Gleditsia triacanthos L. (Caesalpiniaceae), another thorny, exotic fodder tree gone wild

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Summary

Attention is drawn to the proliferation of *Gleditsia triacanthos* L. (honey locust tree) at several locations in south east Queensland and New South Wales. Although promoted and planted as an attractive garden ornamental and as a high protein fodder tree, this thorny, exotic tree has the potential to smother pastures and replace native riparian vegetation. *G. triacanthos* appears well suited to sub-tropical and temperate climates and could become a serious pest on alluvial soils throughout the south-eastern states of Australia. In Queensland, *G. triacanthos* was declared noxious in March 1993 and an eradication program has been implemented. Where feasible, early control of this species in other States is recommended.

Introduction

A range of exotic shrub and tree species have been imported into Australia to improve the quality and availability of fodder for cattle and sheep. Unfortunately, some species have spread to become destructive weeds, forming dense thickets and outcompeting pasture species over large areas. This paper addresses the long-term pest potential of *Gleditsia triacanthos* (the honey locust tree), an introduced fodder tree which is believed to be in its early stages of spread in Australia.

Description and biology

Gleditsia triacanthos L. is a deciduous, leguminous tree often reaching 25 m in height. The trunk and branches are protected by an armoury of long, strong spines some of which may be 15 cm in length (Figure 1).

G. triacanthos is native to central and eastern North America, ranging from Ontario south to Texas (Little 1971). The species occupies a variety of habitats throughout its natural range, including woodlands, rocky upland slopes and abandoned pastures (Schnabel and Hamrick 1990a). It is particularly suited to the Central Plains region of the United States and grows vigorously on fertile alluvial soils associated with the Ohio and Mississippi Rivers (Skerman 1977).

G. triacanthos is reported to reach its greatest size in the valleys of small streams in southern Indiana and Illinois (Sargent 1965), where it can form dense thickets. Throughout the mid-western United States *G. triacanthos* invades pastures and old fields (Schnabel *et al.* 1991, Schnabel and Hamrick 1990a) and often co-occurs in woodlands and early successional habitats with *Maclura pomifera* (osage orange), another deciduous tree species.

Although capable of tolerating most soil types, including soils which are moderately saline, *G. triacanthos* grows most prolifically on fertile, alluvial soils with a pH of 6.0–8.0 (NAS 1980). The plant develops an extensive lateral root system with a weakly developed tap root (Bedker and Blanchette 1983). Good growth occurs in areas receiving from 500 mm to more than 1500 mm annual precipitation (NAS 1980), although the plant has been reported to survive in areas which receive an annual rainfall as low as 355 mm (Mitchell 1978).

G. triacanthos is subdioecious—a small number of hermaphroditic individuals may occur within a population of dioecious individuals (Schnabel and Hamrick 1990b). Male trees flower yearly, whereas flower and fruit production in females is highly variable from year to year (Schnabel 1988, Schnabel and Hamrick 1990b). Flowers emerge in spring, either after or at the same time as the leaves. Female individuals produce loose racemes containing 10–40 small, yellow-green, perfect flowers with abortive stamens. Most male individuals produce dense racemes that often contain more than 100 greenish staminate flowers which lack pistils (Schnabel and Hamrick 1990b). Schnabel and Hamrick (1990b) have observed that the number of seeds produced by hermaphrodite plants varies from year to year, but is always much less than the number produced by female individuals. Yearly variation in pollen and seed production is also common for purely male and female individuals, respectively.

In the United States, *G. triacanthos* is pollinated by a variety of insects, including bees, moths and butterflies (Schnabel 1988). Schnabel (1988) has shown that 15–50% of pollination in three *G. triacanthos* sites was by pollen originating outside the sites. These values are similar to pollen migration rates recorded for wind-pollinated species (Friedman and Adams 1985, Nagasaka and Szmidt 1985, Harju and Muona 1989).

