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Weed Biocontrol

WHAT'S NEW?

Contents

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St John's wort beetles

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The Economic Benefits of Two Beetles

Does anyone remember St John's wort (*Hypericum perforatum*)? This nasty plant was one of the four worst weeds in New Zealand in the 1930s. St. John's wort infestations were particularly serious in hill-country grazing land, reducing productivity and poisoning livestock due to a toxin known as hypericin. Today, many people are unaware of the detrimental impacts this weed had on pastures and the plights of hill-country farmers, because the weed has all but disappeared. The St. John's wort weed biocontrol programme is also a great international success story. For example, biocontrol reduced St. John's wort infestations in California by over 99% in just 10 years.

The reprieve from St. John's wort is thanks to two chrysomelid beetles, the lesser St John's wort beetle (*Chrysolina hyperici*), and the closely related greater St John's wort beetle (*Chrysolina quadrigemina*), released in New Zealand in 1943 and 1965 respectively. Only 4 years after release, the lesser St John's wort beetle, alone, was reported to have cleared over 180 ha of the weed in the Marlborough district. Although evidence is mostly anecdotal, insecticide exclusion experiments in New Zealand indicated higher densities of St. John's wort in the absence of the beetles. Another study reports that small infestations appearing after disturbance, or plants grown for medicinal purposes, are quickly colonised and destroyed by the beetles.

Recently, two of our weed biocontrol researchers, Simon Fowler and Ronny Groenteman, along with James Barringer (MWLR – Informatics) and Grant Humphries (Black Hawks Data Science Ltd., Scotland) revisited the history books to conduct an ex-post economic analysis of this most spectacular programme. "This is the second ex-post economic analysis of weed biocontrol in New Zealand after ragwort (*Jacobaeae vulgaris*). Other economic analyses of weed biocontrol in New Zealand have been ex-ante, assessing possible benefits of future weed suppression," explained Simon. "The analysis was multifaceted, pulling together predictions on expected modern day

St John's wort beetle

An insecticide exclusion trial showing the impact of the beetles

geographic range and past spread of St John's wort, with data on economic losses caused by St John's wort, and comparing this to annual investment in weed biocontrol research (all cost adjusted for the year 2022)," he added.

The starting point was to estimate the spread of St John's wort by 2022 if biocontrol had never been implemented. There was very little historical data on the extent of St John's wort pasture invasion, and what little information was available confirmed that it had probably not reached its maximum potential range when the biocontrol programme was first started in 1943. So the team had to make some inferences. The expected range of St John's wort for the present day was simulated using ecological niche modelling overlaid with GIS-mapped land-use vulnerabilities to model the potential range of St John's wort in South Island pastures that would have been affected economically by the weed. Overall, 660,000 ha was the final estimated figure of maximum saturation, which would have been reached just after 1989 in the absence of biocontrol.

Next, production losses (using stocking rate data reported for extensive South Island sheep farms) were calculated, along with estimates of the predicted pasture displacement that would occur. The amount of return a farmer can make off the land was estimated at $65.48/ha (2011 value), and it was conservatively assumed that farmers would make efforts to control the weed, but with serious infestations would still lose 30% of their productive land to St John's wort. Overall, we predicted that total annual losses to South Island farmers from St. John's wort in the absence of biocontrol would have been $0.119 million in 1940, increasing logistically to $15.7 million in 2022 (with both figures at 2022 rates).

The next piece of the puzzle was working out what NZ had invested in SJW biocontrol over the years. The team used excellent historical records of NZ biocontrol activity to estimate the cost of the programme started in 1943 and ran intermittently until 1993.

"To work out the present value (PV), each annual productivity loss, or biocontrol cost, was inflated at 4% each year, from when it occurred through to 2022," explained Simon. "We then calculated the net PV benefit of biocontrol as the cumulative PV of annual productivity losses (1940–2022) *without* biocontrol, less the cumulative PV of annual productivity losses (1940–2022) *with* biocontrol," he added. The benefit–cost ratio is then calculated as the net PV benefit of biocontrol divided by the total cumulative PV of biocontrol costs.

