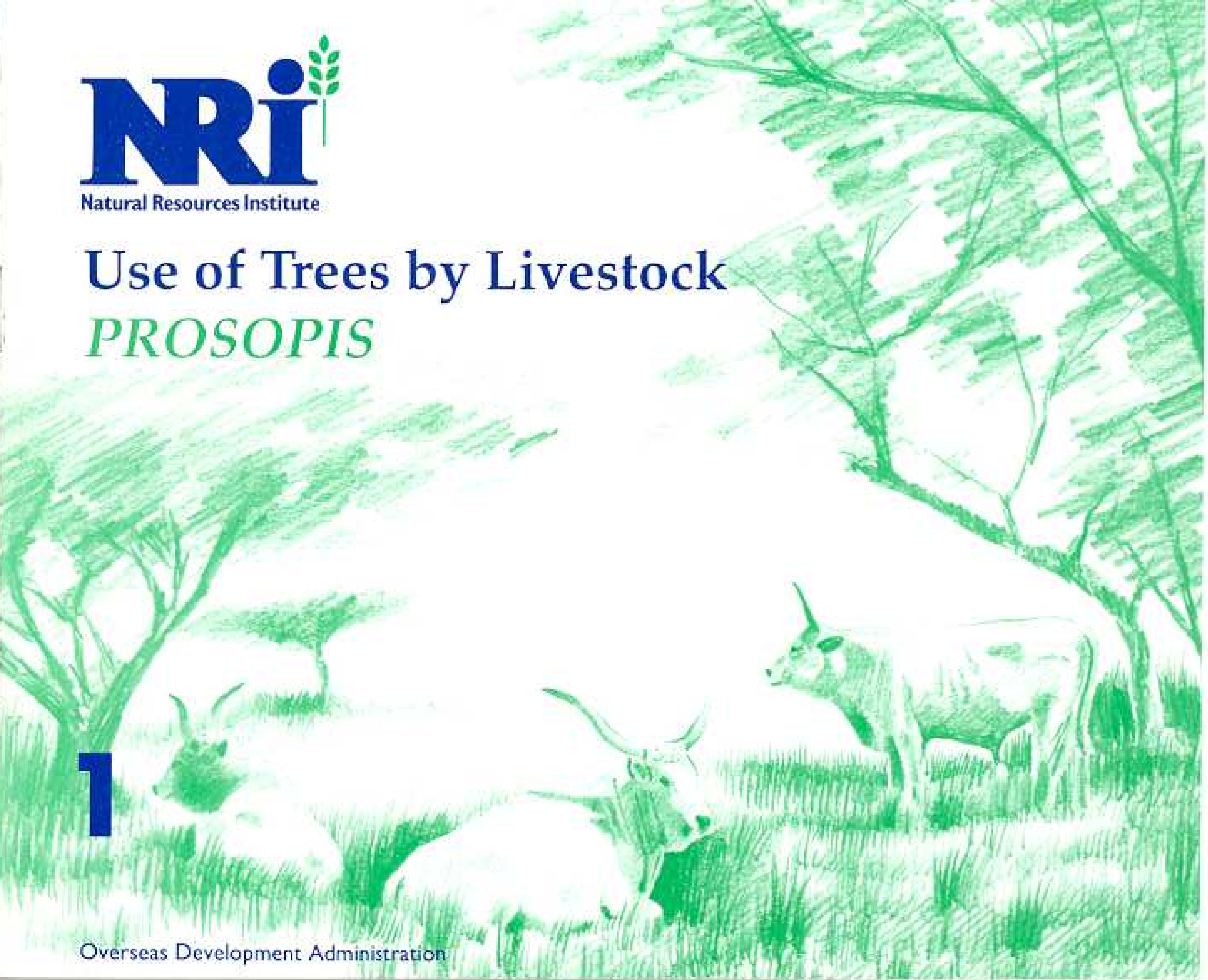
Natural Resources Institute

Use of Trees by Livestock

PROSOPIS



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PROSOPIS

Overseas Development Administration

Use of Trees by Livestock
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N.J.L. Clinch, J.J. Bennison and R.T. Paterson

