Regeneration of Old Ungrazed Old Man Saltbush (*Atriplex nummularia*) Stands in South-West Australia

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Abstract
Many old man saltbush (*Atriplex nummularia*) stands were sown in the grainbelt of Western Australia for soil regeneration and salinity management up to 25 years ago, but have not been effectively grazed subsequently, such that the main feed available for sheep is above grazing height. The aim of the study was therefore to see if it was possible to return the old man saltbush stands to a productive grazing stand.

Two sites were chosen that had been sown up to 25 years previously in Goomalling and Corrigin, in the south-west of Western Australia. The sites were split into four treatments that would reduce the height of the stands and bring all grazing material back to less than 1.2 m (the maximum grazing height for sheep in Australia); cutting to 0.5 m, cutting to 1 m, rolling to ground level, and a uncut control. Available feed above and below 1.2 m was assessed before cutting or rolling and then four times over the next two years.

The results found that all three treatments removed feed above 1.2 m and that after 2 years the amount of feed below 1.2 m was increasing. The greatest feed available below 1.2 m was in the rolled treatment, followed by cutting to 0.5 m. Cutting old man saltbush stands to 1 m provides greater feed on the plants after cutting, but within one year of cutting some of the new feed is already above grazing height.

It is concluded there is potential to return old established stands of old man saltbush to a productive grazing stand.

Introduction
Old man saltbush (*Atriplex nummularia* Lindl.) is a saline-tolerant, halophytic woody shrub from the family Chenopodiaceae that is native to Australia. It occurs in the arid and semi-arid rangeland areas, and was widely recommended for sowing in the agricultural areas of southern Australia that were becoming unproductive for cropping (Barrett-Lennard, 2002). However, many plantings of old man saltbush sown 15 to 20 years ago were planted too close together for effective management and subsequently are now over-grown and too tall to be an effective feed resource for sheep. Close and over-grown saltbush also leads to limited regeneration of a pasture understorey, and thus poor biodiversity. This means that although they have been successful in the reclamation of degraded land in terms of potentially reducing soil erosion, rising salinity or waterlogging, they are not an economic resource for landholders and so have not been adapted as a profitable component of the farming system.

Currently landholders with old woody and overgrown old man saltbush plantings are unsure what to do with them, are thus considering removing them, plus wouldn't plant anymore of their farm to fodder shrubs. However, this increases the risk of on-farm salinity and waterlogging increasing as the watertable rises with the removal of perennial summer-active vegetation from the system (Bennett & Barrett-Lennard, 2013). (Monjardino et al. (2010) have previously shown that if 10% of the farm is sown to perennial forage shrubs, farm profitability can be increased by an average of 24%, primarily through the provision of 'out-of-season' feed and the productive use of marginal soils. It is therefore not advantageous to landholders to remove their old man saltbush plantings, and there is an urgent need to determine methods of bring them back into a productive and profitable component of the farming system.

The aim of the study was to; determine if old man saltbush plantings can be regenerated to form a useful resource, to determine the most effective method of regeneration, and to demonstrate that regeneration can increase and improve feed availability for livestock.

Methods and Study Site

The trial consists of two sites sown approximately 15 to 20 years prior to the commencement of the trial; Goomalling (-31.307185, 116.831752) and Corrigin (-32.333748, 117.873180), Western Australia. Both sites are in the medium rainfall zone of Western Australia with a mean annual rainfall of 365 mm and were sown into sites that were becoming saline and unprofitable for cropping). The site at Goomalling is sown as two rows of old man saltbush, followed by two rows of river saltbush (*Atriplex amnicola* Paul G. Wilson), another endemic halophytic perennial shrub, with an 8 m gap between rows. The site at Corrigin was sown as three rows of old man saltbush, each 8 m apart, with an inter-row of 28 m (wide enough to be cropped), before the next set of three rows.

