SIAM WEED OUTBREAK IN FAR NORTH QUEENSLAND: PROGRESS REPORT ON ERADICATION EFFORT

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Summary Infestations of Siam weed, one of the world's worst tropical weeds, were discovered near Tully (north Queensland) in July 1994. Although they had remained unrecognized for some years, the infestations were confined within two small catchments. Eradication of Siam weed, which has the potential to infest humid coastal areas from the Kimberley region to southern New South Wales, is considered to be feasible. A five-year eradication program, jointly-funded by the States and Commonwealth and managed by the Queensland Department of Natural Resources, was commenced within several weeks of the discovery. Excellent progress has been made to date and the prospects of eradication are promising.

INTRODUCTION

Siam weed (*Chromolaena odorata* (L.) R. M. King & H. Robinson; formerly *Eupatorium odoratum* L.) belongs to the tribe Eupatorieae within the Asteraceae (daisy family).

Description Siam weed is a much-branched perennial shrub, which forms dense, tangled thickets 2–3 metres tall in open situations, and can attain heights up to 10 metres by scrambling on adjacent trees. It tolerates partial shading, but will not grow beneath closed canopies. Siam weed has freely-branching cylindrical stems which become woody near the base. Adventitious roots sometimes form at the nodes of broken stems. Characteristic pairs of lateral branches develop from axillary buds along the main stems, and the leaves are opposite, 3-nerved, softly hairy and aromatic when crushed.

Flowering occurs between June and August (in the southern hemisphere) and makes plants much more conspicuous. Flower heads develop in axillary and terminal flat-topped corymbs. Each head contains 20–36 pale lilac, pale pink or bluish-white flowers; with long-exserted styles giving the fresh flowers a fluffy appearance. Siam weed produces huge numbers of seeds, estimated by Gautier (1993) to be in the vicinity of 86 000 seeds m^{-2} in stands of mature plants. The achenes are dark-coloured, linear, about 4 mm long, with a pappus of pale bristles; adapted for dispersal by wind.

Native distribution Siam weed is native to the neotropics, extending from southern Bolivia and Paraguay, northwards through the Amazon basin, central America and the Caribbean, to southern Florida (McFadyen 1989, Gautier 1992).

Exotic distribution Siam weed is thought to have been introduced to the Calcutta Botanical Gardens in the 1840s, and by the 1870s was naturalized on the Ganges flood plain (McFadyen and Skarratt in press). Since then it has become a pest throughout southern and southeast Asia (including southern China), extending eastwards into the Pacific islands. It occurs throughout Indonesia and its presence was recently confirmed on the Papua New Guinea mainland (Waterhouse 1992). Since its introduction from Asia in the 1930s, it has also become a serious weed in West Africa and more recently in South Africa. The movement of people and their goods has been very important in the accidental spread of Siam weed to new locations.

Siam weed is essentially a weed of the tropics and subtropics, occurring between 31°S (in South Africa) and 27°N (in Texas). In South America it occurs up to 2800 m above sea level (Gautier 1992); but maximum elevation declines with increasing latitude. McFadyen (1989) suggested that Siam weed has the potential to become a weed in all tropical and sub-tropical areas with rainfall higher than 1200 mm per year, but data collected by Gautier (1992) suggests it can establish in much drier regions.

Importance as a weed Siam weed has been listed as one of the world's worst weeds (Holm *et al.* 1977). It is an aggressive invader of pastures and plantation crops, and a significant environmental weed. Its dense growth and smothering habit suppresses other vegetation and can kill or stunt growth of saplings in plantations or regenerating forestry areas. Crops affected in Asia and Africa include rubber, cocoa, oil palm, teak, coffee, tea, sugarcane, cotton, pineapples tobacco, and dryland rice. High nitrate content of young foliage is toxic to livestock, and results in loss of several thousand cattle per year in the Philippines (Parsons and Cuthbertson 1992). The plants die back after flowering, creating highly

combustible fuel which promotes hot fires in areas which would otherwise rarely burn.