Natural Resources Institute

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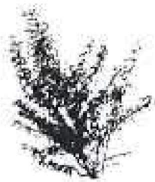


Contents

Foreword

The importance of trees and shrubs in feeding animals in the tropics and sub-tropics has long been recognized by livestock owners. In arid areas where the growth of herbaceous plants is limited by lack of moisture, leaves and edible twigs of trees and shrubs can constitute well over 50% of the biomass production of rangeland. At high altitudes, tree foliage may provide over 50% of the feed available to ruminants in the dry season, branches being harvested and carried to the animals. Even in regions of higher rainfall where grass supplies the major proportion of the dry matter eaten by ruminants, tree leaves and fruits can form an important constituent of the diet, particularly for small ruminants.

In the last two decades interest in planting trees as a source of feed for livestock has been encouraged by workers in research and development, but in contrast to the hundreds of indigenous species which are used as fodder, attention has focussed on a limited number of introduced species. Thus there are many publications reporting the chemical composition of *Leucaena leucocephala* leaves and suggesting management strategies for utilization of the tree for fodder, but it is more difficult to find information on alternative genera which might be equally, or more appropriate.

The aim of this series of publications is to bring together published information on selected genera of trees which have the potential to increase the supply of fodder for ruminants. Each booklet summarizes published information on the fodder characteristics and nutritive value of one genus, with recommendations on management strategies, where available. Further, since the leaves of woody species frequently contain secondary compounds which may have an anti-nutritional, or toxic, effect, a separate booklet summarizes the effects of a number of these compounds. It is hoped that the booklets will provide useful resource material for students, research and extension workers, interested in promoting the use of trees as a source of fodder for ruminants.

Margaret Gill
Livestock Production Programme

Genus *Prosopis*

Family LEGUMINOSAE
Subfamily MIMOSOIDEAE
Tribe ADENANTHEREAE
Subtribe FABACEAE

Principal species

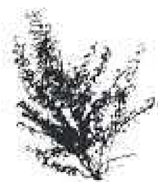
Prosopis africana
Prosopis alba
Prosopis articulata
Prosopis caldenia
Prosopis chilensis
Prosopis cineraria
Prosopis flexuosa
Prosopis glandulosa
Prosopis juliflora
Prosopis nigra
Prosopis pallida
Prosopis tamarugo
Prosopis velutina

Main common names

Mesquite (North America)
Algarrobo (South America)
Khejri (India)

Summary

Prosopis includes species that are extensively used, or have great potential in arid and semi-arid regions for a multitude of purposes. There are, however, constraints to their inclusion in agroforestry systems. While the fruits are valuable feeds for man and his livestock, anti-nutritive factors, particularly the presence of tannins and alkaloids, have been reported and some species have the potential to become noxious weeds. Nevertheless, remarkable tolerance of heat, drought and soil salinity, the ability to recover from severe defoliation and a wide range of uses are attributes that place the genus amongst the most promising plants for reafforestation and development of harsh, tropical regions.



Description and distribution

Prosopis is a genus of sub-tropical trees and shrubs, many of which are armed with prickles, or straight, stout spines. The leaves are bipinnate, tending to drop under the influence of severe climatic stress. The flowers are small and greenish white in colour. Pods, which show little tendency to shatter, are often formed in clusters and contain a sweet pulp surrounding each seed. This is attractive to both humans and livestock. The wood is close-grained and heavy and the root system extensive. The genus is well adapted to arid and semi-arid regions, where it is favourably regarded for rehabilitation of land that would otherwise remain economically worthless (NAS, 1979).

Species delineation is confused by synonymy and variable forms, but 44 species are generally recognized. While centres of origin appear to be in South America and India, the genus is now widespread throughout sub-tropical North and South America, Asia and Africa but uncommon in Europe and Australia (Allen and Allen, 1981).

Within North America, where *Prosopis* spp. are commonly known as mesquite, *P. glandulosa* and *P. velutina* have potential to become devastating weeds. These species are sometimes confused with *P. juliflora*, which shows much promise as a multi-purpose tree for arid regions. In some areas, mesquite leaves and pods are major sources of forage for a range of livestock and indigenous animals during the dry season (Skerman *et al.*, 1988).

