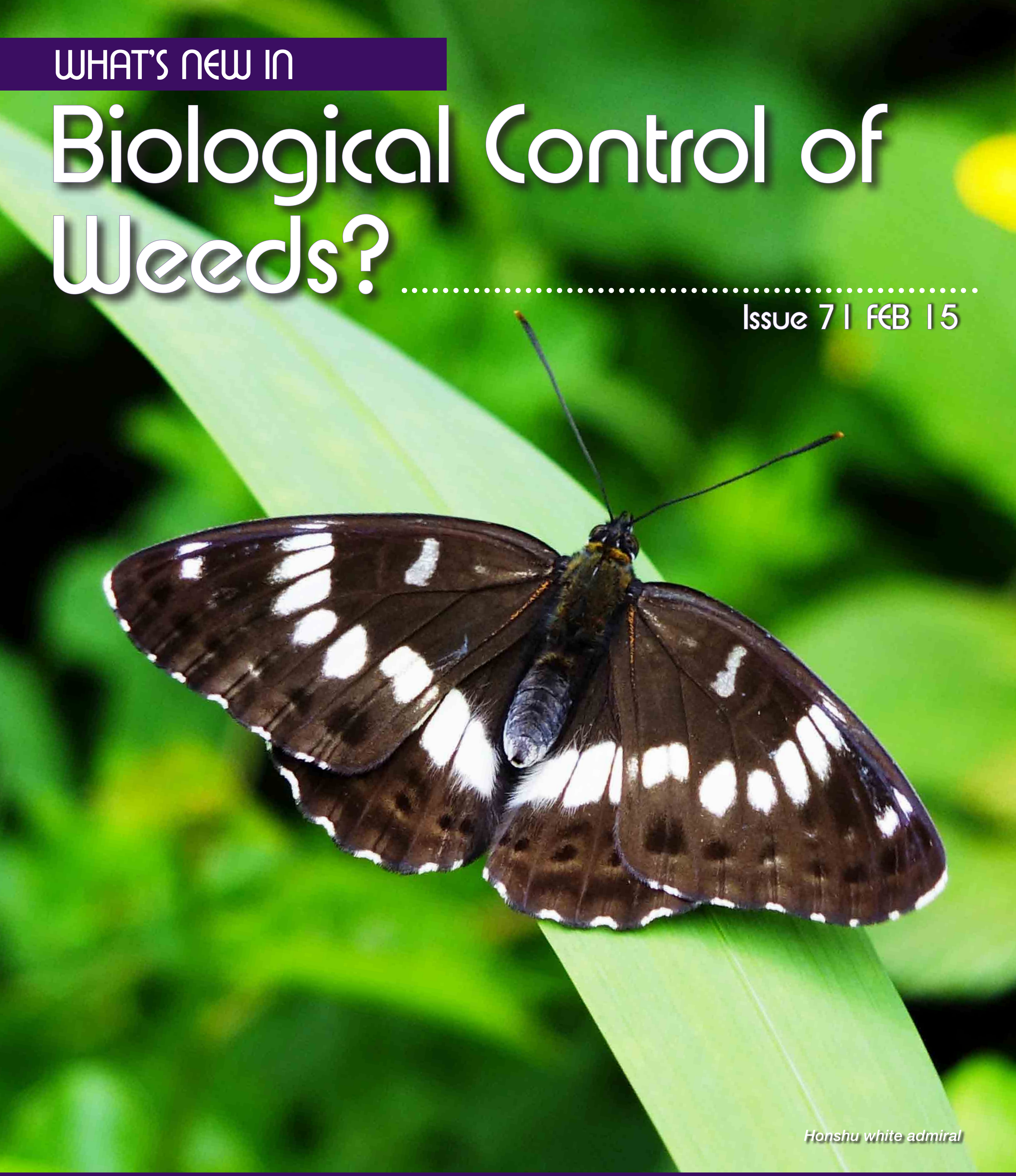
WHAT'S NEW IN

Biological Control of Weeds?

Issue 71 FEB 15



Honshu white admiral

What's Inside?

Landcare Research
Manaaki Whenua

Honshu Butterflies Take Off at Last!

