Perennial forage shrubs — from principles to practice for Australian farms

A companion publication to *Perennial forage shrubs providing profitable and sustainable grazing: Key findings from the* Enrich *project*

FUTURE FARM
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Contents

Enrich project contributors include:

Introduction and overview

A lack of green feed during summer and autumn was stopping Western Australian farmer Don Nairn from increasing his stocking rate and farm livestock profitability. However, by introducing forage shrubs Don achieved this without the risk of soil erosion — a potential problem on his sandplain soils. Combined with strip grazing; incorporating the forage shrubs tagasaste, rhagodia and old man saltbush has allowed him to maintain his flock throughout the year and increase profitability. It was the multiple benefits derived from planting these perennial species that made Don see the positive contribution forage shrubs could make to his whole farm. The benefits of planting forage shrubs can include:

- **Feed stability**

  The perennial nature of forage shrubs provides an opportunity to supply green feed at any time of the year. Their ability to withstand dry conditions and offer out-of-season feed is one of their great strengths. While resilient to our harsh environmental conditions, they can capture and respond to out-of-season rainfall and turn this into feed. However, their usage need not only be confined to the summer–autumn period. Producers have found shrubs to be a valuable forage in early winter when pasture growth is slow (especially in years with a late seasonal break) and in the period leading up to harvest. This makes them a real option to manage the year-to-year variability experienced across our low rainfall agricultural zone.

Western Australian farmer Don Nairn has seen the positive contribution forage shrubs can make to his farm

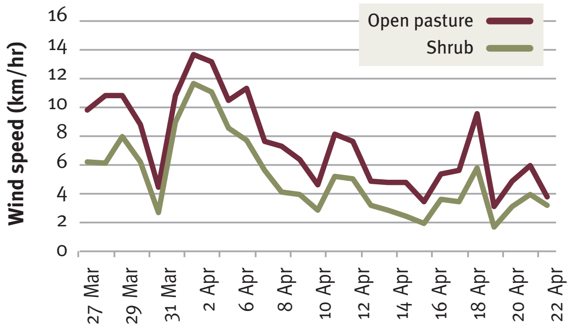

Livestock seek out the shade forage shrubs can provide

- **Shade and shelter**

  Forage shrubs can provide shade and shelter — an easily forgotten management tool, which impacts on the efficiency of animal production. Animals can tolerate cold but they must eat more to generate body heat and they can tolerate heat but it costs them energy to keep cool (e.g. by panting more). Either way, it means less efficient production.

  Shrubs provide shade for livestock with temperatures being lower within a shrub plantation. For well-fed, adult animals, the effects of higher temperatures are substantial. For example, sheep with a full fleece

FIGURE 1. Average wind speed within a shrub system and in open pasture during autumn



will often increase their respiration rate when the temperature reaches 18–21°C. Wind chill is also a major risk. For example, a 10 km/hr wind at sheep height can lower the effective temperature from 10 to -3°C. Forage shrubs can reduce wind speed (see Figure 1) and have a particular role to play during off-shears and lambing. It is also likely that the micro-climate created by shrubs provides favourable conditions for companion pasture growth (see Section 1).

Photo courtesy G. Stainer, DAFWA

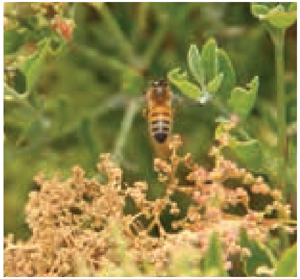


Photo courtesy Anita Smyth

Native forage shrubs provide habitat and food for birds, many insect species and other native animals

- **Natural resource management**

  Shrubs' extensive root systems, coupled with their perenniality, enable them to reduce the risk of dryland salinity through greater water use and protect soils, reducing erosion. Adding shrubs creates a new vegetation layer, resulting in increased biodiversity compared with simpler agricultural landscapes. Increased numbers of birds[1] and reptiles[2] have been found in forage shrub plantations compared with annual pasture systems. The forage shrub species detailed later in this booklet also host beneficial predatory insects offering potential advantages for integrated pest management (IPM)[3] in nearby crops and pastures.

1. Collard SJ, Fisher AM (2010) Shrub-based plantings of woody perennial vegetation in temperate Australian agricultural landscapes: What benefits for native biodiversity? *Ecological Management and Restoration* **11**, 31–35.
2. Lancaster ML, Gardner MG, Fitch AJ, Ansari TH, Smyth AK (2012) A direct benefit of native saltbush revegetation for an endemic lizard (*Tiliqua rugosa*) in southern Australia. *Australian Journal of Zoology* **60**, 192–198.
3. Taverner P, Wood G, Jevremov D, Doyle B (2006) 'Revegetation by Design' Guidebook: A guide to using selected native plants to reduce pests and diseases in the horticulture region of the northern Adelaide Plains, (SARDI: Adelaide).

- **Increased animal productivity through plant bioactivity**

  The native shrubs studied were abundant in natural plant secondary compounds which, when grazed appropriately (see Section 7), can modify the rumen (gut) environment leading to better digestive efficiency. Not only can this lead to better animal productivity but it can also reduce the intensity of greenhouse gas emissions from grazing livestock. The innate chemistry of the plants may also provide some control of intestinal parasites due to their toxic effect on livestock parasites (see Section 4). Livestock are also less likely to ingest parasite larvae as they spend less time grazing near the soil surface when foraging in shrub systems.

- **Profitability and risk**

  Bioeconomic modelling has indicated that converting 5–20% of a mixed farm to shrub-based systems could increase whole-farm profit up to 20%. Whole-farm profit is increased by reducing supplementary feeding during autumn and by deferring the grazing of regenerating annual pastures on other parts of the farm, which in turn increases seasonal feed availability. Shrubs also enable production on land classes unsuitable and uneconomic for cropping. Being able to reduce the intensity of cropping and avoid cropping on marginal soil types, without compromising whole-farm profit, lowers risk to the farm business. Every farm is different, but the optimal shrub area is based on the premise that enough shrubs are needed to provide an adequate number of grazing days to have an impact on the whole farm feed budget, but not so many, that land is taken away from more profitable enterprises. Generally, the greater the area of low productivity land classes on the farm, the greater the optimum area of forage shrubs.

The *Enrich* Project

In 2005, the *Enrich* project began a new research path into shrub-based systems. It aimed to increase knowledge about developing and managing these grazing systems across southern Australia, particularly in low–medium rainfall zones and on soils marginal for cropping. It differed from existing work through 1) a systematic focus on Australian native species, 2) the approach that a mix of species all contributing to the profile of nutrients and secondary plant compounds will be better at sustaining grazing systems than relying on a single species and 3) grazing management based on the principles of animal behaviour and physiology can be practically used to modify the diet selection of livestock and successfully graze diverse forage mixes.

Over eight years the project has brought together researchers, extension specialists, local authorities and producers. All have shared knowledge and worked towards the common goal of developing a grazing system that will contribute to farm productivity without compromising natural, including human, resources.

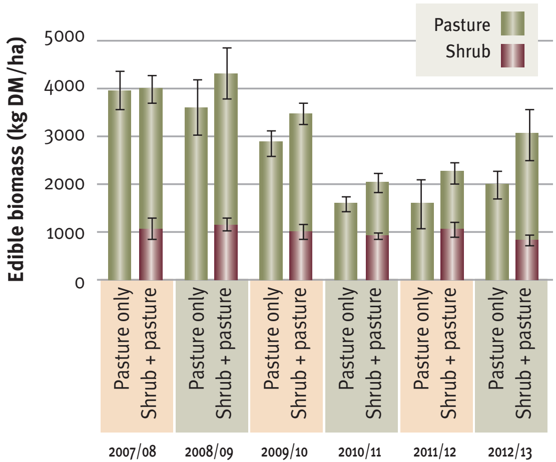
The *Enrich* team at Glenroy Estate, SA

Findings from the first phase of this project were detailed in the booklet — *Perennial forage shrubs providing profitable and sustainable grazing: Key findings from the* Enrich *project*. In this current booklet we explore some of the issues further and provide more specific details to help apply shrub-based systems on farm.

1. The value of diversity to the grazing system

The resilience and perenniality of forage shrubs creates a more stable feed supply especially during dry or erratic seasons. When grown with understorey pastures, the bulk of the biomass will generally be produced by this understorey. However, these herbaceous and grass pastures are substantially influenced by seasonal rainfall and consequently production can be highly variable from year to year (see Figure 2). During six years of research, greater annual productivity was achieved with the addition of forage shrubs in all but the first year. Forage shrub production was stable from year to year and contributed around 1000 kg/ha. This 'extra' tonne in autumn is higher in crude protein and mineral content than the inter-row pasture of annual plant species, which are dead at this time of year. Animals can only utilise the fibre in senesced pasture and crop stubbles if they have a source of nitrogen (crude protein), so forage shrubs provide a useful dietary complement.

FIGURE 2. Annual forage production measured as spring and autumn annual pasture biomass and including autumn shrub biomass for the shrub and pasture system*



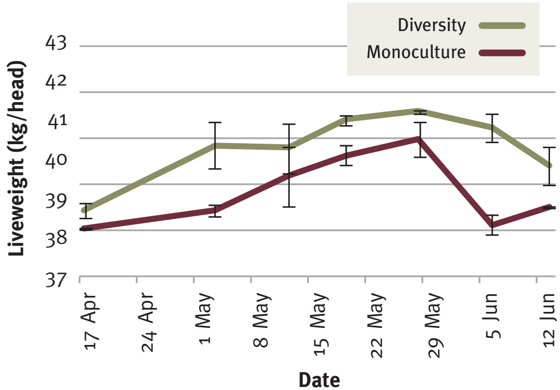
* Shrubs were planted at a density of 2066 plants/ha

Due to their growth habit, shrubs can create substantial changes in the surrounding micro-climate, which may have positive or negative effects on the understorey species. The shade provided by shrub species can create favourable soil moisture conditions through reduced evaporation and lead to better pasture survival in conditions such as false breaks. Annual pasture species remain green for longer at the end of the cooler growing season when afforded some protection by shrubs. During winter, minimum temperatures are higher within shrub stands and frosts are less common. Annual legumes appear to particularly benefit from growing in association with shrubs. The presence of shrubs brings increased nutrient cycling and experimental work has shown companion pastures have higher levels of phosphorus and potassium. Understorey legume species may provide an important source of nitrogen to the shrub component. Shrubs may also protect companion species from grazing animals, especially when shrubs and other plants are of differing palatability.

The micro-climatic conditions created by the shrubs have allowed pasture growth on the south side of the shrub row after only a little early autumn rainfall

Increasing the diversity of shrub-based grazing systems can lead to increased feed utilisation, feedbase stability, nutrition and ultimately animal performance (see Figure 3). This is because animals seek to consume a mixed diet to avoid excess toxins and nutrient deficiencies. Diversity in the feedbase also allows for individuality in a livestock herd, where different animals will have different nutritional requirements. This is especially true when considered over time. Grazing different plants in forage systems has often been considered difficult to manage appropriately, with a particular species commonly being over-grazed. However, by considering the nutritional experiences of livestock and their potential to 'learn' about novel feeds, it has been repeatedly shown that grazing diverse mixtures of forage shrubs is not only possible but also productive (see Section 7 and 8). Work within the *Enrich* project has shown that animal preferences for these species can vary depending on animal experience, time of year, plant genotype and location. Exactly why livestock make these choices remains unknown, but this emphasises the fact that providing diversity and

FIGURE 3. Change in liveweight of 10-month-old sheep during grazing of two different shrub-based systems*



* The first system (Diversity) was a diverse mixture containing 20 shrub species plus senesced volunteer pasture, and the second (Monoculture) was comprised of only one shrub species plus senesced volunteer pasture. Both systems were grazed at 20 sheep/ha over six weeks during autumn. The contribution of shrubs to the actual diet eaten was much greater in the diverse system throughout the whole grazing period.

A mix of shrub species allows for many benefits to be realised by enabling plants with different qualities to be used together

allowing animals to make choices may be a sensible approach. The role of the manager is to provide the dietary choice and create the best environment for animals to optimise their feed intake. The *Enrich* project has never aimed to find a single species that will have the potential to be the sole source of 'fuel' for grazing animals or provide the full range of benefits possible. Rather, our efforts have been directed towards developing a system with a suite of species that, along with conventional understorey pasture, can provide a more stable and better-balanced feed supply.

In addition to achieving better feed utilisation and animal performance by providing diversity in the diet of livestock, using multiple species is the way to realise as many of the potential benefits as possible. While it is tempting to think that all shrubs are much the same, this is not the case. The forage plants researched in the *Enrich* project have a range of different nutrient profiles and other desirable attributes. For example, the different species varied in crude protein from 8 to 28%, and for the most prospective species (see Section 2) the salt content varied at least four-fold.

A wide range in 'extra nutritional' traits was also found — that is, characteristics due to plant chemistry beyond the provision of nutrients for energy, such as toxicity to gut parasites. Most species do not have all of the attributes that may be required — for example they may be high in crude protein but not show any potential for controlling intestinal worms or providing shade. However, by growing a mix of species, each of which provides an attribute, the range of benefits is widened.

2. Selecting shrub species for profitable and sustainable farming systems

Three main criteria were used to select shrubs for the initial research in the *Enrich* project: 1) having a perennial life habit and woody growth form, so as to include plants that are trees or creepers, 2) being native to the traditional livestock–cropping zone (temperate) or the southern pastoral zone (semi-arid) and 3) evidence of being palatable. This selection process identified more than 100 species. A total of 87 species were successfully grown in the field and research on another 14 species was conducted using plants growing in native locations (see Figure 4).

