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1. Introduction

In south Western Australia, the lack of good quality feed in late summer and autumn is a major constraint to livestock production. This feed gap is usually filled by costly supplementary hand feeding of grain or hay.

The ability of some trees and shrubs to provide good quality forage during summer and autumn has generated interest for many years (Corbett, 1951; Everist, 1969; Snook, 1987; Oldham *et al.,* 1991, Lefroy, 1991). The dual benefits of reducing the need for supplementary hand feeding and deferring the grazing of annual pastures until they are well established has recently led to the recognition of tagasaste (*Chamaecytisus palmensis*) and saltbush (*Atriplex* species) as important forage plants in Western Australia (Malcolm; 1986, Oldham *et al*., 1991.

Both of these plants are adapted to very specific and different positions in the landscape. Tagasaste is well suited to well drained soils, such as deep sands or gravelly loams in areas receiving more than 400 mm of annual rainfall, or in lower rainfall areas if there is fresh water within a few metres of the surface. It is intolerant of waterlogging or salinity (Snook, 1987; Hawley, 1984; Negus, 1988). Economic analyses suggest that although tagasaste will grow on other soil types, it is best on deep sandy soils for maintenance feed for stock during the autumn feed gap. This is because the pasture it replaces generally grows poorly, therefore the tagasaste is not competing within the farming system with a good, productive feed source. On better soils, it appears that good sub–clover based pastures are more economically competitive. The tagasaste also provides excellent cover to reduce the risk of wind erosion on deep sands.

Saltbush, on the other hand, has been found to be best suited to moderately saline areas which are summer moist, but only occasionally waterlogged and receiving 300 mm to 600 mm of rain annually (Malcolm, 1986). Providing stock have access to fresh water, saltbush may provide maintenance feed for sheep during the autumn feed gap. It also provides useful vegetative cover on erosion–prone sites.

Species of *Acacia*, in particular *Acacia saligna*, have also been planted in Western Australia. Although suited to a wide range of soil types from deep sands to saline loams, the value of most wattles as forage is presently limited by low digestibility (Craig, 1989; Downes, 1988) and low intake. Recent evaluations of stock response to combinations of fodder shrubs and hay suggest that stock performance may be improved by providing other feed together with the fodder shrubs (B.E. Warren, pers. comm.).

This report details the results of a literature survey on fodder shrubs for the temperate high rainfall area of Western Australia, defined here as greater than 500 mm of rainfall annually. The species lists are offered as a guide to further selection and should not to be interpreted as recommendations. The second section reviews the likely indirect benefits of forage trees and shrubs in addition to their immediate economic value. Section three lists species according to their suitability to different landscape positions and in the fourth section species are listed alphabetically and available information summarised.

It must be emphasised that very little is known about most of these plants from direct experience in Western Australia. Information on their value as forage is needed in particular and the following criteria adapted from Wheeler and Mochrie (1981) is given as a guide to the conditions that each of these plants would need to meet before being widely used.

For plants to be successful as fodder shrubs they need to demonstrate their ability to:

- survive environmental stress;
- economically produce forage that is digestible (≥ 55%), palatable and nutritious;
- produce fodder free of toxins;
- regrow following autumn grazing and/or cutting;
- resist insects and diseases;
- establish easily; and
- have little potential of becoming noxious weeds.

The potential of a species of becoming a noxious weed is important to consider before planting it. Consultation with the Agricultural Protection Board is recommended where there is any doubt.

In addition to this, information on the water use of different species under different climatic conditions and grazing systems would be useful to assess their role in preventing recharge and lowering saline groundwater tables. There is a sound theoretical basis for trees and shrubs to be able to use more water than crops and pastures (see 2.2) and some comparative measurements have been made in Western Australia (Greenwood, 1986). In addition, trees have been used successfully to reduce ground water recharge and lower groundwater levels relative to pasture (Schofield *et al.*, 1989; Schofield and Scott, 1991). However, the extent to which this occurs with trees and shrubs in high rainfall areas that are cut and grazed or simply grazed for forage is not well established.

The ecological benefits of forage trees and shrubs represent a significant incentive to their wider use on farms and is an area that requires research to quantify these effects.

It must be emphasised that only by regular cutting of the taller species (i.e. ≥ 2 m) to bring new growth within the reach of stock can these trees and shrubs make a significant contribution to the feed supply. Otherwise they must be considered only as emergency feed in times of drought. Regular mechanical pruning is carried out in Western Australia with tagasaste and to a lesser extent *Acacia* species. *Salix* sp., *Populus* sp. and *Morus* sp. are cut and used as drought reserves in other countries. The consumption of plants by stock does not necessarily confer benefits to the animals, and little is known about the quality of many of the species mentioned in relation to animal requirements. Care should be taken with rapid and comprehensive changes in animal diet.