Like many weeds, *G. triacanthos* is a prolific seeder. It produces long (20–30 cm), flattened pods which may contain up to 30 seeds separated by a sweet pulp (Gordon 1966, Mathwig 1971). Pods are first produced when the plant is 3–5 years old. The number of pods produced can increase dramatically as the tree matures. Trees over 12 years of age may produce in excess of 500 kg of pods per tree (Hart, undated). Seed dispersal can be highly localized since most of the pods fall directly beneath the parent tree. Secondary

Figure 1. Thorns of *G. triacanthos*.

dispersers include cattle, horses, deer, rabbits and a variety of small mammals (Bugbee and Riegel 1945, Dice 1945, Peattie 1953, Fowells 1965) all of which may facilitate spread. Field observations of seed dispersal in south east Queensland suggest the species is spread by cattle (which ingest the pods and pass the seed in their dung) and by floodwater (the pods float).

The seed of *G. triacanthos* requires damage before it will germinate and is believed to be effectively scarified by passing through the digestive systems of cattle. Scarified seed has 10 times the emergence of unscarified seed (Burton and Bazzaz 1991). Laboratory experiments showed 100% of scarified seed germinated within 60 days. Unscarified seed field sown in 1985 emerged in 1987 and even into 1988 (Burton and Bazzaz 1991) suggesting a dormancy period of up to three years under field conditions.

The ability of *G. triacanthos* to resprout multiple stems after injury to the primary stem suggests that many clumps may be single individuals (Fowells 1965, Smith and Perino 1981).

G. triacanthos has been promoted and planted as a fodder tree in North America, Europe, Australia, New Zealand and South America (NAS 1980). The leaves have a crude protein content ranging from 14.3–17.3% (Skerman 1977) and the sweet pods are relished by grazing animals. Although young plants provide a valuable source of protein-rich cattle feed, the leaves of mature trees are either out of the reach of grazing stock or protected by the thorns.

In addition to its fodder value, *G. triacanthos* is also a popular garden ornamental in North America and Australia. It grows rapidly, has attractive form and foliage, is tolerant of poor soils, is easily propagated, and is readily transplanted (Dirr 1983, Bastian and Hart 1990). A large number of cultivars and variants have been developed by horticulturists. So called "thornless" variants of this species, included under the group name *G. triacanthos* var. *inermis*, include "Moraine", "Shademaster", "Rubylace" and "Sunburst" (varieties described by Bradley 1978, Rowell 1991). Seeds produced by thornless honey locust varieties bear true for that characteristic for up to 80% of any one seed lot (Hart, undated) whereas the remaining 20% may produce thorny trees. Ornamental varieties can be grafted onto thorny rootstock, which produce thorny suckers if damaged (Hart, undated).

Whereas *G. triacanthos* grows pest-free in Australia, it is subject to attack by a range of insects and fungal diseases in North America. North American pests include the canker causing pathogens *Nectria cinnabarina* (Bedker and Blanchette 1983) and *Thyronectria austro-americana* (Crowe *et al.* 1982) and the honey locust plant bug (*Diphnocoris chloriensis*) (Herms *et al.* 1987). The most damaging pest of ornamental varieties is the mimosa webworm moth (*Homadaula anisocentra* Meyrick) which can cause repeated defoliation (Bastian and Hart 1990, North and Hart 1983).

Pest status overseas

G. triacanthos has been recorded as a pest in South Africa, Chile and the United States (Holm *et al.* 1979, Wells *et al.* 1986). It has become naturalized in parts of Europe (NAS 1980). Even within its natural range, *G. triacanthos* can invade pastures and old-fields (Burton and Bazzaz 1991, Schnabel *et al.* 1991, Schnabel and Hamrick 1990a). Sargent (1965) comments that *G. triacanthos* in the United States occasionally covers considerable areas on moist fertile soils, excluding most other species.

