MESQUITE

Mesquite (*Prosopis* spp.) in Queensland

PEST STATUS REVIEW SERIES - LAND PROTECTION BRANCH

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Contents

1.0 Summary

Mesquites (*Prosopis* spp.) cause losses in the United States of some $200-500 million per annum. At least three species of mesquite have been introduced into Queensland and now exist as isolated infestations, scattered across much of the State.

The area of land currently infested with mesquite in Queensland is only a fraction of the total area at risk. Crude estimates based on climatic parameters suggest mesquite species have the potential to become established on grazing land over at least 60% of Queensland (1,036,200 km^2). Based on overseas experience, it is conceivable that mesquite could reduce pasture production by up to 90% in some areas. Mesquite is expected to become particularly dense along watercourses in semi-arid regions.

There is the danger that additional species of mesquite will be introduced into Queensland for use as fodder or ornamental trees. Out of approximately forty species not yet established in the State, at least eight are considered to have pest potential.

Effective chemical control techniques are available for scattered mesquite plants. High costs of herbicide and labour, however, may restrict control action by some landholders. Dense infestations are much more difficult to control and may require an integrated approach involving the preliminary use of fire or mechanical removal prior to follow-up chemical treatment of regrowth.

The commercialisation of mesquite may create a conflict of interests between industries which seek the plant's eradication and industries which seek a large, sustainable supply of mesquite-based products. In the United States, conflicts of interest have stalled the release of potential biological control agents for mesquite.

The complete eradication of mesquite in Queensland is unlikely, principally because of the scattered and remote nature of the infestations and the longevity of its seed. However, a significant reduction in the distribution and rate of spread of mesquite is achievable by eradicating new and small infestations and strategically important infestations, such as those high in river catchments. Property management practices are an important aspect of maintaining control and integrated management of mesquite should form part of a property pest management plan.

2.0 Taxonomic Status

The genus *Prosopis* contains 44 species of shrubs and trees in the family Leguminosae (Burkart 1976). Species of *Prosopis* occur naturally in arid and semi-arid areas of North America (9 species), South America (31 species), northern Africa (1 species) and eastern Asia (3 species). Common names for the various species of *Prosopis* in Queensland include "mesquite", "algaroba", "Cloncurry prickle bush" and "Quilpie algaroba".

There is considerable taxonomic confusion about the genus *Prosopis*, due largely to genetic and phenotypic variation within species and hybridisation between species. Isozymic studies by Panetta and Carstairs (1989) suggest that intergrading between species may be widespread, particularly in tropical regions of Australia. Furthermore Hunziker *et al*. (1986) list twenty six known hybrids between South American *Prosopis* species, including *P. pallida x P. juliflora*. As a result, the exact number of species and varieties that have become naturalised in Queensland is uncertain.

March (1995a) recognises three species of *Prosopis* in Queensland, *viz*.: *P. pallida, P. flexuosa* and an unknown hybrid species. Heard (unpubl.) suggests that at least four taxa have become naturalised in Queensland and Australia, including *P. pallida*, *P. velutina* (previously misidentified as *P. flexuosa*), *P. juliflora*, and a hybrid between *P. pallida, P. glandulosa* and an unknown species (possibly *P.laevigata*). Parsons and Cuthbertson (1992) provides a key for the identification of five taxa and a hybrid, believed to be naturalised in Australia, *viz*.: *P. glandulosa* var. *glandulosa, P. juliflora, P. flexuosa, P. velutina, P. pallida* and *P. juliflora x P. velutina*.

Three of the species present in Queensland (*P. juliflora, P. glandulosa* and *P. velutina*) are in the series Chilensis of the section Algerobia. *P. pallida*, however, is in the series Pallidae of the section Algerobia (Heard, unpubl.). Panetta and Carstairs (1989) believe there is a high degree of affinity between species of the series Chilensis and Pallidae.

For the purpose of this document, it is assumed that at least three *Prosopis* species and a hybrid are naturalised in Queensland:

- *Prosopis pallida* (Syn. *P. limensis*) in scattered infestations throughout a large area of
  North-west Queensland
- *Prosopis velutina* (previously misidentified as *P. flexuosa*) in isolated infestations around Quilpie in South-west Queensland
- *Prosopis glandulosa* var. *glandulosa* (possibly synonymous with *P. juliflora* var. *glandulosa*) in scattered infestations near Gladstone
- An unknown hybrid (possibly *P. juliflora x P. velutina* or *P. pallida x P. glandulosa x*
  P. laevigata) in scattered infestations in north-west Qld.

Prosopis pallida is believed to be a native to drier parts of Peru, Colombia and Ecuador along the Pacific Coast (NAS 1980). Quilpie mesquite *(P. velutina)* occurs naturally in Argentina, the USA and Mexico. It is documented as an aggressive invader in Arizona (USA) and Sonora (Mexico) (DeLoach 1985).

P. glandulosa occurs from eastern Texas and southern Kansas to central Mexico and west to California and Baja California (DeLoach 1985).

The "hybrid species" in Queensland is of unknown origin. It is also not known whether the plant was imported as a hybrid or if hybridisation took place in Australia.

DeLoach (1985) points out that several North American species were once referred to as *P. juliflora* and it is suspected that several North American *Prosopis* spp. were exported to other countries under the erroneous name of *P. juliflora*. Any reference to '*P. juliflora*' in the literature, therefore, should be treated with caution.

3.0 History of Introduction and Spread

Mesquite is believed to have been introduced into Queensland in the early 1900's. By the 1920's and 1930's it was widely planted throughout northern and western Queensland, primarily as a shade tree around homesteads, but occasionally as shade and fodder trees on bore drains. At Cloncurry, mesquite is reported to have been planted to stabilise soil on gold and copper mines.