In South America, *P. chilensis* is widespread, extending southwards into Chile and Argentina. With other species such as *P. alba*, *P. flexuosa* and *P. nigra*, it is known by the general term algarrobo, and is considered to be a vital part of agrosilviculture and pastoral land use systems in the semi-arid regions of Argentina (Marmillon, 1986).

P. cineraria (khejri) is native to Arabia, Iran, Afghanistan, Pakistan and India and is worshipped by the people of the Thar desert, who value it as a famine food (Harris *et al.*, 1989). It has been described variously as the most important top-feed (browse carried at a height well above ground level) for all livestock in the desert areas of Asia (Bohra, 1980), and as an unexploited treasure of the Thar desert (Jatasara and Paroda, 1981).

P. africana is native to parts of North, West, Central and East Africa but is mainly used as a durable hardwood for furniture and construction and for charcoal (Dalziel, 1948; Booth and Wickens, 1988). *P. chilensis* has been introduced into West Africa and *P. juliflora* is now naturalized in India, West Africa and the Sudan, where it prefers soils with a shallow water table, or a coastal climate (Le Houerou, 1980).

Fodder Characteristics

Prosopis is recognized as an important source of fodder for all livestock species in arid and semi-arid environments, although there are conflicting reports regarding the palatability and nutritive value of the leaf material. Representative data for proximate and fibre analyses are shown in Table 1. In India, Parthasarathy (1986) found that leaves of *P. cineraria* were well accepted by weaner kids (daily voluntary dry matter (DM) intake of up to 4.3% of bodyweight), but that animal performance was limited by low digestibility, possibly due to excessive lignification of the twigs and leaves. Lyon *et al.*, (1988) considered that the leaves of *P. alba, P. articulata, P. chilensis, P. nigra, P. velutina* and *P. velutina* var. Ruby were suitable sources of forage. Conversely, NAS (1979) suggested that the major contribution of the genus was in terms of pod production and that where leaves were consumed, this could be seen as an occasional bonus. This view appears to be shared by both Ibrahim and Gaili (1985), and Abdelgaabar (1986), who classed *P. chilensis* foliage as unpalatable. The latter author went so far as to suggest that supplementation with this forage source should consist entirely of pods. Leaf acceptability varies with species and possibly also with geographic location. Le Houerou (1980) described *P. juliflora* as moderately palatable, while Toutain (1980) noted that *P. chilensis* was not appreciated greatly by livestock and *P. africana* was occasionally appealing. Nevertheless, Le Houerou, (1980) recommended lopping systems of management for *Prosopis* spp. and classed *P. cineraria* as an important source of top-feed during lean months in the more arid parts of Asia. In the Rajasthan area of India, leaves of *P. cineraria* are collected in the period from February to March for feeding later in the year (Bhandari *et al.*, 1979). The leaves have a relatively high crude protein content (15-16%), although the digestibility is usually low.

Prosopis pods have long been recognized as feed for both humans and livestock. Harden and

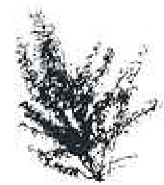


Table 1 Proximate and fibre analyses for genus: *Prosopis*

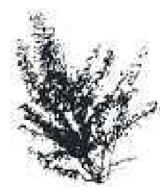
	Dry matter %	Crude protein	Crude fibre	Ash (% of dry matter)	Ether extract	NFE	NDF	ADF
Prosopis africana SEED								
No. of data	0	1	1	1	1	0	0	0
Mean		**16.0**	**7.6**	**3.4**	**1.7**			
Prosopis chilensis FRUIT								
No. of data	1	3	3	3	3	3	1	1
Low	94.6	7.6	22.3	3.4	1.1	52.6	32.7	27.1
High	94.6	13.7	27.9	5.4	2.2	56.5	32.7	27.1
Mean	**94.6**	**10.9**	**25.4**	**4.2**	**1.7**	**54.4**	**32.7**	**27.1**
Prosopis chilensis LEAVES								
No. of data	1	4	4	4	4	3	1	1
Low	90.7	13.5	19.9	1.5	1.4	41.5	54.4	46.8
High	90.7	28.4	37.3	9.9	9.2	46.0	54.4	46.8
Mean	**90.7**	**21.1**	**27.2**	**6.1**	**4.4**	**43.9**	**54.4**	**46.8**
Prosopis cineraria LEAVES								
No. of data	2	18	3	3	3	3	17	17
Low	89.6	9.9	14.6	6.2	2.7	52.8	41.0	32.2
High	92.8	21.9	22.6	10.1	4.3	57.2	64.3	49.3
Mean	**91.2**	**15.9**	**19.6**	**8.2**	**3.4**	**54.4**	**59.1**	**40.6**
Prosopis glandulosa SEED								
No. of data	1	1	0	1	1	1	0	1
Mean	**92.5**	**39.3**		**3.6**	**4.1**	**52.2**		**7.0**
Prosopis juliflora FRUIT								
No. of data	3	4	4	3	3	3	0	0
Low	84.3	8.7	17.9	4.5	2.2	52.0		
High	94.4	13.0	27.0	5.4	4.0	58.9		
Mean	**90.4**	**11.5**	**22.7**	**5.0**	**2.9**	**55.0**		

