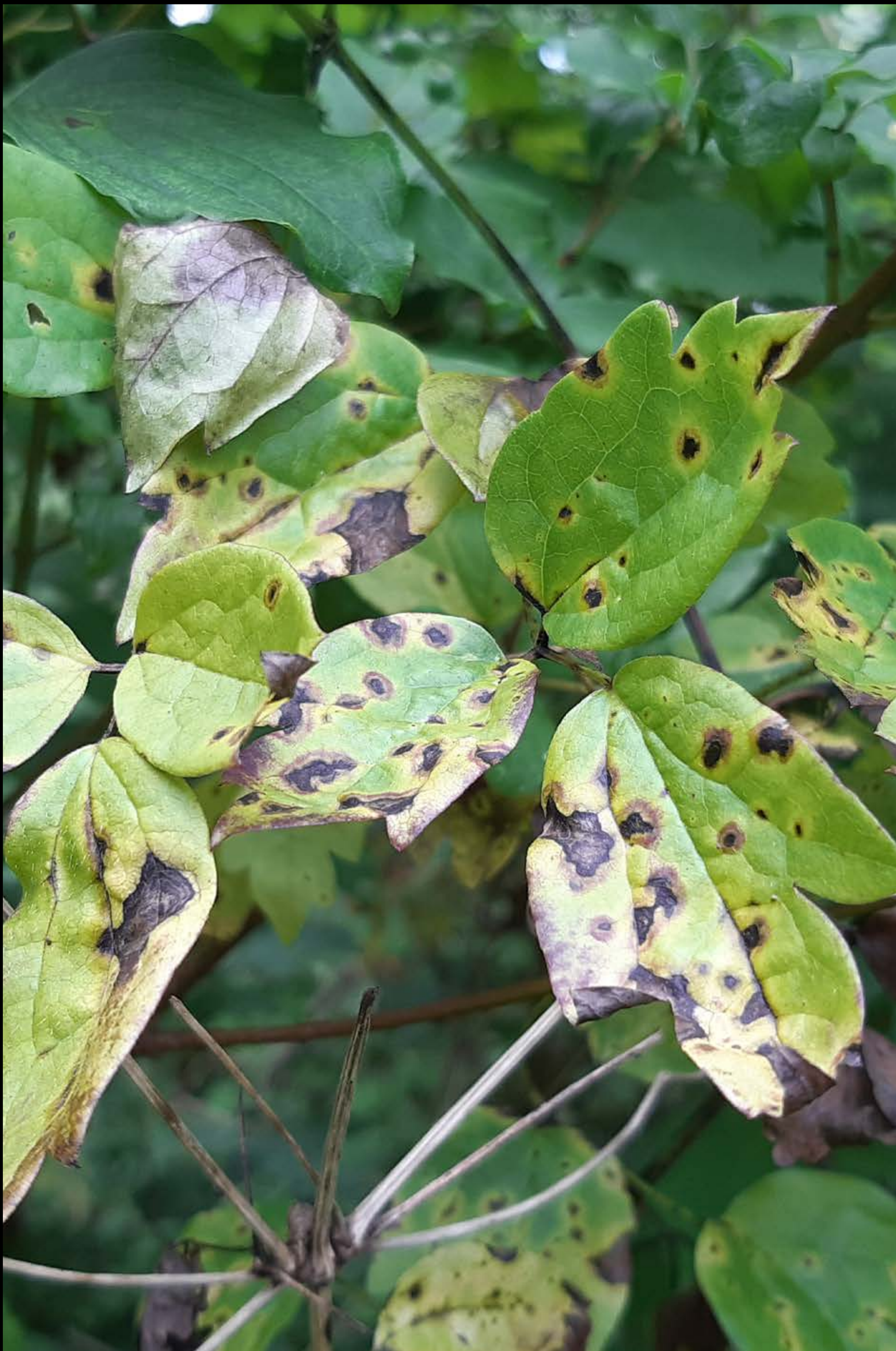
#108

MAY 2024

Manaaki Whenua
Landcare Research

Weed Biocontrol

WHAT'S NEW?