During the 1930's, *Prosopis velutina* (Quilpie mesquite) was probably introduced onto properties on the Bulloo and the infestation peaked at around 10,000 hectares on the flood plain in the 1980's. Since then, control efforts by officers of the Queensland Department of Natural Resources and Mines and landholders, have reduced the plant's rate of spread considerably.

The hybrid was first reported in the Richmond area in the 1930's from where it may have been transported to properties north of Nelia and around McKinlay (March 1995a).

The role played by grazing animals in accelerating the increase of mesquite in North America is quite clear. Domestic livestock and other animals relish the pods and disperse the seed in their faeces. The ease of seed dispersal, the heavy utilisation of normally competitive pasture plants and the severe disturbance of the soil by trampling in areas where large numbers of grazing animals congregate offer almost ideal conditions for rapid invasion by mesquite. In North America, some of the heaviest infestations in the early days of grazing and during recent times have developed around holding yards, cattle trails and along drainage ways where forage cover has been depleted and erosion of the soil has taken place.

There is anecdotal evidence to suggest that significant spread of mesquite infestations may occur in "bursts", in response to highly favourable but irregular climatic events such as periods of exceptional rainfall and floods. Simulations of rainfall patterns by Harrington (1991) indicated that episodic woody plant establishment events may have occurred six times in the past 97 years in an area of Northern NSW which receives approximately 300 mm of rainfall per annum. The requirement for such irregular climatic events may partly explain why a "lag phase" has been observed for the populations of many woody species, including mesquite, in their early stages of naturalisation.

The invasion pattern of mesquite spread in Queensland appears similar to such invasions in other States and countries. For example, in Western Australia, mesquite was planted in the early 1930's around towns and on many properties in the North-West to provide shade and fodder. Initially, the plants showed little tendency to spread and occurred primarily along drainage lines and around homesteads. The first major spread followed the wet season of 1945 when, as with the American pattern, plants appeared on higher ground some distance from waterways (Meadly 1962). By 1954 on Mardie Station, mesquite was established over more than thirty square miles (Meadly 1962).

4.0 Current and Predicted Distribution

4.1 Current Distribution in Queensland

Most mesquite in Queensland currently occurs along bore drains and low-lying areas along rivers and creeks. Experience in the United States, South Africa and Western Australia clearly shows that the limited distribution of mesquite along watercourses is typical of the early phases of invasion and should be seen as a warning.

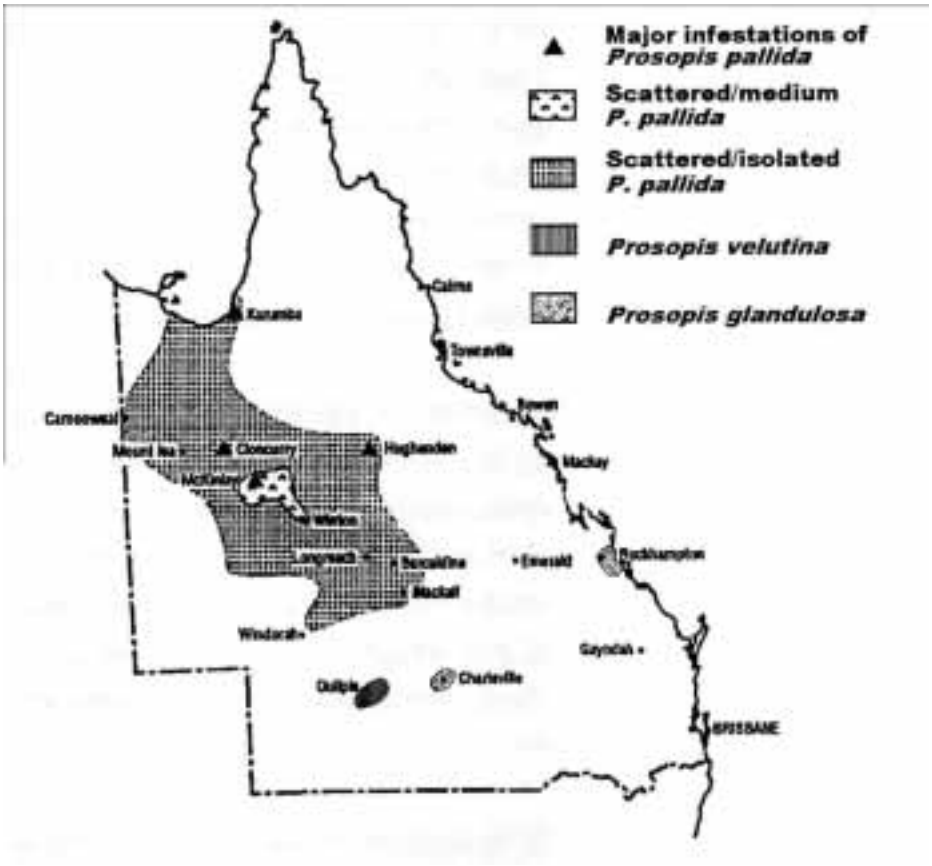

Fig. 1. *Current distribution of mesquite in Queensland (after March 1995a).*

Indeed, the species present in Queensland are well documented invaders of uplands in their native habitats (Archer *et al*. 1988, Wright *et al*. 1976).

March (1995a) has provided a map of the distribution of mesquite in Queensland (Fig. 1). At least three taxa within *Prosopis* have become naturalised in Queensland.

