranging from devolved grant, to competitive tenders, and potentially in the future to marginal pricing type schemes. In order to show the potential for remote sensing to facilitate the implementation of marginal pricing schemes we present some results from the hypothetical application of this approach in the

Australian rangelands[2]. We measured an expected level of ground cover conditional on rainfall to define a distribution of expectations for a sample of sites. This allows the setting of a benchmark and upper and lower bounds of site 'performance' based on quantiles of estimated expected ground cover to which observed ground cover for a set of sample properties is compared.

Although the optimal benchmark for grass cover – balancing private benefits and social costs – is not currently known, in order to provide an example of the application of this approach we arbitrarily specify four alternative levels for the benchmark based on subjective quantile judgements. Specifically we consider the case where the benchmark is considered to be the 40$^{th}$ percentile of the conditional ground cover distribution, the 50$^{th}$ percentile of the conditional ground cover distribution, the 60$^{th}$ percentile of the conditional ground cover distribution and, finally, the 50$^{th}$ percentile again but with 10% error bounds above and below this level inside of which no reward/penalty is applied. The conditional ground cover distribution refers to the distribution of expected levels of ground cover calculated using 258 estimated relationships between rainfall (the Foley series) and ground cover on separate sites in the rangelands.

Individual sites were assessed against the distribution of expected ground cover values for the 258 estimated equations. This provided a robust, empirical distribution of expected ground cover. A matrix of expected level of ground cover was developed to facilitate interpretation of the comparison between expected-versus actual ground cover for sample sites in this dataset. A shortened version of this matrix is presented in Table 1. This table can be replicated for arbitrarily small differences in the Foley series and for any specified quantiles (we used 10$^{th}$ percentiles in Table 1). In practice, a computer program could be used to assess ground cover performance, relative to a benchmark, exactly; Table 1, however shows the intuition behind these assessments – A benchmark quantile is chosen, the Foley score (representing rainfall) for a particular site is calculated and assessed against the expected level of ground cover conditional on the selected quantile/model and Foley score.

[2] We gratefully acknowledge Juliana McCosker for the use of this data as an example of the *hypothetical* scenarios presented in this paper.

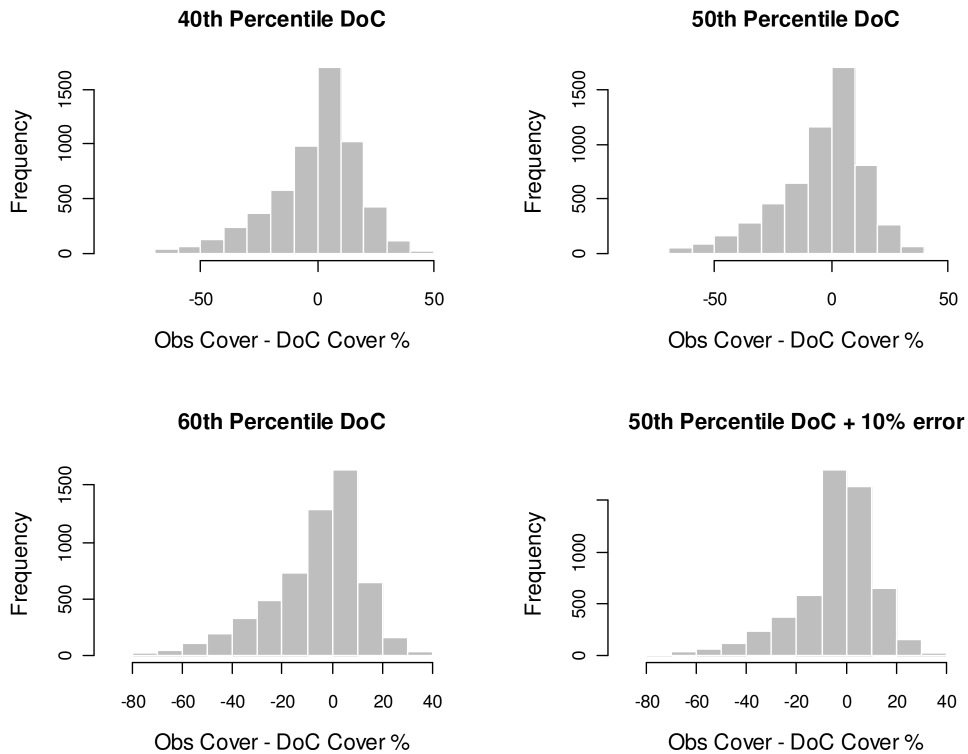
**Table 1: Expected ground cover for 10th-90th percentile quantiles conditional on rainfall (Foley series) and with no fire scar[3]**

