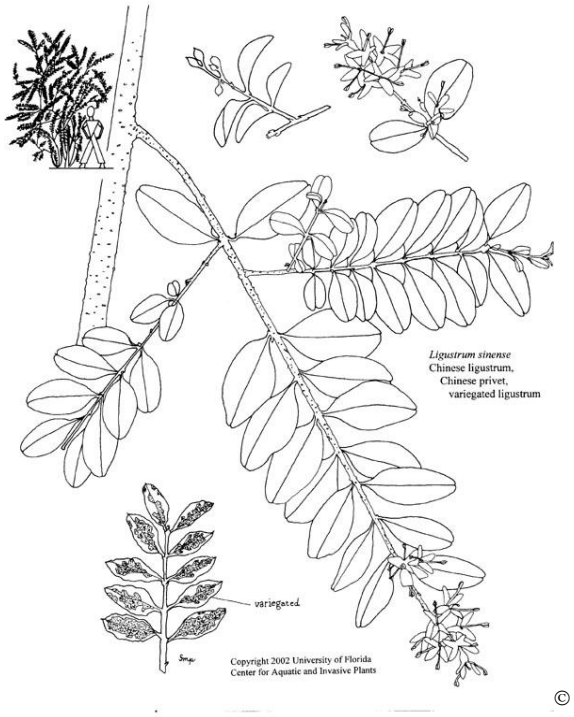
An Ecological Study of Chinese Privet (*Ligustrum sinense* Lour.) in the Waikato Region



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CBER Contract Report No. 41

Prepared for Environment Waikato Regional Council

2005

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

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Summary

Chinese privet (*Ligustrum sinense*) has naturalised across the Waikato region invading lowland native forest and wetland habitat. This shrub has the ability to form a dense canopy or subcanopy and appears to exclude other native species from establishing in the understorey. Chinese privet seedlings were found in abundance underneath privet canopy, where they grow slower than when invading a new site yet are able to succeed adult plants and continually occupy a site. Chinese privet seedlings establish readily under intact native canopy but are more prolific in disturbed high light environments. Fruit is produced in abundance and is dispersed by birds particularly beneath perch sites, which limits seed dispersal over open ground. Chinese privet seedlings appear to be palatable to stock, but rapidly out-compete and dominate regenerating native species when grazing pressure is removed. A short-lived seedbank, six months to one year viability, suggests that the removal of adult plants will quickly reduce the number of seedlings establishing.

This invasive shrub is a serious weed in south-eastern USA where it is well established and would appear to have similar potential in New Zealand to form vast, dense thickets with very low floristic diversity.

Contents

1. Introduction

The introduced ornamental shrub Chinese privet (*Ligustrum sinense*) is not listed as a National Pest Plant in New Zealand, although it is a Containment Pest in the Waikato Regional Council Pest Management Strategy (Environment Waikato 2002). It is recognised as an invasive shrub in several other countries including Australia, USA, Argentina and several islands in the Pacific. Very few overseas or local studies have quantified the effects of privet invasion and naturalisation on native flora. This report summarises the known behaviour of Chinese privet in the New Zealand environment and presents field data from various sites in the Waikato where privet is present. The impact of Chinese privet on lowland forest and wetland floristic composition and structure is investigated in order to assess the species' status as an ecological pest in the Waikato region. A review of available literature has been conducted and field population studies undertaken at four sites.

2. Objective

This study aims to investigate the following three questions:

1) What native habitat is vulnerable to Chinese privet invasion and establishment?
2) What is the impact of Chinese privet on plant species composition following establishment?
3) What is the reproductive potential of Chinese privet?

3. Species Description

Chinese privet (*Ligustrum sinense*) is a member of the cosmopolitan Oleaceae family of around 29 genera and 600 species. It is a shrub or small tree growing up to 5m tall, and tends to be evergreen but may be semi-deciduous in cold districts. The dull green leaves are small, 2.5-6cm length by 1.25-2.5cm width, elliptic and often have wavy edges. The leaf midrib is hairy on the underside and often above in the lower part, new shoots and petioles are also hairy. Small, fragrant white flowers occur in long panicles, up to 10cm length, mauve to purple anthers distinguish this species from other *Ligustrum* species in New Zealand. Fruit are round, 4-6mm diameter and purplish black, containing a single 3-4mm long, oblong, shallowly grooved seed (Webb *et al.* 1988).