2. The ecological benefits of trees and shrubs on farms

Although difficult to measure, the benefits of having trees and shrubs in the farming landscape can be described by the extent to which they have a positive influence on four main ecosystem functions: the cycling of nutrients and water, the flow of energy and the maintenance of biodiversity. The extent to which these functions are affected by planting trees and shrubs will depend on the selection and combination of species and by the aspect, orientation and planting density chosen. Planting can be in dense blocks, as widely spaced rows with crop or pasture between or as belts along ridges, fencelines, contour banks or waterways. The particular configuration chosen will be decided by a combination of ecological objectives and the practical and economic constraints of farming.

2.1 Energy use efficiency

When trees and shrubs with differing canopy characteristics are interspersed with crops or pasture and are spatially arranged and properly orientated to intercept light energy from the sun at different canopy levels and times of the year, the nett primary production through photosynthesis on a given piece of land can be considerably higher than if the same land was under crops or pasture exclusively, if other growth factors are not limiting (Trenbath, 1979, 1986). This principle has been used very successfully in many countries in intercropping or in mixed cropping systems (Reddy and Willey, 1979; Natarajan and Willey, 1979; Okigbo, 1979). The particular benefit to be gained from this approach in a mediterranean type environment such as south Western Australia is the addition of perennial plants into a farming system presently dominated by annuals which are actively growing and intercepting solar energy for only 5 to 7 months of the year. The influence exerted by trees and shrubs on energy flows is reflected in the improvement of the microclimate by the moderation of temperature, wind speed and humidity which have been shown to have beneficial effects on crops and pastures (Kort, 1988).

Recent work by Bicknell (1991) has shown similar responses in crop on the Esperance sandplain, but beneficial effects of microclimate modification on stock is yet to be conclusively shown in Western Australia. The benefits of buffering the effects of extreme climatic events is supported by anecdotal evidence (Bicknell, 1991).

2.2 The water cycle

The modification of the natural water cycle through the replacement of the original perennial native vegetation with annual crops and pastures and the consequences on land and stream salinity in Western Australia has been documented by Schofield *et al.* (1988). Similarly, the influence of deep rooted perennial plants on various aspects of the water cycle, namely improving infiltration, water holding capacity and evapotranspiration, has been reported by many authors. Specht (1957, 1981) and Slatyer (1965) have reported that the infiltration of rain water is substantially higher under trees and shrubs which may be due to stem flow, the presence of decayed root channels, holes made by soil fauna, higher organic matter content, better soil structure, greater aggregate stability and porosity. Nulsen *et al.* (1986) reported that in the study of a vegetated catchment in south Western Australia, 40% of rain falling on the canopy of mallee trees was channelled down the stem, through root channels to depths of up to 28 m where it is apparently stored and used during summer. In addition surface sealing and compaction are less under trees and shrubs due to the dissipation of rain drop energy, thereby increasing infiltration.

The roots of perennial trees and shrubs penetrate to greater depth than annual crops and pastures, thus the volume of soil tapped for moisture is considerably greater. Because of the greater rooting depth, the quantity of rainwater percolating below the root zone and recharging groundwater is likely to be less under trees and shrubs than annual pasture. Engel and Negus (1988) have demonstrated that the planting of flat topped yate (*Eucalyptus occidentalis*), salt river gum (*E. sargentii*), red river gum (*E. camalduelnsis*) and sheoak (*Casuarina obesa*) at a density of 80 trees per hectare lowered a saline water table by 100 cm within five years of planting. Schofield *et al.* (1989) have also shown the usefulness of revegetation strategies to lower watertables to mitigate land and stream salinisation. The site described by Engel and Negus (1988) is showing signs of severe moisture competition or allelopathy limiting pasture production under some species more than others. This is likely to be true for fodder shrubs also.

The ability of trees to reduce the moisture stress of pasture late in the season by modifying the microclimate and evaporative demand is implicated by higher soil moisture contents in spring in pine agroforestry versus open paddock (Anderson and Batini, 1979). Microclimate modification, together with protection from wind erosion may be an important inducement to incorporate fodder trees and shrubs into the farming system.

2.3 Nutrient cycling

Trees and shrubs may affect the nutrient cycle in two main ways. Firstly, by virtue of a deeper root system they extend the cycling of nutrients over greater soil depth. Secondly, by reducing the loss of nutrients through top soil erosion by wind and water.

Trees have been shown to influence the nature of the soil in which they grow (Young, 1989). The processes involved here have been proven in some cases, but only hypothesised in others. The main processes likely to be relevant to high rainfall fodder shrubs are as follows (Young, 1989).

Processes which augment additions to the soil:

- Maintenance or increase of soil organic matter through carbon fixation in photosynthesis and subsequent litter and root decay.
- Nitrogen fixation by leguminous shrubs.
- Nutrient uptake from deeper layers of the soil.