| | Quantile of expected cover | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Foley value** | **0.1** | **0.2** | **0.3** | **0.4** | **0.5** | **0.6** | **0.7** | **0.8** | **0.9** |
| **-1.8** | 0.153521 | 0.244264 | 0.3268 | 0.395805 | 0.461956 | 0.519398 | 0.583607 | 0.645544 | 0.725018 |
| **-1.766667** | 0.158503 | 0.251732 | 0.335873 | 0.407073 | 0.469992 | 0.526735 | 0.58802 | 0.651426 | 0.728331 |
| **-1.733334** | 0.165599 | 0.261876 | 0.346505 | 0.418672 | 0.478271 | 0.534062 | 0.59259 | 0.657714 | 0.731624 |
| **-1.700001** | 0.175028 | 0.269992 | 0.357311 | 0.430342 | 0.485296 | 0.541379 | 0.599629 | 0.66409 | 0.735166 |
| **-1.666668** | 0.184791 | 0.27886 | 0.367134 | 0.442072 | 0.493859 | 0.548546 | 0.606636 | 0.671136 | 0.740354 |
| **:** | : | : | : | : | : | : | : | : | : |
| **-0.533346** | 0.518118 | 0.618734 | 0.68411 | 0.729517 | 0.764782 | 0.78863 | 0.811847 | 0.84572 | 0.880097 |
| **-0.500013** | 0.526633 | 0.628612 | 0.69766 | 0.736735 | 0.771497 | 0.794033 | 0.817233 | 0.850972 | 0.883884 |
| **-0.46668** | 0.535107 | 0.638577 | 0.703212 | 0.744081 | 0.777793 | 0.79838 | 0.823286 | 0.854282 | 0.887823 |
| **-0.433347** | 0.546589 | 0.647278 | 0.706295 | 0.750611 | 0.784698 | 0.803644 | 0.829402 | 0.858311 | 0.890855 |
| **-0.400014** | 0.558658 | 0.655153 | 0.712171 | 0.758015 | 0.792174 | 0.808397 | 0.834881 | 0.861449 | 0.894179 |
| **:** | : | : | : | : | : | : | : | : | : |
| **0.133314** | 0.706793 | 0.779402 | 0.814973 | 0.842971 | 0.87018 | 0.889901 | 0.906216 | 0.923728 | 0.939295 |
| **0.166647** | 0.713078 | 0.784768 | 0.820303 | 0.847049 | 0.874757 | 0.894941 | 0.91018 | 0.927429 | 0.941772 |
| **0.19998** | 0.714866 | 0.789769 | 0.828013 | 0.852791 | 0.879221 | 0.899066 | 0.91411 | 0.930679 | 0.944144 |
| **0.233313** | 0.723851 | 0.795268 | 0.832428 | 0.857712 | 0.883402 | 0.902553 | 0.918081 | 0.933375 | 0.946643 |
| **0.266646** | 0.73434 | 0.800595 | 0.83654 | 0.862326 | 0.887526 | 0.905951 | 0.92097 | 0.936373 | 0.949163 |
| **:** | : | : | : | : | : | : | : | : | : |
| **1.333302** | 0.886064 | 0.926191 | 0.946975 | 0.962369 | 0.968745 | 0.976588 | 0.981715 | 0.98626 | 0.991309 |
| **1.366635** | 0.889274 | 0.927849 | 0.948833 | 0.96473 | 0.970548 | 0.977538 | 0.982546 | 0.987141 | 0.991813 |
| **1.399968** | 0.892955 | 0.931117 | 0.95092 | 0.966207 | 0.972308 | 0.978857 | 0.983457 | 0.987875 | 0.992315 |
| **1.433301** | 0.896053 | 0.933976 | 0.952358 | 0.967719 | 0.974008 | 0.979792 | 0.984324 | 0.98855 | 0.99287 |
| **1.466634** | 0.898016 | 0.935708 | 0.953791 | 0.969107 | 0.975467 | 0.980736 | 0.985092 | 0.98919 | 0.993415 |