continued

	Dry matter %	Crude protein	Crude fibre (% of dry matter)	Ash	Ether extract	NFE	NDF	ADF
Prosopis juliflora LEAVES								
No. of data	1	2	2	2	2	2	0	0
Low	42.8	19.0	21.0	8.0	2.0	47.9		
High	42.8	19.0	21.6	8.5	2.9	48.0		
Mean	**42.8**	**19.0**	**21.3**	**8.3**	**2.5**	**48.0**		
Prosopis tamarugo SEED								
No. of data	1	1	1	1	1	1	0	0
Mean	**90.8**	**27.3**	**10.8**	**6.1**	**5.3**	**50.5**		
Prosopis tamarugo FRUIT								
No. of data	3	3	3	3	3	3	1	1
Low	91.6	10.5	29.7	3.8	0.5	44.8	54.4	46.8
High	96.7	13.3	34.2	6.4	1.7	49.9	54.4	46.8
Mean	**94.2**	**11.8**	**32.1**	**4.9**	**1.2**	**47.3**	**54.4**	**46.8**
Prosopis tamarugo LEAVES								
No. of data	3	3	3	3	3	2	1	1
Low	43.7	10.0	10.7	9.8	1.3	45.9	31.2	24.8
High	90.5	15.6	15.2	22.0	1.9	52.9	31.2	24.8
Mean	**74.8**	**12.2**	**13.2**	**14.7**	**1.6**	**49.4**	**31.2**	**24.8**

NFE - Nitrogen free extract
NDF - Neutral detergent fibre
ADF - Acid detergent fibre

Sources Joshi, (1985); Upadhyaya, (1985); Sehgal, (1984); Harden *et al.*, (1988); Bhandari *et al.*, (1979); Le Houerou, (1980); Habit *et al.*, (1981); Duke, (1981).



Zolfaghari (1988) report that whole pods contain 9-17% crude protein, 13-31% sucrose and 17-31% crude fibre (see Table 1).

Pods are produced hanging on small stalks in clusters of up to 12. Usually about 20 cm long, they are either flat or coiled into a spiral. They contain several seeds embedded in a sweet, dry, yellow pulp. The amount of pulp, which is principally sucrose, varies between individual trees. NAS (1979) noted that cattle, sheep, mules, donkeys, goats and wildlife all consume them avidly. Pods may be produced twice per year, but estimates of the feeding efficiency and digestibility vary widely.

While steers on over-grazed pastures in semi-arid areas of South America lost liveweight, supplementing their diet with mature pods of *P. caldenia* with a DM digestibility of 63.8% resulted in weight gains (Menvielle and Hernandez, 1985). Pods of *P. juliflora* were successfully used to replace wheat bran at varying levels in diets for crossbred calves and lambs. Incorporation affected neither nutrient digestibility of rations nor balances of nitrogen, calcium and phosphorus. No significant differences were reported either for average daily gain, feed intake, feed efficiency or carcass characteristics (Rao and Reddy, 1983). In contrast, when desert Sudanese goats were fed on crushed pods of *P. chilensis*, cottonseed meal and wheat bran in differing proportions, intake, liveweight gain and dressing-out percentage all decreased linearly with increasing proportion of pods. A bitter taste was noted, which may have contributed to the low intake (Ibrahim and Gaili, 1985).

