# Fork in the road: forage shrub plantings by crop-livestock farmers in a low rainfall region of southern Australia

**Rick Llewellyn**<sup>1</sup>, Anthony Whitbread<sup>1</sup>, Roger Lawes<sup>2</sup>, Nat Raisbeck-Brown<sup>2</sup>, Patricia Hill<sup>3</sup>

<sup>1</sup> CSIRO Ecosystem Sciences, Waite Campus, Adelaide. Future Farm Industries CRC. Email rick.llewellyn@csiro.au

<sup>2</sup>CSIRO Ecosystem Sciences, Floreat, Perth. Future Farm Industries CRC.

<sup>3</sup>Victorian Department of Primary Industries, Horsham, Victoria.

## Abstract

Perennial forage shrub species have long been the subject of development, extension and incentive initiatives aimed at farmers in crop-livestock regions of southern Australia. In the low-rainfall Mallee region (250mm-350mm), most forage shrub plantings have used native saltbush species, mainly *Atriplex nummularia* (Old Man Saltbush). In this study we first present ground-truthed results from 90cm aerial imagery and terrain analysis that identifies existing forage shrub plantings and their landscape location. The results show that while there were many plantings, they were generally small in area, 75% were in sandier paddock locations rather than swales, and only a very small proportion of farmers had established several forage plantings. Of the farm blocks with saltbush, 65% had just 1 or 2 areas planted to saltbush. To further understand the current status of saltbush plantings and potential by landscape location/soil type, results from field analyses of existing?on-farm plantings are presented. These show edible biomass production levels prior to annual autumn grazing of generally less than 1 t/ha. Finally, agronomic and soil-specific land management developments are considered in developing conclusions about the likely future extent and landscape benefit of forage shrub plantings. Research and development efforts into new forage options are needed if extensive perennial forage shrub plantings are to be undertaken by crop-livestock farmers in this region.

## **Key Words**

Mixed-farming systems, forage, fodder, Mallee, grazing, perennial, saltbush, Atriplex.

## Introduction

Considerable extension, research and incentives have been invested in developing the role for perennial forage shrub species for the crop-livestock zone of southern Australia (de Koning and Milthorpe 2008). This has been largely motivated by the potential natural resource management benefits of perennial species (e.g. for salinity management and soil protection) and the animal production benefits from feed produced during periods where there is typically a gap in production by annual species. Other potential benefits from forage shrubs include supply of high protein content feed, feed during periods of drought, shelter, antihelmintic properties and increased flexibility in stock/paddock management. Bio-economic analyses have demonstrated that there is a potential for increased whole-farm profit (e.g. Monjardino *et al.* 2010) when a small proportion of the farm is dedicated to perennial shrub-based plantings. Negative attributes that have been identified include high establishment costs of forage shrub plantings, high salt/low energy content of common commercially available Atriplex (saltbush) species and the need for supplementary feed to maintain livestock production.

In the low and highly variable rainfall (250-350mm) Mallee region of southern Australia there are several ongoing farming systems developments that have implications for the potential role and fit for forage shrub species. Livestock numbers have greatly declined across this cropping-oriented region, although mixed farming enterprises remain common in this region with 85% of grain growers in the South Australian Mallee and 56% of growers in the Victorian Mallee having a sheep enterprise of some size (Llewellyn and D'Emden 2010). The typically dune (sandy soil) –swale (heavier soil) landscape is one of high soil variability where, over the past decade in particular, uptake of no-tillage systems has led to successful and relatively reliable cropping on the lighter-textured soils. Increasing cropping input costs

and technological capacity for soil-specific management is leading to greater consideration of the potential for lower input crop and/or grazing options for the soils with less reliable and low potential grain production. These include the currently cropped areas with high stone content and chemically-constrained heavier-textured soils where dry springs commonly lead to crop failure (Whitbread *et al.* 2008). For farms with livestock, new grazing options are being considered for these high-risk soils, including possible perennial-based systems.

