Application to

Release a new organism without controls

That is not a genetically modified organism

BP House
20 Customhouse Quay
PO Box 131, Wellington
Phone: 04-916 2426 Fax: 04-914 0433
Email: info@ermanz.govt.nz
Web: www.ermannz.govt.nz

ENVIRONMENTAL RISK MANAGEMENT AUTHORITY
ERMA New Zealand
NGĀ KAIWHAKATŪPATO WHAKARARU TAIAO

Publication number 122/01

Please note

This application form covers the import for release, or release from containment any new organism that is **not a genetically modified organism** under s34 of the Hazardous Substances and New Organisms (HSNO) Act. This form may be used to seek approvals for more than one organism where the organisms are of a similar nature with similar risk profiles.

Do not use this form for genetically modified organisms. If you want to release a genetically modified organism please use the form entitled *Application to release a genetically modified organism without controls.*

This is the approved form for the purposes of the HSNO Act and replaces all other previous versions.

Any extra material that does not fit in the application form must be clearly labelled, cross-referenced and included as appendices to the application form.

Confidential information must be collated in a separate appendix. You must justify why you consider the material confidential and make sure it is clearly labelled as such.

If technical terms are used in the application form, explain these terms in plain language in the Glossary (Section 6 of this application form).

You must sign the application form and enclose the application fee (including GST). ERMA New Zealand will not process applications that are not accompanied by the correct application fee. For more information regarding fees refer to our Fees and Charges Schedule on our website at www.ermanz.govt.nz.

Unless otherwise indicated, all sections of this form must be completed to the best of your ability for the application to be processed.

Please provide an electronic version of the completed application form, as well as a signed hard copy.

All applications to release new organisms are publicly notified. A hearing may also be required.

If you need additional guidance in completing this form please contact a New Organism Advisor at ERMA New Zealand or email noinfo@ermanz.govt.nz.

This form was approved on 6 May 2010 by the Chief Executive of ERMA New Zealand acting under delegation from the Authority.

Figure 1 Neolema abbreviata

Figure 2 Lema basicostata

Figure 3 *Tradescantia fluminensis* smothering the forest floor and a close up of overlapping stems

Section 1: Application details

a) Application title

Importation and release of two beetles, *Lema basicostata* and *Neolema abbreviata,* as biological control agents for the weed tradescantia

b) Organisation name

Auckland Council

c) Postal address

Auckland Council
Private Bag 92300
Victoria Street
Auckland 1142

Section 2: Provide a plain language summary of the purpose (including the proposed use) of introducing the organism into New Zealand and the associated benefits and risks

Dense mats of tradescantia (sometimes called wandering Willie or wandering jew) form at many forest margins, in forest clearings, and on stream margins in northern New Zealand. Mats overshadow and kill low-growing plants, including native tree seedlings that are essential for forest regeneration. Without intervention, heavy tradescantia infestations guarantee the eventual destruction of small forest remnants, and shrinkage of larger stands over time as forest margins retreat. Tradescantia is a hated weed in suburban backyards and civic parks, and commonly causes severe allergic reactions in dogs that walk in it. Tradescantia has no recognized virtues.

The biological control programme aims to gain control over this weed by establishing a range of natural enemies that damage it in a variety of ways (Appendix 3.6). ERMA has already approved introduction of the leaf-feeding beetle *Neolema ogloblini* (approval code NOR000043). This second application seeks to introduce the beetles *Lema basicostata* Monros and *Neolema abbreviata* (Lacordaire) (Coleoptera: Chrysomelidae). These feed on the stems and shoot tips of tradescantia respectively, and will be introduced from Brazil, the home range of the weed.

Together, the damage caused by control agents is expected to benefit the environment in two ways: by reducing the growth rate and bulk of tradescantia where it currently exists, baring enough ground to restore recruitment of native seedlings in forest ecosystems, and by stopping the development of damaging mats at new sites of invasion (Appendix 3.4).

The following potentially adverse effects of introducing these two species have been identified;

- the risk of direct damage to valued plant species, especially natives
- indirect effects on flora and fauna as a result of disruption of trophic relationships
- the removal of tradescantia as a habitat for native fauna
- damage to ornamental species related to tradescantia.

None of these risks is considered to be significant. Host range tests show that no native plants will be at risk from these control agents (Appendix 4). Significant disturbance of ecological relationships outside of tradescantia infestations are extremely unlikely because the agents are host specific to the weed, and because significant populations will occur only where the weed is abundant. The presence of tradescantia itself massively modifies natural interactions between species, and any reduction in the weed will help reverse those impacts. Some organisms are more abundant in tradescantia than in other vegetation, but this small benefit is unlikely to ever outweigh the adverse effect of the weed on other species. House plants related to tradescantia were susceptible to attack in tests, but the beetles are highly unlikely to colonise these plants indoors. These plants might be at risk if they become established outdoors but planting these potentially invasive species outdoors should be avoided anyway.

The application is made by Auckland Council, representing the National Biological Control Collective, a consortium of all regional councils and the Department of Conservation. Landcare Research is the science advisor to the collective.

Section 3: Identification of the proposed organism(s) to be released

Family:	Family: Chrysomelidae Subfamily: Criocerinae
Genus and Species:	*Neolema abbreviata* (Lacordaire), 1845 *Lema basicostata* Monros, 1947
Common name(s):	There are no common names in use for these insects
Brief description (morphological and biological):	***Biology*** *N. abbreviata* adults have yellow and black alternating longitudinal wing case stripes (Figure 1), and lay white elliptical eggs on the undersurface of leaves. Each female lays over 100 eggs in its lifetime. Larvae feed within leaves at first (see video), destroying the growing point. Larger larvae feed on the surface of the leaves. Adult beetles of both species are slender, and 4–5 mm in length. Females are generally larger than males. *L. basicostata* adults are black (Figure 2), and unlike other related species of that feed on tradescantia leaves, the adults of *L. basicostata* can heavily notch the stems as well. Females lay 2 mm canary yellow eggs in leaf axils and shoot tips. Each female lays 50-100 eggs in its lifetime. Larvae enter the stem on hatching, hollow out the stem, and complete development there. Eggs of both species hatch after 7-10 days. The larvae of both species complete development in 20-25 days. Pupation occurs inside a solidified cocoon made from threads of white foam secreted from the mouth of the larva. The cocoon is stuck to the underside of a leaf or to the litter. As with *N. ogloblini*, both species may have 2–3 overlapping generations, and if adults overwinter, then it is likely that all stages will be present from late spring to late autumn. ***Origin of imported beetle populations*** *Lema basicostata* Brazil; Curitiba (Paraná), Caxias do Sul, (Rio Grande do Sul) and Serra do Rio do Rastro, (Santa Catarina) *Neolema abbreviata* Brazil; Curitiba (Paraná), Lages (Santa Catarina)

Host records
Both species are reported to attack plant species of the family Commelinaceae (Monros 1948).
Predators and parasites
Several parasitoid species were isolated from adults imported into containment in New Zealand. It is not known whether these parasitoids limit populations (and hence the damage potential) of these beetles in Brazil.

It is unlikely that there any native parasitoids capable of attacking these beetles in New Zealand because the native chrysomelid beetle fauna is species-poor, and there are no indigenous *Lema*-like species of this type in New Zealand (Syrett et al. 1996).

Any parasitic organisms capable of causing significant disease in these beetles will detected in imported populations and eradicated before release (see Section 5).

There are reports worldwide of significant predation of larvae of related beetle species (e.g. Schmitt 1988; Vencl et al. 2004). However, surveys by Winks et al. (2003) found no predatory species on tradescantia plants in New Zealand that would significantly prejudice the success of the proposed control agents. The distinctive pupal cases (Figure 1) are unique and no similar insect structures exist in the native fauna. This may hide beetles from predators or parasitoids resident in New Zealand.

Predicted distribution in New Zealand
The prevailing climate in the area of Brazil from which the imported beetles were originally collected (Appendix 3.4) suggests that the proposed control agents should establish anywhere where the host plant thrives in New Zealand.

Predicted impact in New Zealand
The extent of damage to tradescantia caused by insects in Brazil is presented in Appendix 3.6, but the proportion of that damage caused by the proposed control agents alone is not certain. The level of control obtained in New Zealand will depend on the levels of populations achieved. The key factors that limit populations of criocerine beetles in Brazil are not known. It is therefore not possible to accurately predict what population density the beetles will attain in New Zealand once freed from parasitoids, predators, and diseases. However, the beetles are not expected to suffer from heavy predation and parasitism in New Zealand (see above).

Section 4: Identification of positive and adverse effects

a) Identify any possible positive/beneficial effects of the organism(s) that you are aware of (including those that were identified during consultation). The effects considered by the applicant to be potentially significant are presented in **bold**:

i. On the environment:

Source of potential benefit	Comments
Maintenance of habitats	
Successful control reduces competition from tradescantia leading to increased survival and diversity of native and other desirable plants in affected forest margins, resumption of forest regeneration, and a halt in the process of long-term collapse of forest remnants.	This is the major expected benefit of the biological control programme. Successful biological control of tradescantia will restore regeneration in threatened forest margins wherever the weed occurs, and will act far beyond the reach of existing conservation efforts. Control will reduce the potential adverse effects of this weed as it spreads, see Appendix 3.4, Standish 2001.
Sustainability of flora and fauna	
Successful control leads to improved plant diversity in affected bush margins, resulting in increased invertebrate biodiversity at all trophic levels.	Biodiversity under monocultures of tradescantia is highly compromised. Even partial restoration of native plants will increase invertebrate diversity; see Appendix 3.4.
Ecosystem processes	
Successful control benefits parasitoid, predator and disease relationships in trophic webs	Increased plant diversity as tradescantia monocultures break up will increase the diversity and complexity of trophic webs, but effects will vary locally, spatially and temporally.
Feeding by control agents increases nutrient turnover in the litter and beneficially affects natural nutrient cycles, increasing the growth rate and survival of valued forest seedlings.	Consumption will increase turnover under tradescantia, slightly enriching soil and aiding establishment of alternative vegetation; see Appendix 3.4, Standish 2004.
Intrinsic value of ecosystems	
Successful control reduces biomass and survival of tradescantia plants, leading to greater success of active habitat restoration programmes	There are many active habitat restoration projects in New Zealand for which managing the adverse effects of tradescantia is the primary task. Suppression of tradescantia would increase the likelihood of restoration success at infested sites nationwide; see Appendix 3.4.

ii. On human health and safety:

Source of potential benefit	Comments
Successful control reduces infestations in gardens leading to fewer skin reactions to tradescantia.	This benefit is likely, but few such allergic reactions are reported nationally.
Successful control reduces the frequency of control operations, reducing occupational injuries to gardeners and conservation workers	Current situation unknown, but such benefits are likely to be rare nationally.

iii. On the relationship of Māori and their culture and traditions with the environment :

Source of potential benefit	Comments
Successful control of tradescantia improves forest regeneration, waterway vegetation, and the quality of spawning grounds	See comments in Appendix 2. An increasing benefit as tradescantia spreads
Successful biological control reduces herbicide use, reducing the toxin load on forest animals, mud fish, kakahi mussels and soil and waterways	See comments in Appendix 2. Benefit limited because current herbicide use is low
Otherwise, consultation conducted in 2007 and 2010 did not identify any benefits that are unique to Māori.	

iv. On society and communities:

Source of potential benefit	Comments
Successful control reduces the need for tradescantia control operations, leading to better targeting of community resources and use of conservation volunteers.	Many community projects are based on tradescantia control, but overall form a small part of the nation's conservation effort; see Appendix 1, 3.4, 3.5, Anon 1995, Brown & Rees 1995.
Successful control leads to less tradescantia management by home gardeners, allowing composting of garden waste, reducing the incidence of roadside dumping of garden waste containing tradescantia, and reducing the consequent risk of weed invasion into forests from roadsides.	Roadside dumping is an acknowledged source of forest invasion near cities, but constitutes a small proportion of the weed risk nationally; Timmins and Williams 1991.
Successful control leads to fewer instances of dermal allergies in dogs.	A likely benefit, but cases are not frequent

v. On the market economy:

Source of potential benefit	Comments
Reduced costs to owners of allergy treatment for dogs	A likely benefit, but cases are not frequent
Management of control agents creates business opportunities for Landcare Research	A potential benefit, but a relatively minor revenue source for Landcare Research

b) Identify any possible adverse effects/risks of the organism(s) that you are aware of (including those that were identified during consultation). The effects considered by the applicant to be potentially significant are presented in **bold**:

i. On the environment and New Zealand's inherent genetic diversity including any displacement of native species and deterioration of natural habitats:

Source of potential adverse effect	Comments
Maintenance of habitats	
Increased/decreased nutrient flows in weed patches adversely affects regeneration	Tradescantia itself adversely affects regeneration. Reduction in weed density is likely to be achieved by chronic damage that is unlikely to modify nutrient flows rapidly; see Appendix 3.4, Standish et al. 2004.
Successful biological control leads to regeneration of the wrong vegetation assemblage, or to colonisation by worse weeds.	Vegetation assemblage following biological control is likely to be more 'natural' than a tradescantia mat; No worse weeds are known, see Appendix 3.4, Kelly & Skipworth 1984a.
Sustainability of flora and fauna	
Non-target feeding by newly established control agents significantly reduces native plant populations.	Experimentation indicates no such effect is likely. Native plants are not at risk; see Appendix 4.
Sub-lethal grazing by control agents reduces leaf area, leading to reduced efficacy of herbicides, and higher rates of herbicide application.	Even if this theoretical effect was real, herbicide is applied to only a small proportion of tradescantia nationally; see Appendix 3.5
Successful control leads to reduced habitat quality for some native snails and other fauna.	Biological control is unlikely to remove tradescantia entirely; replacement vegetation will also support an invertebrate fauna; see Brown and Rees 1995, Standish et al. 2002; Appendix 3.4.
Ecosystem processes	
Food web interactions are adversely affected by the introduction of two new prey species.	Local adverse effects are conceivable but not expected. Increased plant diversity as tradescantia monocultures break up will increase the diversity and complexity of trophic webs, but effects will vary locally, spatially and temporally. See Appendix 3.5, Winks et al. 2003.
The process of control increases nutrient turnover in the litter, adversely affecting nutrient cycles.	Tradescantia itself adversely affects regeneration. Reduction in weed density is likely to be achieved by chronic damage that is unlikely to radically modify nutrient flows; see Appendix 3.4, Standish et al. 2004.
Intrinsic value of ecosystems	
No significant effects have been identified	

ii. On human health and safety:

