Evaluation of forage shrub plantations as a drought preparedness strategy for landholders in the Central-west of NSW.

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Abstract

The central-west region of NSW accounts for a significant proportion of the states' livestock numbers and cereal crops but production is constrained mainly by a lack of water available for plant growth. Water availability for this region is characterised by low annual average rainfall, which is non-seasonal and highly variable. Land managers have adopted techniques that minimise the physical and economic impacts of this constraint, for example, moisture retention farming practices and conservative stocking strategies. However, prolonged dry periods still cause significant physical damage and financial hardship to the land resource and the landholder respectively. Despite the increased ability to forecast climate land managers still have to be prepared for long dry periods. This can be achieved by strategic decisions such as fodder storage and enterprise diversification and tactical decisions such as agistment, livestock sales and fodder purchase.

This paper presents an alternative strategic option whereby a small proportion of the farm is set aside to establish a plantation of forage shrub, in this case Old Man Saltbush (OMSB). Managed properly and utilised as a forage source in both normal and extended dry periods, a plantation of OMSB, could delay the adoption tactical decisions such as agistment, grain feeding or selling livestock. This will reduce the short term financial pressure which is characteristic of prolonged dry periods. A benefit-cost analysis was conducted for the development of a shrub plantation using three alternative establishment techniques, direct seeding, speedlings and bare-rooted stock which are compared to a traditional tactical feeding strategy. Probability distributions for climate variability were identified and stochastic efficiency analysis was used to determine the efficient set of investment alternatives. This study provides a useful reference for the evaluation of strategic compared to tactical decisions of drought preparedness and the impact of climate variability on investment performance.

It was found that landholders could potentially benefit from the introduction of a forage shrub plantation, establishing two and a half percent of the property using the bare-rooted technique, when compared to the existing strategy of tactically grain feeding. However, when the area of saltbush was increased to 5 percent of the property the existing tactical grain feeding strategy was desired. In all cases, it was found that the the existing tactical grain feeding strategy was desirable when compared to the speedling and direct seeding alternatives

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Introduction

The central-west region of NSW accounts for a significant proportion of the states' livestock numbers and cereal crops but production is constrained mainly by a lack of water available for plant growth. Water availability for this region is characterised by low annual average rainfall, which is non-seasonal and highly variable. Land managers have adopted techniques that minimise the physical and economic impacts of this constraint, for example, moisture retention farming practices and conservative stocking strategies. However, prolonged dry spells still cause significant physical damage and financial hardship to the land resource and the landholder respectively. Despite the increased ability to forecast climate, land managers still have to be prepared for long dry periods.

This report presents an alternative drought preparedness strategy whereby a small proportion of the farm is set aside to establish a plantation of forage shrub, in this case Old Man Saltbush (OMSB). Managed properly and utilised as a forage source in both normal and extended dry periods, a plantation of OMSB could reduce the short term financial pressure of grain purchases during dry periods and potentially delay tactical decisions such as agistment, grain feeding or selling livestock.

Three establishment techniques, direct seeding, speedlings (tubestock) and bare-rooted stock and two plantation sizes are compared to a traditional tactical grain feeding strategy. Benefit-cost criteria were applied to the development budgets for the alternative investment proposals to determine if the returns from establishing a plantation of OMSB cover the capital investment cost. However, investing in drought preparedness before drought is experienced rather than tactically responding to drought also changes the landholders exposure to climatic and price risk. Therefore, when assessing these investment proposals, not only must expected returns be considered but also the risks associated with each alternative. Stochastic dominance tests were used to determine the dominant strategy considering climatic variability, size of plantation and landholders risk preferences.

