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LANDCARE RESEARCH
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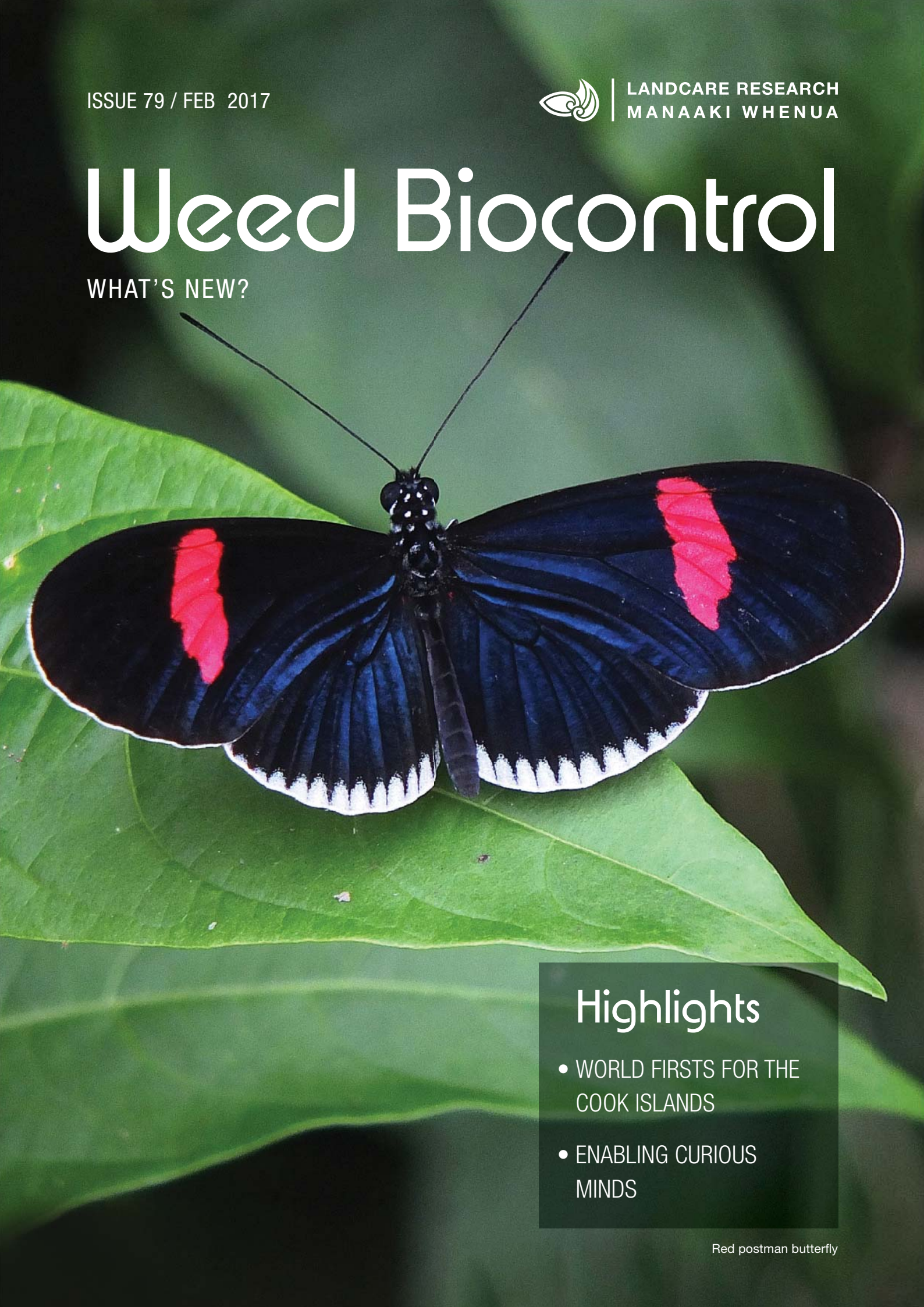
Weed Biocontrol

WHAT'S NEW?