Source of potential adverse effect	Comments
No significant effects have been identified	

iii. On the relationship of Māori and their culture and traditions with the environment:

Source of potential adverse effect	Comments
Introduced beetles directly adversely affect the ecology of native species	See Section 4b(i) and Appendix 4. No adverse effect is expected.
High rate of nutrient turnover resulting from insects feeding on tradescantia adversely affects ecosystems.	Ecosystems under tradescantia are already heavily modified. Foliar damage that is insufficient to achieve control is unlikely to significantly worsen existing state. Heavy damage leading to successful control is temporary, restoring the ecosystem in the medium to long-term. Affected area is relatively small compared to total forest estate, see Section 4b(i).
Beetles bring new diseases to New Zealand	Introduction of new diseases not expected, see Section 4c.
Large beetle populations on tradescantia increase the available food biomass in forests, increase the destructive potential of predators such as rats, causing adverse knock-on effects for native fauna.	Foliar damage that is insufficient to achieve control is unlikely to significantly increase biomass. Dense populations leading to successful control will be temporary, restoring the ecosystem in the medium to long-term. Affected area is relatively small compared to total forest estate, see Section 4b(i).
Larvae sequester toxins from tradescantia that are passed through the food chain, adversely affecting population of predators, especially birds and bats.	Sequestration of plant poisons by related beetle larvae is common worldwide, but there are no records of direct bird poisoning as a result. Toxins are usually sequestered for the purpose of 'teaching' predators to avoid particular prey species (deterrency) rather than to directly poison (Appendix 2).
Introduction of new species to New Zealand and without adequate protocol proves detrimental to mauri and tapu	First releases into the New Zealand environment will be made in close consultation with local Iwi.
Introduction is made without adequate Māori peer review, and without Māori participation at all levels.	Consultation and collaboration is ongoing, see Appendix 2.
Inadequate post-release monitoring.	See Section 5.

iv. On society and communities:

Source of potential adverse effect	Comments
No significant effects have been identified.	

v. On the market economy:

Source of potential adverse effect	Comments
Damage by control agents to ornamental plants related to tradescantia adversely affects the profitability of the nurseries that sell them.	Ornamental species related to tradescantia and sold in NZ nurseries, such as 'Tahitian bridal veil' are adequate hosts for these beetles in laboratory tests while others ('Moses-in-a-basket') are not. Plants growing indoors are unlikely to be found by control agents. Those growing outdoors are likely to be colonised. Tradescantia-like plants are not a significant proportion of nursery inventory, and attack is unlikely to affect profitability overall

c) Please answer "yes" or "no" to the following:

	Yes	No
1. Can the organism cause disease, be parasitic, or become a vector for human, animal, or plant disease, (unless this is the purpose of the application)?		✓
2. Does the organism have any inseparable organisms that cannot be managed by MAF Biosecurity New Zealand?		✓
3. Does the organism have any affinities with other organisms in New Zealand that could cause an adverse effect to either organism that you have not identified elsewhere?		✓
4. Can the population be recovered or eradicated if it forms an ***undesirable*** self-sustaining population?		✓

i. Briefly summarise the reason for each of your answers above:

1. *Neolema abbreviata* and *Lema basicostata* are not parasitic, and are not equipped to directly transmit human or animal diseases.

Neither species appears to have any biological, morphological or ecological features that would significantly enhance the risk of passive transport of disease particles, and so neither is more likely to transfer disease in the New Zealand environment than any other insect. Any overall increase in passive plant disease transmission in New Zealand following release of these beetles will be negligible.

2. No inseparable organisms have been recorded for either species. Before clearance for release is sought from MAFBNZ, populations will be examined to ensure freedom from associated micro-organisms that are likely to cause significant insect disease. The populations that are intended for release have been reared for at least four generations in containment and no imported life stages remain. Only New Zealand-born captive-bred insects will be released.

3. Klimaszewski and Watt (1997) record 134 native and 19 adventive species of the family Chrysomelidae in New Zealand belonging to five sub-families. There is one introduced species, *Lema cyanella,* which was released in 1990 for the control of Californian thistle (*Cirsium arvense*), but otherwise, the sub-family Criocerinae is not represented in the New Zealand fauna.

Little is known about the natural enemies of chrysomelid species in Brazil. Hymenoptera are known to attack the larvae of leaf beetles (Vencl et al, 2004), and several parasitoid species belonging to the Hymenoptera and Diptera were reared from beetles imported into quarantine in New Zealand in January 2009. The generalist parasitoid *Pnigalio soemius* has been recorded attacking *Lema* species elsewhere (J. Berry, pers. comm.; Appendix 1.5). This species was introduced to New Zealand for the successful control of the oak leafminer (*Phyllonorycter messaniella*). It is a parasitoid of small leaf-mining larvae, and it is not certain whether larvae of *N. abbreviata* or *L. basicostata* would be at risk (see Appendix 1). Otherwise, few parasitoids capable of attacking *Lema* spp. are likely to exist here because New Zealand has no indigenous *Lema*-like species (see above) and a species-poor chrysomelid beetle fauna (Syrett et al. 1996).

There are reports of *Lema* species worldwide being attacked by natural enemies, with ants and bugs (reduviids and pentatomids) known to prey on larvae (e.g. Schmitt 1988; Vencl et al. 2004). Winks et al. (2003) observed no predatory species on tradescantia that currently give cause for concern for the success of these control agents in New Zealand. Some predation of larvae can be expected, but the impact of such predation on control potential is uncertain.

The complex pupal cases, which are unlike any other insect structures in the New Zealand entomological fauna, may provide protection from native predators or parasitoids that have never encountered such devices before, and may obscure pupae from birds.

4. The object of introducing *L. basicostata and N. abbreviata* to New Zealand is to establish desirable self-sustaining populations as biological control agents for tradescantia. Given the evidence presented in this application, this introduction would only be considered undesirable if feeding occurred on ornamental species such as Tahitian bridal veil, which belong to the family Commelinaceae. In this unlikely event (Appendix 4) both species could be effectively controlled with garden and household pesticides. Although initial releases are likely to be made in the Auckland Region, the climate in the country of origin suggests that the insects will be able to colonise tradescantia populations wherever these occur in New Zealand.

Section 5: Is there any other relevant information that has not been mentioned earlier?

Weed threat

Tradescantia poses a serious threat to forest ecosystems in New Zealand. These threats have been well documented in the science literature, and are reviewed in Appendix 3.4. Where tradescantia is present on the forest floor (Figure 3), tall native seedlings tend to be absent, implying the death of small seedlings under this weed (Kelly and Skipworth 1984). There are concerns about the serious effect of tradescantia invasion on the ability of forest remnants to replace themselves (e.g. Esler 1988). Heavy shading by tradescantia kills all seedlings, no matter how many are present. This means that robust forest ecosystems with abundant seedlings are just as much at risk from tradescantia as struggling urban reserves (Standish et al. 2003, Appendix 3.4). Tradescantia is now seen by many as one of the weeds that most threaten the integrity of important forest remnants in the North Island (Appendix 1.3). Edge effects or microclimate extend at least 40–50 m into New Zealand forest remnants, so remnants smaller than 9 ha are dominated by edge effects such as tradescantia invasion (Standish et al. 2004). Weed management can remove the shading threat, but current control measures themselves have significant side effects, and potential damage to vegetation by control measures (Esler 1988) needs to be weighed against the estimated impact of continued weed invasion in the event of no weed control (Standish et al. 2002).

The adverse effects of tradescantia are evident at several trophic levels. It grows in a radically different way from any native vegetation. It therefore fundamentally alters ecosystem processes such as litter decomposition, nutrient cycling (Appendix 3.4, Standish et al. 2004), and the process by which lowland podocarp-broadleaved forests, swamps and stream margins regenerate (Appendix 3.4). There is also an indirect relationship between the presence of tradescantia and the nature of the invertebrate communities in lowland forests (Yeates and Williams 2001, Appendix 3.4,).

Reducing the threat using biological control

Biological control using insects would alleviate the adverse effects of tradescantia by reducing its biomass and cover. The biomass of tradescantia can reach 800 g/m^2 in the zone of medium shade surrounding forest remnants (zone 2; Figure 3.1 in Appendix 3). Standish (2001) estimates that reduction of this biomass by 75%, to 200 g/m^2 or less (estimated to be equivalent to 70–90% cover), would allow regeneration of tolerant native species to resume. R. Grimmett (pers. comm.) suggested that a 50–70% reduction in tradescantia cover would be required to re-establish native seedling regeneration (see Appendix 1.4 for other comments).

In New Zealand only vestiges of the original pre-European landscape remain intact, often as forest remnants in heavily modified or peri-urban areas (Whaley et al. 1997; Smale & Gardner, 1999). Those reserves close to towns have more weeds than those further away (Timmins & Williams, 1991), often as a result of the dumping of garden rubbish. Tradescantia is often a major component of such garden waste, and invasion into margins and along waterways is continuing. If these reserves are to continue to protect natural values, they will require regular attention to prevent the establishment of weeds (Timmins & Williams, 1991). Future population pressure on such amenities will make this a difficult task without the technological change that biological control could provide.

Post-release monitoring

It is Landcare Research policy to monitor release sites for the establishment of biological control agents. Each release site will be visited for two years following the first release of *L. basicostata* and *Neolema abbreviata* and all tradescantia plants up to a 20m radius of the release point will be examined for the presence of adults, pupae or larvae, or for characteristic leaf damage.

Although no damage is expected, the foliage of non-target plants within a 5m radius of any significant tradescantia damage at any site will be examined within 2 months of release for damage characteristic of beetle feeding. If any damage is detected, more detailed examinations will be undertaken to determine the causative agent. If damage can be attributed to control agent attack, then this, and all other release sites will be treated with insecticide in an attempt to eliminate the insect. However, once a full generation has passed the adult beetles will have dispersed and eradication will be impractical.

Measuring the impacts of tradescantia beetles

Once established, it is likely that populations of the control agents will grow for some years before approaching maximum density. Until this happens, the expense of conducting detailed monitoring and evaluation of the impact of the beetle on conservation values cannot be justified. In the meantime, Landcare Research will establish vegetation plots at one or more release sites to gather baseline data on the cover and biomass of tradescantia, and the density of desirable plant species in the release area in preparation to measure the beneficial change to plant communities should the agent eventually control tradescantia. More detailed development of this methodology will be considered only once establishment is confirmed.

Section 6: List of appendices and referenced material (if applicable)

a) List of appendices attached

Appendix Number	Title
1	Opinions obtained during consultation over the biological control programme for *Tradescantia fluminensis*
2	Pre-application consultation with Māori over the biological control programme for *Tradescantia fluminensis*
3	The biology and pest status of *Tradescantia fluminensis,* and the search for control agents
4	The host ranges of the potential biological control agents *Neolema abbreviata* and *Lema basicostata*
5	References

b) List of references used – hard copies must be attached to the application form.

Author	Title and Journal
NB:	**All references cited in this application are listed in Appendix 5 and provided as digital (pdf) files on an accompanying CD. A video clip is also provided on the CD**

Section 7: Declaration and signing the application form

In preparing this application I have:

- taken into account the ethical principles and standards described in the ERMA New Zealand Ethics Framework Protocol (http://www.ermanz.govt.nz/resources/publications/pdfs/ER-PR-05-1.pdf);
- identified any ethical considerations relevant to this application that I am aware of;
- ensured that my answers contain an appropriate level of information about any ethical considerations identified, and provided information about how these have been anticipated or might be mitigated; and
- contacted ERMA New Zealand staff for advice if in doubt about any ethical considerations.

I have completed this application to the best of my ability and, as far as I am aware, the information I have provided in this application form is correct.

Signed ______________________________ **Date** ________________

Signature of applicant or person authorised to sign on behalf of applicant

Before submitting your application you must ensure that:

- all sections are completed;
- appendices (if any) are attached;
- copies of references (if any) are attached;
- any confidential information identified and enclosed separately;
- the application is signed and dated;
- your application fee has been paid or is enclosed; and
- an electronic copy of the final application is e-mailed to ERMA New Zealand.

Appendix 1 Opinions provided during consultation over the biological control programme against *Tradescantia fluminensis*

1.1 Summary

A wide range of interested organisations were consulted over the proposed biological control programme against tradescantia before the application to introduce the first control agent (NOR07001) was submitted to ERMA in 2007. No additional pre-application consultation was considered necessary for the current application. The responses presented in NOR07001 are reproduced here to provide background for the current application. Several recent comments have been included, and are flagged. The potential beneficial and adverse effects identified are summarised and addressed in Section 4 of the application.

1.2 The scope of consultation

The Auckland Council is the applicant. It is acting on behalf of a consortium of organisations responsible for biosecurity that comprises the Department of Conservation and all regional councils. This proposal is made under the requirements of the Regional Pest Management Strategies for those regions, and the RPMSs themselves are subject to consultation with local communities as required by the Biosecurity Act 1993.

An application (NOR07001) to introduce *Neolema ogloblini*, the first biological control agent for tradescantia was lodged in 2007. Wide consultation was conducted nationally, and many organisations and individuals responded. There was significant input from Department of Conservation staff, conservation and land management organisations, selected regional and district councils. Responses concerned the possible effects of the introduction of exotic foliage-feeding chrysomelid beetles and the effects of changing tradescantia abundance through successful biological control. On the assumption that the introduction of two further closely-related insect species would not raise additional issues, no additional public consultation was undertaken before the current application was prepared. The responses contained in the 2007 application have been reproduced here.

Before preparing this application meetings were held to discuss issues with ERMANZ and Department of Conservation staff. As preparation of the application proceeded, the following organisations were asked to comment on Auckland Council's intention to apply for permission to introduce this control agent. Each was asked to raise any issues that should be addressed in the application.