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COVER IMAGE:
Longididymella vitalbae damage to old man's beard leaves (Sarah Thomas)

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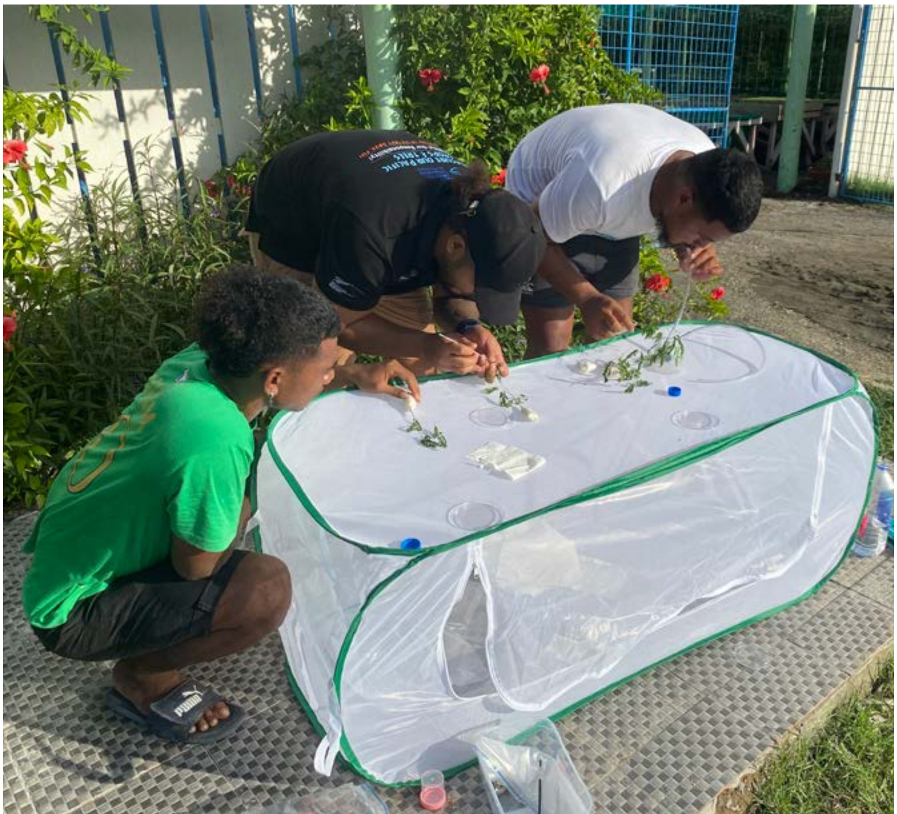
A First for Tuvalu

With assistance from MWLR's Natural Enemies - Natural Solutions (NENS) programme, Tuvalu welcomed its first-ever natural enemy to control an invasive weed in April. Although one of the tiniest nations in the Pacific, Tuvalu still has its fair share of weed problems. Addressing invasive species issues has been acknowledged as a key step towards strengthening the resilience of Pacific communities that are already beginning to experience the impacts of climate change.

In March 2022 a stakeholder workshop to determine priorities was held in Funafuti, the capital of Tuvalu. It was agreed that leucaena (*Leucaena leucocephela*), or tamalini as it is called there, should be a top priority to target with natural enemies. In Tuvalu, leucaena was deliberately introduced to Vaitupu atoll for soil improvement and accidentally to Funafuti atoll in soil contaminated with the seeds. It has subsequently become very weedy on both islands.

Leucaena is native to Central America and has been widely introduced across the Pacific as an agroforestry crop. However, it has quickly become an aggressive invader in many tropical and sub-tropical regions and is listed in the top 100 of the world's worst invasive species. In New Zealand leucaena is currently only recorded at a small number of sites in the Auckland region but may become more problematic in the future.

Leucaena can quickly outcompete and replace other vegetation, forming dense, impenetrable thickets that disrupt natural successional processes. Coastal areas, semi-natural areas, roadsides, waste ground, plantations, hedgerows, recreational areas, and agricultural land are all at risk. Biodiversity is reduced, and ecological processes such as nutrient cycling and soil chemistry are affected. Leucaena can also be toxic to animals and reduce growth in pigs. Its ability to rapidly colonise newly disturbed areas makes it particularly well suited to take advantage of changing environmental conditions, including those caused by climate change, so its harmful impacts are expected to increase in the future.



Collecting psyllid nymphs to release

Leucaena is difficult and expensive to control with conventional methods. It has a large root mass that can resprout vigorously if the plant is cut off at ground level, so additional treatments such as herbicide or a cutter bar operating below ground level are required to ensure plant death.

"Fortunately, there is an easier solution in the shape of a tiny, sap-sucking psyllid (*Heteropsylla cubana*)", said Lynley Hayes, leader of the Pacific NENS programme. This leaf-feeding psyllid is native to tropical America but has self-established throughout much of the Pacific following the spread of its host plant, leucaena. However, it has not yet found its way to some of the more remote islands. The psyllid only attacks plants in the *Leucaena* genus. Both nymphs and adults feed on, and damage, the soft new growing tips of leucaena, which can cause severe tree stunting and the death of seedlings. They insert their needle-like mouthparts into the leaf tissue and suck out the fluids, which causes leaf shrivelling and defoliation. Plants infested with psyllids look as if breadcrumbs have been sprinkled on their leaves. This is due to a mixture of the life stages: white skins shed during moulting, and honeydew droplets produced by the psyllids during feeding.

