



Coorong Tatiara Local Action Plan

Sustainability, Agriculture & the Environment

Developing sustainable shrub-based forage systems for profitable mixed farming

A Caring for Our Country project

Technical summary of the project major findings

Coorong District Local Action Planning Committee

18/1/2012



This report summarizes the major findings from a series of demonstrations, sponsored by the Federal Government's Caring for Our Country Program. The project was undertaken under the sponsorship of the Coorong District Local Action Planning Committee. The demonstrations focused on the three aspects of managing shrub-based forage mixtures for livestock enterprises in the Upper Southeast of South Australia. This work emphasizes the potentialities and limitations of improved use of forage shrubs and the associated animal production, provided by different shrub species combinations, and herbaceous companion plants, grazing management and supplementation.

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INTRODUCTION

Ruminant livestock such as sheep, cattle and goats are versatile foragers. They can usefully graze many different plant types, not just lush grasses and legumes but browse trees and shrubs. This ability to graze so broadly is based on the capacity of the four-chambered stomach common to ruminants. The change is the result of the fermentation. A 'soup' of micro-organisms, bacteria, fungi and protozoa in the first two stomachs breaks down the basic ingredients of these plants and later re-assembles these raw forages species into a more densely nutritious diet. Even though domestic livestock use wide range of plants as food, they do discriminate between plants according to their nutritive values, digestibility, tastes, toxicities and saltiness.

This versatility opens to livestock a variety of forages of the ranges and pastoral lands of southern Australia. The native shrubs have been a constant, notable component of the grazing feedbase of this zone. Most forage shrubs are perennials. As perennials, the shrubs are long-lived species, surviving soil water-deficits, and high temperatures. Many species grow most actively during late spring and summer. Summer growth can capture 'out-of-season' rainfall, or tap deeper water reserves. The net effect is to reduce deep recharge - a gain for greater water use efficiency and reduced deep drainage that can add to saline discharge elsewhere in a landscape.

The shrubs are well-adapted, robust perennial plant that can offer a variety of benefits in agricultural regions. Forage shrubs can:

- Add *size and stability* to the farm's feed supply.
- Produce a relatively *nutritious* feed in late summer or autumn. There are useful levels of copper, iron, selenium, and vitamin E.
- Improve the productivity of either *saline* or *infertile* land.
- Provide *shelter/shade* and *windbreaks*
- Reduce *recharge and excessive deep drainage*

NUTRITIVE VALUE OF FORAGE SHRUBS

The focus of this report is a group of native shrubs: the saltbushes. The saltbushes belong to a larger plant group called the chenopod plant group: saltbushes, maireanas (bluebushes), rhagodias, ruby saltbush (enchyleanas). Oldman saltbush is among the most productive of this group of shrubs, producing approximately 0.4 to 1.5 kg/plant.

These shrubs are 'salty' or halophytic. They contain high concentrations of mineral salts such as sodium chloride and potassium chloride as well as other important nutritional elements such as magnesium, calcium and phosphorus. Together, the total measure of these salts is called the 'ash content' which frequently exceeds 25% in the case Oldman saltbush varieties. Shrubs growing on salty soils will have higher ash content, in particular, sodium chloride and potassium chloride.

Generally, these elements occur in high concentrations that are greater than those recommended for good health. The effective ash content of the shrubs may be less than these nutritive analyses might suggest as some elements may escape dissolution and then absorption. Nonetheless, the concentrations of these elements in many forage shrubs present considerable challenges to balancing the diets of livestock grazing these forage shrubs. Surprisingly, as a result of complicated effects of one element on another and the changes

in the digestion and absorption in response to these high concentrations, deficiencies might occur, for example, calcium and magnesium (Mayberry et al 2010). Mineral additives do not effectively reverse these deficits.

Shrubs often contain chemicals call plant secondary compounds (PSC) such as tannins, terpenes, and oxalates (Norman et al 2007). PSCs are the unexceptional products of plants' energy-fixing processes. They have many roles. PSCs can discourage grazing by their unpleasant taste, protecting the plant from overgrazing, or aid the plant in balancing its salt concentrations and regulate water uptake in saline soils (Osmond 1963). Their effects on grazing stock can be either toxic or beneficial depending on their concentrations in the plant and the amount ingested. At lesser concentrations, PSCs are in the common pasture forages such as lucerne and grasses including cereals.

Despite these limitations, this group of forage shrubs is high in nitrogen, moderately digestible and low fibre (Mayberry et al. 2010). Commonly, forage shrubs have 12-20 crude protein contents that can support growth and maintenance, and sufficient metabolisable energy (6-11 ME MJ/kg) to support maintenance. Yet, the high mineral content complicates the use of these forage shrubs (Thomas et al. 2007). A major effect of increasing the concentration of sodium chloride in the diet is to reduce the effective digestibility of the forage.

The high salt concentrations, along with the PSCs are thought to account for markedly lower palatability, and smaller intake rates of these species compared to common pasture plants (Thomas *et al.* 2007).

As evergreen perennial, key nutritional traits – crude protein, digestibility, fibre contents of the forage shrubs - do not vary as markedly as the herbaceous, pasture plants throughout the year. This relative stability is an important difference with the herbaceous, pasture plants whose nutritional values vary widely. As the seasons change and plants grow, the herbaceous pasture plants flower, set-seed and senesce or become dormant. The herbaceous plants are least nutritious during the late summer and autumn. It is a time of relative advantage for the shrubs. Forage shrubs, with their higher nitrogen values, have been viewed as a supplement whose production value lies in reducing supplementation and its costs during periods of feed shortage.

SHRUB-BASED FORAGE MIXTURES

In the Upper South East, and southern Mallee, forage shrub stands have been planted as plantations over the 25 years. Stand sizes vary from 0.5 ha to 150 ha with an average 13 ha. These small stands are unlikely to have been planned as calculated additions to the farm feed-base. The size is more likely to be the area of troublesome saline or erodible soils on the farm or a 'one-off' experiment with these forages. The current forage value of the shrubs will not justify replacing an enterprise using reliable, productive land.

A survey of intentions of landholders who had planted shrubs in the Coorong District Council (CDC) area over the past 20 years suggested that the shrubs were planted to increase the productivity of saline lands or anchor shifting dunes as much as to achieve production goals such as higher stocking rates (Anonymous 2009). These minimal areas and placements of shrubs on the farm are appropriate. The greater value of forage shrubs is where they replace risky, unreliable, and unprofitable enterprises such as cropping in infertile or easily eroded soils. And there is a clear intention to obtain multiple benefits, not just greater animal production.

There is a great variety of designs of shrubs stands. More frequently in the CDC area, there are one or two shrub species in a stand, most frequently Oldman saltbush alone. In the wetter southern areas, Tagasaste has been used Tagasaste is a legume which produces the PSC tannin but is not burdened by high salt content.

The [basic layout](#) of a stand consists of belts of one more rows of shrubs between alleys of understorey plants that contain a mixture of volunteer and/or planted grasses and/or legumes. A number of factors can influence

the dimensions of the stand, and its parts the shrubs belts and alleys. They are i) the main purpose of the stand: to protect soils from wind erosions or reduce recharge, modify the fertility of saline soils or supplement a feedbase ii) the physical size of the area that requires remediation, iii) the approximate size and seasonality of the feed deficit which the stand is intended to bolster, iv) in the case where stand is a windbreak, the topography, soil type and seasonal wind directions and strengths, v) the intended frequency and duration of their use of the stand either for autumnal grazing or all-year round and vi) the necessity for machinery access through the alleys.

The value of shrub stand to livestock production, and the effectiveness of its protective role are both influenced firstly by the species make-up of the forage mixture both shrubs and alley pastures (if any) and secondly the ways in which these forage mixtures are used.

PROJECT APPROACH

The nutritive values of herbaceous plants change with maturity, season and grazing frequency. Sheep and cattle grazing these pastures choose diets from among these species. Choice is influenced by the species available, their current digestibility and nutritive values, taste, novelty and the animal's experience of eating the plant. Frequently, the selected diet is more nutritious than that suggested by the average nutritive values of the available pasture. Forage shrubs are very different in taste, nutritive value and form. They add to the range of choices for grazers. The choice of the plants that make up the forage mixture set the first constraint on nutrient intake.