Processes which reduce losses from the soil:

- Protection from wind and water erosion.
- Nutrient retrieval through exploitation of deeper soil layers and the action of mycorrhizal systems associated with roots.
- Reduction of the rate of organic matter decomposition by shading.

Processes which affect soil physical and chemical conditions:

- Maintenance or improvement of soil physical properties (structure, porosity, moisture holding capacity).
- Breaking up of compacted/indurated layers by roots.
- Reduction in soil temperature extremes.
- Reduction of acidity through the addition of bases in leaf litter.

Soil biological processes:

- Production of a range of different qualities of plant litter (leaf, stem, root) encouraging diverse soil fauna.

2.4 Biodiversity

The diversity of living organisms is a characteristic of natural ecosystems that serves to protect them against all forms of cyclic and chance disturbances such as fire, flood, drought, storms and outbreaks of disease and insects. An indirect and little documented advantage of trees and shrubs on farmland is to reduce the effects of these perturbations. Provision of a suitable habitat for insect predators and parasites such as birds, spiders, predatory insects and parasitic wasps may help to control population levels of major insect herbivores such as leaf hoppers and locusts (Ostlie, 1979; Hobbs and Wallace, 1991).

3. Species selection by landscape position

Species are discussed in terms of their likely suitability to three different positions in the landscape: Hilltop and hillslopes, valley floor and the intermediate change of slope position. This distinction is based on generalised soil and water conditions that affect plant growth and is represented pictorially in Figure 1. A further distinction is made within the intermediate and valley floor positions between the presence of a saline or fresh watertable and within the valley floor position between the presence or absence of waterlogging.

Figure 1: Schematic diagram of a typical groundwater system in the high rainfall area.

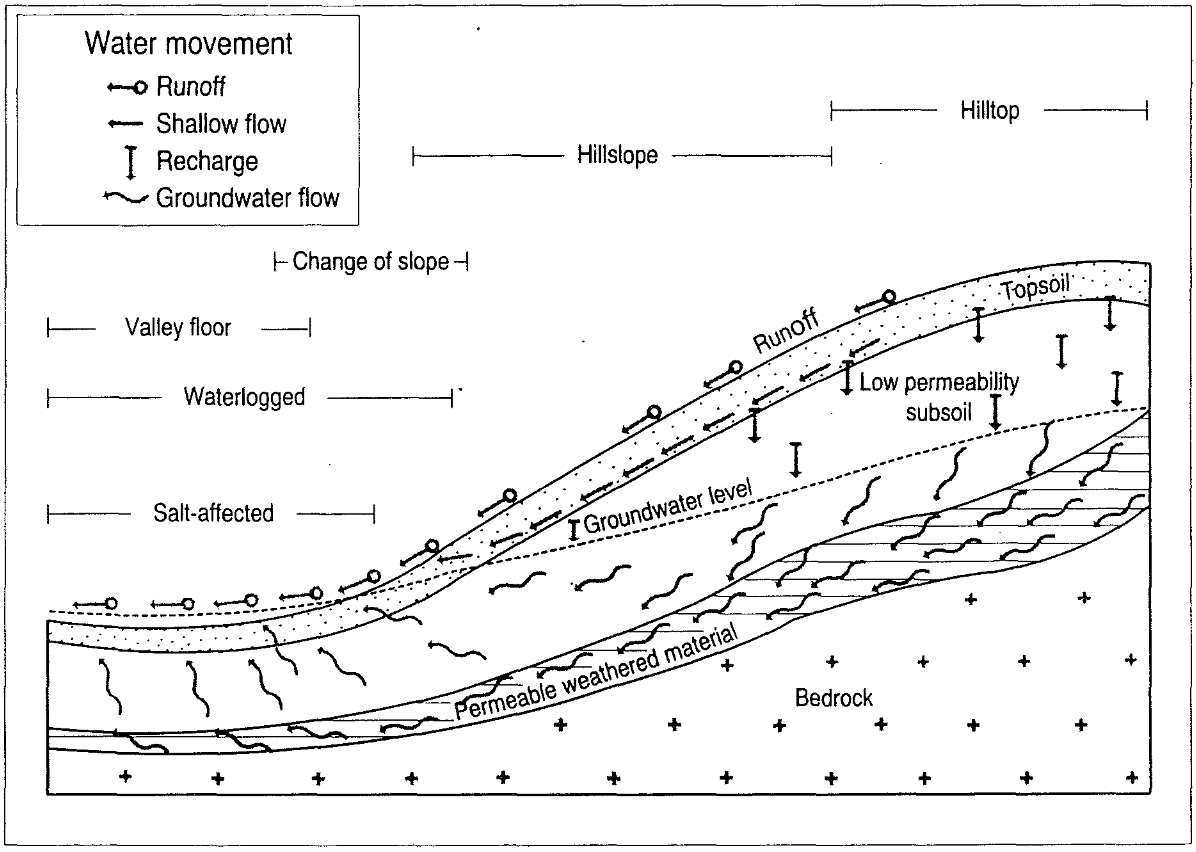

Figure 1. Conceptual diagram of landscape positions and groundwater hydrology distinguished for species selection.