Data on plant attributes have been gathered primarily from three main sites — Condobolin (NSW), Merredin (WA) and Monarto (SA) — with each planted with multiple provenances (genotypes) of more than 50 species. Subsequently, with the support of numerous local groups/organisations, another 16 sites across southern Australia were established (see Figure 5, page 13) to test a smaller range of species.

FIGURE 4. Shrub species selection process

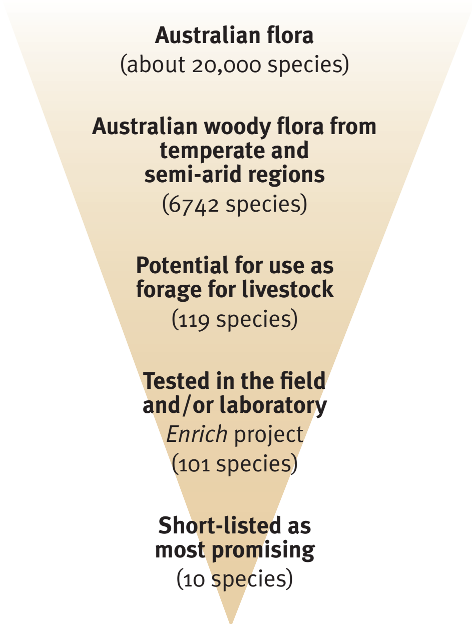
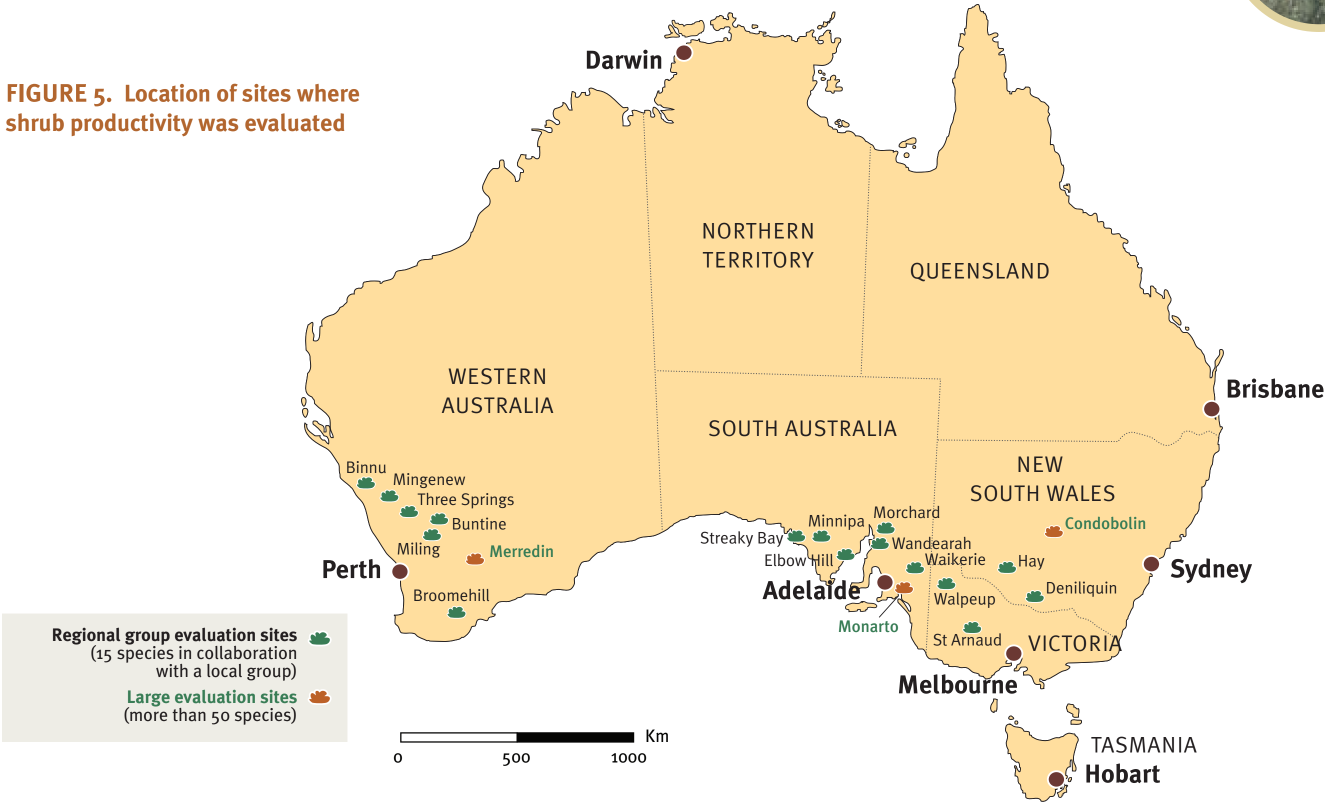


FIGURE 5. Location of sites where shrub productivity was evaluated



Shrub species have the potential to provide a range of benefits, so the measurements taken during the project reflect this. Data was routinely collected on the following plant attributes:

- Edible biomass
- Plant growth over time
- Growth form and height
- Regrowth after grazing
- Animal preferences (palatability)
- Nutritive value (protein, fibre, minerals)
- Effects on rumen fermentation (gas production to indicate digestibility)
- Bioactivity (pattern of rumen fermentation end products including methane, ammonia, volatile fatty acid composition)
- Bioactivity (anthelmintic properties).

While many of the 101 species had at least one desirable attribute, the list has been narrowed down to a subset of those with the most potential. Species were short-listed using a method that allowed species to take various pathways to prioritisation, so any one species did not need to possess every desirable trait (which would be an unrealistic expectation). However, a species must have certain critical attributes. These are: being long lived, moderately palatable and grazing tolerant, and having a low or negligible weed risk. Once again, the project was not set up to find one superior plant, but a mixture of plants that could all contribute to the overall success of a grazing system.

As a further guide to which species are more suited to particular conditions, a simple decision tool was developed using questions primarily based on soil characteristics (see Figure 6, page 15). Where other (not prioritised) species are already present or landholders want to plant other species, this is supported, and information on the original full list of species can be found in the booklet, *Perennial forage shrubs providing profitable and sustainable grazing: Key findings from the* Enrich *project*.

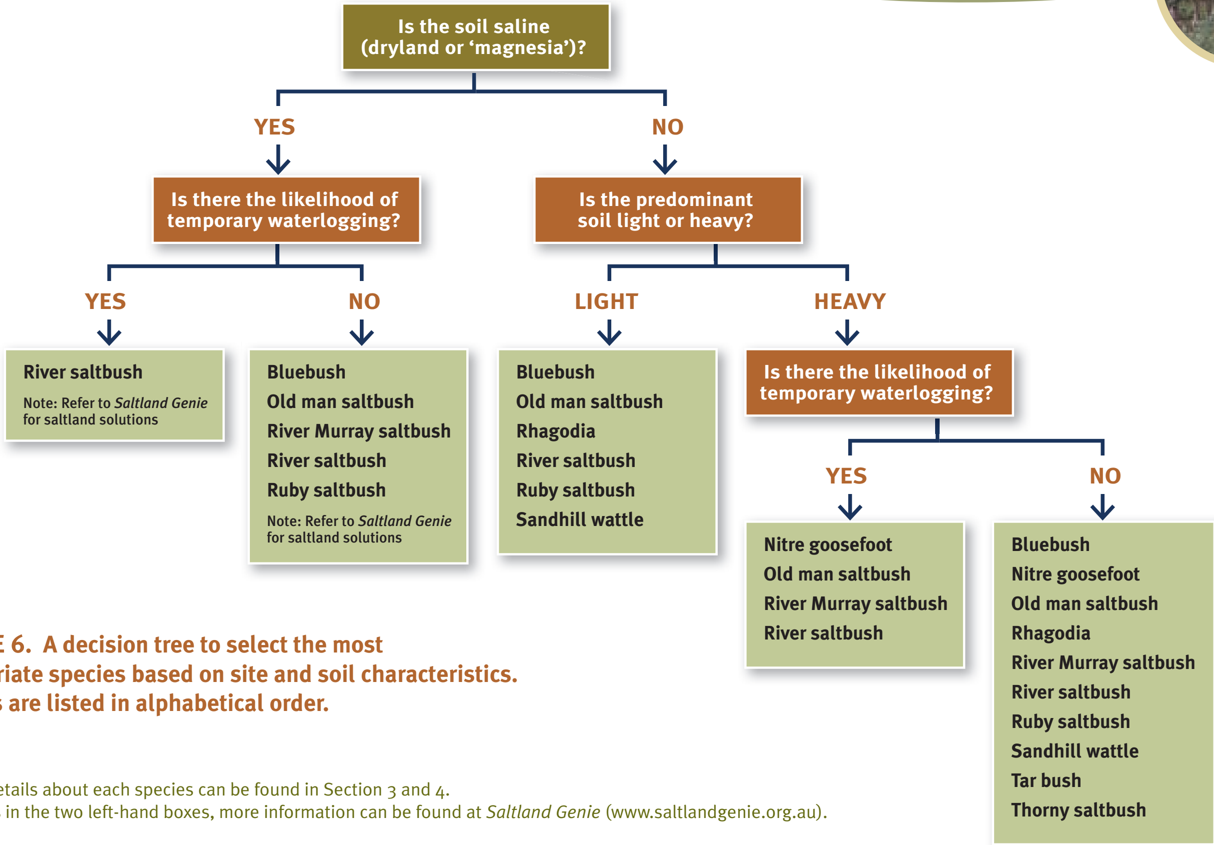


FIGURE 6. A decision tree to select the most appropriate species based on site and soil characteristics. Species are listed in alphabetical order.

Further details about each species can be found in Section 3 and 4.
For plants in the two left-hand boxes, more information can be found at *Saltland Genie* (www.saltlandgenie.org.au).

3. Plant species profiles

Bluebush, small leaved bluebush, yanga bush (*Maireana brevifolia*)

Plant description: Small perennial shrub, which grows to about 1 m in height and erect in habit. It commonly grows naturally in areas not cultivated and will readily colonise bare ground.

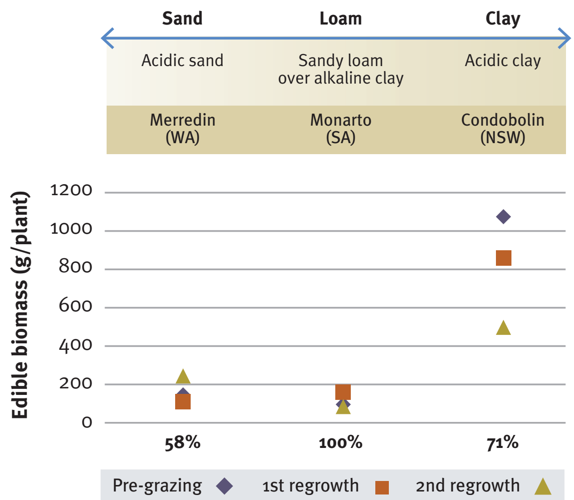
Soil preference: Small leaved bluebush grows on a wide variety of soil types. It is moderately salt-tolerant but has poor waterlogging tolerance.

LEFT: Unripe fruit

TOP RIGHT: Shrub form

BOTTOM RIGHT: Leaf form

FIGURE 7. Production of edible biomass (g/plant) of bluebush at different sites. Survival (%) after three years is shown for each site at the bottom of the figure



General characteristics: Small leaved bluebush seed loses its viability rapidly under moderate–high humidity. If possible only use fresh seed. Small leaved bluebush can produce large quantities of seed and new seedlings are common. Regeneration of stands can be achieved by allowing plants to produce seed and protecting seedlings from grazing. Volunteer seedlings of small leaved bluebush are regularly seen and spread from existing plantations is commonly observed. It is a regular coloniser of bare and disturbed ground. It is possible to allow the spread of small leaved bluebush into adjacent areas and thus increase the area to this species with low establishment costs.

Small leaved bluebush has become a cropping weed in some areas of the Northern Agricultural Region (NAR) of Western Australia.

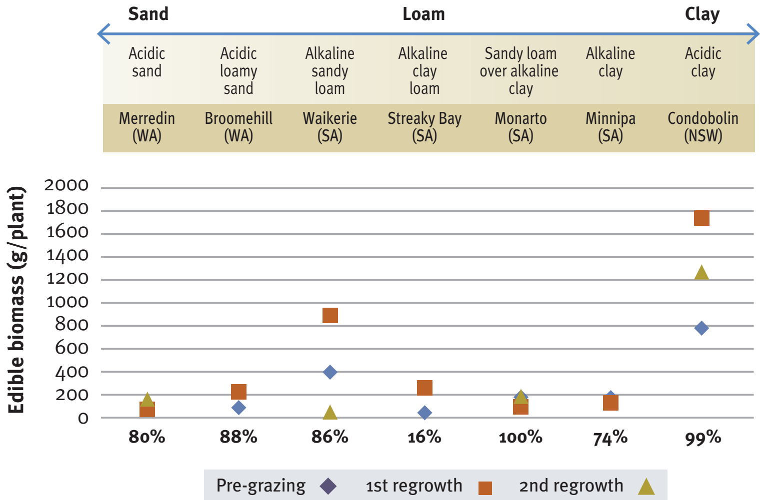
Nitre goosefoot (*Chenopodium nitrariaceum*)

Plant description: A tall upright straggly-looking shrub growing to 2 m in height. After flowering, the flower stalks become hard and dry and resemble blunt spines. The seeds are small and black.

Soil preference: Nitre goosefoot frequently grows in habitats periodically inundated such as black box communities along the River Murray. These soils tend to be heavy, such as clays to clay loams. Experimental work has shown nitre goosefoot's preference for these heavier soils and tolerance to temporary waterlogging.

