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Useful Trees of the Tropical Region of North America

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SEMARNAP

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PROSOPIS *Spp.*

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Synonyms: There are no Latin synonyms.
Common names: mesquite (United States), kiawe (Hawaii), bayahonda (Haiti), cujuy (Venezuela), algarrobo (Argentina and Chile).

Introduction

Prosopis are nitrogen-fixing trees and shrubs that are adapted to semiarid and arid regions. Taxonomists agree that the systematics of *Prosopis* are most difficult due to naturally occurring interspecific hybridization that results in hybrid swarms with intermediate morphological characters. The taxonomic confusion has been compounded by the introduction of additional *Prosopis* species to the semiarid regions of Africa, Asia, and Latin America where new hybrids have occurred. *Prosopis* has been extensively used by native peoples in India and the deserts of the Western Hemisphere for the pods and fuelwood, while it has been detested by some ranchers in the southwestern United States and South Africa for invading their pastures.

Due to the worldwide taxonomic confusion and the controversial nature of the utility of *Prosopis*, this article will attempt to provide an overview of the most important weedy and utilitarian *Prosopis* species.

Description

The largest subtropical *Prosopis* (principally *P. alba*, *P. chilensis*, *P. hassleri* and *P. nigra*) occur in Argentina and may be 15 m tall with trunk diameters of about 1 m (Burkart 1976). Exceptional specimens with 1.5- to 2.0-m basal diameters exist. The largest North American specimens (*P. glandulosa*, usually found in south Texas) are typically about 10 m tall with trunk diameters of about 60 cm. Open grown trees frequently have large low lying limbs that may touch the ground. Under arid conditions, mature stands may occupy only 30 percent of the ground surface area, possibly due to difficulty in seedling establishment. It appears as if arid adapted trees have to capture the site in a horizontal rather than vertical fashion. This extensive branching results in trees with a much smaller height-to-basal-diameter ratio than trees such as pines.

In contrast to arboreal *Prosopis* species, there are shrubby species in Argentina (*P. strombulifera* and *P. denudans*), the United States (*P. glandulosa* var. *prostrata*), and North Africa (*P. farcta*) that are less than 2 m tall and often spread by root suckers or underground rhizomes (Burkart 1976). Much of the mesquite in New Mexico and far west Texas is multistemmed, less than 3 m tall, and does not have the genetic potential to grow into a tree (Felker and others 1983). Perhaps high grading by earlier settlers contributed to this growth form.

Some *Prosopis* with the genetic potential to become trees may not do so because of aridity or because they are mechanically shredded using tractor-powered mowing machines in land clearing operations. For example, if the annual rainfall is less than 70 mm and the groundwater is deeper than 15 m, *P. glandulosa* var. *torreyana*, with the genetic potential to be a tree, will only be a 2-m tall shrub (Meinzer 1927).

In nearly all of the species, the leaves are pinnately compound with the number of leaflet pairs ranging from 6 to 50 per pinnae. There may be up to five pairs of pinnae per leaf. The regular small flowers have a 5-parted corolla and are clustered into ball-shaped (about 3 cm in diameter) or slender (about 10 cm long) catkins (Simpson 1977). The fruits are indehiscent and usually range from 10 to 25 cm long, 7 to 20 mm wide, and vary in color from purple to straw yellow (fig. 1). The fruits vary in sugar (mainly sucrose) content from 10- to 40-percent sucrose and in protein content from 9 to 17 percent (Oduol and others 1986). The dry fruits fall from the tree at maturity and are readily eaten by nearly all animals.

Habitat

Geographic range, Climate, and Topography. Some broad concepts are helpful in understanding the genus. *Prosopis* is a primitive genus, as exemplified by the presence of native species in Africa, Asia, and the New World. Burkart (1976) believed these species spread from east to west at the end of the Mesozoic or the beginning of the Tertiary period (about 60 million years ago) when land connections were more prevalent.

In the Western Hemisphere, *Prosopis* extends from the subtropical deserts of California (37 degrees N latitude in Death Valley), along the western dry coastal corridor of Mexico to tropical Mexico and Central America, Colombia, Northern Venezuela, Ecuador, and Peru. In South America, the first frost hardy species (*P. tamarugo*, *P. flexuosa* and *P. alba*) occur in the deserts of northern Chile. These species also occur at elevations of nearly 3,000 m in Chile at San Pedro D'Atacama on the Bolivian border. There the *Prosopis* distribution transverses the Andes to the high elevation (2,400 m to 3,700 m) northwestern Argentina deserts (Puna) where *P. ferox* exists (Burkart 1976). Nearly subtropical *P. alba* species occur in the lowland, low latitude deserts of Argentina in the Chaco, but cold hardy species exist as far as 48 degrees S latitude in Patagonia (Burkart 1976).