After a great deal of perseverance and skill, Quentin Paynter and his team have managed to pull off one of the scientific highlights of 2014. The Honshu white admiral butterfly (*Limenitis glorifica*), a native to Japan, has the potential to help control Japanese honeysuckle (*Lonicera japonica*), a serious up and coming environmental weed in New Zealand. The Environmental Protection Authority approved the release of the butterfly in August 2013, but attempts that spring to mass-rear and release it failed.

The project has stalled several times due to unforeseen problems such as the 2011 Japanese tsunami, which wiped out study and collection sites and prevented travel to Japan for a year, but the main problem with this agent has been trying to get the butterflies to mate in captivity. "They have an elaborate courtship display where the male circles around the female and they need plenty of space to do this," explained Quent. The white admirals failed to breed at Butterfly Creek, which is a relatively spacious butterfly house in Auckland. Previously we had flown in the 'master-mater', Professor Bob Platt from the USA, to try to hand-pair the butterflies, but that didn't work either.

In a final attempt to establish the butterflies, Quent and his colleague Chris Winks planned another trip back to Japan in September last year. The idea was to catch wild females (the assumption being that they had already mated) and collect fertile eggs from them, bring this material back to New Zealand and eventually directly field-release the resulting new adults. "We hoped that if we released newly-emerged adults into suitable natural conditions in spring they would mate and reproduce," said Quent. "It was the only remaining viable option left to us," he added. It meant keeping the imported material in containment in New Zealand until we were sure it was safe to release it. We needed to double-check we had the right species (there is another similar species in Japan with a wider host range), and ensure it was free of disease.

With Japan and New Zealand being in different hemispheres, there was also a seasonal timing issue to overcome. We had to attempt to collect butterflies or eggs as late as possible in Japan and slow development down so the new adults would not emerge too early, before temperatures had warmed up sufficiently. "We knew that the white admiral normally has three generations a year in Japan, but because we had never visited in autumn before we weren't sure exactly when, or at which sites, the third generation would be present, so we booked flights to stay in Japan for the first three weeks of September, to give us the best chance of our trip coinciding with the white admiral flight period," Quent said.

"This proved to be a wise decision, because after the first 10 days or so we had virtually nothing to show for our efforts in the field. We did, however, visit Dr Hideshi Naka at Tottori University, who showed us his technique for hand-pairing butterflies, which differed from techniques we unsuccessfully attempted with Bob Platt. However, Dr Naka's technique was very fiddly, but it did represent another 'if all else fails' option," added Quent.

After unsuccessfully visiting numerous sites that had yielded many eggs on previous trips, Quent and Chris found a large patch of Japanese honeysuckle in riverine forest near Utsonomiya where they were able to collect eggs and a few adult females, which laid further fertile eggs. The key thing now was to ensure that the emerging larvae did not enter their usual overwintering diapause. We kept the caterpillars relatively cool, but at a long day length, so that they continued to develop slowly, and fortunately this strategy worked perfectly.

In theory an insect can become established through releasing just one male and female, but historical data tell us that establishment success is related to the numbers released and that small releases usually fail. "Although pleased with our efforts, we still had relatively few eggs and larvae (especially considering a minimum of 30 would need to be sacrificed for disease-testing) and time was rapidly running out. But to our great relief we managed to collect three more adult females and a good haul of eggs on our penultimate day in Japan," explained Quent.

On return to New Zealand the female butterflies were fed on a diet of Pokari Sweat (a Japanese sports drink that Japanese entomologists claim has everything a butterfly needs!) and they began ovipositing soon after being installed in the Beever Containment Facility in Auckland; producing dozens of fresh eggs. After several days the team breathed a huge sigh of relief when the eggs proved to be fertile and larvae emerged – and another big sigh of relief when subsequent disease-testing indicated that the caterpillars were healthy. However, we soon had a new problem: the caterpillars appeared to be developing too quickly when the weather was still too cold. Again we turned the temperature down to slow development, but nevertheless the first adults still emerged in mid-October – rather earlier than hoped.

Once the new adults had emerged, and with permission to take them out of containment granted, the adults were released at a site in the Waikato and another in Auckland. Adults were released over a 2-month period as new butterflies emerged, with the first release of 27 adults occurring at the end of October and the "lucky last" being released in early December. A total of 178 were released at the Waikato site and 56 in Auckland.