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Key contacts

EDITOR: Lynley Hayes
Any enquiries to Lynley Hayes
hayesl@landcareresearch.co.nz

THANKS TO: Ray Prebble
LAYOUT: Nicolette Faville

CONTRIBUTIONS: Alison Evans

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World Firsts for the Cook Islands

The Cook Islands are the focus of a 5-year biocontrol project, funded by the New Zealand Ministry of Foreign Affairs and Trade, aimed at bringing some of their most rampant weeds under control. A workshop was held in 2009, where a range of Cook Island experts prioritised which weeds were suitable as biocontrol targets using a scoring system that considered weed importance and the predicted cost and likelihood of successful biocontrol. Funding was then secured to implement biocontrol for the top seven weed species, and to do further work to explore the appropriateness of targeting an eighth species, peltate morning glory (*Merremia peltata*). There are conflicting views on whether this invasive vine is native or introduced to the Pacific, and a molecular study is seeking to resolve this. Results to date suggest peltate morning glory may have been introduced from the North Pacific to the South Pacific, but more samples of this vine are needed from across its range to confirm this.

"The development of a comprehensive biocontrol programme was necessary to prevent further deterioration of native forests and disruption to agricultural systems in the Cook Islands, and to prevent one bad weed simply being replaced by another," said Quentin Paynter, who is leading the work. "For example, three invasive vines species are widespread and commonly occur together, so we needed to tackle all three at the same time."

As is often the case with these projects, there have been one or two unexpected challenges pop up. Surveys for potential release sites in April 2015 revealed there had been confusion between giant reed (*Arundo donax*), which it turns out is quite rare on Rarotonga, and elephant grass (*Pennisetum purpureum*), which is more widespread. "We then suggested that giant reed would be a good candidate for eradication using manual control rather than going down the biocontrol route," explained Quentin. However, the work sourcing giant reed agents for Rarotonga, and maintaining colonies of them in containment at Tamaki, has not gone to waste. Giant reed is an up-and-coming weed in New Zealand, particularly up north, and so the Northland Regional Council took the opportunity to seek approval from the Environmental Protection Authority (EPA) to release the gall-forming wasp (*Tetramesa romana*) and a scale insect (*Rhizaspidiotus donacis*) here. The EPA granted this permission in January, and releases of the wasp can get underway soon.

Recently there have been some promising signs that the ambitious Cook Islands project will pay dividends. Red passionfruit (*Passiflora rubra*) is one of the most vigorous invasive vines there, but biocontrol has not been attempted against this target anywhere else in the world before now. "There is always a higher risk of failure with novel programmes and I initially thought that red passionfruit would prove to be an impossible target given the level of funding at our disposal," said Quentin. "However, *Heliconius* butterflies have been extremely well studied and are commonly kept in butterfly houses for their good looks. Published literature indicated that some Heliconius species do not attack the edible passionfruits (which belong to a different *Passiflora subgenus* to *P. rubra*) and might therefore attack the unwanted red passionfruit while not harming closely related desirable species. The red postman butterfly (*Heliconius erato cyrbia*), which is native to Colombia and Ecuador, was therefore considered. We were able to obtain this subspecies from Heliconius Butterfly Works – a commercial supplier for butterfly houses, which reduced costs enormously."

Host-range testing confirmed that the red postman does not attack edible passionfruits and permission to release it on Rarotonga was then obtained. This attractive butterfly was subsequently released there in August 2016 and is already firmly established and spreading. "I'm feeling confident that it will have a major impact on red passionfruit as larval feeding severely damaged plants in containment. They are quite wasteful feeders and commonly

chewed through whole stems," said Quentin. It is hoped that the butterflies can be eventually released on other islands such as Atiu, which has an internationally important remnant makatea forest that is being invaded by red passionfruit.