4. Related species

Four other *Ligustrum* species are found in New Zealand including the widely naturalised tree privet (*L. lucidum*) which grows up to 14m height and occurs from Northland to the Bay of Plenty, which is listed as a National Pest Plant. Common privet (*L. vulgare*) a small, semi-deciduous tree up to 5m height is not commonly planted now but can be found naturalised around Tauranga, Wellington, Canterbury and central Otago. Privet (*L. ovalifolium*) is an upright, evergreen shrub to 5m height commonly planted as hedging in Auckland, Wellington, Westland, Invercargill and Bluff. This species is the least common in the wild, possibly due to low fruit production (Webb *et al.* 1988).

5. Reproductive Biology

Chinese privet reproduces by seed and also coppices readily from the base. Flowering occurs from September to December but may extend from July to March (BIOWEB, Department of Conservation). This is both an earlier and extended flowering period when compared to other privet species naturalised in New Zealand. Flowers are bisexual and pollinated by insects (Timmins & Mackenzie 1995). The small, dark ripe fruits are dispersed by birds or gravity from autumn through the winter months, and do not require the removal of berry flesh for germination (Panetta 2000; Timmins & Mackenzie 1995).

6. Habitat

Chinese privet occurs in the wild in lowland and coastal habitats, from forest margins and remnants to shrubland and wasteland areas and wetlands (Timmins & Mackenzie 1995). It is found particularly near human habitation where ornamental plantings and hedges still exist. Chinese privet appears to have a broad ecological niche tolerating a wide range of environmental conditions from dry to wet, cold to hot and shaded or open habitat (Timmins & Mackenzie 1995).

7. Distribution

Originating from China this shrub has been used widely in garden and roadside hedges. Chinese privet was first recorded wild in New Zealand in 1950 (Webb *et al.* 1988) and is now abundantly naturalised from Northland to the Bay of Plenty occurring as far south as Hokitika (BIOWEB, Department of Conservation).

Chinese privet is considered an invasive shrub in the South-eastern United States where it occurs in 19 states having been introduced in 1852 (Matlack 2002; Merriam & Feil 2002; Miller 2003; Morris *et al.* 2002). It is also a serious environmental weed in subcoastal eastern Australia (Panetta 2000), Argentina (Montaldo 1983, cited in Morris *et al.* 2002) and several Pacific Islands including Hawaii, Lord Howe Island and Norfolk Island (Institute of Pacific Islands Forestry).

8. Pest Status

Chinese privet pollen may aggravate respiratory problems such as asthma and hayfever, although this is arguable given that the comparatively heavy pollen is insect dispersed rather than wind dispersed (Webb *et al.* 1988). The fruit and leaves of all of the naturalised privet species are considered poisonous to humans and stock, isolated poisoning cases have been recorded in New Zealand and overseas including the death of cows and horses, and human sickness and diarrhoea from eating fruit (Connor 1977). Nevertheless stock appear to graze seedlings in New Zealand (B.D. Clarkson pers. comm.) and the species is a common component of deer diet in parts of the USA (providing up to 75% of winter diet during a study in Georgia: Stromayer *et al.* 1998).

In the Waikato there is no legal obligation for landowners to control Chinese privet on private property being designated a Containment Plant Pest which relies on voluntary control by the land occupier (Environment Waikato 2002). However, if a valid health related complaint is received from a neighbour a landowner may be required to control Chinese privet within 50m of the property boundary. Chinese privet in public amenity areas must be controlled following any complaint by a member of public, and it can be the subject of a community control initiative. Chinese privet may not be knowingly released, sold, propagated, distributed or commercially displayed in the Waikato Region.

9. Control Methods

Small plants can be physically removed or sprayed with herbicide and larger plants must be treated with herbicide to prevent re-growth. Larger trees can be injected with herbicide or felled and the stump painted with a suitable herbicide.

It has been recommended that open or disturbed areas are planted in native plants to reduce privet germination and reinvasion (Environment Waikato www.ew.govt.nz). Existing hedges can be trimmed regularly to prevent flowering and fruiting. For further information on control see websites listed in references.

10. Population Studies

Sampling Method and Sites

Demographic data was gathered for Chinese privet and associated vegetation from four locations around the Waikato region comparing different aged privet populations (stages of invasion) and habitat types (Table 1).