Small white admiral caterpillar with its 'pier.'

Quent then waited anxiously, like an expectant father, for eggs to be produced in the field. "My main concern was whether the butterflies had mated because they can sometimes panic when they are released and immediately disperse, and if they disperse too far there is a big risk that the males and females never find each other to mate," he said. "We unfortunately had one of the coldest and wettest springs in years, which would have seriously curtailed butterfly activity." Quent was encouraged when he found eggs at the Waikato site in early November, but his hopes were dashed when they proved to be infertile. However, more eggs were discovered there in early December and, to Quent's immense relief, they produced caterpillars.

Visits to the field sites in the Waikato in mid-December revealed a number of adults still flying around, which was encouraging because it meant they were capable of surviving for 2–3 weeks (the equivalent of an old-age pensioner in white admiral butterfly terms!). As an additional insurance measure, some eggs were collected from the site and taken back to Tamaki where they could be reared on in safety. The butterflies that emerged were returned to the Waikato field site in January, where second-generation butterflies were readily observed, indicating they had also made it through successfully on their own.

"The females can lay up to 200 eggs each and the caterpillars have a good appetite for Japanese honeysuckle," said Quent. "As far as predation is concerned, we suspect white admiral larvae will fall victim to wasps, but white admiral larvae are better camouflaged than monarch larvae and they develop much faster, so are exposed to predation for less time. The small larvae also have a 'trick' to avoid predators – they construct a 'pier' on the tip of a leaf, made out of silk and frass, which serves as a refuge from predators that search the leaf, but do not notice the pier beyond.

"Now we have to wait and see how it goes from here, but things are looking really promising – quite an achievement considering all the hurdles we had to jump to get this far," said Quent modestly. Next spring we hope to be able to begin harvesting butterflies from the two initial sites to supply other areas that need them. "This project has thrown a number of 'curve balls' at us, yet with perseverance, our experienced team has achieved the almost impossible," remarked Team Leader Lynley Hayes.

This project is funded by the National Biocontrol Collective.

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Changes to Pages

If you are keeping your copy of *The Biological Control of Weeds Book* up to date you might like to download the following new or amended pages from www.landcareresearch.co.nz/publications/books/biocontrol-of-weeds-book :

Information sheets

- Index
- What is biological control of weeds?
- Techniques for assessing the impact of biocontrol agents
- National Assessment Protocol
- National Assessment Protocol – Specific Guidelines
- Broom gall mite
- Darwin's barberry
- Darwin's barberry flower weevil
- Darwin's barberry seed weevil
- Honshu white admiral
- Scotch thistle gall fly
- St John's wort beetle
- Woolly nightshade lacebug

Release and Monitoring Forms

- Pre-release sheet
- Release sheet
- Broom gall mite
- Broom leaf beetle
- Broom psyllid
- Broom shoot moth
- Broom twig miner
- Honshu white admiral
- Lantana blister rust
- Lantana leaf rust
- Tradescantia leaf beetle
- Tradescantia stem beetle
- Tradescantia tip beetle
- Woolly nightshade lace bug

How Much Do Biocontrol Projects Cost?

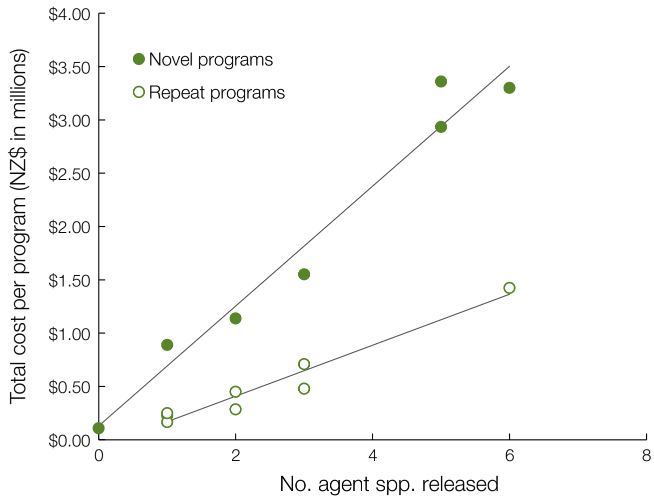
Being able to predict the cost of a weed biocontrol programme is an important part of improving the prioritisation of targets and success of projects. "Super sleuth" Quentin Paynter has been busy delving into the archives again, but this time focusing on which factors influence the cost of biocontrol programmes the most. Quent looked at the following key factors:

1. Opposition to controlling a particular weed because of its perceived economic or ornamental value
2. Taxonomic isolation relative to native New Zealand plant species
3. Whether the project type was 'novel' or had already been attempted overseas for the same weed target.

"In total we reviewed the information for 43 weed biocontrol agents released between 1972 and 2013 in New Zealand and which had been subjected to stringent host-range testing prior to their release," explained Quent. "This information was sourced from Landcare Research databases and comprised projects funded by all sources, including the National Biocontrol Collective and the Ministry for Primary Industries' Sustainable Farming Fund," he said.

Quent compiled a comprehensive list of costs associated with each agent released, as well as a list outlining the cost of biocontrol programmes for specific weed targets in New Zealand. By summarising the information in this way it became apparent that opposition to specific biocontrol programmes did not contribute greatly their cost. There were only a few examples where opposition significantly delayed and affected the programme cost. "These days, we conduct a feasibility study prior to a programme commencing and would always ensure that conflicts of interest are resolved before embarking on a project," said Quent. This would often include a comprehensive cost–benefit analysis in the early stages, and the project would only proceed when the costs of the weed (both economic and environmental) outweigh the desired attributes.

Taxonomic isolation of the weed was surprisingly not a strong predictor of the cost of releasing agents against weeds either. "Despite host-range testing being more complex and time-consuming when the target weed is more closely related to native New Zealand plants, taxonomic isolation did not greatly influence the cost of the programme," said Quent. This suggests other factors are more important. "Certainly disease can inflate the cost of projects hugely," said Quent. For example, the three beetles selected to control tradescantia (*Tradescantia fluminensis*) were infected with gut parasites that were difficult to eliminate. Individual eggs had to be painstakingly sterilised and line-reared for many months before disease-free populations were achieved that were suitable for release. Clearing the beetles of disease was estimated to cost around NZ$200,000 for each species, or an additional NZ$600,000 all up.



Relationship between the cost of weed biocontrol programmes in New Zealand and the number of biocontrol agents released for novel targets and repeat programmes for the three species.

Programme type was a strong predictor of cost. Where a programme used agents that had already been developed for release overseas, not surprisingly programme costs were cheaper – nearly four times less (c. NZ$0.5 million) than projects starting from scratch with new (or novel) agents (c. NZ$1.9 million). There was also a strong correlation between programme cost and the number of agents released (see graph). This suggests that there could be savings if agent selection was improved so that fewer, more effective agents are released. This means that sometimes it might be better to wait and see how agents released overseas perform before introducing them to New Zealand.

This study reinforces that weed biocontrol agents developed in New Zealand have been extremely cost-effective compared with other countries with much bigger budgets. The average cost of developing an agent for New Zealand was NZ$355,686 (with the average cost per novel agent being NZ$475,334, more than double the average of NZ$202,803 for repeat agents). By comparison in 1997 the cost on average to produce a weed biocontrol agent overseas (based on the number of scientist-years to test an agent reported by practitioners in Canada, Europe and the USA) through to introduction was estimated to be US$460,000. This equates to approximately NZ$1 million in 2014 (taking into account the exchange rate of the day and CPI adjustment). "With a growing number of weeds to target and limited funds, we will to continue to identify where savings can be made without compromising safety or efficacy," concluded Quent.

Paynter QP, Fowler SV, Hayes L, Hill RL 2015. Factors affecting the cost of weed biocontrol programs in New Zealand. Biological Control 80: 119–127.

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

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Lantana Rust Releases to Begin

Lantana (*Lantana camara*) is considered one of the world's 10 worst weeds. So far in New Zealand lantana is mostly only problematic in Northland, but it is an emerging weed, or at least one to keep an eye on given its reputation, in the Auckland, Waikato, Bay of Plenty and Wellington regions. Biological control is being attempted as a "pre-emptive strike" rather than the more usual tactic of "last resort".

