Weed Biocontrol

WHAT'S NEW?

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Manaaki Whenua
Landcare Research

Contents

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Our New Look and Purpose

Landcare Research recently celebrated its 25th birthday, and in keeping with such a key milestone our organisation has thought deeply about our future purpose and vision for New Zealand. As a result we will now more fully embrace our Māori name, Manaaki Whenua. These two words hold deep meaning for us as an organisation, describing the role and responsibility we have been given by New Zealanders to care for Aotearoa. Manaaki means to cherish, conserve and sustain. Whenua encompasses the soil, rocks, plants and animals, and the tangata whenua (the people of the land). This name also challenges us to weave a Māori world view into our science and research in order to develop deeper insights and realise solutions for all New Zealanders. Manaaki Whenua is also part of our heritage, being the name we were founded under in 1992.

Our Purpose

Science for our land and our future
Ko te pūtaiao mō tō tātou whenua, mō āpōpō

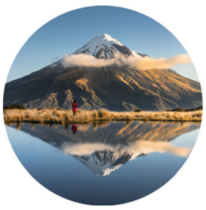
Our Vision

Kia matomato te tupu a Tāne, a Rongo, a Haumia-Tiketike
Let it be that the land and all its fruits may flourish

Our Values

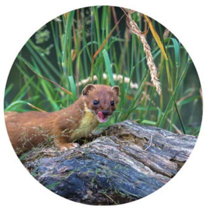
Manaaki tangata • Science that delivers

Our Ambitions



OUR ENVIRONMENT
We are an environmentally informed nation, taking action together.

OUR BIODIVERSITY
We know, value and actively preserve our unique biota and ecosystems.



OUR BIOSECURITY
Our land is protected from invasive biological threats.

OUR LAND
We use our land, soil and water resources wisely.

You will also notice that our organisation has a new look, which is reflected in this issue of this newsletter (which has been produced under various guises throughout the 25 years of the existence of Manaaki Whenua – Landcare Research!). Our new logo is an evolution of the previous one. The two koru, representing strength and growth, curve together to form two halves of a kinetic circle – a form that expresses the constant balance and interconnectivity of people, place and environment. The simplicity of the infinite circle has long been associated with cycles of life, learning and nature. For us, as New Zealanders, it expresses the intergenerational science that will ensure we will live in harmony with our land, now and in the future.

Manaaki Whenua
Landcare Research

What Does Evolution Mean for Biocontrol?

We are often asked about the implications of evolution for weed biocontrol: can biocontrol agents mutate or adapt over time to thrive better under New Zealand conditions, or perhaps to attack new hosts, and can weeds develop resistance to them? In this story we examine the evidence and consider what evolution might mean for weed biocontrol.

First of all, could successful biocontrol break down over time because the host develops resistance? Resistance to herbicides and pesticides by plants and insects is commonly reported, but resistance to biocontrol agents appears to be rare. Releases of biocontrol agents have been made for over 100 years around the world, but there are few examples of resistance developing. One example, which is close to home, relates to insect biocontrol. There has been some concern recently that Argentine stem weevils (*Listronotus bonariensis*) in New Zealand pasture are becoming resistant to a parasitic wasp (*Microctonus hyperodae*) that was introduced as a biocontrol agent in 1990. The parasitic wasp is parthenogenetic, which means it reproduces asexually, producing offspring that are all females. This reproductive strategy has the advantage of not needing to find a mate to breed, but it has the disadvantage of not having the opportunity provided by sexual reproduction to recombine genes and thus provide opportunities for adaptation to changing conditions.