Prosopis dispersal is dependent on man and his animals eating the pods and disseminating the seeds along their travels. Perhaps prehistoric man stimulated the dispersal of *Prosopis* along the dry western corridor of North, Central, and South America that led to speciation along this route.

When the *Prosopis* from Hawaii, Senegal and Peru were grown in temperate regions (i.e., Texas and California), they did not lose their leaves with the onset of cool weather, as did the temperate adapted species, and they suffered complete mortality with temperatures of only -5 degrees C (Felker and others 1981). Temperate species that harden off by shedding leaves with the onset of cooler weather would be at a disadvantage in tropical regions where no frost occurs.

The evolution of *Prosopis* in Peru and Ecuador evidently included lack of cold hardiness mechanisms (e.g., no leaf drop) in order to more effectively compete with native vegetation in cooler winter months. Alternatively, New World *Prosopis* may have evolved from the Old World tropical *Prosopis africana*, when Africa and South America were connected, as suggested by Burkart (1976). If this is the case, then the temperate *Prosopis* of North and South America would have had to have evolved from the tropical species by developing freeze hardiness mechanisms.

A religious cross still exists in the town square of Coro, Venezuela that was made from *Prosopis* around 1505 when the first Spaniards landed on the South American mainland (Felker personal observation). It appears that *Prosopis* occurred in Venezuela before the Spanish arrival. Possibly the *Prosopis* in northern Venezuela was spread to the Caribbean Islands via the Lesser Antilles by Indians before the arrival of the Spanish. *Prosopis* specimens nearly 1.2 m in diameter at breast height (1.37 m) that probably predate the arrival of the Europeans occur in Haiti.