Current distribution and pest potential in Australia

Due to its desirability as a garden ornamental and fodder tree, *G. triacanthos* has been planted throughout Australia. Distribution data collected from State Herbaria indicate, however, that the species has become naturalized only in Queensland and New South Wales. Major infestations occur in south east Queensland along the Condamine River and its tributaries (Darling Downs region) and in the Brisbane Valley (Esk and Toogoolawah area). The latter infestation is believed to have originated from a small number of ornamental specimens planted by a Mr. McConnell early this Century (hence the local name of "McConnell's curse"). The species was first reported as a pest in Queensland in 1955 at a location adjacent to the original planting by McConnell (Lands Department records). In Queensland, *G. triacanthos* has formed dense thickets amongst native vegetation along creek and river banks and has invaded improved pastures on surrounding alluvial clay soil flats (Figure 2). Similarly, *G. triacanthos* has formed dense infestations at several locations in New South Wales in areas surrounding the original planting sites. Major infestations exist along the Nepean River and its tributaries and at Schofields. The infestations in New South Wales are believed to have originated from original plantings by William Mac-arthur at "Camden Park" in the mid 19th Century.

Sizeable infestations in south east Queensland and New South Wales, which have originated from small numbers of specimens planted over 50 years ago, provide a valuable insight into the long-term propensity of this thorny tree to become a destructive pest. As suggested for other serious weed species such as *Mimosa pigra* (Lonsdale, in press), there appears to have been a significant "lag phase" between initial introduction and the development of significant infestations of *G. triacanthos*. In the long-term, therefore, the continued naturalization of *G. triacanthos* from cultivated specimens in other areas of Australia is likely.

Figure 2. Infestation of *Gleditsia triacanthos* invading improved pasture at Esk, south east Queensland.

CLIMEX modelling

The CLIMEX modelling package developed by the CSIRO Division of Entomology (Maywald and Sutherst 1989, 1991, Sutherst and Maywald 1985, 1991) was used to predict the potential distribution of *G. triacanthos* in Australia. The 'compare climates' module in CLIMEX was used to generate a prediction, using a

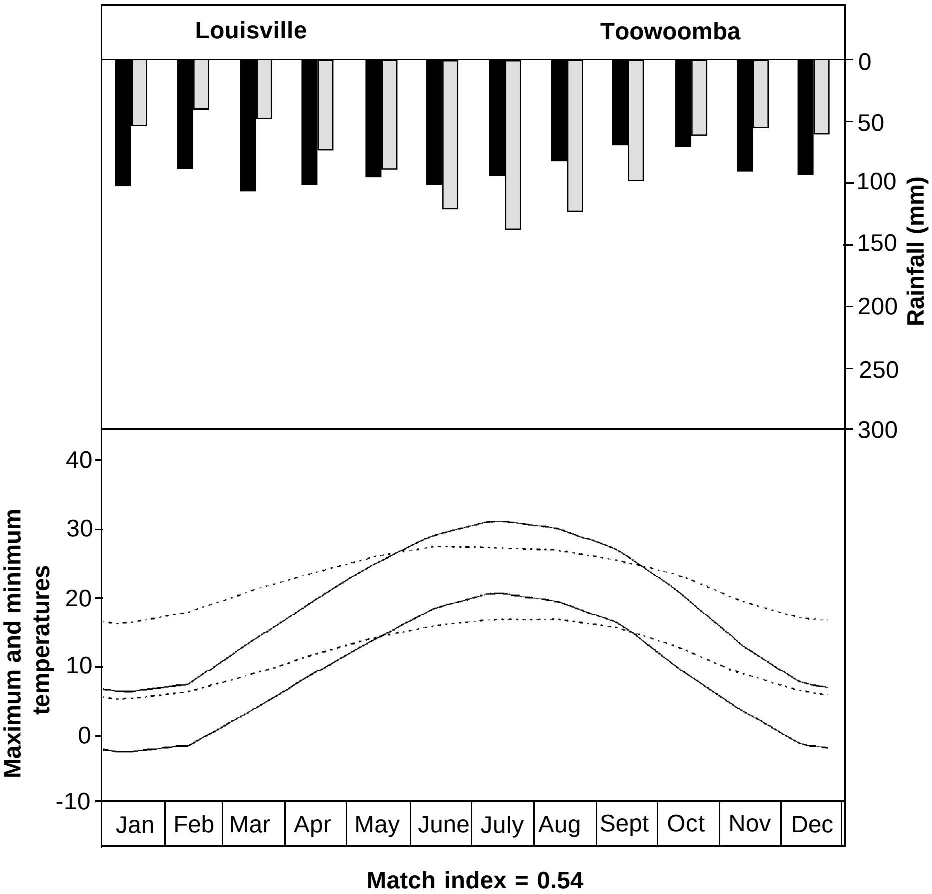

Figure 3. Climate comparison between Louisville (USA) and Toowoomba (Queensland, Australia). The dashed line for maximum and minimum temperature is for Toowoomba.