Once a stand has been planted, grazing management becomes an important tool to influence intake per animal and perhaps their forage choices. It is a challenge to effectively manage the diet of sheep, grazing selectively with so many choices, particularly when those choices include native shrubs. Higher grazing pressures effectively reduce the amount of feed per sheep. Foraging can be more competitive. Livestock may be forced to be less discriminating, increasing the chances of combining different forages, and obtaining a more nutritionally balanced diet. Under these greater competitive pressures, livestock might graze more shrubs and understorey plants, more evenly, and hopefully, increase the chances that different plants would be combined together.

Supplementation, often as grains, is another more influence on the effectiveness of the forage stand. The addition of nutrients that are insufficient in the standing feed is flexible and direct means of improving the quality of the diet although at additional cost.

Together the choice of forages, grazing intensity and supplementation can affect:

- livestock productivity and profit– live weight gain, pregnancy, lambing percentage , lamb survival, maintaining effective flock size
- effective use of the forage – the percentage of the pasture grazed, and forage used, and the make-up of a sheep's diet and the grazing pressures on the plants in the forage mixture.
- protecting easily erodible soils by retaining effective soil cover
- longer term productivity and persistence of the forage stand or pasture by improving the retention of more productive and palatable species.

In our CDCLAP demonstrations the tactics we explored to make more effective use of forage shrubs were based on:

1. grazing management
2. the choice of forage species that are included in the mixture that is

- a. variety of species and their 'nutritional preferential fit' with one and other and,
 - b. quantity and quality of each of the companion forage
3. Supplementation types

TRIAL SITES

Our demonstration sites were located near the townships of Coomandook, Peake and Nethererton in the Upper South East of SA. These sites planted in dune - swale landscapes.

At Coomandook, there were two sites Booderoo Hills, and Mount Russell. At the Booderoo Hills site the demonstration plots contained rows of belts of forage shrubs: saltbushes, mainly *Oldman saltbush*, but also *River saltbush* and *Rhagodia*, and alternating alleys or inter-rows of *veldt grass* and *lucerne* in most plots. Lucerne-veldt grass combinations are common perennial pasture plants in the Upper South East. There were also plots that contained *triticale* alone. The triticale had been sown in the previous season, and spray-topped at grain milk-stage. The grain crop was thought to retain its nutritional value better than senescent perennial or annual pasture grasses into the early autumn. Together, the combinations of understorey of lucerne and veldt grass, and triticale alleys, with the forage shrubs were intended to provide more nutritious mixtures than a volunteer annual pasture. By including these companion species with the shrubs we were trying to bolster the nutritional value of the mixture forage, and take a first step to optimising the diet.

It was intended to compare the use of two forage shrub mixtures: 1) Oldman saltbush – River saltbush and 2) River saltbush –*Rhagodia*. The two shrub pairs differing in palatability were to provide an opportunity to explore the effects of contrasting 'preference gaps' between the shrub species combinations on shrub use. Poor establishment eliminated *Rhagodia* plantings from the comparison of the two shrub pairs. In these plots, the River saltbush occupied half of the shrub belts in these plots, compromising its use as a single species plots. Only the Oldman saltbush – River saltbush plots could be compared with the Oldman saltbush alone. To obtain a more complete answer, we would need other comparisons. Nonetheless, the available comparisons that have suggested that grazing patterns differ, as well as livestock production.

Two levels in grazing intensity were used to test grazing management as a tool for influencing choice. Grazing intensity was measured as stocking density. The base number of animals per plot was determined by the FOO, the numbers of available animals, their class, and intended duration of the demonstration. Under intensive grazing, sheep were confined to cells (1/4 plot area) that they grazed one after the other without the opportunity to back graze. Here, pastures grew ungrazed in cells that were accessed later. Alternatively, sheep grazed anywhere across the plots where grazing level was less intensive.

Intensive grazing was equivalent to cell-grazing. In autumn, the likelihood of active pasture growth was small so cells were a means of increasing stocking rate, rather than of improving re-growth and more frequent cycling of the pastures. Two grazing intensities in the autumn 2010 trial were ~ 15 ewes/ha vs. ~ 65 ewes/ha. In the spring trial, the stocking rates differed across the autumn 2010 trial from 55- 75 ewes/ha in the higher intensity grazing plots to 10 to 20 ewes/ha in the lower intensity grazing plots. The remaining demonstrations were run at ~22 sheep/ha.

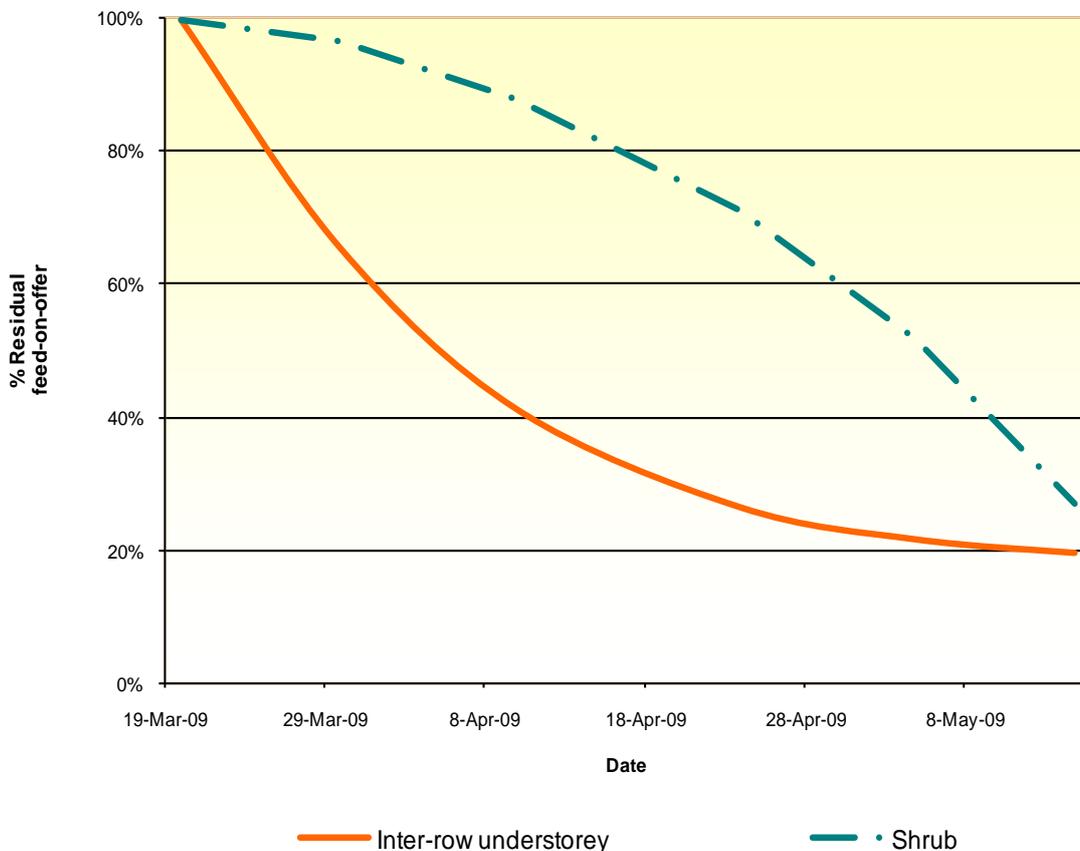
The Mount Russell site contained a weedy volunteer pasture in a long-established Oldman saltbush stand. At this site, the emphasis was on the effects of supplementation on shrub use, and animal production.

