RISK ASSESSMENT OF INUNDATIVE BIOLOGICAL CONTROL WITH CHONDROSTEREUM PURPUREUM IN NEW ZEALAND

T. D. RAMSFIELD
Ensis, Private Bag 3020, Rotorua, New Zealand
tod.ramsfield@ensisjv.com

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ABSTRACT

The host range and geographic distribution of the basidiomycete fungus *Chondrostereum purpureum* (Pers.) Pouzar in New Zealand were determined through analysis of herbarium records from Landcare Research and the New Zealand Forest Research Institute Limited, as well as published reports. The fungus has been recorded in every geographic region of the North Island, with the exception of Northland and Rangitikei, and from the northern portion of the South Island, as well as Southland, Otago Lakes, south Canterbury, and mid Canterbury, but it is known to be present throughout New Zealand. It has been recorded on 23 angiosperm families and 1 gymnosperm family in New Zealand. Based on the geographic distribution and epidemiological studies of the pathogen that have been conducted elsewhere, it is concluded that the utilisation of *C. purpureum* as an inundative biological control agent would not significantly alter the risk of infection by *C. purpureum* within New Zealand.

Keywords: mycoherbicides; inundative biological control; *Chondrostereum purpureum*.

INTRODUCTION

Chondrostereum purpureum is a wound-invasive basidiomycete fungus that is currently being developed as an inundative biological control agent for woody weed control in Canada (Becker *et al.* 1999, 2005; Harper *et al.* 1999; Pitt *et al.* 1999) and The Netherlands (de Jong 2000) as an alternative to chemical herbicides. This fungus is also the causal agent of silver leaf disease of stone and pip fruits (Butler & Jones 1949) and extensive work has been conducted on silver leaf disease in New Zealand (i.e., Bus *et al.* 1996; Spiers & Brewster 1997; Spiers *et al.* 1998). In New Zealand, woody weeds such as buddleia (*Buddleja davidii* Franch.) and gorse (*Ulex europaeus* L.) are problematic in forest plantations and pasture land. Currently, research is under way to assess the potential of *C. purpureum* for woody

weed control in New Zealand (Bourdôt *et al*. 2006; de Jong 2000). Inundative biological control involves artificially raising the inoculum load of an endemic pathogen to epidemic levels, resulting in the induction of disease, thereby controlling the target vegetation. One of the benefits of inundative biological control is that the pathogen is a native or naturalised species, therefore the risks associated with introducing an exotic organism, as is the practice of classical biological control (Wall *et al.* 1992), are avoided. *Chondrostereum purpureum* has become established in New Zealand, probably as a result of the importation of infected plant material from England in the early 1900s (Dingley 1969).

Although inundative biological control involves artificially raising endemic pathogens to epidemic levels, there is a potential risk associated with the movement of pathogens during biological control treatment. Releasing an isolate from one geographic area into a different geographic area may result in genetic recombination between the local and exotic strains of the fungus, leading to a change in the virulence. Extensive risk analysis studies of *C. purpureum* have been focused on the population structure (Gosselin *et al*. 1995, 1999a; Ramsfield *et al.* 1996, 1999; Spiers *et al.* 2000), mating system (Wall *et al.* 1996), spore dispersal mechanisms (de Jong *et al.* 1990, 1996), and non-target impacts (Gosselin *et al.* 1999b; Becker *et al.* 2005) of *C. purpureum* and it has been concluded that the risk of pathogen movement within the endemic range is minimal.

In New Zealand, *C. purpureum* has been recorded on several different host species and from many different geographic regions. In order to assess the risk of movement of the pathogen around the country during biological control treatment application, databases were searched and the host and geographic distribution collated to summarise the current (2005) distribution of this pathogen in New Zealand.

METHODS

The information summarised in this report was collected from published information, from the Landcare Research New Zealand Fungi database, and from the Forest Health database of the New Zealand Forest Research Institute Limited. Geographic regions are named following the scheme of Crosby *et al*. (1975).