Table 1. Population study sites indicating presence/absence of Chinese privet trees and seedlings.

Location	Plot no.	Habitat type	Established privet subcanopy trees	Privet seedlings
Te Aroha	1	Regenerating native kanuka-edge	✓	✓
	2	Regenerating native kanuka-edge	×	✓
	3	Regenerating native kanuka-interior	×	✓
	4	Native broadleaf forest	×	✓
Waingaro	5	Tall podocarp forest river terrace	×	✓
	6	Tall podocarp forest river terrace	×	✓
	7	Pine plantation	×	✓
	12	Privet dominant canopy	✓	✓
Kopuatai wetland	8	Kahikatea swamp-pooled	✓	✓
	9	Kahikatea swamp- dry	✓	✓
Herekawe SR, Benneydale	10	Regenerating native broadleaf forest	✓	✓
	11	Regenerating native broadleaf forest	×	×

At each sampling site a 10m x 10m quadrat[1] was laid out and all tree species present (> 3cm diameter at 20cm from the stem base) were counted and diameter measured. All saplings (>1.35cm height, but <3cm diameter) and seedlings (0.15-

[1] Plot 12 only 5mx5m.

1.35m height) were counted, and all species <0.15m height were recorded as present. Site characteristics were also recorded including: aspect, altitude, slope, drainage, physiography, groundcover composition and canopy percentage cover and height.

Using a destructive sampling technique twenty-two Chinese privet trees at Waingaro were cut at 20cm height from the stem base and the annual growth rings counted.

The pine plantation site at Waingaro (plot 7) has been removed for analysis of understorey species richness due to the high degree of site modification making comparison with species composition at other sites unsuitable.

Demography

Chinese privet was found to be persisting in a wide variety of environmental conditions from wetland with standing pools of water at Kopuatai to dry, well drained lower slopes at Te Aroha. The seedlings occurred in the shade directly under both Chinese privet trees and other tree species and were also found to be colonising open grass areas around trees. Seed dispersal across open ground appeared to be strongly influenced and limited by available bird perches. Chinese privet seedlings were found establishing at least 30m into native forest and kahikatea swampland habitat.

The abundance of Chinese privet seedlings and saplings in secondary kanuka forest, mature podocarp forest and mature pine plantations demonstrates the species ability to invade new sites both with and without canopy disturbance (Figure 1). The abundance of young Chinese privet at the two Waingaro podocarp sites appears to have resulted from the removal of stock grazing in the forest, with no change in canopy cover. The cessation of stock grazing 3 years ago has lead to dominance of <1m height Chinese privet seedlings in the understorey. The site with the highest density of Chinese privet trees also had a very high density of Chinese privet seedlings (Waingaro privet).