LEFT: Leaf form
TOP RIGHT: Shrub form, flowering
BOTTOM RIGHT: Fruit

FIGURE 8. Production of edible biomass (g/plant) of nitre goosefoot at different sites. Survival (%) after three years is shown for each site at the bottom of the figure



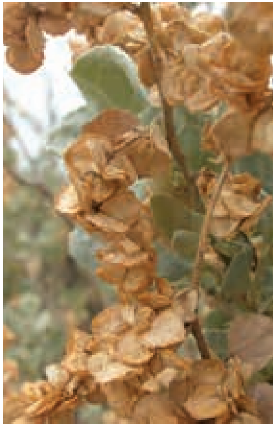
General characteristics: Although growing naturally in inundated areas, nitre goosefoot has good drought tolerance, but will shed leaves in severe dry times. Nitre goosefoot is highly palatable and livestock will graze stems up to 6 mm in diameter. Regular grazing is essential to keep nitre goosefoot short in stature and leafy. It tolerates grazing and recovers well. There is variation within nitre goosefoot with some provenances being leafier and less 'spiny'.

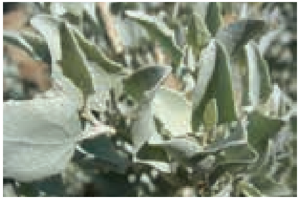
Nitre goosefoot is readily grazed and has relatively high digestibility

Old man saltbush (*Atriplex nummularia*)

Plant description: Large woody shrub that can grow to 3 m in height and diameter but occasionally more. Generally it has an erect growth form but some types such as the Eyres green cultivar have a sprawling habit. Old man saltbush can have male, female or bisexual plants. Plantations derived from cuttings therefore may only contain plants of one sex. Seed collected from female plants may have cross pollinated with males from over a kilometre in distance and the complex genetic structure of the species means that plants from seeds may not be similar to the parents. Seed production can be highly variable and many saltbush fruit contain no seed.

Soil preference: Old man saltbush occurs naturally on heavier soils but will grow on a range of soil types. It tolerates saline soils but does not tolerate waterlogging for extended periods of time.





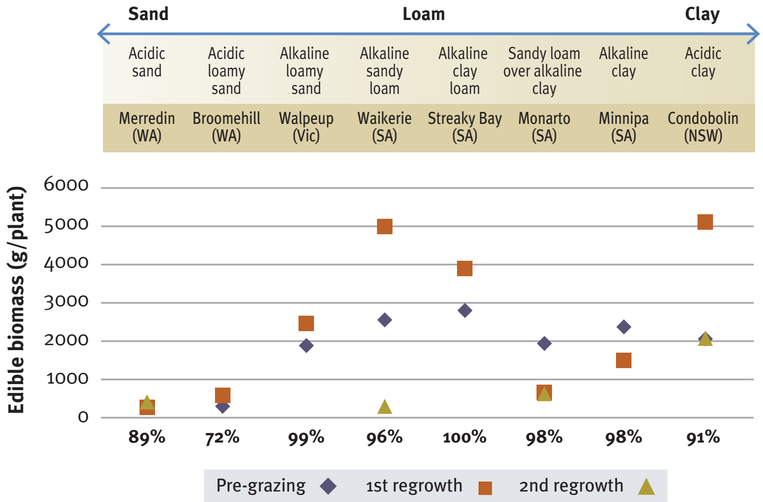
TOP: Shrub form

LEFT: Ripe fruit

MIDDLE RIGHT: Eyres green leaf form

BOTTOM RIGHT: Male flowers

FIGURE 9. Production of edible biomass (g/plant) of the cultivar Eyres green at different sites. Survival (%) after three years is shown for each site at the bottom of the figure



General characteristics: Old man saltbush is one of the most common forage shrubs used in southern Australia. It provides a useful forage resource on both saline and non-saline soils. Its drought tolerance has allowed it to be grown in areas of particularly low rainfall. It occurs naturally in many parts of the pastoral region and in some cases has been successfully established in these regions. Old man saltbush is relatively frost tolerant but some leaf damage can occur. Red-legged earth mite and lucerne flea can cause significant damage to young seedlings. There has also been a number of caterpillar species recorded that feed on the leaves of old man saltbush. Other insect pests associated with old man saltbush include scale, leafhoppers and borers. Plants generally recover from these pests and economic losses from these pests have been rare.

If vigorous early growth has occurred, plants can be grazed lightly when they are about six months to a year old. Older plants of old man saltbush can be grazed until only a fraction (10%) of the original leaf remains. Plants should be grazed to this level within six weeks and then allow them to recover for at least six months. Old man saltbush should not be set stocked as continual grazing will kill the plants. If plants are not grazed adequately they can become too tall and out of reach of stock. They can also become too woody, which causes a decline in the amount of leaf available to stock. To prevent this, it is essential to graze old man saltbush annually, even when other feed is adequate (see Section 7). Plants can be slashed back to 25 cm in height if they have become too woody. Some producers regenerate stands by flattening old plants and allowing them to regenerate from the base. The salt content of old man saltbush can be high although there is no clear relationship between salinity of the soil and salt in the leaves. This will limit feed intake and increase the consumption of water.

Improved old man saltbush

The Future Farm Industries Cooperative Research Centre has funded a project to examine variation in nutritional value, relative palatability and growth of old man saltbush collected across Australia. There is a considerable amount of diversity in all of these traits. The team has identified plants with higher digestibility and crude protein that are generally preferred by sheep. These plants are nearing commercialisation and should be released to industry during 2014/15.

Case study. John Arentz, Manangatang, Victoria

When John bought his current property, near Manangatang in the north-west Victorian Mallee during 2004, poor returns from cropping marginal soils in a dry climate caused him to search for a resilient permanent forage option.

Initial discussions with local Landcare coordinators led John to investigate the potential of old man saltbush. Initially, he planted seedlings four metres apart both within and between rows. Over time John moved to six-metre spacings within the rows and 10 m between the rows. He says that if he started again he would even go for wider spacings as it allows greater opportunity for volunteer species between rows and even facilitates cropping — only when seasons look promising. While saltbush provides an important source of feed, sheep cannot survive on saltbush alone, so an alternative feed source between the rows is important to reduce the need for supplementary feeding.

John's earliest saltbush paddocks were about 20 ha, but later paddocks have been reduced by about half. This allows sheep to graze the paddocks more evenly.

Photo courtesy John Arentz

Leaving plenty of space between saltbush shrubs allows volunteer grasses to establish, providing a more balanced diet for sheep

The saltbush provides a feed option for ewes during spring and summer. Having all the ewes removed from the cropping paddocks during spring and summer leads to much more ground cover in these paddocks and no soil erosion.

For John, the saltbush has numerous benefits — it provides a profitable option on country that will not consistently support cropping and a valuable forage source that fills seasonal feed gaps. According to John, saltbush also gives him the flexibility to take advantage of seasons and markets as they arrive.

To view the full story go to www.futurefarmonline.com.au

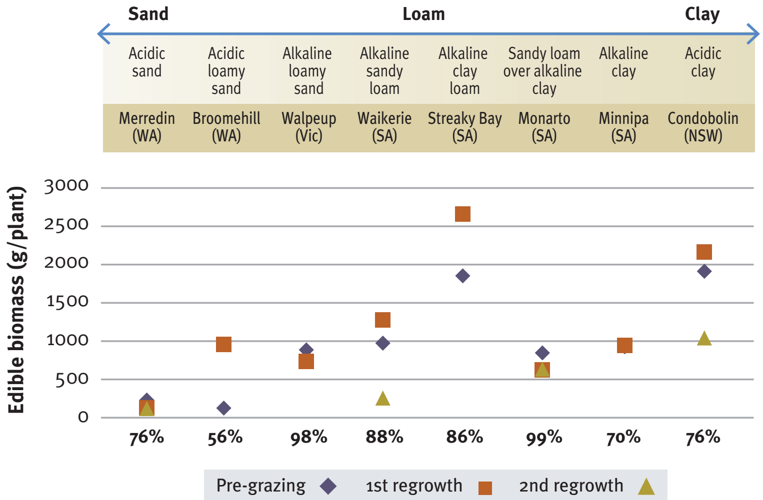
Rhagodia, Mallee saltbush (*Rhagodia preissii*)

Plant description: A compact green shrub, which can grow to 1.5 m in height and more than 2 m across. It is native to southern Western Australia and the livestock cropping zone of much of south-western South Australia. Rhagodia has bright red berry fruits.

Soil preference: Rhagodia grows naturally on a range of soils, such as sands, loams, calcareous and massive earths and yellow duplex soils. Experimentally, it has also grown well over a range of soil types. It does not appear to have significant salinity or waterlogging tolerance.

LEFT: Flowers and leaf form
TOP RIGHT: Shrub form
BOTTOM RIGHT: Fruit

FIGURE 10. Production of edible biomass (g/plant) of rhagodia at different sites. Survival (%) after three years is shown for each site at the bottom of the figure



General characteristics: Rhagodia has proven to be fairly easy to establish by tubestock and direct seeding experiments have been successful. It can be attacked by a number of pests, such as scale, but will recover. From many studies, rhagodia appears to be relatively low in palatability. However, there are some instances where it has been highly preferred and variation between individual plants has been commonly seen. While some samples of rhagodia have inhibited intestinal parasite development in the laboratory, there has been wide variation in the level of inhibition. There also appears to be variation in this trait between individual plants and also between seasons.

River Murray saltbush, silver saltbush (*Atriplex rhagodioides*)

Plant description: A large grey shrub resembling old man saltbush. It can grow to 2 m in height and spread to 2.5–3 m. Fruits are produced on female or bisexual plants and are smaller in size than those found on old man saltbush.

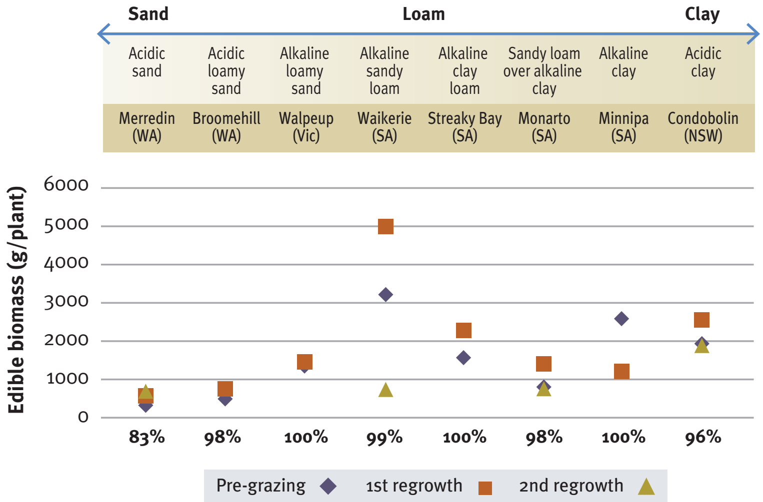
Soil preference: Naturally, it grows on the heavy river flats of the River Murray. Experimental work has shown it will grow on a much wider range of environments and it is particularly productive on sites that are naturally saline, commonly referred to as 'magnesia soils'.

LEFT: Fruit

TOP RIGHT: Shrub form

BOTTOM RIGHT: Male flower

FIGURE 11. Production of edible biomass (g/plant) of River Murray saltbush at different sites. Survival (%) after three years is shown for each site at the bottom of the figure



General characteristics: River Murray saltbush has vigorous winter regrowth following autumn grazing. To maximise productivity, plant River Murray saltbush at a lower density (500–1000 plants/ha) and reduce competition between plants. Do not allow it to grow too tall if stocked with only sheep.

While similar in appearance to old man saltbush, River Murray saltbush has different plant chemistry and forage attributes

River saltbush (*Atriplex amnicola*)

Plant description: Varies from a prostrate to erect medium woody shrub. Grows to about 1.5 m in height but often spreads for two or more metres. There are separate male and female plants with seed being produced on female plants.

Soil preference: Naturally, river saltbush grows in creek beds and salt lake margins. It has the potential to be grown on saline soils where some periodic inundation occurs. Experimental work has shown it is productive on sands, loams and clays.

LEFT: Male flower
TOP RIGHT: Shrub form
BOTTOM RIGHT: Plant fruit
BOTTOM FAR RIGHT: Leaf form

FIGURE 12. Production of edible biomass (g/plant) of river saltbush at different sites. Survival (%) after three years is shown for each site at the bottom of the figure

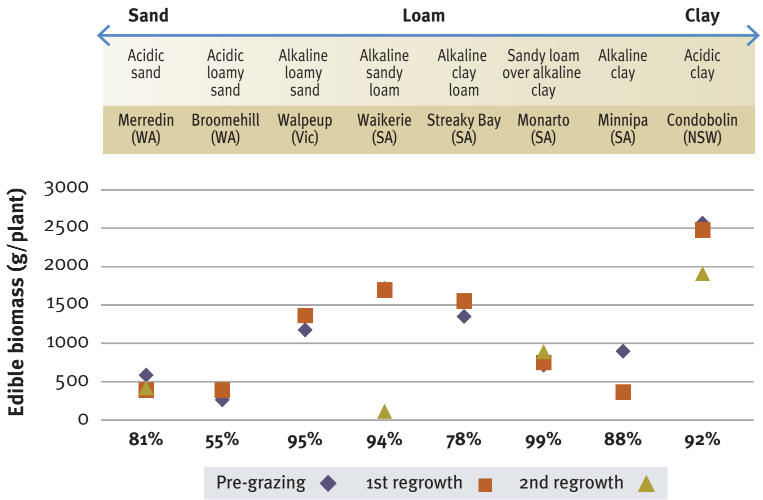
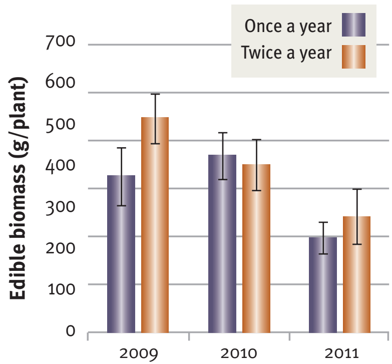


FIGURE 13. Annual edible biomass production of river saltbush when grazed once a year (autumn) or twice a year (autumn and spring)



General characteristics: Viability of river saltbush seed is generally low. Direct seeding has had low success in the past and using established seedlings is the more reliable option. River saltbush has a low leaf to stem ratio so regular grazing is vital to ensure the plants do not become too woody. River saltbush has an excellent ability to recover from grazing when allowed a rest period (see Figure 13). However, avoid set stocking, as continual grazing will kill the plants. It is generally the most palatable of the *Atriplex* species and so can be useful in getting livestock accustomed to grazing saltbush species.