In the Mount Russell supplementation demonstration (autumn 2009) ewes grazing the shrub stands had a narrow choice of long-lived Oldman saltbush and alleys of volunteer, weedy annual pastures. The alley understorey was a mixture of skeleton weed, silver grass, and an assortment of annual legumes and less abundant annual grasses. The Mount Russell stand was typical of stands in the area and had been planted about 20 years ago. The Oldman saltbush was the only shrub species planted, although livestock grazed preferentially markedly among individual plants. .

An illustration of the changes in residual forages caused by preferentially grazing appears in Figure 1. The ewes grazed the alley forages heavily before the shrubs, despite the low energy content, and ‘card-board like’ indigestibility of the volunteer weedy pasture. This pattern of grazing is common for sheep grazing single species saltbush stands (Jolly pers. comm.).

In this Mount Russell trial, the point at which the forage shrubs had been used (~80% of the leaf-shoots) coincided with heavy grazing of the volunteer weedy pasture and very little plant soil cover (200 kg/ha). In this case, the complete use of the shrubs forces livestock to graze the alley pastures very heavily.

Figure 1 Percentage changes in feed-on-offer of the volunteer weedy pasture inter-row or alley and Oldman saltbush (Mount Russell autumn 2009)



This grazing pattern was repeated across the demonstrations. Stock grazed more palatable alley plants more heavily, and left the forage shrubs until the residual pastures in the alley plants had reached a stable minimum below which no more was or could be removed. This disjointed use of the available forages, associated with the 'preference gap', posed a significant obstacle to obtaining full use of the shrubs and keeping erodible soils covered. The maximal use of the understory alleys occurred earlier than that of forage shrubs with the important consequence: maximum shrub use can lead to overgrazing of the alley pastures, with a higher risk of erosion. Second, the heavier grazing pressures threaten the persistence of the more palatable species. The task of balancing conflicting aims is complicated: supporting livestock production, maintaining soil protection and making best use of both pastures and shrubs.

The forage mixtures, with limited replication made it difficult to separate the effects of different alley forages, shrub combinations, and grazing intensities rigorously.

AUTUMN 2010

The first of the Booderoo Hills demonstration took place in autumn 2010. This 2009-2010 summer and following autumn had been particularly wet, at least compared to recent years. The demonstrations featured a comparison of three forage mixtures: Oldman saltbush shrub belts with lucerne – veldt grass alleys, Oldman saltbush with triticale alleys and Oldman and River saltbush mixtures with lucerne – veldt grass alleys. Two grazing intensities were imposed over these mixtures.

The *forage mixture* influenced both total intake, and the relative amounts of shrub and pasture used (Table 1). Sheep, grazing a mixture of Oldman and River saltbushes consumed the most shrub compare to those grazing Oldman saltbush alone at both grazing intensities. The shrub intake of the mixture of the two shrub species was

Table 1 The effects of two grazing intensities on intake of forage mixtures by ewes grazing during autumn 2010 at Booderoo Hills Coomandook.

Forage mixture		Grazing Intensity								
		High	Low	High	Low	High	Low	High	Low	
Shrubs	Companion alley plants	Estimated total forage intake (g/ewe/day)		Estimated pasture intake (g/ewe/day)		Estimated shrub intake (g/ewe/day)		% Shrub in total forage intake		
	Oldman saltbush	Lucerne-Veldt grass	1518	3003	1192	2946	326	57	21	2
	Oldman saltbush	Triticale	1028	1325	674	1206	354	119	34	9
	Oldman-River saltbush	Lucerne-Veldt grass	1280	2475	731	2347	549	129	43	5

43% of the total forage intake. Oldman saltbush intake in the single species plots alone contributed less to the forage used in those plots. Ewes, grazing forage in plots with a triticale understorey, had the lowest pasture intake rates but higher shrub intake, compared to those grazing plots containing lucerne-veldt grass alleys.

The effect of the forage mixtures on live weight changes was not consistent with intake rates (Table 2). The triticale alley plots supported the highest growth rates at both grazing intensities but sheep grazing these plots had the lowest total FOO and pasture intake rates. We observed ewes grazing selectively the triticale spikes or heads that contained small grains.

Table 2 Changes in live weights of ewes grazing forage shrub mixtures in autumn 2010 at Booderoo Hills, Coomandook.

Shrub	Companion	Grazing Intensity	
		High	Low
Oldman saltbush	Lucerne -Veldt grass	57	146
Oldman saltbush	Triticale	97	155
Oldman & River saltbush	Lucerne -Veldt grass	61	99

Grazing intensity had a substantial effect on intake. Under less grazing pressure shrubs were a minor part of total intake. Under higher grazing pressure, the diet eaten mirrored the forage types and their proportions in the FOO prior to grazing. The estimated daily intake (g/ewe/day) of the total FOO, its components: alley pastures and shrubs were all reduced by more intensive grazing. At higher stocking rates, higher shrub intake was associated with lower rates of live weight gain.

SPRING 2010 BOODEROO HILLS

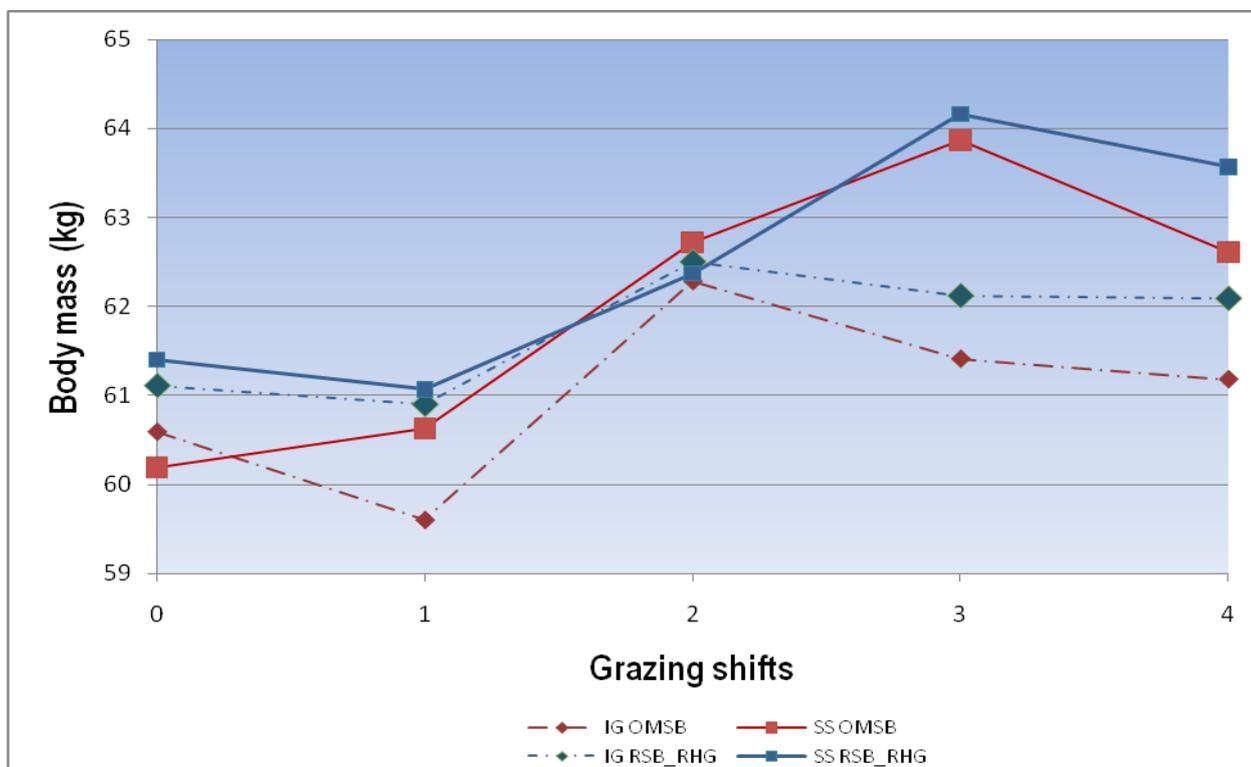
A spring demonstration was run at Booderoo Hills in 2010. The plots that were available for this trial had common alley pastures of lucerne and veldt grass but contrasting shrubs: Oldman saltbush versus a combination of River saltbush and a minor *Rhagodia preissii* component. Again there were two grazing intensities imposed over these forage comparisons. As the higher stocking rate (IG) was imposed by restricting the sheep to cells, all livestock were weighed when they were moved/shifted between cells. Similarly, pasture and shrub residues were measured in the currently used and next unused cells at each shift.