The distribution of ground cover on sample sites, relative to the site- and time-specific benchmark, is shown in Figure 8. The zero value on the x-axis reflects the ‘benchmark’ with negative values implying below-benchmark ground cover (financial penalties to graziers) and positive values suggesting above-benchmark ground cover (financial rewards to graziers). As expected, the 40th percentile benchmark results in the largest number of payments or rewards and the least number of receipts or penalties and vice versa for the 60th percentile duty of care. What is not clear from Figure 8 however is the extent to which receipts would cover payments for any one these schemes using data from these sites.

[3] Note that not all predictions are included due to space considerations.

**Figure 8: Histograms of performance relative to the four benchmark specifications**




The distributions of ground cover levels, relative to the respective benchmark, are skewed to the left. This suggests that there exist a small number of properties, or time periods, where there is low ground cover relative to the majority of the sample. Visual examination of cross-sectional variation versus temporal variation in ground cover suggested that the skewness did indeed originate from spatial rather than temporal variability – that is, there are sites which consistently have lower ground cover than the expected level from our models.

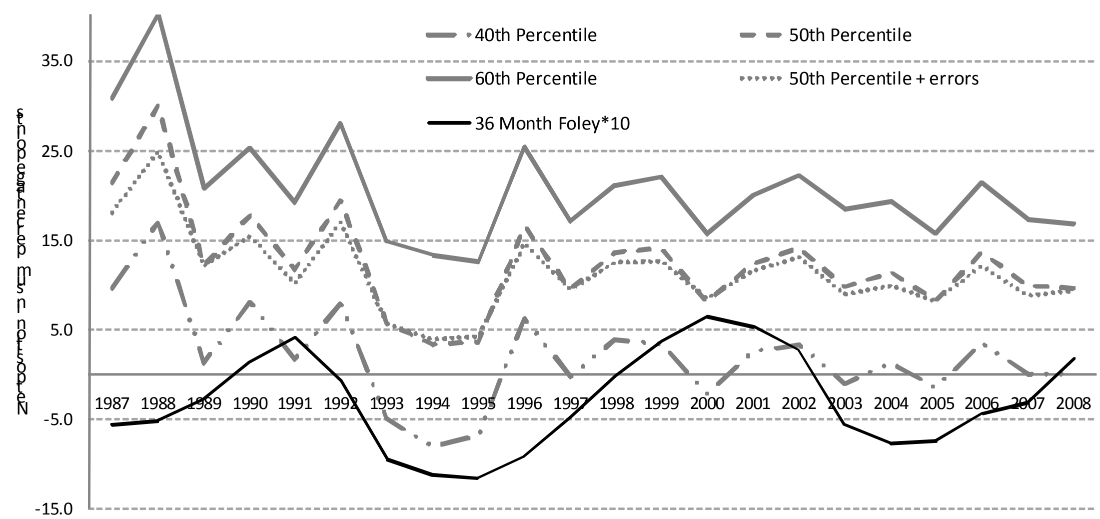
Expected 'payments' and 'receipts' were calculated for each year of the dataset across the sample of sites available (n=299). Table 2 shows the total payments, receipts and net position for the financing of such a scheme based on the sum of percent differences from the relevant benchmark level of ground cover level for each year. We assume that the equal penalty/reward scheme is implemented in this case. Net funding positions for the proposed policy, under any benchmark specification considered here are positive in most years. That is, under the four benchmark specifications, the scheme would have a higher value of receipts than payments if penalties were applied at the same rate as rewards (not taking into account adjustments to provision of EBs via ground cover improvements). Specifically, the $40^{th}$ percentile benchmark specification had a net positive financial position in 13 out of 22 years (59%), the remainder were positive in all years examined.