We received advice early on from Michael Day (Biosecurity Queensland), who has worked extensively on lantana biocontrol in Australia, that none of the many insect agents, which have been used with mixed success elsewhere, were likely to thrive in New Zealand conditions. One specialist lantana insect, a plume moth (*Lantanophaga pusillidactyla*) that feeds on the flowers, has self-introduced here but its impact is thought to be insignificant.

So we focused instead on two rusts from South America. The lantana leaf rust (*Prospodium tuberculatum*) can cause leaf-death and defoliation. The lantana blister rust (*Puccinia lantanae*) can cause dead patches on stems, leaf stalks and leaves, and sometimes systemic infection leading to stem dieback. With the assistance of Michael's team in Australia, and Carol Ellison, Sarah Thomas and colleagues at CABI in the UK, we were able to determine that New Zealand lantana (both the pink and orange forms) is susceptible to both pathogens and that no other significant damage to beneficial plants was likely to occur. With Northland Regional Council as applicant, a successful case was then made to the Environmental Protection Authority to release the rusts in 2012.

Once our new plant pathogen facility was up and running in Auckland in 2013 we imported both rusts with the aim of getting mass-rearing and releases under way. Unfortunately we ran into some unexpected problems. "The lantana leaf rust shipment was found to be contaminated with another fungus and by the time we had identified the contaminant and demonstrated that it would not be a risk, the spores were no longer viable," explained plant pathologist Maj Padamsee. Another shipment was sourced and tested for viability on arrival, but we found that it was quickly rendered non-viable through storage at 4°C. However, with this knowledge it was third time lucky with another shipment received from Michael in spring 2014.

Things also did not go smoothly with the first shipment of the blister rust in 2013. Infected plants shipped from the UK got held up in transit and were slower than expected to develop symptoms. Spores were eventually produced and used to infect plants. However, after initial signs of successful inoculation the

Plant infected with lantana leaf rust.

plants outgrew the symptoms and the rust colony was lost. While the plants were relishing the conditions in the facility, it was clearly too dry for the rust. Therefore humidity chambers were constructed to ensure the necessary 100% humidity could be achieved when needed. Then last spring Sarah Thomas kindly delivered a second shipment of the blister rust by hand and, with the benefit of her experience, successful infection was achieved.

Maj, and Chantal Probst, have managed to successfully bulk up both rusts over the summer and obtain permission to take them out of containment. Releases of both rusts are scheduled to get underway this autumn. Since both require warmth and moisture for infection, spring and autumn are the best times for releases. The climatic requirements of the two rusts differ slightly. The lantana leaf rust is subtropical whereas the lantana blister rust is tropical. Consequently, we expect the lantana leaf rust to be active across a wider area in New Zealand, including the more southern parts of lantana's range, while the lantana blister rust may be limited to the warmer and wetter areas of the Far North.

This project is funded by the National Biocontrol Collective with additional funding provided by Northland Regional Council, Auckland Council, Bay of Plenty Regional Council, and Greater Wellington Regional Council.

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National Biocontrol Assessment Protocol

An important component of all biocontrol projects is assessing how successful they have been. Proof of impact is needed to back up anecdotal evidence that agents are doing a good job and provide justification for continued investment in biocontrol. It is equally important to also identify where agents are not up to scratch so additional species can be sought to strengthen the attack or alternative control methods developed. However, the cost of undertaking assessment studies has to date proven to be a major obstacle both in New Zealand and worldwide. When a project has clearly been highly successful it is unappealing to channel further resources into a former problem when so many others still require attention. Likewise if a project appears to have failed there is little incentive to spend precious resources documenting this in more detail, although there is a danger here that changes are actually happening but are too subtle to be easily noticed. "However, the National Biocontrol Collective (NBC), the major funder of the development and release of new weed biocontrol agents in New Zealand, has recently strengthened its commitment to ensuring that some assessment is undertaken," confirmed Lynley Hayes. They asked Landcare Research to develop a suitable protocol outlining minimum standards plus further options where additional resources are available.