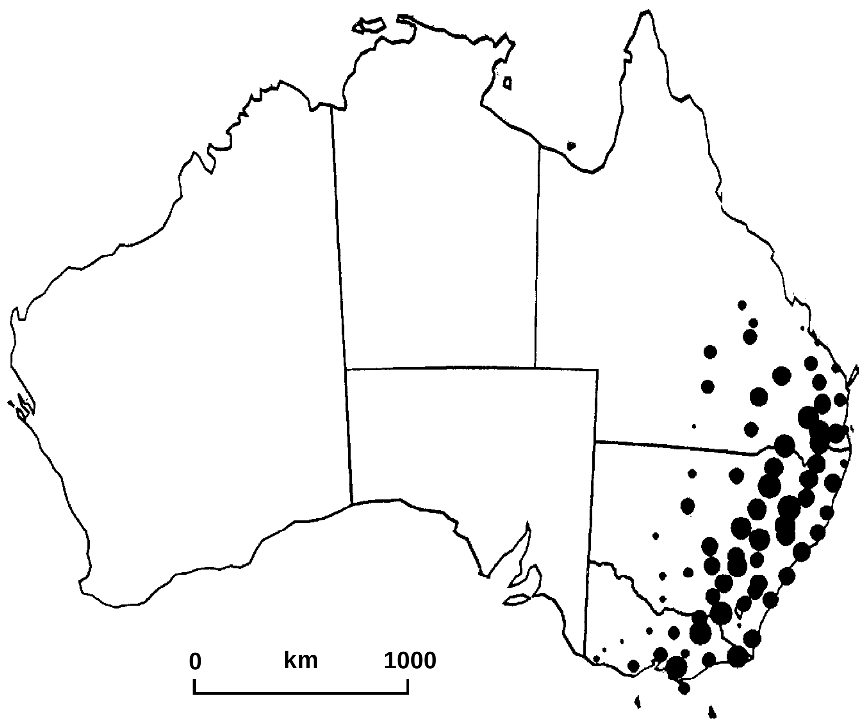

Figure 4. Similarity of climates between selected weather stations in the USA (Dallas, Louisville, St. Louis and Wichita Falls), and climate stations in Australia with a climate match index threshold of 0.5. The size of the shaded circles indicates the relative size of the climate match index.

0.7 threshold for closeness of match. It has become accepted that a climate match threshold of 0.7 (from a possible range of 0–1) generally provides an indication of a high degree of climatic similarity (Maywald and Sutherst 1991, Scott 1991). The climatic parameters were derived from locations detailed in published sources for the distribution of *G. triacanthos* in the United States. The output from the model was interpreted in terms of known distributions of the species in Australia and the United States.

Using a threshold of 0.7 and prime locations in the United States produced very few climate matches. Close examination of the model's output indicated that the range of climatic conditions in Australia is considerably smaller than in the United States. For example, a comparison between the climate of Louisville (where *G. triacanthos* is recorded to grow prolifically) and Toowoomba (in south east Queensland) produced a climate match index of only 0.54 (Figure 3).

The fact that one of Queensland's worst infestations of *G. triacanthos* is located near Toowoomba (at Clifton on the Darling Downs), suggests that a climate match index of 0.5 would be a more appropriate threshold for climate suitability assessment in this case. Using a 0.5 threshold for closeness of match, a second prediction was generated (Figure 4). This prediction suggests that *G. triacanthos* may have the potential to colonize alluvial soils over large areas of south-eastern Australia.

The 'match index' process used in CLIMEX to identify sites with a similar climate employs a least-squares technique as an indication of the combined closeness of match of maximum temperature, minimum temperature, rainfall and evaporation (Maywald and Sutherst 1989, 1991). This index is insensitive to the direction of the difference between the climatic parameters being compared. A climate which is 'milder' in terms of the range of any of the four climate parameters may show up as having a poor match compared with the climate from which the species has originated.