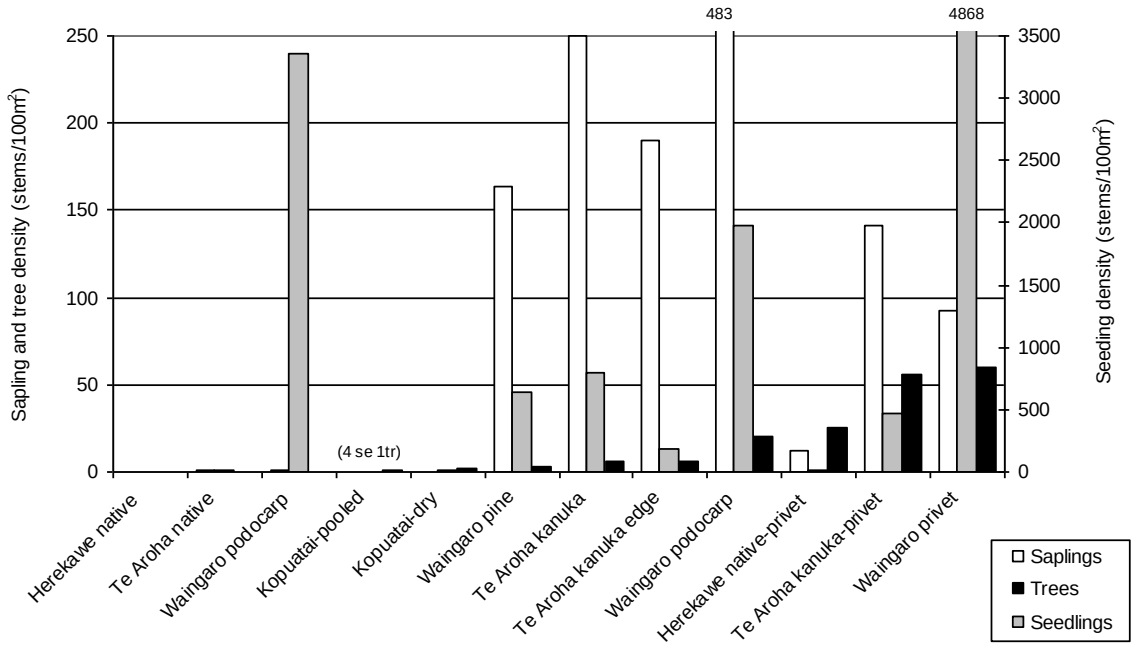

Figure 1. Chinese privet density in three size classes for 12 study sites (ordered by tree density).

Chinese privet seedlings and saplings were found to be common at a range of tree basal areas suggesting an ability to establish and persist in a shade (high basal area) or high light environment (Fig. 2). Chinese privet seedlings occurred at much greater density than other species where they were establishing and were found where native seedlings were both sparse and common (Fig. 3).

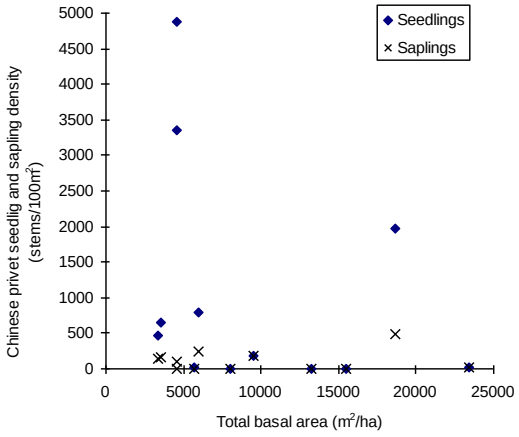

Figure 2. Density of Chinese privet seedlings and saplings in relation to basal area at 12 plots.

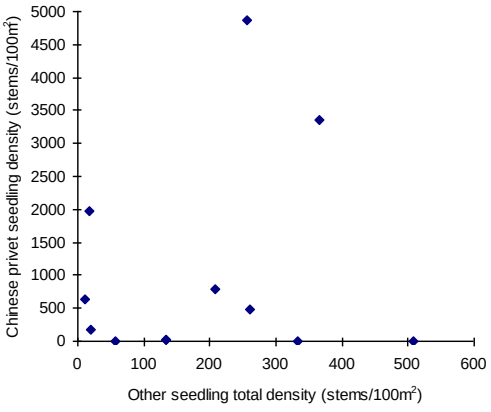

Figure 3. Comparative densities for Chinese privet and all other seedling species (15-135cm height) at 12 plots.

Those sites dominated by privet trees all had privet seedlings present and showed a reduced number of other species present in the seedling tier (Fig. 4) indicating that floristic diversity is adversely affected by Chinese privet canopy dominance. The species found most often in the understorey with Chinese privet were common native lowland forest shrubs- karamu (*Coprosma robusta*), *Coprosma rhamnoides*, mahoe (*Melicytus ramiflorus*) and hangehange (*Geniostoma rupestre* var. *ligustrifolium*). *Coprosma rotundifolia*, *Melicytus micranthus*, kawakawa (*Macropiper excelsum*) and the introduced Jerusalem cherry (*Solanum pseudocapsicum*) also occurred commonly with Chinese privet at one or two sites.

A decrease in the number of introduced species present as privet seedling density increases (Fig. 5) suggests that Chinese privet is excluding other weeds or colonising areas with few weeds already present. The latter seems more likely given the shade tolerance of Chinese privet and the ability of some native seedlings to persist amongst privet seedlings.

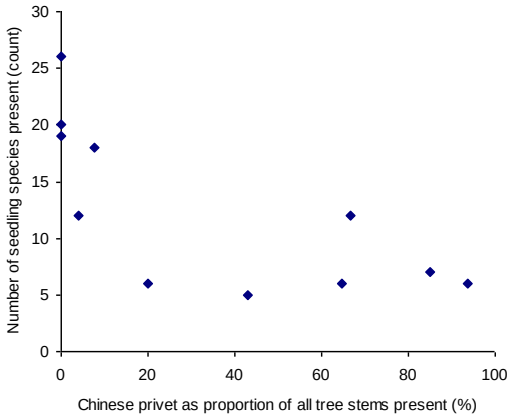

Figure 4. Relationship between seedling species richness and privet dominance in the canopy (pine plantation not shown).