The final results of the cost benefit analysis showed that biocontrol of St. John's wort provided an ongoing, annual national benefit, in terms of improving pasture productivity, of $15.5 million in 2022. To put this saving in perspective, NZ's current annual investment in all weed biocontrol is around $1.34 million (i.e. just 9% of the ongoing annual benefit that NZ is receiving from the SJW biocontrol programme alone). The PV analysis shows that the 2022 benefit-cost ratio was 6254:1: i.e. NZ has gained $6254 for every $1 invested in SJW biocontrol. All these analyses were robust to substantial sensitivity testing. As with all such historical analyses, there are uncertainties and caveats. For example, we cannot be certain whether biocontrol was responsible for all the reductions in St. John's wort, and whether the biological suppression of St. John's wort led to any secondary weed invasion of pastures. Nevertheless, it does seem certain that the benefits of biocontrol of St. John's wort to NZ have been huge, and are self-sustaining. Of course, the benefit that NZ continues to get from SJW biocontrol can be so easily overlooked when we are no longer confronted with SJW as a weed problem!

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The Highs and Lows of Cost–Benefit Analyses

New Zealand is one of only a handful of countries in the world which have been historically very active in classical biological control of weeds. Since the 1920's New Zealand has released 69 biocontrol agents against 28 weed species. Notable successes that have been analysed economically include the suppression of pasture weeds such as ragwort (*Jacobaeae vulgaris*) and St. John's wort (*Hypericum perforatum*). Such economic analyses are still rather rare globally for weed biocontrol.

Cost-benefit analyses are a tricky beast to wrangle, but they are a necessary exercise in self-reflection that is not explored enough in the weed biocontrol space. There is a plethora of difficulties with analysing cost-benefits for any weed biocontrol project. Economic losses caused by the weed and records of weed control costs are either spotty or non-existent. This is particularly hard when environmental weeds targeted for biocontrol are often not being extensively (and expensively) controlled currently so we lack baseline economic cost data for them. Also with biocontrol programmes, the limited financial resources available to fund programmes are unsurprisingly pushed toward activities that lead to successful agent release, whilst monitoring and evaluation after release, which are needed to quantify outcomes and assign value, are neglected.

We asked Dr Simon Fowler, weed biocontrol researcher at MWLR why so few economic studies have been completed in New Zealand. "Cost-benefit analyses can be relatively straightforward when you have easily quantifiable, market-based measurements. Weeds that heavily impact the agricultural sector such as ragwort and St John's wort are ideal for this since we can work out the economic losses and costs involved in controlling them from historic records. Environmental weeds, on the other hand, are much harder to evaluate. To begin with, environmental weeds are often seen as beyond control over much of their ranges, so money is not invested in them, giving us no starting point for weed control costs. This is the first problem we have with cost-benefit analyses of environmental weeds" explained Simon. "The second problem is that there are issues with determining how to put a value on environmental benefits e.g. how do we monetarise reductions in biodiversity losses and improvements to ecosystem services, which often comprise the bulk of the benefits from environmental weed biocontrol (and are the primary reason for undertaking the programmes in the first place).


A nodding thistle infestation

With these limitations, it is not surprising that cost benefit analyses are few and far between when so many of the weeds the team and its sponsors choose to target have primarily environmental impacts.

There are currently no universally agreed criteria for cost-benefit analyses of productive sector or environmental weeds. This is an area of research that really needs expanding. The language of the economy is money, and weed biocontrol researchers need to translate their work into this language if they want to be heard.

With this in mind, Simon and the team recently decided to undertake their most comprehensive weed biocontrol cost benefit analysis yet. The team was inspired by a pioneering study by Australian researchers A.R Page and K.L Lacey from the AEC group who, in an extensive analysis, collated data across all weed biological control programs in Australia (past and current) to determine the economic benefit in investing in biocontrol to control pest plants.