Because the psyllid can be so damaging, hybrid forms of leucaena have been developed that are resistant to the psyllid. This meant the first thing to check was whether leucaena in Tuvalu is susceptible. Leucaena seeds were sent from Tuvalu and grown in our Auckland containment facility. "We collected some psyllids from Rarotonga in the Cook Islands in 2023 and it was quickly obvious that the psyllids could attack the material from Tuvalu. We were able to establish a colony on these plants and within a few weeks their damage potential was noticeable," said research technician Stephanie Morton. No additional host testing was needed for Tuvalu, so the remaining step was to get clearance that the psyllids had a clean bill of health, and to apply for permission to introduce them.

With all steps completed early in 2024, the psyllids were released on Funafuti in April with the assistance of Tuvalu's National Invasive Species Co-ordinator, Sam Panapa. "We are happy to be able to benefit from this natural enemy and to manage more weeds through this technique in the future," said Sam. "This method is safer than using chemicals and more cost effective." The psyllid's establishment success and post-release impact in Tuvalu will be closely monitored.

This project is funded by New Zealand's Ministry of Foreign Affairs and Trade as part of the Managing Invasive Species for Climate Change Adaptation in the Pacific (MISCCAP) programme, and by the GEF-6 Regional Invasives Project. The NENS programme is supported by the Pacific Regional Invasive Species Management Support Service.

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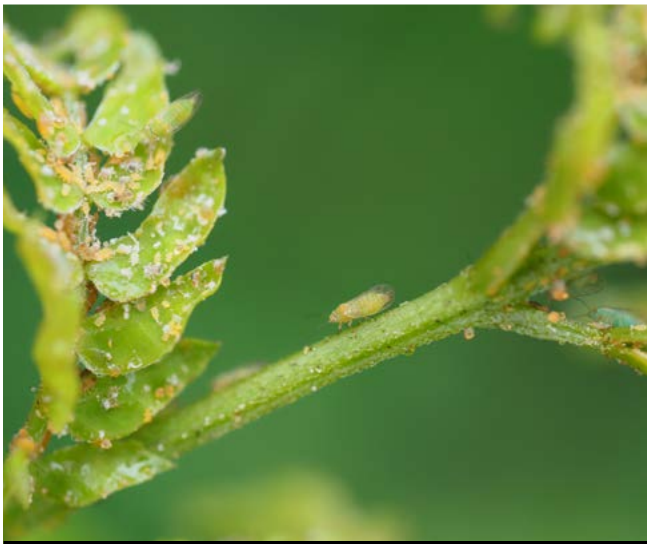
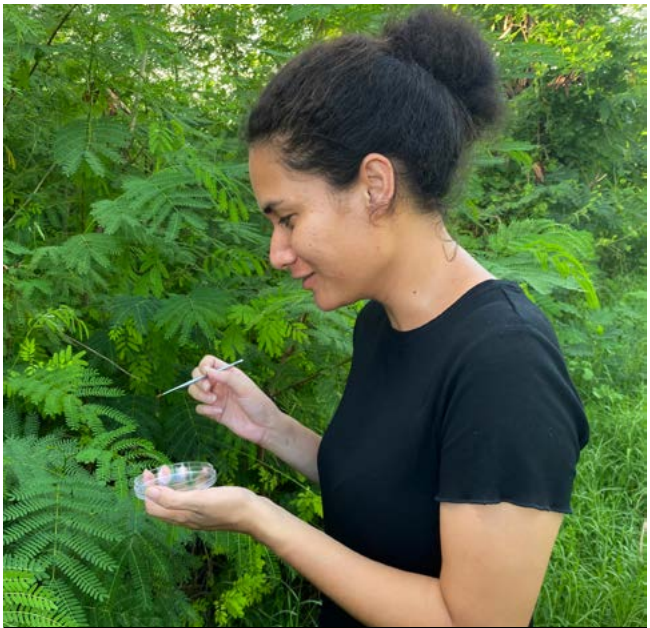
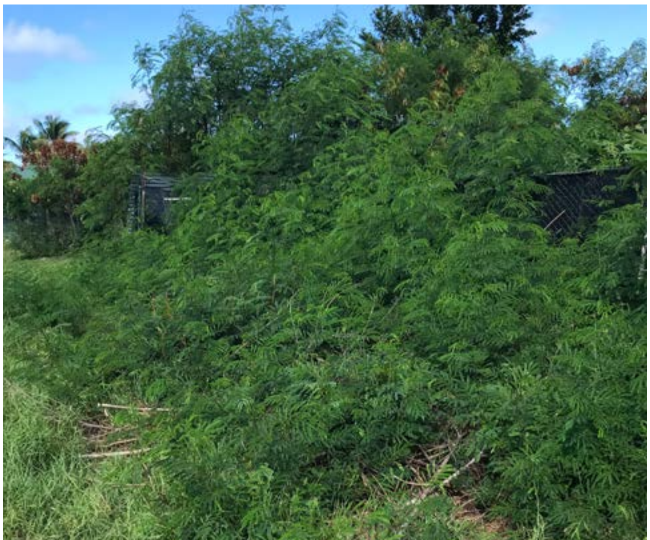