3.1 Species for hilltops and hillslopes

Hilltops are sometimes not suitable for conventional agriculture due to rock outcrops, laterite caps or boulders and breakaways. Soils are often stoney, gravelly or sandy making these areas unproductive and sites for preferential groundwater recharge or increased runoff. Many such areas were cleared in the past to eradicate poisonous plants.

These conditions make hilltops and slopes susceptible to wind and water erosion, the susceptibility to water erosion increasing with increased steepness and length of slope. Trees and shrubs can be combined with soil conservation measures such as banks to stabilise these hillslopes. When hillslopes are gravelly or sandy they may act as preferential groundwater recharge areas and cause waterlogging and/or salinisation in the valley floors below. Trees and shrubs can be used to minimise this by reducing the amount and frequency of groundwater recharge events. The well–drained nature of the soil means that the availability of moisture is a major limitation of the landscape position; therefore hardy, drought tolerant species should be selected.

Non-arable hilltops and slopes generally constitute a small proportion of the farm and are an ideal place to establish a drought reserve of fodder trees or shrubs, or a regular autumn feed reserve. Species that may be well adapted to these sites are listed in Table 1. Note that previous attempts to establish perennial and tree lupins, and tree medic in Western Australia have been largely unsuccessful.

Table 1. Species for hilltop and hillslope positions

Species	Common name	Remarks
Acacia saligna	Golden Wreath wattle	Hardy, drought and salinity tolerant
Casuarina cristata	Black Sheoak	Drought and frost tolerant
Casuarina huegeliana	Rock Oak	Small to medium tree, fast growing
Bossiaea aquafolium	Waterbush	Native understory species, short–lived
Bossiaea lynophylla	-	Native understory species, short–lived
Ceretonia siliqua	Carob	Medium tree, edible seed pods
Chamaecytisus palmensis	Tagasaste	Tall shrub, prefers deep sandy soil
Daviesia cordata	Bookleaf	Native species, short–lived
Dodonaea viscosa	Sticky Hop Bush	Drought, salt and alkali tolerant
Gleditsia trichanthos	Honey Locust	Tall tree, nutritious pods in autumn
Lupinus arborea	Tree Lupin	Tall shrub, variable palatability, short lived
Lupinus polyphyllus	Perennial Lupin	Shrub, variable palatability
Medicago arborea	Tree medic	Shrub, drought tolerant but prone to insect attack
Morus alba	Mulberry	Tree or shrub forms, highly palatable leaves
Rhagodia preissi	Rhagodia	Palatable native shrub
Robinia pseudacacia	Black Locust	Tree, leaves and pods palatable
Teucrium fruticans	Shrubby Germander	Favours rocky, sandy soil
Quercus ilex	Holm oak	Small tree, fruit palatable
Quercus suber	Cork oak	Deciduous tree, palatable fruit

3.2 Species for change of slope

A wide range of soil types are found at the change of slope in the landscape. The soils may be gravelly, sandy, loamy, clayey or sand over clay. Groundwater may be close to the surface at the change of slope. In duplex (sand over clay) soils there may be a seasonal perched water table on top of the clay layer which can create seasonal waterlogging. Trees and shrubs planted at the change of slope can tap the moisture from the watertable or the capillary fringe of the watertable. As the change of slope can be either saline or non–saline, species selection should be based on salt tolerance and depth to watertable. Tables 2 and 3 are subdivided according to salt tolerance, and many species are common to the valley floor. Planting around the margins of saline/waterlogged areas may help to reduce the extent of waterlogging/salinity providing sufficient area is planted. Some species may have some additional value as timber or firewood.

Table 2. Salt tolerant species for the change of slope

Species	Common name	Remarks
Acacia saligna	Golden Wreath wattle	Tolerates salinity and waterlogging
Casuarina obesa	Swamp Sheoak	Very tolerant of salinity and waterlogging
Dodonaea viscosa	Sticky Hopbush	Drought, salt and alkali tolerant
Elaeagnus augustifolia	Russian olive	Tolerates mild salinity and waterlogging
Populus sp. variety "Euphrates"	Euphrates Poplar	Tolerates mild salinity and winter waterlogging