The New Zealand analysis collated data on 6 historical projects where we are sure that biocontrol has suppressed the target weeds to a substantial extent and data were extensive enough to analyse. These included:

- three agricultural weeds – ragwort, St John's wort, nodding thistle (*Carduus nutans*)
- two environmental weeds – mist flower (*Ageratina riparia*) and heather (*Calluna vulgaris*)
- one weed that was both an agricultural and an environmental weed – alligator weed (*Alternanthera philoxeroides*).

Quite a few more recent programmes were judged as ongoing or too recent to assess economically such as biocontrol of tradescantia, broom, Californian thistle and buddleja.

For the analysis, we compiled costs associated with these 6 weed species in the absence of biocontrol. We then estimated the impact of biocontrol on reducing these weed costs. Finally, we estimated the total costs of the classical biological control programmes against weeds in NZ (for all weed targets, whether any success was achieved or not).

“The results were staggering” says Simon. “Overall, New Zealand spends only a little more than $1 million on weed biocontrol per year: the figure was NZ$1.34 million for 2022 for example. The three most economically successful weed biocontrol programmes in New Zealand (ragwort, SJW and nodding thistle) yielded an annual saving of $84.7 million in 2022.

But not everything came up roses. The analysis also highlighted differences in cost-benefit ratios between agricultural vs. environmental weed programmes. Overall, environmental weed biocontrol programmes provided a negative return on investment of between 0.88:1 - 0.46:1. With hindsight, this was not surprising: the main reason is that it remains a challenge to monetarise reductions in biodiversity losses, improvements to ecosystems services or benefits to human/animal health. This is disappointing, since benefits in these usually non-market values are the main purposes for controlling environmental weeds. “Unfortunately, until we can find acceptable and appropriate methods to monetarise benefits to biodiversity, ecosystems services or animal/human health, there is little value in continuing to run traditional economic analyses on environmental weeds that are based only on relatively easily quantified market-based evaluations” said Simon.

Fortunately, the analysis has demonstrated some very convincing evidence that there is a highly positive net gain in weed biocontrol for productive sector weeds. The three weed biocontrol projects in New Zealand that show the greatest economic gains produce enough ongoing annual dollar-benefit to dwarf the costs of the entire weed biocontrol programme year on year. The analysis also highlights the need to investigate ways to value the suppression of environmental weeds. Cost-benefit analyses are used to translate what we as weed biocontrol researchers know and see, to the wider economy in order to justify its investment in our work. Without meaningful valuation criteria we are a bit stuck. Alternative methods of assessing benefits versus costs do exist such as multi-criteria analysis, and are worth exploring for weed biocontrol. But for now, in NZ, a reliance on cost-benefit analyses in the regional pest management strategies of many of our major sponsors is required by the Biosecurity Act (1993).
This project was funded by Manaaki Whenua – Landcare Research's Beating Weeds Programme funded by the Ministry for Business, Innovation and Employment Strategic Science Investment Fund MBIE- SSIF).

