Weed Biocontrol

WHAT'S NEW?

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Contents

Key contacts

EDITOR: Angela Bownes
Any enquiries to Angela Bownes
bownesa@landcareresearch.co.nz

THANKS TO: Ray Prebble

LAYOUT: Cissy Pan

CONTRIBUTIONS:
Quentin Paynter, Ronny Groenteman, Chris McGrannachan, Arnaud Cartier, Lynley Hayes

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Water celery, *Trevor James*

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New Insights into Predicting Non-Target Impacts

Weed biocontrol has several proven advantages over conventional control methods, yet concerns over its environmental safety persist. This is despite evidence that modern host range testing protocols are highly reliable. Globally, examples of biocontrol agents that cause persistent damage to non-target plants are rare and declining as host range testing protocols are refined and improved. For the small proportion (less than 1%) that have serious non-target impacts, the non-target attack was predictable and those agents would not be approved for release today.

However, it is possible that non-target attack is under-reported, particularly when impacts are minor, due to a lack of rigorous post-release monitoring. In New Zealand, systematic surveys were undertaken to assess the non-targets impacts of several biocontrol programmes. Here, 8 out of the 33 (24%) arthropod agents surveyed attack non-target plants, which is higher than the world average of 13%. This higher figure is probably due to greater sampling effort in New Zealand, where only minimal to minor damage to non-target flora has been recorded. Nevertheless, even minor non-target attack is potentially concerning if agents adapt due to selection pressures (external factors that affect an organism's ability to survive), allowing them to exploit non-target plants more effectively.

In a recent publication, Quentin Paynter and colleagues from South Africa and Australia discuss new insights and developments on non-target impacts of weed biocontrol.

Direct non-target effects of weed biocontrol agents

Most examples of this are 'spill-over damage' (non-target attack on related plant species growing in the vicinity of the target weed, when agent densities are high), which is unlikely to cause significant negative impacts at the population level. Herbivorous insects are known to expand their host ranges during population outbreaks, and effective biocontrol agents are likely to have population outbreaks for a period of time following their release. Laboratory host range testing protocols have been developed to predict this spill-over attack on plant species that cannot sustain agent populations.

It is a generally accepted principle in weed biocontrol that the laboratory and fundamental host range of a biocontrol agent is much broader than its realised/field host range. This can make host range test results difficult to interpret, and can potentially result in the rejection of safe agents. Pre-release assessments of the impacts of agents on non-target test plants over multiple generations can help in assessing risk and refining predictions of the realised host range. Open-field tests in the native range have also been improved to replicate situations that might occur after they are released into their introduced range in order to predict non-target host use.

Another, more recent, approach to improving the predictability of host-range testing is the "relative performance" approach. Biocontrol practitioners in New Zealand effectively demonstrated, using all the arthropod agents established here between 1929 and 2010 as case studies, that the relative performance of candidate biocontrol agents on potential non-target and target plants is an excellent predictor of host use in the field. This approach was recently corroborated by a study in North America, although it demonstrated that common methods of host specificity screening are still insufficient to eliminate risk, without also excluding some agents that would be host specific in the field.

Novel techniques aimed at investigating the importance of olfactory and visual cues for arthropod agents in host selection have been developed, and the authors suggest that the use of demographic models in host range testing to predict the implications of non-target damage at the population level could improve risk assessments.

Indirect non-target effects of weed biocontrol agents

A common criticism of biocontrol is the lack of studies to help understand the indirect effects of releasing biocontrol agents into new environments, although these are inherently difficult to predict and quantify. This includes indirect impacts on food webs and ecosystems, such as "apparent competition" (indirect competition where two or more species, including a biocontrol agent, share a natural enemy such as a parasitoid that might increase in abundance in the presence of a biocontrol agent).

"Weed biocontrol agents that have ecological analogues (native arthropods taxonomically closely related that have a similar feeding niche) are susceptible to attack by parasitoids that attack their analogues," explained Quentin. "This potentially reduces their efficacy and increases the likelihood of indirect non-target impact. In New Zealand, it is now common practice to give low priority to candidate biocontrol agents that have native analogues," he added.