Adult psyllid


Transferring nymphs onto plants


Leucaena in Tuvalu

Revisiting Broom Gall Mite Release Sites

Monitoring the effectiveness of weed biocontrol agents is essential, but it can be neglected. Understandably, stakeholders tend to prefer to invest in new projects rather than make room in tight budgets for expensive, high-quality evaluation studies. To help solve this investment conundrum, here in New Zealand we have been developing cost-efficient methods that can yield adequate (rather than 'Rolls Royce') data on the impact of biocontrol agents on their target weeds. We have achieved this by collaborating with the National Biocontrol Collective (represented by 16 regional councils, unitary authorities, and the Department of Conservation) to revisit large numbers of the sites where an agent was released.

Since the 1980s Manaaki Whenua – Landcare Research (MWLR), together with its stakeholders, has maintained a comprehensive database of release sites for weed biocontrol agents, particularly in the decade or so after their first release. The information stored in this database is not as high quality as we would gather for a flagship monitoring programme, but the size and geographical spread of the available data sets lend considerable statistical and interpretative power. We developed and refined this 'release site reassessment' method with the ragwort (*Jacobaea vulgaris*) and nodding thistle (*Carduus nutans*) biocontrol programmes, and recently applied it to the broom gall mite (*Aceria genistae*), the latest and probably most effective agent against Scotch broom (*Cytisus scoparius*).

A suite of biocontrol agents has been released against Scotch broom in New Zealand, of which the most widespread and common species - both introduced in the 1990s - are the broom psyllid (*Arytainilla spartiophila*) and the broom seed beetle (*Bruchidius villosus*). In addition, the broom twig miner (*Leucoptera spartifoliella*) was a self-introduced agent, first detected in 1950, which causes considerable damage in some areas by attacking the stems.

The seed beetle is now destroying much of the seed produced annually. The psyllid damages new growth in spring and is becoming common, but very damaging outbreaks occur infrequently. The gall mite, released in 2008, has established widely in New Zealand and, particularly in the southern half of the South Island, has been observed causing high levels of damage and mortality in large stands of Scotch broom.

Gall mite release sites for reassessment in 2021/22 were identified from the MWLR biocontrol database and using local stakeholder knowledge. On each revisit a visual, but quantitative, assessment was made of the release site and immediate surroundings using a questionnaire form developed and improved with the ragwort and nodding thistle site reassessment projects. As with these studies, where possible a questionnaire interview was also carried out with the landowner or site manager. Although the survey focused on the gall mite, we scored both galls and the three widespread other broom agents.

Agent occurrence in the site reassessments

The data showed that most of the four broom agents are widespread across New Zealand wherever Scotch broom is prevalent. The broom gall mite was present at 74 of 130 sites (57%) revisited in the 2021/22 study. Assuming these mites all originated from the deliberate releases at the sites from 2009 to 2015, 57% could be considered a reasonable estimate of the establishment rate for broom gall mite releases. However, this figure is prey to a range of uncertainties, such as immigration of mites from other sites and the potential loss of established mite populations at some sites (e.g. if broom declined markedly).

Evidence for the impact of broom gall mite on broom

Encouragingly, there was a significant decline in the percentage cover of Scotch broom at broom gall mite release sites in this study. At or around the time of release the percentage cover of broom at the sites was 66.5%, and by 2021/22 it had declined to 44.4%. This decline in broom cover at agent release sites appears to be a promising sign of successful biocontrol, but the data are merely correlative: this is not an experimental study comparing release sites with appropriate non-release sites as controls.

However, we can look at the variation in abundance of the broom gall mite between sites to explore this pattern of reduced broom cover more closely. We might expect, for example, that broom cover would have declined more at sites where the broom gall mite was abundant (if abundance of the agent was causing the decline in cover of the weed), but it turns out this is not the case. An exploratory look at the data showed that the greatest reduction in broom density (from the time of release to the reassessment in 2021/22) occurred where broom gall mites were absent or rare. What might be going on to create this unexpected correlation?