In this demonstration, the forage supply was very dynamic. The FOO in both the lucerne and veldt grass alleys increased under both grazing regimens. The pasture forages, supplied from the alleys, grew rapidly, began to flower and mature. As flowering approached, and stems extended, sheep tended to graze the veldt grass selectively, avoiding the lengthening flowering stems for leafier bases. In general, grazing livestock prefer pasture plants that are shorter, less fibrous and vegetative Illius and Gordon 1987.

In the first two phases of four in the demonstration (0-32, 32-54 days), the pasture FOO continued increasing under less intensive grazing. This continued pasture increase growth suggests that growth rates exceeded intake rates. Sheep, at lower stocking rates, grazed the lucerne preferentially, allowing the FOO in the veldt grass alleys to continue increasing more quickly than those in the yet-to-be grazed cells in the more intensively grazed plots.

The accumulating forage in the pasture alleys delayed the use of shrubs by the more freely grazing sheep. The total FOO in the alleys was substantially greater than that produced by the shrubs.

Figure 2 Changes in live weight of hoggets grazing forage shrub-based mixtures in spring 2010 at Booderoo Hills



Legend OMSB- Oldman saltbush RSB – River saltbush Rhg-Rhagodia preissii IG – intensive grazing SS less intensive grazing

Shrub intake in these plots did not increase substantially until the supply of the alternative alley pastures declined. In most plots, the total of pasture supply greatly exceeded the feed offered by the shrubs. In the River saltbush and Rhagodia preissii plots, shrubs consisted about 11% whereas Oldman saltbush biomass was about 30% of total biomass at the start of grazing. Oldman saltbush increased to approximately ~ 45% of the total FOO before the maximal amounts (~50%) of the available forage shrubs were grazed. In contrast, large percentages of the mixed shrubs were grazed but these shrubs remained a small proportion of the available feed (<~10%). The residues of both lucerne and veldt grass in the River saltbush – *Rhagodia preissii* plots at which the maximum amounts of shrub were used were larger than those with the Oldman saltbush. Either River saltbush or a combination of both River saltbush and Rhagodia appear to be more palatable than the Oldman saltbush. Alternatively, given the relative small proportions that these mixtures represented, the two shrubs may have been grazed as a novelty or a genuine minor supplement. With more intensive grazing, residues of all forages were lower than those in the less intensively grazed plots.

Under both grazing regimens, shrub intake was higher at higher residues in the veldt grass alleys than those in the lucerne alleys in all plots. Thomas and other (2007) have suggested that digestible dry matter (%DOMD) was an important factor determining food preferences. Animals with the choice between less digestible non-salty diet and a less fibrous salty alternative would increase the proportion of the saltier alternative. Nutritive values of the pasture components were measured at the start of the spring trial but not

progressively through the demonstrations. It is likely that the %DOMD of the veldt grass would fall substantially with the onset of flowering and the preceding stem extension.

In both the autumn and spring demonstrations, animals at greater grazing pressure ate less forage per animal, and gained weight more slowly. Plots in which shrub intake was higher tended to have lower live weight gains. A difficulty with the comparisons of the two grazing intensities was the arbitrary stopping points at which the sheep were moved between the cells. As a result, shrub use could become disconnected from any diet combinations.

AUTUMN 2011 BOODEROO HILLS

The autumn 2011 demonstrations at Booderoo Hills repeated the two of the forage shrub comparisons in autumn 2010. Mobs of lambs grazed plots containing Oldman saltbush or a combination of Oldman saltbush and River saltbush with all plots containing alleys of lucerne and veldt. There was only one intensity of grazing (~ 22 lambs/ha).

As the landholder was targeting a winter sale of the lambs, supplements: oats, barley and molasses, were used and compared. The supplement effects will be considered in more detail below.

As with the other autumn grazing, the total shrub biomass accounted for between 25% and 35% of the total FOO at the start of grazing. In the Oldman saltbush plots, the shrubs accounted for 32% of the FOO whereas the shrubs accounted for 29% in the mixed shrub plots.

Grazing in mixed species plots was associated with heavier shrub and pasture use, except for the plot where barley was the supplement. The alley pastures were consumed more quickly in the mixed shrub plots. Lambs grazing in the Oldman saltbush plots ate less veldt grass than lambs in grazing in the mixed shrub plots where the veldt grass accounted for a larger fraction of the diet (~55% vs. ~38%). Greater use of the lucerne balanced the total pasture intake between mixed and single shrub species plots that were supplemented with oats (Table 3).

Table 3 Estimated daily intake (g/lamb/day) of total plot pasture, lucerne and veldt grass between the start and finish of the autumn 2011 demonstration at Booderoo Hills.

Alley pasture	Shrub	Ration		
		Barley	Molasses	Oats
Total plot pasture	OMSB	1832	*	2697
	OMSB_RSB	3198	2817	2717
Lucerne	OMSB	1147	*	1655
	OMSB_RSB	1353	1310	1207
Veldt grass	OMSB	685	*	1041
	OMSB_RSB	1846	1507	1511

The trial stopped when the lucerne and veldt grass residues had reached about ~ 250 kg/ha and ~ 450 kg/ha respectively. Increases in shrub intake, as the lesser preferred forage, could be assumed to correspond to the point at which pasture residues are insufficient to meet the full DM intake requirements of the livestock.

Lambs grazing the mixed shrub plots ate more shrubs, particularly those lambs in the molasses supplemented plots (Table 4). More Oldman saltbush was used in the Oldman and River saltbush plots than in the plots containing Oldman saltbush alone, if the different plant densities between the two shrubs mixes are considered. Given the molasses supplement provided less energy than the grains, it is not be surprising that total forage intake with this supplement was greater.

Table 4 Changes in total shrub intake (g/lamb/day), with supplementation at Booderoo Hills, autumn 2011

Rations				
Date	Forage	Barley	Molasses	Oats
		Total shrub intake rates		
		(g/lamb/day)		
4/04/201	OMSB_RSB	59	77	110
	OSMB	0	*	41
13/04/20	OMSB_RSB	168	311	232
	OSMB	10	*	0
20/04/20	OMSB_RSB	302	850	318
	OSMB	35	*	40

Legend: OMSB-Oldman saltbush, OMSB_RSB – Oldman saltbush – River saltbush mixture

Oldman saltbush and River saltbush together appeared to support relatively higher live weight gains than the Oldman saltbush alone 198 vs. 171 g/lamb/day respectively. The net changes in body mass where oats and molasses were supplements appear significant, and approached the targeted daily increase in body mass (~225g/lamb/day). It is likely that the heavy supplementation drove the magnitude of these changes. However, the molasses supplement provided much less energy to the livestock, than the grain supplements. In a mixed forage system such as this one, the intermediate changes in body mass, as well as intake of both shrubs and pastures during the demonstration are more revealing than final values (Table 6). Lambs grew quickly between the first weighing, and then slowed. Increases in body mass slowed as the pasture residues fell and shrub intake increased. The decline in the lamb’s growth rates later in the demonstration could be attributed to either the falling total FOO or a decline in the underlying potential growth rate of the lamb.

However, these results suggest, at least superficially, that a mixture of forage shrubs species may contribute to a higher weight gains than Oldman saltbush alone when used with supplements. Balanced comparisons are necessary to confirm this finding (See Table 5).