Royal Forest and Bird Protection Society
World Wildlife fund
QEII National Trust
NZ Landcare Trust
The Nursery and Garden Industry Association of New Zealand

Northland Regional Council
Waitakere City Council
Environment Waikato
Environment Bay of Plenty
Gisborne District Council
Hawkes Bay Regional Council
Greater Wellington Regional Council
Horizons Manawatu-Wanganui
Taranaki Regional Council
Tasman District Council
Marlborough District Council
Christchurch City Council

Individuals who responded to previous applications were contacted and invited to participate in early dialogue
Dr Cliff Mason

The responses obtained from these correspondents were either provided to ERMANZ, or are captured amongst the following communications. Consultation with Iwi is presented in Appendix 2.

1.3 Responses from Department of Conservation staff (2007 responses)

Tom Belton, Technical Support Officer (Biosecurity and weeds), West Coast/ Tai Poutini Conservancy, Department of Conservation

On the West Coast of the south island Tradescantia is probably the most significant weed threat to our riparian forest remnants. Once present in a catchment it is spread rapidly through flooding, and establishes quickly to densely cover large areas of forest floor. In actively regenerating riparian areas (such as early successional tutu scrub) a carpet of tradescantia can virtually stop regeneration in its tracks. Very few if any secondary successional species will establish as seedlings through the tradescantia.

We are undertaking several tradescantia control projects in South Westland where it's distribution and density is still relatively limited. The largest project is in a catchment where we can be almost certain that the tradescantia has only been introduced sometime after 1965 (the road wasn't there before that), and has now spread with a scattered distribution through a site of 48ha. Control costs for this site have been approximately $60k spread over the last 7 years ($17k pa in 2001/2002 down to $6k pa now).

While we have significantly reduced the infestations at that site, there are numerous much worse infestations in northern Westland and Buller which are not controlled simply because we do not have the resources to tackle them, and tradescantia is too widely established there to practically control using herbicides. Any agent which could help to reduce the vigour of tradescantia would be most welcome here.

Keith Briden, Canterbury Conservancy, Department of Conservation

1. Note there are large areas people would like to control this weed but don't because it's too expensive and/or impractical.
2. As tradescantia inhibits regeneration of canopy species this could result in less forest cover and carbon loss.

Phil Brown, Auckland Conservancy, Department of Conservation

DOC in Auckland doesn't have a great problem with tradescantia on its main reserves, but it is extremely common throughout our region, as I'm sure you'd know. We're only controlling a couple of very small patches (eradicating it from Rangitoto Island and in probably 100 - 200m2 along a stream in another reserve). The cost of these is negligible.

In urban reserves though and in road ends where it's been dumped it creates dense swards that can get quite deep, pretty much stopping regeneration of many species. I also imagine its monoculture nature means low diversity of animal taxa too. It can be particularly difficult to manage near streams or on flood plains where it is regularly buried, as large parts of its biomass can be kept away from sprays. Also triclopyr, the preferred spray for us, can't be used willy nilly near streams and is banned from many of the urban reserves as per council policy.

J. Campbell, Programme Manager Biodiversity Assets, Whanganui Area Office, Dept of Conservation

Whanganui Area Office is situated in the Western North Island and is responible for 176,000ha public land from coastal dunes to northern Taumarunui forests. This block includes the Whanganui National Park and the Waitotara CA.

Tradescantia is widespread throughout our managed lands . It is most common within and along the Whanganui River trench where floods spread it downstream easily and river silt seems to be an ideal habitat. I target about 15 specific sites. Campsites, (who wants to show weeds to their visitors), important reserves, and areas that have little or no history of tradescantia. Total area would be around 200 to 300 sq metres. Some areas of infestation are extremely dense would be limiting regeneration.

We control it here for several reasons; aesthetics, regeneration, protect priority areas/habitats/plants, reduce new infestations.

Bio-control agents would be welcomed in this neck of the woods. If necessary, costings could be estimated. Call me if more info is required.....

Graeme La Cock (TSO Flora) knows of its distribution for the rest of the Wanganui Conservancy so may have more to add.

Glen Coulston, Northland Conservancy, Department of Conservation

a) Significant suppression of seedling recruitment resulting in loss of understorey/sub canopy/ground level species, and, speculated long-term successional change to forest canopy structure and forest collapse.
Particularly affects riparian and wetland zones and Northland broadleaf/hardwood forests.

b) Limited resources mean we are only controlling small and /or new infestation incursions when they occur in our priority reserves or where in direct conflict with existing threatened plant sites. In Whangarei Area - treating approx 5ha per annum at a cost of $4,000.

Also started a large scale programme in 2003 at Mangonui River with about 100ha of the stuff and had $25,000 budgeted but unfortunately it fell over after the first year because of fund cuts and the budget being reprioritised. So never got a chance to achieve much.
Vast tracts of tradescantia remain untreated in Northland.

Sarah Crump, Biodiversity Technical Support Officer (Weeds), Bay of Plenty Conservancy, Department of Conservation

Here in the Bay of Plenty we control tradescantia at several small, scattered infestations around the place. Tends to be mixed in with other garden dumping type weeds so are controlling these at the same time. Size of area varies from a couple of square meters to large sites (all the way down a gully that we don't control as too expensive when compared with our total weed budget).

Tradescantia is having an impact on regeneration of natives in some of our reserves. However only control tradescantia at the top priority sites - there are a lot more sites around on both DOC & private land, without even starting to look in peoples gardens...would be good to have an effective biocontrol agent for it.

Usually use grazon to control it - this is a bit more of an expensive chemical so costs go up. Really rough guess but by the time you add chemical to contractors time etc you get a few k worth of control per year (kind of hard to separate out when control everything at a site at once).

Katrina Merrifield, Ranger for Biodiversity Threats, Palmerston North Area Office. Department of Conservation

I'm controlling tradescantia in the Manawatu Gorge where a river terrace became infested with it after the 2004 flooding event. I'd say there's 3-5ha of it and where it has become dense (~70cm height) it stifles everything else on the forest floor, preventing regeneration - but making treatment easy in that one can happily spray it all without worrying about non-target plants! Where I have successfully eliminated it the regrowth of native plants has been quite surprising over the course of a year. To finish the job off will probably take 2 people 4-5 weeks of spraying over the summer season, so it has quite a cost attached.

Kate McAlpine, Weed Ecologist, DOC R,D and I Division, Wellington

Technically there is one (a weed-led management programme) in the Chatham Islands, but it does not appear to receive any funding. As for site-leds, it is much more difficult to find that out formally, but our guess would be that many (most?) site-led projects would include tradescantia.

From Graeme Miller (gmiller@doc.govt.nz), Pest Plant Control Officer,
Southland:

From Lynne Sheldon-Sayer (lsheldon-sayer@doc.govt.nz), Ranger, Biodiversity

Nicholas Singers, Technical Support – Flora, Tongariro-Taupo Conservancy, Department of Conservation

Tongariro Taupo Conservancy is situated in the Central North Island. Tradescantia is (as far as I know) only found close to Lake Taupo where the temperature is more mild as the Lake provides some buffering from frosts. It is most common within and around the Taupo township, elsewhere next to Lake Taupo around bach's (e.g. Little Waihi) and at Turangi. I would estimate that there would be <100 known sites and I probably only know personally about 20 sites. Most infestations still get frosted which causes some winter dieback and limits its vigour. I've only seen a couple of infestations that I'd say were limiting forest regeneration. We don't control it here because of this.

Monica Valdes, Ranger Threats Whangarei Area Office, Department of Conservation

As you might be aware, Tradescantia is widely spread in Northland. The favourable weather conditions of this part of the country make its control a bit of a challenge. Many of our Reserves are affected by it, regeneration of natives practically non existent. Although we don't have enough resources to control it at all sites, we have managed to keep it at bay at sites considered priority.

One of this sites is Wihongi Island (Hikurangi Swamp complex) north west of Whangarei. The site contains the endangered Swamp Hebe (Hebe aff. bishopiana) and also Heart-leaved kohuhu (Pittosporum obcordatum). The area is located in an oxbow, and when we started the control in 2003, Tradescantia was knee deep. We have been spraying the area twice yearly since then, using Grazon at 0.6% with good results, Tradescantia has declined significantly but still persists (probably due to the presence of long grass, which hides it from view). The size of the oxbow is approx 3.5ha.

We had another site, Manganui Reserve, where we started controlling Tradescantia in 2003. Same scenario, Tradescantia invading the forest floor, with areas completely covered (see photo attached). The Reserve received 2 treatments, however due to restrictions in fundings we had to drop it from the list and currently doesn't have any control.

Unfortunately, we haven't got the resources to target the rest of the Reserves under our jurisdiction, and unless they have some especial significance or priority, sites normally don't get much attention. And that's just DOC land, many private properties and Council Reserves are affected. A biocontrol for Tradescantia is definitely needed.

The presence of cattle in many reserves (leases) or the transit from areas affected to clean ones is an issue. We normally don't use contractors, tackling the spraying ourselves. Estimated costs per area were:

Manganui River (2003/04): 12.4ha treated - 69 hours spraying and approx 17K spent as a whole, including wages, surveying (lots of it), field equipment, herbicides, etc.

Wihongi Island (2006/07): 3.54ha treated - 56 hours in spring and 36 hours in autumn, approx 1.5K spent including wages, survey, etc.

Evan Ward, Department of Conservation

Tradescantia is widespread around the region as far as I know. It is one of those weeds that we control when they are on our major reserves and impinging on something we want to protect. Fortunately for us this doesn't happen that often and when it does it is because of roadside dumpings or from old house sites. But to answer your questions specifically:

a) If we let it get out of hand then it would affect the recruitment of native species around the stream margins and then in the forests as it moves up the banks into the bush

b) We control it at 4 sites all around 200m2 in size and currently use Tordon Brushkiller. But currently we are only devoting a week or two at the most to controlling it a year using 1 or 2 staff.

Jenny Whyte, Ranger (Biodiversity)| Wairarapa Area Office, Department of Conservation

In the Wairarapa Area, Tradescantia is a problem in several of our reserves, mainly in terms of smothering seedlings and 'ground dwelling' plant species and altering ecosystem structure.

In 2006-07 we had around 21.85 hectares under sustained management for Tradescantia at a cost of about $3,890. I would expect similar figures for this financial year.

Thelma Wilson, Mainland Biodiversity Programme Manager, Warkworth Area Office, Department of Conservation

The weed is present in various parts of Rodney & smothers reveg & undergrowth. In some sites, notably Logues Bush, (near Wellsford) it out competes threatened plants for habitat (Pseudowintera insperata). Main locations are along stream & river banks & floods spread invasions/ fragments regularly. With the exception of small areas of forest floor that are controlled by hand weeding (around parent plants) we are not undertaking widespread control, mainly due to the harmful effects of the actual control. We'd welcome a Bio control.

The weed also causes problems in some urban parks in the district, as many dogs are allergic / get skin rashes from contact with it.

1.4 Responses from Regional Council staff (2007 responses)

Craig Hornby, Taranaki Regional Council
In reply to your letter dated 3 August 2007 concerning the application to ERMA for the release of a biological control agent for wandering dew.

1. What does tradescantia mean to your region, and how do you rank it against other biosecurity risks you face?

Tradescantia is a well established garden escapee which has been in the Taranaki region for many decades. It is presently wide spread throughout the region. Most infected areas tend to be private gardens and small bush reserves located close to urban townships and New Plymouth city.

The Taranaki Regional Council gives advise an education on complaints and inquires received from the public. During the 2006-07 year the Council received approx five complaints or inquires concerning the identification and control methods for tradscantia.

Tradescantia is not on the Regional Council's present Pest Plant Strategy. This could be interpreted that it is ranked at the lower end of the scale of present biosecurity risks within the region. Although tradescantia is still a major problem for many property owners and for District council parks and reserves departments.

2. What environmental damage does it cause on habitats under your purview?

Damage to ecological values through competition with, and the exclusion of , native plants along forest margins, and in low and disturbed forest. Amenity values, particulary in gardens, open areas and other amenity areas.

3. What area of weeds does your organisation treat each year?

The Taranaki Regional Council's main focus is on advise and education and enforcement if necessary. The Council does carry out small scale direct control on some pest plants that are of limited distribution, also that it would be more appropriate and cost effect than the property owner carrying out the control work.

4. How successful are your control efforts, and how permanent is the control.

The Taranaki Regional Council's control efforts have been very successful in the control of pastoral and ecological pest plants. This has been achieved by using the Biosecurity Act as an education and enforcement tool. Also the Council has implemented an annual programme of investment in a nationally based biological control of weeds group, run by Landcare Research, that organises the introduction and distribution of available and new bio-control agents. This has worked well in the reduction of such plants as ragwort and nodding thistles.

5. What long term and permanent reduction in tradescantia cover would mitigate the effects of the weed to an acceptable level for you.

Any long term reduction in plant cover would be helpful, but for the public to view this introduction of an alien organism as a worth while and successful control agent the amount of plant biomass control would have to be in the 50-80% vicinity.

Phil Karaitiana, Biosecurity Officer, Gisborne District Council
Tradescantia fluminensis is generally well established and widely spread in the Gisborne Region. It is not listed in the Regional Pest Management for this district and therefore does not have a control status. However we do recognise the adverse impacts that tradescantia has in both urban and rural situations where infestations are present.

In most situations where tradescantia is located, the adverse impacts would be considered to be high in our more environmentally sensitive areas.

We carry out no control of tradescantia in the Gisborne Region. Community groups do target tradescantia in some urban recreational reserves as part of weed awareness projects.

Any permanent reduction in tradescantia would be beneficial nationally as well as here in the Gisborne Region.

Providing the agents being considered are host specific then I have few reservations about biological control of tradescantia.