Firstly, it seems highly unlikely from other observations of gall mites damaging Scotch broom that the agent is directly causing an increase in broom density at sites where the agent is common. We investigated whether there were other control methods being applied at the sites, in particular herbicide applications. Fortunately, there were data from 35 sites on both the change in broom cover *and* on whether the site had recently been sprayed with herbicide. We found there was a significantly greater reduction in broom density at the 12 sites where herbicide was recorded as having been applied (41% reduction in broom cover) compared to the 23 unsprayed sites (7.9% reduction in broom cover). However, there remained the unexpected effect that there were greater declines in broom at sites where broom gall mites were less prevalent.

It is likely that recent spraying would cause a major decline in percentage cover of Scotch broom, after all, that's why people spray. However, the smaller, but still statistically significant, effect of broom declines at sites with lower broom gall mite prevalence is harder to interpret. It certainly suggests that the current levels of galling are not having a rapid effect on the mortality of broom bushes, otherwise some effect of high prevalence of galling on reducing broom cover might be expected. It is possible that the broom gall mite does better at sites where there are higher levels of broom cover, and that we will not detect an effect of these higher gall mite prevalences without follow-up site visits to detect subsequent broom declines.

It is also possible that our data are recording only very recent use of other control methods against broom, so that we are missing earlier control. Earlier control using herbicides, that was not recorded in our site reassessments, might explain the large number of sites where broom abundance had declined markedly but there were zero or low numbers of galls. Scotch broom control using herbicides is likely to have a negative effect on the prevalence of broom gall mite. In extreme cases, if broom cover had been reduced to near zero by earlier, unrecorded, spraying, then current broom gall mite prevalence could be expected to be very low because its host plant is now rare at the site.

We then tested whether there is any evidence that spraying affects broom gall mite prevalence. We found that there is such an effect, with a mean prevalence of galls of 29.3% at unsprayed sites versus 16.7% at sprayed sites. This suggests that sprayed sites do have a lower prevalence of broom gall mite, which could mean herbicide spraying harms broom gall mites, directly or indirectly. Overall, recent use of herbicide to control Scotch broom was noted at almost a third (30%) of broom gall mite release sites.

There is some other positive evidence in these data on the potential impact of broom gall mite on broom. A significantly smaller proportion of Scotch broom plants appeared healthy at sites as the percentage of plants attacked by gall mites at the site increased.

The key take-home message is that the data are difficult to interpret, mainly because of the large proportion of broom gall mite release sites where herbicide has been used to control broom. Also, the weed density at or near the year of broom gall mite release was only recorded in 36 (26%) of sites, which compromised many of the analyses through absence of back-point comparison. Broom may also be a challenging weed to target with the site reassessment method because it invades a wide range of habitat types and, in some of these habitats, natural vegetation succession may tend to reduce broom cover over 10-20 years regardless of agent impacts.


Broom infested with broom gall mite

Two obvious recommendations for the future are to try to select release sites that are unlikely to have been subjected to other control efforts against broom, and to ensure that a pre-release assessment of weed density is made. The latter could even be obtained retrospectively, provided good quality-photos were taken at sites at the time of release, particularly if these were taken from drones, allowing percentage cover to be reliably estimated from above. This technology was not widely available at the time the gall mite was released, but its time has come, and we could start using it now. For weeds invading multiple ecosystems, we may also need to investigate agent impact separately for each type of ecosystem under threat.

In conclusion, detailed impact studies over time are required to show subtle, but potentially beneficial, effects of weed biocontrol agents. Overall, a range of ecological studies suggest that Scotch broom is a promising target for suppression by biological control in New Zealand. However, the economically attractive release-site reassessment approach may not be the best option to assess the impacts of biocontrol for this particular weed.

This project was jointly funded by the National Biocontrol Collective and the Ministry for Primary Industries' Sustainable Food and Fibre Futures Fund (Grant #20095) on multi-weed biocontrol.

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Old Man's Beard Pathogens

The old man's beard (*Clematis vitalba*) weed biocontrol project started in the early 1990s, when a fungal pathogen (*Phoma clematidina*), sourced from another *Clematis* species (*Clematis ligusticifolia*) in the USA, was released in New Zealand. While this pathogen initially caused significant damage to old man's beard soon after its release, it failed to persist.

In 2021 we embarked on a fresh search for old man's beard pathogens in its native range, in collaboration with plant pathology researchers from the Centre for Agriculture and Bioscience International (CABI) in the United Kingdom. Field surveys were undertaken across the UK and Europe, focusing on regions that are climatically similar to New Zealand and where old man's beard proliferates. Fungal isolations were made throughout these regions from all old man's beard leaves displaying pathogenic symptoms.