Ruby saltbush (*Enchylaena tomentosa*)

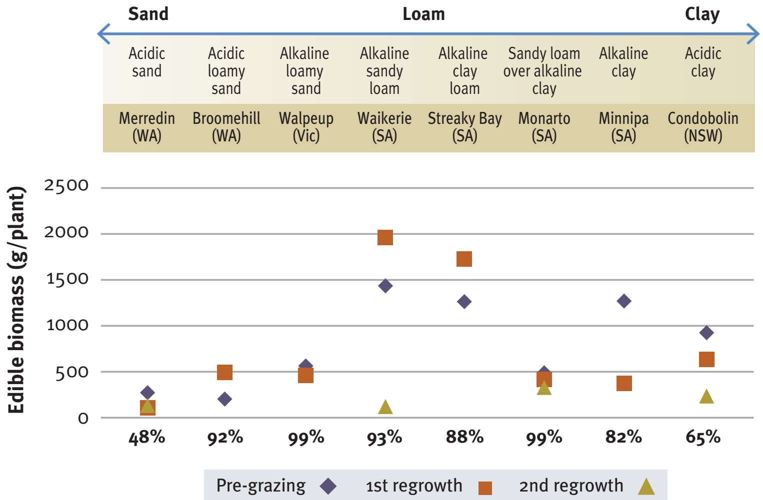
Plant description: Ruby saltbush is a common native plant, occurring through most of southern and central Australia, often under trees. Ruby saltbush is a low-growing shrub, which occasionally attains a height of 1 m but it will also grow up through taller neighbouring plants. However, plants are often less than half this size and some forms are prostrate. It produces a large amount of small berries, which can be red, yellow, orange or even pink in colour.

Soil preference: Ruby saltbush can be found across a wide range of soils from coastal, partially-stabilised, dune sands near the Southern Ocean in South Australia, to riverine clay loams, in saline depressions, and to the deep siliceous, sandy soils in many semi-arid regions of Australia.

TOP RIGHT: Shrub form

BOTTOM RIGHT: Fruit and leaf form

FIGURE 14. Production of edible biomass (g/plant) of ruby saltbush at different sites. Survival (%) after three years is shown for each site at the bottom of the figure



General characteristics: Ruby saltbush commonly recruits many plants naturally. This makes direct seeding of ruby saltbush a potential option and good results have been obtained in revegetation programs. The viability of ruby saltbush seed is usually better than other saltbushes but it is beneficial to test the seed viability before seeding. Ruby saltbush can also be established using seedlings. It is able to withstand periods of frost.

Sandhill wattle (*Acacia ligulata*)

Plant description: A rounded, largish shrub growing to 4 m high and 2.5 m wide with dense foliage and a branching habit. Flowers are bright yellow and the resultant pods split when ripe, but stay attached to the plant. It is native to much of southern and central Australia.

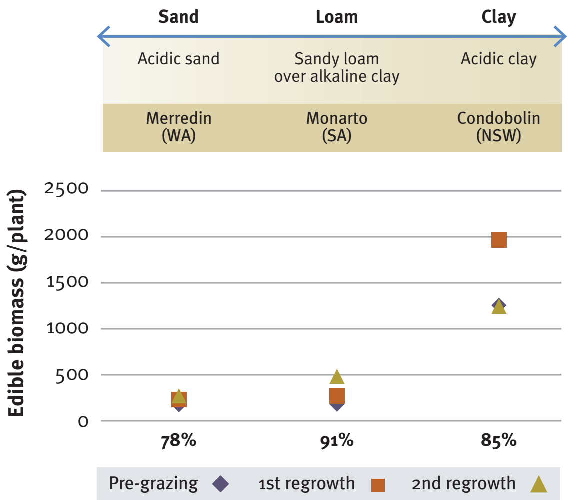
Soil preference: Sandhill wattle grows naturally on a wide range of soils and landscapes but as its name suggests, it does grow on deep sands. Experimental work has shown it to grow in a range of environments and it is particularly productive on heavier soil types, such sandy loam over clay and clay loams.

LEFT: Flower

TOP RIGHT: Shrub form

BOTTOM RIGHT: Flower bud and leaf form

FIGURE 15. Production of edible biomass (g/plant) of sandhill wattle at different sites. Survival (%) after three years is shown for each site at the bottom of the figure



General characteristics: Like most wattle species, sandhill wattle is easy to germinate and grow but the seed requires a heat treatment, such as boiling water, to break dormancy and stimulate germination. Sandhill wattle has a relatively fast growth rate and due to its growth habit is ideal as a low windbreak.

Wattles (*Acacia* species)

Wattles are among the most common native plant species across southern Australia and there are probably a number of species local to your area. Research from the *Enrich* project has found most wattle species are utilised to some extent by livestock and have similar forage attributes. However, they do differ in their height and longevity.

Some wattle species have been shown to be invasive weeds in parts of Australia where they are not native and in overseas countries such as South Africa. Caution should be taken when deciding to plant wattles. A prudent option would be to plant species and provenances native to your area. This approach also has the advantage of using locally-adapted species.

Tar bush (*Eremophila glabra*)

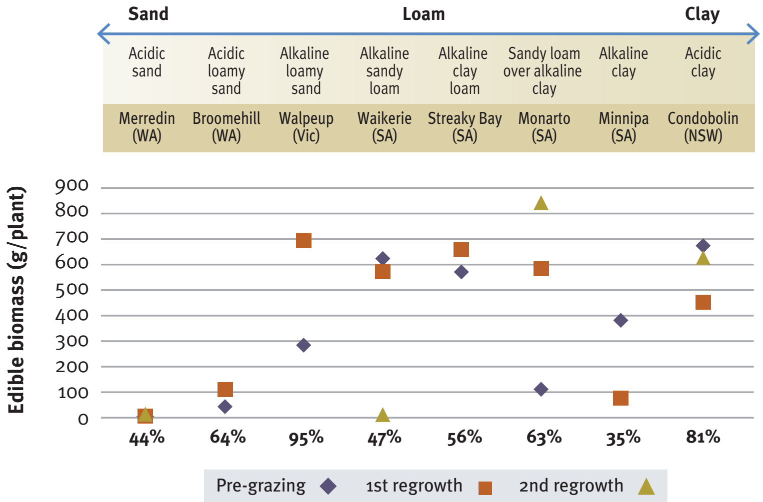
Plant description: Tar bush is highly variable in morphology ranging from a low ground cover to a more erect shrub up to 2 m high. On some types, the foliage is sticky to touch, hence its common name. Tar bush is native to most of Australia south of the tropic of Capricorn but it does not does occur in Tasmania and south-eastern Victoria. Tar bush is found in a variety of habitats including Acacia and Eucalyptus woodlands and chenopod shrublands, Mallee, low heathlands, dunes, rocky hill slopes, Mulga wash country, depressions and riverside flats.

Soil preference: Tar bush grows in a variety of soils including red–brown clay loams, cracking clays, red–brown sandy loams, red earths, solonized brown soils, skeletal stony soils, sands and calcareous sandy loams. It also tolerates slightly saline soils. Tar bush appears to tolerate highly calcareous, high boron and high sodicity soils. It grows on very shallow soils and has low fertility requirements.

TOP RIGHT: Shrub form, flowering

BOTTOM RIGHT: Leaf and flowering form

FIGURE 16. Production of edible biomass (g/plant) of tar bush at different sites. Survival (%) after three years is shown for each site at the bottom of the figure



General characteristics: Tar bush has become an exciting species under research conditions. It has been shown to influence the conditions and fermentation profiles in the rumen, such as producing less methane (waste) when digested compared with other forages. It has also been able to mitigate the condition of acidosis in the rumen (the dropping of pH usually associated with feeding of some grains). Being a highly variable species, tar bush shows wide genetic variation in productivity and other attributes. It has good grazing tolerance and resilience once established. However, tar bush can be difficult to establish and young seedlings are sensitive to frost and weed competition. The only reliable method of propagation is by cuttings, so planting tubestock is the only current method of establishment.

Thorny saltbush (*Rhagodia spinescens*)

Plant description: A medium-sized compact shrub growing to around 1 m in height. It has dense foliage and is intricately branched. Although called thorny saltbush, it does not contain thorns or spines. Dark red-orange berry-like fruits are borne on the end of stems.

Soil preference: It grows naturally on a variety of soil types ranging from sands to clays, in numerous habitats including dunes and depressions.

LEFT: Leaf form

TOP RIGHT: Shrub form

BOTTOM RIGHT: Flower

BOTTOM FAR RIGHT: Fruit

FIGURE 17. Production of edible biomass (g/plant) of thorny saltbush at different sites. Survival (%) after three years is shown for each site at the bottom of the figure

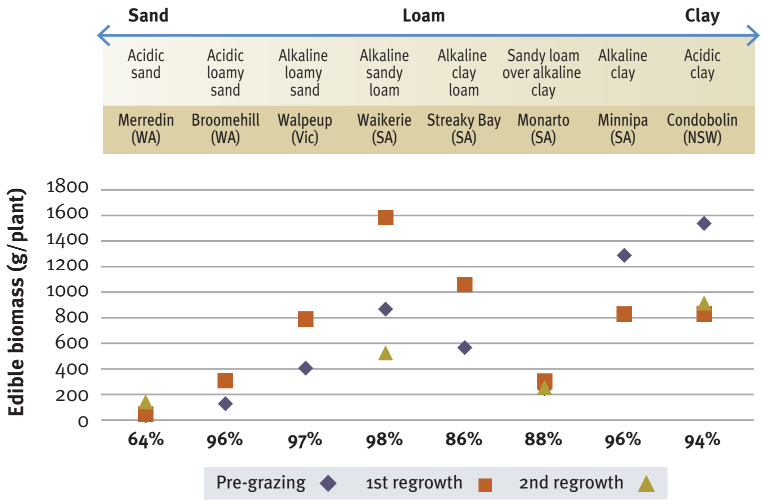
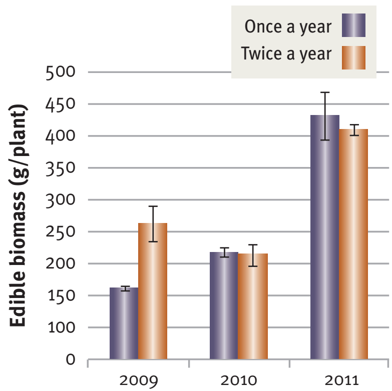


FIGURE 18. Annual edible biomass production of thorny saltbush when grazed once a year (autumn) or twice a year (autumn and spring)



General characteristics: Thorny saltbush varies greatly in morphology and growth habit. Some provenances investigated in the *Enrich* project displayed greater leafiness and were shorter in stature creating greater biomass accessible to grazing livestock. In very dry times it will shed leaves, but is drought tolerant. Thorny saltbush responds well to regular grazing (see Figure 18).

TABLE 1. Summary of the shrub species growth attributes

Common name	Scientific name	Salt tolerance	Waterlogging tolerance	Preferred soil	Maximum height (m)	Maximum diameter (m)	Seedling frost tolerance
Bluebush, yanga bush	*Maireana brevifolia*	Moderate	Low	All	1.0	1.0	High
Nitre goosefoot	*Chenopodium nitrariaceum*	Low	High	Medium–very heavy	2.0	1.5	High
Old man saltbush	*Atriplex nummularia*	High–moderate	Moderate	Medium–heavy	2.5	2.5	High
Rhagodia	*Rhagodia preissii*	Low	Low	Light–medium	1.5	1.5	Moderate
River Murray saltbush	*Atriplex rhagodioides*	High–moderate	Moderate	Medium–very heavy	2.0	2.5	High
River saltbush	*Atriplex amnicola*	High–moderate	High	Medium–heavy	1.5	2.0	Moderate
Ruby saltbush	*Enchylaena tomentosa*	Moderate	Low	All	1.0	1.0	High
Sandhill wattle	*Acacia ligulata*	Low	Low	Light–medium	4.0	2.5	Moderate
Tar bush	*Eremophila glabra*	Low	Low	Medium–heavy	2.0	1.0	Low
Thorny saltbush	*Rhagodia spinescens*	Low	Low	Medium–heavy	1.0	1.5	High

Case study. Scott Williams, Cowell, SA

Continuing dry years and increasing problems with non-productive areas of land, commonly called 'magnesia' patches, encouraged Cowell farmer Scott Williams to look at the potential of forage shrubs to help reduce erosion and improve soil cover and productivity. Magnesia patches 'salt up', particularly in dry conditions and just become scalded bare ground where nothing will grow. Scott became interested in forage shrubs to provide a feed reserve for when times are tough, such as providing a feed supply during the autumn feed gap after stubbles have been grazed and before winter growth gets going. In collaboration with *Enrich*, an initial forage shrub species evaluation site was planted on Scott's farm and the results encouraged an expansion of the project site. Another 5 ha was planted with some of the best-performing shrubs. Four 'star performers' from the first trial have been selected, based on survival rates, growth and nutritive value. These include old man saltbush, ruby saltbush, River Murray saltbush and sea-berry saltbush. The areas under trial included some of the problem magnesia patches. Scott has been encouraged by the growth of the perennial shrubs and the ground cover now in the trial site.