Don McKenzie, Northland Regional Council
This pest plant invades waterways throughout northland blocking drains and forming dense mats on the margins of rivers, lakes and drainage channels. If left uncontrolled it out competes all other native seedlings and most other pest plants - It is shade tolerant , readily spread by river flow, easily spread by pest animals, domestic stock, machinery etc and establishes well under forest canopy, the regeneration of any other species is virtually nil. It has successfully colonized many of Northlands river systems and terrestrial habitats and it would be rare to find entire catchments in the lower and mid north which don't have tradescantia. It is a significant environmental weed which also impacts on agricultural properties where it is kept grazed by farmers as a form of control. Large areas have been sprayed using Grazon and many private forest owners are in the process of controlling tradescantia as part of a wider weed control activities on their land.

Despite the plant not setting seed I would rank tradescantia as one of the many top problem weeds of northland because of its widespread nature and ability to grow from the smallest of nodes. In saying this control by spraying is effective where reinvasion (particularly from upstream) can be prevented. It would be a huge step forward if a permanent reduction in tradescantia cover could be achieved- often control works attempted downstream of tradescantia sites are simply reinfested and whole catchment approach to the problem needs to occur.

We have completed some recent and specific works on tradescantia control around lake Omapere and for these details I recommend you email directly Doug Foster of our Biosecurity team for a further explanation and results.

Wendy *Mead, Biosecurity Officer and Peter Russell, Biosecurity Operations Manager, Environment Waikato*
See letter attached to application NOR07001.

Robyn Packe, Hawkes Bay Regional Council
Tradescantia does not feature very highly in HB. Although we do have some significant areas especially on the Napier hill, it does not, (not as yet anyway) have any major impact on the other plants. I do however consider it a potential problem, and any biological control agents that can potentially control Tradescantia would be very welcome.

We do not actively do any control work at present but we do receive a number of calls for advice on control measures which indicates some measure of concern from the general public. We would definitely support any effort to introduce biological controls for this plant.

Hilary Webb, Biosecurity Officer, Horizons Manawatu Wanganui
Under the (hopefully) soon to be adopted RPPMS to 2011, tradescantia is designated a site specific pest. This is a common fate for widespread plant pests. This means that HRC will only carry out service delivery control at sites of significant biodiversity value (ie Top 100 wetlands or Top 250 bush remnants). So - in a nutshell, a major biodiversity, rather than biosecurity, threat.

- Environmental damage - suppresses regeneration.
- Area treated per year - unknown, will ask colleagues. Personally, I treat 30 ha of bush and wetland sites each year.
- Relatively successful using herbicides, although effective control with a product like triclopyr can conflict with the need to allow regen or to replant areas with vulnerable non-target spp. Less successful using manual techniques and community groups/school children due to inconsistent follow up. Control is relatively/theoretically permanent if re-invasion is prevented.
- 90%

Robin van Zoelen, Biosecurity Manager, Tasman District Council
Tradescantia is often a problem on stream banks draining through urban areas, especially older settled areas. It is an ongoing cost to landholders.

It is a scattered problem throughout the region where there has been habitation, especially on stream margins. In the Aorere Valley (Golden Bay) is solid on stream banks.

The Tasman District Council spends about $15K per annum while Nelson City Council spends $4K. Apart from this official work there is a large amount of volunteer effort going on in the region but it is very hard. Success requires a high degree of motivation and persistence, and sometimes control investment is wasted.

1.5 Responses from other organisations and individuals (2007 and 2010)

Jo Berry, Hymenopterist, Landcare Research, Auckland

Since Pnigalio soemius has actually been recorded from L. cyanella it seems that would be the most likely thing known here to attack your Lema sp.

It didn't strike me as that weird that P. soemius would go for Lema, it is very polyphagous but when I looked at the records I see that most of its hosts are indeed leaf-miners (leps, beetles and flies but also gall-forming sawflies). There is one other chrysomelid host of P. soemius recorded though, Sphaeroderma rubidum, a galerucine flea-beetle. Still if the first instars of your Lema mine I guess that would make more sense.

The spp mentioned by Ensis, Enoggera nassaui, Neopolycystus insectifurax and the hyper Baeoanusia abifunicle have only been recorded in association with the three chrysomeline genera: Paropsis, Trachymela and Chrysophtharta.

There are also some parasitoids of bruchines in New Zealand that may be possible risks to your Lema, e.g. Pediobius bruchicida and Anisopteromalus calandrae (both parasitoids of Bruchus spp.).

Rich Leschen, Coleoptera taxonomist, Landcare Research, Auckland (2010)

I have examined thoroughly the beetles you sent me and based on the unpublished notes by Fred Vencl for *Tradescantia* beetles of the genus *Neolema*, I can confidently confirm that the specimens you presently have in culture are *Neolema* (*Lema*) *abbreviata* (Lacordaire) and *Lema* (*Pachylema*) *basicostata* Monrós. The specimens match the descriptions provided by Dr Vencl based on color and also the critically diagnostic morphology of the elytral puncturation and surface structure.

Richard A. B. Leschen

New Zealand Arthropods Collection
Landcare Research, Auckland, New Zealand

David Moverley,Contracts Manager, Te Ngahere Ltd, Forest Management

See letter attached to application NOR07001.

Mark McNeill, AgResearch Lincoln

Marlon Stufkens of DSIR Plant Protection briefly tested *Lema cyanella* as a potential host of *Microctonus aethiopoides* a parasitoid introduced for the control of *Sitona* weevils.There was no attack. See attached memo re test results.

Quent Paynter, Landcare Research, entomologist and ecologist

No parasitoids reared from Lema cyanella adults. We were too late to collect eggs/larvae/pupae last field season, but will collect this field season.

Astrid van Meeuwen-Dijkgraaf, QEII National Trust

* What does tradescantia mean to your organisation, and how do you rank it against other biosecurity risks you face?

It is difficult to rank against the other risk, not sure that QEII has ever declined a covenant because it has a severe Tradescantia problem but we certainly have applied for funds from the Biodiversity

Condition Fund and other agencies to help control it in covenants and occasionally provide some QEII funds to do the same.

Severity of Tradescantia

	Approved covenants	Formalised covenants	Registered covenants	Grand		
High	6		76	82		
Medium	16	2	107	125		
Low	10		124	134		
Unknown	4		10	14		
Grand	36	2	317	355		

Priority for controlling Tradescantia

	Approved covenants	Formalised covenants	Registered covenants	Grand		
High	23	1	174	198		
Medium	8	1	110	119		
Low	4		25	29		
Unknown	1		8	9		
Grand	36	2	317	355		

Management Aim for Tradescantia

	Approved covenants	Formalised covenants	Registered covenants	Grand		
Eradicate	8		60	68		
Progressive	16	2	181	199		
Contain	4		24	28		
Monitor	7		48	55		
Unknown	1		4	5		
Grand	36	2	317	355		

* What environmental damage does it cause on habitats under your purview?

Prevents regeneration of canopy species which will eventually result in canopy degradation

* What area of weed does your organisation treat each year?

We do not treat Tradescantia ourselves but rely on landowner to use the funds available to tackle the task

* How successful are your control efforts, and how permanent is the control?

Just a quick look show little change in most cases, a few covenants showing an increase and where there is concerted effort a decrease and sometimes temporary eradication. There are often sources nearby that re-infest the covenants also fragments are easily transported from one place to the next

* What long-term and permanent reduction in tradescantia cover (or biomass if more appropriate) would mitigate the effects of the weed to an acceptable level for you?

Ideally completely disappeared but more realistically sufficient bare areas on the ground to allow canopy seedlings to establish.

Dr Fredric Vencl, expert on the biology and taxonomy of Criocerine chrysomelids, State University of New York, Stony Brook, U.S.A.
http://life.bio.sunysb.edu/ee/people/venclindex.html

Peter Wigley, BioDiscovery NZ, Auckland, insect pathologist
Provides expert diagnoses of potential disease organisms in imported insects for Landcare Research.

Chris Winks, Landcare Research, biological control of weeds
I can categorically say there are no parasitoids, predators or diseases of native Criocerinae in New Zealand (Stephen Thorpe pers. comm.). The main reason for that is that there are no native Criocerinae in New Zealand!

Appendix 2. Opinions obtained during consultation with Māori over the biological control programme against *Tradescantia fluminensis*

2.1 Summary

This appendix outlines the steps taken to consult with tangata whenua about this proposal. It records the scope of the consultation, and the responses obtained are recorded. The issues are addressed here, or there is a reference to elsewhere in the application. The issues raised concerning biological control projects are similar from application to application. Significant relevant issues that have been raised in previous consultations are also presented.

Apart from benefits accruing to the general population, consultation identified reduction in the toxin load of forest animals, mudfish, kakahi mussels and soil and waterways as benefits of particular importance to tangata whenua.

The key potential adverse effects of specific interest to tangata whenua but not raised in consultation with the general public were inadequate protocol and other Māori participation around introduction and release, and the potential knock-on effects of bioaccumulation of tradescantia toxins in high level predators. Both direct and indirect effects on native flora and fauna were seen as the most important potential risk, and these issues are addressed in Section 4 of the application

2.2 Scope of pre-application consultation with Māori

Iwi, hapū, and Māori organisations comprising the ERMA Māori National Network were contacted on 20 July 2010 and invited to enter dialogue on the proposal to introduce these two species. A total of 140 were contacted, 18 of which were papatipu rūnanga of Ngāi Tahu. The message described how the applicant intended to assess the risks, costs and benefits surrounding the proposed introductions in the application, and respondents were asked to identify any issues that were inadequately, or not covered in those plans. Recipients were given the option of responding by form letter (a SAE was included), by email, by phone before 27 September.

The responses obtained recently are provided below. The substantive responses to application NOR07001 obtained in 2007 are also provided. Subjects raised in previous consultation regarding biological control of weeds are also reproduced below. The main beneficial and adverse effects raised during consultation are listed in the application form.

Attempts continue to meet the Tai Tokerau Iwi Technical Committee to further discuss this programme. All organisations consulted will be informed when the application has been submitted and is open for public submissions.

2.3 Responses from Iwi, Hapū and other Māori organisations

Email or written responses were received from 6 sources including one representing the 18 rūnanga of Ngāi Tahu. The originals of these responses have been supplied to ERMANZ. Two respondents made detailed responses or requested further information. In these cases there was further dialogue with respondents by email or phone, and more information was supplied on request. Respondents were reassured that their issues would be addressed in the application. The issues abstracted from those submissions are provided below, and the applicant's comments are in parentheses.

Responses were received from:
Ngāi Tahu, and Hokonui Runanga
Cheri van Schravendijk
Tanenuiārangi o Manawatu Inc.
Raukawa Charitable Trust
Tūwharetoa Māori Trust Board

"We would like to be included in any development for the control of tradescantia we have some major infestations here in the Manawatu which TLA's spend considerable resources on in terms of trying to control it across our region, and we see considerable benefits in developing and distributing any measure available to holt its spread." (Further discussions are in hand)

"The main impacts of these infestations is on forest regeneration, waterway veg, spawning area in lower river/stream reaches and toxin loading of forest animals, mud fish, kakahi mussels, and soil and waterways associated control area." (Noted, see Section 4a(iii)

"Any comments we have would be similar to those we expressed for the dung beetle application" (Noted, some relevant issues summarised below)

"A concern that pops up straight away then, is whether these beetles could switch to our softer-leaved native understorey plants like parataniwha …. Or, even our more light-loving Astelias, Collospermums etc etc. Some of these plants don't necessarily have the same nasty toxins that can be found in WJ, and so, could they potentially become a more palatable food source for the beetle? ". (Neither beetle can feed on plants outside the family Commelinaceae. There are no native plants remotely related to tradescantia; see Appendix 4).

".. what level of confidence is there re: little/no overlaps between weetaa, native beetles, and Tradescantia leaf beetle ecology - in particular, habitat and rodent predation… I'm thinking density-dependant relationships here and prey-switching …". (See sections 4b(i), 4b(iii), 5 and Appendix 3).

"…making assumptions here that the beetle can accumulate the toxins found in wandering jew and use them as a insectivore defense system, similar to what GLS and monarch butterflies can do? …How will the potential toxic effects in the food chain be monitored and/or mitigated by the researchers? Or, is this system not relevant to the beetle?" (insectivorous birds..Bats?). (There are tradescantia toxins in the faecal shields with which these larvae cover themselves. This suggests that the larvae are excreting rather than sequestering the toxins. Theory would suggest that toxins accumulated in herbivorous larvae would deter generalist predators. If the larvae were a rare food item, then predators would accumulate little toxin. Specialist predators and parasitoids might home in on such toxins, but as the herbivore will be novel to New Zealand, no such specialist natural enemies will exist here. The applicant could find no examples where a predatory insect has sequestered toxins from a herbivore with consequent adverse effects on a higher level predator; see Section 4b(iii)).

2.4 Relevant responses obtained in previous new organism applications

The following responses were obtained in 2007, during consultation over the application to import *Neolema ogloblini* (NOR07001). Responses are in parentheses.

"As you stated in your letter, we are not 100% happy with the introduction of non-native species to Aotearoa. We will consult our kaumatua who have knowledge of rongoa area and will submit our findings…" (Noted)

'We are looking for further information on what tests have been accomplished to confirm that the biological control will in no manner impact on our native species…" (see 4b(iii), Appendix 4)

"Will this insect actually eradicate the weed.. ..are we just inviting it for a feed?" "Can control in this way be justified?" (History shows that biological control of weeds can succeed in New Zealand. The level of control that will be achieved will depend on the population levels that these beetles will achieve once released in New Zealand. Although it is known that they will be introduced to Aotearoa-New Zealand without the natural enemies that limit their numbers in Brazil, we cannot be certain what mortality factors will apply in New Zealand until the insects are released).

"Does the insect have flying capabilities (to take it) to restricted areas…with rare indigenous plant life?" (Yes, but will be host specific wherever it occurs; see Appendix 4)

When it changes to a beetle, what will it eat?" (see Appendix 4)

"Everything…has a tapu… What then do we do about the tapu of the insect world…? / What protocols… to relocate the mauri of this insect?" (Release of agents will be conducted in collaboration with tangata whenua).

"At this stage we would like to discuss the proposal…At this stage we are taking a precautionary approach until we are satisfied that all checks and balances are in place" (noted)

"What plans to reverse this….?" (see section 5).