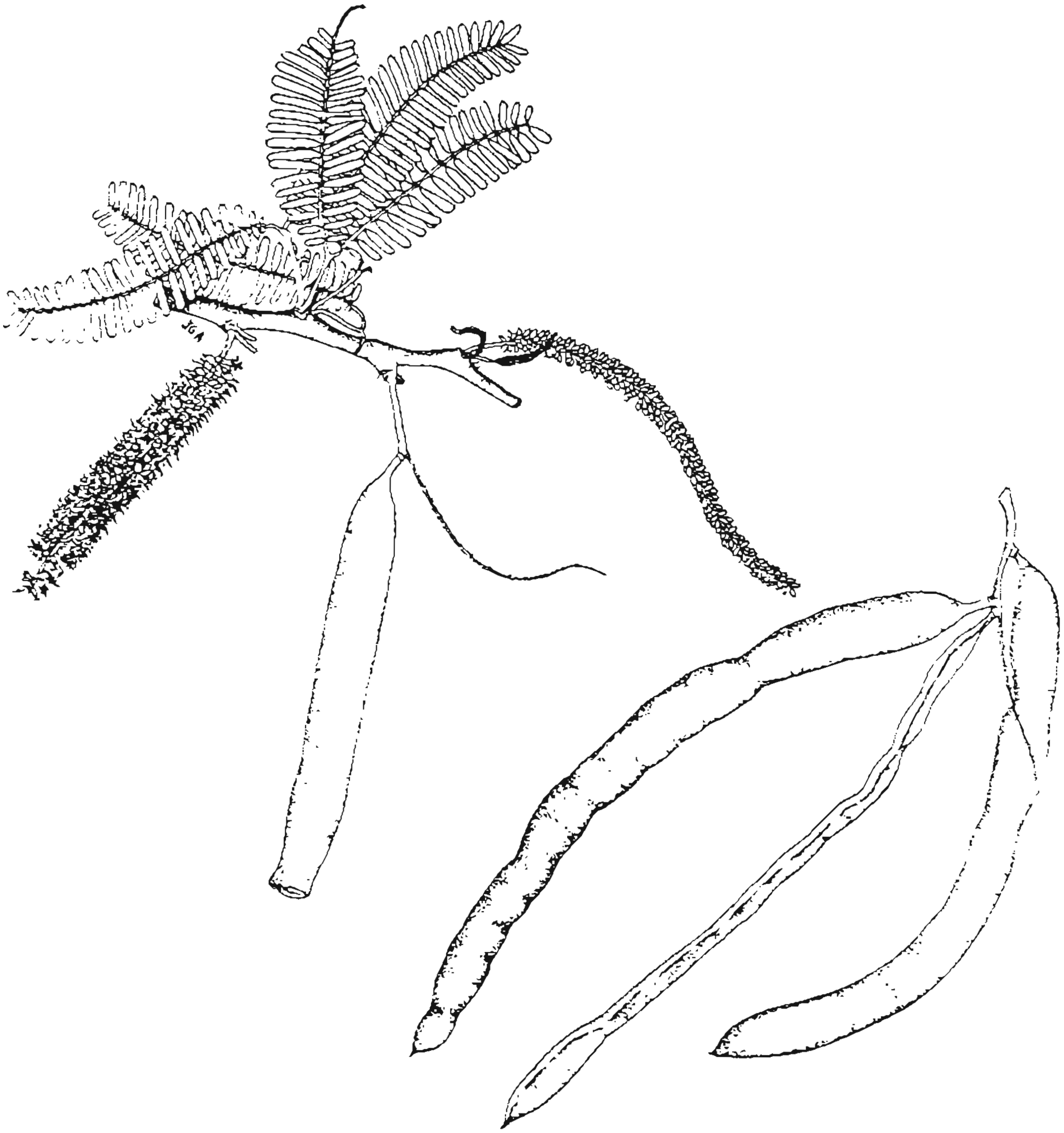

Figure 1. Leaf, flower, and fruit of *Prosopis juliflora*, approximately 2/3 of actual size. (After Little and Wadsworth 1964).

It appears that a center of genetic diversity of truly tropical *Prosopis* occurs in the Caribbean and/or Peru. Furthermore, the truly tropical *Prosopis* found in Hawaii, Senegal, Sudan, India, and Pakistan probably had its origins in this center.

The tropical *Prosopis* of Peru are known for long, sweet pods that have been used to make a syrup-like product known as 'algarrobina' for human consumption (National Academy of Sciences 1979). In 1942, seeds from the Peruvian *Prosopis* were imported into Brazil for cultivation for the dry northeastern region (Reis 1982). The longest pods we have ever observed (about 50 cm) were from the Brazilian *Prosopis*. In 1983, the Brazilian forestry plan called for planting more than 100,000 ha of *Prosopis*.

Tropical *Prosopis* species have become naturalized in semiarid regions, such as Brazil, Senegal, Sudan, Pakistan, and India, where they have been widely used by poor people for fuelwood and animal fodder. While only anecdotal records describe the introduction of these species to new areas (Mohan 1940), the lack of cold tolerance in this group (Felker and others 1981) as well as their leaf and pod morphology strongly suggest a Central American origin. Burkart (1976) describes the original distribution of *P. juliflora* as being 'northern South America (Venezuela and Colombia), Panama, Central America to Mexico, and the Antillean Islands.' He describes subspecies of *P. juliflora* as being indigenous to Ecuador and Peru.

The taxonomy of the tropical *P. juliflora/P. pallida* complex has been widely regarded as the most difficult. It is particularly difficult to distinguish *P. pallida* from *P. juliflora* in Hawaii, Haiti, Pakistan, Senegal, Brazil, and India.

There has been controversy regarding the distribution of the temperate *Prosopis*, known as mesquite in Texas. Considerable folklore suggests that mesquite was brought to Texas from Mexico during the cattle drives in the mid-to-late 1800's. However, the type specimen of *Prosopis glandulosa* was collected on a tributary of the Canadian River in present Union County, New Mexico on August 2, 1820 (Johnston 1962). As the date of collection is considerably before the cattle drives, and as this location is farther north than either Amarillo, Texas or Tulsa, Oklahoma, it is clear that mesquite was native to Texas long before the cattle drives.

Associated Vegetation. *Prosopis* is often associated with other woody legumes such as *Acacia berlanderir, A. rigidula* and *Cercidium floridium*. Nonleguminous perennials such as creosote bush *(Larrea tridentata)*, saltbush *(Atriplex* spp.), and various *Opuntia* species are commonly associated with *Prosopis*. There appears to be a strong selectivity in grass species associated with *Prosopis*. In Texas and Puerto Rico, *Setaria texana* and *Panicum maximum*, respectively, appear to occur primarily under, rather than outside of, the canopies of *Prosopis*.