Previous Research

Evaluating the biological and economic contributions of forage shrubs, particularly OMSB, at an individual farm level has been the focus of many studies. Many use techniques for economic evaluation such as gross margin comparisons (Condon 1990, Lyon 1995, Allerton undated), single period partial budgeting (Condon and Sippel 1992) and case studies of individual landholders (DLWC 1995, Lyon 1995). While these studies provide a valuable resource regarding the potential benefits and costs of forage shrub establishment and utilisation, they do not include in their evaluation the interactions between enterprises, the time value of money and the use of forage shrubs for the purposes of drought preparedness, filling seasonal feed gaps and/or as a 'spelling tool'. For these types of analyses it is important to distinguish firstly between tactical and strategic decisions and adopt evaluation techniques that incorporate the complementary and competitive interactions between enterprises and secondly use techniques that are able to incorporate all the benefits and costs over the investment period.

Strategic and Tactical Decisions

Land managers make both strategic and tactical decisions in the preparation for and management of prolonged dry periods. Tactical decisions are usually short term, less than one year, whereas strategic decisions are usually long term, effective for many years if maintained. Strategic decisions, eg. conservative stocking rates, fodder storage and enterprise selection would typically be made prior to drought. Tactical decisions, eg. agistment, livestock sales and fodder purchase, are typically made during the period of drought or after drought. Typically land managers would make a combination of both strategic and tactical decisions based on their perception of risk (risk preferring, risk neutral or risk averse), some historical events or experience and perceptions about the future. Trebeck and Hardaker (1972) and Hardaker *et al.*(1991) provide a more detailed discussion of this decision making process. The use of benefit-cost techniques in this study is appropriate as short term tactical decisions based on climatic variability, ie grain feeding, can be compared to long term strategic decisions such as investing in a perennial forage shrub like OMSB.

Investment period

Land managers can make decisions about drought preparedness and management from a wide range of alternatives which are effective for different lengths of time. Benefit-cost analysis (BCA) provides an effective framework for evaluating different investment alternatives by comparing their net present value of future benefits and costs. In this study the investment period is 20 years.

Social implications

It is also important to note that investments that potentially reduce the financial burden associated with prolonged dry periods concern not only individual land managers but society generally. This is evident by community support in the form of interest subsidies to drought exceptional circumstance victims. In 1996/97 a total of $30.8M assistance was provided as an interest subsidy for drought exceptional circumstance victims in NSW.

No attempt has been made to quantify the social benefits and costs of the proposals in this report. The objective of this analysis is to evaluate the investment proposal from an individual landholders viewpoint.

Outline of Study

Ideally the contribution of forage shrubs to a farming and grazing system would be determined by analysing the complex interaction between the pasture, cropping and livestock activities considering the stochastic nature of climatic and market environments (Hardaker *et al.* 1991) and sequential decision processes for a changing resource stock (Kennedy 1981). Some studies that have utilised these techniques for analysing drought management strategies include Toft and O'Hanlon (1979) and resource use Passmore and Brown (1991). However, in the absence of data necessary to describe these dynamic interactions, a development budgeting technique using benefit-cost criteria were applied to analyse the net present value of alternative establishment techniques and plantation sizes. This approach has been adopted for similar studies in the central-west of NSW (Tapp *et al.* 1995).

Methodology

Enterprise Selection

Individual landholders could establish forage shrub plantations that vary by, the size, the location on farm, and technique of establishment. Landholders could also vary the management of the established stands by, the timing of first grazing, grazing intensity and duration, type of livestock grazed, grazing as a supplement to stubble or pasture or as a drought reserve. To undertake an economic analysis of all these alternatives is beyond the scope of the study. Instead; three establishment techniques, direct seeding, speedlings and bare-rooted stock; and two plantation sizes, two and a half percent and five percent of total farm area, have been analysed. These proposals have consequences for all enterprises on farm but are not expected to affect the farm overhead costs hence a partial budgeting approach was employed which focussed on the income and cost streams for the enterprises affected by the proposals.

A representative farm was developed based on that originally identified in Tapp *et al.*(1995), with additional input from local researchers and land holders. The representative farm has similar characteristics to farms around the Condobolin region of central-west NSW and consists of a 2,800 ha property, of which 1,800 ha is arable and the remainder being open timbered country which is used for the extensive grazing.