A similar approach may help predict the risk of indirect ecological impacts of predators. For example, the gorse thrips (*Tetranchus lintearius*) and the broom gall mite (*Aceria genistae*), have close relatives here that occupy similar niches on native plants in the same families as their target weeds. Both of these agents are attacked by native specialist predators in New Zealand, in the same genera as their primary predators in their respective native ranges.

However, most predators that attack weed biocontrol agents are generalists, and if we assume that some predation by generalist predators is inevitable, so are some indirect interactions of this. "The key to minimising these impacts is to select effective biocontrol agents that decline in abundance as the target weed is suppressed," said Quentin. "And although competition and apparent competition may lead to declines in some native species, they are unlikely to cause extinctions of any of these species. Invasive plants have much greater impacts on native biodiversity, so the risk of doing nothing is worse than some indirect negative impacts of the agents," he added.

Newly recognised risks

Several species of sap-sucking bugs are able to transmit disease-causing bacteria during feeding. This includes the broom psyllid (*Arytainilla spartiophila*), which vectors a bacterium (*Candidatus* Liberibacter europaeus) that was unknown to science in 1993 when the psyllid was released in New Zealand to control Scotch broom (*Cytisus scoparius*). Although this bacterium may actually enhance the biocontrol impacts of the broom psyllid, there are concerns it could be transmitted to non-target plants (e.g. if broom psyllids pierce other plants with their mouthparts as part of their host selection behaviour, or if feeding by generalist sap-sucking bugs vectors the bacterium from broom to other plant species).

Several studies have demonstrated the importance of using molecular techniques to detect micro-organisms (e.g. fungal associates and gut microbiota) associated with candidate biocontrol agents. Not only will this help to identify unwanted associated organisms prior to their release, but it could also prevent the release of populations of agents infected with debilitating, pathogenic micro-organisms that could reduce their efficacy.

Can risks change over time? Evolution and climate change

Biocontrol agents do not exhibit extreme evolutionary adaptation, and any micro-evolutionary changes are unlikely to result in host range shifts. It is possible, however, that non-target attack that is already taking place may increase over time due to selection pressure. Geographical range expansion of a biocontrol agent, as a result of evolutionary change, has been reported in North America. Thus, potential non-target plants that occur outside of the predicted distributional limits of a candidate biocontrol agent may still be at risk and should be included in host range testing.

Climate change could potentially alter the risk of non-target impacts of biocontrol agents. Potential scenarios include an increase in spill-over attack if agent abundance increases due to warming temperatures, and range expansion of biocontrol agents into areas where at-risk non-target plants occur due to changing climates. Predicting the consequences of climate change for weed biocontrol systems is very difficult, because plants and insects will vary in their responses to elevated CO_2, warming temperatures and extreme weather events.

In conclusion, despite the excellent and improving safety record of weed biocontrol worldwide, further refinement of host range testing protocols is desirable to avoid the rejection of safe agents due to over-estimation of risk. More monitoring is needed to detect any non-target attack and indirect negative impacts of biocontrol agents, and to investigate whether evolutionary and/or climate change can enhance the ability of agents to attack non-target plants.

"New Zealand's exemplary regulatory system, which weighs the risks against the potential benefits, as opposed to only the risks, helps to avoid rejecting safe and effective candidate biocontrol agents," said Quentin. "And ideally, risk assessments should also consider the impacts of the target weed so that the risk of doing nothing versus the potential benefits from biocontrol are included in all assessments."

Further reading: Paynter Q, Paterson D, Kwong RM 2020. Predicting non-target impacts. Current Opinion in Insect Science 38: 79-83. https://doi.org/10.1016/j.cois.2020.02.002

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CONTACT
Quentin Paynter – paynterq@landcareresearch.co.nz

New Recruits

Stephanie Morton (Auckland)

Stephanie first joined Manaaki Whenua – Landcare Research (MWLR) as a summer technician at our Tamaki site in 2018, shortly after completing her MSc in Biosecurity and Conservation through the University of Auckland. For her MSc, which focused on the chemical ecology of honeybee pollination, Stephanie was based at Plant & Food Research in Lincoln. Her research involved training bees to recognise odours and testing their learning and memory behaviours.