Table 3. Non salt tolerant species for the change of slope

Species	Common name	Remarks
Amorpha fruticosa	False Indigo	Small tree, edible leaves
Colutea arborescens	Bladder Senna	Small tree palatable leaves
Ceratonia siliqua	Carob	Medium tree, edible seed pods
Chamaecytisus palmensis	Tagasaste	Sandy soils, medium to low watertable, not tolerant of seasonal waterlogging
Gleditsia tricanthos	Honey Locust	Tall tree, nutritious pods
Lupinus arborea	Tree Lupin	Tall shrub, variable palatability, short lived
Lupinus polyphyllus	Perennial Lupin	Shrub, variable palatability, short lived
Medicago arborea	Tree Medic	Shrub, prone to insect attack
Morus alba	Mulberry	Tree or shrub, highly palatable leaves
Populus deltoides	Carolina Poplar	Deciduous tree tolerates winter waterlogging
Populus x *euramericana*	Hybrid Cotton Wood	Deciduous, tolerates winter waterlogging
Populus sp. variety "Flevo"	Poplar	Resistant to rust and leaf spot
Salix matsudana x *alba*	Hybrid Willow	Very palatable, tolerates winter waterlogging

3.3 Species for valley floors

As valley floors are often prone to waterlogging, drains and levee systems are often necessary to control surface and shallow sub–surface water before any planting can take place. Planting machinery that forms a double ridged mound which reduces the exposure of young plants to both salinity and waterlogging is recommended (Howes, 1991).

Even with earthworks to control water, waterlogging often remains a problem on these sites in winter and species need to be selected accordingly. Tables 4, 5 and 6 show suggested species for saline, saline/waterlogged, and waterlogged conditions. Characteristic of this position in the landscape is the availability of soil moisture over summer which increases the range of species and potential production.

Table 4. Species for saline areas with little or no waterlogging

Species	Common name	Remarks
Acacia saligna	Golden Wreath wattle	Tolerates moderate salinity
Atriplex lentiformis	Quail Brush	Tall shrub, very palatable, prefers warmer areas
Atriplex nummularia	Old Man Saltbush	Tall shrub, less palatable than other Atriplex
Atriplex paludosa	Marsh saltbush	Low palatable shrub, sensitive to grazing
Atriplex undulata	Wavy leaved saltbush	Low palatable shrub

Table 5. Species for saline areas prone to waterlogging

Species	Common name	Remarks
Acacia brumalis	Wattle	Shrub tolerates moderate salinity, palatability uncertain
Acacia ligustrina	Wattle	Shrub tolerates moderate to high salinity, palatability uncertain
Casuarina obesa	Swamp Sheoak	Very tolerant of salt/waterlogging
Atriplex cinerea	Grey Saltbush	Prostrate habit
Atriplex amnicola	River Saltbush	Low shrub, palatable
Elaeagnus angustifolia	Russian olive	Tolerates mild salinity, prefers alkaline soils
Tamarisk aphylla	Evergreen Tamarisk	Tree, tolerates high salinity, drought. Evergreen
Tamarisk gallica	French Tamarisk	Small tree, tolerates high salinity. Evergreen
Tamarisk parviflora	Early Tamarisk	Small tree, tolerates mild salinity. Deciduous
Tamarisk pentandra	Late Tamarisk	Small tree, tolerates mild salinity. Deciduous

Table 6. Species for non–saline areas prone to waterlogging

Species	Common name	Remarks
Albizia lophantha	Crested Wattle	Fast growing small tree
Alnus glutinosa	Black Alder	Grows well in boggy areas, moderately palatable
Casuarina cunninghamiana	River Sheoak	Suitable for stream bank stabilisation
Cornus baileyi	Dogwood	Shrub suitable for stream bank stabilisation
Cornus stolonifera	Dogwood	Shrub suitable for stream bank stabilisation
Populus alba	White Poplar	Prone to leaf rust
Polulus deltoides	Caroline Poplar	Timber and fodder tree
Populus euramericana	Hybrid Poplar	Prone to leaf rust
Populus sp. variety "Euphrates"	Euphrates Poplar	Very palatable foliage
Populus sp. variety "Flevo"	Flevo Poplar	Resistant to leaf rust
Salix matsudana x *alba*	Hybrid Willow	Palatable foliage, keep away from stream banks due to spreading

4. Description of species

Acacia species – (Wattle)

Leguminous trees or shrubs, evergreen, adapted to a wide range of conditions:

A. brumalis is a low shrub that tolerates moderately high salinity.

A. ligustrina is a large rounded shrub, up to 2.5 m tall that grows on sandy duplex soil and tolerates moderate to high salinity. The latter two are reportedly palatable to sheep.

A. saligna (Golden Wreath Wattle) is a fast growing shrubby tree to 5 m in height. Hardy, moderately drought and frost tolerant but short lived (10–20 years). Grows on soils from deep sands to moderately saline loams. Palatable to stock but digestibility generally low in sheep and cattle (40–50%). Some selections produce vigorous suckers.

Further information: Turnbull (1986 a, b).