Table 5 Changes in body mass (g/lamb/day) of lambs grazing shrub mixtures, with supplementation at Booderoo Hills, autumn 2011

Date	OM_RSB			OSMB		
	Barley	Molasses	Oats	Barley	Molasses	Oats
	(g/lamb/day)			(g/lamb/day)		
4/04/2011	218	296	347	311	*	337
13/04/2011	-91	125	93	-50	*	85
20/04/2011	152	72	79	89	*	165

SUPPLEMENTATION

Saltbushes have high mineral (ash) contents and produce secondary plant compounds. Both can have disruptive effects on ruminant digestion. The principal culprit appears to be the high mineral content. The PSCs found in many shrubs have been thought to be the principal driver of plant choice. Research in the south-west United States has focused on how grazing animals choose and combine storage shrubs with different PSC profiles. However, others (Jolly pers. comm.) have suggested that the mineral content of the saltbushes may principally affect plant choices of livestock as it disrupts digestive processes. Evidence indicates that as the salt content of a diet increases, intake of that diet decreases. As the ash content of the saltbushes is significant, it would follow that intake of saltier forages will be less. High mineral salt concentrations in these plants appear to devalue the energy contents, indicated by current methods of feed testing.

Special attention must be given to *access to adequate water* for which there must be provision. Daily water requirements of stock grazing salty shrubs can double. The salt content of this water is another factor to be considered as excessive salt can lead to a salt imbalance.

Higher intake of salts in the diet shortens the time that forage is retained in the rumen, reducing the time for digestion. The shorter retention times limit the completeness of the digestive process, so, the apparent digestibility of the forage. As a further consequence, there is an apparent shortage of energy. Less energy limits the production of rumen microbes 'bugs' that capture the crude protein, and free nitrogen in the forage to synthesis proteins for latter absorption and use in maintaining, and growth of the animal.

In the case of the saltbushes, the net effect of high salt levels is an energy deficit that can't be met by the shrub alone. The extent to which different ingredients are chosen is mediated by the relative digestibility of the alternative diet ingredients to the saltbush. Thomas et al. (2007) has suggested that sheep tend to substitute less digestible forages with saltier but more digestible ones

Hence, the emphasis of much research into supplementation to livestock grazing shrubs has been to bolster energy content of the forage diet using different energy supplements.

In our project, these supplements have included the cereal grains, oats, barley, the grain legume lupins, and molasses. The four supplements have different nutritive profiles (Table 6). The greatest contrast was between molasses which is principally an energy source (~12 MJ/kg), with no fibre and little crude protein (3%) and lupins which has very high crude protein content (35%), an energy content (11MJ/kg). The barley, oats and molasses provide energy in different forms that affect the rates at which the energy can be integrated into digestive processes. The energy supplied by barley is readily available.

At high rates of supplementation, without an adjustment period, barley poses a risk of inducing acidosis, an excess of lactic acid which disturbs rumen function, slows weight gain and can cause death. Oats with a lesser energy content and higher fibre content poses less of risk. Over use of molasses shares the same risks as barley. Our work used single supplements, rather than mixed rations. Metabolisable energy content of the FOO was the only parameter used to assess the adequacy of the forage diet, and the size of the ration.

Table 6 Basic nutritional parameters of the feed sources across the sites, Booderoo Hills(BH) and Mount Russell (MR) averaged over the 2009-2011.

Site	Crude Protein %		Metabolisable energy (MJ/kgDM)		%DOMD	
	BH	MR	BH	MR	BH	MR
Alley forages						
Lucerne	12.7		7.6		52.0	
Veldt Grass	9.0		6.9		49.0	
Triticale	7.8		7.3		50.9	
Annual pasture		7.1		7.2		50.1
Shrubs						
<i>Oldman saltbush</i>	18.8	11.4	11.3	10.9	70.7	68.3
<i>River saltbush</i>	16.1		9.9		63.7	
<i>Rhagodia preissii</i>	20.8		12.5		76.2	
Supplements						
Barley	9.6		13.3			
Lupins		32.9		11.5		
Molasses		3.8		12.6		
Oats	9.5	10.2	13.4	12.1		

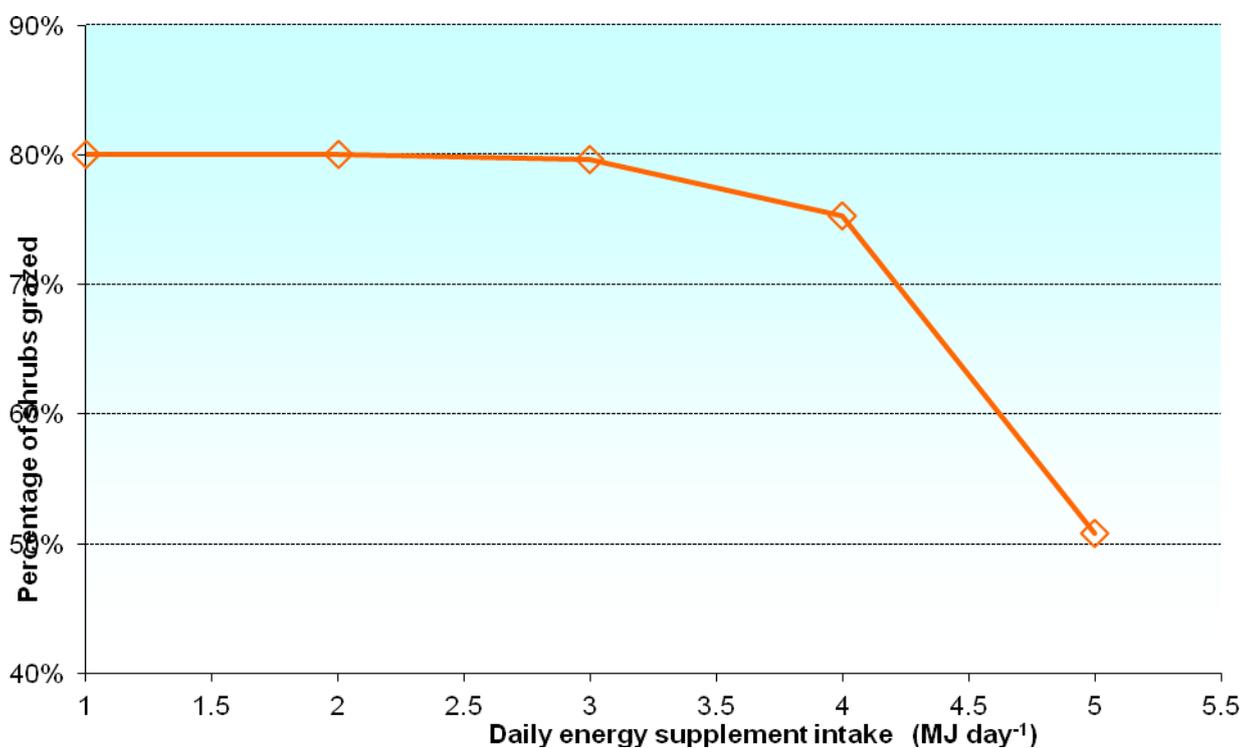
Supplementation increases the likelihood of livestock increasing body weight in these situations. Ideally, a supplement will supply the missing ingredients of a well-balanced diet. In reality, the diet can be incomplete and additions of supplement may replace intake of the forages. A balance needs to be reached between the live weight gain target, the effective and economical use of the forage and the supplement.

Managing the supplement ration of livestock grazing a forage shrub stand is 'to shoot at a moving target'. The nutritive value of plants that animals prefer to graze determines the diet. The supplement target should be the 'chosen' diet not necessarily the nutritive value of the standing pasture or the forage mixture. Animals grazing mixtures in our demonstrations showed strong preferences first for prime understorey plants, such as lucerne, and annual legumes and grasses prior to the flowering, then a less decisive choice between the forage shrubs and veldt grass. *Supplementation would need to be adjusted to meet the energy deficits that emerge as different diets are selected, and anticipate future needs based on the quality and quantity of the residual*

forages. Given the freedom with which livestock can select, this task requires regular monitoring, particularly to pick the transition of the diet's base from that founded on alley pastures to the shrubs.