The other novel programme being developed for the Cook Islands is for African tulip tree (*Spathodea campanulata*). An eriophyid mite (*Colomerus spathodeae*) was selected as the first agent for this plant, which is considered to be a major problem throughout the Pacific region and elsewhere – indeed African tulip tree is listed as one of the world's 100 most invasive species. The mite, which was recently approved for release in the Cook Islands, was sourced from Ghana by Dr Iain Paterson (Rhodes University). The mite mainly attacks the new foliage, severely distorting it and thereby stunting the growth of this tree.

Iain hand-delivered the fragile critter to our containment facility in Auckland, where a back-up culture is being maintained. He then travelled with Quentin to Rarotonga, where he successfully released the mites onto plants growing in a shade house at the Ministry of Agriculture (MoA) and made some preliminary field releases. Iain stayed on in Rarotonga for a few more days to oversee further field releases around the island. "The mite gets to work very quickly, and we already know that most of the initial releases have taken well," said Iain. Furthermore, host-range testing of a second agent, a leaf-mining beetle (*Paradibolia coerulea*), is at an advanced stage. Testing to date strongly

Red postman butterfly.

indicates that it is host-specific, so the beetle may also be introduced to Rarotonga during the current programme.

Strawberry guava (*Psidium cattleianum*) is another ominous invader in the Cook Islands, as well as one to watch here in New Zealand. This woody shrub is native to Brazil and was introduced to the Pacific region in the 1800s. It displaces native plant communities and is dispersed mainly by birds and pigs, which find its fruit irresistible. Strawberry guava is considered to be one of the worst weeds in Hawai'i, so considerable research has gone into biocontrol options already. A promising scale insect (*Tectococcus ovatus*) was approved for release in the Cook Islands, and following successful rearing of it at the MoA facility in Rarotonga has recently been released onto strawberry guava plants on the island. The scale insects cause galls on the leaves

Iain Paterson releasing mites on African tulip tree, and (inset) promising results a week later.

The technique used for releasing the strawberry guava scale.

and stunt the growth of the plant. "We found galls on plants in the field during this last visit, so establishment looks likely," said Quentin. "This trip we made multiple additional field releases of this insect along the southern section of the cross-island walk where strawberry guava is abundant and invading native forest and fernlands," he added.

The aptly named mile-a-minute vine (*Mikania micrantha*) is still rampant, however, after initial attempts to establish the rust (*Puccinia spegazzinii*) were unsuccessful. "This has been a challenging plant to work on. Although it grows rampantly in the field, it is attacked by all manner of pests when grown in a shadehouse, and staff at the MoA have had difficulty maintaining plants and the associated rust culture adequately. We therefore tried a different approach during the latest visit by conducting direct field releases using plants that were inoculated multiple times in containment in New Zealand. Multiple inoculations should extend the time over which spores will be maturing, thereby increasing the chances of sporulation when conditions in Rarotonga were most suitable for the rust," said pathologist Chantal Probst.

"To meet phytosanitary requirements, the roots of the plants had to be washed bare and the plants inspected, which we arranged to have done the day before departure from New Zealand to minimise stress on the plants. On arrival in Rarotonga, the plants were re-potted and placed in a mist-chamber at the MoA facility as soon possible and allowed to recover overnight," she explained. This tactic was obviously successful, because some plants had perked up and were displaying mature rust pustules the day after they arrived, and after a few days immature pustules had begun to form on the younger growth. "We planted the infected vines at multiple field sites covering a range of different environmental conditions and hopefully the field releases made during my trip will finally see the rust establish and take off now," said Quentin. This rust is reported to have had a noticeable impact on mile-a-minute in Papua New Guinea and Vanuatu only a few years after release there, so we remain hopeful it will also do good things in the Cook Islands.