Parthenogenetic agents are not often used for weed biocontrol in New Zealand. Current examples include the hieracium gall wasp (*Aulacidea subterminalis*) and the soon-to-be-released giant reed gall wasp (*Tetramesa romana*). However, old man's beard sawfly (*Monophadnus spinolae*) females can produce offspring parthenogenetically if mates are in short supply. Ironically, while clonal biocontrol agents might not be ideal, biocontrol of weeds appears more likely to succeed against clonal plants than sexually reproducing weeds. "We hypothesise that there is an 'evolutionary arms race' going on and plants that reproduce asexually (e.g. producing clonal offspring) have less opportunity to evolve resistance to agents," said Simon Fowler. It might be significant that our two fully parthenogenetic agents attack hieracium (*Pilosella* spp.), which is an apomict (produces seed asexually), and giant reed (*Arundo donax*), which does not produce viable seed and reproduces clonally. Perhaps these insects and their hosts are clonal because they don't have to keep up with an evolutionary arms race?

There is some evidence that an evolutionary arms race can at different times favour a biocontrol agent or its host plant. We are studying this relationship in Scotch broom (*Cytisus scoparius*). Studies have shown that broom seeds in Zealand, while highly variable in size, are still on average around 40% bigger than their European counterparts, which helps explain why broom is so invasive here. In its home range broom relies on disturbance to regenerate or it disappears. Not so in New Zealand, where seedlings happily grow up below existing stands, ensuring populations are perpetuated. There is evidence to suggest that big broom seeds are more successful at producing seedlings that can survive and grow in the shade of existing stands.

"We hypothesise that broom seeds have gradually become bigger in the exotic range because of an absence of broom seed beetles (*Bruchidius villosus*)," explained Quentin Paynter. Seed size has implications for the seed beetles: the larger the seed, the larger the beetle that emerges, and big beetles are more successful at surviving winter and producing offspring. Now that broom seed beetles are abundant here they may over time create a selection pressure that favours small seeds, as these will reproduce more successfully than the big-seeded plants favoured by the beetles. "This could result in less competitive broom like that seen in the native range," suggested Quent. However, the broom seed beetle would not do as well under that scenario, so biocontrol could break down, potentially allowing broom to bounce back.

If this were to happen, another seed-feeder that does not appear to rely on large seeds is available, which could be introduced to New Zealand. Larvae of the broom seed weevil (*Exapion fuscirostre*) feed externally on multiple seeds and are therefore not affected by seed size. Also, with the way the broom gall mite (*Aceria genistae*) is performing, many broom plants may in future not survive to produce much if any seed! We are monitoring broom seed size here every 5–10 years to see if changes are occurring, so we will know if any other actions will be needed to stay on track with our goal to successfully biologically control broom.

Another evolutionary consideration is whether agents can rapidly evolve to adapt to new environments, given that evolution is often a slow process. This is the primary focus of Professor Peter McEvoy from Oregon State University, in the USA, who visited New Zealand recently. "I like to test some

Broom seed beetle


Cinnabar moth

of the assumptions of ecological theories associated with biological invasions," said Peter. "It is important to understand the evolution of plant strategies such as dispersal, or their ability to defend themselves against pathogens or predators in relation to biocontrol programmes," Peter said, adding that it is also important to understand how evolution itself actually works.

Evolution in the form of natural selection occurs only when there is underlying variation in the relevant ecological traits. The variation must also be heritable – passed on genetically from parents to offspring – for persistent change to occur. Also, the change must not compromise any other important traits. For example, if faster development led to smaller body sizes, that could have negative consequences for survival and reproduction. Finally, there must be strong and consistent selection pressure so that individuals with a particular set of traits do consistently better. "These can be measured by comparing fitness over time, which increases the ability to contribute to future population growth," explained Peter.

To test some of the assumptions regarding rapid evolution, Peter and his team have been studying the response of the cinnabar moth (*Tyria jacobaeae*) to variable season length. The cinnabar moth was introduced to the USA as a biocontrol agent for ragwort (*Jacobaea vulgaris*) in 1960, readily establishing in the Willamette Valley (87 m a.s.l), Oregon. Not only did the moth expand its geographical range to occupy the Cascade Mountains (up to 1,572 m a.s.l), but it also then encountered and attacked two native plants, which like ragwort are also in the Asteraceae family. This attack was predictable in advance and not a host shift, outlining the importance of considering the potential geographical range an agent can occupy when deciding if it is safe to release. Peter argues that there is a strong case for evaluating the evolutionary potential of candidate agents to adapt to new climates prior to their release.