The trial at Goomalling was laid out with four treatments, each 120 m long, of fodder shrubs that comprised 2 rows of old man saltbush and 2 rows of river saltbush. The four treatments were a) rolled/ squashed to ground level, b) cut to 50 cm height, c) cut to 100 cm height, and d) left as the control. Each treatment row was split into four replicated sampling blocks (10 m) along each treatment, with 15 m between blocks. An initial assessment of available edible 'food-on-offer' biomass sampling of material of both old man and river saltbush was conducted on 4th April 2016, prior to the treatments being imposed using the 'Adelaide' method described by Andrew et al. (1976). For the purposes of this paper only the results of the old man saltbush will be reported.

The site at Corrigin was laid out with three treatments, each 120 m long, of fodder shrubs that comprised 3 rows of old man saltbush, 8 m apart. The three treatments were a) rolled/ squashed, b) cut to 50 cm height, and c) left as the control. Each treatment row was split into four replicated sampling blocks along each treatment, as above. No initial sampling of the biomass took place at Corrigin, but the initial biomass was estimated from the ends of each of the rows after the treatments were imposed on 4th April 2016 using the same method described above.

Food-on-offer biomass samples (Andrew et al., 1976) were taken from both sites in September 2016 to measure growth in each block over the late autumn and winter. Sites were sampled again in January and March 2017 to determine spring and summer growth in the treatments. Final cuts were taken in early July 2017 at Goomalling. This was not a scheduled sampling time, but due to the very dry start to the season in 2017 the farmer needed to use the study site for feed for his sheep. The site was therefore assessed for available feed before the sheep entered the site. The final assessments were taken in October 2017 at Corrigin, as initially planned. Sample dates for the trials at both sites are shown in Table 1 below.

Table 1. Seasonal dates fodder shrub study sites at Goomalling and Corrigin, Western Australia were sampled for available 'Food-on'offer' biomass (Andrew et al., 1976) as a feed resource across the four and three treatments respectively imposed at each site.

Trial sites	Prior to treatments	Spring	Start of summer	End of summer	Winter	Spring
Goomalling	4/4/2016	30/10/2016	18/01/2017	23/03/2017	06/07/2017	
Corrigin	4/4/2016	3/10/2016	14/12/2016		13/06/2017	10/10/2017

Results

The increase in available grazing biomass in old man saltbush below 1.2 m (Goomalling) and 1 m (Corrigin) in all treatments over the 2 years since the treatments were imposed is shown in Figures 1 and 2. In both the rolled/ squashed and cut to 0.5 m treatments the amount of feed available above 1.2 m (Goomalling) or 1 m (Corrigin) is negligible following the start of the experiment, highlighting that all the new growth is available to grazing sheep. At the Goomalling site in the treatment, cut to 1 m, the amount of feed above 1.2 m was negligible in the Oct and Jan measurements, but one year after it was cut, the amount of feed-on-offer above 1.2 m was not significantly different ($P>0.05$) to that recorded at start of the experiment. The decrease in the food-on-offer biomass available in the 6th July 2017 assessment, compared to the previous assessment in all treatments is thought to be due to leaf drop as a result of the dry start to the season.

At the Corrigin site both the rolled/ squashed treatment, and the treatment cut to 0.5 m showed negligible feed-on-offer above 1 m in the assessments made in the initial year. In the two assessments made in 2017, the amount of feed-on-offer above 1 m had started to increase. However, the amount of feed-on-offer biomass below 1 m had increased significantly ($P<0.05$) in the treatment cut to 0.5 m. Although the amount of feed-on-offer biomass below 1 m had increased in the rolled/ squashed treatment in 2017, it was not significantly different to that recorded in the control.