Supplementation here poses two questions. First, what elements of the likely diet are insufficient to meet the animal's current nutritional needs? Second, how do different supplements affect which forages are chosen, and how much of each is eaten? To optimize the value of the supplement, the 'trick' is to establish the extent to which the supplement substitutes for the intake of forage shrubs. Supplying larger amounts of lupins, barley and oat supplements were associated with lower forage intake (both understorey and shrub). This effect is illustrated in the later phase of the 2009 Mount Russell trial when the rations are expressed in terms of their energy values (Figure 3). It is evident that the same effect is at work in the autumn 2011 Booderoo Hills demonstration (Table 5).

Figure 3 Changing shrub intake by pregnant ewes related to the estimated energy intake of supplements while grazing an Oldman Saltbush stand at Mount Russell 2009.



In our demonstrations, the different supplements appear to alter the choice of diets. This outcome is not unexpected, given their different nutritional profiles.

At the Mount Russell demonstrations in autumn 2009, 2010 and 2011, the livestock were either pregnant ewes or hoggets that were being prepared for sale. The nutritive values of the alley pastures were consistently low (Table 7). In these circumstances, supplements were considered essential as these livestock classes have high nutritional needs. As reported above, the Booderoo Hills autumn 2011 demonstration was supplemented also.

In 2009 the supplements were set at approximately 30% of the metabolisable energy requirement while the understorey plants are a significant part of the diet (~200g/day). As these forage shrubs became a significant part of the diet the ration supplement was increased (~ 600 + g/day). Without high levels of supplementation, it is unlikely that ambitious growth targets will be reached (~200g live weight/day). Professional advice on supplementation should be sought if high growth targets that require high levels of supplementation are being set. The risks to an animal's health are significant.

Figure 4 illustrates the course of the changes in body mass at Mount Russell. There is sharp fall in body mass times at day 45. This fall coincides with the low alley residues (~150 kg/ha) and accelerating shrub intake. The shaded area marks the area in Figure 5 encloses the shrub intake and alley residues that corresponds to day 45 of the trial. Jolly (pers. comm.) had warned of the risk of damagingly, heavy grazing of the alleys prior to take –off of shrub use. This first demonstration highlighted this problem.

At Mount Russell, the effects of lupin supplements were compared with those of oats and molasses in 2009 and barley and no supplements in 2010. In 2011, oats and barley supplements were compared. The pregnant ewes receiving either of one of the three supplements in 2009 did not grow significantly faster than the others. There appeared to be no advantage from feeding the more expensive lupins over oats or molasses. No clear difference emerged between barley, lupins and no supplement in 2010. In 2011, there was clear advantage for lambs feed oats, rather than barley (Table 7)..

Table 7 Changes in body mass (kg) of lambs feed oat and barley supplements while grazing Oldman saltbush stand at Mount Russell 2011.

Date	Supplement	
	Barley	Oats
13/05/11	51.8	52.0
26/05/11	53.0	53.9
15/06/11	52.7	54.7
28/06/11	52.6	55.2

At Booderoo Hills in autumn 2011, with sown alley pastures, barley appeared to displace forage intake more directly than oats or molasses. Oats supplements seemed to support a wider choice of forages, and greater consumption of the forages. Molasses was the least complete forage supplies a 'sugar hit'. Molasses supplement was rationed at 300g/lamb/day and then doubled to 600 g/lamb/day at day 21 for a further 19 days. The energy supplied by these molasses rations was less (3.8 and 7.3 MJ/lamb/day) than that of the other two supplements (~1000g/lamb/day, ~ 12 ME MJ/lamb/day). This supplement did not reduce the intake of either the understorey pasture plants or the forage shrubs as strongly as the grains. So, molasses made best use of the available forage mixtures as we saw at Mount Russell 2009. Oats despite the large ration still allowed to stock to make use of the total forage. Fewer shrubs were used than lambs feed the molasses supplement but achieved overall greater live weight changes. The growth rates, associated with a molasses supplement, are more likely to reflect the quality and availability of the feed on offer.

Figure 4 Changes in body mass (kg) of pregnant ewes grazing a saltbush stand with supplementation at Mount Russell autumn 2009

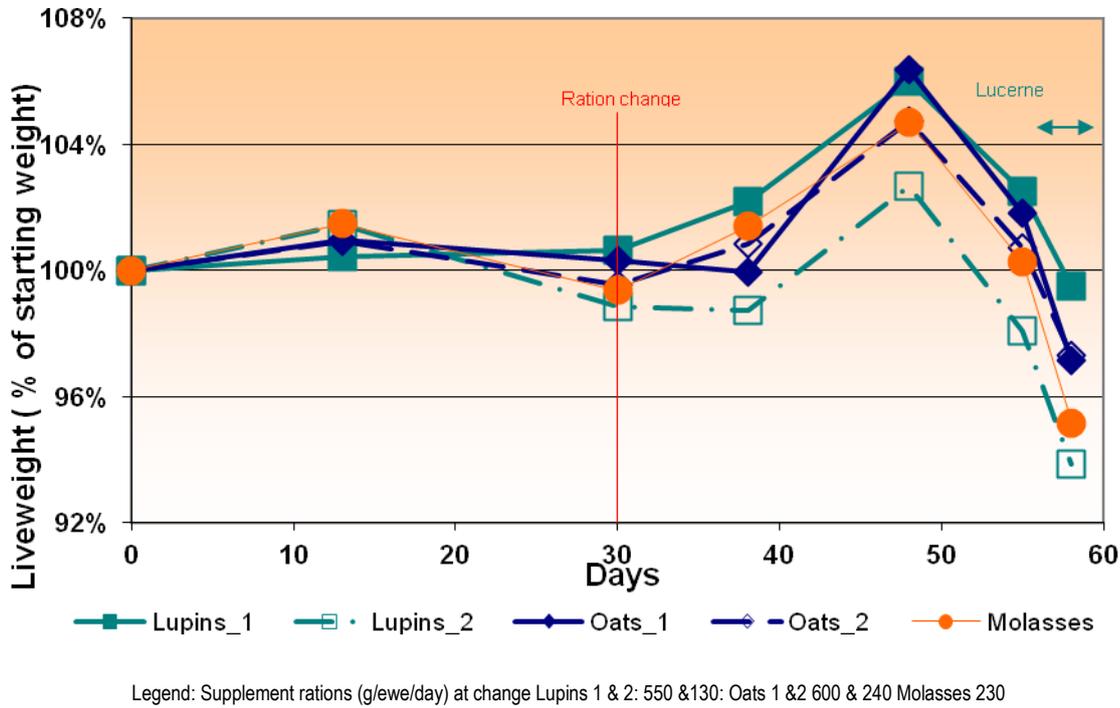
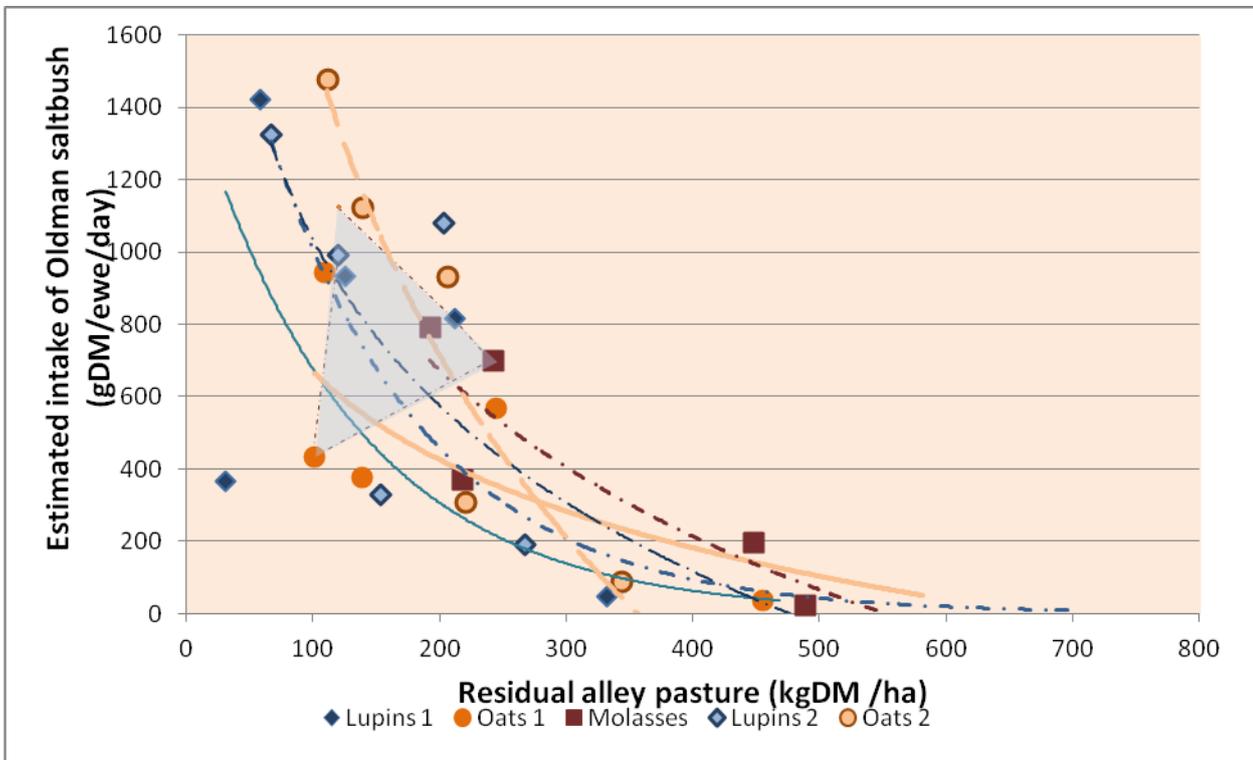