Peter and his colleagues used altitude as an environmental gradient, comparing the development times of juvenile cinnabar moths from the valley floor with those in the mountains. "In the mountains, the season length is short and the number of days with sufficient temperatures for the moth to develop is reduced," explained Peter. Essentially, the question they were asking was: can evolution rescue a faltering population at the margin of its range by speeding up development? "We found that as you moved up the gradient of increasing elevation, there was evidence that the moths had evolved a shorter development time to adapt to the shorter growing season," said Peter. The study concluded that natural selection was a reliable explanation for the observed differences in phenology (timing of lifecycle activities).

"The question of rapid adaptive evolution has been examined closely in the heather (*Calluna vulgaris*) biocontrol programme here in New Zealand," said Simon Fowler. For various reasons the population of heather beetles (*Lochmaea suturalis*) established in New Zealand was extremely small and lacked genetic diversity, creating a genetic 'bottle-neck'. This limited the ability of the heather beetles to survive in their new, and relatively harsh, environment at Tongariro National Park. "The beetles' body mass was too small and they had insufficient fatty reserves to survive the conditions they faced over the winter," said Simon. Since then, larger heather beetles have been brought over from the UK to improve the genetic diversity. Nevertheless, in the interim the original population has expanded hugely, causing significant damage to heather, so it is possible that they may have already evolved to cope better with the conditions without intervention.

Adaptive evolution could also explain some of the lag phases that we see when agents are released. "Often agents are released and don't seem to cause much damage to their host plant for quite a few years, and then all of a sudden become abundant and start doing their job," said Simon. An agent released against the Californian thistle (*Cirsium arvense*) is a good example. The Californian thistle leaf beetle (*Lema cyanella*) was released widely, and in large numbers, in the 1990s, but only survived and clung on in low numbers at one site in Auckland. Then, around 15 years after first being released at the site, the beetle became common, causing considerable damage to the thistles. It is plausible that the leaf beetle has evolved in some way to perform better, like the cinnabar moth has at higher altitudes in Oregon.

Research into rapid adaptive evolution of biocontrol agents also has important implications for predicting responses to climate change. Predicting the potential for biocontrol agents to adapt and keep pace with climate change will become increasingly relevant. Previously we have studied whether the currently successful biocontrol for ragwort is likely to break down under climate change scenarios. "But there did not appear to be undue cause for alarm," said Simon Fowler. Generally it seems that if weeds change their distributions, their biocontrol agents will simply follow, as the changes will not be outside the acceptable range for them. Plus warmer temperatures and fewer frosts may even suit some biocontrol agents better.

While adaptive evolution to better exploit local climatic conditions would appear to be a good thing for biocontrol, the ability to evolve to attack other hosts may not be desirable. There is no evidence worldwide to suggest this has occurred for any weed biocontrol agents. Follow-up studies of attack on other hosts invariably finds that the agent was always able to attack it, but that testing had been insufficient to show this beforehand, rather than an evolutionary expansion of host range occurring. The potential to evolve and attack new hosts remains possible, but fortunately it appears that the conditions for this to happen are very rarely met. First, a random mutation needs to occur that is overwhelmingly beneficial. Then conditions need to favour the mutation becoming more common when, as a rule, a rare mutation will struggle to persist in a population because it is rapidly 'swamped' by more common genotypes. It has been calculated that the risk of an agent evolving to change host is between 1 in 10 million and 1 in 100 million. The risk of a native species unexpectedly becoming a problem is the same.

One safeguard to prevent biocontrol agents from over time attacking non-host plants is limiting the types of organisms used for biocontrol to invertebrates and fungi. Simpler organism like viruses and bacteria are less stable and more easily able to mutate and change, or even to share genetic information with similar species, so we have steered clear of them.