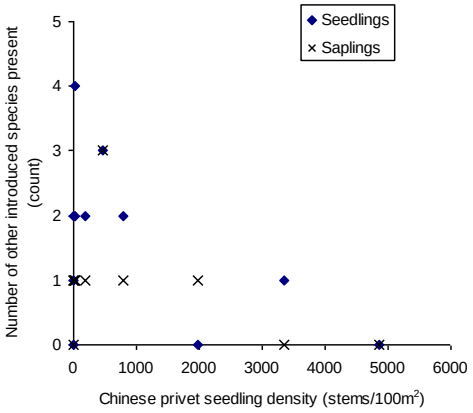

Figure 5. Relationship between introduced seedling and sapling species richness and Chinese privet seedling density (pine plantation not shown).

Flowering and fruiting

Sixty-one percent of privet trees sampled were bearing or had borne fruit this season. All plants >8cm diameter or >5m height produced fruit (Fig. 6) yet fruiting was also observed on plants from as small as 1-1.5m height, including some saplings (<3cm diameter) growing in high light conditions. No distinct relationship between plant size and fruiting was detected due to variation in canopy height at the study sites. Plants within a privet canopy bore fruit when smaller than those which formed a subcanopy tier under natives, e.g. kahikatea, suggesting a light requirement for fruit production.

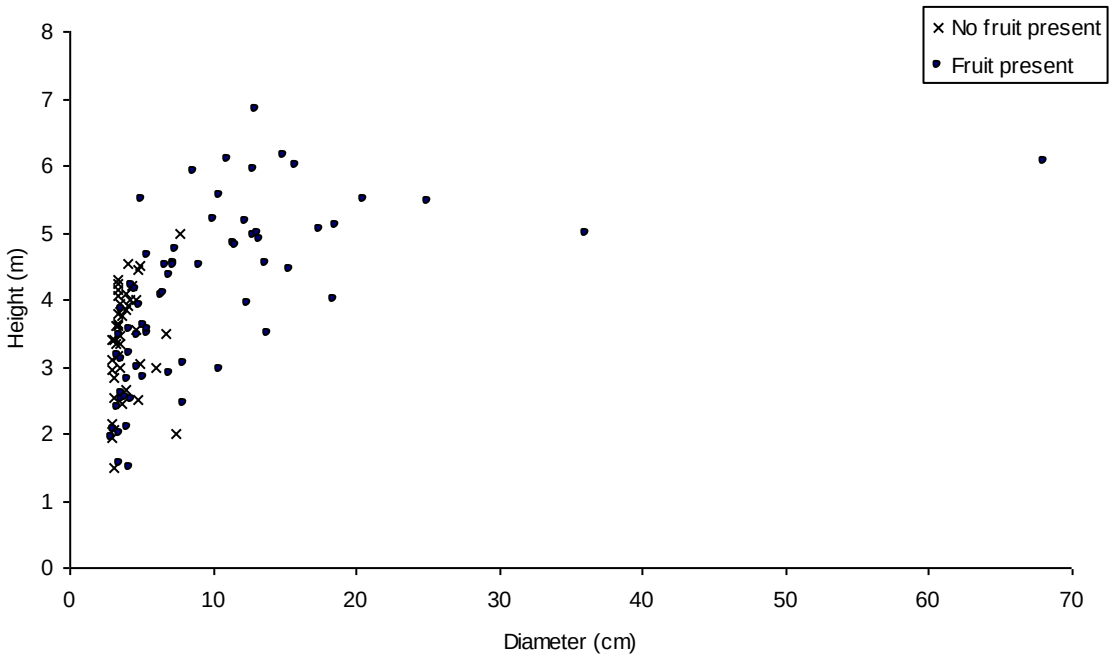

Figure 6. Relationship between fruit production and stem height and diameter for Chinese privet plants at all study sites.