It is generally accepted that *P. tamarugo* fruits are a reasonably good feed for ruminants, but in two trials with eight Merino sheep in Chile, individual estimates of digestibility ranged from 37.7 to 60.1% for crude protein and from 32.8 to 46.3% for crude fibre (Habit *et al.*, 1981). The wide variation between animals could be due to some seed passing undigested through the gut. Punj (1988) saw this as a major problem and recommended development of suitable processing technologies.

Published analyses of the mineral and amino acid composition of *Prosopis* tend to be restricted to those species which are eaten by humans in the Americas. Some data are presented in Table 2. They appear to show a generally satisfactory profile, although total sulphur-containing amino acids could be limiting (Felker and Bandurski, 1979; Harden and Zolfaghari, 1988).

Table 2 Amino acid composition of *Prosopis* seeds and pods

Species and part	% N	Val	Thr	Leu	Ileu	Met + Cys	Phe + Tyr	Arg	Try	His
				(g/16 g N)						
P. chilensis Seed	11.0	3.9	2.4	6.9	3.5	1.7	7.3	10.3	3.3	2.6
P. juliflora Seed	9.6	3.2	2.1	7.1	3.5	1.1	7.2	11.7	3.3	1.3
P. glandulosa Seed	6.3	4.4	3.0	7.7	3.2	2.8	6.3		0.8	
P. glandulosa Pod	1.1	5.9	3.3	8.7	3.3	2.2	5.4		0.8	

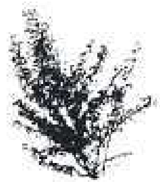
Key to amino acids

Val	Valine
Thr	Threonine
Leu	Leucine
Ileu	Isoleucine
Met + Cys	Methionine plus Cysteine
Phe + Tyr	Phenylalanine plus Tyrosine
Arg	Argenine
Try	Tryptophan
His	Histamine
N	Nitrogen

Sources

Felker and Bandurski (1977)

Harden and Zolfaghari (1988)



Anti-nutritive factors

Harden and Zolfaghari (1988) reported that green and ripe *Prosopis* pods were used as food for both humans and animals. Gohl (1981), however, stated that green pods were bitter, with little feed value and that only ripe pods were relished by stock. Gohl went on to state that stock poisoning had occurred when *P. juliflora* pods were eaten after being exposed to rain. NAS (1979) noted that cattle fed on an exclusive diet of pods of *P. pallida* and *P. glandulosa* became malnourished and developed jaw and tongue troubles which caused difficulty in chewing and resulted in weight losses. The anti-nutritive factors in pods are not well understood but it would seem prudent to balance a pod-based diet with other feedstuffs where possible.

There is some evidence that certain parts of *P. africana* contain the alkaloids prosopine and prosopinine (Booth and Wickens, 1988), although it is not certain that these compounds have an anti-nutritive effect on ruminants. Dalziel (1948) reported that the bark of *P. africana* trees in east Sudan contained 14-16% tannin, capable of giving a reddish brown colour to both leather and cloth. Tannin is recognized as an anti-nutritive factor when fed to ruminants at concentrations above about 5% (McLeod, 1974).

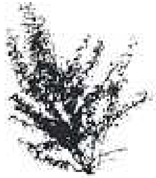
Tannins are also present in the leaves of certain *Prosopis* spp. including *P. cineraria*, *P. juliflora* and *P. glandulosa* and there are a number of reports of the negative effects of tannins on DM and crude protein digestibility (Bhandari *et al.*, 1979; Kumar, 1983; Upadhyaya, 1985; Lyon *et al.*, 1988 and Holechek *et al.*, 1990). Kumar (1983) observed that low crude protein digestibility of *P. cineraria* had been attributed to the presence of high levels of tannins. The low *in vitro* digestibility of crude protein (32.8% for a crude protein content of 13.7%) appeared to be due to the presence of condensed tannins, estimated with a vanillin-HCl assay to be 160 mg/g, with a protein precipitating capacity of 10.6%. Further reports of low digestibility values for crude protein (average 30.2%) were attributed to the high content of tannins and structural carbohydrates in the leaves. Lyon *et al.*, (1988) negatively correlated *in vitro* digestibility with phenolic content of various species of *Prosopis*. Livestock deaths have also been linked with consumption of *Prosopis* leaves with a high tannin content (Kumar, 1983).