However, while the risk of host expansion beyond the fundamental host range (plants that an agent is physiologically able to complete its life cycle on, but may not currently attack in the field) is low, theoretically host expansion within the fundamental host range is more likely. Should we therefore routinely host-range test the offspring of individuals that survived on non-target hosts to determine the potential for the evolution of improved performance on non-target hosts so that they become realised hosts in the field?


Californian thistle leaf beetle

Simon and Quentin agree that more can, and should, be done here, particularly when using oligophagous insects, which can attack several closely related plant species. "We need a framework for assessing whether a fundamental host is ever likely to become a signifcant realised host," agreed Simon. Ideally these tests would be completed in the native range of the agent, but this is not always possible for logistical reasons so we need to be able to predict the risk of attack using more conservative laboratory tests. We might, on the basis of a relative risk score, decide that a plant is unlikely to be a field host. However, if there is adequate selection pressure, an agent might evolve to perform better on that fundamental host and include it in its realised host range. This risk can be tested by rearing an agent for multiple generations on a potential non-target plant to see if there is selection for improved performance. "For example, when we reared the privet lace bug (*Leptoypha hospita*) for more than one generation on the non-target host lilac (*Syringa* spp.), the culture died out, indicating that the risk was low," commented Quentin.

But there are occasionally situations where evolutionary host range expansion might not necessarily be a bad thing. In one example from Australia, eight strains of the blackberry rust fungus (*Phragmidium violaceum*) were released to try to improve biocontrol of blackberry (*Rubus fruticosus* agg.). The common name 'blackberry' refers to multiple morphologically distinct but closely related species, known as microspecies. These range from highly resistant to susceptible to the strain of blackberry rust illegally released in Australia in 1984, which also quickly self-introduced to New Zealand. The plan behind releasing multiple strains of the rust was that they would interbreed and hopefully develop forms that could attack blackberry, yet remain constrained within the *Rubus fruticosus* aggregate and not attack indigenous *Rubus* species. This example highlights the requirement for further testing to understand the implications of evolution for weed biocontrol, and for adequate risk assessment prior to agent release.

Work to better understand the implications of evolution for weed biocontrol in New Zealand is funded by the Ministry for Business, Innovation and Employment as part of Manaaki Whenua – Landcare Research's Beating Weeds programme. *Peter McEvoy is keen to find out whether the cinnabar moth has also expanded its range here. He would greatly appreciate any information from New Zealand about where people have observed cinnabar moths in recent years, or where they are seen this coming summer. Please email Peter at mcevoyp@science.oregonstate.edu*

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Could Dwarf Mistletoe Help Solve the Giant Wilding Conifer Problem?

Waves of wilding conifers are currently moving across the New Zealand landscape and there seem to be few long-term options available to control them, or even limit their spread. Almost all regions have got problems with self-sown wilding conifers originally introduced for silvicultural purposes. Not only do they invade productive agricultural land: they also change iconic grassland habitats, and are even invading beech forest, where they alter forest composition as well as ecological processes.

One of the main culprits is lodgepole, or contorta pine (*Pinus contorta*), which was planted extensively for shelterbelts and forestry in the past. Although plantations are now rare, they were major sources for the current wilding contorta problem. The previous government recently awarded the NZ Wilding Conifer Management Group $16 million over 4 years to try to tackle the problem in some of the worst areas, which include the Mackenzie Basin, Molesworth Station, Central Otago, Mid Dome in Southland, and areas of the Central Plateau, North Island. However, management tools for this invasion are poorly developed and long-term solutions are required.

In its native range of North America, *Pinus contorta* falls into four sub-species: shore pine (*Pinus contorta* subsp. *contorta*); lodgepole pine (*Pinus contorta* subsp. *latifolia*); tamarack pine (*Pinus contorta* subsp. *murrayana*) and Bolander's beach pine (*Pinus contorta* subsp. *bolanderi*). All have been introduced into New Zealand, with the most invasive probably being shore pine, which is native to coastal California, Washington and Oregon.