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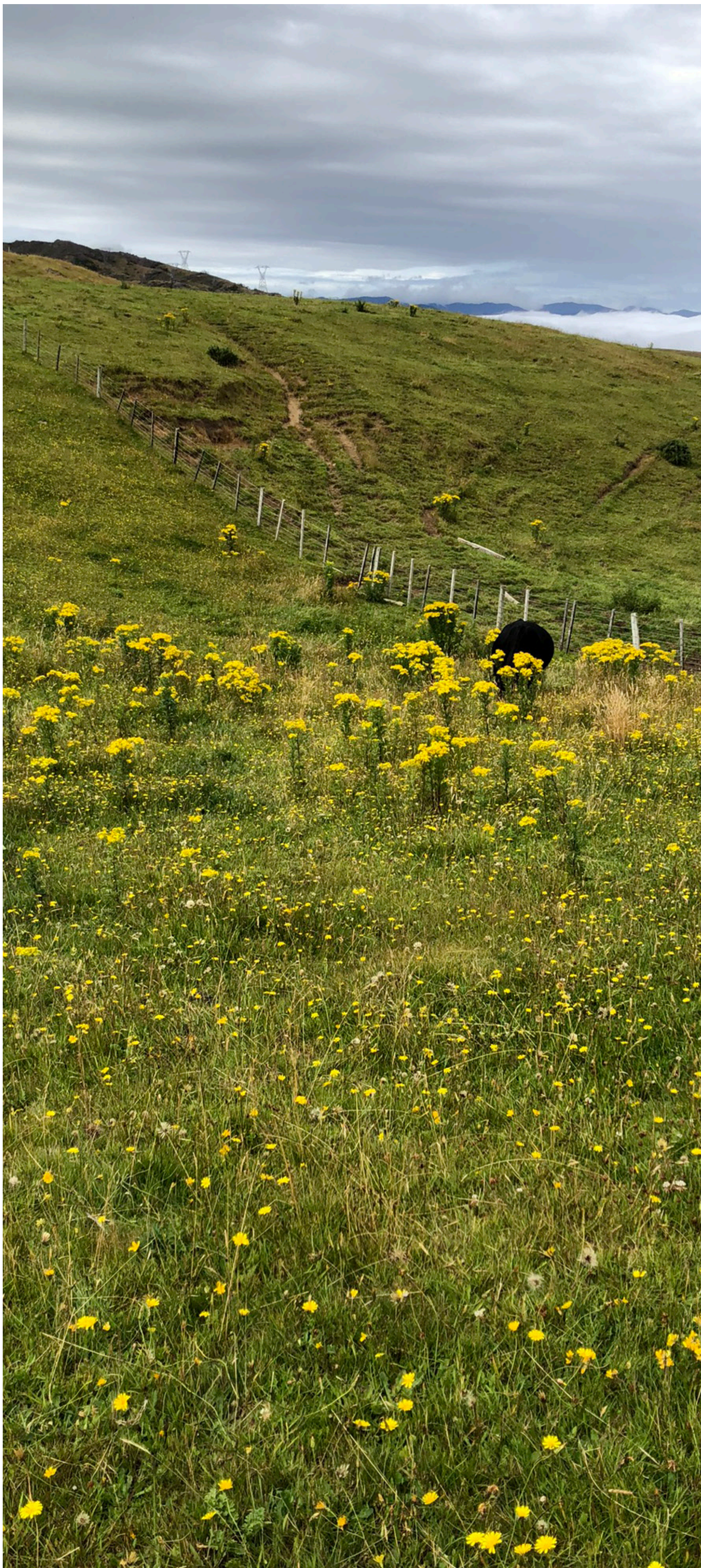

A ragwort infestation

Weed Biocontrol in the Cook Islands Shows the Way for Others

MWLR is assisting eight developing countries in the Pacific to develop biocontrol programmes for their most problematic invasive weeds as part of the Pacific Regional Invasive Species Management Support Service. By managing invasive weeds in the Pacific, the health and resilience of ecosystems significantly improves over time, supporting communities and islands to be able to adapt to the impacts of climate change. This increased involvement in the Pacific was launched off the back of MWLR's longest-running weed biocontrol programme in the Cook Islands, which has been underway for nearly a decade. The programme began in 2014 and set out to target six weeds on the main island of Rarotonga. Seven weed biocontrol agents have now been successfully released, and the project has moved into its monitoring phase to measure the outcomes of the work. We're happy to report that the team already has a lot to boast about!

In their most recent visit to Rarotonga during July/August this year MWLR staff conducted surveys to assess progress and explore the use of remote-sensing technology to monitor weed populations and measure the long-term impacts of the biocontrol agents released. Baseline data on the extent of weed populations at the outset of weed biocontrol projects are often poor, at best, making it difficult to make the case for action and demonstrate the impact of biocontrol over time. The move to using this new technology has been needed for a while, because it will provide much more accurate data on weed distributions, on a more efficient scale for collection. "It is a big step up in data collection compared to transect surveys and ground-based photo points," said Lynley Hayes, who is leading the Pacific programme of work.