Since the introduction of the *Phoma clematidina* pathogen into New Zealand in the 1990s, two major taxonomic reviews of the *Phoma* genus have been undertaken. Consequently, a new genus, *Longididymella*, was described, including only two species - *Longididymella clematidis* and *L. vitalbae*. Molecular analysis of the fungal isolates collected from the UK and Europe indicated that the most prevalent pathogen infecting old man's beard leaves in its native range is the latter species, *L. vitalbae*. This species was originally described from old man's beard in Switzerland, France, Germany, and the Netherlands. Interestingly, the molecular study also showed that the original pathogen, called '*Phoma clematidina*' when released in New Zealand in 1996, was in fact the other *Longididymella* species, *L. clematidis*.

The next step for the biocontrol programme for old man's beard was to determine whether the strain of the pathogen

Longididymella vitalbae **on detached leaf**

collected in the UK and Europe can cause disease on old man's beard from New Zealand. Old man's beard has an extensive native range, spanning regions from southern England and the Netherlands to North Africa, and from Spain to the Middle East and the Caucasus. Population genetics studies conducted in 2019 also revealed a diverse range of old man's beard populations in New Zealand, which were most closely matched genetically with old man's beard from the UK, Germany, and France.

However, a more recent population genetics study, led by molecular ecologist, Caroline Mitchell, analysed a larger subset of old man's beard samples collected in the UK and Europe. This study identified five distinct genotypes throughout the native range, with varying prevalence in different regions. Remarkably, all five of these genotypes appear to be present in New Zealand, with different regions hosting a mixture of genotypes. This suggests that old man's beard was introduced into New Zealand on multiple occasions from different sources, followed by deliberate spread across the country.

The most prevalent old man's beard genotype in New Zealand shares similarities with genotypes from the UK and Italy, while other genotypes correspond to those from Germany and Sicily. Another genotype hails from Serbia, and the least common one originates from other European countries.

To determine whether the new species of the old man's beard pathogen can cause disease on New Zealand genotypes of the weed, plants had to be propagated from seed exported to the UK in August 2022. In the spring of 2023 Dr Sarah Thomas (Plant Pathologist, CABI) successfully inoculated detached old man's beard leaves using mycelial plugs. Whole inoculations of three of the five New Zealand genotypes to test pathogenicity are currently underway. If the pathogenicity testing doesn't show a significant variance among the three old man's beard genotypes currently being tested, we can reasonably assume a similar trend for the remaining two genotypes.

The isolate in the current study that seems to offer the most potential for biocontrol of old man's beard has been confirmed as *L. vitalbae*, originating on the target host plant species, old man's beard. The recently identified genetic diversity within old man's beard populations in New Zealand presents both challenges to and opportunities for developing tailored biological control strategies that account for genotype-specific interactions.

This project was jointly funded by the National Biocontrol Collective and the Ministry for Primary Industries' Sustainable Food and Fibre Futures Fund (Grant #20095) on multi-weed biocontrol.

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Biocontrol Training for Kaitiaki

In early April, Science Team Leader Angela Bownes and Senior Researcher Ronny Groenteman ran an introductory weed biocontrol workshop for mana whenua kaitiaki from the Tāmaki Makaurau / Auckland region. Mana whenua kaitiaki provide expertise and advice on how to maintain the mauri (life force) and the mana (the power) of te taiao (the environment), and how to conserve our maunga (mountains), awa (water), ngahere (forests) and moana (oceans).

The weed biocontrol group at MWLR, through a Technology Transfer Programme funded by the National Biocontrol Collective (NBC), runs similar workshops annually for council biosecurity staff working on weed biocontrol. However, the course for Tāmaki Makaurau / Auckland kaitiaki was an Auckland Council initiative, fully funded by their pest plants team. Auckland Council, also a member of the NBC, is seeking new ways to deepen their partnerships with Ngā Iwi Mana Whenua o Tāmaki Makaurau, recognising that each iwi is wholly autonomous, individual and unique. Initiatives include engaging with mana whenua (Māori with territorial rights over land) about weed biocontrol.