In many regions, perennial plantings have often been targeted at areas affected by dryland salinity. Salinised land due to rising groundwater is not a common feature of the study area and it has been estimated that only 5% of forage shrub plantings are on saline land (Bulman 2003). Therefore, any future widespread use of forage shrubs relies on success on soils where common annual crop and pasture species can grow. Further, the study by Bulman (2003) of existing forage shrub stands in the Mallee (all *Atriplex* spp.) raised issues with persistence in some situations and concluded that saltbush was growing best on land with a history of cropping and fertiliser application, and worst on deep infertile dune sands and non-cropping areas of shallow stony ground over calcrete. It is in this soil-specific and increasingly spatially-oriented crop management context that the potential role for a range of perennial forage options in mixed-farming systems is currently being evaluated.

In the first section of this paper we present results from a study of existing forage shrub plantings based on spatial-analysis of aerial imagery from the South Australian Mallee region. The aim being to assess existing plantings in terms of the uptake by farmers following at least a decade of extension and incentives for perennial forage shrub plantings (MMLAP 2008) and the typical area and landscape location of plantings. In the second section we look briefly at production levels from some of these existing forage shrub stands, before raising implications and future directions for the development of perennial-based grazing systems in this environment.

#### Method

#### Identifying existing forage shrub plantings

The size and location of perennial forage shrub plantings within areas of the South Australian Mallee east and south of the Murray River with less than 350 mm annual average rainfall region were determined using remote imagery and geographical information systems (GIS). Based on sets of known plantings, the visual patterns of forage shrub plantings were detected using 90cm aerial imagery captured in October 2008. A total area of 0.45 million ha was searched for plantings. Polygons were then generated to capture each of the forage shrub sites identified in the analysis. Areas were determined using the planting boundaries with no consideration of internal row spacings. Ground truthing revealed that widely spaced plantings in alley-farmed paddocks were uncommon and the vast majority of plantings were in shrub-dominant patches. The area of each planting was calculated using GIS. Cadastral data accessed from South Australian state government departments was used to allocate plantings to farm blocks based on ownership. These were overlayed onto the airborne imagery and used to calculate the area of farm blocks. These farm ownership blocks (average size 799 ha) are, on average, smaller than the average land area managed in the region, suggesting current farmers are likely to manage an area comprising more than one of these farm ownership blocks.

Terrain analysis was conducted to identify small localised (paddock scale) variation in topography and classify these local variations into dune, midslope and swale. Fuzzy Landscape analysis GIS (Roberts *et al.*, 1997) was used to calculate local lowness (a derivative of relative elevation). Upslope contribution indices were also derived that describe areas low in the local landscape and have a high upslope contributing area. Groundtruthing was conducted by visiting 66 (approximately 20%) of the identified forage shrub plantings across the study region and confirming the presence or absence of forage shrubs at each location. The plantings shown to be something other than forage shrubs (often young tree and non-forage native shrub plantings) were omitted from the analysis.

#### Production of existing saltbush plantings

On-farm plantings of *Atriplex nummularia* were selected from within the study region on the basis of meeting specific criteria relating to the plantation age (>3 years; <20 years), plant density (blocks with not less than 3 m row spacings) and time since last intensive grazing (>7 months). The sites presented here come from northern (Waikerie), central (Kulkami) and southern locations in the study region. Sites were visited between the 12 March and 17 April 2009 and representative plots measuring 20 m x 20 m were marked.

The standing biomass of saltbush per plant and per hectare was measured using the "Adelaide" technique (Andrew *et al.* 1979) and represented the total amount of edible biomass produced by each plantation in the time since its last grazing. The representative saltbush plant branches used in the "Adelaide" estimations were stripped of all edible material (including leaves and soft twigs) to allow edible dry matter biomass to be measured and then calculated for each plant and the planting.