The drone with claw flying in Rarotonga

During the trip to Rarotonga earlier this year, the MWLR team led by Senior Field Technician, Paul Peterson, trialled the use of satellite imagery (50 cm resolution), imagery from an aeroplane (10 cm resolution), and drone close-up imagery (less than 4 cm resolution) to investigate which approach is likely to be the most cost-effective and practical for future use.

In addition to using RGB (red, green, blue; i.e. visible) photography, the team collected multi/hyperspectral imagery to capture reflected light that can't be seen with the naked eye. They also used LiDAR, which is a method for determining ranges by targeting an object or a surface with a laser and measuring the time for the reflected light to return to the receiver. "It is likely that a combination of these methods will be used to produce weed distribution maps that we can use to monitor weed densities over time after biocontrol introductions", explained Paul. By using these innovative appooaches, we are not only improving how we measure the climate impact of our work, but these techniques can be adapted and used by others as part of our fight against the climate and biodiversity 'twin crises'.

One of the weeds the team chose to focus on in these trials is the African tulip tree (*Spathodea campanulata*), which is considered one of the 100 worst alien invasive species in the world and is widespread throughout much of the Pacific region. African tulip trees are large trees that grow fast in disturbed areas, outcompeting native flora to take a dominant position in the canopy. They have large, bright red-orange flowers, which makes them easy to distinguish from the air when they are in flower from May to August, making them an ideal weed to monitor by aerial surveillance.

Two natural enemies of the African tulip tree have been released in Rarotonga. A gall-forming mite (*Colomerus spathodeae*) that stunts new growth was released in 2016 and quickly became well established and widespread. Galled leaves are easy to see, even when they are high up in tall trees. However, establishment of a leaf-mining flea beetle (*Paradibolia coerulea*) released in 2021 has been more difficult to determine. Beetle damage is quite subtle at low population levels, and difficult to spot up in the canopy, where it is suspected the beetles may be most active. This required Paul and his team to test another expensive tool at their disposal.


Balloon vine rust in Rarotonga

On their recent trip the team used a drone to take close-up images of the canopy. The drone was also equipped with a special claw attachment to sample foliage to look for signs of the beetles and their larvae. "This indicated that establishment of the flea beetle is looking likely. The RGB, multi/hyperspectral imagery, and LiDAR taken of the canopy have also been a success and will serve as the baseline data for long-term monitoring," said Paul. It is hoped the beetle population will build up to damaging levels over the next few years, causing tree defoliation, which the team will be able to measure in the canopy composition across Rarotonga.

And now for some other exciting updates from the Cook Islands. The most impressive biocontrol agent released in the Cook Islands to date, the balloon vine rust fungus (*Puccinia arechavaletae*), still has its host, grand balloon vine (*Cardiospermum grandiflorum*), well under control. The balloon vine rust fungus was released in Rarotonga in 2017, and within 6 months a 90% decrease in balloon vine cover was achieved at some sites. Within 2 years the total percentage cover of the vine at the 20 release sites declined from over 75% to under 30%.

As part of best practice MWLR regularly undertakes field surveys to check for unanticipated non-target damage from weed biocontrol agents. The team checked on the two closest relatives of balloon vine in Rarotonga, broad-leaved hopbush (*Dodonaea viscosa*) and *Allophylus timorensis*, and were able to confirm a clean bill of health with no sign of non-target attack, as predicted by host-range testing before release.

Progress is also being made against two other vines. A rust fungus (*Puccinia spegazzini*) is reducing the abundance of mile-a-minute (*Mikania micrantha*) at inland sites, although it appears to be much less effective in the coastal lowlands. Also, the red postman butterfly (*Heliconius erato*), which was released to control red passionfruit (*Passiflora rubra*), is now a common sight in Rarotonga.