Photos courtesy T. Zwar and N. Ackland, EPNRM

Scott Williams (above left) with Neil Ackland looking at how forage shrubs have provided a useful feed supply on previously unproductive and erodible land

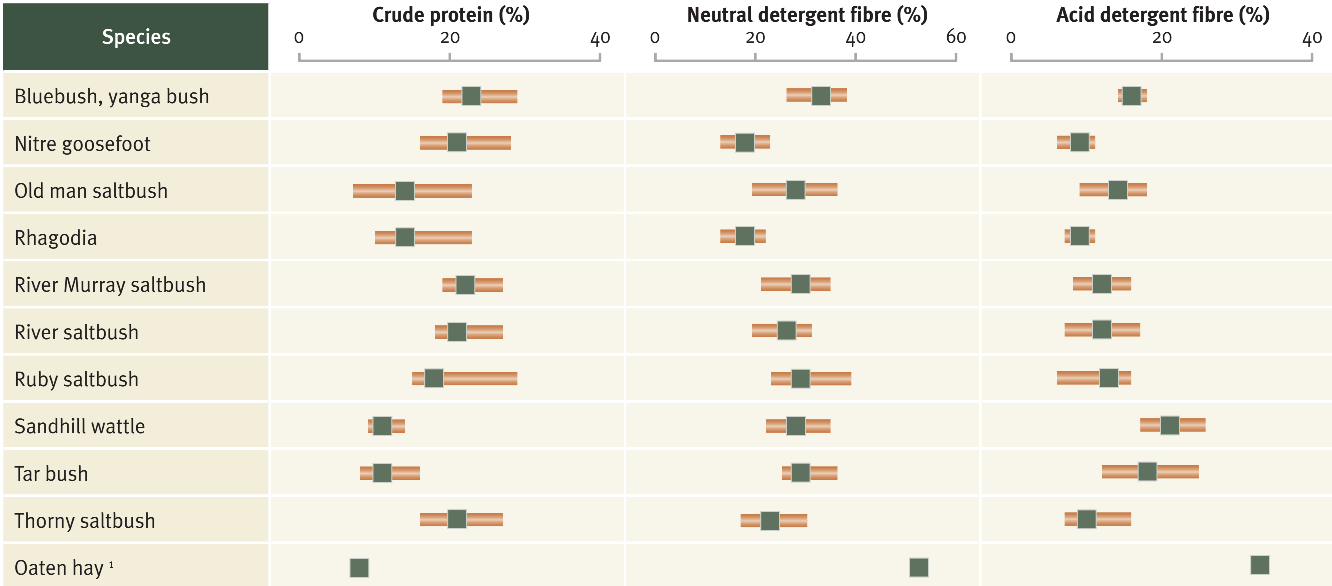
To view the full story go to www.futurefarmonline.com.au

4. Forage quality of shrub species

Nutritive value is a function of digestibility, protein, minerals, vitamins and secondary compounds, and the efficiency with which they are utilised by livestock. Some common indicators of nutritive value are neutral detergent fibre (NDF), acid detergent fibre (ADF), hemicellulose (often considered as 'digestible fibre', which is the difference between NDF and ADF), crude protein, and mineral content (see Figure 19 page 41).

There is real potential for shrubs, in combination with a well-managed pasture, to meet the crude protein and mineral requirements of grazing animals

FIGURE 19. Crude protein, neutral detergent fibre (NDF) and acid detergent fibre (ADF) values for the selected shrub species



1. Oaten hay quality varies widely but values shown are for a ‘typical’ medium-quality oaten hay and are provided as a general comparison

Average value　Range in actual values

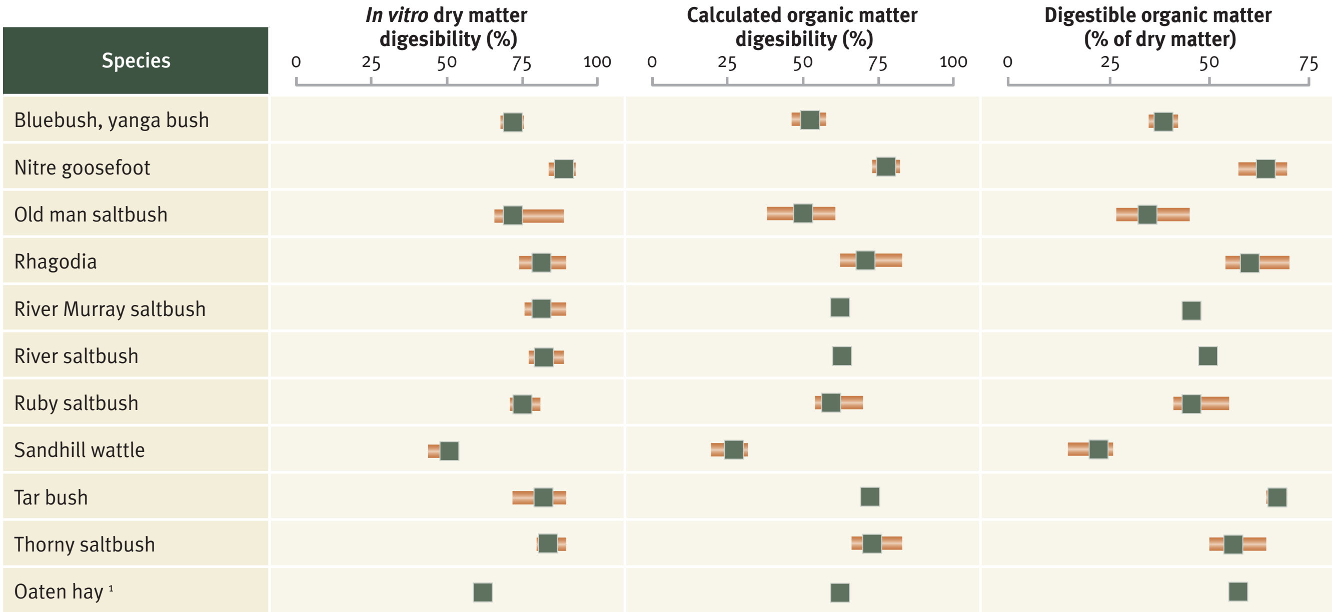
***In vitro* dry matter digestibility** is a laboratory-based (i.e *in vitro*) estimate of the digestibility of plant material. It is based on the *in vitro* digestion by two gut enzymes; pepsin and cellulase (which break down protein and carbohydrates such as cellulose, respectively). From other studies, it is expected this value of *in vitro* dry matter digestibility will actually be overestimating the amount of digestible material in animals, largely because the laboratory procedures were established with more conventional forages such as the more typical pastures or hays.

A more conservative estimate of the contribution each plant species could make to the available energy supplied to an animal is the value termed **'calculated organic matter digestibility'**. This is calculated from the dry matter digestibility, but also takes into account the organic matter fraction (i.e. the non-salt, or non-mineral, component) of the dry matter, and adjusts for the apparent overestimation when the standard laboratory methods are used with shrubs[4]. The components of feeds that can provide energy to animals are all in the organic matter fraction (minerals do not yield energy directly, although they may be required in energetic pathways in cell metabolism), so considering the digestibility of the organic matter is indicative of the digestible energy content of a feedstuff.

So, if a particular plant has an organic matter content of 80% – which is the average for all the shrub species tested in *Enrich* (the other 20% being minerals) – and the organic matter digestibility is 65%, then every kilogram of dry matter only provides 0.52 kg of digestible organic matter (i.e. 1 kg x 0.8 x 0.65). This value is termed the **'digestible organic matter in the dry matter (DOMD)'**.

4. Norman HC, Revell DK, Mayberry DE, Rintoul AJ, Wilmot MG, Masters DG (2010) Comparison of *in vivo* organic matter digestion of native Australian shrubs by sheep to *in vitro* and *in sacco* predictions. *Small Ruminant Research* **91**, 69-80.

FIGURE 20. Digestibility values for the selected shrub species



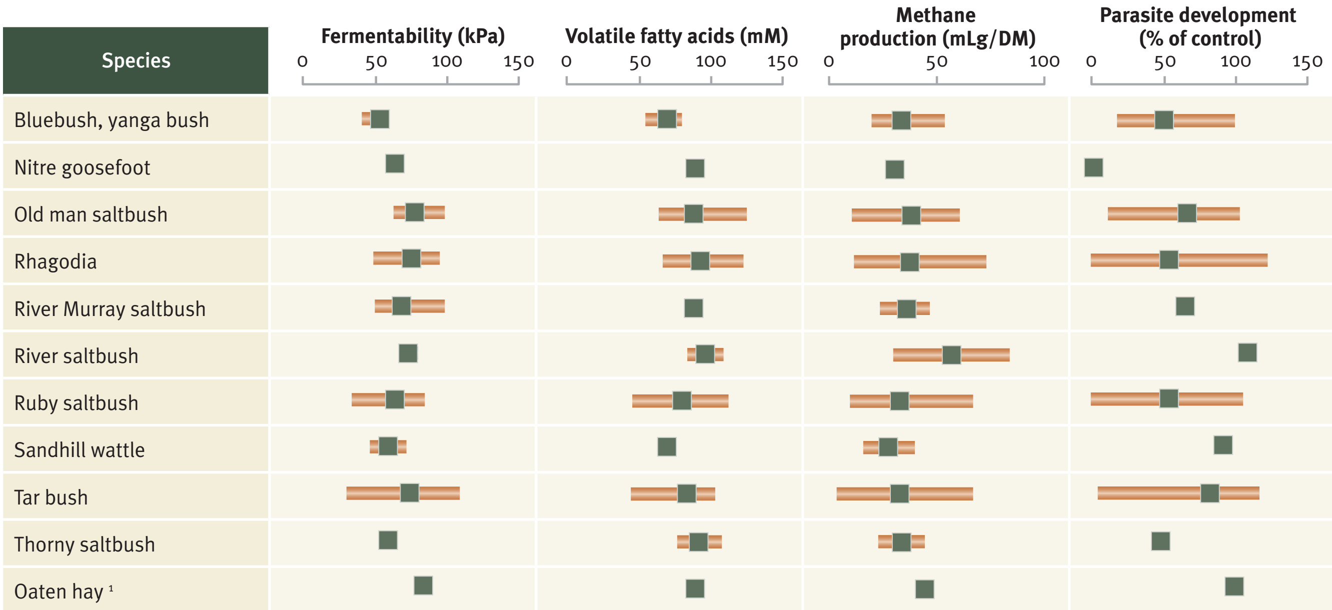
1. Oaten hay quality varies widely but values shown are for a 'typical' medium-quality oaten hay and are provided as a general comparison

All of the estimates of digestible fractions described above are estimates from laboratory analyses, using the best available information, but they are estimates nonetheless. Therefore the plant material has also been tested for **'fermentability'**, which involved the anaerobic fermentation of a sample of plant material in the presence of microbes sourced from the rumen of sheep. Total fermentability is measured by the amount of gas produced during 24 hours of fermentation, and expressed as a gas pressure (kPa): the higher the value, the more fermentable the plant material by rumen microbes. Some of the end products of fermentation were also measured, including **volatile fatty acids** and **methane**. **Volatile fatty acids** are the main sources of energy available to ruminant livestock from the fermentation of plant material, so in general a high value is desirable. However, lower **methane** production is a desirable trait because methane is a loss of energy from the animal and is a greenhouse gas.

A shrub species' anthelmintic potential was assessed under laboratory conditions where free-living parasite larvae were exposed to extracts of the shrub foliage. Only a small amount of research has been done in this area and results should be viewed accordingly. The data in Figure 21 page 44 show the **parasite development** expressed as a percentage of a control; therefore, the lower the value, the greater the toxicity to parasites.

Many shrubs also have desirable traits beyond the provision of nutrients or energy, a characteristic often called 'bioactivity'

FIGURE 21. Rumen fermentation parameters and anthelmintic potential for the selected shrub species



1. Oaten hay quality varies widely but values shown are for a 'typical' medium-quality oaten hay and are provided as a general comparison

Average value ■ Range in actual values ▬

Shrub species can bring different nutritional attributes to the diet than annual grasses and legumes. This reiterates the complementarities between shrubs and the companion pasture.

Generally, the shrub species researched contain relatively high levels of most minerals (see Figures 22 and 23, pages 47 and 48). This may be because their large rooting habit gives them access to a wide range of nutrients. This gives shrub species the potential to act as living 'mineral supplements' for livestock. In some cases, a shrub species' level of mineral exceeds an animal's requirement. However, the bio-availability of the minerals in these shrubs — that is how much of the minerals in the edible biomass are actually available to the animal grazing them – is not yet known. In addition, toxicity issues are only likely to be a problem when one species makes up a large proportion of the diet. In a mixed shrub system, this is unlikely to occur as there is a range of different plants available. It does appear that the companion pasture can also benefit from the shrubs' acquisition of nutrients from deep in the soil. In some instances it has been found that the pasture growing among shrubs is higher in certain minerals, such as phosphorus. This also has the potential to impact the quality of the overall diet of livestock.