For her summer job with MWLR, Stephanie assisted with rearing Honshu white admiral butterflies (*Limenitis glorifica*), tradescantia beetles (*Neolema ogloblini, Lema basicostata, N. abbreviata*), privet lace bugs (*Leptoypha hospita*), and moth plant beetles (*Freudeita cupripennis*). She also assisted with field releases of some of these agents, and was involved in the Healthy Trees Healthy Future project, collecting cones from native forests for kauri dieback research.

After brief stints working on the Queensland fruit fly incursion on Auckland's North Shore and in a commercial Good Manufacturing Practice laboratory, Stephanie joined us again in November 2020 as a weed biocontrol technician. Stephanie provides technical support on a variety of projects at Tamaki, including mass rearing moth plant beetles and Japanese honeysuckle beetles (*Oberea shirahatai*), and assisting with testing and rearing of the moth plant fly (*Anastrepha australis*).

Stephanie also provides technical support for the Managing Invasive Species for Climate Change Adaptation in the Pacific (MISCCAP) and Vanuatu projects.

Stephanie Morton

CONTACT

Stephanie Morton – mortons@landcareresearch.co.nz

Robyn White (Lincoln)

Robyn White

Robyn joined MWLR in November 2020 as a weed biocontrol technician at our Lincoln site. Robyn's extensive experience with rearing insects will be put to good use for many of our weed biocontrol projects. Robyn is currently rearing Honshu white admiral butterflies (*Limentis glorifica*) for release against Japanese honeysuckle (*Lonicera japonica*) and tutsan beetles (*Chrysolina abchasica*) for tutsan (*Hypericum androsaemum*). She also provides assistance with other weed biocontrol projects based at Lincoln, such as old man's beard (*Clematis vitalba*) and field horsetail (*Equisetum arvense*), and has recently taken over as the lead for a National Biocontrol Collective project evaluating the field impact of nodding thistle agents.

Prior to joining MWLR, Robyn was based at Plant & Food Research in Lincoln, where she worked as a soils, field and laboratory technician in the Sustainable Production Group, and as a research technician in the BioProtection Group. Her roles at Plant & Food involved rearing a variety of insect pests such as leaf-mining flies (*Scaptomyza* sp.) and diamondback moth (*Plutella xylostella*) for use in testing novel pheromone and kairomone lures. She also assisted with testing lures in the field and laboratory for codling moth (*Cydia pomonella*), various fruit flies (*Drosophila* spp.), as well as important pollinator species.

Robyn has an MSc in Ecology from the University of Canterbury. Her research project involved studying anti-predatory behaviours of native and exotic birds in different environments in New Zealand. Robyn's research interests include behavioural ecology, biological control, integrated pest management, conservation ecology and regenerative agriculture.

CONTACT

Robyn White – whiter@landcareresearch.co.nz

A New Aquatic Weed on The Radar

Water celery (*Helosciadium nodiflorum*; synonym *Apium nodiflorum*) was recently highlighted as a problematic aquatic weed in New Zealand, yielding high scores in a weed risk assessment conducted by Paul Champion (National Institute of Water and Atmospheric Research) in 2018.

Water celery is a perennial herb in the carrot family, Apiaceae. It is a sprawling, emergent aquatic plant that can grow up to one metre in height. Plants have glossy, bright green leaves and white flowers that grow close to the leaf bases. Water celery grows in shallow ponds and lakes, drains, canals, ditches, the margins of slow-flowing streams and riparian zones, in marshy areas and around springs. It can form submerged patches in slow-flowing deep water. Seedlings contribute to its spread from the edges of existing stands, and new populations establish from detached shoots that readily develop roots.