(a) *Prosopis pallida*.
This is the most widespread species and it occurs as scattered infestations over about 500,000 ha of Queensland (March 1995b), with most infestations being recorded from north-western Queensland. Dense infestations of *P. pallida* have been recorded at Cloncurry (about 5000 ha), Hughenden (about 1000 ha), near Karumba and McKinley (around the township and south-western section of the shire). Lighter infestations of *P. pallida* occur at Camooweal, Boulia, Winton, near Burketown, Yaraka ("Bell View" Station, Isisford Shire) (Akers pers. comm.) and "Retreat" Station, Barcoo Shire (may be *P. velutina* or *P. pallida*). Scattered infestations also occur over large areas to the west and north of Longreach.

Infestations occur on dry inland areas (e.g. Winton) on cracking clay soils to coastal, high rainfall areas on the edges of mangrove swamps (e.g. Townsville) (March

1995a). Most mesquite stands currently occur along bore drains or in low lying areas along rivers or streams (Brown, unpubl.).

In a survey of landholders in four north-western Shires of Queensland (March 1995b), 37% of landholders surveyed in the Cloncurry Shire reported medium to light infestations of mesquite (mainly *P. pallida*). By comparison, 16% of landholders surveyed in the Richmond Shire reported mesquite on their land, 15% reported mesquite in the McKinlay Shire and 8% reported mesquite in the Flinders Shire.

(b) *Prosopis velutina*

P. velutina ("Quilpie mesquite") is believed to be restricted to isolated infestations around Quilpie in the State's south west. Dense infestations occur on at least two properties ('Comongin' and 'Wanko') as well as adjacent properties. Scattered infestations occur over a larger area.

(c) *Prosopis glandulosa*

P. glandulosa var. *glandulosa* (possibly synonymous with *P. juliflora* var. *glandulosa*) is believed to occur as scattered infestations at a number of locations (Akers, pers comm.):

- Industrial estate and nearby grazing land at Boyne island near Gladstone
- Byrnestown (Gayndah Shire) - one paddock with about 80 ha of scattered plants
- Reserve just outside Amby (Booringa Shire)
- Cunnamulla town reserve and reserve at Clover Downs - seedlings established around parent plants which have been poisoned
- Charleville town reserve - about dozen trees and seedlings
- Isolated trees around Rockhampton - ornamentals/shade trees

An unknown hybrid (possibly *P. juliflora x P. velutina* or *P. pallida x P. glandulosa x P. laevigata*) occurs at south-western McKinlay (about 10,000 ha), Rockvale (north of Nelia) Moorooka and Richmond. The McKinlay infestation sits astride the headwaters of the McKinlay River and threatens the headwaters of the Diamantina and Hamilton Rivers in the Lake Eyre catchment (March 1995).

4.2 Predicted Distribution in Queensland

Ecoclimatic modelling, using 'CLIMEX' (Maywald and Sutherst 1989, 1991, Sutherst and Maywald 1985, 1991) was used to predict the potential distribution of two *Prosopis* species (*P. velutina*: Quilpie mesquite and *P. glandulosa*: honey mesquite) found in Queensland, based on the known distribution of these species in North America. The model was based on the similarity of climates between weather stations in Arizona (Phoenix), New Mexico (Roswell), Texas (Abilene), Mexico (Monterrey) and climate stations in Australia with a climate match index of 0.5 or greater. The results (Fig. 2) suggest the distribution of mesquite in Queensland could increase substantially from its current one. A prediction of the potential distribution of *P. pallida* could not be made due to a lack of information on its natural distribution in South America. Based on the broad climatic parameters of temperature, rainfall and relative humidity, it is reasonable to assume that, at least 60% of Queensland is suitable for the growth of *P. glandulosa, P. flexuosa* and *P. pallida* combined.

The fact that most *Prosopis* species are drought tolerant and are capable of thriving under a wide range of soil and rainfall conditions tends to support the predictions presented above. *P. juliflora* syn. *P. glandulosa* requires only 150-750 mm rainfall per annum for good growth and *P. pallida* requires 250-1250 mm per annum (NAS 1980).

There is also the danger that some forty other *Prosopis* species could be introduced into Queensland for use as fodder or shade trees, as garden ornamentals or to stabilise degraded land. Eight species considered to possess pest potential in Australia have been listed by Csurhes (1991, unpubl.). A species of particular concern is *P. ruscifolia*,

which is reported to be an aggressive weed of Northern Argentina and Southern Paraguay (Hunziker *et al.* 1986).

Although other species of *Prosopis* are not known to occur in Queensland, there is a high probability that they will be introduced and promoted as garden ornamentals or as fodder and shade trees in the future. A very large specimen of mesquite, possibly *P. pallida*, currently exists in the Brisbane Botanic gardens. Other specimens probably exist in private gardens across the State (in a survey of 59 towns in Texas, USA, 4354 houses had used mesquite as an ornamental shade tree).