In 2001 *Pinus contorta* was declared an unwanted organism under the Biosecurity Act 1993 and currently has no economic value. "This opens the door for biocontrol to be considered as an option," said Simon Fowler. In the past the possibility of cone or seed-feeding insects has been suggested. However, this has met with scepticism from the forest industry, which is concerned about non-target effects and transmission of diseases such as pitch canker to the more valuable conifer species like radiata pine (*Pinus radiata*). Simon Fowler believes there are three potential options (not necessarily mutually exclusive) for progressing biocontrol of *P. contorta*, which has no commercial value in New Zealand:

1. conduct further research to quantify the risk that insect agents might exacerbate disease transmission
2. switch attention to other seed-feeders that are less likely to create entry points for, and/or vector, pine pitch canker
3. investigate the potential for agents that attack other parts of the plant.

With these options in mind Simon has suggested that dwarf mistletoes (*Arceuthobium* spp.) could hold the answer. "The idea is novel but has merit for several reasons," said Simon. "Dwarf mistletoes are serious parasites of coniferous forest trees in western North America. These widespread parasites retard growth of infected trees and cause extensive timber losses through direct and indirect mortality. In addition, the dwarf mistletoes reduce seed production and wood quality of the host plants. Plus the host-specificity of *Arceuthobium* spp. is well documented, and some species are known to be highly specific," Simon explained.

One potential advantage of using mistletoes is that even if there is potential for spill-over non-target attack on rare hosts, mistletoes are unlikely to become a problem in commercial plantations. They disperse too slowly and would be destroyed in a typical 25- to 30-year *P. radiata* forestry cycle in New Zealand. Furthermore, *A. americanum,* a species affecting *P. contorta,* is dioecious (with separate male and female plants required for establishment), and generation times are typically slow, limiting spread in their native range to 30–60 cm per year.

Simon has established links with researchers at the University of Oregon, where groups work on dwarf mistletoes and weed biocontrol, and is planning a fact-finding visit soon. "We want to establish the genetic provenance of the invasive contorta pine in New Zealand, and analyse the existing literature and expert opinion from the USA/Canada as to what the best dwarf mistletoe species would be, or the best combination," he said. The host range of the contorta pine dwarf mistletoes, as well as their potential impacts given different projected dispersal rates, will need to be thoroughly evaluated. Also, since the pine dwarf mistletoes are currently classified as unwanted organisms in New Zealand, we would need to apply to have that changed before we could import and study them." Simon concluded by saying, "We will keep the forest industry well informed of our plans."

This project is funded by the Ministry for Business, Innovation and Employment as part of the Winning the War on Wildings programme.

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A dwarf mistletoe *Arceuthobium* sp. on *Pinus* in USA.

How Good Are Beetles at Finding St John's Wort?

Biocontrol of St John's wort (*Hypericum perforatum*) is undoubtedly a success story. Where there were once vast areas of the weed infesting agricultural land, the plant is much less common thanks to two small beetles, *Chrysolina hyperici* and *Chrysolina quadrigemina*, which were introduced into New Zealand in the 1940s and 1960s, respectively.

Over the past year intern student Anna Pittam from the University of Birmingham has been looking at how good the beetles are at locating the now much rarer St John's wort plants in the landscape, and the implications for biocontrol and for growing the plant for its medicinal properties. "I was interested to find out how good the St John's wort beetles are at detecting small, isolated patches of their host plant, and how this relates to keeping the weed under control."

The ability of the beetles to detect relatively isolated plants is dependent on how far they have to travel and factors such as weather patterns, terrain and geographical isolation. "In the same way we think of offshore islands, patches of St John's wort occur now as 'islands' in the rural landscape," said Ronny Groenteman, who has been guiding Anna. "We were interested in seeing whether there was a relationship between the size of St John's wort infestations and the presence of the beetles," Ronny explained. A positive relationship would support the well-known island biogeography theory (suggested by MacArthur and Wilson in 1967), which suggests that there is a link between the size of islands and the likelihood of fauna finding them.