Germination

A total of 162 fruit were collected from three plants in the Te Aroha area in late August for a germination trial. Half of the fruit were sown with flesh intact and half had flesh removed to emulate bird digestion. In a shade house under a regular watering regime the first germination occurred within 8 weeks for both treatments. After 11 weeks the fleshy fruit and bare seed treatments had germination success rates of 7.4% and 6.3% respectively.

Growth rings

Stem growth rings were counted at a privet canopy site (plot 12), a kahikatea canopy site (plot 6) and at the edge of a kahikatea canopy (near plot 6). Up to 10cm diameter, stems of equivalent diameter were older beneath privet canopy than when beneath a kahikatea canopy (Fig. 7). This suggests that Chinese privet trees grow faster when first invading native habitat with an open understorey and subcanopy but slower once a privet subcanopy has formed. A degree of shade tolerance allows Chinese privet seedlings and saplings to persist at a site. Two much younger trees growing on the edge of the kahikatea stand indicated an ability to grow very rapidly in open light conditions, one eight year old stem averaging 1.3cm diameter growth per year.

Growth rings showed that at one of the Waingaro podocarp sites Chinese privet formed a thick understorey 3-4m in height 10 years after the exclusion of grazing stock.

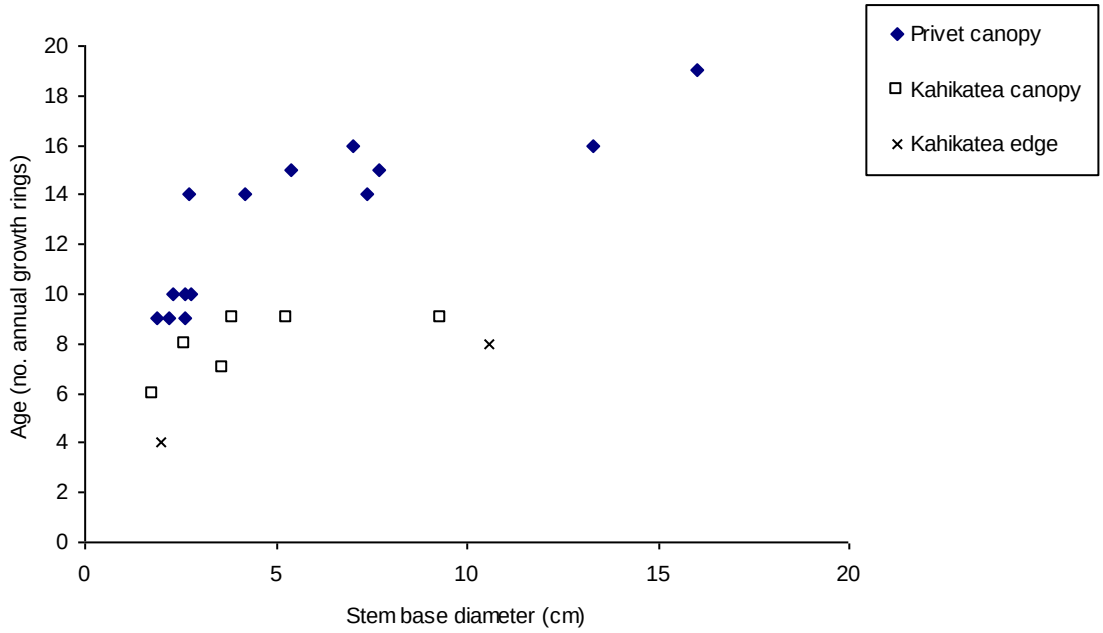

Figure 7. Age-diameter relationship for Chinese privet in three canopy types.

11. Allelopathy

Due to observations of a limited number of species regenerating under Chinese privet dominated canopy a preliminary experiment was undertaken to investigate a possible allelopathic effect by Chinese privet which could inhibit seed germination or

growth. Chinese privet leaf leachate was used as leaves often produce the toxic substances in other allelopathic tree species, although stems and roots may have a similar effect (Rice 1984; van den Bosch *et al.* 2004). Radish seeds were germinated and left for four days on damp filter paper in sealed dishes in an incubating oven at 25°C. Distilled water was the control and privet leaf leachate the treatment. After four days 92% of the control seeds had germinated compared to only 80% of the treated seeds. Mean root length for seeds treated with leachate was significantly lower (p=0.01309) than for the control seeds, mean stem length was also lower for treated seeds but not significantly (Table 2).