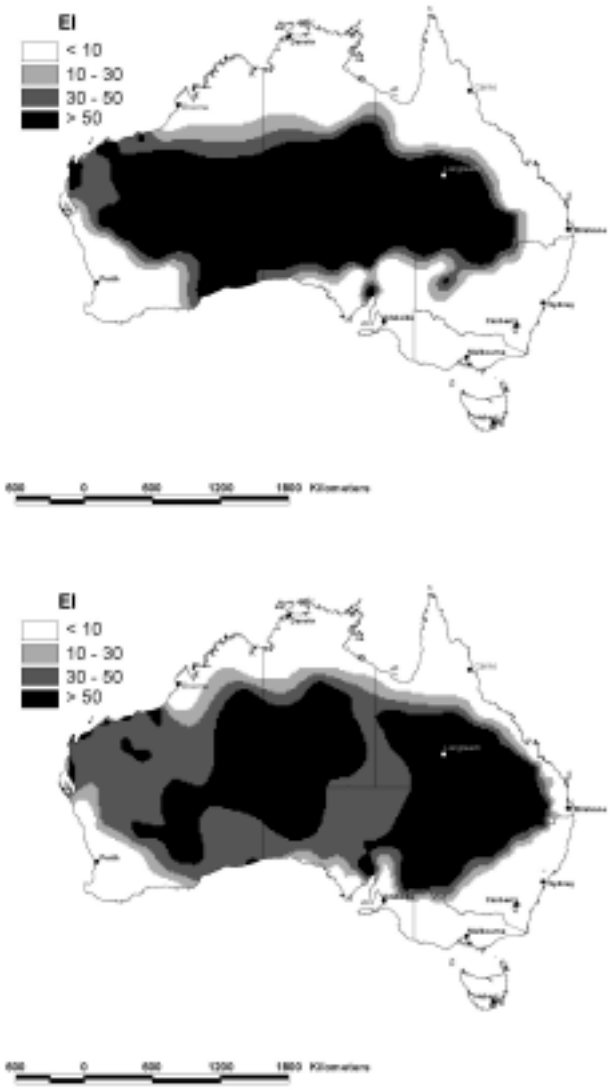

Fig. 2. *Predicted combined distribution of Quilpie mesquite and honey mesquite produced using the 'match climates' function of CLIMEX. The darker the colour the greater the suitability of the area for mesquite.*

5.0 Estimates of Current and Potential Impact

5.1 Impact in Other Countries

P. glandulosa (honey mesquite) and *P. velutina* (velvet mesquite) are serious weeds within their native ranges in south-western North America. Together, they infest some 38 million hectares in the United States (DeLoach 1985). *P. glandulosa* (var. *glandulosa* and var. *torreyana*) is believed to be the most widespread and problematic species in the US states of Texas, New Mexico and Arizona and adjacent areas in Mexico.

Direct losses attributable to mesquite in the United States have been calculated at $200 - 500 million annually. Soil erosion, desertification and loss of soil water add greatly to these losses. The total economic loss is estimated to be $0.5 - 1.5 billion annually. In the more arid regions (Arizona, New Mexico, Trans-Pecos Texas), mesquite consistently reduces grass production by 50-90% (DeLoach 1985). During the 1800's and early 1900's in the United States, mesquites were portrayed as the all-purpose staple of human culture. Many of the proposed uses in industrialised societies have since proved to be economically impractical. DeLoach (1985) estimates that in the US, total direct losses attributed to mesquite are probably 20-30 times the present beneficial values of the plant.

In South Africa, at least five *Prosopis* species, one with two sub-species, have become naturalised. Three of these species (*P. velutina, P. glandulosa* var. *torreyana* and *P. juliflora*) have become problematic, particularly in the arid north-western Cape Province. Infestations have been estimated to cover some 180,400 ha (Zimmerman 1991). The area considered at risk of *Prosopis* invasion in the north-western Cape is 935,000 ha. Wells *et al.* (1986) have listed *P. glandulosa* and *P. velutina* as problem weeds of pastoral land and native floral communities in South Africa.

Prosopis species have been introduced as "useful" plants in many other countries, notably India, Pakistan, Egypt, Kuwait, Hawaii, Brazil (DeLoach 1985) and Namibia (Zimmerman 1991). Holm *et al.* (1991) list eleven species of *Prosopis* which have been reported as weeds in one or more countries (including *P. campestris* in Paraguay, *P. chilensis* in Hawaii, *P. farcta* in Israel, *P. glandulosa* in Australia and Peru, *P. humilis* in Argentina, *P. juliflora* in Mexico, USA, Australia, Dominican Republic, Indonesia, Iraq and Venezuela, *P. pallida* in Australia, *P. pubescens* in USA, *P. ruscifolia* in Paraguay and Argentina, *P. spicigera* in Pakistan and *P. stephaniana* in Turkey, Iran and the Soviet Union).

5.2 Current Impact in Queensland

There are no data on the economic impact of mesquite in Queensland. Since the plant is still in its early phase of spread its current impact is likely to be quite small.

(a) Impact on Primary Industry
Isolated mesquite plants have a minor impact on grazing production and may even enhance production in the short-term due to the nutritious seed pods and shade they provide. With time, however, isolated trees reproduce to form dense thickets which replace pasture plants. At several locations in Queensland (e.g. in the McKinlay Shire), dense thickets of mesquite have significantly reduced the productivity of grazing enterprises. Dense mesquite can interfere with the mustering of stock and mesquite thorns injure stock and damage the tyres on vehicles. Mesquite seed pods provide food for feral pigs and may lead to an increase in feral pig numbers.

A survey conducted in four Shires of north-west Queensland (March 1995b) found that dense infestations of mesquite can reduce grass loads by up to 80%. One

hundred percent of landholders surveyed in the McKinlay Shire regarded mesquite as a liability.

The roots of *Prosopis* can extend more than fifteen metres beyond the canopy and up to fifteen metres into the soil profile. The loss of ground cover under mesquite is generally believed to result in increased soil erosion and loss of soil moisture. It is not known to what extent mesquite can reduce wind velocity and hence reduce soil loss in overgrazed environments.

(b) Environmental Impact
Mesquite has the potential to form dense thickets, excluding native plants and substantially changing community structure. The continued increase in the distribution and density of mesquite, particularly in semi-arid regions, is predicted to result in a physiognomic conversion of open grassland or open woodland to thorned shrublands, with deleterious impacts on populations of native flora and fauna.