**Table 2: Receipts versus payments (proportion of penalties applied to payments made) under the four alternative benchmark specifications**

| Year | 40th Percentile | | | 50th Percentile | | | 60th Percentile | | | 50th Percentile + errors | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Receipts | Payments | Net | Receipts | Payments | Net | Receipts | Payments | Net | Receipts | Payments | Net |
| 1987 | 27.4 | -17.8 | 9.6 | 34.0 | -12.7 | 21.3 | 40.1 | -9.3 | 30.9 | 27.4 | -9.3 | 18.1 |
| 1988 | 33.9 | -17.0 | 16.9 | 42.1 | -12.2 | 29.9 | 49.1 | -9.1 | 40.0 | 33.9 | -9.1 | 24.8 |
| 1989 | 23.4 | -22.1 | 1.2 | 27.8 | -15.8 | 12.0 | 32.0 | -11.3 | 20.6 | 23.4 | -11.3 | 12.0 |
| 1990 | 24.5 | -16.4 | 8.0 | 29.6 | -11.9 | 17.8 | 34.2 | -9.0 | 25.2 | 24.5 | -9.0 | 15.5 |
| 1991 | 20.5 | -18.8 | 1.7 | 25.2 | -13.5 | 11.6 | 29.4 | -10.4 | 19.1 | 20.5 | -10.4 | 10.1 |
| 1992 | 26.7 | -18.7 | 8.0 | 32.7 | -13.4 | 19.4 | 37.8 | -9.8 | 28.0 | 26.7 | -9.8 | 16.9 |
| 1993 | 19.0 | -24.0 | -5.0 | 23.7 | -18.0 | 5.7 | 28.2 | -13.3 | 14.9 | 19.0 | -13.3 | 5.7 |
| 1994 | 18.4 | -26.5 | -8.0 | 23.0 | -19.6 | 3.4 | 27.8 | -14.5 | 13.3 | 18.4 | -14.5 | 3.9 |
| 1995 | 19.0 | -26.0 | -7.0 | 23.3 | -19.6 | 3.6 | 27.4 | -14.8 | 12.6 | 19.0 | -14.8 | 4.2 |
| 1996 | 24.2 | -17.9 | 6.2 | 29.5 | -13.0 | 16.5 | 34.9 | -9.6 | 25.3 | 24.2 | -9.6 | 14.6 |
| 1997 | 23.6 | -23.9 | -0.3 | 27.7 | -18.2 | 9.5 | 31.3 | -14.2 | 17.1 | 23.6 | -14.2 | 9.4 |
| 1998 | 22.5 | -18.6 | 3.8 | 27.0 | -13.4 | 13.6 | 31.1 | -10.0 | 21.0 | 22.5 | -10.0 | 12.4 |
| 1999 | 24.2 | -20.8 | 3.4 | 29.1 | -15.2 | 14.0 | 33.5 | -11.5 | 22.0 | 24.2 | -11.5 | 12.7 |
| 2000 | 21.0 | -23.2 | -2.2 | 24.7 | -16.7 | 8.1 | 28.1 | -12.5 | 15.7 | 21.0 | -12.5 | 8.5 |
| 2001 | 22.6 | -20.1 | 2.5 | 27.2 | -14.8 | 12.4 | 31.1 | -11.2 | 20.0 | 22.6 | -11.2 | 11.5 |
| 2002 | 24.4 | -21.1 | 3.3 | 29.3 | -15.2 | 14.2 | 33.6 | -11.3 | 22.3 | 24.4 | -11.3 | 13.0 |
| 2003 | 20.0 | -21.0 | -1.1 | 24.9 | -15.2 | 9.8 | 29.5 | -11.1 | 18.5 | 20.0 | -11.1 | 8.9 |
| 2004 | 20.3 | -19.0 | 1.3 | 25.1 | -13.7 | 11.4 | 29.6 | -10.4 | 19.2 | 20.3 | -10.4 | 9.9 |
| 2005 | 20.2 | -21.6 | -1.4 | 24.1 | -15.8 | 8.2 | 27.7 | -11.9 | 15.7 | 20.2 | -11.9 | 8.2 |
| 2006 | 21.8 | -18.2 | 3.5 | 26.7 | -13.1 | 13.6 | 30.9 | -9.6 | 21.3 | 21.8 | -9.6 | 12.1 |
| 2007 | 19.5 | -19.5 | 0.0 | 24.1 | -14.3 | 9.8 | 28.2 | -10.8 | 17.4 | 19.5 | -10.8 | 8.7 |
| 2008 | 19.5 | -19.5 | 0.0 | 23.4 | -13.9 | 9.5 | 27.0 | -10.2 | 16.8 | 19.5 | -10.2 | 9.2 |