RESULTS

Chondrostereum purpureum has been recorded in every geographic region of the North Island of New Zealand, with the exception of Northland and Rangitikei, and all of the South Island with the exception of Westland, the Mackenzie Country, Central Otago, Fiordland, Dunedin, and Stewart Island (Table 1; Fig. 1). These results are based on database records, but the databases are incomplete; the fungus

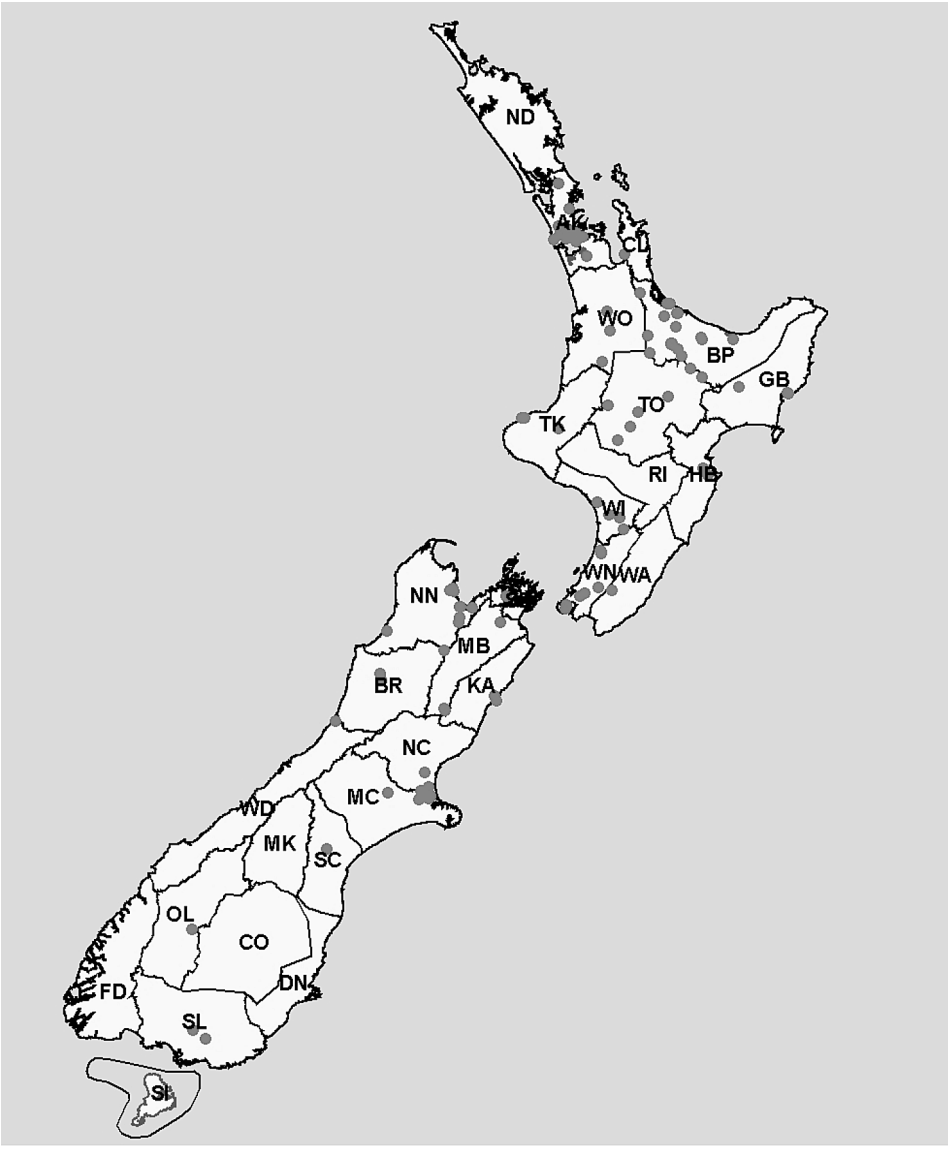

FIG. 1–Dots represent geographic records of *Chondrostereum purpureum* present in the Landcare Research New Zealand Fungi database and the Forest Research Forest Health Database. Two letter abbreviations are regional Crosby codes.

has been observed in every geographic region of New Zealand, including Central Otago where it has infected poplar and willow in nurseries (A.Spiers pers. comm.).

TABLE 1–Host species and geographic regions from which *Chondrostereum purpureum* has been recorded in New Zealand, compiled from records in the Landcare Research NZFUNGI database (93 records) (NZFUNGI 2005) and the Forest Health database (44 records) of the New Zealand Forest Research Institute Limited. Records that do not specify the host were not included in the table.