Anna surveyed some councils and Department of Conservation offices to try to get a handle on beetle densities and whether there was subsequently less reliance on manual or chemical control of the plant, repeating a similar survey conducted in 1987. "Five out of six of the councils reported the presence of the beetles and indicated that they had observed a decline in St John's wort as an agricultural weed, but that it still occurred in isolated patches along the roadside," said Anna. There was an expansion in the geographical area where the beetles were found compared with the 1987 survey, with higher beetle densities in the lower-rainfall eastern side of the South Island. "The beetles don't like the wet weather on the West Coast," said Ronny, but St John's wort is not common in these parts of the country either – the plant and its natural enemies fortunately favouring similar conditions in this instance."

In 1987 there were 10 control programmes being undertaken, mainly in the eastern parts of New Zealand, whereas in 2016 there were none, and some council staff weren't even familiar with the weed! "Overall, St John's wort beetles appear to be continuing to control the plant well, keeping it much less prevalent than before," said Anna. Although the beetles appear to be effective at finding and controlling small, isolated patches of the weed, their migration between patches can be slow.

Anna's work also included a survey of herb growers cultivating St John's wort to ask whether they had noticed any damage to the foliage. Although there wasn't a strong response rate, the indication was that crops on the eastern side of New Zealand were more commonly defoliated, as were crops that have been grown continuously for longer periods of time. "Unfortunately, most of the growers were not able to comment on the proximity of nearby St John's wort infestations and whether they may be acting as reservoirs for the beetles. But as the weed declines in the landscape, there will be fewer beetles around and less impact on plants being grown as a herbal remedy," concluded Anna. As an example, one of the respondents to the survey had been growing St John's wort for 27 years, but the small number of plants (only 1 m^2) had not suffered any significant defoliation.

Anna has returned to the UK now, where she is continuing her studies towards her environmental science degree. This includes a dissertation on horehound (*Marrubium vulgare*), which she also studied during her internship here.

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

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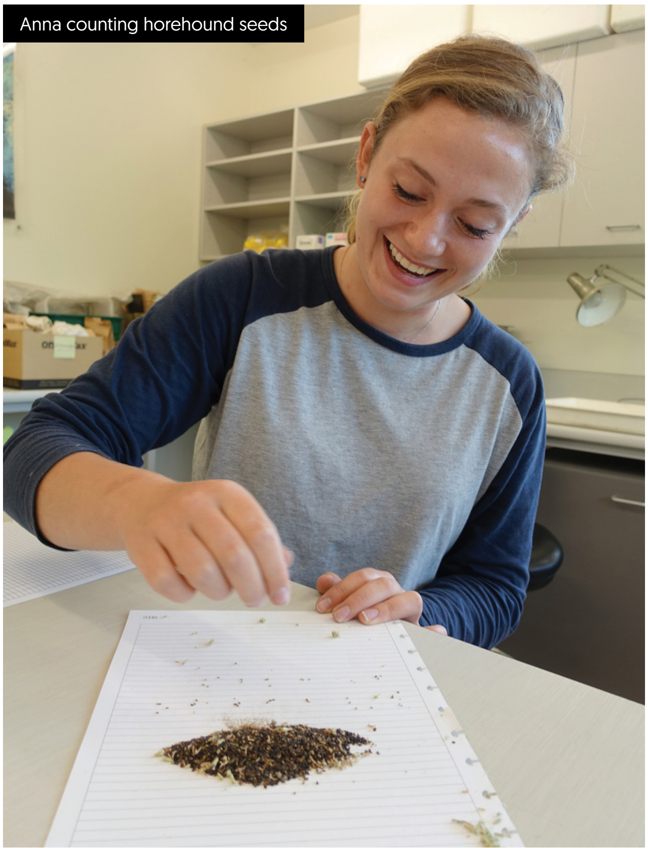
Anna counting horehound seeds



Summer Activities


Tutsan moth larva inside fruit

Summer is a busy time for many biocontrol agents so you might need to schedule the following activities.