Water celery is native to Europe, North Africa and western Asia. The plant has naturalised in parts of North, Central and South America, and in south-western Australia, and is a declared invasive weed in Chile. It is common in many river systems in its native range, even being regarded as weedy in Portugal and Spain, where it is native.

In New Zealand, water celery was first recorded as naturalised in 1947, most likely introduced as a contaminant via seed or ornamental aquatic plants. Infestations are now scattered from Northland to Wellington, and the plant is locally abundant in many regions, especially in coastal areas. It has also established in the north and west of the South Island, where its distribution is confined to a small number of streams.

Water celery contributes to the degradation of water quality in streams, especially in combination with farm drainage entering these systems. Infestations trap nutrients and deplete dissolved oxygen when plants decompose, and they threaten endangered native species in wetlands. In the North Island, water celery needs to be regularly managed to clear drainage networks. If the weed is not cleared from slow-flowing streams, the build-up of plant biomass reduces water flow and can lead to flooding. Water celery is currently controlled mechanically and chemically, which only provides temporary relief, with rapid regrowth of surviving plants or recolonisation through seed germination.

The prospects of developing a biocontrol programme for water celery in New Zealand were recently assessed at the request of Nelson City Council. In a thorough desk-top study led by Ronny Groenteman, and assisted by Peter Heenan and plant pathologist Jane Barton (independent contractor), several pathogen and insect natural enemies associated with water celery were identified.


Water celery
Trevor James

"A total of nine pathogenic micro-organisms have been recorded from water celery, which is a relatively small number as far as plant pathogens go," observed Jane. "However, only one of these, a white smut (*Etyloma helosciadii*), appears to be a promising candidate due to its potential to have a restricted host range," she added. Eleven arthropods were identified in the literature as associated with water celery, but, again, only one is a promising candidate agent, a stem-mining moth (*Depressaria ultimella*). The moth is common on water celery in the United Kingdom, where plants with extensive larval mining collapse late in the growing season. The moth reportedly has a preference for water celery growing in slow-flowing water, such as roadside ditches, as opposed to streams. Nevertheless, it may be worth pursuing, since our research suggests the moth could be sufficiently host specific for New Zealand and has the potential to be very damaging.

"Any biocontrol agents for water celery would need a fairly high degree of host specificity due to water celery's taxonomic affinities with valued food plants in the carrot family (e.g. celery, celeriac, parsnip, carrot, parsley and coriander) and New Zealand natives in the genus *Lilaeopsis*," explained Ronny. "Fortunately, after taxonomic revision, water celery is no longer in the same genus as celery as it once used to be. This increases the likelihood of finding natural enemies that are sufficiently host specific," she added. Based on this research, water celery appears to be a viable biocontrol target, with some natural enemies already identified, and with the possibility that additional candidate agents will be discovered during native range surveys. Also, aquatic plants tend to be good biocontrol targets, based on evidence from programmes elsewhere in the world. Since water celery is regarded as the worst among a suite of aquatic weeds being managed around Nelson and Wellington, a biocontrol programme may be timely.

This project was funded through an Envirolink Grant (2042-NLCC111) to Nelson City Council.

Further reading: https://envirolink.govt.nz/assets/2042-NLCC111-Feasibility-for-biological-control-of-water-celery-Helosciadium-nodiflorum.pdf

CONTACT
Ronny Groenteman – groentemanr@landcareresearch.co.nz

The More the Merrier? Testing Efficacy of Multiple Agents

New Zealand's native forest remnants are important habitats, providing substantial conservation, scientific and aesthetic value. However, they are often detrimentally subjected to human disturbances, leading to understorey invasions by problematic weed species, including tradescantia (*Tradescantia fluminensis*). Tradescantia commonly dominates in these forest habitats, forming a dense ground layer that negatively affects native forest regeneration and seedling recruitment.