Albizia lophantha – **Crested Wattle (South-West Australia)**

Small, fast growing, nitrogen fixing tree with a semi-deciduous nature. Moderately drought and waterlogging resistant. Has shown potential to spread from profuse seed production and is naturalised in many other countries. Palatable to stock, but does not coppice. Further information: Turnbull (1986 a), Thamo (1992).

Alnus glutinosa – **common or Black Alder (Europe, Asia)**

Deciduous tree to 18–25 m high, fast growing and suited to very wet and boggy areas. Often found on river and stream banks in its natural environment. Best suited to higher rainfall areas (800–1,200 mm). Timber is water resistant and often used for making piles. Reportedly palatable leaves. Propagation by seedlings or rooted cuttings.

Amorpha fruticosa – **False Indigo (America)**

Leguminous shrub. Often planted as an ornamental outside its native north America. Under investigation in France, Italy and Greece for its potential as a source of browse feed for sheep and goats. No local experience.

Atriplex **species – Saltbush (Australia, America)**

Salt tolerant shrubs common in semi-arid areas of Africa, Southern Europe, America and Australia. Palatable to stock despite high mineral content. Best fed in conjunction with fodder with higher energy content such as grasses. Generally suited to sandy loams with summer moisture in areas with 600 mm rainfall or less. Further information: Runciman and Malcolm (1989).

A. amnicola (River Saltbush)

Native to river flats in the Murchison and Gascoyne districts. As for most *Atriplex* protein content about 10% with digestibility of leaf and small stem material about 55–60%. Tolerant of waterlogging when mature. Palatable.

A. cinerea (Grey Saltbush)

Native to southern Australia. Prostrate, spreading shrub, moderately tolerant of waterlogging. Some variation according to ecotype.

A. lentiformis (Quail Brush)

Native to the hot, arid deserts of North America. Fast growing tall shrub that can exceed the browsing height of sheep. Short lived but easy to establish from seed.

A. nummularia (Old Man Saltbush)

Found naturally throughout semi-arid Australia on heavier soil types. Like quail brush is tall and exceeds the browsing height of sheep. Palatability is generally low. Sensitive to waterlogging.

A. paludosa (Marsh Saltbush)

Found naturally on saline coastal marshes in Southern Australia. Sensitive to grazing and palatable.

A. undulata (Wavy Leaf Saltbush)

Originally from Argentina. A lower growing shrub with distinctive small wavy leaves. Not as tolerant of waterlogging as *A. amnicola*. Very easy to establish from seed.

Propagation is by seed, bare rooted stock or seedlings. Direct seeding is variable due to low seed viability. Over 5,000 ha planted each year in Western Australia.

Bossiaea aquafolium **– Waterbush**

Grown naturally as an understory species in the lateritic uplands of the Darling Range. About 1.5 m tall and prefers shady locations. Will grow on sands. Short lived species that is preferentially grazed by stock in bush blocks. Dry matter digestibility about 55%, metabolisable energy about 7.6 MJ/kg and crude protein about 9%. Little experience in cultivation.

Bossiaea lynophylla

Grows naturally as an understory species in the lateritic soils of the southern Darling Range. About 1 m tall and prefers shady locations. Short lived species that is preferentially grazed by stock in bush blocks. Dry matter digestibility about 53%, metabolisable energy about 7.4 MJ/kg and crude protein about 11%. Little experience in cultivation.

Casuarina **species – Sheoaks**

Hardy evergreen trees with leaves reduced to tiny scales along branchlets. Are able to fix atmospheric nitrogen due to a symbiotic association with various species of *Frankia*. The hard timber is valuable as fuel or fence posts.

C. cunninghamiana (River Sheoak)

Grows naturally along water courses in the north and east of Australia to a height of 20 m. Prefers neutral to acid soils, will tolerate clay and occasional waterlogging. Wood makes excellent fuel. Used extensively for shelter.

C. heugeliana (Rock Oak)

Prefers sandy well drained soil and is a useful windbreak tree. Grows on difficult sites. Propagation is by seedlings.

C. obesa (Swamp Sheoak)

Small tree 5–14 m. Highly salt tolerant, will grow on heavy soils and prefers moist sites. Commonly found on the edges of salt lakes, mud flats and water courses. Native to Western Australia.

Ceratonia siliqua **– Carob (Mediterranean)**

Leguminous tree to a height of 10–15 m. The pods have a high sugar content and represent a valuable source of energy when they fall between February and April. Main disadvantage is the time taken to reach maturity (10–15 years). Grafted trees can give yields of 200 kg of pods per tree. Grow on a wide range of soil types but do not tolerate frost or waterlogging. Pods contain about 40% sugar and are highly palatable. Carobs are dioecious having separate male and female trees. Further information: Esbenshade and Wilson (1986).