Expectation of Siam weed's arrival in Australia McFadyen (1989) warned that northern Australia was under imminent threat of the arrival of Siam weed. In fact, given its spread associated with movement of people and materials in World War II, it is surprising that Siam weed did not arrive in Australia earlier. Michael (1989) listed it as the most important tropical exotic weed threat to Australia because of the serious problems experienced after its invasion overseas, and rapid spread in the region. It has been a target of weed surveys conducted under the auspices of the Northern Australia Quarantine Strategy since 1990. In anticipation of its arrival, Siam weed was pre-emptively declared as a P1 and P2 category noxious weed by the Queensland Department of Natural Resources (formerly Department of Lands).

Potential distribution in Australia Using climatic data from its known distribution in Asia and the Americas, McFadyen and Skarratt (in press) used the climate-matching program CLIMEX to predict areas suitable for establishment in Australia, Oceania and Africa. In Australia the predicted distribution includes all the humid coastal areas from the Kimberleys to south of Sydney, and possibly at a few sites in south-western Australia (McFadyen and Skarratt in press). It is unlikely that Siam weed would extend far inland over much of this range.

DISCOVERY IN AUSTRALIA

Extent of infestations Several flowering Siam weed plants were discovered growing along a roadside near Bingil Bay (far northern Queensland) on 15 July 1994. It was apparent that this was not the primary infestation, so teams of personnel from the Department of Natural Resources and Department of Primary Industries commenced an immediate search of the surrounding district (Waterhouse 1994).

The primary infestation was discovered on a pastoral property in the vicinity of Echo Creek, a tributary of the Tully River. Another smaller outbreak was detected in the headwaters of Davidson Creek which drains the same property. Dense thickets and isolated plants were growing in paddocks adjacent to the rainforested creeks and along the banks of the Tully River for a distance of approximately 30 km from the junction with Echo Creek, extending to the tidal reaches. The major secondary infestation was at Bingil Bay with smaller outbreaks at Murray Upper and Feluga. Intensive weed management regimes in sugarcane and banana plantations along the Tully River had apparently limited development of infestations there (Waterhouse 1994).

The extent of the Queensland infestations had been delineated within several weeks of the initial discovery, and no extension of range has been reported since then.

Age of infestation and possible mode of introduction Anecdotal reports from landholders suggested that plants had been observed along the banks of the Tully River for at least seven years. Senescent plants with basal stem diameters up to 10 cm were found in the upper reaches of Echo Creek. Reduced growth during and after flowering leaves 'growth rings'. The core of the stem-base on the senescent plants had rotted away, but up to 10 rings were visible, suggesting a minimum time-frame of 10+ years.

During subsequent eradication efforts, the plants near Davidson Creek were observed to look different and flower two months earlier than the majority of plants. DNA testing has confirmed that there are two different genotypes present (Scott and Lange 1996). The common genotype in the Queensland infestations is widespread throughout Siam weed's native and exotic range, but the Davidson Creek genotype is only known from southern Brazil (Scott and Lange 1996).

Pasture legume and grass seeds were imported from Brazil and sown in the vicinity of Echo and Davidson Creeks from the mid-1960s to the early 1970s (Hardwick 1994). It is likely that at least one batch of this pasture seed was contaminated with the two types of Siam weed (Scott and Lange 1996).

Eradication program approved Due to the confined nature of the outbreak, a five-year eradication program was approved by the Standing Committee on Agriculture and Resource Management (SCARM). Funding of the program is shared between the Commonwealth and mainland States (except South Australia); with the Commonwealth providing 50% and Queensland 25% of the cost burden, the remainder being split according to potential distribution and effects in each State.

The Queensland Department of Natural Resources is the agency responsible for the eradication of Siam weed; with co-operation from the Departments of Primary Industries and Environment (e.g. loan of equipment). Research on appropriate herbicides and seed ecology, as well as public awareness activities have been undertaken as part of the eradication effort.

ERADICATION METHODS

The eradication effort was commenced on 27 July 1994. Accurate mapping of the infestations was assisted by use of GPS units to obtain site co-ordinates. Relocation of sprayed sites is also facilitated by use of GPS.