5.3 Impact in Other Australian States

In Western Australia, almost 120,000 ha are infested with mesquite (Dodd and Martin 1986). Most infestations occur on pastoral land in the Pilbara and Kimberley regions of the State's north-west. The major problem area is on Mardie Station in the West Pilbara between Onslow and Port Headland where 15-20,000 ha are infested (Heard, unpubl.). The infestation at Mardie is believed to be a hybrid species, possibly *P. pallida x P. glandulosa x P. laevigata* (Heard, unpubl.) and the cost of aerially spraying has been estimated at $1 - 1.5 million.

P. pallida occurs at Minderoo in the State's north-west (Heard, unpubl.).

In New South Wales, the total area has been estimated at about 24,000 ha. The most common species is *P. juliflora*. There are two areas with heavy infestations of *P. juliflora*, one near Tibooburra and the other near Broken Hill (Parsons and Cuthbertson 1992).

In the Northern Territory, *P. pallida* is largely confined to the Barkly Tablelands and Alice Springs district. Most Barkly stations have mesquite. In the Alice Springs district it occurs as single trees associated with homesteads (Heard, unpubl.).

6.0 Biology and Ecology of Weed Spread and Control

Most mesquites are thorny shrubs and trees although some "thornless" varieties have been developed by plant breeders). The largest species, *P. pallida*, usually has a single stem and a spreading crown and can reach 15 metres in height. Other species, including *P. velutina, P. glandulosa* and the hybrid, are smaller trees and shrubs which often have multiple stems and branches that droop to the ground.

The leaves of mesquite are bipinnate. Small greenish-cream flowers are produced near the ends of the branches in spikes, 5-8 cm long. Seed pods are 10-20 cm long, straight to slightly curved, smooth, with slight constrictions between the seeds. Each pod contains between 5-20 seeds.

Prosopis species possess characteristics that make them very competitive. These attributes have been described in detail by Glendening and Paulsen (1955) and Milthorpe (1975) and can be summarised as: the rapid germination of seedlings under a wide range of temperature, moisture and soil conditions, rapid vertical penetration of tap roots and long, shallow lateral roots, a low shoot:root ratio, an ability to resprout from dormant stem buds following injury, drought resistance, spines, readily dispersed hard-coated seed, long seed dormancy and high fecundity.

6.1 Preferred habitat

It is difficult to make accurate generalisations concerning the preferred habitat of mesquite. Anecdotal evidence suggests that mesquite species in Queensland favour semi-arid to arid rangelands that are prone to flooding. In general, soil moisture appears to determine mesquite distribution rather than soil type since mesquite tends to establish most successfully on clay soils and alluvial soils which have good moisture retention.

P. pallida has proven to be an aggressive invader of grasslands and disturbed sites. Dense infestations occur in horse paddocks and along roadsides and bore drains. Field observations suggest that *P. pallida* will grow on a wide variety of soil types. In Queensland, *P. pallida* has become established in areas which receive an annual rainfall from 250-1500 mm. This observation conforms with NAS (1980) which stated that *P. pallida* requires from 250 mm to 1250 mm rainfall per year.

6.2 Reproduction, seed production, dispersal and longevity.

Mesquite reproduces primarily by seed. Field observations in Queensland suggest that plants generally produce their first flowers and seeds when they are between 2-5 years of age. Flowering occurs in spring. Pods takes two to three months to mature and fall in late summer. Plants generally produce a single crop of seeds per season, although up to three crops in one year have been recorded (Carroll, 1992).

Mature trees are prolific seeders with estimates of seed-set ranging from 630,000 to 980,000 seeds per tree per annum (Felker 1979, Harding 1988). *P. velutina* shrubs have been recorded to produce up to 5,000 seeds per year (Glendening and Paulsen 1955).

The seed is contained within long pods, which can be transported by floodwaters, run-off and by animals. Dispersal by floodwaters may contribute to the observed concentration of mesquite plants along water courses and in low-lying areas.

Since mesquite pods and seeds are high in sugar (16%) and protein (12%) (Kingsolver *et al*. 1977) they are sought by a variety of predators, including insects (bruchid beetles) small mammals (such as rodents), birds (emus) and domestic stock (cattle and horses in particular, pigs). Feral pigs are an important vector of spread of

P. velutina in south-west Queensland (D. Akers, pers. comm.). Feral goats, horses and donkeys may also ingest and spread the seed (Carroll 1992). Parrots have been observed feeding on the seed, but it is not known whether their strong beaks destroy the seed.

The majority of seed consumed by cattle and horses passes through the digestive system intact. Sheep are less effective in seed dispersal. Fisher *et al.* (1959) found that 82% of mesquite seed germinated after passing through horses, 69% through cattle and 25% through sheep. Brown and Archer (1987) consider cattle to be the most effective dispersal agents for mesquite seed. The high sugar content of the pods and the hard seed coats may represent evolutionary adaptations which ensure the effective dispersal of mesquite by grazing animals.

Perhaps the most effective dispersal vector of mesquite is man, since he has transported mesquite across the landscape and across the world for use as ornamental, shade and fodder trees. The transport of stock which has consumed mesquite pods also results in its spread over large distances.

For maximum germination to occur, seeds require some form of scarification (damage to the outer seed coat). This is achieved when the seed passed through the digestive tract of animals or has lain dormant for some while in the soil.