Chamaecytisus palmensis **– Tagasaste (Canary Islands)**

Leguminous shrub or small tree with long drooping branches. Hardy plant adapted to a wide range of climatic conditions but will not tolerate waterlogging or salinity. Best grown on well drained sand or gravel. Very palatable with a protein content of about 15% but in fresh leaf and stem growth reaching as high as 25%. Stocking rates of 3,000 grazing days per hectare per year have been safely achieved by grazing for one to two months in autumn and spelling for the rest of the year. Mechanical pruning is important for this level of production. Propagation is by direct seed, bare rooted stock or seedlings. Further information: Oldham *et al*. (1991), Snook (1986).

Colutea arborescens

Small often multi–stemmed leguminous tree to 3 m high with very palatable foliage. A component of dry mediterranean woodland, it is becoming scarce in the wild but is now planted in Southern France and Italy as a fodder shrub. Prefers neutral to alkaline soils and requires mechanical pruning for high production. Propagation by seedlings.

***Cornus baileyi* and *stolonifera* – Dogwood (Mediterranean)**

Deciduous shrubs 2–3 m high which are good for stabilising stream banks. Tolerates low temperatures and waterlogging but not salinity. Reportedly palatable to stock, they are propagated by stem cuttings.

***Daviesia cordata* – Bookleaf**

Grows naturally in the lateritic soils of the Darling Range in association with Jarrah and Wandoo. Up to 2 m tall and will tolerate sun or shade. Short lived species that is preferentially grazed by stock in bush blocks. Also used as 'filler' in the cut–flower trade. Dry matter digestibility about 58%, metabolisable energy about 8.1 MJ/kg and crude protein about 9%. Little experience in cultivation.

***Dodonea viscosa* – Sticky Hop Bush (Australia)**

An evergreen, multi–stemmed shrub or small tree to a height of 1.5 m. It is adapted to infertile sandy or gravelly soils or loams. It is hardy and reportedly salt and alkali tolerant. Can be propagated by seed. Very little is known about its fodder value. Further information: Turnbull (1986 a).

***Elaegnus augustifolia* – Russian Olive (Southern Europe, Western Asia)**

A deciduous shrubby tree 4–7 m in height. Grows in a wide range of soils from sand to clay. A nitrogen fixing tree, although not a legume. Tolerates moderate salinity, flooding and extreme cold. Prefers pH above 6 and can be propagated by one year old seedlings or rooted cuttings. Reportedly palatable and digestible. Further information: Van Kraayenoord (1986).

***Gelditsia tricanthos* – Honey Locust (North America)**

Deciduous leguminous tree to 25 m. The pods have a protein content of 7–10% and sugar content of 30–40%. Good selections commence bearing in 5–10 years producing annual crops of 15–30 kg of pods (dry weight). Heavily fruiting selections may yield bout 100 kg per tree when more than 25 years old. Most wild plants have large thorns. The variety "Inermis" is thornless although its seedlings may revert to thorny types. Prefers fertile well drained soil. Performs poorly on very sandy or very heavy soils. Further information: Van Kraayenoord (1986), Thamo (1992).

***Lupinus arborea* and *polyphyllus* – Tree Lupin and Perennial Lupin (California)**

Both of these plants are multi–stemmed shrubs to 2 m high. Being legumes they have high protein content but variable palatability due to alkaloid content. Often used for dune and minesite reclamation as a pioneer species.

L. polyphyllus is used in California and New Zealand as a browse shrub. Noted as being weakly invasive and has been declared a noxious weed in some countries. Further information: Van Kraayenoord (1986).

***Medicago arborea* – Tree Medic (Greece)**

A multi–stemmed shrub to 3 m preferring neutral to alkaline soils. Drought tolerant, although response to very dry conditions is complete leaf fall. Does not tolerate waterlogging. Its very high palatability to insects may limit its usefulness.

Morus alba **- Mulberry (Asia)**

Some cultivars of Mulberry are highly palatable and nutritious. Fast growing tree requiring pruning. Major limitation is that it is not drought tolerant. Planted for forage on a small scale in Southern Europe where dwarf varieties selected originally for silkworm production have been used. It can be propagated from stem cuttings.

Populus **species - Poplars (Europe, Asia and North America)**

Poplars are deciduous trees with deep and extensive root systems. Some 30 species are known and numerous hybrids have been bred. Because of winter dormancy they can tolerate frosts and winter waterlogging. Roots spread laterally close to the surface and produce suckers. This characteristic has led to their widespread use overseas for gully and water erosion control. Also used extensively for special purpose timber because of its strength relative to its weight. Propagated by cuttings, bare rooted trees, stakes or poles. Varieties other than "Flevo", which is resistant, should be checked for leaf rust.

P. alba common white poplar.
P. euramericana hybrid cottonwood.
P. deltoides Carolina Cottonwood, good timber tree.
P. var. *"Euphrates"* tolerates mild salinity (evergreen).
P. var. *"Flevo"* resistant to leaf rust.

Further information: Van Kraayenoord (1986), Thamo (1992).