Total grazing capacity is set at 1225 ewes plus offspring and it was determined that the primary sheep enterprise for the region was a self replacing merino ewe flock. The property was sub-divided into 21 paddocks with each cropping paddock 100 ha.

A typical cropping program consists of 900 ha of winter crop each year, 450 on long fallow and 450 on stubble. The stubble crop is undersown with annual pasture and grazed for two years before re-fallowing. All operations are carried out by the farmer, except harvesting which is done by contract.

Of the three establishment techniques used for the shrub stands, direct seeding refers to OMSB seed being placed directly in the plantation site, speedlings involve the commercial propagation of seedlings in a nursery to be planted at the plantation site and bare-rooted stock refer to seed being germinated in sand beds by the farmer and then later planted as bare-rooted seedlings. All three establishment techniques were included to determine the sensitivity of the financial returns to various commercially available establishment techniques. These development proposals were compared to the existing farming system, without a shrub plantation, where periods of short, medium and long term drought are managed by tactically feeding grain (oats).

Development of the forage shrub plantation involves planting eight blocks, four blocks in the first year and four in the second, each of 17.5 ha (8.75 ha), or five percent (two and a half percent) of the total area of the property. Good management of these blocks is essential and this was achieved by rotating their use between a drought reserve and an annual supplement for stubble or pasture. Each year, two blocks are allocated as a drought reserve, the remaining six grazed by ewes in autumn and by weaner lambs in summer. Autumn grazing is assumed to increase lambing percentages and wool cut while summer grazing by weaner lambs is assumed to increase their sale weight, hence value.

Saltbush plantations are established on arable land reducing the amount of cropping to 830 ha and 865 ha for five percent plantation and the two and a half percent plantation respectively. Further analysis is required to determine the optimal amount of land to devote to a saltbush plantation.

Data Collection

Data required for the analysis were collected from various individual farmers in the region, rural businesses and government agencies. These data included individual enterprise information relating to livestock stocking strategies, livestock feeding strategies, mortality rates, weaning percentages, micron specifications, livestock selling strategies and crop selection. Information was also collected for machinery costs, fencing materials cost, water reticulation system costs, saltbush seed and speedling costs and for regional crop yields, commodity prices, plantation size and historical rainfall.

A workshop, attended by farmers, rural businesses and government agencies, assisted in providing information about failure rates in saltbush establishment, grazing strategies for plantation stands, livestock production from saltbush plantations and saltbush utilisation during drought (Milthorpe *et al*. 1998).

Economic Analysis

The utilisation of saltbush as a drought preparedness strategy was evaluated by comparing the private benefits and costs of the saltbush plantation proposals (Table 1) with the existing mixed farming operation.

Table 1: List of private benefits and costs of the plantation proposals.

Private Benefits	**Private Costs**
Cropping income	Cropping variable costs Reduction in cropping area
Grazing income Increase in lambing percentage Increase in wool cut per head Potential increase in weaner sale weight Reduced feed costs	Grazing variable costs Grain feeding lambs if carried through to end of Feburary
	Cost of establishing saltbush Cost of infrastructure for saltbush plantations and their utilisation

Expected returns from each activity were established on a gross margin basis. Cropping returns were valued at \$107.55 and \$8.61 per hectare for long and short fallow wheat respectively (included in the short fallow budget is the cost of pasture seed, \$19.20 per hectare). Returns from the merino self-replacing ewe flock were \$22.32 per ewe respectively prior to development of the saltbush plantations. This does not include any grain feeding costs.

Benefits to the sheep enterprise of grazing saltbush include an increase in lambing percentage from 85 to 95 percent, increased wool cut per head for adult sheep, reduced feeding requirements in normal, moderate and severe dry periods (Table 2) and in favourable seasons (>227mm rainfall between May and November), lambs grazing OMSB with an additional grain supplement (0.5kg/hd/day of oats) may be sold in February to average 18-20kg dressed weight, (\$20.12/hd) rather than being sold in December to average >16kg dressed weight (\$17.66), season permitting. Given these expected benefits no change is expected in the carrying capacity of the farm with the introduction of the plantation of OMSB.