In order to facilitate a comparison between the four benchmark specifications, the annual net financial positions were plotted; the results are shown in Figure 9.

**Figure 9: Net position of payments-receipts for the four alternative benchmark specifications and the average 36 month Foley value for 1987-2008**




The results and modelling approach above are novel in that they show the potential for: (1) increasing the environmental responsibility of the grazing industry in the rangelands by specifying more clearly property rights in terms of a level of ground cover conditional on events beyond their control (i.e. rainfall, soil nutrients), and; (2) implementing a potentially self-funding conservation incentive scheme using redistribution of penalties levied on landowners performing poorly with respect to the environmental benchmark as rewards to those performing relatively well.

## Conclusions

Interest in the conservation of ecosystem services on the rangelands remains unabated despite widespread attempts to mitigate their decline over the last few decades. In this paper we have shown that competitive tenders may not realise economic efficiency even in the case of full contractual compliance. The result shown in this paper is due to implicit incentives to reduce supply of environmental benefits prior to the implementation of a competitive tender; however this effect remains to be empirically tested. Current observations of limited effectiveness for competitive tenders may be more associated with a lack of program consistency, the targeting of actions rather than outputs, a lack of funds for individual implementations of these programs, difficulties with engaging large numbers of graziers in such programs, and a lack of monitoring to ascertain changes in environmental performance of participating properties.

The results contained within show there is potential for alternative methods for the procurement of environmental benefits on the rangelands to be developed. An alternative approach to purchases of environmental benefits may be via a simple marginal payment mechanism where all landholders in a region are paid a uniform (but not necessarily uniform) amount per unit of environmental benefits based on their additions to the supply of these above some socially acceptable benchmark. This type of scheme provides potential for self-funding by applying a dual penalty-reward payment schedule for (respectively) below or above benchmark provision of environmental benefits. This approach would make explicit the property rights of the landowner over the use of natural resources with external environmental benefits on their property.

In this paper we set out to answer several questions. From the research contained within we may suggest the following conclusions: Strategic behaviour amongst participants in competitive tenders arises from the purchase mechanism itself rather than from the attempt to purchase non-market public goods/services; A marginal reward/penalty scheme such as suggested above mitigates these strategic behaviours albeit at a short term cost of reducing the capacity of the purchaser to capture producer surplus, and; Remote sensing technology and leasehold agreements for the rangelands in Australia are favourable to incorporating such a scheme and thus more clearly defining the property rights of leaseholders and the public over the use of rangelands for grazing and environmental purposes.

This paper points to several future research directions:

(1) Formulate and implement an empirical model such as the one described in this paper to examine the impact of grazing and conservation programs in the rangelands over the two or more decades

(2) Further pursue the potential for an alternative environmental benefit procurement scheme which involves institutional changes to the rangelands grazing industry and which may be

(partially) self funding via dual levies/rewards on poor/good performers with respect to environmental benefits

(3) Incorporate measured expected environmental benefits from the empirical model in this paper with a production/profit model to develop a robust understanding of the contributions of pasture and environmental benefits to the profit/utility function of rangelands graziers

(4) Extend this research to more intensive agricultural industries in the future as better remotes sensing tools and models become available.

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