FIGURE 22. The calcium, magnesium and copper content contained in the forage of the selected shrub species

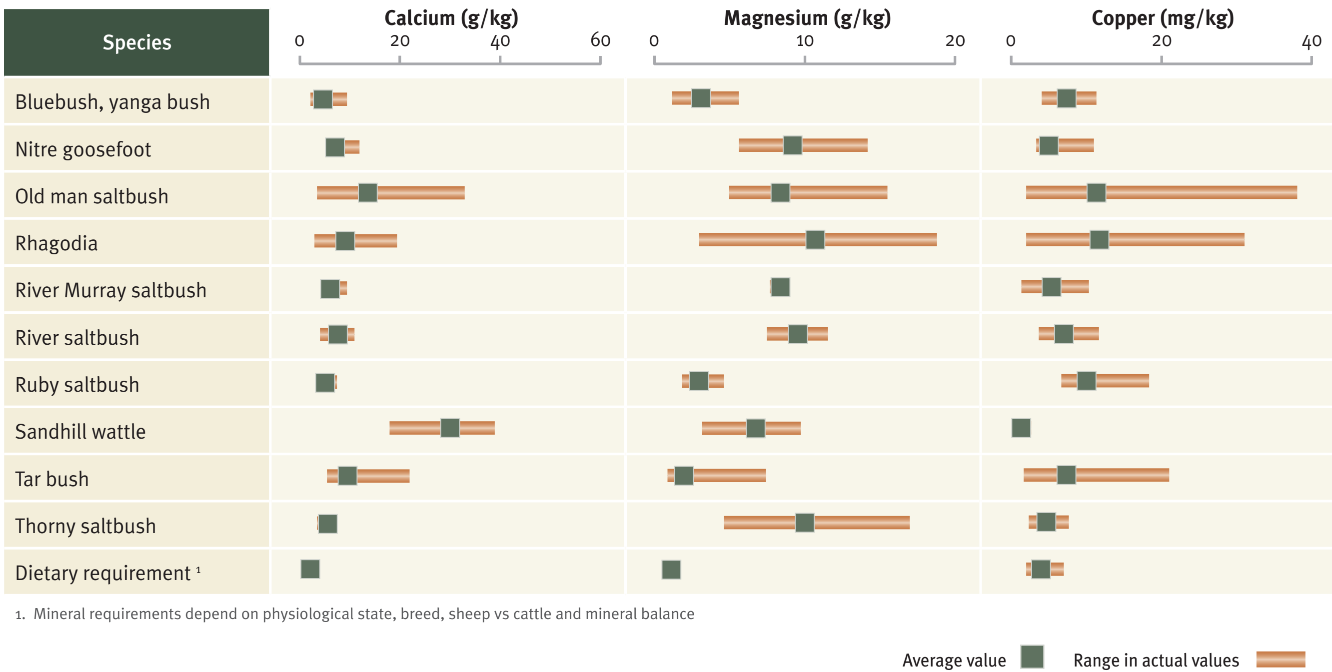
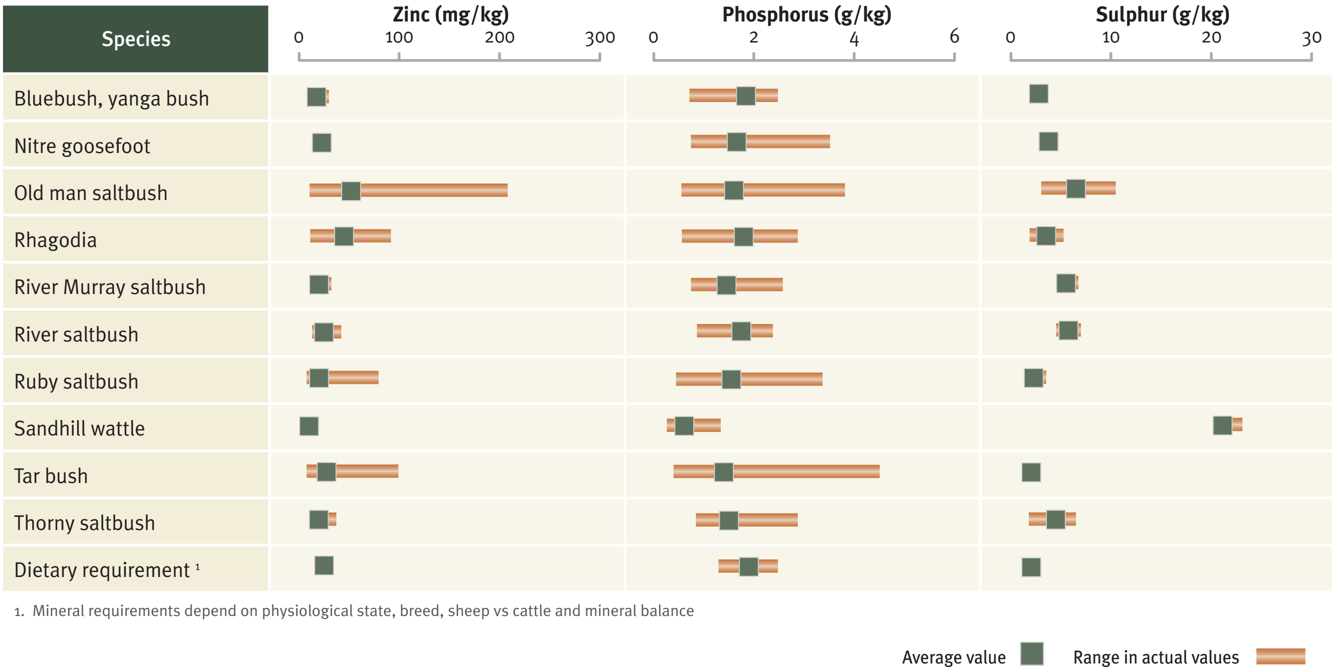


FIGURE 23. The zinc, phosphorus and sulphur content contained in the forage of the selected shrub species



1. Mineral requirements depend on physiological state, breed, sheep vs cattle and mineral balance

TABLE 2. Distinguishing attributes of the shrub species — a list of both the growth and forage quality key traits of each species

	Common name (scientific name)	
	**Bluebush** (*Maireana brevifolia*)	
	• High in crude protein • Grows on a wide range of soil types	• Volunteers freely • Moderate salt tolerance
	**Nitre goosefoot** (*Chenopodium nitrariaceum*)	
	• High digestibility • High palatability	• Good waterlogging tolerance • Suited to heavy soils
	**Old man saltbush** (*Atriplex nummularia*)	
	• Strong seedling resilience • Good salt tolerance	• Good drought tolerance • High productivity
	**Rhagodia** (*Rhagodia preissii*)	
	• High digestibility • Strong seedling resilience	• Good productivity • Compact growth habit
	**River Murray saltbush** (*Atriplex rhagodioides*)	
	• Good growth on ‘magnesia’ soils • Superior winter regrowth	• High in crude protein • Suited to heavy soils (loams and clays)

Continued page 50

TABLE 2. Distinguishing attributes of the shrub species — a list of both the growth and forage quality key traits of each species (continued)

	Common name (scientific name)	
	**River saltbush** (*Atriplex amnicola*)	
	• High in crude protein • Good salt and waterlogging tolerance	• Generally most palatable of the true saltbush species • Good regrowth from grazing
	**Ruby saltbush** (*Enchylaena tomentosa*)	
	• Grows on a wide variety of soil types • Easy to establish (seed or tubestock)	• Moderate salt tolerance • Volunteers freely
	**Sandhill wattle** (*Acacia ligulata*)	
	• Dense foliage and roundish habit; good shelter • Good growth on sandy soils	• Good regrowth after grazing • Suitable for soil stabilisation
	**Tar bush** (*Eremophila glabra*)	
	• High digestibility • Possible bioactivity in lowering methane production and mitigating acidosis	• More suited to heavier soils (clays and loams) • Good regrowth after grazing
	**Thorny saltbush** (*Rhagodia spinescens*)	
	• High in crude protein • Good drought tolerance	• Good regrowth after grazing • More suited to heavier soils

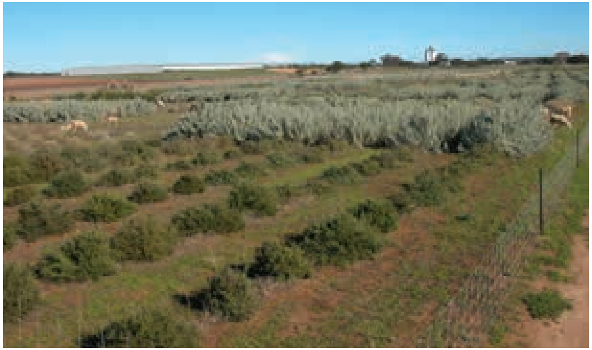
5. Designing a shrub-based system — practical considerations

A shrub-based grazing system is comprised of shrubs with a pasture understorey of grasses and/or legumes. In most situations this companion pasture will be the most productive component of a shrub system and will comprise a significant proportion of the livestock diet, even when dry. The proportion of shrubs to pasture in an animal's diet depends on the relative abundance and nutritive value of the various components and the experiences of the animals. The importance of animal experience is discussed further in Section 7. Having full ground cover between the shrubs is also an essential strategy to mitigate soil erosion, which is a substantial issue across most of southern Australia. Therefore, it is important to consider the planting and conditions of the understorey pasture when planting a forage shrub system. Shrubs can be planted into an existing pasture paddock, or the pasture established just prior to shrub planting.

Forage shrub production appears to be sensitive to competition from other pasture species and other shrubs. Competition with companion pasture and weeds is particularly pronounced in the first year after

Companion pasture production is important to the overall success of the shrub system

planting. However, the benefits of companion annual pasture far outweigh the small loss of shrub production due to competition. Perennial pasture, such as lucerne, causes the most significant reductions in shrub productivity, so growing perennial pastures spatially separated from shrubs is a good approach.



Design and layout of shrub systems must be carefully considered

Generally shrubs can be planted in blocks, alleys or as isolated belts on the edges of paddocks. Block plantings have a high density of shrubs and small inter-row spacing. Alley plantings are comprised of two or more closely planted rows of shrubs with a wide spacing (alley) between one shrub belt and the next for pasture or crops to be grown. There is no single 'right' way to arrange a shrub planting but it is important to consider the implications of the design before planting commences. Block plantings can be useful for periods requiring shelter, such as off shears or lambing, or in areas which don't support much pasture growth.

If the inter-row pasture will be the major component of the feedbase, it is important that it can be physically managed and manipulated. Machinery access between shrub rows can be impossible if shrubs are planted densely. Mustering stock in dense stands can also be difficult. On the other hand, achieving high grazing pressure and adequate utilisation of the shrubs can be difficult with alley and belt plantings in large cropping paddocks. This is not a problem if the planting is primarily for natural resource management (e.g. to reduce wind erosion), but can be problematic if the shrubs are to be used as forage for discrete periods of time, often with inexperienced animals (see Section 7). Adequate attention to suitably sized subdivisions of widely spaced alleys and knowledge of more intensive grazing management strategies can assist in utilising shrubs without over-utilising other plants. Planting layouts that allow for cropping, grazing and shrub growth in the same area will maximise the return on investment for shrub plantings as the ancillary benefits will assist crop and pasture production.

Case study. Bruce Maynard, Narromine, NSW

Bruce Maynard, farms near Narromine in NSW and has been planting forage shrubs for more than 25 years. Originally Bruce planted forage shrubs on his property to increase the feed supply, particularly in dry times. Since then he has modified the density, species mix and layouts to gain a range of further benefits including shelter, shading, wind flow reduction and a greater recycling of deep soil nutrients. Over the years Bruce has planted his shrubs in blocks, shelterbelts on fencelines and in different alley configurations. Through trial and error, he now understands the merits of each method. Bruce started with block plantings but concludes they didn't allow for the inter-row pasture growth to reach its potential. This flows on to the performance of the livestock as their feed choices are less in a block planted area. However, he maintains block plantings are ideal near yards where stock can be kept overnight — especially where stock may be at risk from extreme weather. Bruce thinks small block plantings near stockyards are an ideal way for farmers to make a start with forage shrubs and begin to get experience with how to manage the particular species of shrub being trialled.

Photo courtesy Bruce Maynard

NSW farmer Bruce Maynard has trialled many different shrub plantation designs

Bruce then went to an alley style design with straight triple rows of shrubs and a strip of about 20 m of pasture. This shrub to pasture ratio of about 15% suits his country but should be adjusted to suit soil and rainfall types. The alley system allowed good pasture production but the straight rows created a wind tunnelling effect and affected livestock movement as they tended to walk more along the rows. In an attempt to overcome this, Bruce trialled many different configurations but now maintains that curved rows offer the best way to slow the wind flow in any

Case study. Bruce Maynard (continued)

direction. Curved rows use the same number of plants and cost the same to plant as straight lines so they are a great compromise between getting the most biological benefit while suiting practical farm operations. Planting along the contour is a good starting point as it provides possible groundwater usage benefits in addition to fitting in with cropping programs. Using double (or more) rows of shrubs instead of a single row minimises the chance of 'gaps' where some plants don't establish or else die over time and create a resultant wind channel.

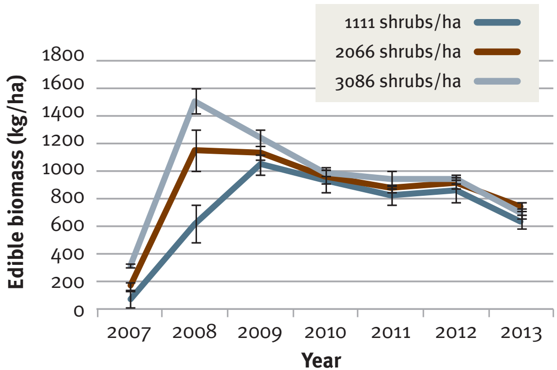
Photo courtesy Bruce Maynard

Curved shrub rows provide shelter regardless of wind direction

Bruce successfully grazes his shrub-based pastures at any time of year and doesn't have a problem with selective grazing of the grass pasture or getting full utilisation of the shrubs, even in the alley configuration. This result is a combination of how much is planted to shrubs in the particular area and the animals' experience with eating that type of shrub. When animals regularly graze paddocks that contain shrubs, they gain a greater benefit with each subsequent paddock they graze. Having beneficial experience minimises the fear that livestock may have of eating 'novel' feeds and also means the livestock have learnt how to browse shrubs instead of only grazing pasture. Being highly social, livestock readily copy behaviour from other animals, so this knowledge is passed through the herd over the years. Bruce has also used a variety of livestock species to 'finish up' shrubs which have grown out of reach of smaller animals. He is able to get effective grazing of both the pasture and shrubs and can move stock from paddocks while there is still good ground cover. This is important because the health of the inter-row plants drives soil health, which in turn affects how the shrubs might use nutrients and moisture.