In response to the threat posed by tradescantia, four biocontrol agents have been released. These include the leaf beetle (*Neolema ogloblini*), the stem beetle (*Lema basicostata*), the tip beetle (*Neolema abbreviata*), and the yellow leaf spot fungus (*Kordyana brasiliensis*). All three beetle species have already proven effective in controlling tradescantia in multiple regions, most notably Northland and the Waikato. Trial releases of the fungus have also shown promising results. While the beetles have been released together in some locations, the impacts of their combined release with the yellow leaf spot fungus have yet to be assessed. Given that the beetles are less active during winter and the fungus prefers wetter conditions typical of New Zealand winters, it is hoped that their combined impacts will provide year-round control of tradescantia.

In order to investigate this, a long-term (3–5 years) field experiment was initiated in September 2020 in the Auckland, Northland and Waikato regions. The project is led by Chris McGrannachan and Zane McGrath and seeks to answer four main questions:

- How effective are the beetles and the smut fungus, both separately and in combination?
- How does biocontrol compare with herbicides in controlling tradescantia?
- What impact does tradescantia biocontrol have on native vegetation biomass, richness and regeneration?
- How does a reduction of tradescantia biomass affect other exotic plant species?

Similar trials undertaken previously in Northland showed promising early results from the beetles but could not be continued for long enough, hence this new study.

The study is being conducted at 21 native forest remnant sites on both private and conservation land. At each site, five 1.25 m^2 subplots, each subjected to one of four different treatments and a control, are arranged randomly at 10 m intervals along a transect line. The four treatments include: herbicide only, beetles only, smut fungus only, and the beetles and smut fungus combined. The control and experimental subplots will be treated with an insecticide and a fungicide, as necessary, to keep the plants clean of insect and/or fungal damage, according to their assigned treatments.


Tradescantia infestation in a Waikato forest

"The first phase of the project is complete," said Chris. "Zane and I have visited all 21 field sites to lay the transect lines, to demarcate the subplots, and to release the yellow leaf spot fungus. The beetles are already well established at many of the sites in Northland, so the next step is to field capture beetles for release at the remaining sites," he added. The study sites will be revisited every 4–6 months to check on progress and to collect data. Several measurements, including environmental factors (e.g. soil moisture and canopy cover) and vegetation characteristics (e.g. tradescantia height and cover and plant species richness) will be taken at each sampling interval to assess efficacy of biocontrol versus herbicides, and efficacy of the insect and fungal biocontrol agents either alone or in combination.

"It is hoped that this study will increase our knowledge of best practice techniques in order to provide tools and guidelines to improve the long-term sustainability of New Zealand's native forest remnants, and for improved management and control of tradescantia in these environments," concluded Chris.

The findings from the field trial will be supplemented by the results of controlled glasshouse experiments being undertaken by University of Canterbury PhD student, Simone Cunha. Simone is conducting manipulative tests with different densities and combinations of all four tradescantia biocontrol agents to assess synergistic or antagonistic interactions between them.

This project was funded by the Ministry of Business, Innovation and Employment as part of Manaaki Whenua – Landcare Research's Beating Weeds programme.

CONTACT
Chris McGrannachan –
mcgrannachanc@landcareresearch.co.nz

Old Man's Beard Agents Show Promise

Old man's beard (*Clematis vitalba*), one of New Zealand's worst and most widespread invasive alien plants, is a deciduous, climbing, layering vine that can grow up to 20 metres in height. In suitable habitats it rapidly dominates, smothers and eventually kills all types of vegetation.

Four biocontrol agents have been developed for old man's beard in New Zealand, three of which were released two decades ago in the late 1990s. The first agent, a leaf-mining fly (*Phytomiza vitalbae*), established and spread rapidly. Unfortunately the fly accumulated native parasitoids, which maintain the agent populations at low densities, and damaging outbreaks are now quite rare. The second agent, a fungus (*Phoma clematidina*), did not persist and is believed to be outcompeted by native fungi.