Under laboratory conditions, the seeds of mesquite can remain viable for many years. *P. velutina* seed has been shown to retain 60% viability for at least 50 years, when kept at the Herbarium of Tucson, Arizona, where a dry atmosphere and moderate temperature prevail (Glendening and Paulsen, 1955). Hunziker *et al.* (1986) comments that the seed of mesquite can be stored, probably for decades, provided the eggs and larvae of *Bruchidae* are killed by freezing and the dry seed subsequently stored at low humidity and low or moderate temperatures. Under field conditions, however, it is unlikely that many seeds would survive longer than 2-3 years, due to fungal attack or predation (Brown unpubl.).

Several *Prosopis* species of the section Algarobia are known to be self-incompatible and require cross-fertilisation between plants (Hunziker *et al*. 1986). This may explain field observations made at certain locations in Queensland, where mature, isolated specimens of *Prosopis* do not appear to have produced any seedlings.

All mesquite species are capable of regenerating from basal buds located at, or just below the soil surface, when top growth is removed. Subsequent growth can either be expressed as single stemmed trees or multiple stemmed shrubs. New shoots do not develop from the roots (Fisher *et al*. 1959).

7.0 Efficacy of Current Control Methods

7.1 Chemical Options

Good chemical control options are available for mesquite. The most effective method of control will vary depending on the size, age, density and habitat of the target plants. For example, tall dense infestations may require mechanical control, followed by fire and foliar spraying of seedlings. Isolated multiple-stemmed plants such as the hybrid, may require foliar sprays and are generally more difficult to treat. Isolated, single-stemmed plants can be treated using basal bark or cut-stump techniques. The high cost of herbicides and associated labour is often quoted by landholders as an obstacle to control. Research is underway at the Tropical Weeds Research Centre (Queensland Department of Natural Resources and Mines) to investigate chemical control options further.

- **Basal Bark/Cut Stump Treatment**

The *basal bark technique* involves the application of herbicide (usually 'Garlon 600' mixed in diesel) onto the bark from ground level to knee height all the way around the stem. Best results are achieved when the plants are actively growing.

The *cut stump technique* involves the application of herbicide to a freshly cut stump. Application should be within 30 seconds of the cut being made. The cut should be no more than 15 cm from the ground and horizontal. Cut stump application can be conducted on any size plant at any time of the year and application rates are the same as those for basal bark spraying.

- **Foliar (Overall) Spray Treatment**

Foliar sprays (Table 1) are best applied on dense thickets of seedlings less than 1.5 metres tall. The plants must be actively growing with a large area of foliage. A wetting agent, such as BS1000, must be added to the mix of Grazon DS in water.

Table 1. *Summary of foliar spray regimes used on mesquite.*

Herbicide	Efficacy % Kill	Rate	Cost/100L
Garlon 600®	97-100	1L/60L diesel	$153
Access®	97-100	1L/60L diesel	$133
*Grazon DS®	>90%	1L/200L water + wetting agent	$18

** For plants less than 1.5 metres tall.*

- **Aerial Spray Treatment**

In a demonstration trial by the McKinlay Land Care Group, Grazon DS (plus Pulse wetting agent) was aerially applied by helicopter to stands of mesquite. The treatments cost $250-280 per hectare. Mortality at all application rates was high (Table 2) and this is a promising control method, although it is not yet a registered control method for mesquite in Queensland.

Table 2. *Summary of aerial spray regimes used on mesquite (all rates in 200 L of water per hectare and Pulse wetting agent).*

Rate of Grazon DS®	Basal Diameter (cm)	Height Range (m)	Mortality %
6L/ha	2-55	0.5 - 4.6	85
4L/ha	1-60	0.2 - 6.0	97
3L/ha	1-20	0.4 - 3.5	90

- **Soil-Applied Herbicides**

Soil-applied herbicides such as hexazinone ('Velpar') can be effective, however, problems with application in dense thickets, cost and lack of selectivity make these chemicals, for the most part, undesirable (Carroll 1992). Aerial application of these chemicals can kill desirable native tree species as well as pastures. In the United States, application of tebuthiuron (sold as 'Graslan') has been found to be ineffective against mesquite (Bovey and Meyer 1983).

7.2 Mechanical Options

Trials in the Quilpie area of south-west Queensland have shown that *P. velutina* can be physically removed from the soil using "grubber" attachments on bulldozers and tractors, with best results being achieved in late autumn and winter in a normal wet season year.

Chaining of *P. pallida* using two bulldozers and a length of heavy chain has recently been trialed at Cloncurry and Hughenden in western Queensland. The treatment appears to have been very effective. Very little suckering has been observed although some seedlings do emerge and require follow-up chemical treatment.

Blade-ploughing can be effective for *P. velutina*, provided the blade passes under the root-crown of the plant, that is at a minimum of 30 cm below the soil surface (Akers pers. comm.). Failure to lift the root-crown leads to significant regrowth. Unlike the taller *P. pallida*, chaining of *P. velutina* is considered ineffective due to the plant's robust nature and potential for regrowth from the root system.

Two hundred and fifty ha of dense mesquite (*P. velutina*) were blade-ploughed in 1990 at 'Comongin' (Quilpie) and reseeded with Mitchell grass, buffel grass and forage sorghum. Following good rains in 1991 and early in 1992, mesquite seedling regrowth had become a problem with densities of 1095 plants per ha (P. Jones, unpubl.). Despite seedling regrowth, the blade-ploughing produced substantial pasture growth and part of the huge seed source was eliminated. The improved pasture growth offset the cost of the operation: in the trials, a 385 hp D-9 dozer was required to pull a 4 metre 'Homan' blade-plough. The machinery was capable of treating approximately 1.14 ha of mesquite per hour at a cost of $148 per hour (P. Jones, unpubl.).