Major survey and spray programs have been undertaken approximately every four months since the original program. Each has involved eight or nine personnel working in teams. Four Toyota 4 × 4 vehicles were fitted with remote control spray units (Quikspray). These units are suited to the rainforest and creekline environments; the self-winding hose reel assisting the operators to move between the rainforest trees and shrubs. Ground co-ordination of the teams is assisted by use of 2-way radios. The Tully River banks have been sprayed from the river, using a flat-bottomed boat on loan from the Department of Environment. This is fitted with a 400 litre spray tank and a diaphragm pump. To date, picloram + triclopyr 1:300 (Grazon DS®) combined with a wetting agent has been the herbicide of choice; with a small amount of glyphosate 1:100 adjacent to a teak plantation. Mechanical control has been necessary at several sites, including an organic farm (Halton *et al.* 1996).

To achieve eradication within the five-year timeframe it is essential that flowering and seed production is prevented. Flowering commences in late June and seed is set 3–4 weeks later (G. Hardwick personal observation). Three major programs are undertaken during the year: in April/May before flowering; in July during flowering when plants are most conspicuous; and in October/November before the wet season commences and sites become inaccessible. This program is strategically designed to maximize use of resources (e.g. spraying during the wet season would result in numerous lost days); and hit the plant at its most vulnerable stages, that is, when the plants are growing rapidly, and before seed is set.

Progress of the eradication campaign has been measured by visual assessment of the reduction of the Siam weed population throughout the infested area, and by monitoring the use of chemicals over time.

Table 1. Chemical usage and worker days.

	Grazon DS (litres)	Workforce (days)
Initial program (July 1994)	360	330
Follow-up (October 1994)	200	60
Second major program (May 1995)	380	300
Follow-up (July 1995)	47	117.5
Follow-up (November 1995)	75.5	75.5
Total to date	1062.5	883.0

RESULTS TO DATE

It is estimated that there has been a reduction of the population by 95–98% to date. As expected, after the first spray program, there was a very large germination of seedlings. Table 1 illustrates that chemical usage was slightly greater in May 1995 than in the initial round of spraying, but there has been a large reduction since then.

It is expected that the amount of chemical used will continue to decline, but that worker days will remain at similar levels because the seedlings and scattered mature plants are more difficult to find. Selected sites are monitored on a regular basis between surveys and spray programs to assess seedling regeneration.

Up to the present, Grazon DS has been used because of its residual properties; but has the drawback of damaging non-target species. Now that the seed bank has been reduced it should be possible to use a non-residual herbicide. Fluroxypyr (Starane 200®) is currently being trialed, and if successful its use should facilitate the recovery of native vegetation in Siam weed infested areas.

DISCUSSION

The Department of Natural Resources has made a commitment to eradicate Siam weed from northern Queensland. Because of the isolated nature of the infestation, eradication appears a feasible objective. Close monitoring of the populations and continuation of the intensive follow-up is vital. Personnel from elsewhere in the State have been rotated through the survey and control teams to gain first-hand experience of the weed in all its stages, and increase the likelihood of recognition elsewhere. To date there has been no evidence of its spread outside the Tully district.

The eradication campaign has now entered its most difficult phase. Seedlings are concealed by dense growth of tall pasture grasses along the river and creek systems where dense stands of Siam weed previously grew. Prevention of any further seed production is the primary goal of the ongoing campaign.

Studies of the seed population dynamics of Siam weed are scarce. Yadav and Tripathi (1982) demonstrated that buried seeds can remain viable for a minimum of two years, but with dramatic reduction of the seed bank over this time. With this in mind, and considering that a few mature plants escaped the first major spray program, a slightly longer time-frame may be required to accomplish eradication (up to eight years).

Highly motivated and tenacious personnel have been an essential ingredient for the success of the program. Hazards such as crocodiles, snakes, stinging trees (*Dendrocnide moroides*), lawyer vine (*Calamus moti*), mosquitoes, continuous rainfall (3.5 metres per year) and stifling conditions make the work trying at times.

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