The third agent, a sawfly (*Monophadnus spinolae*), was released over several years from 1998 at multiple localities, but due to adverse weather and human disturbance many sites were lost. In 2015 a few sawflies were spotted at an old man's beard site near Nelson, confirming they are established but persisting at very low numbers, having remained undetected for almost 20 years. Establishment of this sawfly population was speculated to be constrained by genetic bottlenecks during rearing due to the production of male-biased progeny.

The discovery was nevertheless encouraging, and the project was revived with the importation of a new sawfly population from Serbia into containment at Lincoln in 2019. Mass-rearing methods were improved and geared towards obtaining a more balanced sex ratio. In late 2019, thousands of sawfly larvae along with mated adult females were released in Amberley in the Waipara district in the Canterbury Region in the South Island.

Later in the season, in February 2020, the release site was visited by both technicians working on the project at the time, Arnaud Cartier and now-retired, Lindsay Smith. "It didn't take us long to see adults flying around, which would have been second generation adults. We even saw some larvae feeding on the leaves," enthused Arnaud.

The site was checked again this summer, and both adults and larvae were observed. "Given the complex life history of this agent, it was fantastic to see adults this summer for the second year in a row," said Arnaud. "We are now very hopeful that sawfly numbers will steadily increase, which will eventually allow for collection and redistribution of adults and larvae to other old man's beard infestations," he added.

The fourth and last agent approved for release against old man's beard is an eriophyid mite. Feeding by this leaf- and bud-galling mite stunts plant growth and reduces shoot production. This has been another very difficult agent to

Female old man's beard sawfly

Old man's beard mites

work with, and the first few attempts at establishing a viable laboratory colony failed. Persistence and hard work paid off, however, and a mite colony was finally established with the importation of new material from Serbia in 2019, hand delivered by Dr Biljana Vidovic (University of Belgrade). The microscopic mites were painstakingly transferred on pinheads to fresh plant material and finally … success! After receiving MPI approval to remove the mites from containment, the infested plants were transferred to an outdoor shadehouse for mass-rearing.

Over the past 18 months the mites have slowly transferred to fresh plants placed alongside the original mite-infested plants removed from containment. "I regularly dissect buds to monitor the population and have found that even a small number can effectively stunt new growth. The damage has become more obvious this summer, presumably due to increasing numbers, with plants now showing galled and deformed leaves," explained Arnaud.

Even more encouraging, the mites have been found on old man's beard plants growing in other shadehouses, and even on wild plants growing on the Lincoln campus. "At first, I was very surprised that they had dispersed so far and so quickly. I even had to get confirmation of the ID from a mite expert," said Arnaud. "However, since eriophyid mites disperse passively on winds, a phenomenon known as 'ballooning', it isn't really surprising that they have established themselves on nearby plants. These early findings suggest natural dispersal in the field should be good," he concluded. And the last bit of good news – the first official field releases of the old man's beard mite will go ahead later this year in spring.

This project is funded by the National Biocontrol Collective.

CONTACT
Arnaud Cartier – cartiera@landcareresearch.co.nz

Autumn Activities

Gall-forming agents

- Check broom gall mite (*Aceria genistae*) sites for signs of galling. Very heavy galling, leading to the death of bushes, has been observed at some sites. Harvesting of galls is best undertaken from late spring to early summer, when predatory mites are less abundant.
- Check hieracium sites, and if you find large numbers of stolons galled by the hieracium gall wasp (*Aulacidea subterminalis*) you could harvest mature galls and release them at new sites. Look, also, for the range of deformities caused by the hieracium gall midge (*Macrolabis pilosellae*), but note that this agent is best redistributed by moving whole plants in the spring.
- Check nodding and Scotch thistle sites for gall flies (*Urophora solstitialis* and *U. stylata*). Look for fluffy or odd-looking flowerheads that feel lumpy and hard when squeezed. Collect infested flowerheads and put them in an onion or wire-mesh bag. At new release sites hang the bags on fences, and over winter the galls will rot down, allowing adult flies to emerge in the spring.
- Check Californian thistle gall fly (*Urophora cardui*) release sites for swollen deformities on the plants. Once these galls have browned off they can be harvested and moved to new sites (where grazing animals will not be an issue), using the same technique as above.
- Look for swellings on giant reed (*Arundo donax*) stems caused by the giant reed gall wasps (*Tetramesa romana*). These look like small corn cobs on large, vigorous stems, or like broadened, deformed shoot tips when side shoots are attacked. Please let us know if you find any, since establishment is not yet confirmed.