Many submissions on previous applications to introduce new insects to Aotearoa-New Zealand are also relevant. Some recognised benefits for ecological webs, native animals and nutrient cycling (mahinga kai), and employment. The benefit for land and waterways of potential reduction in herbicide applications (and other human health issues) is a frequent comment.

Many past submissions stress the role of Māori as kaitiaki, both of taonga, and of tapu, mauri and whakapapa. As a result, these submissions seek reassurance that control agents are, and will remain safe for taonga species following release. Similarly, indirect adverse effects on non-target species, ecological relationships and landscapes are a common area of concern. The need for meaningful post-release monitoring of non-target effects and impact on the target weed is also a consistent theme.

Appendix 3. The biology and pest status of *Tradescantia fluminensis* Vell., and the search for biological control

3.1 Summary

The potential benefits of biological control of tradescantia arise from reducing the adverse environmental effects of the weed in New Zealand. Those adverse effects are reported here. A review of the ecological damage caused by the weed in New Zealand is presented, along with background information on its distribution, ecology and biology. The current approach to management of tradescantia in New Zealand forests is presented and discussed. Progress in the biological control programme is reviewed, including surveys in New Zealand to identify resident natural enemies, the goal of biological control, the identification of the home range of the weed, and the search for and development of appropriate agents likely to prosper in New Zealand.

3.2 Distribution and dispersal of *T. fluminensis*

Tradescantia fluminensis is indigenous to the tropical rainforests of SE Brazil and NE Argentina. It has been grown worldwide as an ornamental, and has either naturalised or become invasive in:

Australia – reported as invasive
Bermuda
Italy
Japan
Kenya
New Zealand – reported as invasive
Portugal – reported as invasive
Puerto Rico
Russian Federation
South Africa
Swaziland – reported as invasive
USA – invasive in Florida

(http://www.issg.org/database/species/ecology.asp?si=497&fr=1&sts=&lang=EN)

Distribution within New Zealand is said to be restricted by intolerance of frost (Bannister 1986). It occurs in all regions, but is presumably restricted to sheltered habitats in frost-prone areas.

The related species *T. virginiana* L. and *T. cerinthoides* Kunth. are both fully naturalised in New Zealand (Ngā Tipu o Aotearoa database**)**, although field records are limited. There are other species of *Tradescantia* in cultivation but none are as widespread as *T. fluminensis*. *T. zebrina* Bosse has green and white stripes with deep purple undersides. *T. cerinthoides* Kunth is shortly creeping, and rather succulent and velvety or hairy. There has only been one unpublished record of seed production by *T. fluminensis* in New Zealand (Graeme Bourdôt, AgResearch, pers. comm.), and so reproduction appears to be almost exclusively vegetative. Stem fragments as small as 10 mm can successfully establish new plants if there is a node (Kelly & Skipworth 1984a).

Tradescantia fluminensis disperses widely by the spread of fragments, and the predominant pathways for invasion appear to be the dumping of garden refuse in forest remnants or naturally via carriage of fragments in streams (Esler 1988). Its absence from large tracts of forest may be related to lack of anthropogenic dispersal. However, in 2001 it was present in 11 of 13 DOC conservancies (not listed as a problem weed by Taupo-Tongariro, Otago or Southland conservancies) (Owen 1997). It continues to invade within conservancies in which it is present, and has also spread to offshore islands such as Stephens Island (Brown & Rees 1995), and Matiu, Mana, Chatham and Rangitoto islands (Standish 2001).

The National Pest Plant Accord is a cooperative agreement between the Nursery and Garden Industry Association, regional councils, and government departments with biosecurity responsibilities. Under the Accord *T. fluminensis* has been declared an 'unwanted organism' under Sections 52 and 53 of the Biosecurity Act 1993, and cannot be sold, propagated, or distributed in New Zealand (http://www.biosecurity.govt.nz/pests-diseases/plants/accord.htm).

3.3 Biology of *T. fluminensis*

Based on its biological capability and its potential effect on systems, it has a weed ranking of 25, compared with a ranking of 22 for periwinkle and 23 for selaginella, two other weeds that also colonise forest margins in urban areas (Owen 1997).

The vertical profile of a tradescantia mat has three intergrading zones: erect, soft stems that can be 40 cm long with fleshy leaves; a horizontal mat of intersecting, chlorotic stems with no leaves, but with adventitious roots; and a lower zone near the ground where tissues are dying (Kelly & Skipworth 1984a). The dense mat of horizontal overlying stems is commonly 60 cm deep. A single stem may be 1.5 m long with many branches. Kelly and Skipworth (1984a estimated that a square metre of ground with standing crop of 1400 g could comprise 300 tradescantia plants with a total stem length of 900 m. The vigour of *T. fluminensis* enables it to persist as an invasive weed of natural areas, where it carpets the ground and prevents native regeneration.

In another study Maule et al. (1995) found that tradescantia grew 0.2–0.3 cm per day in summer and 0.04–0.06 cm per day in winter. Overall, plants grew 60–70 cm per year. In one site dry matter production was 477 ± 177 g/m^2 and there were 303 ± 19 $stems/m^2$ in March.

The physiology of *T. fluminensis* enables rapid response to the availability of two key resources, light and nitrogen. Incident light is greatest at the edges of forest remnants. Maule et al. (1995) found that *T. fluminensis* could grow under canopy at 1% irradiance as well as in the open, and that irradiance level is likely to be the primary factor limiting the extent of invasion into forests.

Kelly and Skipworth (1984a) found a close, apparently linear relationship between the standing crop of tradescantia and incident light as irradiance rose to about 10% of that on open ground. Maule et al. (1995) found that as irradiance increased to 30%, the rate of dry matter accumulation reached an asymptote. *T. fluminensis* can therefore be categorised as a facultative shade plant. Standish et al. (2004) record that edge effects or microclimate extend at least 40–50 m in New Zealand forest remnants, so remnants of less than 9 ha are dominated by edge effects.

Damp fertile soils support the densest swards of *T. fluminensis* whereas growth is sparse on rocky substrates (Smale & Gardner 1999; http://www.issg.org/database/species/ecology.asp?si=497&fr=1&sts=).

3.4 Ecological consequences of *T. fluminensis* infestation

The adverse effects of *T. fluminensis* are evident at several trophic levels. Reasonably extensive ecological research shows that *T. fluminensis* alters litter decomposition, nutrient cycling, the successional trajectory amongst plant species, and invertebrate biodiversity in New Zealand lowland podocarp-broadleaved forests, and probably adversely affects the integrity of native ecosystems elsewhere.

Conservation of biological diversity, including invertebrate biodiversity, is thought to be important for the stability and functioning of ecosystems (Toft et al. 2001). Conservation of regional biota worldwide depends heavily on the retention and management of fragmented areas of the original vegetation. In New Zealand only vestiges of the original pre-European landscape remain intact, often as forest remnants in heavily modified or peri-urban areas (Whaley et al. 1997; Smale & Gardner 1999). Those reserves close to towns have more weeds than those further away (Timmins & Williams 1991), often as a result of the dumping of garden rubbish. If these reserves are to continue to protect natural values, they will require regular attention to prevent the establishment of weeds (Timmins & Williams 1991), although future population pressure on such amenities will make this a difficult task using current management methods.

Tradescantia can slowly penetrate quite shaded forest (zone 1 in Fig. 3.1), but its biomass here is no threat until a light gap appears (e.g. a tree dies). Then it can quickly become dense enough to prevent regeneration, creating an internal forest 'edge'. All edges, real (zone 2) or internal, tend to expand because of the lack of native regeneration, so trees are not replaced as they die. If a forest remnant is damaged, then irradiance through canopy gaps makes the effects of *T. fluminensis* important throughout the remnant, not just at the margins. At higher light levels (zone 3) tradescantia is out-competed by other exotic weeds, perhaps even facilitating the invasion of serious weedy vines that can kill remaining trees. In general, the margins of forest remnants are likely to remain weedy unless 'armoured' with vegetation (Standish 2001), so it may be pointless to remove *T. fluminensis* from this zone (unless to control spread).

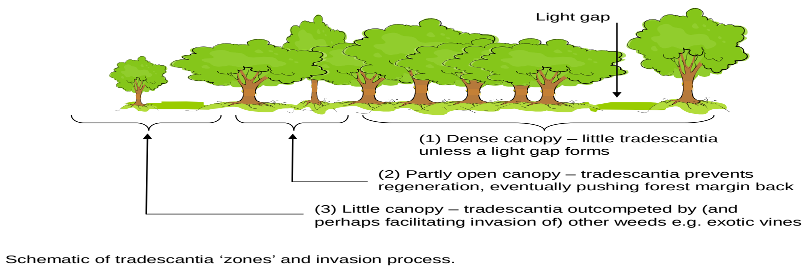


Fig. 3.1 Shade zones within a forest as they affect *Tradescantia fluminensis.*

Esler (1988) noted that *T. fluminensis* invaded forest when disturbance (such as tree fall and stock grazing) caused canopy degeneration. This disturbance increased available nitrogen, the element limiting growth, which made the disturbed area more invasible. Even when the canopy closes once more, its ability to survive low irradiance allows mats to persist. Increased irradiance facilitates encroachment of tradescantia from elsewhere in the remnant.

Esler expressed concern about the serious effect of *T. fluminensis* invasion on the age structure of forest remnants. Earlier, Kelly and Skipworth (1984a) had found many small seedlings under tradescantia, but showed a strong negative relationship between the presence of tall seedlings and the presence of tradescantia, implying the death of small seedlings under tradescantia. This relationship has been measured many times since. Tradescantia is now seen as one of the weeds that most threaten the integrity of important forest remnants in the North Island.

Standish (2001) estimated that a dry biomass of >200 g/m^2 of *T. fluminensis* (equating to 70–90% cover) prevented any regeneration of indigenous New Zealand forest plants. In a preliminary study of the relationship between plant biomass in different light levels in Brazil, it was found that, unlike in New Zealand, the biomass level in Brazil seldom exceed 200 g/m^2 (Landcare Research, unpublished data).

Species richness and abundance of native seedlings increase with decreasing *T. fluminensis* biomass (Kelly & Skipworth 1984a; Standish 2001; Standish et al. 2001). The biomass often reaches 800 g/m^2 in the 'middle' zone surrounding forest remnants. Reduction of this biomass by 75% to 200 g/m^2 or less (estimated to be equivalent to 70–90% cover) would allow regeneration of tolerant native species (Standish 2001). In another paper Standish suggested that 80 g/m^2 (40% cover, 90% reduction in biomass) was necessary for good regeneration.

A degree of shade tolerance is generally necessary for tree species to survive in New Zealand lowland forest communities (Standish et al. 2001. The biomass of *T. fluminensis* in two forest remnants increased logistically to peak at 10–15% of full light. At 500 g/m^2, incident light beneath was reduced to <1% irradiance. Species richness and abundance pf native seedlings were reduced exponentially with increasing weed biomass, falling from 3.4 to 0.37, and 81.5 to 6.3 g/m^2 respectively at maximum weed biomass. *Dysoxylum spectabile* seedlings were relatively shade tolerant, and established under the weed, but survival after 20 months was only 6% under the weed compared with 84% in full light. Standish et al. (2001) concluded that invasion by *T. fluminensis* is likely to result in changes to the composition of the native plant community because of the differential effects on native seedling survival, resulting in more *Dysoxylum spectabile* and less *Macropiper excelsum* in the canopy in those remnants. Ultimately the persistence of a species in such a remnant will be driven by its ability to tolerate the effects of *T. fluminensis*, which in turn determines long-term species composition. This weed can therefore be seen as an ecosystem modifier.

The presence of heavy infestations of *T. fluminensis* does not always result in irreversible loss of plant species. Smale and Gardner (1999) found that, contrary to experience elsewhere, dominants appeared to be replacing themselves in a Mt Eden reserve infested with *T. fluminensis*, the only reserved fragment of primary broadleaved forest on basaltic lava on the Auckland isthmus. This may be because the rocky nature of the substrate did not allow the weed to form unbroken dense mats, as it does elsewhere in New Zealand. Tradescantia was a major invasive herbaceous weed suppressing regeneration on moist fertile alluvial soils in Claudelands Bush (Hamilton), and was a major factor in the loss of species from this remnant. One-third of the indigenous vascular flora of 122 species that survived grazing and was present in 1933 became locally extinct between 1954 and 1980, mostly ground layer species and small shrubs with small populations (25 species). Smothering by the locally dominant *T. fluminensis* and desiccation resulting from drainage and habitat fragmentation were implicated in this loss (Whaley et al. 1997). This forest remnant has been the subject of a recovery programme. Smale et al. (2005) concluded that fencing for 20 years may be sufficient to return grazed forest remnants elsewhere in the Waikato, but also acknowledged that the widespread presence of weeds such as tradescantia might well alter the recovery pathway.

High seedling abundance does not 'protect' a species from the threat of local extinction in tradescantia-infested forest remnants (Standish et al. 2003), as the mortality attributable to shading is not density-dependent.

Tradescantia fluminensis not only causes direct mortality of regenerating seedlings, but also modifies the habitat in which they grow. Infestations increase litter decomposition and alter nutrient availability. Standish et al. (2004) found that the productivity of several sites examined was high, but that litter breakdown was particularly rapid where tradescantia occurred. Available nitrogen was higher under weed mats than in non-tradescantia plots. They concluded that these differences were probably due to differences in vegetation structure between tradescantia-infested plots and tradescantia-free plots, and associated differences in microclimate.

There is also an indirect relationship between the presence of *T. fluminensis* and the nature of the invertebrate communities in lowland forests. In a comparison of the effect of tradescantia on communities of beetles and fungus gnats flying above tradescantia-infested and tradescantia-free forest floor, the proportion of tradescantia was a poor predictor of species richness or abundance. This may be because a proportion of the insects sampled by Malaise traps above tradescantia may have been vagrant, and not closely associated with the weed mat. However, effects on individual species were evident. The strongest predictor of species richness was the richness of the vegetation within the forest. Changes in forest structure as a result of tradescantia presence would therefore also influence the species richness of the insect fauna.