This attractive butterfly is also the subject of an evolutionary study being led by Assistant Professor Gabriela Montejo-Kovacevich, who was formerly based at the University of Cambridge but has recently begun work at the Uppsala University in Sweden. This study is investigating potential changes in the butterflies due to different evolutionary pressures in Rarotonga compared to its native range; for example, the butterfly has fewer natural enemies in Rarotonga than in South America.

Lastly, two other biocontrol agents released in Rarotonga, a scale insect (*Tectococcus ovatus*) for strawberry guava (*Psidium cattleyanum*) and a rust fungus (*Puccinia xanthii*) for cocklebur (*Xanthium pungens*), were checked on. Populations of scale insects appear to be slowly building, and the rust is continuing to reduce the vigour of its host plant.

In summary, the recent, highly successful Cook Islands trip has provided more crucial markers for monitoring the impact of the biocontrol agents released, and has confirmed proof of concept for the new technology, which is encouraging for future use across the Pacific. A strong foundation has been built in the Cook Islands from which future benefits will be reaped. The lessons learnt can be used to help other Pacific Island nations as new biocontrol agents, currently in development, become available.

This project is part of the Managing Invasive Species for Climate Change Adaptation in the Pacific programme, which is funded by New Zealand's Ministry of Foreign Affairs and Trade. This project would not have been possible without considerable international collaboration and assistance from: Cook Islands Ministry of Agriculture, Cook Islands National Environment Service, Droneworks Consultancy, Rhodes University, Te Ipukarea Society, University of the South Pacific, Federal University of Viçosa, United States Department of Agriculture, and United States Forest Service.


Aerial imagery showing African tulip tree infestation

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Summer Activities

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 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 move across.

Giant reed gall wasp *(Tetramesa romana)*

- Check release sites for swellings on the stems caused by the gall wasps. These look like small corn cobs on large, vigorous stems, or like broadened, deformed shoot tips when side shoots are attacked. The galls often have small, circular exit holes made by emerging wasps.
- It will probably be too soon to consider harvesting and redistribution if you do see evidence of the gall wasp establishing.

Green thistle beetles *(Cassida rubiginosa)*

- December is often when green thistle beetle activity is at its peak. Look for adult beetles, which are 6–7.5 mm long and green, so they are well camouflaged. 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. Please let us know if you discover an outbreak of these beetles.

Honshu white admiral *(Limentitis glorifica)*

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

Moth plant beetle *(Freudeita cupripennis)*

- This beetle is now well established in Northland, Bay of Plenty and Waikato. Look for adult beetles on the foliage and stems of moth plant. The adults are about 10mm long with metallic orangey-red elytra (wings) and a black head, thorax and legs. The larvae feed on the roots of moth plant so you won't find them easily.
- It will probably be too soon to consider harvesting and redistribution if you do find the beetles.

Tradescantia yellow leaf spot *(Kordyana brasiliensis)*

- Look for the distinctive yellow spots on the upper surface of the leaves with corresponding white spots underneath, especially after wet, humid weather.
- The fungus is likely to disperse readily via spores on air currents. If human-assisted distribution is necessary, again you will need permission from MPI to propagate and transport tradescantia plants. These plants can then be put out at sites where the fungus is present until they show signs of infection, and then planted out at new sites.

Tutsan beetle *(Chrysolina abchasica)*

- The best time to look for this agent is spring through to mid-summer. Look for leaves with notched edges or whole leaves that have been eaten away. The iridescent purple adults are around 10–15 mm in size, but they spend most of the day hiding away so the damage may be easier to spot. Look also for the creamy-coloured larvae, which are often on the undersides of the leaves. They turn bright green just before they pupate.
- It will be too soon to consider harvesting and redistribution if you do find the beetles.

Tutsan moth *(Lathronympha strigana)*

- Look for the small, orange adults flying about flowering tutsan plants. They have a similar look and corkscrew flight pattern to the gorse pod moth (*Cydia succedana*). Look also for fruits infested with the larvae.
- It will be too soon to consider harvesting and redistribution if you do find the moths.

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

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