The introduction of the saltbush stand is not expected to satisfy the total feed requirements of livestock for severe drought but rather reduce the amount of additional supplement (grain oat) required (Table 2).

Table 2: Feeding requirements with and without saltbush.

Seasonal Conditionals	**With Saltbush (140 ha)**	**With Saltbush (70 ha)**	**Without Saltbush**
Normal			
- *Occurance (years)*	-	-	1

- Feeding Duration (weeks)	-	-	3
- Feed req.(kg/hd/day)	-	-	0.50
Moderate Dry Spells			
- Occurance (years)	-	3.89	3.89
- Feeding Duration (weeks)	-	12	18
- Feed req.(kg/hd/day)	-	0.25	0.50
Severe Drought			
- Occurance (years)	5.83	5.83	5.83
- Feeding Duration (weeks)	16	26	32
- Feed req.(kg/hd/day)	0.25	0.25	0.50

Establishment of the plantation area incurs costs for site preparation, fencing, water provisions, seed or seedling purchase, sowing and watering. Ground preparation is spread over two years and it is not until the year after establishment that the saltbush is able to be grazed by livestock. The variable cost of establishing the plantation are $152.55, $695.31 and $174.90 per hectare for direct seeding, speedlings and bare-rooted alternatives respectively.

An appropriate framework for evaluating the introduction of OMSB is BCA. BCA calculates the net benefit (benefits minus costs) for each investment alternative. As people prefer benefits sooner rather than later, benefits and costs that occur in the future are discounted to their present value. The sum of the discounted net benefits is the basis of the net present value (NPV) criterion.

A positive NPV indicates that there is a net benefit, after discounting, to be gained the introduction of the investment proposal. A discount rate of 10% is used here to evaluate the benefits and costs of establishing a plantation for an investment period of twenty years.

Risk Analysis

Plantations of forage shrubs have the potential to increase farm income by improving lambing percentage and increasing wool cut per head for adult sheep. In addition, the variability of farm income during extended dry periods may be reduced as less tactical grain purchases may be required during these periods. Also the frequency of establishment failure for alternative establishment techniques will affect investment returns. Therefore, landholders, when assessing these alternatives should consider not only the production benefits and capital investment requirements of OMSB but also the impact of climatic uncertainty upon returns.

Monte Carlo simulation techniques in @RISK (Palisade 1994) were used to examine the implications of climatic uncertainty (rainfall variability) by estimating the distribution of outcomes (cumulative distribution functions [CDF]) for each alternative. Stochastic dominance testing was then used to rank the alternatives for risk efficiency.

For this study, historical rainfall data was collected for the years between 1891-1995 for Condobolin. These data were used to define rainfall distributions which were used to determine the supplementary feeding requirements, establishment success or failure and whether lambs were able to be carried through to February. In the case of supplementary feeding, the strategy was to attach feeding strategies identified in table 2 to low, medium and normal annual rainfall events. A low rainfall year is defined as receiving less than 260 mm of annual rainfall and results in the feeding strategy labelled “severe”. A “moderate” feeding strategy corresponds to annual rainfall of 261 to 350 mm and a “normal” feeding strategy corresponds to annual rainfall greater than 351 mm.

In the case of establishment success or failure, the criteria for success or failure differ depending on the establishment technique. Given the management strategy identified direct seeding requires favourable rainfall after sowing whereas planting speedlings and bare-rooted stock rely on stored moisture prior to sowing. In our study successful establishment using the direct seeding technique required more than 21mm and 27mm of rain to fall in August and September respectively. Planting speedlings and bare-rooted plants rely on stored moisture and are only expected to fail one year in twenty. The approach used here was if failure occurred, establishment would be repeated the following year, if it failed again establishment was repeated the next year and so on. The benefits of OMSB were not included until establishment was successful.