To maximise shrub production, competition should be minimised, especially during the establishment phase; i.e. during the first 6–12 months from planting. To avoid shrubs competing with each other, it is desirable to plant at a lower density and attempt to capitalise on individual plant potential. Studies in the *Enrich* project have shown biomass is dependent on shrub density in the second year but from year three biomass is not increased by planting more than 1100 shrubs/ha (see Figure 24). Planting fewer shrubs also helps reduce establishment costs by lowering total seedling cost. While growing multiple species is beneficial, they do not necessarily need to be grown close together (for example in the same row). It is more important that animals have access to the available plant diversity. Growing species spatially separated may also make them easier to plant and manage.

FIGURE 24. Total forage shrub production from old man saltbush over the first seven years from planting at three different shrub densities



The shrub species mentioned in this booklet do not all have the same growth habit and potential size (see Table 1, page 38), and so have different optimum planting densities. For example, old man saltbush (*Atriplex nummularia*) would need fewer plants to achieve optimum density than the smaller ruby saltbush (*Enchylaena tomentosa*).

However, as yet no research has been conducted to address these issues on a species-by-species basis. As a guide, larger shrubs can be planted at 500–1000 plants/ha and smaller shrubs at 1000–1800 plants/ha. Both within-row and between-row spacings can be altered to change planting density (see Table 3).

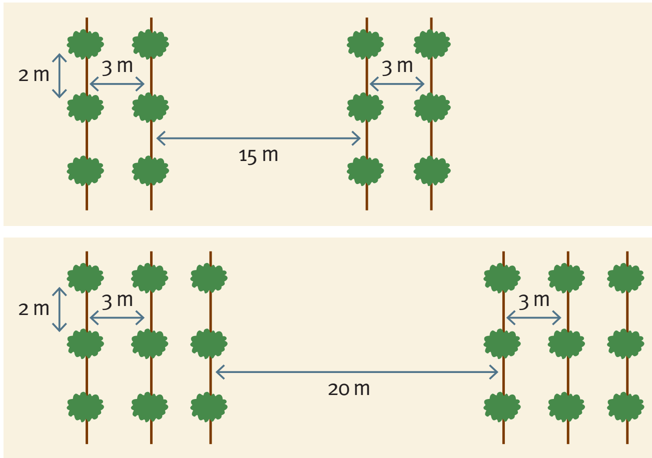
TABLE 3. Examples of different block planting configurations

Within-row spacing (m)	Between-row spacing (m)	Planting density (plants/ha)	Possible uses
4.0	4.0	625 plants/ha	Large shrubs; low productivity environments
3.0	4.0	833 plants/ha	Large shrubs
2.0	5.0	1000 plants/ha	Large–medium shrubs
3.0	3.0	1111 plants/ha	Medium shrubs; large shrubs in higher rainfall (>425 mm)
2.5	2.5	1600 plants/ha	Smaller shrubs; higher rainfall

With an alley planting, also consider the width of the alley as well as the number of rows within the shrub belt. To calculate the number of plants required, work out the total number of shrub rows to be planted. Then divide the total row length by the within-row spacing and multiply the two. Some examples of alley planting configurations are shown in Figure 25.

When considering the proportion of each species in a mixed planting, there is no single correct method. It is generally a case of balancing biomass productivity with nutritive value (see Sections 3 and 4) and, critically, the cost and availability of the plants. Not all species have the same biomass potential, so planting the same number of each species will most likely mean the actual biomass available to the animals will not be equally proportioned between species. To attempt to balance this, fewer individual plants of the larger species, and more individuals of smaller species, could be planted to provide a more mixed diet on offer. While this is not essential, the benefits of including a mix will more likely to be found when all species are significantly represented (at least 10% of biomass). Plant traits (nutrient content or bioactive properties) vary over time, location and even between plants and so no single plant is a winner in all respects, all of the time (see Table 2, pages 49 and 50).

FIGURE 25. Examples of different alley planting configurations



Designing a shrub-based system — A practical example

Tim has a small 20 ha paddock close to the shearing shed, which does not yield well when sown to cereals. He has decided to plant it to a shrub-based system. It is a well drained non-saline sandy soil. By using the decision tree on page 15, he has identified six species with potential on that soil type. Tim decides to plant a mixed planting of five species — sandhill wattle, river saltbush, old man saltbush, ruby saltbush and rhagodia. He omits planting small leaved bluebush as it naturally volunteers on the farm anyway. To allow for the opportunity to sow different pasture options, Tim decides to plant in an alley configuration separated by twin shrub rows 2 m apart. Alleys need to be 20 m wide. The paddock in question is 400 m wide, which will allow for 18 twin-row shrub belts. He decides to proportion a third of shrub belts to old man saltbush and the remaining belts equally to the other four species. With ruby saltbush being a small shrub this is planted at 2 m spacing, while all the rest are planted at 3 m. Rows are 490 m long. This equates to a total of 6370 shrubs to be ordered (see Table 4).

TABLE 4. Shrub calculation example

Species	Within -row spacing (m)	Total number of rows	Total number of plants
Old man saltbush	3	12	1960
Rhagodia	3	6	980
River saltbush	3	6	980
Ruby saltbush	2	6	1470
Sandhill wattle	3	6	980
Total		**36**	**6370**

Where the primary purpose of planting shrubs is to provide shelter from the wind, the effectiveness of a shelterbelt is determined by its species composition and planting design. There is a range of forage shrub species of contrasting height, width and foliage density that can combine to form a near impermeable wind barrier. These species vary from low, ground-hugging species such as ruby saltbush and river saltbush (*Atriplex amnicola*), to intermediate shrubs such, as old man saltbush, and taller shrubs, such as sandhill wattle (*Acacia ligulata*).

6. Establishing forage shrubs

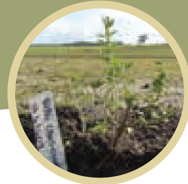
Currently, woody forages are commonly established by planting seedlings (tubestock). This has generally been regarded as the most successful method, particularly in low-rainfall regions. However, it is expensive (about 35 c/seedling for species that are commercially available), and may require contract planters. Direct seeding on the other hand, is more economical but has not been highly successful due to seed quality and dormancy issues, seeding depth control and climatic factors. There is nearly always a longer time for establishment and a delay to the first grazing compared with planting seedlings.

In most cases it is necessary to deep rip the soil as early as possible. On heavier-textured soils, if deep ripping is done too close to transplanting, the soil will be lumpy and full of large air pockets causing seedling roots to dry out. An Agrowplow type implement, cultivating at a depth of 30–50 cm, is ideal. This shatters any compacted layers without soil inversion. Ripping only needs to be done in the rows into which the shrubs will be planted.

Forage shrubs are commonly planted as tubestock into rows which have been deep ripped. Weed control at this early stage is vital for success

Weed control is critical in the establishment year. The object is to have soft, weed-free conditions at planting. Multiple weed kills before planting are desirable if seasonal conditions allow. The use of an 'autumn tickle' (light cultivation to stimulate germination followed by a non-selective herbicide) approach may be useful to lower weed numbers before planting. When aiming for multiple weed kills, a balance needs to be found between weed control and the risk of late planting. Scalping the soil surface along the row to be planted has been used successfully as a weed control method. Information regarding species' tolerance to herbicides is extremely limited, so planning and weed control before planting is critical. If herbicides are used to control weeds between the rows, it is important to prevent spray drift onto the forage shrubs as the likely impact is not known.

Start planting relatively soon after the break of season so adequate moisture is available to allow plants to establish before summer. Bear in mind that the risks of frost, greater annual weed germination, waterlogging and slow plant growth are disadvantages of late autumn–winter planting. However, spring planting carries the risk that if an early finish to the season occurs, plants may run out of moisture. In areas prone to frosts, tree guards may be needed to protect young seedlings in vulnerable parts of a paddock. If planting occurs late or in dry conditions, watering is an option. The frequency of watering will depend on weather conditions; the higher the air temperature and the stronger the winds the more water is needed. Continue to monitor the seedlings regularly over the first six weeks to determine whether watering is needed. When the roots reach the stored soil moisture, the plant will be self-sufficient and watering is no longer necessary.



Rabbits, hares and kangaroos can destroy seedlings and there is a high risk of failure without some form of protection. Tree guards may give some protection to young seedlings but this may not be feasible with large plantings.

At present there is little evidence of the benefits of initial fertiliser on shrub growth. However, it will increase inter-row pasture production. A well functioning shrub-based system is unlikely to require regular fertiliser input due to increased rates of nutrient cycling and the presence of legumes in a proportion of the pasture.

Tubestock can be bought from plant nurseries that specialise in growing farm trees and shrubs. These nurseries work on 'grow to order' where an order is placed during the year, no later than November–December and the plants are propagated over the warmer months to be ready for planting the following winter. Therefore forward planning is required when planting forage shrub paddocks.

Nurseries that have worked with the *Enrich* research project are:

- Chatfields Tree Nursery, Tammin, WA
- Wongan Trees, Wongan Hills, WA
- Waikerie Saltbush, Waikerie, SA
- Jayfields Native Nursery, Holbrook, NSW

Photo courtesy J. Crettenden, SARDI

Ruby saltbush, which has been direct seeded

Forage shrubs can also be established by direct seeding, but success depends on the species and a raft of factors that are not yet fully understood. Work over many years has shown results to be extremely variable; one year remarkable success can be achieved and the next year brings a complete failure.

There are a few critical factors that are known to influence the success rate:

1) **Seed viability** — Do not assume the seed (even if it is bought) is viable. An easy way to assess the viability of seed is to put 30–40 seeds on some cotton wool and keep moist for 1–2 weeks. Count the number of germinated seeds and this will give an idea of the seed viability and the seeding rate can be adjusted accordingly. When seeding *Atriplex* species (such as old man saltbush and river saltbush) it is common to sow the fruit, which are often called bracts. Seed of *Acacia* species (wattles) need to be immersed in boiling water to break dormancy before they are sown.
2) **Depth control** — Seeding depth is critical. Ideally, seed needs to be lightly buried at a depth of 5 mm. When the seed is placed any deeper than this, establishment declines markedly.

3) **Weed and pest control** — Forage shrub seedlings are much slower growing than annual grass and broadleaf species and so can be outcompeted easily. There are limited post-emergent herbicides, so as much work as possible needs to go into weed control before planting. Scalping and double knock applications of non-selective herbicides are methods used before seeding to minimise potential weed competition.

While fruit production of most species has been seen within two years, the ready availability and cheap production of seed are necessary to make direct seeding viable. Methods for cheaply harvesting and cleaning seed also need to be found.

Scalping the soil surface along only the rows to be planted provides some residual weed control and allows for pasture growth in the alley

Seed collection is the first step in shrub propagation

7. Getting the best from shrub-based systems — grazing management

Forage shrubs can provide an important component of the diet of livestock, especially when other sources of abundant, nutritious feed are scarce or expensive. Best results occur when animals quickly incorporate the forage shrubs into their daily selection, in combination with other feed sources — whether that be inter-row or understorey pastures, pasture or crop stubble in adjacent areas, or supplementary feed.

As with any new feed sources, animals can take some time to adjust their eating behaviour; they need time to learn about the attributes and constraints of the new food, and the microbes in the gut (rumen) need time to adjust to fermenting different material. *Enrich* research has shown that when animals without prior experience of shrubs start to graze set stocked in a shrub-based paddock, there is a temporary dip in liveweight for about two weeks, and another week or two before they recover that weight. This is not necessarily unique to forage shrubs, as any new feed can cause this response. Also, the aim is to avoid the animals eating the pasture first and only eating shrubs after the pasture is gone; this is not ideal for NRM outcomes, nor for animal nutrition.

To get the best from shrub-based systems attention to grazing management is critical

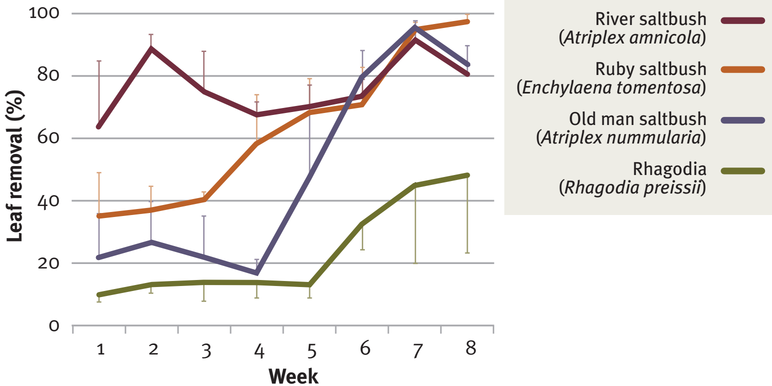
High stock density is a management strategy that can be used to minimise selective grazing —particularly important with livestock unaccustomed to the forage on offer

Fortunately, these problems associated with adapting to the new forages can be reduced or avoided through management. Here are some tips:

1. **Use stocking density** — If paddocks are grazed lightly with animals not experienced with all feed components that are on offer, they will most likely focus their grazing on the plants they are most familiar with. But with some competition, well-nourished and low-stress animals are encouraged to select a broader range of plants. This is partly because the competition means they can't afford to be so selective (think of one kid in a sweet store taking their time to choose, versus a classroom of kids grabbing whatever they can). But animals also learn from one another and, in a more intensive situation, they are more likely to see one of their counterparts eating something new, and copy that behaviour. Grazing pressure is a function of animal numbers and grazing area; i.e. increasing group size or reducing paddock size can both increase grazing pressure.