Host	Bioregions recorded	Records
Acacia sp.	BP	1
Acacia baileyana	AK	2
Actinidia deliciosa	NN	1
Alnus viridis	NC	1
Betula sp.	SC	1
Betula alba	AK, MB, BP	3
Betula pendula	WN	1
Cassia corymbosa	AK	2
Casuarina sp.	BP	1
Corylus avellana	NN	1
Cotoneaster sp.	AK	1
Crataegus sp.	BP	1
Crataegus oxyacantha	BP	2
Cupressus macrocarpa	AK	1
Cydonia oblonga	HB	1
Cytisus sp.	TO	1
Cytisus scoparius	MC, WN, KA, TO, BP	6
Eriobotrya japonica	AK	1
Escallonia sp.	SL, AK	2
Eucalyptus sp.	MC, WO, BP	3
Eucalyptus botryoides	SD, WI, TO	3
Eucalyptus cladocalyx var. *nana*	BP	1
Eucalyptus delegatensis	NN, SD, TO, BP	5
Eucalyptus fastigata	WO	1
Eucalyptus ficifolia	BP	1
Eucalyptus globulus	BP	1
Eucalyptus maidenii	BP	2
Eucalyptus nitens	MC, NN	2
Eucalyptus regnans	BR	1
Eucalyptus saligna	BP	1
Euonymus japonicus	WN	1
Fagus sylvatica	MC, NN, GB	3
Fuchsia hybrida	MC	1
Leucadendron sp.	BP, WO	3
Lonicera tatarica	WI	1
Lupinus arboreus	AK, WI	4
Malus sp.	MC	1
Malus sylvestris	WI, SL, WA, AK, WN, HB, NN	13
Nothofagus solandri var. *cliffortioides**	BR, TO	3
*Pittosporum crassifolium**	AK	1
Populus sp.	CL, NN, WN, NC, MB, SL, MC	7
Populus deltoides	GB	1

TABLE 1–Cont.

Host	Bioregions recorded	Records
Populus fastigiata	AK	2
Populus tremula	WI	1
Populus trichocarpa	SD	1
Protea sp.	WN	1
Prunus sp.	WN, AK, BP, TK	4
Prunus amygdalus	AK	1
Prunus cerasus	AK	1
Prunus communis	AK, NN	2
Prunus domestica	TO, MC, WO	3
Prunus glandulosa	WN	1
Prunus lusitanica	MC	1
Prunus persica	WN	1
Pyrus serotina var. *hosui*	NN	1
Rhododendron sp.	WO	1
Robinia pseudoacacia	AK	1
Rosa sp.	AK	1
Rubus idaeus	MC, WA, WI	3
Salix sp.	AK, BP, WN	5
Salix babylonica	AK	1
Salix caprea	AK	1
Salix matsudana	AK	1
Salix matsudana var. *tortuosa*	TO	1
Salix × *reichardtii*	TK	1
Sorbus sp.	OL	1
Ulex europaeus	SL, AK, WO	4
Viburnum opulus	AK	1
Weigela florida	AK	1

* New Zealand native.

In addition to the hosts listed in Table 1, *C. purpureum* has also been recorded in New Zealand on *Aesculus hippocastanumi* L., *Ceanothus papillosus* Torr. & A.Gray, *Chamaecytisus palmensis* (Christ) F.A.Bisby & K.W.Nicholls, *Crataegus monogyna* Jacq., *Fraxinus excelsior* L., *Laburnum* sp., *Malus angustifolia* Michx., *Malus* × *domestica, Mespilus germanica* L., *Physalis peruviana* L., *Populus* × *euramericana* (Dode) Guinier, *Populus* × *interamericana, Populus maximowiczii* Henry, *Populus nigra* L., *Populus yunnanensis* Dode, *Prunus armeniaca* L., *Prunus avium* (L.) L., *Prunus dulcis* (Mill.) D.A.Webb, *Prunus salicina* Lindl., *Prunus serrulata* Lindl., *Pyrus communis* L., *Pyrus pyrifolia* Nakai, *Ribes nigrum* L., *Ribes rubrum* L., *Ribes uvacrispa* var. *sativum*, and *Salix alba* var. *vitellina* (L.) Stokes (Pennycook 1989).

In summary, *C. purpureum* has been recorded on 46 different genera, represented by 86 different species, in New Zealand. Of the 46 genera, 45 are spread across

24 angiosperm families, as outlined in Table 2. The only gymnosperm record is infection of *Cupressus macrocarpa* Gordon, family Cupressaceae.

TABLE 2–Plant families* on which *C. purpureum* has been recorded in New Zealand.