#### Results

#### Identifying existing forage shrub plantings

The analysis identified and mapped 305 plantings of forage shrubs. The total area of these plantings was 3070 ha. The groundtruthing indicated a false positive rate of 5%. On the road routes used for groundtruthing, false negatives were identified at a similar frequency to false positives (5% of identified plantings). The +/- 5% forage shrub identification error rate was deemed acceptable and likely to be more accurate than would be possible using common social surveying methods. For comparison, records of the Murray Mallee natural resource management organisation that has been offering incentives for plantings across the SA Murray Mallee region (MMLAP 2008) show 3413 ha of forage shrub planting registered over the past decade. The groundtruthing confirmed that almost all identified forage shrub plantings were Atriplex spp. e.g. the most commonly commercially available *Atriplex nummularia* (Old Man Saltbush). Of the sites visited, only 2 were identified as tagasaste (*Chamaecytisus proliferus*).

Plantings were found on 124 farm blocks. Consistent with the expectation that a farmer is likely to manage adjacent farm blocks, 64% of farm blocks with a planting were adjoining a farm block that also contained a planting. Of the farm blocks with a planting, 41% of farm blocks had only 1 planting; 24% had two planting; 11% had 3 plantings. However, there are examples of extensive plantings, with 4 farm blocks containing plantings greater than 150 ha. On farm blocks with a planting, the median area of planting was 13ha which represents an average proportion of the farm block area of 2.7%.

The terrain analysis classified 66% of the total farm block area as dune, with 26% of the farm landscape classified as the midslope and 7% of the farm landscape classified as a swale. In general, plantings tended to be on dunes. A pair wise comparison of the farm and planting terrain found 75% of the planting area was on dune. This weighting towards dune soils was significant (p<0.001). An emphasis of natural resource management programs on potential recharge zones and erosion-prone soils, together with the relatively low proportion of agricultural land affected by dryland salinity discharge may partly explain the absence of any weighting towards perennial plantings on low-lying areas. There was no relationship between planting area and the terrain of the planting ( $r^2 = 0.01$ ).

#### Production of existing saltbush plantings

Biomass production from existing saltbush plantings measured in 2009 are shown in Table 1. The results are comparable with the relatively few biomass production figures from long term saltbush plantings under farmer management (Bulman 2003; de Koning and Milthorpe 2008). While acknowledging that a shrub-based forage area requires a mix of species to achieve successful forage quality and value, the results show generally low biomass production under these on-farm conditions, well below the quantities suggested as threshold levels discussed for profitable plantings (de Koning and Milthorpe 2008) and assumed in economic analyses of forage shrub potential (Monjardino *et al.* 2010). However, the potential for higher levels of biomass production by some plant types on particular sites is also demonstrated (e.g. Parilla, Table 1).

Location	Landscape position	'Cultivar'	Months since grazed	Edible biomass/plant	Edible biomass/ha
Kulkami 1	Dune	de Koch	>9	0.61	957
Kulkami 2	Dune	de Koch	>9	0.47	787
Lameroo	Dune	de Koch	7	0.73	1060
Lameroo	Dune	de Koch	lightly grazed	0.68	782
Parilla	Flat	Eyres Green	lightly grazed	3.03	1514
Pinnaroo	Dune	de Koch	lightly grazed	0.26	237
Waikerie 1	Dune	de Koch	>10	0.35	716
Waikerie 2	Swale (stoney)	de Koch	>10	0.23	284
Waikerie 3	Dune	de Koch	>10	0.31	505
Waikerie 4	Swale (stoney)	de Koch	>10	0.35	496
Waikerie 5	Flat	de Koch	>10	0.37	601

Table 1. Edible biomass (kg) of *Atriplex nummularia* in SA Mallee forage block plantings 2009.