7.3 Fire

Small scale trials and anecdotal evidence from the Cloncurry and Hughenden areas suggest that *P. pallida* is particularly susceptible to fire. At Cloncurry, a number of controlled fires as well as "wild" fires have occurred in situations where buffel grass and other grasses have provided sufficient fuel. *P. pallida* appears to have died relatively quickly following the fire, with the bark splitting away from the trunk a few weeks afterwards. Mature trees as well as seedlings have been found to be susceptible. After a period of three years, no significant seedling growth has been noted and buffel grass has established under the dead trees.

Dense growth of *P. pallida* can preclude the accumulation of sufficient grass and debris to fuel a fire, even when grazing animals are removed and this may restrict the use of fire as an effective control for this species.

7.4 Biological Control

The United States Department of Agriculture (USDA) has studied insects feeding on mesquite in North and South America for many years and has published lists of insects known to attack mesquite. Knowledge collected by the USDA is of considerable value to scientists in Queensland.
In 1992, the Queensland Department of Natural Resources and Mines (Alan Fletcher Research Station) imported the insect, *Heteropsylla texana*, into quarantine for host

specificity testing. Unfortunately, *H. texana* was not host specific and was not released.

In the late 1980's, South Africa introduced two seed-feeding beetles (*Algarobius prosopis* and *A. bottimeri*) from the USA The larvae of these beetles consume and destroy mesquite seeds. The Alan Fletcher Research Station has imported these beetles into quarantine for host specificity testing (currently in progress). If they are found to be host-specific, they may be released subject to Australian Quarantine and Inspection Service approval. Another seed-feeding beetle, *Neltumius arizonensis,* was recently released in South Africa as a biocontrol agent for mesquite and may be a future biocontrol agent for mesquite in Australia.

7.5 Grazing Management Systems

It is widely accepted that grazing favours the establishment and survival of woody plant species by reducing competition from grass and by reducing the incidence and intensity of fires. Many workers have proposed that fire is one of the most important factors in maintaining native grasslands free of shrub invasion, not only in the United States but in other areas of the world (Komarek 1972, Vogl 1974, Scifres 1980, Wright and Bailey 1982, Csurhes 1992).

The rapid increase in cattle numbers from fewer than half a million head in 1830 to over 9 million in 1900 was probably the most important factor influencing the dramatic increase in density of mesquite in Texas (Fisher 1977). In New Mexico, the number of cattle increased from about 158,000 in 1870 to over a million in 1886 (Ares, 1974). During the same period, the land surface covered by mesquite on the Jornada Experimental Range increased from 4.8% to 50.3% while grassland declined from 90% to 25% (Buffington and Herbel 1965).

Several field studies have been conducted in North America to investigate the influence of pasture biomass and grazing pressure on mesquite abundance. These studies suggest the rate of pasture invasion by mesquite can be reduced by exclusion of stock, but not entirely prevented. For example, Brown (1950) studied mesquite increase at Santa Rita in exclosures that provided different degrees of protection from grazing animals over an 18 year period. Mesquite density was found to increase by 55% in exclosures that were grazed by cattle, but only increased by 24% when cattle were excluded. Similarly, Meyer and Bovey (1982) sowed mesquite seed into a good stand of mixed grass and found that after 5 years, an average of 276 plants/ha were present in ungrazed grass whereas plots that were mowed, to simulate grazing damage, had 927 plants/ha. Smith and Schmutz (1975) and Schmutz and Smith (1976) found, however, that over a 28 year study, velvet mesquite increased rapidly on both protected and closely grazed ranges. They also concluded that protection from grazing alone may not prevent mesquite invasion and that some other factor such as fire was needed to control mesquite.

Mesquite seedlings can tolerate the removal of above ground foliage as soon as two weeks after emergence (Weltzin 1990). Small mesquite plants with trunk diameters of less than 1 cm are reported to be susceptible to fire but larger trees are increasingly resistant to fire (Glendening and Paulsen 1955, Wright *et al*. 1976). Survival of 2- and 3-year old seedlings is reported to exceed 60 and 90% respectively, following hot burns (Wright *et al*. 1976). Glendening and Paulsen (1955) point out that repeated foliage removal either by fire or grazing animals may limit the expression of mesquite and prohibit the development of populations of seed producing individuals.

Based on the available literature, a reduction in grazing pressure alone may, at best, result in a reduction in the rate of invasion and will not prevent mesquite invasion entirely. The maintenance of competitive pastures combined with regular grass fires may be more effective in minimising the establishment and spread of mesquite. Regardless of the land management regime applied, therefore, areas grazed by cattle will be prone to some level of invasion.

Conservative stocking rates combined with regular fires, regular property inspection and 'spot spraying' of young mesquite plants are required to prevent invasion entirely.

Drawbacks to the use of fire in semi-arid and arid grazing lands are the cost of spelling pastures (short-term income loss) and the difficulty of accumulating sufficient grass cover and hence fuel load to carry a fire. Long periods of below average rainfall, economic pressures, inadequate property size and the impact of introduced pest herbivores (such as rabbits and goats) will all hamper efforts to incorporate fire as a component of sustainable land management regimes.

To minimise the impact of *Prosopis* a combination of control options can be integrated into the grazing management system and the property plan and include:

- biological control agents
- chemical control of isolated infestations
- mechanical removal of dense infestations
- strategic use of fire
- careful control of stocking rates
- holding stock in yards for two weeks prior to movement into new paddocks (to allow seed held in animals' digestive tracts to be expelled).