Family	Genus
Actinidiaceae	*Actinidia*
Betulaceae	*Alnus, Betula*
Caprifoliaceae	*Weigela, Viburnum*
Casuarinaceae	*Casuarina*
Celestraceae	*Euonymus*
Corylaceae	*Corylus*
Cupressaceae	*Cupressus*
Ericaceae	*Rhododendron*
Escalloniaceae	*Escallonia*
Fagaceae	*Fagus, Nothofagus*
Grossulariaceae	*Ribes*
Hippocastanaceae	*Aesculus*
Leguminosaecaesalpinioideae	*Cassia*
Leguminosaemimosoideae	*Acacia*
Leguminosaepapilionoideae	*Chamaecytisus, Cytisus, Laburnum, Lupinus, Robinia, Sarothamnus, Ulex*
Loranthaceae	*Lonicera*
Myrtaceae	*Eucalyptus*
Oleaceae	*Fraxinus*
Ongraceae	*Fuchsia*
Pittosporaceae	*Pittosporum*
Proteaceae	*Leucadendron, Protea*
Rhamnaceae	*Ceanothus*
Rosaceae	*Cotoneaster, Crataegus, Cydonia, Eriobotrya, Malus, Mespilus, Prunus, Pyrus, Rosa, Rubus, Sorbus*
Salicaceae	*Populus, Salix*
Solanaceae	*Physalis*

* According to *Vascular Plant Families and Genera* compiled by R.K.Brummitt and published by the Royal Botanic Gardens, Kew, in 1992.

DISCUSSION

Since the suspected arrival of *Chondrostereum purpureum* in New Zealand in the early 1900s, the pathogen has spread from the original site, or sites; it has been observed in all geographic regions of the country (A.Spiers pers. comm.) and the distribution within most of the country can be confirmed from the database records. Epidemiological studies of *C. purpureum* in New Zealand have shown that both the number of different hosts and ideal climatological conditions of New Zealand have enabled extensive dispersal and colonisation by this pathogen (Spiers 1985).

Management of silverleaf disease in New Zealand has been accomplished by pruning shortly after fruit harvest, when the inoculum load is low (Dye 1967), but resistant apple cultivars are being sought to improve disease control (Bus *et al.* 1996).

The major risk associated with the use of *C. purpureum* as a biological control agent for woody weeds in forests is infection of non-target trees after biological control application (de Jong *et al.* 1990; Wall 1997). Artificial inoculation of Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco), grand fir (*Abies grandis* (D.Don) Lindl.), and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) resulted in small cankers that healed over (Wall 1996) and, with the exception of *Cupressus macrocarpa*, conifers have not been recorded as hosts for this pathogen, indicating that the predominant forest crops are not at risk from the pathogen. Between the two databases that were examined, 134 records identified the host to at least the genus level; three of those records were on the New Zealand native *Nothofagus solandri* var. *cliffortioides* (Hook.f.) Poole and one record was on *Pittosporum crassifolium* Banks et Sol. ex A.Cunn. *Nothofagus* and *Pittosporum* spp. are thus susceptible to *C. purpureum*, yet the small number of records and the wide geographic distribution of the pathogen suggest that the risk posed to native trees does not differ from that of any angiosperm tree species. In Canada and The Netherlands, studies of fructification after biological control treatment application (de Jong *et al.* 1996; Wall 1997) and modelling of spore dispersal after treatment (de Jong *et al.* 1990) have concluded that the risk to horticultural crops is low. Two factors led to this conclusion; firstly, the inoculum level produced after biological control treatment application was calculated to be the same as the natural inoculum level or lower; and secondly, there was a considerable physical distance between forests where the biological control activities would occur and horticultural areas. Based on models of spore dispersal, Dutch regulators concluded that a buffer of 500 m between treatment areas and fruit-growing areas is an acceptable safe distance (de Jong *et al.* 1990). In addition to quantification of fructification, the environmental fate of isolates used in biological control treatments has been assessed. Gosselin *et al.* (1999b) found that 2 years after biological control treatment, 85% of the infection of non-target vegetation occurred from naturally occurring strains of the pathogen. Becker *et al.* (2005) cut 600 young red alder (*Alnus rubra* Bong.) trees located close to a field inoculation site after biological control treatment application, exposing fresh wounds to *C. purpureum* spores produced by basidiocarps present on the treated stumps. A total of 43 individuals were found colonising these spore traps and none of the isolates represented the biological control isolate; therefore, it was concluded that the field trial had no impact on the local population of *C. purpureum*.

The host range and geographic distribution data recorded in databases in New Zealand were collated as part of a risk analysis for the application of *C. purpureum*

as an inundative biological control agent for woody weeds in New Zealand. The results indicate that *C. purpureum* is common and widespread in New Zealand, infecting many different host plants throughout the country. A study of the New Zealand population by Spiers *et al*. (2000) and of New Zealand isolates by Ramsfield *et al*. (1996) suggested that there is genetic diversity and extensive intermixing of isolates in New Zealand. Based on the distribution of the fungus, and studies in Canada and The Netherlands, it is unlikely that the inoculum loading of this pathogen in New Zealand would change significantly after biological control activities.

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