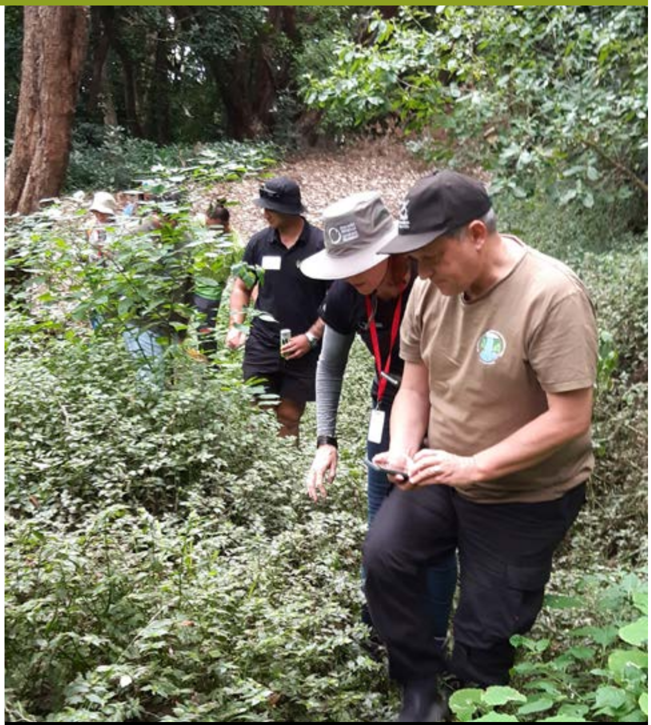
Currently, Māori are predominantly involved during pre-lodgement consultation on release applications to the Environmental Protection Authority to gain approval to release new biocontrol agents. This is a statutory requirement. However, engaging kaitiaki early in the process, even at the scoping stages of a project, will not only uphold our commitment to be better Treaty partners, but might also help members of the NBC and Māori in their rohe to reach common ground ahead of the formal regulatory process. Hopefully, this will also provide an opportunity in the future to engage more meaningfully with mana whenua about the proposed release of new organisms into New Zealand and the associated potential risks, costs, and benefits.

The 2-day workshop covered the mandatory six steps in weed biocontrol projects in New Zealand:

1. establishing feasibility
2. conducting New Zealand surveys
3. finding agents, and host specificity testing
4. gaining permission to import and release
5. mass rearing and release
6. monitoring and assessment.

Also included were sections on the theory of weed biocontrol and examples of successful weed biocontrol programmes in New Zealand.

The workshop participants visited the Beever Plant Pathogen Containment Facility and associated mass-rearing glasshouses, the New Zealand Arthropod Collection (Ko te Aitanga Pepeke o Aotearoa), the New Zealand Fungarium (Te Kohinga Hekeheka o Aotearoa), and two urban field sites in Auckland, where they were able to see weed biocontrol in action. This last visit was one of the most valuable aspects of the course, as we could clearly show evidence of host specificity in the field. The stars of the show were the tradescantia leaf beetle (*Neolema ogloblini*), the tradescantia yellow leaf spot fungus (*Kordyana brasiliensis*), and the alligator weed flea beetle (*Agasicles hygrophila*).



Tradescantia site at Mt Smart

The feedback we received from the workshop participants was overwhelmingly positive. This success was a team effort, with assistance from other members of the MWLR weed biocontrol group, Auckland Council staff, the collections managers, and, of course, the participants themselves, who were actively engaged and interested in learning about weed biocontrol and providing feedback to help improve our engagement with mana whenua in the future.

This project was funded by Auckland Council.

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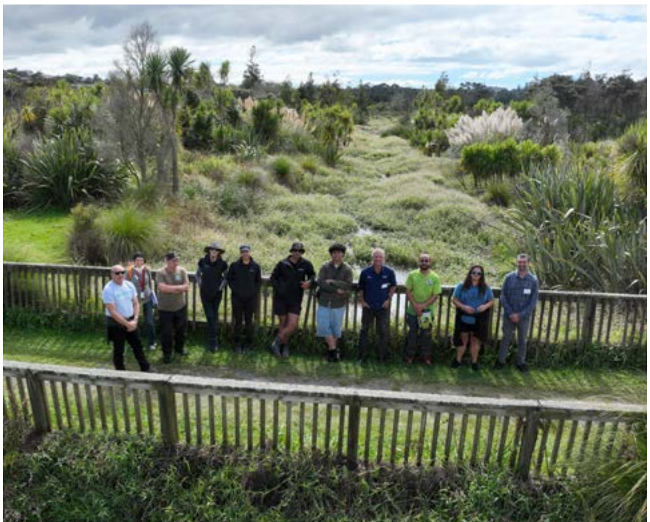

Workshop trainers and participants

New Team Members

Welcome Hester Williams

We are delighted to welcome Hester Williams to the Biocontrol & Molecular Ecology team at MWLR. Hester joined us in February 2024 as a researcher in weed biocontrol and is based at our Lincoln site. She contributes to research on arthropod biocontrol agents on invasive plants in natural and productive sector ecosystems.

Hester has a background in entomology and biological science and has been involved in biocontrol research in South Africa, Canada, and New Zealand. She completed her PhD through Auckland University while being stationed with MWLR in Lincoln from 2016 to 2019. In support of finding novel management tools for new invasions, Hester used a biocontrol system to study factors influencing population dynamics in the early stages of invasion. Following completion of her PhD, she worked as a postdoctoral researcher at the Summerland Research and Development Centre with Agriculture and Agri-Food Canada. There she contributed to research on understanding the contemporary status of biocontrol against St John's wort (*Hypericum perforatum*), Canada's oldest invasive plant biocontrol system.