In another study, removal of tradescantia within 50-m^2 plots by hand weeding or herbicide spraying did not lead to any major impacts on the ground-dwelling invertebrate community. Invertebrate abundance and taxonomic richness were similar in hand-weeded, herbicide-treated, and non-treated plots 7 weeks after treatment (Standish 2004). Nevertheless, Standish (2004) concluded that *T. fluminensis* could impact invertebrate communities because:

1. It forms dense layers of vegetation > 60 cm tall, contrasting with natives, which are of small stature.
2. It produces litter that decomposes faster than litter of the mixed-species forests it invades, and alters nutrient availability.
3. Soil moisture is greater under tradescantia than under sparse native subcanopy.
4. Invasion is closely associated with decreases in abundance and species richness of native forest seedlings, and hence on their characteristic fauna.

In a study of the soil microfauna, Yeates and Williams (2001) found similar relationships. Although the presence or absence of tradescantia was not a strong predictor of species richness or abundance, infestation with tradescantia was associated with detection of seven additional taxa of nematodes, while eight fell below the level of detection, indicating significant alteration/turnover in community composition that was not picked up well by the indices. The density of herbivorous nematodes was higher under tradescantia than in plots where the weed was absent.

Other microfauna also varied between sites with and without tradescantia, reflecting the physical qualities of the litter under different vegetation, for example, rotifer abundance was affected.

Such differences in the array of invertebrates associated with tradescantia can benefit rather than adversely affect species of conservation significance. Standish et al. (2002) measured the abundance and population structure of the endangered snail *Powelliphanta t. traversii* in 18 forest remnants. Overall, tradescantia affected only a small part of the total habitat. Seven sites had *P. traversii* but no tradescantia, indicating that the weed is not essential for snail survival. However, five snail colonies were definitely affected by the presence of the weed. Snails commonly occurred under tradescantia, and in some cases exclusively in this habitat. Some snails foraged from and returned to the weed mat. Standish et al. (2002) found that tradescantia was an important refuge for young snails, and in this case removal of the weed could be detrimental to recruitment. They suggested that graduated control of tradescantia, with replacement by native cover, would be of mutual benefit to the snails while achieving other biodiversity maintenance goals.

Forest regeneration has been identified as a key component in securing the status of many species on Stephens Island (Takapourewa), including Hamilton's frog and the striped gecko, *Hoplodactylus stephensi* (Brown & Rees, 1995). The growth of tradescantia in the two remaining forest remnants on the island has prevented or greatly reduced the establishment of seedling tree and understorey plants, and greatly impaired the access of tuatara and fairy prion to their burrows. However, in the process of hand-removal of the weed, Brown and Rees (1995) found that tradescantia-infested areas carried higher densities of striped gecko, snails (*Rhytida stephensensis*), and native earthworms than tradescantia-free areas, possibly because the weed mat provided partial protection from predation by tuatara. An attempt has been made to eradicate the weed from the island. Although individuals of these animal species may have been lost in the eradication process, the effect on populations across the whole island appears to be insignificant (Brown & Rees 1995).

3.5 Current control strategies for *T. fluminensis*

Standish et al. (2002) noted that weed control measures themselves constitute a significant disturbance to communities, and any benefits they offer need to be weighed up against potential side effects and the estimated impact of continued weed invasion in the event of no weed control.

A number of regional councils distribute factsheets describing the threat of tradescantia and methods for its management (e.g ARC 2010). Manual weed removal is considered to be a suitable tactic for the control of small infestations because it has least impact on non-target plants growing near or amongst the weed. Stem fragments as small as 10 mm can successfully establish new plants (Kelly & Skipworth 1984a), so great care must be taken to remove every small piece of stem. For this reason repeated efforts are usually required to achieve eradication.

For larger infestations chemical control is currently considered to be the only practical method (McCluggage 1998). Non-target impacts on native flora (e.g. Kelly & Skipworth 1984b; Brown & Rees 1995) are generally accepted in the light of the perceived benefits. In Northland *T. fluminensis* invades damp shady areas of forest and of stream banks, and prevents the regeneration of any other vegetation. McCluggage (1998) found that Grazon (Triclopyr) had the superior kill rate, and was the most cost-efficient herbicide. Using this technique on a 3.4-ha infestation gave 90% die-off on first spray, whereas other mixes required two retreatments. The cost of four tankloads, labour costs for two people plus equipment, and spot-spray follow-up was $1,366 per day (in 2007 dollars).

In another case study, Ogle and Lovelock (1989) noted that initial treatment of tradescantia mats at 'Rangitawa' with the herbicide Roundup™ was likely to cause loss of indigenous seedlings and herbs, including sedges, but the patchy distribution of wandering Jew meant there would be adequate replacements for those in sprayed areas. They warned that particular care would be needed with species that were of limited distribution but occurred with tradescantia. They found that repeat treatment was required, and in 2007 dollars the control cost per hectare equated to $4,343.

Standish (2002) also found control using herbicides difficult. Herbicide spray and hand-weeding applied to separate plots did not prevent regrowth after three treatments.

Standish (2002) suggested that shading using artificial means or by restoration of native species showed potential as a means to suppress the weed by shading. Artificial shading to 2.5% of full light was the best approach to control, yielding 81.3 ± 10.6 g/m^2 of biomass compared with 597.6 ± 6.6 g/m^2 in unshaded (15–27% of full light) plots after 17 months. Native seedlings were planted into *T. fluminensis*. After 2.5 years, 61% of the seedlings had emerged successfully from that cover, but the effects of this future canopy in shading out the weed remained uncertain.

Kitchener Park is an 11-ha forest reserve near Fielding. It is an important remnant of original Manawatu forest, containing 140 plant species in 1928. For various reasons, by 1961 only 80 of these remained. Restoration has been in progress since 1991. *T. fluminensis* was well-established in the reserve by 1944. Since then thousands of hours of labour, much of it voluntary, has been applied to the removal of tradescantia, and by 1995, two-thirds of the area had been cleared (Anon. 1995).

The following mixtures are suitable for knapsack application (ARC 1999):
• Glyphosate (Roundup G2 or Nufarm).....200 ml + 10 ml Pulse per 10 litres of water
• Escort ....5 g + Glyphosate 100 ml + Pulse 10 ml per 10 litres of water
• Grazon .... 60 ml + 10 ml Pulse per 10 litres of water
• Yates Hydrocotyl Killer ....150 ml + 10 ml Pulse per 10 litres of water
• Renovate ....120 ml per 10 litres of water (no Pulse reqd)
• Amitrol 4L ....200 ml + 10 ml Pulse per 10 litres of water

Tradescantia afforded protection to several native animals on Stephens Island, but on balance, the decision was made to eradicate the weed (Brown & Rees 1995). Manual removal of the weed proved ineffective. Although Grazon was capable of killing non-target plants, careful use protected canopy species while killing 85% of the weed in one pass.

3.6 The search for biocontrol agents

There are no native or naturalised relatives of *T. fluminensis*, nor a significant trade of plants that would preclude the use of a control agent with genus-or family-specific host range.

Standish (2001) completed a biocontrol feasibility study, and found the biomass of *T. fluminensis* often reaches 800 g/m^2 in the semi-shaded margins of forest remnants. Species richness and abundance of native seedlings increase with decreasing *T. fluminensis* biomass. She suggested that for native forest regeneration to occur, biological control needed to reduce the standing biomass of weed by 75% to less than 200 g/m^2 (which equates to 70–90% ground cover), and considered this goal to be realistic. Control of *T. fluminensis* on forest margins, by whatever means, opens the possibility of invasion of other weeds such as kahili ginger and selaginella. However, she concluded that the gradual reduction in biomass typical of biological control might reduce the chance of reinvasion. She also concluded that integration of biological control with restoration planting may assure greater success than using either method in isolation. Following this report a biological control project was initiated by the Department of Conservation in 2002/03.

To assist in the selection of the most appropriate control agents to introduce, Winks et al. (2003) surveyed the fauna and pathogens associated with *T. fluminensis* at 18 sites in New Zealand. Forty-nine herbivores and two potentially pathogenic fungi were recorded. The total damage attributable to herbivores was minimal (<2% foliage damage). The only herbivores found at levels classified as ‘abundant’ (>200 individuals collected and present at 10 or more sites) were small, native snails (shells 2–5 mm diameter) that probably feed on the microflora on leaves rather than the leaves themselves. Fungal colonies were cultured from plant parts that had possible pathogen damage. A total of 27 fungal species were identified, of which only a *Phomopsis* species and a *Colletotrichum* species are likely to be pathogens of *T. fluminensis*. Given the low levels of observed damage in the field we are not investigating these species further. The survey indicated that there were no specialist natural enemies attacking *T. fluminensis* in New Zealand.

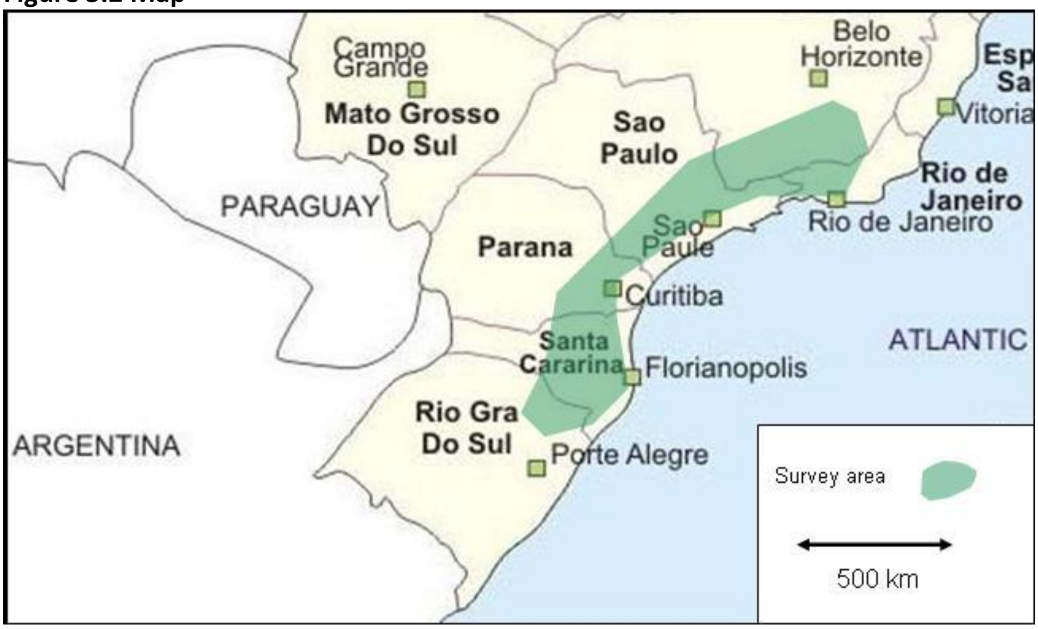
The predator and parasitoid fauna was also assessed to help identify any potential natural enemies of introduced control agents (Winks et al. 2003). Spiders were common at all sites. Six species of predaceous Carabidae were encountered, including four indigenous species. The most common of these was found at only four of the 18 sites. One predaceous clerid beetle and two coccinellids were also encountered. One of these, *Halmus chalybeus*, was present at 50% of sites, but is known to be a specialist predator of scale insects. Earwigs (Dermaptera) can be significant predators, but were present in samples at only two of the 18 sites. Vespulid wasps were only recorded at one site. The most common of the four ant species was present at only four of the 18 sites. The most common facultative predators present were small ground wētā (Rhaphidophoridae), which were found at eight of the 18 sites. Apart from spiders, the biomass of generalist predators was therefore relatively low, possibly because of the low density of herbivores on which to prey. At this level general predation would be unlikely to influence the population dynamics of chrysomelid control agents, but if prey populations grew following introduction, then there could be a numerical response amongst one or more of these generalist predators (Winks et al. 2003), possibly affecting agent efficacy and food web interactions Neolema abbreviata larvae feed in the shoot tips of tradescantia as a small larva, and Lema basicostata feed solely inside the stems. These feeding habits will hide larvae from many general predators.

The plant is little studied, either as an alien invasive weed in other countries such as Australia, Portugal and the USA, or as a native plant in SE Brazil and northern Argentina. In particular, the potential natural enemies associated with the plant in its native range that might offer potential for introduction as biocontrol agents into New Zealand were almost completely unknown. Surveys for potential biocontrol agents in Brazil were initiated in 2003. The surveys have focused on SE Brazil (Fig. 3.2) because this area has a good climate match to the warmer regions of New Zealand (Standish 2001). Surveys have extended as far north as Rio de Janeiro and Belo Horizonte, but more effort has been put into the lower latitude, higher altitude, and hence cooler, areas in the southern three states (Parana, Santa Catarina and Rio Grande do Sul) (Fowler et al 2007).

Local surveys for natural enemies of *T. fluminensis* with potential as biocontrol agents in New Zealand have been conducted periodically by Brazilian collaborators, and Landcare Research entomologists carried out surveys in SE Brazil in Jun/Jul 2003, Nov 2003, Nov/Dec 2005, and in Feb 2007. Field surveys have identified a total of 42 insect species associated with *T. fluminensis*. Many of these have yet to be reared to allow full identification, and/or are undescribed species.

However, based on available knowledge and field/laboratory assessments in Brazil, the species listed in Table 3.1 could be selected as biocontrol agents.

Figure 3.2 Map



Surveys in New Zealand and Brazil have been undertaken to allow a comparison of dry biomass levels in *T. fluminensis* stands in the two countries, and to provide a pre-biocontrol baseline dataset for New Zealand. This research is ongoing, and detailed methods and results will be published elsewhere (S. Fowler, pers comm.). However, preliminary analyses show that the samples taken to date from New Zealand have dry biomasses ranging from 116 to 3999 g/m^2, with 83% of quadrats exceeding 200 g/m^2. In Brazil, comparable dry biomass samples ranged from 46 to 296 g/m^2, with only 12% exceeding 200 g/m^2 (Fowler et al. 2007). If this is due to natural enemies then a classical biological control programme has good prospects. The comparison is conservative, because selected sites in both countries had a high percentage cover (100% where possible) of *T. fluminensis*. In Brazil, this 'snapshot' approach will overestimate the real dry biomass of a typical *T. fluminensis* stand over time. The rationale is that many sites in Brazil are likely to suffer damage from natural enemies that, over time, would reduce the levels of cover such that we would not have selected these sites in a subsequent survey. For example, in February 2007, at sites located in November 2005, the biomass of healthy *T. fluminensis* was so low that completely new sites needed to be located. When sites in New Zealand have been revisited, normally the weed has completely infilled the quadrats where the biomass samples were taken.