A rust fungus (*Puccinia xanthii*) aimed at cockleburr (*Xanthium pungens* – part of the *Xanthium strumarium* sp. agg. complex, and known as Noogoora burr in Australia) has proven a little easier to establish in Rarotonga. Cockleburr is an annual herb that has a widespread geographical range throughout the Pacific, growing well in sandy habitats. This particular rust fungus, which successfully keeps Noogoora burr under control in Australia, was released in Rarotonga in 2015. Survey work undertaken during the latest visit revealed that the rust has established at two sites on opposite sides of the island. "If the rust has the same impact on Rarotonga as it does in Australia, then cockleburr should cease to be a major problem in Rarotonga, once this pathogen begins to reach outbreak levels," predicts Quentin.

The final target weed under consideration is grand balloon vine (*Cardiospermum grandiflorum*), which is native to South America. Two agents – another rust fungus (*Puccinia arechavaletae*) and a weevil (*Cissoanthonomus tuberculipennis*) – were identified as having potential, but at this stage only the rust fungus has been advanced. "This plant is also a big problem in South Africa, so most of the host range testing has already been completed for the fungus, giving us a head start," explained Quentin. A shipment of the rust fungus from South America arrived early in the New Year following a rather prolonged transit, so there were concerns about how viable the material would still be. "Thankfully inoculations have worked and we have a small number of pustules beginning to develop on plants in the Auckland containment facility. We just need to test one non-target plant to check it is not susceptible to the rust and then, assuming we are happy with the results, apply to release it in Rarotonga," he said.

While good progress has been made in this project, there is clearly much more to do, including establishing agents on islands other than Rarotonga in the Cook Islands group. A separate environmental impact assessment must be made ahead of releasing any new agent on any other island. "Obviously this is quite a big undertaking, so we'd like to confirm that the agents released on Rarotonga are successful before applying to release them on other islands," Quentin concluded.

*If you might be able to help provide some of the much-needed additional samples of peltate morning glory (*Merremia peltata*) from across its current distribution please get in touch!*

CONTACT: Quentin Paynter
paynterq@landcareresearch.co.nz

Science Fair Success

A secondary school student from Kerikeri scooped the 2016 Excellence Award at the Far North Science and Technology Fair for her study on one of the Brazilian beetles released in the region to control tradescantia (*Tradescantia fluminensis*). Aimee Leaming, who was also the dux of Kerikeri High School in 2016, investigated some of the factors that might influence the survival of the leaf beetle (*Neolema ogloblini*), also affectionately known as 'Shiny'. Aimee's hypothesis was that the beetles would feed at different rates under different light and temperature conditions.

Aimee firstly investigated the levels of light intensity found under forest canopies in New Zealand, where tradescantia is a problem, and then studied how that affects the distribution and amount of tradescantia eaten by the leaf beetle. Aimee designed a choice chamber test using different layers of shade cloth to create a range of light intensities between 150 and 3,450 lux to determine which light intensity they preferred, and under which light intensity they consumed the most leaf material. After a 24-hour period the number of beetles in each chamber was counted and the amount of leaf material eaten was measured. Her results suggested only a weak relationship between increasing light intensity and the number of beetles present, but more leaves were eaten under high-light (3,450 lux) than low-light conditions (150 lux).

Aimee also looked at the effect of temperature on the amount of leaf surface area eaten. To do this she selected 90 beetles of a range of sizes and withheld food from them for 24 hours. She then presented the beetles with tradescantia leaves and kept them at a range of different temperatures. Aimee showed that the amount of leaf area eaten was significantly less at lower temperatures (15˚C and below) compared with the highest temperature (35˚C).

Aimee was also interested in whether it was possible to reliably tell the difference between male and female beetles, as this would help researchers to release a good sex ratio of beetles in founding populations establishing in new habitats. Essentially, she needed to look for a phenotypic marker to identify beetle gender. By dissecting and measuring 32 beetles that ranged in length (measured from the top of the head to the base of the abdomen), she was able to show that females are slightly larger, with a median body length of 4.92 mm compared with males, whose median length was only 4.21 mm.]