Life History

Pollination, Flowering, and Fruiting. *Prosopis* flowers are one of the richest sources of nectar in the desert (Simpson 1977) and therefore it is not surprising that *Prosopis* are insect-pollinated. Under natural conditions, *Prosopis* will flower and set seed after about 3 years. Flowering first occurs in the spring (April and May in Texas) but continues as late as October if warm temperatures and rainfall occur. Both fertile pollen and ovules are contained in the same *Prosopis* flowers but due to the presence of self-incompatibility, the flowers are obligately outcrossed (Hunziker and others 1986). Fertility barriers between North and South American species such as *P. glandulosa* and *P. alba* are very low with the result that natural interspecific hybrids have formed naturally where these species were grown together. As a result of this obligate outcrossing, variability in progency is extremely high for many important characters. Therefore, intensive efforts have been made to develop asexual propagation methods. To date, the only reliable method of asexually propagating *Prosopis* is by rooted cuttings (Klass and others 1984).

The fruit is an indehiscent pod that may vary in length from 10 to 50 cm. In a survey of *Prosopis* species and families, Oduol and others (1986) found the pod to vary in protein from 10 to 17 percent and the sugar to vary from 10 to 40 percent. They also found that the protein and sugar content were similar for the same half-sib families over 3 years at two sites. The entire pod may contain as much as 44 percent sucrose (Averginos and Wang 1980).

Seed Production, Dissemination and Reproductive Behavior. In order for mesquite seeds to germinate, they must be mechanically scarified. Scarification usually occurs when animals chew the high sugar content pods. Seed weevils are killed as the scarified seeds pass through the animals' alimentary tract. Germination occurs rapidly in the high moisture content, high fertility feces. Since the animals may walk considerable distances between the time of ingestion and excretion of the seeds, this serves to disperse the seeds. Young seedlings do best when very little vegetative cover is present, such as after overgrazing. Overgrazing also depletes the fertility of the soil so that nitrogen-fixing *Prosopis* can more effectively compete with non-nitrogen fixers on low fertility arid sites.

Tolerance to Environmental Factors. *Prosopis glandulosa* from Amarillo, Texas has tolerated -18 degrees C without damage while *Prosopis juliflora* from Peru has been killed by temperatures of only -4 degrees C (Felker and others 1981). Most of the arboreal *Prosopis* species from Argentina will tolerate -9 degrees C but not -14 degrees C without being killed nearly to ground level. *Prosopis* occur naturally in the hottest deserts of North America (Death Valley, California--absolute maximum of 55.6 degrees C) and South America (Santiago del Estero, Argentina--absolute maximum of 46.7 degrees C).

Most *Prosopis* grow on soils with a pH from 6.5 to 8.3 with little difficulty. Surprisingly, Indian *Prosopis juliflora* have been able to withstand a pH of 10.3 if amendments of gypsum, zinc, and barnyard manure were provided (Gill and Abrol personal communication 1986). Some *Prosopis* species are highly tolerant of salinity, and in the greenhouse some species have been able to withstand irrigation with the same salinity as seawater (Rhodes and Felker 1987). *Prosopis* has been observed in areas that are periodically inundated by seawater, between the mangroves and the ocean, in Haiti (Felker unpublished observations).

Stocking. Natural stands of mesquite may vary in density from more than 10,000 young trees/ha of 3-5 cm basal diameter to about 40 mature trees/ha with basal diameters of about 40 cm. In the past, when dense stands of small trees became established, ranchers bulldozed the entire stand which only served to further scarify the site, and within about 15-20 years the dense young stands had reoccurred.

Felker and others (in press) found a highly significant negative logarithmic relation between stand density and basal diameter per tree. They concluded that natural mortality led to self-thinning and that the best long-term solution to high density mesquite stands, impenetrable to cattle, lies in thinning them to produce selected crop trees for lumber. These large trees would also contribute to soil fertility, pod production for domestic stock and wildlife, and provide competition to prevent dense young seedlings from becoming established.

Rotation Age. Native stands are not currently being managed on a rotation for lumber. However, *Prosopis* can be quite old. Burkart (1976) has suggested that some large trees in Argentina are more than 400 years old.

Natural Enemies. Several insects cause substantial damage to *Prosopis*. The mesquite cutworm (*Melipotis indomita*) feeds on the foliage at night, migrates down the trunk just before dawn, and hides in the ground during the day. These insects may reduce the foliage on mesquites by 95 percent (Parker 1987). The blister beetle (*Epicauta nigritarsus*) severly defoliates *P. glandulosa* in the summer months (Felker unpublished observation). The mesquite twig girdler (*Oncideres rhodosticta*) severs branches about 8 mm in diameter and lays its eggs in the fallen branches (Parker 1987).