Honshu white admiral (*Limenitis glorifica*)

- Look for the adult butterflies at release sites, pale yellow eggs laid singly on the upper and lower surfaces of the leaves, and for the caterpillars. When small, the caterpillars are brown and found at the tips of leaves, where they construct pier-like extensions to the mid-rib. As they grow, the caterpillars turn green, with spiky, brown, horn-like protrusions.
- Unless you find lots of caterpillars, don't consider harvesting and redistribution. You will need to aim to shift at least 1,000 caterpillars to start new sites. The butterflies are strong fliers and are likely to disperse quite rapidly without any assistance.

Privet lace bug (*Leptoypha hospita*)

- Examine the undersides of leaves for the adults and nymphs, especially leaves showing signs of bleaching.
- If large numbers are found, cut infested leaf material and put it in chilly bin or large paper rubbish bag, and tie or wedge this material into Chinese privet at new sites. Aim to shift at least 1,000 individuals to each new site.

Tradescantia leaf, stem and tip beetles (*Neolema ogloblini, Lema basicostata, N. abbreviata*)

- Look for the distinctive feeding damage and adults. For the leaf and tip beetles, look for the external-feeding larvae, which have a distinctive faecal shield on their backs.
- If you find them in good numbers, aim to collect and shift at least 100–200 beetles using a suction device or a small net. For stem beetles it might be easier to harvest infested material and wedge this into tradescantia at new sites (but make sure you have an exemption from MPI that allows you to do this).

Tradescantia yellow leaf spot (*Kordyana brasiliensis*)

- Look for the distinctive yellow spots on the upper surface of the leaves, with corresponding white spots underneath, especially after wet, humid weather. Send a photo to us for confirmation if you are unsure, as occasionally other pathogens do damage tradescantia leaves.
- The fungus is likely to disperse readily via spores on air currents. If human-assisted distribution is needed in the future, again you will need permission from MPI to propagate and transport tradescantia plants. These plants can then be put out at sites where the fungus is present until they show signs of infection, and then planted out at new sites.

Tutsan moth (*Lathronympha strigana*)

- Look for the small orange adults flying about flowering tutsan plants. They have a similar look and corkscrew flight pattern to the gorse pod moth (*Cydia succedana*). Look, also, for fruits infested with the larvae. Please let us know if you find any, as establishment is not yet confirmed.
- It will be too soon to consider harvesting and redistribution if you do find the moths.

Woolly nightshade lace bug (*Gargaphia decoris*)

- Check release sites by examining the undersides of leaves for the adults and nymphs, especially leaves showing signs of bleaching or black spotting around the margins.
- It is probably best to leave any harvesting until spring.

National Assessment Protocol

For those taking part in the National Assessment Protocol, autumn is the appropriate time to check for establishment and/or assess population damage levels for the species listed in the table below. You can find out more information about the protocol and instructions for each agent at: www.landcareresearch.co.nz/publications/books/biocontrol-of-weeds-book

CONTACT
Angela Bownes – bownesa@landcareresearch.co.nz

Target	When	Agents
Broom	Dec–April	Broom gall mite (*Aceria genistae*)
Lantana	March–May	Leaf rust (*Prospodium tuberculatum*) Blister rust (*Puccinia lantanae*)
Privet	Feb–April	Lace bug (*Leptoypha hospita*)
Tradescantia	Nov–April	Leaf beetle (*Neolema ogloblini*) Stem beetle (*Lema basicostata*) Tip beetle (*Neolema abbreviata*)
	Anytime	Yellow leaf spot fungus (*Kordyana brasiliensis*)
Woolly nightshade	Feb–April	Lace bug (*Gargaphia decoris*)