At MWLR Hester is involved with preparing applications to the Environmental Protection Authority for the release of several new biocontrol agents. She lends expertise to studies on potential biocontrol agents in the containment facility and assists in addressing research questions on established biocontrol systems. Hester also manages and supports the mass-rearing programme of new biocontrol agents for release in New Zealand.

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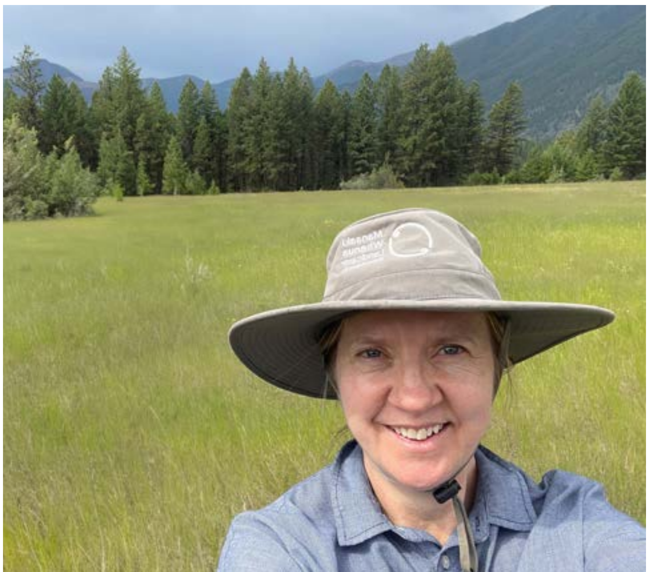
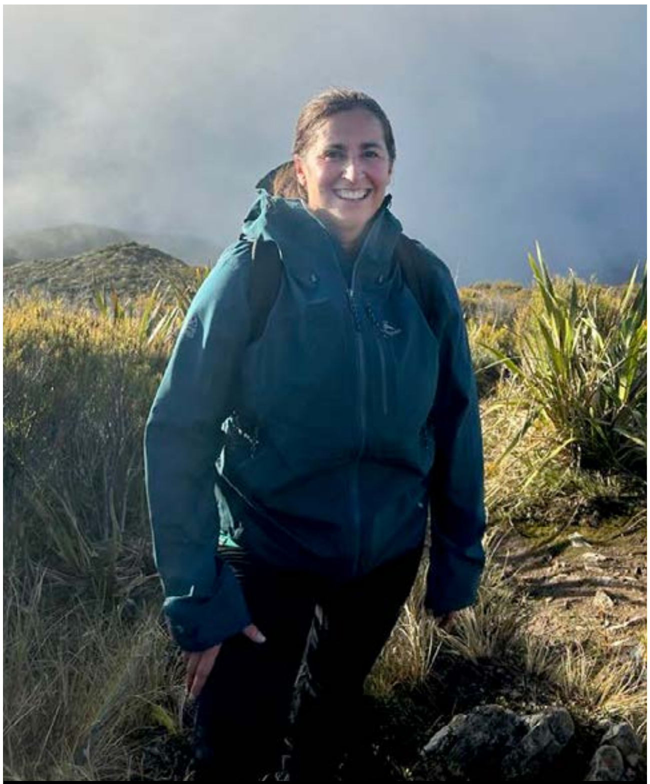


Hester Williams



Anna Vaughan

Welcome Anna Vaughan

It is a pleasure to welcome Anna Vaughan to the Biocontrol & Molecular Ecology team at MWLR. Anna joined the team in January 2024 and is based at our Lincoln site. She is employed part time as a weed biocontrol knowledge broker/project manager.

Anna holds a Bachelor of Agricultural Science with Honours from Lincoln University and has spent over 10 years working on sheep and beef farms, predominantly in Southland and Otago, and more recently in Wairarapa. In recent years Anna has been involved with a variety of project and extension work, with a particular focus on livestock genetics, emerging agriculture technology and trends, and farm systems. She continues her work in these areas when not working for MWLR.

With a love of the outdoors and a background in agriculture, Anna is enjoying the opportunity to learn and share the intricacies of weed biocontrol and the impact it can have on both conservation and land productivity outcomes. Anna's role is diverse, with plenty of variety. As she becomes more familiar with the role, some of the work she will be responsible for will include editing the *Weed Biocontrol What's New?* newsletter, facilitating workshops, looking after the weed biocontrol social media content, and helping the team behind the scenes to ensure projects are progressing smoothly.

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