Figure 5 Changes in shrub intake (g/lamb/day) as alley pasture residues are grazed at Mount Russell autumn 2009.



Shaded area indicates the zone which corresponds to the fall in body mass on day 45 in Figure 5}

DEVELOPING A FORAGE-BASED GRAZING SYSTEMS

At the commencement of the project, the grand aim was to develop shrub-based forage systems that could provide an important addition to the farm's feed resources - especially during the recurrent seasonal feed deficits in autumn. Our measure of the performance of such systems was animal production – changes in body mass or body condition. It was considered the most relevant and credible measure of systems performance.

The general approach was to improve the resilience, availability, and nutritive value of the forage mixtures as a way of providing grazing livestock with more forage mix that is more nutritious, at a time of the year when there is less of lesser nutritious forage. A strong local emphasis on fat lamb production shifts the flock to being younger, more female, more pregnant and hungrier for nutritious forages. Hence, we set our standard high by using animal in this class: the classes of animals trialed included growing lambs and pregnant ewes that would be sensitive to differences in nutrition. Inadequate nutrition for these livestock classes would affect the medium and long-term productivity of the flock lock directly, and the profitability of the livestock enterprise.

Two commercially available saltbush species were planted – Oldman saltbush and River saltbush, as a platform to the system. A conservative, but perhaps defensible, choice. Oldman saltbush is generally the most productive saltbush species. In addition, there was scant evidence with which to include others or alternative shrub species. Nonetheless, the narrow choice of the saltbushes or the absence of well-founded productive alternatives proved critical.

We planted perennial veldt grass and lucerne as companion plants in the alleys between the shrub belts as a means of raising the total nutritive value of the total forage mixture, and naively, enhance the value of the forage shrubs. The superior crude protein, ME and DOMD of the forage shrubs to herbaceous plants during autumn presented an opportunity on which to build an advantage.

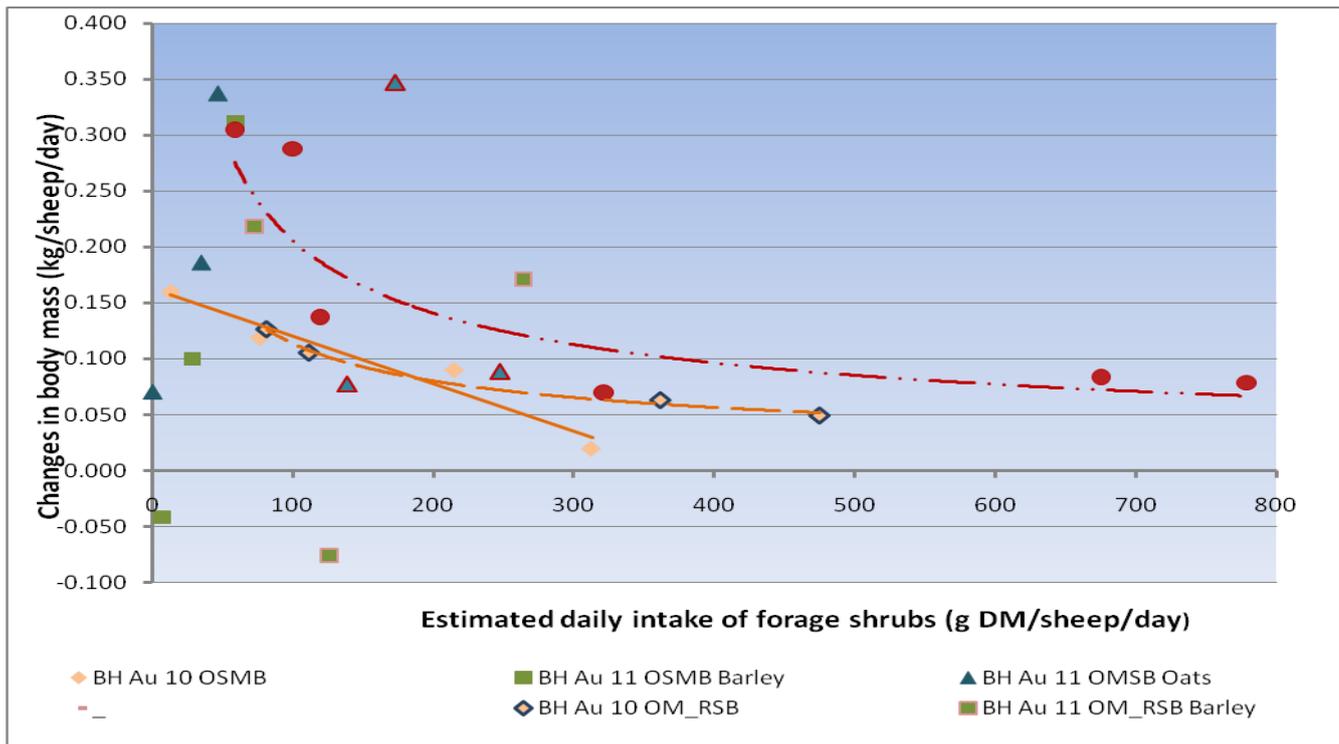
Regardless of these intentions, the sheep used in the trials had not been informed. Their preferences dominated the outcomes of the demonstrations. These saltbush species were not preferred until the mobs had grazed much of the herbaceous alley plants. The rate of increase in body weight tended to fall as shrub intake increased.

However, our estimates suggest that total forage intake from the plot is falling as the shrubs are browsed more intensively. The shrubs are eaten as the total feed supply diminishes. Hence, the shrubs are unfairly assessed. In practical terms, it may not be important whether or not the total feed supply is inadequate when the shrub intake reaches its maximum, a feed shortage may be necessary before sheep are induced to graze shrubs heavily.

To estimate shrub use, we used a simple assessment tool, with the shortest intervals being 10 days between measurements. There have been no detailed measurements of effects of the residual shrub forage on shrub intake rates, and attempt to distinguish this effect from salt ingestion. During the demonstrations, it is easy to over estimate how much forage is left on grazed shrubs, and how limiting the feed supply, based heavily on the shrubs, has become.

Importantly, the demonstrations suggested that despite the inverse relation between shrub intake and rate of growth, the rates of growth of sheep grazing a combination of two shrubs rather than one slowed less steeply (Figure 6).

Figure 6 Changes in body mass as shrub intake increases across the Booderoo Hills trials.