Thus, especially with *P. cineraria*, it is clear that *Prosopis*, one of the most abundant and important top-feeds of desert regions, is both poorly digestible and occasionally causes stock losses. There are a number of possible explanations for these observations. Firstly, the levels of tannins in the leaves of *Prosopis* vary considerably. Sehgal (1984) reported tannin levels of 2.18%, measured by the Folin-Denis test, while in an examination of 15 individual trees, Joshi *et al.*, (1985) found levels ranging from 10.6 to 25.3%. The latter authors did not record the analytical procedures used to determine the tannin contents and it may be that their data are not directly comparable with those of Sehgal (1984). Nevertheless, they serve to demonstrate extreme variability between the foliage from individual trees. Newly emerging leaves had a higher tannin content than older ones, showing greater phytochemical protection for the structures which are of most importance in plant survival. Secondly, environment and stress on the plant are thought to play a part in tannin concentration, although Vaithiyanathan and Singh (1989), while noting seasonal changes in the tannin contents of top-feeds in the arid region, failed to relate this to temperature variation. Lastly, *Prosopis* is not necessarily suitable as a sole feed for livestock. Some of the *in vivo* digestibility trials reported in the literature have used *Prosopis* as the sole feed for small ruminants, but in most on-farm situations, it is likely that animals would self select, or that the fodder would be fed in combination with other feeds. This would dilute the toxic principle and mitigate the more extreme effects.

Management

While *Prosopis* spp. have been traditionally valued in their centres of origin and have been introduced into many new areas, particularly in the arid and semi-arid regions of the world, little is known about appropriate browse management practices to optimize animal productivity. The genus has a recognized capacity for recovery from severe injury such as lopping (Booth and Wickens, 1988), but lopping is not necessarily the best way to achieve optimum sustainable productivity of high quality forage, especially in those species where the foliage is less palatable than the fruit.

In the absence of comparative data, the following establishment and management practices employed



with *P. tamarugo* in a reafforestation programme in the Tamarugal Pampa sector of the Atacama desert in Chile (Habit *et al.*, 1981), are presented as practical examples of techniques which may be suitable for other species of *Prosopis*.

Seed production

There are wide differences between individual trees in terms of phenotypic characteristics. Selection of the seed producers is, therefore, of great importance. The mature pods are ground in a stone mill set at 4 mm and clean seed is obtained by sieving and flotation. Insects attack seed if it is not treated with 0.2% Aldrin solution or an equivalent, prior to storage.

Seed germination

Scarification is necessary to promote germination. Sulphuric acid has been used in Chile, although other authors suggest scalding, or treatment with giberellic acid (Booth and Wickens, 1988).

Seedling production

A potting mixture of two parts of soil to one part of sheep manure has been used to raise seedlings. Fumigation with methyl bromide, or treatment with fungicides prior to sowing reduces seedling mortality. Seeds are sown to a depth of 1.5 cm and carefully watered to avoid accumulation of water in the lower level of the soil. In pots or plastic bags 30 cm deep, seedlings are grown for a period of three to five months, when they are 8 to 10 cm tall. Roots grow faster than shoots and care must be taken to avoid them growing out of the bags.

Planting out

While spacings ranging from 6 x 6 m to 13 x 13 m have been tested, current plantings are carried out either at 10 x 10 m in square, or at the much lower density of 15 x 15 m in triangular formation. Closer spacing results in faster cover but this is offset by higher costs, particularly in watering, which is of vital importance in the desert environment. Within this range of tree densities, closer spacing produces faster canopy closure but appears to have little effect on forage yield of the mature forest.

Pruning

The abundant growth of thorny, basal branches necessitates pruning at between four and six years of age, to allow animal access to the forage which falls from the trees. In Chile, this is done by hand, using a sickle.