Despite a match index of 0.54, the 'milder' climates at locations such as Toowoomba may be suitable for the growth of *G. triacanthos*, due perhaps to the lack of climatic extremes in combination with the reduced effects of limiting factors such as natural enemies or interspecific competition.

The insensitivity of the climate match index to the direction of the difference for each climate parameter calls into question its usefulness as a sifting mechanism for indicating locations which are climatically suitable for a particular plant species. An index which is sensitive to the direction of the difference between each of the climatic parameters of the target and origin site would be preferable for predicting the climatic suitability of a site. The problem with the climate match index underlines the fact that models serve only as a guide and are no replacement for a clear understanding of the real processes being modelled.

The observation that *G. triacanthos* has formed dense infestations in south east Queensland and on the central coast of New South Wales tends to support the validity of the prediction generated by CLIMEX. In addition, as predicted by the model, *G. triacanthos* has failed to naturalize in Western Australia, the Northern Territory or South Australia (P. Pheloung, personal communication, State Herbaria records). The plant has not, however, naturalized in Victoria or Tasmania, as could be expected from the prediction. A more accurate assessment of the validity of the prediction can only be made over the next 50–100 years, when *G. triacanthos* has had sufficient time to become more firmly established in Australia.

Risks posed by cultivated varieties of *G. triacanthos* and other species of *Gleditsia*

There are 14 species of *Gleditsia* with a broad range of natural distribution from Asia to North and South America (Gordon 1966). Other aggressive, thorny, rapidly growing species of *Gleditsia* may have significant pest potential in Australia. Two species of particular concern are *G. sinensis* which is reported to be a "rapidly growing tree, thriving along stream courses, upland glens and mountain slopes of the temperate zone" (Paclt 1982) and *G. caspica* which can form thick impenetrable groves, as exemplified in forests in the region of Astara in Talys (Talish, USSR) (Safarov 1960, 1965, cited in Paclt 1982). Additional *Gleditsia* species should not be imported or sold until a thorough review of the pest potential of the entire genus is complete.

The potential for *G. triacanthos* to hybridize with other species of *Gleditsia* is also of concern. Artificial hybridization between male *G. triacanthos* ('Moraine' and 'Skyline' varieties) and *G. melanacantha* Tang and Wang (Syn. *G. caspica*) has been documented by Santamour (1976). The hybrid seed germinated and grew normally. In addition, *G. texana* is believed to be a naturally occurring hybrid between *G. aquatica* Marsh. (water locust, native to the southern USA) and *G. triacanthos* (Schnabel and Hamrick 1990b). Hybridization between *Gleditsia* species and between varieties of *G. triacanthos* may lead to increased morphological variability and an ever-increasing variation of genotypic combinations in the hybrid off-spring. Resultant morphological and genetic variability may complicate and reduce the effectiveness of future biological control programs in a similar manner to that which has been experienced with other pest plants in Australia such as *Lantana camara* (Willson 1993) and *Prosopis* species.

Summary

In view of the plant's climatic requirements, broad natural range and prolific growth on alluvial soils, *Gleditsia triacanthos* is considered a threat to native riparian vegetation and pastures along watercourses and on flood plains throughout much of south-eastern Australia. Pastures established on alluvial soils associated with the Murray-Darling river system may be particularly prone to invasion since pods floating down the Condamine River (from Queensland into New South Wales) will find ideal conditions for establishment.

G. triacanthos possesses similar attributes to *Acacia nilotica* and the *Prosopis* complex, some of Australia's most destructive introduced fodder trees (i.e. rapid growth, thorniness, prolific seed production, animal and water dispersal, freedom from pests and propensity to form impenetrable thickets along watercourses and out onto pastures). Unlike the situations for the latter species, however, infestations of *G. triacanthos* in Australia are still relatively localized. There is an opportunity to control small populations of *G. triacanthos* before they become firmly established. An eradication program for *G. triacanthos* was initiated in Queensland in March 1993. Restrictions on the continued sale of *G. triacanthos* and the importation of closely related *Gleditsia* species are also recommended.

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