More detailed work may reveal if this outcome is robust, and if the alley pastures, which are important part of the overall protective soil cover are grazed less intensively before shrub intake of mixtures of shrubs increases. After a period of exposure to a variety of native shrub species – salty and non-salty, lambs grazing the stands ate less herbaceous plants, and left larger residues in the alleys (J Emms *pers. comm.*) while browsing the shrubs. A point that needs to be considered here is the high salt contents of many of the halophytic shrub species is likely to limit their intakes regardless of possible synergies among them.

The average energy content and digestibility of the lucerne and veldt grass at Booderoo Hills, compared to the volunteer pasture at Mount Russell, were similarly low, in contrast to the crude protein contents. Less than optimal; heavier grazing during the previous spring may have improved the quality of the lucerne, and possibly veldt grass but risk a poor recovery up to autumn. The values shown in Table 7 are averages for forages at the two sites. These averages tend to reflect the autumn values rather than the energy (MJ/kg) MJ/kg) contents of the lucerne and veldt grass at the start of the grazing in spring. The planting of the perennial pastures in the forage mixture did not appear to a boost the energy supply for the livestock grazing the shrub stands in autumn. Crude protein levels were always higher in the lucerne, particularly in the spring, than the veldt grass or the volunteer pasture at Mount Russell.

Triticale despite its measured, poor nutritional quality may have delivered a more nutritious addition to the autumn diet via its grain. Triticale was disadvantaged by the additional effort at controlling weeds, limited grazing offered.

The sheep generally did not show a strong preference for the veldt grass alleys over the shrubs. Changing digestibility does appear to play a role in the determining choice between the shrubs and the alley pastures in these field scale demonstrations. Livestock selectively grazed the lucerne and digestible annual grasses and legumes within the lucerne and veldt grass alleys. Lucerne was always the most preferred species, even though measured nutritional values suggest that the shrubs are more digestible. The substitution of shrubs for veldt grass intake was related to season.

Importantly, the perennial pasture plants, particularly veldt grass, retained larger protective residues after grazing than the volunteer pastures at Mount Russell. The alleys pastures increase the versatility of a shrub stand by providing feed at other times of the year, and reduce the opportunity cost of the shrub planting

More intense grazing was associated with greater use of all shrub species, lower pasture residues, and estimated daily dry matter intake. The difficulty with intensive grazing is to identify the levels of alley and shrub residues at which animal production, soil protection and forage use efficiency are optimized. More than likely this point occurs before full use has been made of the shrubs. Incomplete shrub use can lead to shrub stems growing unchecked and eventually beyond grazing height. Trimming is necessary to compress forage production into an accessible height range. A trial at Peake examined cutting regimes.

If livestock with higher nutritional needs are to graze shrubs, it would appear that supplementation is essential. The rations of a single supplement need to be adjusted as the alley pastures are removed, and the shrub intake increases. Added nutrients may be necessary to raise both the smaller total feed supply, as well as supplement the nutritional short-comings of the forage shrubs.

Molasses, as the least nutritious supplements, requires livestock to make fuller use of the available feed supply. If so, it is likely that changes in body masses will be more closely related to the nutritional quality of the available forage than when more complete supplements are used. Barley in contrast, readily displaced all forage use at high rates, with oats as a useful intermediate, and in two demonstrations associated was with lower body weights. Oats supported higher weight gains without displacing forage use. Given the already high nitrogen content of the shrubs, lupins with its high crude protein content would appear not to be a good match with the shrub as they generally

SHRUB BASED FORAGE MIXTURES PROTOTYPE:

It is not possible to specify in detail, but a shrub-based forage mixture may have these features:

- **DESIGN, DIMENSIONS AND USE OF THE SHRUB** stand will be guided by the physical dimensions and characteristics of environmental 'challenges', the size and timing of feed requirements of the flock, as well animal class and cost of establishment.
- The shrubs stands will be placed on poorly productive land where perennial plants can offer production or remedial environmental benefits at the **LEAST OPPORTUNITY COST** e.g. unreliable, easily eroded cropping land.

SHRUB BELTS

There will be a mixture of species in the shrub belts. A polyculture of shrub species can be chosen to optimize the windbreak characteristics, and encourage greater shrub use, and perhaps, reduce grazing pressure on the alley pastures. There is still a task to identify 'more preferred or palatable' shrub combinations. Diversity will be limited by the cost until a broader set of shrub species is produced a greater scale. Importantly, there is a program to select and develop more preferred Oldman saltbush varieties.

There are fewer non-saline shrubs that are as productive and accessible to smaller ruminants such as sheep. Tagasaste has been used in the more southerly wetter parts of the project. The Australian native shrubs such as the Acacia and Eremophila genera that are grazed but do not have the bulk to provide the mainstay of a forage stand.

ALLEYS.

The *width of the alley* is the product of the need for *machinery access* for cropping or pasture re-sowings, weed and insect control, and animal access and *grazing* and *shelter*. If shelter is a key requirement, then the height of the tallest shrub species in the shrub belts will determine width (20 x shelter heights). The coming generation of farm machinery may require wider alleys matched to the expected 2m heights of the taller shrubs (e.g. *Acacia ligulata*) in this environment. In the Booderoo Hills demonstrations, a ~8m alley space was used. The distance was equivalent to older style pasture seeders. If wider alleys can protect the soils against wind erosion, then the cost establishment can be reduced, as well as the opportunity cost above that of a pasture alone.

The *choice of plant species* for the alleys is problematic. In our demonstrations, livestock did not combine the shrub and pasture species as a result of strong differences in preference. The disconnected use of the two forage components limited the chance for more balanced diets. Using the measured values, the digestibility, and energy content of sown pastures did not survive to autumn. In the absence of more preferred shrubs, the addition of pasture plants would need to serve another purpose: soil protection.

Veldt grass is hardy but exotic perennial grass that can survive on the mid- and upper-slopes of the sand dunes. It is already used as an anchor plant in these circumstances albeit a low quality one. The sheep appeared to graze parts of the veldt grass plant selectively leaving its crown, and fibrous shoots intact as they graze these shrubs. Lucerne which may be constrained to the lower slopes and swales, duplicates the nitrogen content of the saltbushes, is more preferred and will be grazed preferentially to smaller residues, with greater soil exposure.

Robust soils can tolerate faster wind speeds with less plant cover after intensive grazing than the easily eroded local soils. Annual grass and legume pastures may be sufficient in these circumstances to provide grazing outside of summer and autumn.

GRAZING MANAGEMENT

More intense grazing produced lower residues and less soil cover. As applied in these demonstrations, there did not appear to be any enhanced nutritional benefit from this practice. We did not determine whether or not sheep at higher densities repeated the same but compressed consumption patterns of animals at lower stocking rates or achieved a more balanced diet while driving residues lower. Nonetheless, the fall in body condition is likely to be less at higher stocking rates where forage is removed in days rather than weeks. Identifying the appropriate stopping points which best support soil protection and animal production is still an issue under intensive grazing or cell grazing. The margin for error is smaller with more intensive grazing, requiring a higher order of management and monitoring.

SUPPLEMENTATION

Supplements are essential for livestock to grow while grazing simple shrub-based forage mixtures. Of the grains, oats appears to be a safer option compared to barley. Molasses while interesting, may rely more heavily on the basic quality of the available forage mixture. Knowing the effective nutritional quality of the forage components is important when supplementing animals that require a nutritious diet. The supplements appeared more effective with a mix of shrub species than the industry standard of Oldman saltbush alone. Further testing of the reliability of this system is necessary.

Supplements provide greater control over supply of nutrients to the sheep. It is an advantage to responding to changing selection and intake patterns. Shrub use is more easily managed because the stock's choices are limited. Finally, the demonstrations suggest that while a shrub-based forage mixture can bring multiple benefits beyond the livestock enterprise, its production value for sheep with high nutritional demands is limited to those periods of acute forage shortage. Use of the mixtures needs to be accompanied by supplementation. The value of these mixtures will be greater in the drier parts of the project area where these feed shortages will be more frequent and severe. Careful management of grazing is required to support their soil protection role.

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