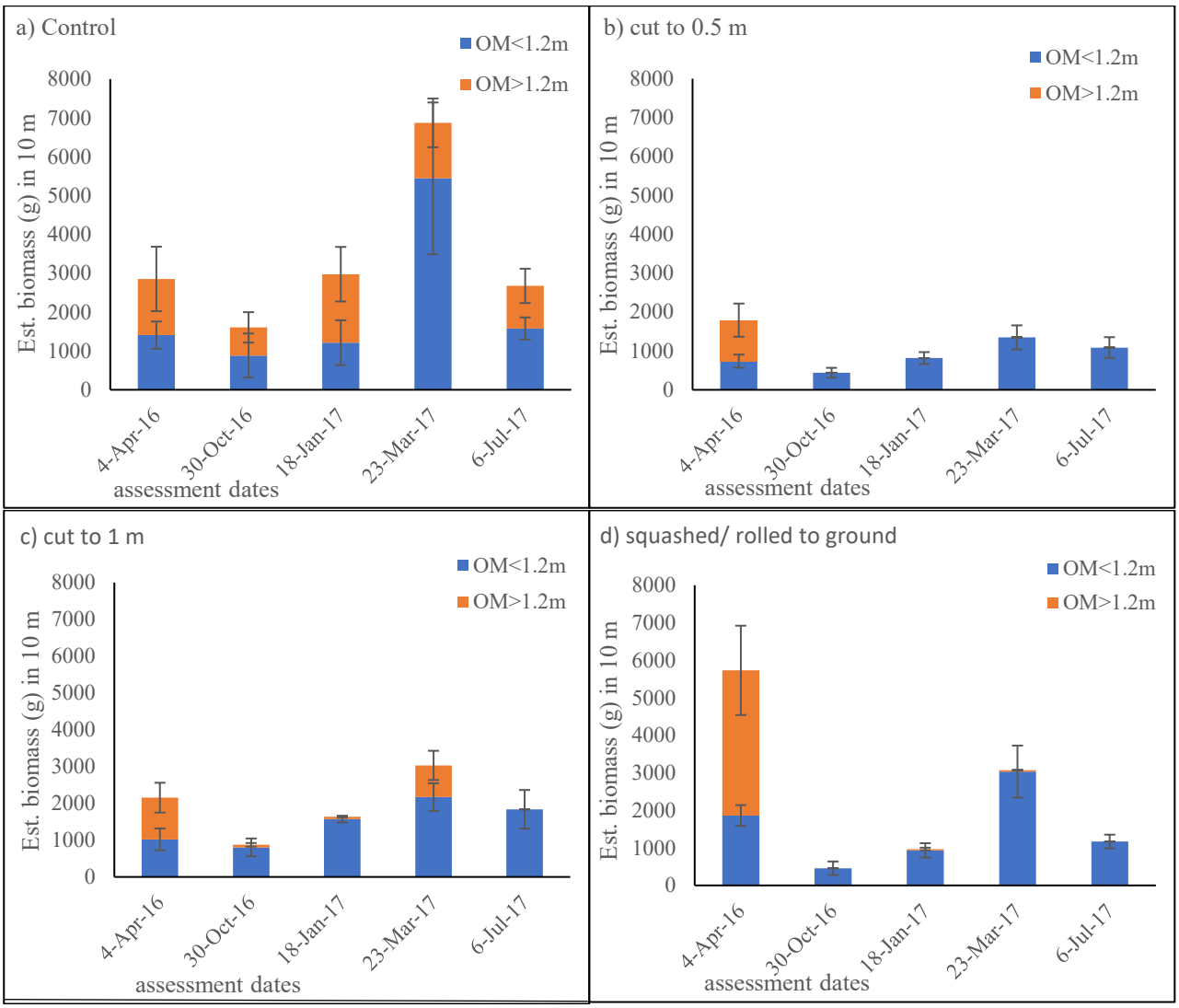

Figure 2: Feed-on-offer biomass available on old man saltbush above and below 1.2m grazing height across the four treatments at Goomalling; a) control (not cut), b) cut to 0.5 m height, c) cut to 1.0 m height and d) plants rolled to ground. Sample date 4th April 2016 is before treatments were imposed.