Table 3.1 Insect species associated with *Tradescantia fluminensis* potentially suitable for biological control

	Insect species/RTU (recognisable taxonomic unit):								
	Neolema ogloblini	***Neolema abbreviata***	***Lema basicostata***	***Buckibrotica cinctipennis***	**Sawfly**	***Scirtothrips* sp.**	***Idioglossa* sp.**	***Mouralia tinctoides***	**Gall midge**
Organism type	Coleoptera: Chrysomelidae	Coleoptera: Chrysomelidae	Coleoptera: Chrysomelidae	Coleoptera: Chrysomelidae	Hymenoptera	Thysanoptera	Lepidoptera: Coleophoridae	Lepidoptera: Noctuidae	Diptera: Cecidomyiidae
Observed field damage	Low–moderate	Low–moderate	Low–moderate	Can be high	Can be high	Can be high	Can be high	Low	Low
Damage in cages	High	High	High	High	Unknown	High	Unknown	Unknown	Unknown
Type of adult damage	External on leaves	External on leaves	External on leaves and stems	External on leaves	None	Sucking: distorts shoots	None	None	None
Type of larval damage	External on leaves	Older larvae bore into growing tips	Older larvae bore into stems	Probably root or older stem feeder	External on leaves	Sucking: distorts shoots	External feeder in web on leaves	External fn leaves	Galls young leaves
Climate match	Good	Good	Good	Good	Good	Good	Poor	Good	Good
Attacks NZ *Tradescantia*?	Yes	Yes	Yes	Yes	Probably	Probably	Probably	Almost certain	Unknown
Ease of rearing and testing	Good	Good	Good	Some challenges	Probably difficult	Difficult	Unknown	Good	Probably difficult
Host specificity	High	Specific to family	Specific to family	Likely high (but larvae?)	Likely high	Unknown	Likely high	Acceptable	Likely high
Escape from specialist enemies in NZ?	Likely high	Likely high	Likely high	Likely high	Likelye high	Unknown	Unknown (possibly high)	Likely low	Unknown (possibly high)
Escape from generalist enemies in NZ?	Likely high	Likely high	Likely high	Likely high	Likely high	Unknown	Unknown (possibly high)	Likely low	Unknown (possibly high)

Damage levels from plant pathogens and insect or other herbivores have been quantified during surveys in Brazil and New Zealand. At each of the 35 sites in Brazil and 26 sites in New Zealand, five shoots with 5–10 leaves were randomly selected. In total, 1376 leaves from Brazil and 1028 leaves from New Zealand were assessed visually for several damage types. Detailed methods and results will be presented elsewhere, but a preliminary analysis shows that mean foliar damage was much higher in the samples from Brazil compared with those from New Zealand, i.e. pathogens 3.62 ± 0.36% cf. 0.12 ± 0.08% ($P < 0.0001$, $t = 12.01$, d.f. = 1507); insect/other herbivores 6.99 ± 0.40% cf. 0.83 ± 0.17% ($P < 0.0001$, $t = 20.88$, d.f. = 1939) respectively (Fowler et al 2007).

While the higher damage levels in Brazil are encouraging, the overall mean damage levels even in Brazil did not exceed 10% of leaf area. Care is needed in interpreting this figure though for the same reasons discussed under the biomass sampling, i.e. these samples are a 'snapshot' of damage levels, at sites that had sufficient *T. fluminensis* to be of interest to the survey (which was primarily aimed at collecting natural enemies and biomass samples). A better measure of damage would be obtained by marking individual shoots and monitoring these over time. This was beyond the scope of the current survey.

To summarise, if biomass levels of *T. fluminensis* in New Zealand could be reduced to the levels found in the native range in Brazil then the weed would largely cease to interfere with native regeneration. There is limited data on the damage caused by natural enemies to *T. fluminensis* in its native range, and although mean levels recorded were <10%, there were sites where much higher levels were recorded, and anecdotal observations from repeat visits to some sites were very encouraging. The next section reports on the results of the field collections of insect herbivores and plant pathogens, which was the most important aim of the field surveys.

Field-collected insect herbivores and plant pathogens

Like *Neolema ogloblini*, the adults of both *Neolema abbreviata* and *Lema basicostata* are feed on the foliage of tradescantia, notching leaves. *Lema basicostata* adults also notch stems. *Neolema abbreviata* can often be found feeding on the new leaves or resting in unfurled leaves of shoot tips. Young *Neolema abbreviata* larvae burrow into and mine growing tips or leaves of tradescantia often emerging as larger larvae to feed externally on leaves and pupate on the underside of, or in furled leaves. Larvae of *Lema basicostata* enter and mine tradescantia stems, only emerging to pupate in the litter or soil surface. Both beetles were observed causing moderate damage in the field, but in laboratory conditions readily caused major die back, often death, to potted plants. The larvae of these two species feed at different sites to those of *N. ogloblini,* and are not expected to compete with it, or with each other. The damage caused to tradescantia by the three beetles is therefore expected to be additive.

Neither species was collected from any plant species outside the family Commelinaceae during field surveys in Brazil. Both were observed causing moderate damage in the field, and in laboratory conditions readily cause major reduction in plant growth rates, substantial defoliation, major stem collapse, and even plant death.

Early in the project, formal collaborative agreements were set up with the Universities of Paraná and Viçosa in Brazil, and the project supports the relevant research groups, respectively under Professor Macedo Pedrosa and Dr Roberto Barreto, with ongoing and essential subcontracts. Additional research on the genetics/ecology of the plant in Brazil and New Zealand, its population dynamics, and the effectiveness of chemical and biological herbicides is supported by funding from the FRST project 'Beating Weeds', at Landcare Research and AgResearch.

Preliminary evaluation of the host-range was conducted at the University of Paraná, Brazil, and on the basis of these results an application to ERMA to import these beetle species into containment in New Zealand was made in August 2008 (Approval code: NOC002525 – 28). Several further populations were collected and shipped to New Zealand in Janaury 2009.

Host range tests on these populations have been conducted in containment by Landcare Research staff at Lincoln between July 2009 and September 2010. The results of this testing is reported here.

Plant pathogenic organisms are also being sought as biocontrol agents for this weed. Five fungal species have now been collected during surveys in Brazil: three Basidiomycetes – a rust fungus (*Uredo* sp.), *Kordyana tradescantiae* and *Ceratobasidium* sp.; a hyphomycete – *Cercospora apii*; and an ascomycete – *Mycosphaerella* sp. The *Uredo* rust fungus and *Kordyana tradescantiae* were the most widespread diseases observed to be damaging *T. fluminensis*. Both are leaf diseases that cause necrosis and dieback of the shoot material. However, further testing has shown that none of these isolates is able to infect New Zealand plants of *T. fluminensis* growing at the University of Viçosa. This suggests that there are different biotypes of both fungi in the native range. Work to progress these agents is ongoing whereby 'trap' plants (New Zealand origin) will be placed across the native range to capture biotypes that can attack the New Zealand ecotype of *T. fluminensis*. The third fungal candidate, *Cercospora apii,* is able to infect and damage NZ material so this pathogen is now being assessed in host-range tests for its specificity. Pathogenicity testing on the remaining two leaf diseases, *Ceratobasidium* sp. and *Mycosphaerella* sp., is planned (Fowler et al. 2007).

Appendix 4. The host range of the potential biological control agents *Neolema abbreviata* and *Lema basicostata*.

4.1 Summary

The ability of young larvae of *Neolema abbreviata* and *Lema basicostata* to survive when placed on cut foliage of 17 plant species was assessed in the laboratory. The acceptability of these plants as a food source for adult beetles was also assessed.

There are no native plants in New Zealand that are even remotely related to tradescantia. Apart from some ornamental house plants, there are no closely-related exotic plants in New Zealand that are valued either. Only limited host range testing was required because of these two characteristics. Nīkau palm was tested because it is the most closely related native plant in New Zealand, even though it is not even in the same order as the weed. There was no semblance of attack on this species.

Several host plants supported complete development of *L. basicostata* and *N abbreviata* larvae. All of these plant species belong within the tribe Tradescantieae. Similarly, when confined on test plants, adult beetles did not feed on any plants outside the Tribe. This suggests that adults would not lay eggs on these plants.

These test results indicate that the physiological host range of both *N. abbreviata* and *L. basicostata* lies within the Family Commelinacae, and possibly within the Tribe Tradescantineae. Given the extreme taxonomic distance between this tribe and any valued plant, the risk of significant adverse effects on such plants species in New Zealand (whether native or exotic) is considered to be negligible.

4.2 Source of insects

The population of *Lema basicostata* Monros that was tested combined insects collected from three sites in Brazil: Curitiba, (Paraná), Caxias do Sul (Rio Grande do Sul) and Serra do Rio do Rastro (Santa Catarina).

Two populations of *Neolema abbreviata* (Lacordaire) collected from two sites in Brazil: Curitiba (Paraná) and Lages (Santa Catarina), were tested. The results of these tests were combined (see Section 4.5)

4.3 Selection of plant species to test

A list of plants to be included in host range tests was developed. In order for this list to have the best possible scientific basis, a detailed review of the systematics of the genus *Tradescantia* and the family Commelinaceae was undertaken. The most important finding of this review was that no native New Zealand plant species fall into the family Commelinaceae, or even the order Commelinales. Similarly, apart from a small range of exotic species sold as houseplants, there are no related plants of significant economic benefit in New Zealand.

Because Tradescantia is so isolated from the rest of the flora, host specificity to species, genus, or even subfamily/family is, in theory, not essential to ensure safety in this programme. The phylogenetic relationship between tradescantia and other plants can be found in Table 4.1. The initial list of test plant species was developed for testing in Brazil, and was modified for New Zealand, taking into account the availability of plant species in each country. The plant species tested in containment in New Zealand are listed in Tables 4.2 and 4.3. The native nīkau palm (*Rhopalostylis sapida;* Order Arecales), was selected for testing because even though it is in a separate order, this is probably the closest New Zealand relative to *T. fluminensis* (P. Heenan, Landcare Research, pers. comm.). One species belonging to the Lilliales, Zingiberales and Cyperales were tested as 3 assorted representatives of the 18 other orders in the class Liliopsida other than Commelinales. Eleven species of 6 genera belonging to the Family Commelinaceae were tested. The common names of test plants can be found in Table 4.4.

4.4 Test methods

Adults of both *Neolema abbreviata* and *Lema basicostata* are external foliage feeders notching leaves, with *Lema basicostata* also notching stems. *Neolema abbreviata* can often be found feeding on the new leaves or resting in unfurled leaves of shoot tips. Young *Neolema abbreviata* larvae burrow into and mine growing tips or leaves of tradescantia often emerging as larger larvae to feed externally on leaves and pupate on the underside or in furled leaves. Larvae of *Lema basicostata* enter and mine tradescantia stems only emerging to pupate in the litter or soil surface. Both beetles were observed causing moderate damage in the field, but in laboratory conditions readily caused major die back, often killing potted plants.

Informed by this biology, two test procedures were designed that followed standard, internationally accepted protocols. Research was conducted in the Landcare Research containment facility at Lincoln. Details of the test procedures are as follows:

Adult no-choice feeding tests

Each replicate used one adult beetle from the rearing culture, with a minimum of ten replicates for each beetle species. A freshly excised leaf of the test plant was placed on damp filter paper in a 9-cm Petri dish and an adult beetle added. Tests were scored after 1 day, and then at intervals of 1–2 days, for a total of 5–7days. On each occasion, leaf damage was recorded visually into five categories (0, trace = almost zero damage; 1 = minor damage; 2 = <50% of leaf consumed; 3 = >50% of leaf consumed) and the filter paper and leaves replaced with fresh ones. Any eggs laid were counted and removed. Tests were initiated on a range of dates, with concurrent, matching *T. fluminensis* controls.

Larval feeding/development tests

Ten first or second instar larvae of each species were removed from *T. fluminensis* plants in rearing cages and were placed onto cut test plant material on filter paper in a 9 cm Petri dish, one larvae per dish. Larvae were assessed at 1 or 2-day intervals at first (and then at longer intervals), the paper was moistened, and the plant material was renewed as necessary. Larval development was recorded, and the damage on plant material was scored. On each occasion, leaf damage was recorded visually into five categories (0, trace = almost zero damage; 1 = minor damage; 2 = <50% of leaf consumed; 3 = >50% of leaf consumed). The tests terminated if all larvae were dead or had pupated. Dishes containing *T. fluminensis* were set up for each batch of tests as controls.

4.5 Results

Neolema abbreviata

The results for the two provenances of *N. abbreviata* were combined because their levels of attack on different tests plants were very similar (no significant differences between the provenances for plants in the genus *Tradescantia* – Kruskall-Wallis Test P>0.1; minor differences in other plant species in the Commelinaceae (P<0.05 – indicating a little more attack on the genus *Gibasis* by adult beetles from provenance 1 versus provenance 2). There were no differences between provenances (and no feeding) in plants outside the Order Commelinales.

In 3 of 15 replicates adult beetles caused insignificant trace feeding damage to leaves of the exotic species *Pontederia cordata,* which belongs to a family that is closely related to the Commelinaceae. Otherwise, there was no adult or larval feeding observed on any species outside the family Commelinaceae. No larvae transferred to these test plants completed development (Table 4.2).

Within the Commelinaceae, feeding by adult beetles in no-choice feeding tests (as measured by the mean feeding score) was significantly lower on test plants than on *T. fluminensis* controls, except for *Tradescantia albiflora* (Table 4.2). Feeding intensity on *Gibasis geniculata* was 78% of that recorded on controls and 47% on *T. zebrina.* Larvae fed adequately and successfully developed to pupation on 4 of the 11 species within this family that were tested.