Quercus ilex **- Holm Oak (Mediterranean)**

Evergreen tree growing to a height of 20 m. Prefers light soils and tolerates rainfall as low as 400 mm per annum. Fruit (acorns) palatable to stock but has the same limitation of all trees with edible fruit of requiring some 10 years growth before significant production. Propagation by seed.

Quercus palustris **- Pin oak (Eastern USA)**

Tolerates wet sites but not exposure to wind.

Quercus suber **- Cork Oak (Mediterranean)**

Small deciduous tree to 15 m with edible fruit. In other respects similar to *Q. ilex*. Used for the production of cork in agroforestry systems in Portugal and Spain. Further information on *Quercus* species: Thamo (1992), Van Kraayenoord (1986).

Rhagodia preissii **- Rhagodia (Australia)**

A multi-stemmed shrub to 2 m preferring sandy soils. Found naturally from Geraldton to Bremer Bay and inland to Merredin. Palatable to stock but otherwise forage characteristics unknown. Same family as saltbushes and seed appears to have similarly low viability (5-20%).

Robinia pseudoacacia **- Black Locust (North America)**

Leguminous deciduous tree, often spiny, to a height of 25 m. Widely planted for timber and useful for gully erosion control. Grows well on a range of soils but prefers well drained sites with a pH of 5 to 8. Foliage used for stock fodder, but sucker regrowth can be toxic and prolific. Further information: Van Kraayenoord (1986).

Salix matsudana **x** ***alba*** **- Hybrid Willow (Asia, Europe)**

Closely related to poplars, but do not sucker. The hybrid willow is a deciduous tree that must be managed as a hedgerow with mechanical pruning close to ground to enable stock to reach fodder. Prefers moist soils and can tolerate waterlogging when dormant. Intensive grazing for

7–10 days per paddock has achieved best production levels in New Zealand. Establishment is by 20–30 cm long cutting of 10–20 mm diameter or by rooted cuttings or poles.

The most promising varieties are 1001 and 1002. As they are female hybrids there is a danger they could spread by seed, so should **not** be planted along watercourses. Further information: Van Kraayenoord (1986).

Tamarisk **species – Tamarisk (North Africa and Mediterranean)**

Hardy salt tolerant species commonly found along watercourses in semi–arid regions. Have some potential to spread and are declared weeds in parts of southern United states and in the Northern Territory. Like the Casuarina they have minute cypress like leaves flattened along the branchlets and are more useful for their soil conservation value than for forage, although the foliage is palatable.

T. aphylla Athel Tamarisk 6–8 m high. Fast growing tree with evergreen foliage and whitish pink flowers.

T. gallica French tamarisk smaller evergreen tree to 5 m high with pink flowers.

T. parviflora and *pentandra*. Early and late Tamarisk. Two deciduous species to 4 m high. **Can be propagated from unrooted cutting. Best results with cuttings 30 cm long, 8–10 mm thick with two thirds below ground level.**

Teucrium fruticans **– Shrubby Germander (Mediterranean)**

An evergreen shrub to 2 m having a dense tangled growth habit. Favours rocky gravelly or well drained soils. Suitable for gully control and stabilising slopes. Slow to establish and does not produce suckers.

Leaves and twigs are not highly palatable to stock. Easily propagated from hard wood, semi–hard or softwood cuttings. Further information: Van Kraayenoord (1986).

5. Summary of species by management system

5.1 Low growing species with edible foliage that do not require mechanical pruning

Atriplex amnicola
Atriplex undulata
Atriplex cinerea

5.2 Species with edible foliage that require mechanical pruning for high production levels

Amorpha fruticosa
Chamaecytisyus palmensis
Colutea arborescens
Medicago arborea
Morus alba
Salix matsudana.

5.3 Fast growing deciduous trees for multi–purpose agroforestry (summer shade and shelter, timber, edible foliage plus pasture between trees)

Alnus spp.
Populus spp.
Morus spp.
Salix spp.

5.4 Slow growing species with high energy value fruit or pods

Ceratonia siliqua
Gleditsia trichanthos
Quercus spp.

5.5 Species with higher soil conservation value than value as forage plants

Acacia spp.
Casuarina spp.
Robinia pseudacacia
Tamarix spp.

5.6 Species about which there is little or no local experience

Albizia lophantha
Alnus glutinosa
Amorpha fruiticosa
Bossiaea aquafolium
Bossiaea lynophylla
Colutea arborescens
Daviesia cordata
Dodonea vicsosa
Eleagnus augustifolius
Cornus spp.
Lupinus spp.
Rhagodia preissii
Medicago arborea
Teucrium fruticans.

There are many more species of shrubs and trees which have been observed to be palatable to stock, but about which little is known of their feed value. These have not been included in this publication, but some *Acacia* and *Bossiaea* species warrant investigation.

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