Table 2. One-way analysis of variance (ANOVA) results for radish growth 4 days following germination using a Chinese privet leaf leachate treatment.

	Treatment		Effect		
	Leaf leachate	Control (water)	df	F	P value
Mean root length (mm)	21.76	34.64	48	6.6418	0.01309
Mean stem length (mm)	9.92	12.88	48	1.6966	0.19894

12. Overseas Research

A small amount of research has been published in the USA and Australia regarding the ecological impacts of Chinese privet invasions. In south-eastern USA where Chinese privet is well established (since the mid 1800s) it is one of the most problematic and aggressive invasive shrubs (Miller 2003). Merriam and Feil (2002) found that native species richness and herb and seedling density was reduced under Chinese privet canopy compared to a reference site which had not been invaded by privet in mixed hardwood forest in Western North Carolina. During their study all privet were removed from an invaded site leading to a subsequent increase in herb and tree seedling species and stems in the following season. In a comparative study of plant structure between introduced Chinese privet and a co-occurring native shrub Morris et al (2002) concluded that due to increased photosynthetic capacity (ability to capture light), both spatially and temporally, and far greater fruit production privet possessed a competitive advantage which allowed it to successfully invade the red cedar/hardwood forest edges in Tennessee. Further research in Tennessee investigated the potential for using flooding as a management tool to control Chinese privet, however, despite a reduced growth rate privet appeared to be capable of

withstanding short-term flooding and shading by morphological adaptations such as adventitious roots and lenticels (Brown & Pezeshki 2000). An Australian study found that Chinese privet seeds required high moisture levels to achieve high germination rates on the ground surface or otherwise needed to be shallowly buried (Panetta 2000). Seeds sown in the field did not remain viable for longer than one year and those which were buried were not viable after only 6 months indicating a transient seedbank. Panetta (2000) found that fruits and seeds had similar germination rates, as did this study, indicating that Chinese privet may be reliant on birds chiefly for dispersal rather than fruit flesh removal.

13. Conclusion

Chinese privet has become a prolific and dominating weed shrub in south-eastern USA where it has formed vast mono-specific thickets over a longer history of occupation than in New Zealand. Indications are that the shrub is capable of achieving similar habitat dominance in the Waikato region, and moreover potentially across much of New Zealand.

In the Waikato Chinese privet is successfully establishing in the edge of intact and secondary native lowland forest and wetland habitat across the region. Chinese privet was found to be capable of forming a mono-specific canopy or subcanopy in less than 15 years following disturbance, such as clearance or grazing, of the native species in these tiers. Growth appears to be primarily limited by light environment, with prolific invasion in highly disturbed sites and at forest edges. Chinese privet seedlings also establish under intact forest canopy but at a slower rate.

Chinese privet dominated canopy was found to negatively influence species richness in the understorey, although the species own seedlings were abundant under adult trees. A combination of shading and some allelopathic effect of adult leaf leachate may inhibit the growth of other plants under a canopy of Chinese privet and contribute to a reduction in floristic diversity after invasion. This reduction in diversity and predominance of its own seedlings in the understorey beneath Chinese privet canopy suggests that the species is able to persist at a site and arrest native forest succession.

A degree of shade tolerance appears to allow Chinese privet to invade forest sites that other weeds do not. Seedlings will also establish readily in open grassland providing that bird dispersal of seeds is facilitated by the presence of existing bird perches. Availability of light appears to influence Chinese privet fruit production. Most trees in the subcanopy produce fruit by 8-10 years old. In high light conditions plants may reach fruiting maturity as young as 3 years old. The prolific fruit production of Chinese privet trees ensures that there is a constant source of seed for invasion. However, the apparently short-lived seedbank means that the removal of mature trees may rapidly reduce seedling establishment rates.

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http://www.ew.govt.nz/enviroinfo/pests/plants/Privet.htm

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http://www.vnps.org/invasive/FLIGUS.html

http://ecoaccess.org/info/wildlife/pubs/chineseprivet.html

15. Acknowledgements

Janica Amoore assisted with data collection in the field and Catherine Beard provided help with plant identification. Access to and through private land was provided by S. Clarke and B.D. Clarkson. Daniel Mahon and Shannon Fergie at the Department of Conservation provided helpful site information and access to the BIOWEB database. David Stephens provided comments on the draft report.