2. **Reduce selective grazing** — Where possible, provide animals with a fresh allocation before they run out of any one component of the mixture of feed on offer. *Enrich* research experience has led to the rule-of-thumb that after 3–4 ‘lessons’, animals will be much more willing to sample a broader range of plants (see Figure 26). If animals are left to ‘clean up their plate’ before being moved to a new patch, the undesirable behaviour of high selectivity may be reinforced, because eating the least desirable plants on their own could exacerbate a nutrient imbalance (e.g. too much of something, including secondary plant compounds such as tannins or oxalates, or not enough of a limiting nutrient), thereby increasing their aversion to that plant.

FIGURE 26. The proportion of edible leaf material removed each week by sheep grazing a shrub-based forage system that contained four species of shrubs*



* The animals were moved on a weekly basis (strip grazed) with a stocking density of 71 sheep/ha, so that each week the sheep were offered ample fresh material to consume. All shrubs were consumed to some degree from the onset, but there was a learning process of about four weeks before the animals increased consumption of some of the shrub species. During the first three weeks, river saltbush was clearly the most palatable, highlighting the value of including palatable species to help animals adjust to eating forage shrubs. But by weeks 6-8, three of the four shrub species were all consumed to a high degree.

Temporary fencing can be particularly useful in grazing forage shrubs

Having small paddocks through which animals can be rotated is one way to provide fresh plant material while animals are learning, but this is not always feasible in practice. Another way is to use temporary electric fencing, something that has been used successfully at research sites. With plenty of feed on offer, animals did not often breach the electric fence. A third way is to place animals into a shrub-based paddock for a short period (e.g. a few days), take them out for a short period, and then reintroduce them to the shrub paddock. By the third or fourth re-introduction, the animals should be showing a greater propensity to eat a broader range of the plants on offer.

3. **Learning from experience** — If possible, use animals with experience grazing shrubs. Where there are a naive group of animals (e.g. hoggets that haven't grazed shrubs before), consider including some experienced animals in the flock or mob to help 'teach' the newcomers what is good food. Another management tool is to provide shrubs during pregnancy and/or lactation. Early life exposure — i.e. even that which occurs in the womb — can affect how well animals perform on those shrubs later in life.

Young animals learn from older ones which plants are edible

4. **Fresh water** — Maintain a good supply of fresh water. Many shrub species have a high salt content, and livestock will quickly drop feed intake if water is unavailable or the water itself has a high salt content. This can happen within a day.

Good grazing management is necessary for optimal animal performance, but it is also essential for maintaining plant productivity.

It is critical forage shrubs are allowed a long period of recovery (at least six months) and are not set stocked. Continual grazing of new shoots will kill plants. However, it is important to use forage shrubs regularly (at least annually) as part of the overall feed base of the farm and not save them only for use in drought periods. Ungrazed plants lose biomass through considerable leaf drop, particularly during summer as plants try to reduce demands on transpiration. Grazing is also important to control the height of taller-growing species, such as old man saltbush and some wattle species. These species can grow out of reach of sheep resulting in lower amounts of available biomass. While ungrazed plants do not always accumulate edible biomass, they do still keep increasing in height. More frequent grazing and early grazing (at around 12 months after planting) are particularly critical in controlling height. Grazing does not appear to have a large effect on standard nutritive value properties or mineral concentrations of forage shrubs. This makes the provision of nutrients predictable and adds to the potential of species to be flexible in terms of their timing of utilisation.

Allowing shrubs rest periods for adequate regrowth is critical to their long-term productivity

Case study. Brian Teakle, Karoonda, SA

Brian Teakle, Karoonda, South Australia has successfully managed to implement a system that allows for two grazings per year with full shrub recovery. He started planting old man saltbush and river saltbush in 1991 as a way to improve the stability of the feedbase of his farm and help protect areas prone to soil erosion. He needed the saltbushes as a feed source shortly before harvest and again before sowing (filling seasonal feed gaps) so trialled some management approaches which allowed for two grazing opportunities and two lots of recovery in a 12-month period. Brian found if sheep were taken out when the forage shrubs were about 80% defoliated, recovery would occur in six months.

Brian has learnt that both old man saltbush and river saltbush can withstand strategic grazing twice a year — but if either species is thrashed until it has no leaf left it will take much longer to recover. There must be leaf recovery on the lower parts of the shrub before it is ready to be grazed again. While Brian is really happy with old man saltbush and river saltbush in terms of their role as forage shrubs in his system, he is keen to grow other species. However, Brian believes grazing management is vital — saltbushes are hardy, but if they are thrashed for long enough, without giving them time to recover, they will be killed.

Brian Teakle has found that by closely monitoring the level of defoliation of his shrubs during grazing and the amount of regrowth, he can graze them twice a year

To view the full story go to www.futurefarmonline.com.au

8. Animal performance expectations from a shrub-based system

Many grazing trials over the years and at multiple sites to provide some general rules of thumb for the contribution of a shrub-based forage system. Clearly the amount of feed provided and, therefore, the number of 'grazing days' will vary from site to site and from year to year. Water availability is a major factor determining biomass production of shrubs, just as with any forage, even though they are relatively drought tolerant compared to many of our other forage options. The planting density of the shrubs and the productivity of the inter-row pasture will also have a major effect on the number of grazing days (as discussed in earlier sections).

As with any good grazing management, it is useful to get an estimate of the edible biomass on offer. Unfortunately, this is not so easy to do with three-dimensional shrubs that can differ in architecture under different conditions. Literally thousands of shrubs were measured for their height and width as part of the *Enrich* project, but it was not possible to calibrate these measurements with edible biomass across all times and locations. Shrubs growing under poorer conditions can still be of a similar dimension, but hold less edible biomass than shrubs under good growing conditions. This needs to be taken into account when predicting the number of grazing days available.

Livestock can gain weight during autumn when grazing a mixture of shrubs and inter-row, without the cost and labour requirements of supplementary feeding

Despite the cautionary note regarding the effect of seasonal conditions on shrub biomass, much general information has been learnt that can be helpful in developing plans for shrub-based forage systems. Across a range of different conditions, from set stocking at 8 DSE/ha right through to grazing at more than 300 DSE/ha with a daily rotation, a typical number of grazing days has been 400–700 DSE/ha. Using 500 grazing days as an example, means that each hectare could provide sufficient feed for 100 DSE over five days. A 20 ha paddock would therefore provide 100 DSE with enough feed to last 100 days, or provide 500 DSE enough feed for 20 days.

These figures are a guide only, as the experience with the *Enrich* research sites has ranged from about 220 grazing days/ha under poor conditions right through to two sites that provided more than 4000 grazing days/ha. The outstanding results were from sites with reasonable soil quality and good rainfall, but it is important to realise that drought-hardy perennial shrubs will still respond vigorously to good conditions — not only can forage shrubs help cope with tough conditions, they can also help capitalise on good conditions.

Growth rates of sheep grazing shrub-based forage systems during the autumn feed gap period, without supplementary feeding, have ranged from zero to 150 g/head/day. The range covers different biomass availability of both the shrubs and the inter-row pasture across sites. If weight maintenance is the target (e.g. mature wethers) then that can be relatively easily achieved, but weight gain requires more careful management of the inter-row pasture. But remember any weight gain at all, without hand feeding, during the autumn period of low feed quality and availability is an exciting proposition.

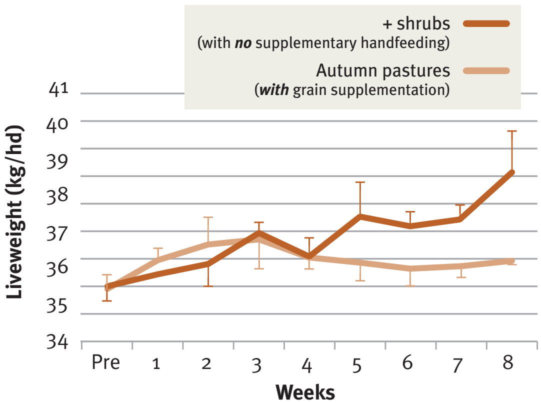
Photo courtesy G. McDonald, DAFWA

Social interactions between animals play an important role in shaping grazing behaviour

Figure 27 is an example of the liveweight performance of nine-month-old sheep grazing a shrub-based forage system. The data is from the same experiment as the data on foliage removal presented in Figure 26 on page 66. The sheep grazing the shrub-based forage system did not receive any supplementary hand feeding, whereas those grazing the senesced annual pasture were supplementary fed grain in order to maintain weight. The shrubs were two years old when this grazing experiment was conducted over eight weeks during autumn 2012; a time of year when hand feeding would be common practice. The year the shrubs were planted (2010) was the driest on record for the region (Quairading, WA).

If higher weight gains are the target, or if pregnant ewes are grazing a shrub-based forage system, supplementary feeding to provide additional metabolisable energy is required. As with any feeding system, it is important to monitor the liveweight and/or condition score of animals, and adjust feeding management as required.

FIGURE 27. Liveweight performance of nine-month-old lambs grazing a shrub-based forage system*



* Five shrub species — old man saltbush, rhagodia, river saltbush, ruby saltbush and tar bush — with an inter-row of sown pasture, including barley and a mix of other grasses

Case study. Greg Richards, Quairading, WA

Trialling the addition of perennial forage shrubs to an annual pasture feed base has yielded production benefits on marginal land for Greg Richards, Quairading, Western Australia.

Greg has about 400 ha of salt-affected land on his 4000 ha farm, and would like to be able to better manage this marginal land and make it more productive. He participated in an *Enrich* trial, run in conjunction with a regionally-based program co-ordinated through the Shire of Kellerberrin. The trial was looking at the benefits of forage shrubs in reducing wind erosion and the role shrubs can play in grazing systems.

Five selected species of shrubs — old man saltbush, river saltbush, rhagodia, ruby saltbush and tar bush — were planted during 2010 in a 20 ha paddock, which was divided into smaller paddocks. It ended up being the driest year on record and the shrubs grew well, even though they did not receive a lot of rain in the first year.

The sheep grazed the shrubs during autumn 2012, only 18 months after planting under very dry conditions and ended up grazing the trial paddocks for eight weeks. The shrub-grazing sheep were not supplmentary fed at all and still gained weight (see Figure 27, page 72).

Greg Richards (left) and Samantha Bickell discuss how the forage shrubs have the potential to convert a paddock considered extremely marginal for cropping into a valuable asset for autumn grazing

Greg has found the forage shrubs to be good value, adding extra feed during the dry times, from late summer, through autumn and in early winter, and he can see their potential on all his marginal land. Greg now aims to slowly keep planting shrubs on these areas and make use of land which is difficult to manage profitably. The shrubs will provide some ground cover, feed during the autumn feed gap and, in the event of an early break, will allow other annual pastures to become established before being grazed.

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Using stocking densities of 40–80 DSE/ha and above, feed on offer can run out quickly. So monitoring feed on offer from the shrubs and the inter-row pasture is still essential. Moderate overgrazing is unlikely to penalise subsequent shrub recovery during a rest period as the species researched have excellent recovery from heavy grazing, but overgrazing will compromise ground cover and increase erosion risks in the inter-row spaces, and potentially compromise pasture regeneration.

9. The main things to consider if interested in establishing forage shrubs

What you're up for:

- 500–1500 plants per hectare (depending on your layout)
- $0.30 + per plant, depending on species and source (contact your local nursery)
- Weed control at establishment
- Planting costs (yourself or a contractor)
- Start small, identifying areas where you are keen for a new option for profitable land use, and consider building up towards about 10% of the farm area to optimise the benefits of having perennial shrubs in your feed base.

Expect establishment to be in the order of $250–450/ha

What you get back:

- 500–600 grazing days/ha that are available at a time of year where feed supply and quality are often limiting productivity
- A forage resource that lasts at least 15 years (which means the high up-front costs provide a return over a long period of time)
- Management flexibility by an additional forage resource, allowing deferred grazing on other parts of the farm
- NRM benefits (e.g. reduced risk of wind erosion, potential reservoir for desirable invertebrates as part of integrated pest management).
- Increase in whole-farm profit (economic modelling indicates it can be as high as 20%), or maintenance of whole-farm profit with less area cropped (providing you with a risk management tool).

The *Enrich* project started during 2004 and many people have contributed to its progress. This includes researchers and technical staff in seven organisations across four states of Australia. Special thanks go to the many regional groups and associations including catchment management authorities (CMAs), natural resource management (NRM) groups and local shires who have worked with the project by collaborating with trials and demonstration sites. The team also recognises the invaluable input and support of the producers who have given up their time and land to help us along the way. Thank you to Jill Griffiths, Publications Manager at the FFI CRC, for her crucial role in editing this booklet and to Megan Hele Design, for insights and skill in graphic design.

The *Enrich* project began with four funding partners — Future Farm Industries Cooperative Research Centre (CRC), Meat & Livestock Australia (MLA), Australian Wool Innovation Limited (AWI) and the Joint Venture Agroforestry Program (JVAP). It has continued as a CRC project with additional funding from MLA, and the Department of Agriculture. In 2013, the *Enrich* project team was awarded a Eureka Prize in the inaugural Sustainable Agriculture category. The award, sponsored by Caring for our Country and Landcare, was presented at the Australian Museum's Eureka Prize dinner in Sydney in September 2013. The award provided recognition for the work carried out by all project participants since the project's inception.

This publication was written by *Enrich* researchers Dr Jason Emms (SARDI) and Dr Dean Revell (CSIRO).

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ISBN 978-0-9871562-6-6
First published 2014