Roundhead borers, especially long-horned beetles (Family Cerambycidae), are especially prominent in logs that have been cut (Parker 1987). The galleries of these insects can be found in both the heartwood and sapwood of *Prosopis*, and as they are often 1 cm wide, they greatly reduce the value of the lumber. In a recent pruning of 100 apparently healthy native *Prosopis* (about 10 cm in diameter), it was observed that about 30 percent of the trees had substantial numbers of these long-horn beetles.

Some native Texas mesquites die gradually from a necrosis that begins at the very tip of one of the branches. Gradually, larger and larger branches die (over about 1 year) as the symptoms spread from the top of the tree to the base. It is not known what causes this necrosis, but it has also been observed on *Prosopis* in Argentina (Ulf Karlin, Univ. of Cordoba personal communication 1989).

While *Prosopis* are 100 percent resistant to cotton root rot (*Phymatotricum omnivorum*) (S. Lyda, Dept. of Plant Pathology, Texas A&M Univ. personal communication 1986), there is evidently some root pathogen that kills *Prosopis*. In Chilean and Texan plantations of South American *Prosopis*, healthy trees died if they were next to a dead or dying tree, either in an adjacent row, or in the same row. All the trees in the affected zone were dead, while none of the trees outside of the zone were affected. However, additional trees died as the zone became larger. This 'disease' has not yet been examined by a plant pathologist.

Prosopis from the low humidity regions of Arizona (*P. velutina*) and southern California (*P. glandulosa* var. *torreyana*) are highly susceptible to stem fungal pathogens present in the high humidity environments of the Texas Gulf coast. More than 100 *P. glandulosa* var. *torreyana* trees from an Indio, CA seed source were successfully established in Kingsville but all eventually died from cankers resulting from stem fungal pathogens (*Botryodiplodia* and *Pestalotia*)(Lesney and Felker unpublished observations 1981). The Arizona *P. velutina* did not die but were nevertheless stunted in growth. In contrast, *Prosopis* native to the Gulf Coast were not affected. South American *P. alba* and *P. chilensis* were not affected, but *P. flexuosa* was affected.

Natural Stands and Their Management

Silvicultural Systems. Traditionally, *Prosopis* has been managed by using range management guidelines that called for total elimination of the stand rather than silvicultural techniques. Total elimination has often achieved 'site scarification' that eventually resulted in a denser stand of small trees than was initially present. It now appears as if *Prosopis* intraspecific competition can be used to hold down invasions of dense stands of small mesquites (Felker and others In press). It appears as if a reasonable goal is a stand of 100 trees/ha (10-m spacing) with 35-cm basal diameters. This goal is compatible with grazing, agroforestry, and lumber objectives.

Pragmatically, the first step in achieving this goal is conversion of all trees with multiple stems arising from the base to single stems and pruning for form. When this was done with chain saws in the stand described below, about 25 m^3 of firewood resulted. Since *Prosopis* is in high demand as a barbecue wood, with a retail value of about $20/$m^3$, much of the cost of the thinning can be recovered in the sale of *Prosopis* for firewood or for barbecue cooking.

Conversion Techniques and Cultural Practices. No information is currently available on these topics.

Growth and Yield. Recent Texas studies measured the influence of understory removal and phosphorus fertilization on the growth of mature stands of native mesquite. The understory was removed with hand implements and, in one treatment, brush resprouts were sprayed with trichlopyr in an attempt to kill them. This stand had 193 trees/ha, many of which were multistemmed at the base. The number of stems/ha arising at ground level was 356. The total volume was 20.2 m^3/ha with a corresponding total fresh weight of 48,300 kg/ha . The average basal diameter was 16.4 cm and 93 percent of the trees were less than 25 cm in basal diameter. Permanently mounted verniers were used to measure increases in tree diameters that were translated into weights and volumes by regression equations. Over a 3-year period, the treatment without understory removal or fertilization had the lowest growth of about

420 kg/ha with a corresponding volume increase of 0.19 m^3. The treatment with understory removal had a growth of 570 kg/ha and 0.27 m^3. The greatest growth (630 kg/ha/yr and corresponding to 0.28 m^3/yr) occurred in the treatment with understory removal plus fertilization.

A separate study examined the influence of disking, mowing, and thinning on the growth of a young sapling stand (1,740 trees/ha, corresponding to 8,700 stems/ha) of mesquite. These trees had a mean basal diameter of 3.5 cm and a mean height of about 2 m. The unthinned plots had a mean basal diameter growth of 0.43 cm/yr versus 0.94 cm/yr for plots that were thinned and annually plowed between the trees.