With the OMSB plantation, landholders have the option, if a favourable winter spring was received, to carry lambs, which would have traditionally been sold in December, forward into February. The strategy was to carry lambs forward if greater than 227mm rain fell between May and November. Lambs would receive a supplement of oats in addition to OMSB. This would not be possible for the without saltbush alternative.

A distribution for oat price was established using 1980-81 to 1997-98 averages converted into 1997 dollars. The strategy was to sample oat price in year one and treat the sampled price as the real price from that year forward.

A simulation of 1500 runs calculated a distribution of outcomes given the feeding requirements, establishment success and the possibility of receiving favourable May-November rainfall. The strategy was to sample firstly, from the annual rainfall distribution for each year to determine the feeding strategy (table 2) secondly, from the August and September rainfall distributions to determine establishment success or failure and lastly from the cumulative May-November rainfall distribution to determine whether lambs are to be carried forward to February. It was assumed that annual rainfall was not serially correlated. However, August and September rainfall distributions and cumulative May-November rainfall distribution were serially correlated with annual rainfall distribution.

The program, Generalised Stochastic Dominance, developed by Cochran and Raskin (1988) was used to identify the risk efficient set of shrub investment alternatives. The basis for discrimination among alternatives is the cumulative probability distribution function (CDF) for each alternative. Anderson *et al.* (1988) provide discussion about the use of Stochastic Dominance testing for decision analysis when considering risk. These tests have been used in similar agricultural investment studies conducted by Tapp *et al.* (1993), Jones *et al*. (1996) and Patton and Mullen (1999).

Results

This evaluation was conducted to compare, for mixed livestock and cropping farms in the central-west of NSW, a tactical approach of managing climatic variability to alternative strategic approaches based on establishing plantations of forage shrubs. To determine the dominant strategy this study used benefit cost techniques and stochastic efficiency criteria for two alternative OMSB plantation sizes, 70 ha and 140 ha. Their CDF's are presented in Figures 1 and 2.

Figure 1: Cumulative Distribution Function for establishment alternatives and without Saltbush scenario - 70 ha plantation.

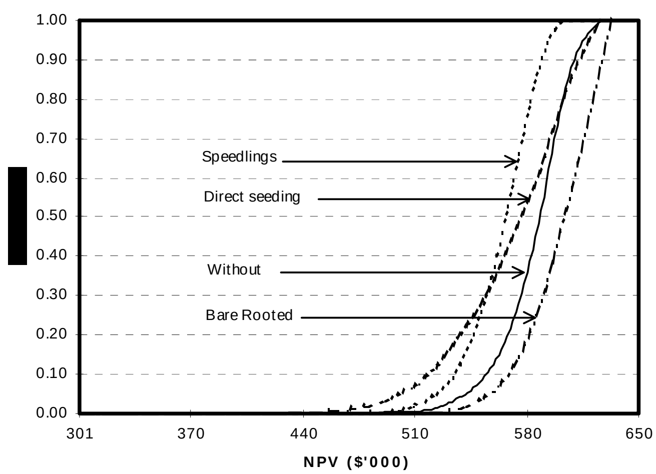

Figure 1 represents the CDF's for analysis of the 70 ha plantation. This graph suggests that only one of the proposed investments in OMSB, established using the bare-rooted technique, will always return more than the without saltbush alternative. Whereas the without saltbush alternative has approx. an 80 percent probability of returning more than the direct seeding alternative and a 100 percent probability of returning more than the speedling alternative. Therefore, as the CDF for the bare-rooted alternative is always to the right of all other alternatives it dominates these alternatives in the sense of first-degree stochastic dominance. Similarly as the without saltbush alternative is always to the right of the speedling alternative it dominates this alternative in the sense of first-degree stochastic dominance. Since, the CDF of the direct seeding alternative overlaps the CDF for the without saltbush alternative a higher order stochastic dominance test was required. Considering Australian farmers are typically risk averse (Anderson *et al.* 1988, Bardsley and Harris 1987 and Anderson and Dillon 1991), decision makers would prefer the without alternative over the direct seeding alternative in the sense of second-degree stochastic dominance.