7.6 Commercial Exploitation

In North America and elsewhere, mesquites have been promoted for a variety of uses, including alternative forms of fuel for the generation of electricity (Wiley 1977), a source of timber, use as firewood and charcoal (NAS 1980), for making paper, as livestock feed, for human consumption, as a source of chemicals and medicine, as a source of alcohol, tannins and gums and as garden ornamentals (discussed further in DeLoach 1985). In the USA in the early 1980's, nationwide interest developed in using mesquite wood as barbecue fuel. The market developed rapidly and a few entrepreneurs made good profits (DeLoach 1985). This is a specialised market however, that probably cannot be developed on a large scale (Parker 1982). It is not known if combustion of the many chemicals in mesquite wood produces carcinogens which can taint food.

In Queensland, mesquites have some value as shade trees, as a source of timber for use in hand carving, as nesting habitats for birds, as soil stabilisers, as wind breaks and as fodder trees.

Production of wood-chips from mesquite is currently being considered by private interests in north Queensland (P. James, pers. comm.). Proponents of commercialisation argue that harvesting could help remove large infestations. Similar experience in the US shows however, that commercialisation can produce a serious conflict of interest (discussed by DeLoach, 1985). Vested interest groups which rely on mesquite as a source of income and employment can stall the release of biological control agents and may oppose the eradication of mesquite. Commercialisation of a particular pest species is not considered to be compatible with biological control programs directed at that pest and may jeopardise the release of effective biocontrol agents (Csurhes, undated).

8.0 Management and Control Practices

8.1 Legislative Status in Queensland

In Queensland, all species of mesquite are declared as noxious plants under Sections 69 and 70 of the *Rural Lands Protection Act.* The declarations take into account the current taxonomy of the species and their detailed distribution in Queensland.

- *Prosopis pallida* (syn. *P. limensis*) is declared in category P3 for the whole State.
- *Prosopis velutina* (formerly known as *P. flexuosa*)is declared in category P2 for the whole State.
- *Prosopis glandulosa* is declared in category P2 for the whole State.
- All known *Prosopis* hybrids are declared in category P2 for the whole State.
- All other *Prosopis* species, not listed above, are declared in categories P1 and P2 for the whole State.

8.2 Containment Strategies in Queensland

The complete eradication of mesquite from Queensland is considered highly unlikely, for the following reasons:

- A large number of specimens probably exist in private gardens and these will be very difficult to detect and will act as sources of seed.
- Seed and perhaps live specimens will be introduced continually into Queensland from overseas and interstate sources either deliberately as garden ornamentals and shade trees or through natural agencies such as floodwaters and animals.
- Mesquite is established over a vast area, much of which is very remote and inaccessible.
- The seed of mesquite may remain viable but dormant in the soil for several years.
- Control programs tend to be sporadic since long-term funding is never guaranteed.

However, a significant reduction in the distribution and rate of spread of mesquite can be readily achieved. This would be a wise investment. Mesquite has a high dispersal ability and strategic control and containment of existing infestations could save many millions of dollars in long-term agricultural production costs. Similarly, preventing the introduction of additional *Prosopis* species will provide substantial savings.

Goals for action on mesquite are:

- Enforcing restrictions on the introduction and sale of mesquite species
- Attempting eradication of strategic (isolated) infestations and containing heavy infestations
- Locating suitable biological control agents
- Promoting sustainable land management regimes conducive to containment of infestations
- Increasing the awareness of the potential impact and benefits of early control measures.

Strategies for the containment of mesquite species can take two approaches depending on their distribution:

i) For mesquite already established in Queensland, their spread can be reduced by

- Developing control programs for heavy infestations found outside the Bulloo and Lake Eyre catchments.
- Improving public awareness of the potential impact of mesquite and methods for its control.

- Changing landholder opinion that Government is responsible for the control of mesquite.
- Continuing to research, develop and implement host-specific biological control and other control techniques.

ii) For mesquite species that have the potential to become naturalised in Queensland their spread can be reduced by:

- Requiring immediate destruction of any plants detected in Queensland, including garden specimens.
- Ensuring mesquite species are not sold or promoted as garden ornamentals or fodder and shade trees.
- Seeking continued declaration of mesquite species in other States to prevent the sale of mesquite species and their establishment elsewhere.
- Collecting information on species not yet established, to facilitate successful early detection and eradication of additional mesquite species.

8.3 Eradication strategies in Queensland

The eradication of selected, strategically located infestations can help in containing the further spread of mesquite in Queensland. Spread away from core areas should be controlled by eradicating new infestations. To these ends:

- The eradication of all infestations in the Bulloo River catchment (primarily *P. velutina*) is required.
- The eradication of the important infestations in the Lake Eyre catchment, including those in the Diamantina River catchment, and the containment, where feasible, of other infestations in these catchments is required.
- The eradication of strategically important infestations found outside the Bulloo and Lake Eyre catchments is necessary, with priority being given to the scattered infestations below the Tropic of Capricorn.

8.4 Property Management Strategies

The control of woody weeds such as mesquite is primarily the responsibility of the landholder. Management practices are an important aspect of controlling the regeneration, spread and density of mesquite infestations and integrated management of mesquite should form part of a property pest management plant.

Dense infestations should be fenced to prevent stock access. Control should be on a paddock by paddock basis, with dams and bore drains being cleared first. Scattered infestations can then be cleared by chemical or mechanical means. Medium and dense infestations can be controlled subsequently. If significant areas of pasture have been lost repasturing should be carried out. Once a fuel load has been established fire may be used to help prevent seedling establishment. Ornamental trees may be removed last if there is no access to them by stock. Stocking levels should be controlled carefully to avoid soil exposure and loss, and stock from infested land should be held in small yards for two weeks prior to moving them onto clean land.

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