Aimee produced a comprehensive report on her study. In it she highlighted the importance of understanding the preferences of the beetles, given that New Zealand has such a highly variable environment, to allow the conditions where the beetles might have the greatest impact to be identified. Her results suggest that while the leaf beetle is probably ideally suited to the Northland climate, they may struggle in cooler parts of New Zealand. She also concluded that beetle length is a good indicator of gender when selecting beetles to be moved to new areas.

"What impressed us was that Aimee understood the importance of replicating the experiment to add certainty to her results and was very thorough with her experimental design", said entomologist Jenny Dymock, who helps the Northland Regional Council with weed biocontrol activities and also gave Aimee a helping hand with her study. Jenny added that Aimee's findings have made a great contribution to predicting the effectiveness of the beetles, and that the results are relevant to other countries interested in biocontrolling this weed.

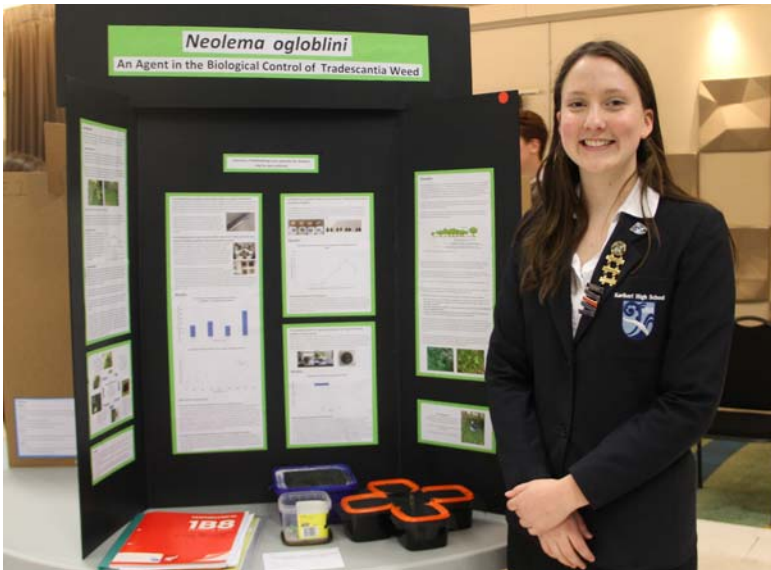
Following her award, Aimee was invited to attend the Powering Potential convention in Wellington, which aims to bring together 40 of New Zealand's top secondary students to discuss solutions for climate change. This initiative is hosted by the Royal Society of New Zealand and is designed to provide a youth perspective on environmental impacts associated with global warming. Aimee was also invited to travel to the Taiwan International Science Fair (TISF) awards, which involve around 250 Taiwanese finalists and 40 overseas students from 20 nations around the world. Here Aimee won her category, placing first in Earth and Environmental Science.

Not only does Aimee have a great scientific mind, but she is also one of New Zealand's top gymnasts, winning her section at the 2016 National Secondary Schools Competition. She is planning to study Health Sciences at Otago University.

Congratulations Aimee, and we are sure that you will make a great contribution to New Zealand science whatever discipline you decide on!

CONTACT: Jenny Dymock
jennydymock@ihug.co.nz

Aimee Leaming with her successful exhibit.



Enabling Curious Minds to Join the War against Weeds

Last year a project conceived by Murray Dawson and Hugh Gourlay was awarded an Unlocking Curious Minds grant by the Ministry of Business, Innovation and Employment (MBIE). These grants are aimed at better engaging New Zealanders with science and technology, especially those who have fewer opportunities to do so. Young people, especially those in remote rural areas and lower decile schools, have been identified as one of the more "hard to reach" groups that this fund hopes to get more involved. An added bonus of targeting this group is the potential to stimulate more young people to consider careers in science and technology – something the country definitely needs for the future.