Scientists at Landcare Research have thought long and hard about how assessment could be tackled in a simple and cost-effective manner yet still yield useful data. "Our suggested approach is to get NBC field staff to collect simple data from many sites around the country but only when it is essential to do so," explained Lynley. Members of the NBC have indicated that they are interested in obtaining data they can share with colleagues, managers, councillors and ratepayers, rather than the loftier goal of obtaining data that could convince scientists. Data that demonstrate a correlation will therefore generally suffice, rather than conclusive proof of cause and effect (which is much more difficult and expensive to obtain). Where possible, information that could be published in peer-reviewed journals will be collected. "Landcare Research will continue to use government funding to undertake more complex cause-and-effect population and ecosystem-level studies for a few flagship projects, and to assess the impact of agents that target reproductive structures only," said Lynley. Because seed-, fruit- and flower-feeders do not impact on existing weed populations, but rather the future replacement of them, this type of assessment is more challenging and so has been excluded from the national protocol, at least for the time being.

The NBC met twice in 2014 to discuss the proposed protocol and suggest refinements. "There are five possible steps, and the number of steps an organisation undertakes depends on results achieved, resources available and the level of proof required," explained Lynley. A lead organisation will be nominated to take overall responsibility for ensuring adequate follow-up occurs for each biocontrol agent. The lead organisation will generally be the one that acted as the applicant to release that agent, and will act as a project champion, involving other organisations as necessary. NBC members will collect data for the weeds that are considered significant in their region. The lead organisation will compile and share the information with those with an interest in it.

Step One: Agree Desired Outcomes & Collect Baseline Data

A key first step is to clarify what successful weed biocontrol would look like. The NBC agreed to a single desired end outcome: that where weeds are widespread, their harmful impacts will be reduced; and where weeds are less widespread (or absent), they will be prevented from becoming a problem. Intermediate outcomes to show if progress is being made towards the end outcome include demonstrating a reduction in weed abundance, density or vigour.

Due to the limitations of current data it will largely be necessary to start collecting baseline data for current weed targets from scratch rather than build on existing datasets. Nationwide, 10–20 good potential, or actual, release sites will be selected taking into account significant regional and national variation. Photos of the sites will be taken. Some sites/weeds will lend themselves to photos that can be analysed using digital software, but if not, ordinary before-and-after shots will be taken to provide a visual record. If the site is already a release site, the abundance of agents present, or their damage levels, will be assessed and recorded. The weed infestation at the site will be defined as either major (as far as eye can see), moderate (>100 m^2), or minor (<100 m^2). At the densest accessible point the percentage cover of the weed (and height for some species) will be estimated. These photos and measurements will be repeated every 2–3 years.

Step Two: Check for Establishment

NBC members will visit at least 75% of release sites at least once to check whether agents they have released have established. The release point will be checked for 5 minutes, following by wider searching of the site for 10 minutes. If agents fail to establish then no further monitoring will be undertaken. If establishment is uncertain, a watching brief will be kept for at least 10 years.

Step Three: Assess Agent Population Build-up/Damage Levels

If the agent has clearly established then its population or damage levels will be evaluated. Where it is easy to collect/count individual

Initial measurements of a weed infestation will be made before agents are released to provide baseline information.

insects, population size will be estimated using broad categories (tens/hundreds/thousands). The method used will depend on the agent: e.g. beat bushes a set number of times, or estimate the number seen over a set time period, etc. Damage will be estimated for pathogens and also where insect population assessments will be difficult for cryptic species. The following categories will be used: occasional (signs of damage present but not common), patchy (signs of damage are present but are variable throughout the site, e.g. some plants may have no damage, and others may have heavy damage but this would be rare), heavy (the majority of plants are showing signs of damage and at least some plants are beginning to show signs of severe defoliation/damage or stress), and heavy (severe damage is obvious and widespread).

If agent population/damage levels are low, a watching brief will be kept for at least 10 years. If they remain low, more research may be required to understand why. If agent populations are high or damage appears significant then the impact on the weed population will be measured. Some members of the NBC may also check for non-target damage to support Landcare Research's efforts to follow up on this for all species released, and study how widely dispersed agents are to inform redistribution efforts.