Figure 2: Cumulative Distribution Function for establishment alternatives and without Saltbush scenario -

140 ha plantation.

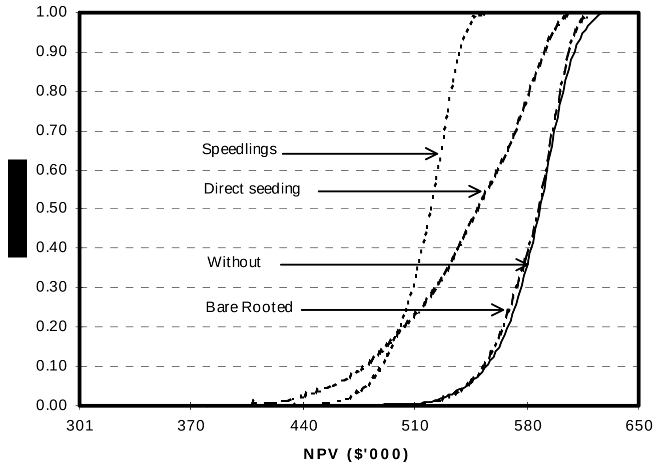

Figure 2 represents the analysis of the 140 ha plantation. This graph suggests that for an OMSB plantation of 140 ha there is a 100 percent probability that the without saltbush alternative will return more than both the direct seeding and speedling alternatives. Hence, it was found that the without saltbush alternative dominated both these alternatives in the sense of first-degree stochastic dominance. Since, at low levels of probability, the bare-rooted alternative has the potential to return more than the without saltbush alternative higher order stochastic dominance testing is required. Meyer's Second Degree Stochastic Dominance with Respect to a Function test (SDWRF) (Meyer 1977a,b) was used concluding that the without saltbush alternative dominates the bare-rooted alternative in the sense of SDWRF.

Discussion of results

The analysis conducted in this report considers not only the livestock benefits from grazing OMSB but also the impact of climatic variability for each alternative. The results suggest that the introduction of a plantation of OMSB established using the bare-rooted technique could financially benefit landholders by achieving an increased income. However, when interpreting these results it is important for the landholder to consider not only the technique of establishment and but the area of land devoted to the plantation.

As mentioned, the potential benefits of OMSB have been considered by many studies. This study has built on previous research by evaluating the contribution of OMSB and its interaction within the farming system through its utilisation as a strategic spelling tool, filling seasonal feed gaps and in drought preparedness. It has used a more appropriate evaluation technique to compare alternative tactical and strategic investment strategies. However, some of the biological complementary and competitive interactions between livestock and OMSB are not well known limiting the scope of the analysis. Hence further research into these dynamic interactions would provide valuable data for future analysis. This may include evaluations that establish the optimal area of saltbush considering limited resources and constraints. Consequently this research should be viewed as a first step in assessing the suitability of forage shrub plantations for landholders in the central-west of NSW.

Conclusion

The objective of the study was to evaluate the investment in a forage shrub plantation as a drought preparedness strategy for landholders in the central-west of NSW compared to the existing tactical grain feeding for drought management. A representative farm was established and a partial budgeting procedure was used in a benefit-cost analysis framework to compare alternatives. Proposals were not only assessed for the change in expected returns from the introduction of OMSB but were also assessed considering the impact of climatic variability for the central west of NSW.

It was found that landholders could potentially benefit from the introduction of a forage shrub plantation, establishing two and a half percent of the property using the bare-rooted technique, when compared to the existing strategy of tactically grain feeding. However, when the area of saltbush was increased to 5 percent of the property the existing tactical grain feeding strategy was desired. In all cases, it was found that the the existing tactical grain feeding strategy was desirable when compared to the speedling and direct seeding alternatives

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