Natural Regeneration. Brown and Archer (1987) recently examined factors that influence natural regeneration of *Prosopis* and found the spread of seedlings in the dung of cattle was essential for seedling establishment. Felker and others (1986) found it essential to eliminate grasses for establishment of transplanted seedlings. It is highly unlikely that mesquite could become established in a dense stand of 60-cm tall grass. Elimination of grass competition for *Prosopis* seedlings by grazing cattle is probably required for successful seedling establishment.

Nursery Practices

Seed Handling and Storage. The ripe pods fall to the ground at maturity. Typically, the seeds are about 10 percent by weight of the pods. Seed weevils (bruchids) rapidly enter the pods, both on the tree and on the ground, and destroy the seeds. If a particular tree is to be used for seeds, is helpful to spray the tree with an insecticide such as malathion 4 to 5 weeks before the pods are fully ripe. Storage of the pods in a freezer will kill the seed weevils and not affect the viability of the seeds.

Due to the high-sugar-content pods and the leathery capsule surrounding the seed, efficient separation of undamaged seeds is difficult. A sharp pair of pruning shears and a pocket knife can be used to separate small quantities of seed (several hundred/hr) without damage. A hand-operated meat grinder with 1-cm diameter holes in the end plate will damage about 30 percent of the seeds and yield about 100 grams of seed per hour. The ground mixture must be sieved or air classified to separate the seed from the chaff. Before grinding, it is necessary to dry the pods at 50 degrees C for a minimum of 8 hours to eliminate the moisture from the sugar in the pods. If the pods are sufficiently dry, a powdery flour will emerge from the grinder. If the pods are allowed to equilibrate with room humidity for as little as 1 hour, they will pick up sufficient moisture to become a sticky mess upon grinding. The seeds are small, about 30,000 seeds/kg.

Germination. If the seeds are hand-scarified by knicking the blunt end of the seed with a knife, 95 percent emergence will occur in 4 days from a depth of 1.5 cm when the temperature is between 30 and 35 degrees C. Viability of most *Prosopis* seeds is usually above 90 percent for periods of 10 years at room temperature. However, there was a substantial decline in the germination of screwbeans (*P. pubescens*) after about 2 years storage at 4 degrees C. Poor success also was experienced with germinating *P. tamarugo* seeds, as the young seedlings die off when they are about 15 cm tall. Recalcitrant *P. africana* seeds were induced to germinate with a 1-hour soak in 200 mm gibberellic acid.

Cultural Practices. Due to the pronounced taproot of *Prosopis* and the limited water availability in semiarid regions, seedlings have been grown in 3.8-cm by 3.8-cm by 38-cm long cardboard plant bands (Monarch Manufacturing Co., Salida, Colorado). The cardboard plant bands were arranged in plastic milk cases with inside dimensions of 30.5 cm by 30.5 cm. It is essential to keep the milk cases off the floor (e.g., on pallets) so that the roots will air-prune. *Prosopis* roots have grown into the ground through black plastic, roofing paper, and asphalt roofing shingles.

A recent comparison was made of the growth and survival of seedlings when cardboard plant bands were left on at planting versus when seedlings were grown in plastic dibble tubes that were taken off at planting. Seedlings in the cardboard plant bands had a 25-percent survival advantage in a dry year but no differences occurred in a more normal year (Felker and others 1988). Thus, the cardboard plant bands have been left on during transplanting.

Because of the large volume of containers, it is essential to use a lightweight soil mix that is devoid of sand. Due to the low pH (3.5) of Canadian peat, builders lime has been added to bring the pH to about 6. The nutrient composition for a complete peat/perlite/ vermiculite nursery mix has been reported by Cline and others (1986).

In the greenhouse, both spider mites (*Tetranychus pacificus*) and psyllids (*Alphalaroida* spp.) can cause serious damage to seedlings. Spider mites can be controlled with a foliar spray of Mavrik or Vendex (the miticide chlorbenzilate will defoliate the seedlings) while psyllids can be controlled with a foliar application of the systemic Orthene. While extreme caution must be used with soil systemics, because of human health hazards, Furadan 10 G provides excellent control of both insects. In contrast to Furadan 10 G, which exhibits almost no phytotoxicity to *Prosopis*, DiSyston is phytotoxic.

Hot greenhouse temperatures are required to grow *Prosopis* (27 degrees C at night and 35 degrees C during daytime). For outplanting in the United States, seedlings should be started in the greenhouse in early fall (October/ November) and planted on the first frost-free date in the spring (March in Texas). After 5 months, the seedlings should be 50 cm tall.

Since glass does not transmit ultraviolet radiation, seedlings will become sunburned, as evidenced by white spots on the leaves, if they are taken directly from a greenhouse to the field for planting. Thus, they should go to an outside hardening-off area several weeks prior to planting.