Lema basicostata
No adults or larvae fed at all on any plants outside the Family Commelinaceae (Table 4.3).

Adults fed significantly better on *Tradescantia albiflora* than on *T. fluminensis*, and larval development success was not significantly different from controls. Similarly, although adults and fed significantly less on *T. zebrina Cyanotis somaliensis* and *Callisa repens* than on controls (Table 4.3) larvae developed to pupation as successfully on these species of the Commelinaceae as they did on controls.

Commelina tuberosa was the least acceptable host for both beetles species. This plant belongs to the tribe Commelineae, whereas all other species tested belong to the Tradescantieae, the same tribe as the target species (Table 4.2, 4.3).

4.6 Discussion and conclusions

Chrysomelid beetles are generally host-specific, and that is one reason why species of this group are commonly used as biological control agents for weeds (Syrett et al. 1996). Tradescantia and other similar plant species are widely separated taxonomically from the rest of the New Zealand native and exotic flora. Given this lack of closely related plants, these two beetle species were not expected to successfully utilise test plants outside of the family Commelinaceae, to which the target weed belongs. Except for slight marking of *Pontederia* leaves, in these tests there was no feeding by adults or larvae of either *N. abbreviata* or *L. basicostata* on test plants outside of this family.

Nīkau palm (*Rhopalostylis sapida*), was not attacked, even under these stringent no-choice or starvation tests. Although nīkau appears to be the native species most closely related to tradescantia, this relationship is very distant, and the lack of attack is not surprising. No native species will be at risk from these two control agents.

The fundamental or physiological host range of both species appears to include *T. albiflora* because feeding damage by adults and larvae was similar on *T. fluminensis* and *T. albiflora*, as was development. *T. albiflora* is in the same subgenus of *Tradescantia* as *T. fluminensis*, and it may be no coincidence that it has a very similar flavonoid profile (Del Pero Martinez & Martinez 1993). These two adventive *Tradescantia* entities ("*T. fluminensis*" and "*T. albiflora*") are both naturalised in New Zealand, and will be subject to attack. The taxonomy of these entities in New Zealand has not yet been fully resolved (Peter Heenan, Landcare Research, pers. comm., 2008).
http://nzflora.landcareresearch.co.nz/default.aspx?selected=NameDetails&TabNum=0&NameId=A6CCD2BA-F90B-479A-A2E4-41906DC03215

While neither *N. abbreviata* nor *L. basicostata* could complete development on species of several genera within the family Commelinaceae, other species were acceptable hosts. For example, *Commelina tuberosa* (which belongs to the tribe Commelineae) was not a suitable host, and nor were *Tradescantia spathacea* (sold in nurseries as moses-in-a-basket) and *T. pallida*. On the other hand, *T. albiflora* appears to be as good a host as the target weed, and the house plants *Callisia repens, Gibasis* spp. (including *G. geniculata* which is sold in nurseries as Tahitian bridal veil) and *Cyanotis somaliensis* appear to be adequate hosts. From the evidence of these host range tests, the control agents are specific to the family Commelinaceae, and possibly within the tribe Tradescantieae. *G. pellucida* (bridal veil) was a marginal host for *N. abbreviata*, but not for *L. basicostata*. In general, test results indicate that *L. basicostata* has a narrower host range than *N. abbreviata*.

Eight species of the family Commelinacae have been field-recorded in New Zealand though a number of others are cultivated as ornamentals. Of these, four *Tradescantia* spp. and *Gibasis schiediana* are considered to be fully naturalised, and *Gibasis pellucida* is a casual record (http://nzflora.landcareresearch.co.nz/default.aspx?NavControl=search&selected=NameSearch) . Although not all of these species were tested, and although laboratory tests of this type can over-estimate field host range (Sheppard et al. 2005), these species are likely to be hosts of *N. abbreviata* and *L. basicostata* in New Zealand. These plants have naturalised and represent a potential invasion threat similar to that of *T. fluminensis* (especially *T. albiflora*), and future non-target attack on these species should not be regarded as an adverse effect. Other species belonging to this family are used as house plants, and systematic colonisation indoors by these control agents is considered unlikely. Any impact of *N. abbreviata* and *L. basicostata* on plants used in the horticultural trade (e.g. *Gibasis geniculata (*synonym *Tripogandra multiflora (*commonly called 'Tahitian bridal veil') is therefore predicted to be negligible.

Although only one native species, nīkau palm, was tested, zero attack on New Zealand native species is also predicted. This is because *N. abbreviata* and *L. basicostata* are host specific within the family Commelinaceae and there are no New Zealand native plants in this family, or even in the order Commelinales.

Table 4.1 . **The taxonomic relationships between *Tradescantia* spp. and the other plants used in host range tests for *Neolema abbreviata* and *Lema basicostata.***

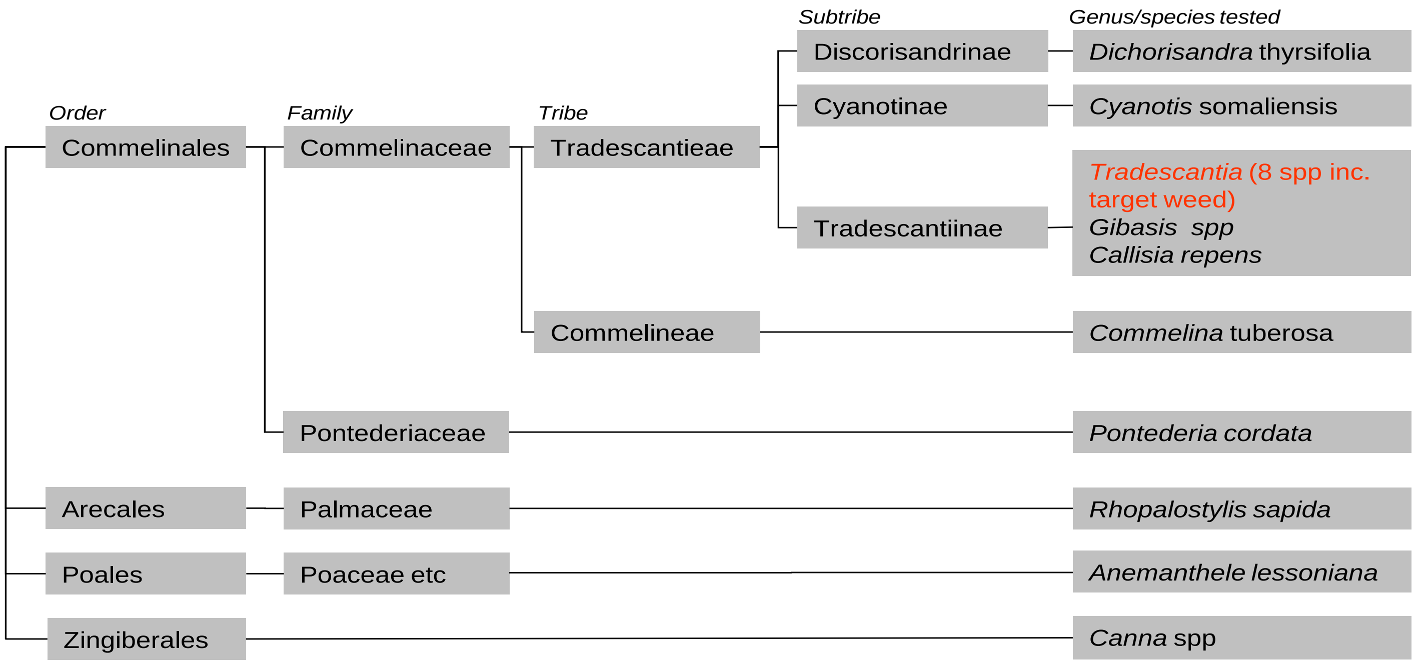


Table 4.2. Summary of host range tests on cut plants for *Neolema abbreviata* originating from Parana and Santa Catarina

	test plant species	LARVAL FEEDING					ADULT FEEDING				
		n	Mean damage score (days 1-20)	Mean damage score (days 21-35)	Significance (days 1-35)	% to pupa	n	Mean damage score (days 1-3)	Mean damage score (days 4-7)	Significance (days 1-7)	total eggs laid
control	*Tradescantia fluminensis*	40	1.79	0.42	-	28	40	1.49	2.00	-	5
same genus	*Tradescantia albiflora*	14	1.83	1.00	NS	21	15	1.56	1.65	NS	0
	Tradescantia virginiana	30	0.38	0.00^	***	0	30	0.44	0.50	***	0
	Tradescantia pallida	10	1.09	0.00^	**	0	15	0.35	0.38	***	0
	Tradescantia spathacea	10	0.73	0.00^	***	0	15	0.70	0.68	***	3
	Tradescantia zebrina	10	1.80	2.33	NS	10	15	0.67	0.95	***	0
	Tradescantia cerinthoides	5	1.80	0.00#	NS	100	5	0.90	1.20	*	8
	Tradescantia sillamontana	5	1.52	0.00*	NS	20	5	0.10	0.40	***	0
same tribe	*Gibasis geniculata*	10	2.15	0.00*	NS	30	15	1.00	1.56	*	0
	Gibasis pellucida	10	1.03	0.00*	***	10	15	0.15	0.16	***	0
	Callisia repens	10	2.32	1.50	NS	30	15	0.20	0.60	***	0
	Dichorisandra thyrsifolia	10	0.62	0.00^	***	0	10	0.00	0.00	***	0
	Cyanotis somaliensis	10	1.14	0.00*	***	20	15	0.00	0.00	***	0
same family	*Commelina tuberosa*	8	0.00	0.00^	***	0	10	0.00	0.00	***	0
same order	*Pontederia cordata*	15	0.03	0.00^	***	0	10	0.00	0.00	***	0
same class	*Rhopalostylis sapida*	10	0.00	0.00^	***	0	15	0.00	0.00	***	0
	Anemanthele lessoniana	10	0.00	0.00^	***	0	10	0.01	0.00	***	0
	Canna sp cultivar	10	0.00	0.00^	***	0	10	0.00	0.00	***	0

all larvae pupated
* all larvae pupated or dead
^ all larvae dead

Table 4.3. Summary of host range tests on cut plants for *Lema basicostata* originating from Parana, Rio Grande do Sul and Santa Catarina

	test plant species	LARVAL FEEDING					ADULT FEEDING				
		n	Mean damage score (days 1-20)	Mean damage score (days 21-40)	Significance (days 1-40)	% to pupa	n	Mean damage score (days 1-3)	Mean damage score (days 4-8)	Significance (days 1-8)	total eggs laid
control	*Tradescantia fluminensis*	50	1.32	0.14	-	50	55	1.52	2.24	-	64
same genus	*Tradescantia albiflora*	40	1.26	0.00*	NS	10	10	2.60	2.40	***	19
	Tradescantia virginiana	35	0.92	0.00^	NS	0	25	0.33	0.38	***	5
	Tradescantia pallida	10	0.71	0.00^	***	0	10	0.60	0.55	***	2
	Tradescantia spathacea	10	1.16	0.00^	NS	0	10	0.40	0.20	***	0
	Tradescantia zebrina	10	0.97	0.00^	*	50	10	0.87	0.73	***	7
	Tradescantia cerinthoides	10	1.35	0.25	NS	50	5	0.00	1.00	***	0
	Tradescantia sillamontana	10	1.13	0.57	NS	0	5	0.00	0.00	***	0
same tribe	*Gibasis geniculata*	10	1.24	0.33	NS	50	10	0.73	0.69	***	3
	Gibasis pellucida	10	0.73	0.00^	***	0	10	0.00	0.10	***	5
	Callisia repens	10	0.91	0.67	**	0	10	0.00	0.00	***	2
	Dichorisandra thyrsifolia	10	0.23	0.00^	***	0	10	0.00	0.00	***	5
	Cyanotis somaliensis	10	1.37	0.67	NS	20	10	0.20	0.20	***	0
same family	*Commelina tuberosa*	10	0.70	0.00^	***	0	10	0.07	0.00	***	0
same order	*Pontederia cordata*	10	0.06	0.00^	***	0	15	0.00	0.00	***	1
same class	*Rhopalostylis sapida*	10	0.00	0.00^	***	0	10	0.00	0.00	***	0
	Anemanthele lessoniana	10	0.00	0.00^	***	0	20	0.00	0.00	***	0
	Canna sp cultivar	10	0.00	0.00^	***	0	20	0.00	0.00	***	1

* all larvae pupated or dead
^ all larvae dead

Table 4.4 Common names of Tradescantia test plants

Tradescantia fluminensis	wandering Willie, wandering Jew, river spiderwort, small-leaf spiderwort, inch plant, nohakata karakusa, small-leaf spiderwort, spiderwort, Vandrande Jude, wandering creeper, white flowered wandering Jew
Tradescantia albiflora	wandering Willie, wandering Jew
Tradescantia virginiana	Virginia spiderwort, spider lily
Tradescantia pallida	purple heart, purple queen, purple-heart tradescantia
Tradescantia spathacea	boat lily, boat plant, faina kula, moses in a boat, Moses-in-a-basket, oyster plant, riri mangio, riri raei, talotalo, laupapaki
Tradescantia zebrina	wandering Jew, inch plant
Tradescantia cerinthoides	flowering inch plant
Tradescantia sillamontana	pussy ears, white velvet, white gossamer plant
Gibasis geniculata	bridal veil, Tahitian bridal veil
Gibasis pellucida	bridal veil, dotted bridal veil
Callisia repens	Bolivian Jew, Bolivian inchplant, creeping inchplant, turtle vine, itsy bitsy inch vine, baby's tears
Dichorisandra thyrsifolia	Blue Ginger, Blue-Ginger, Brazilian Ginger
Cyanotis somaliensis	furry kittens, pussycat ears, teddy bear plant
Commelina tuberosa	blue spiderwort, commelina, dayflower,
Pontederia cordata	pickerelweed
Rhopalostylis sapida	nikau palm
Anemanthele lessoniana	pheasant's tail grass, gossamer grass, bamboo grass, wind grass, hunangamoho
Canna sp cultivar	Canna lily

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