Broom gall mites (*Aceria genistae*)

- Check for galls, which look like deformed lumps and range in size from 5 to 30 mm across. Very heavy galling, leading to the death of bushes, has already been observed at some sites.
- Harvesting of galls is best undertaken from late spring to early summer, when predatory mites are less abundant. Aim to shift at least 50 galls to each site and tie them on to plants so the tiny mites can shift across.

Broom leaf beetles (*Gonioctena olivacea*)

- Look for beetles by beating plants over a tray. The adults are 2–5 mm long and goldish-brown (females) through to orangey-red (males), with stripes on their backs. Look also for greyish-brown larvae, which may also be seen feeding on leaves and shoot tips.
- If you find beetles in good numbers, aim to shift at least 300 to sites that are not yet infested with gall mites.

Darwin's barberry weevil (*Berberidicola exaratus*)

- Although it is early days for checking release sites, you could beat plants in late summer to look for new adults. They are blackish-brown and 3–4 mm long.
- It's too soon to consider harvesting and redistribution.

Green thistle beetles (*Cassida rubiginosa*)

- Look for adult beetles, which are 6–7.5 mm long and green, so they camouflage quite well. Both the adults and the larvae make windows in the leaves. Larvae have a protective covering of old moulted skins and excrement. You may also see brownish clusters of eggs on the undersides of leaves.
- If you find good numbers, use a garden leaf vacuum machine to shift at least 100 adults to new sites. Be careful to separate the beetles from other material collected, which may include pasture pests.

Privet lace bug (*Leptoypha hospita*)

- Check for establishment by examining 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 beetle (*Neolema ogloblini*)

- Look for the shiny metallic bronze adults or the larvae, which have a distinctive protective covering over their backs. Also look for notches in the edges of leaves caused by adult feeding, or leaves that have been skeletonised by larvae grazing off the green tissue.
- If you find them in good numbers, aim to collect and shift 50–100 beetles using a suction device or a small net.

Tradescantia stem beetle (*Lema basicostata*)

- The black knobbly adults can be difficult to see, so look for their feeding damage, which consists of elongated windows in the upper surfaces of leaves, or sometimes whole leaves consumed. Also look for stems showing signs of larval attack: brown, shrivelled or dead-looking.
- If you can find widespread damage you can begin harvesting. If it proves too difficult to collect 50–100 adults with a suction device, remove a quantity of the damaged material and put it in a wool pack or on a tarpaulin and wedge this into tradescantia at new sites (but make sure you have an exemption from MPI that allows you to do this).

Tradescantia tip beetle (*Neolema abbreviata*)

- Look for the adults, which are mostly black with yellow wing cases, and their feeding damage, which, like stem beetle damage, consists of elongated windows in the leaves. Larvae will be difficult to see inside the tips, but brown frass may be visible. When tips are in short supply, the slug-like larvae feed externally on the leaves.
- If you find them in good numbers aim to collect and shift 50–100 beetles using a suction device or a small net.

Tutsan moth (*Lathronympha strigana*)

- Although the moths were only released last autumn, if you can't wait, 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.
- It is too soon to consider harvesting and redistribution

National Assessment Protocol

For those taking part in the National Assessment Protocol, summer 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

Target	When	Agents
Broom	Dec–April	Gall mite (*Aceria genistae*)
Privet	Feb–April	Lace bug (*Leptoypha hospita*)
Tradescantia	Nov–April	Leaf beetle (*Neolema ogloblini*) Stem beetle (*Lema basicostata*) Tip beetle (*Neolema abbreviata*)
Woolly nightshade	Feb–April	Lace bug (*Gargaphia decoris*)

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