New Zealand has a very serious problem with invasive weeds, and as many citizens as possible are needed to join the call to arms. But currently many New Zealanders are not even sure about which plants they see in the environment are native or introduced, or where they can find out, let alone what they should do about them. This Curious Minds project aims to start turning this around by increasing awareness amongst young people about the threats posed by weeds, how to recognise them, and how get further information and do things that will help. "We need to educate students about the importance of early detection being fundamental to controlling the spread of weeds, and hope they will pass the message on to others," Murray said. "The more people in a community involved, the better the chance we have of spotting new and emerging problems and nipping them in the bud."

So Murray and a team of helpers have travelled far and wide visiting schools to spread the word about the importance of recognising and controlling weeds early. "The Unlocking Curious Minds fund was a good fit with the national objective of trying to improve weed surveillance, especially in more remote areas of New Zealand where weed experts are thinner on the ground and have fewer resources for this work," said Murray. "Information about weeds in these areas is often out-of-date or incomplete since little, if any, formal surveillance work has been undertaken," he explained. "We need more 'boots on the ground', and eyes out there looking and reporting what they find."

Students from Hicks Bay examining weeds under a microscope.

Nine schools from Auckland, Gisborne and the West Coast of the South Island, involving years 5–13, participated in this pilot programme. The Brian Mason Trust provided additional financial assistance to allow more schools to be involved on the West Coast. The project has also been fortunate to have support from Weedbusters (who support community groups to manage their weeds) and the Department of Conservation (DOC). "DOC staff from all three regions came along to help," said Murray. "It was also great to see members of the community joining us."

Lincoln University ecologist Jon Sullivan was one of the collaborators, joining the visit to Haast School. Jon is a NatureWatch NZ founder, the citizen science platform chosen to share online the weed observations generated by the project. Landcare Research botanist David Glenny and weed biocontrol expert Hugh Gourlay also added their skills and expertise to the school visits. Monique Russell from the Tread Lightly Caravan (The Urban EcoLiving Charitable Trust) and Robinne Weiss, a heritage interpreter, also assisted as the North and South Island educators, respectively, for this project.

The school visits involved time in the classroom and field trips to local weedy areas. Taking the students out of the classroom to look for weeds growing nearby gave them a chance to use smartphone apps to identify, record and share their weed observations online. The students also collected specimens of weeds and added them to plant presses so that they could be taken back to add to the Allan Herbarium at Lincoln.

The project uncovered some interesting finds, (see Table 1). Not surprisingly, a suite of well-known environmental weed species were found practically everywhere, such as blackberry (*Rubus fruticosus* agg.), creeping buttercup (*Ranunculus repens*), gorse (*Ulex europaeus*), ivy (*Hedera* spp.), privet (*Ligustrum* spp.), Scotch broom (*Cytisus scoparius*) and tradescantia (*Tradescantia fluminensis*). Because gorse is so widespread and recognisable, it was often used to demonstrate the weed identification app. Although cotoneaster (*Cotoneaster* spp.) was found in most places, it was particularly abundant at the Kaniere and Franz Josef field sites. Auckland had the most ornamental plants that

had 'jumped the garden-fence', but Hicks Bay in Gisborne had several weed species not seen in the other locations, such as dragon's-head lily (*Gladiolus dalenii*) and love-in-a-mist (*Nigella damascena*).

A few native treasures were also discovered along the way, including Gunnera prorepens thriving in the lawns at Franz Josef, and raukūmara (*Brachyglottis perdicioides*), a local and rare native shrubby daisy growing in Hicks Bay.

"One of the highlights of the programme was visiting TKKM o Kawakawa Mai Tawhiti School in Hicks Bay, where some lessons were translated into te reo," said Murray. At the end of the 3-day visit Murray was invited to speak about the Unlocking Curious Minds project at the school's assembly, where the three most enthusiastic students were awarded with prizes, including a smart phone and two LED hand lenses. "For many of the students this was their first chance to interact with scientists and weed experts, and it was gratifying to see how much interest we created," said Murray. "There are definitely some budding biologists out there who just need a little nurturing."