Step Four: Assess Impact on Weed Population

The impact of an agent on the weed population will be assessed by continuing to take photos and measure weed abundance and agent population/damage levels every 2–5 years. Some organisations may choose at this point to set up plots that can be manipulated experimentally to prove cause and effect. If no impact is measured then again further research may be needed to understand why. However, if an impact on the weed population is measured through either method then the ecosystem consequences of this can be evaluated and an economic analysis of the project undertaken.

Step Five: Assess Ecosystem Consequences & Undertake Economic Evaluation

Ecosystem consequences will be evaluated through continuing to take photos and measure weed abundance and agent population/damage levels every 5–10 years. Some organisations may again choose at this point to set up experimental plots from which more detailed measurements of change can be made, such as what species are replacing the weed. Organisations may also opt to undertake an economic evaluation of the costs and benefits provided by the project.

"Assessment activities based on the above protocol will get underway in 2015. Detailed instructions and forms have been prepared for the projects that are ready to begin now: broom (*Cytisus scoparius*), Japanese honeysuckle (*Lonicera japonica*), lantana (*Lantana camara*), privet (*Ligustrum* spp.), tradescantia (*Tradescantia flumeninsis*), and woolly nightshade (*Solanum mauritianum*). These are available from the Landcare Research website (see Changes to Pages, pg 3). "In 2016 we will review how well the protocol is working and if necessary make some tweaks," concluded Lynley.

The National Biocontrol Collective consists of 12 regional councils/unitary authorities nationwide plus the Department of Conservation.

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Autumn Activities

There are a few things you might want to fit in before the wind-down towards winter. We would be very interested to hear about what you find.

Broom gall mite (*Aceria genistae*)

- Check release sites for galls, which look like deformed lumps and range in size from 5 to 30 mm across. Very heavy galling has already been observed at some sites (see photo).
- Harvesting of galls is best left until spring when predatory mites are less abundant.

Gall-forming agents

- Early autumn is the best time to check release sites for many gall-forming agents. If you find large numbers of galls caused by the mist flower gall fly (*Procecidochares alani*) and hieracium gall wasp (*Aulacidea subterminalis*), you could harvest mature ones and release them at new sites.
- Do not collect galls caused by the hieracium gall midge (*Macrolabis pilosellae*) as 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 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.

Tradescantia leaf beetle (*Neolema ogloblini*)

- Check release sites, especially the older ones. 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. You may see the dark metallic bronze adults but they tend to drop or fly away when disturbed. It may be easier to spot the larvae, which have a distinctive protective covering over their backs. The white, star-shaped pupal cocoons may be visible on damaged foliage. To see damage you may need to look at the older leaves lower down in the canopy.
- We would not expect you to find enough beetles to be able to begin harvesting and redistribution just yet.

Rob Simons

Heavily galled broom at a release site in Hanmer Springs.

Tradescantia stem beetle (*Lema basicostata*)

- Check release sites, especially the older ones. The black knobbly adults also tend to drop when disturbed, but look for their feeding damage, which consists of elongated windows in the upper surfaces of leaves or sometimes whole leaves consumed. The larvae inside the stems will also be difficult to spot. Look for stems showing signs of necrosis or collapse and brown frass.
- It may be possible to begin harvesting and redistribution at some sites soon, but spring would be the best time to do this.

Tradescantia tip beetle (*Neolema abbreviata*)

- Most release sites are still quite new but there is no harm in looking. The adults are mostly black with yellow wing cases, but like the other tradescantia beetles tend to drop when disturbed. Larvae will also be difficult to see when they are feeding inside the tips, but brown frass may be visible. When tips are in short supply the slug-like larvae feed externally on the leaves.
- We would not expect you to find enough beetles to be able to begin harvesting and redistribution just yet.

Woolly nightshade lace bug (*Gargaphia decoris*)

- Autumn last year was when the first substantial, damaging outbreaks of the lace bug were noticed in the Bay of Plenty. Check release sites by examining the undersides of leaves for the adults and nymphs, especially of leaves showing signs of bleaching or black spotting around the margins.
- It is probably best to leave any harvesting of lace bugs until spring.

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