Lifting and Storage of Seedlings. No information is currently available on these subjects.

Plantation Establishment and Management

Deep tillage in the rainy season prior to planting and constant weed control are key elements in semiarid tree plantings. Research on annual crops in semiarid regions has shown significant correlations between decreased soil bulk density, increased porosity, increased root mass, and increased aboveground biomass (Nicou 1986). While it may be tempting to add 1 liter of water to each plant in the transplanting process, this is expensive and provides only 1,111 l/ha for trees in a 3-m by 3-m spacing. In contrast, tillage practices that save 1 mm over the entire ha provide 10,000 l/ha.

Planting and Spacing. Site preparation begins before the rainy season prior to the season of transplanting, with the objective of capturing as much stored soil moisture as possible. The field is disked, subsoiled at 1-m intervals to assist with rainfall infiltration, and cultivated to keep weeds from using the stored soil moisture. A heavy duty tree transplanter, fabricated from a subsoiler (Felker and others 1984) is used to plant the entire 38-cm long cardboard container.

Several days before planting, a preemergence herbicide--such as oryzalin at a rate of 3 kg/ha or diuron at 1.4 kg/ha--is applied for weed control. Several months after transplanting, the herbicide norflurazon is applied at a rate of 4 kg/ha (Felker and others 1988) since it provides year-long weed control of annual species as well as johnsongrass, nutsedge, bermuda grass, and nightshades.

The tree planter first traverses the field perpendicular to the direction of planting, using a mechanical row marker (similar to that used on row-crop planters) to guide the tractor. This enables the operator of the tree planter to plant trees in a regular grid fashion that allows mechanical cultivation in both directions. Several weeks after planting, sweep cultivators are used over the tops of the seedlings down the rows for weed control. A 3-m-wide disk harrow is used to provide mechanical weed control in the direction of the row and across the rows. In a Texas field trial with no rain 6 weeks before or after planting and no supplemental irrigation, a survival rate of 98 percent was achieved using this system (Felker and others In press).

Short rotations used for fuelwood have employed 3-m by 3-m spacings, the minimum spacing possible with mechanical cultivation. *Prosopis alba* plantings for pod production in a 5-m by 7.5-m row spacing have had canopy closure after 5 years.

Agroforestry Applications. Agroforestry applications of *Prosopis* are many. *Prosopis* pods contain no toxic compounds and they can be a valuable food source for man or animals. Mature trees may produce 40 kg of pods, and it has been suggested that *Prosopis* pod yields may approach 3,000 to 4,000 kg/ha in a good year. The pods of various *Prosopis* strains vary significantly in protein (10-17 percent) and in sugar (10-44 percent) so that end uses vary considerably. Natural stands of *Prosopis* in the California desert have been reported to fix about 30 kg N/ha annually with a 30-percent canopy cover (Rundel and others 1982). Soils under *Prosopis* have been demonstrated to have double the soil nitrogen and organic matter of soils outside the *Prosopis* canopy (Tiedmann and Klemmedson 1986). In India, yields of dryland grain crops were higher under the *Prosopis* canopy than away from it (Shankar and others 1976).

Prosopis undoubtedly consumes substantial quantities of water that could be used for forage or crop production. However, in the absence of applied fertilizer, the benefits of added fertility created by nitrogen fixation in *Prosopis* partially compensates for water loss (Felker and others 1980).

Cultural Practices. No information is currently available on cultural practices.

Growth and Yield. There are no studies on the yields of *Prosopis* in large-scale plantations, but there are estimates of yields from research plots. Ahmed (1961) evaluated the productivity of seven *Prosopis* accessions in several regions in Pakistan after 12 to 15 years growth. Assuming the clear bole had a specific gravity of 0.7, his yields of *Prosopis* ranged from 13 to 8,000 kg/ha annually at 250 mm annual rainfall. The highest biomass productivity reported for *Prosopis* was from a high rainfall area (1,220 mm/yr) in Mombasa, Kenya where groundwater was also near the surface. Here, Maghembe and others (1983) reported a dry biomass of 216 Mg/ha* at the end of 6 growing seasons for a yearly productivity of about 36 Mg/ha.

Felker and others (1989) recently compared the productivity of three *Prosopis alba* clones and one open-pollinated family at two non-irrigated sites in Texas in a 3-year growing period. At the lowest rainfall site (ca. 500 mm/yr), a hybrid thorny clone was the most productive (7.4 Mg/3 seasons) presumably because the thornless clone was heavily browsed by deer. In contrast, at the high rainfall site (650 mm annual rainfall) a thornless clone had a standing dry biomass of 39.3 Mg/ha at the end of three seasons. The last season, this clone had an annual growth of 21.7 Mg/ha.