Utilization

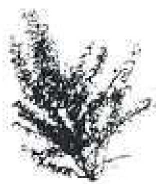
Animals are allowed free access to the established area once the first crop of pods has fallen, about seven years after planting. All classes of livestock tend to pick up fallen leaves and pods, rather than to browse the growing herbage.

Productivity

Productivity of *P. tamarugo* is linked to age, plant spacing, depth and quality of groundwater and land preparation prior to planting. In Chile, trees reach their mature heights of about 10 m at some 24 years of age. Fruit production starts at about seven or eight years and increases steadily with tree height. After year 24, it continues to increase at a declining rate until it reaches its maximum at about year 35. Leaf production starts earlier but also increases to about year 35, by which time annual production of forage DM is about 190 kg/tree (Robertson, 1980), split equally between fallen leaves and fruits. Estimates of available forage related to the area of foliar projection on the soil surface range from 0.75 to 3.4 kg DM/m^2 for young (10 years, Robertson, 1980) and mature (30 years, Habit *et al.*, 1981) trees, respectively. Conservative estimates would suggest that in a relatively closed forest, yields of 10 t/ha DM would not be an unrealistic goal (Felker and Bandurski, 1979), and that this quantity would support about 12 sheep/ha on a year-round basis. Felker *et al.*, (1984) indicated, however, that there was considerable variability in pod production, both between and within accessions, suggesting scope for selection and possibly even breeding to increase forage productivity.

Alternative uses

The benefits to be derived from the nitrogen-fixing ability of leguminous plants are well known and species of *Prosopis* are no exception. They are usually found growing in soils with poor nitrogen status where their leguminous nature allows them to thrive. Members of the genus have a variety of uses and, indeed, *P. cineraria* has been classed as a genuinely multipurpose tree (Leakey and Last, 1980) providing firewood, timber, fodder, soil improvement, shelterbelts, edible fruit, medicines, bee forage, sand-



dune stabilization and extractable tannins and edible gums.

The pods are an important source of human food. In the semi-desert regions of S. America, mature *Prosopis* pods are used to prepare a sweet, floury paste considered a valuable food, particularly for children. The sugary pulp from the pods can be fermented and distilled to produce ethyl alcohol. Green and ripe pods of *P. cineraria* are consumed in India. The green pods are used in curry dishes or are dried and preserved, while the pulp of mature pods is eaten by children (Harden and Zolfaghari, 1988).

The wood is highly valued, being compact, close-grained, heavy, and resistant to borers, termites and general decay. It is used for implement handles, walking sticks, floors, posts, barrels, cabinets and larger constructions. All species are used as firewood and *Prosopis* is renowned as an excellent, slow-burning charcoal (Allen and Allen, 1981; Habit *et al.*, 1981; Booth and Wickens, 1988).

The bark of various species contains substantial quantities of mesquite gum, which resembles gum arabic, has emulsifying properties and is an excellent mucilage. Tannins are also present in concentrations that justify commercial extraction (Allen and Allen, 1981).

Crane (1975) included *Prosopis* spp. amongst the very drought-tolerant, tropical plants in her classification of important world honey sources. The nectar gathered from these trees is purported to yield a honey of superior flavour (NAS, 1979), while the bark can be used to make beehives (Booth and Wickens, 1988).

In Africa, the wood of *P. africana* was traditionally credited with soporific properties (Dalziel, 1948), while the macerated leaves were thought to ensure male fertility (Uphof, 1968). Nearly all parts of the tree are used in local medicines (Booth and Wickens, 1988). Young roots are used as a diuretic and to treat dysentery, while the vapour from boiling them is used against bronchitis and to control vermin. The bark is used to make a mouthwash to alleviate toothache and an eyewash to treat opthalmia. Dried, powdered bark is used against leprosy, orchitis, rheumatism, dermatosis and fever and to heal wounds, while the leaves are used to treat head, eye, ear and tooth troubles, or as a bath for the treatment of migraine and vertigo. Broun and Massey (1929) reported that dried and crushed pods or fruit husks of *P. africana* were used as a fish poison.

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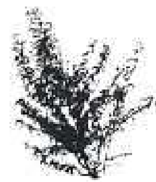

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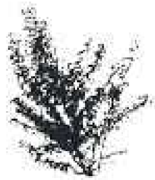

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