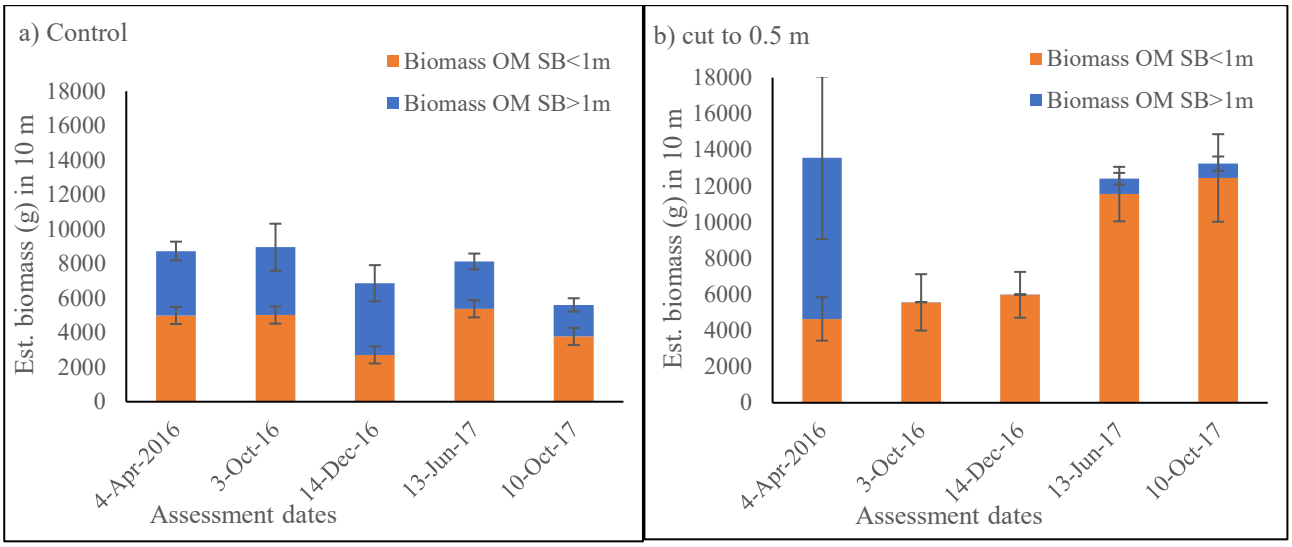

Figure 3: Feed available on old man saltbush above and below 1.2m grazing height across three treatments at Corrigin; a) control (not cut), b) cut to 0.5 m height, c) plants rolled/ squashed to ground not shown). Sample date 4th April 2016 is before treatments were imposed.

Discussion [Conclusions/Implications]

The results of the study show that old plantings of old man saltbush can be regenerated to form a useful resource again. This is highlighted by the landowner at Goomalling requiring the site for grazing in July 2017 following a dry start to the season, as there was no traditional annual pasture available in July (G. White, Pers. Comm.). This is a time of year when sheep are typically grazing annual pasture legumes that regenerate following rains at the start of the growing season in autumn (Dear & Ewing, 2008). Traditionally old man saltbush was recommended as an out-of-season feed for the autumn feed gap, when summer stubbles have been exhausted, but annual pastures have not yet established sufficiently for grazing. However, more recent research has shown that old man saltbush can be a useful feed resource at different times of the year, including in winter as used at Goomalling (Bennett & Barrett-Lennard, 2008).

Although the trial was only run for two years, it is suggested that the most suitable treatments for saltbush regeneration, were those that cut the saltbush lower than the 1.2 m height that sheep can reach for grazing (Andrew et al., 1976), thus the treatments that either cut the saltbush to 0.5 m or rolled/ squashed the saltbush to the ground. Although these treatments showed a slower recovery following the imposed treatments, even after two years the amount of feed above sheep grazing height was negligible, while the amount of feed below grazing height has increased significantly providing a valuable grazing resource that could be managed into the future as profitable component of the farming system. It is recognised that this trial is limited as sheep were not included as part of the saltbush recovery, and that by using the old man saltbush as a valuable component of the grazing system the height of the saltbush should be maintained at a lower level.

To conclude, although Monjardino et al. (2010) modelled that by sowing up to 10% of a farm to perennial fodder shrubs, farm profitability could be increased by an average of 24% in medium to low rainfall mixed crop-livestock farms in Western Australia, this can only be achieved by using land that is marginal or unprofitable for cropping. Providing a method, such as described in this study, that landholders can use to convert unprofitable land, sown to saltbush for saline land regeneration, to a profitable component of the farming system with an out-of-season feed resource ensures that landholders retain their saltbush plantings, protecting land at risk of becoming saline for future generations.

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