In contrast to the relatively slow growth of native mesquite in natural settings, moderately rapid growth occurred for selected families that were planted in a well prepared seed bed and weeded for the first 5 years. In a progeny test of nine Texas native *Prosopis glandulosa* in a 3-m by 4-m spacing, a considerable number of trees achieved a 10-cm basal diameter in five growing seasons (2 cm/yr) (Felker unpublished observations). Although the form of the trees for lumber leaves much to be desired, a combination of pruning (Meyer and Felker In Press) and genetic selection appears capable of greatly enhancing their potential for cabinet quality lumber.

Utilization

Wood and Wood Properties. There is considerable tree-to-tree variation in the physical properties of the wood of *Prosopis* (Rogers 1986). The average values for *Prosopis glandulosa* in Texas are 0.72 kg/l for density, 4.7 percent for volumetric shrinkage and 1,060 kg for side hardness.

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*Mg/ha = megagrams per hectare which is a metric tonne/hectare.

Thus, in terms of hardness and density, mesquite is greater than oak or maple but equivalent to hickory. Mesquite's truly exceptional property is its shrinkage of 4.7 percent, which is much lower than for oak, maple, or walnut, which are in the 14-16 percent range (Rogers 1986). These physical properties are nearly identical to those observed for *Prosopis alba* in Argentina (Tortorelli 1956). The low shrinkage in *Prosopis* indicates high dimensional stability and little cracking or warping for furniture made from mesquite.

Due to the hardness of *Prosopis*, its orange/red colored wood takes on a high polish after sanding, making it suitable for fine furniture. Unfortunately at this time, most *Prosopis* lumber is only 1 to 1.5 m in length and 15 to 25 cm wide, with a considerable number of cracks and knotholes. The present market for this lumber is for crafts, flooring, and custom furniture where its very high price can justify culling 85 percent of the lumber with cracks and knotholes. In the future, it is hoped that managed stands will produce longer lengths of defect-free lumber.

Other Uses Including Links to Social Implications. From a worldwide perspective, the most significant use of *Prosopis* is probably fuelwood for cooking. Such uses are common in the semiarid areas of India, Pakistan, Sudan, Senegal, Haiti, Ecuador, Brazil, and Argentina. The trees in these regions rarely reach a diameter of 10 cm before they are harvested for direct use as fuelwood or for conversion into charcoal. In Haiti, 85 percent of the country's energy is derived from biomass, and it has been estimated that about half of that is derived from *Prosopis* ('bayahonde' in Creole) charcoal (Voltaire 1979). Charcoal production is certainly a major source of income for the rural peoples of Haiti. The stream of women leading donkeys loaded with charcoal into Port-au-Prince every morning, and the women selling 20-cm tall piles of charcoal on every street corner, are clear evidence of the importance of bayahonde charcoal. After being cut, *Prosopis* resprouts indefinitely from any aboveground portion, and thus continues as a fuel source. *Prosopis* has spread into abandoned lots in the urban areas of major cities such as Delhi, India where it is useful in providing forage for goats, fuelwood, and privacy for people who establish tents among the bushes.

In the southwestern United States, with the increasing demand for low-water-requiring, heat-tolerant trees, *Prosopis* is becoming popular as an ornamental tree for residential and commercial applications. Wild trees are usually dug, balled and burlapped and then sold to retail nurseries. Diameters range from 4 cm to 18 cm and wholesale prices range from $25 to $250.

Due to the large quantity of nectar produced by *Prosopis*, it has been an important producer of honey in some areas of East Africa and the United States. More recently in the United States, mesquite wood has become popular for barbecue cooking of meats and vegetables. Several Texas firms are each packaging more than a million kg/yr of chunks in plastic bags containing 2.5 kg for retail sale. An organization of *Prosopis* craftsmen, flooring producers, furniture makers, sawyers, ornamental producers, and barbecue wood producers was formed in 1982 to assist with development of the *Prosopis* industry. The organization, "Los Amigos del Mesquite," holds an annual technical meeting and trade show.

Seed Sources

A seed orchard of *Prosopis alba* was established at Texas A&I in 1981 and is producing improved seed. Plantclone Inc., a for-profit Kingsville company, has acquired a license from Texas A&I University to produce *Prosopis alba* clone B2V50 by rooted cuttings for sale as an ornamental.

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