## Conclusion

After over a decade of development, extension, subsidies and incentives the extent of forage shrub plantings, predominantly saltbush, in this low rainfall environment remains low and new plantings have slowed. The small proportion of farming land in this 1.7m ha region with established perennial forage shrub species means that any net NRM benefits of these plantings at the regional scale are also likely to be low. Despite there being a substantial number of long-established plantings, the diffusion of saltbush plantings has not substantially progressed at either an intra or inter-farm level. Although there are examples of farms with extensive plantings, the establishment of a saltbush forage planting on a farm has generally not promoted substantial areas of plantings in the district or typically even on that farm. The low levels of production being commonly observed at existing on-farm sites mean that this is unlikely to

change unless changed management and/or new plant options (see Emms *et al.* 2006; Hobbs *et al.* 2009) are introduced.

Several technological changes are influencing the potential fit for future perennial forage plantings in this low-rainfall mixed farming farm landscape. These include the shift to no-till cropping to reduce erosion risks and increase productivity on sandy soils, and increasing knowledge and enabling technology to support soil-specific management. There is also increasing emphasis on risk management through more targeted cropping programs as input costs rise, and a shift among mixed farmers from wool to prime lamb production with a consequent change in feed demands (Bell *et al.* 2008). These drivers are generating demands for grazing and soil-specific land management that are very different from the factors that led to much of the existing saltbush area to be established. For production and environmental benefits of perennial forage species to be achieved across extensive areas, the challenge is now for plant development, agronomy and farming systems research to develop new, more profitable options for a greatly changed farming system.

#### Acknowledgements

This research is funded through the CRC Future Farm Industries EverCrop project and CSIRO Sustainable Agriculture Flagship. Contributions from SARDI, SA Department of Water, Land and Biodiversity Conservation and Bill Davoren, Damien Mowat, Anita Smyth and Steve Hughes are gratefully acknowledged.

#### References

Andrew MN, Noble IR, Lange RT. (1979). A non-destructive method for estimating the weight of forage on shrubs. Australian Rangeland Journal, I, 225-231

Bell, LW, Robertson MJ, Revell DK, Lilley JM, Moore AM. 2008. Approaches for assessing some attributes of feed-base systems in mixed farming enterprises Australian Journal of Experimental Agriculture, 48, 789-798.

Bulman P (2003). Evaluation of revegetation options used to reduce recharge. Report for Murray Mallee Local Action Planning Association. 96p.

de Koning, C, Milthorpe, P (2008). Integrating forage shrubs: their potential in mixed-farming enterprises in low rainfall regions. RIRDC Publication No. 08/044. 58p.

Emms J, Bennell M, Hughes S. (2006). Profitable and sustainable perennial grazing systems: searching for the right shrub species. Proceedings of the 13th Australian Agronomy Conference, Perth.

Hobbs, T.J., Bennell, M., Huxtable, D., Bartle, J., Neumann, C., George, N., O'Sullivan, W., McKenna, D. (2007). Potential agroforestry species and regional industries for lower rainfall southern Australia. FloraSearch 2. Publication No. 07/082. RIRDC, Canberra. 120pp.

Llewellyn RS, D'Emden, F. (2010). Adoption of no-till cropping practices in Australian grain growing regions.? CSIRO report for GRDC, SA No-till Farmers Association and CAAANZ. 32pp.

Monjardino, M., Revell, D., Pannell, DP. (2010). The potential contribution of forage shrubs to economic returns and environmental management in Australian dryland agricultural systems. Agricultural Systems, 103, 187-197.

Murray Mallee Local Action Planning Association (2008). Annual Report 2007-08. p5.

Roberts, D. W., Dowling, T. I., Walker, J. 1997. FLAG: a Fuzzy Landscape Analysis GIS Method for Dryland Salinity Assessment. Canberra: CSIRO Land and Water Technical Report No.8.

Whitbread A, Llewellyn RS, Gobbett D,?Davoren B (2008). EM38 and crop-soil simulation modelling can identify differences in potential crop performance on typical soil zones in the Mallee. Proceedings of the



14th Australian Agronomy Conference, Adelaide.