As a bonus, one student from each of the participating schools was given the opportunity to visit Landcare Research's Lincoln campus for 2 days to develop their botanical and entomological skills. On the first day Ines Schönberger and other herbarium staff taught students about the role and function of the Allan Herbarium and how to add the specimens they collected to the research collection. Students also visited the nationally significant harakeke (New Zealand flax) collection with Katarina Tawiri.

On the second day at Lincoln, Hugh showed them around the containment facility, where the insects used for biocontrol are studied and reared. One lucky student was even given a package of beetles to take back to his school to release on the tradescantia that had been found growing under a nearby bridge! Students

Table 1: Contribution to Science

School	No. of Students Involved	No. of NatureWatch Observations	No. of Species Found	No. of Herbarium Specimens Lodged
Fox / Franz Josef	27	85	36	41
Haast	11	74	45	43
Hokitika	45	38	24	28
Kaniere	25	134	52	36
Mission Heights	27	78	48	18
Mount Albert Grammar	34	85	57	17
TKKM	24	144	71	10
Whataroa	22	35	25	30
Total	216	673		223

Whataroa student using phone app to identify gorse.

also looked for and collected biocontrol insects from around the Lincoln grounds and studied them under microscopes. Robinne Weiss then led them through some educational activities on biocontrol, including a small-scale food preference experiment to show how testing to determine whether potential agents are suitably specific or not is determined. When the caterpillars were put into small containers with a choice between three different plant species, the results clearly showed the students that specialist biocontrol insects will voraciously consume only their preferred plant species and nothing else.

"Thank you so much to Murray, Robinne, Hugh and the weedbusting team that came to our school. I had the best time and learnt so much." (Charlotte, Y6)

"I really enjoyed my time at Landcare but I think that my favourite activity was the caterpillar experiment... I found this trip very interesting and inspiring... Suggestions: Please do more trips so that other people can have this same experience. Thank you for having me!" (Lois, Y11)

The feedback from the students, teachers and parents was that they found the programme interesting and inspiring and would like to see it expanded to include more schools.

For more information about Unlocking Curious Minds, see www.curiousminds.nz/about/unlocking-curious-minds/, and for more information about this particular project see www.landcareresearch.co.nz/information-for/citizen-science/weeds. Schools who would be interested in potentially taking part, if funding is available, can express their interest at www.landcareresearch.co.nz/information-for/citizen-science/weeds/schools

CONTACT: Murray Dawson
dawsonm@landcareresearch.co.nz

Autumn Activities

There are a few things you might want to fit in before winter sets in. We would be very interested to hear about what you find.

Gall-forming agents

Early autumn is the best time to check many gall-forming agents.

- Check broom gall mite (*Aceria genistae*) sites for signs of galling. 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 though, 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.
- At nodding and Scotch thistle gall fly (*Urophora solstitialis* and *U. stylata*) release sites 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.
- At Californian thistle gall fly (*Urophora cardui*) release sites look 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.

Privet lace bug (*Leptoypha hospita*)

- Although it is early days it might be worth checking release sites. Examine the undersides of leaves for the adults and nymphs, especially leaves showing signs of bleaching.
- It is likely to be too soon for any harvesting to begin.

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 windowed by larvae grazing off the green tissue.
- The beetles can be harvested 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 the Ministry for Primary Industries that allows you to do this).

Tradescantia tip beetle (*Neolema abbreviata*)

- Look for the adults, which are mostly black with yellow and black 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.
- The beetles can be harvested if you find them in good numbers. Aim to collect and shift 50–100 beetles using a suction device or a small net.

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

Target	When	Agents
Broom	Dec–April	Broom gall mite (Aceria genistae)
Lantana	March–May	Blister rust (*Prospodium tuberculatum*) Leaf 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)*
Woolly nightshade	Feb–April	Lace bug *(Gargaphia decoris)*

CONTACT: Lynley Hayes
hayesl@landcareresearch.co.nz