What's New In Biological Control Of Weeds?

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What's Inside:

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Treading Gingerly in India

With their showy, scented flowers *Hedychium* species are very popular ornamental plants worldwide. There are around 50 species in the *Hedychium* genus and they are native to central and south-eastern Asia with high concentrations in southern China and the Himalayan regions. In countries like New Zealand and Hawai'i, where *Hedychium* species have managed to jump the garden fence, they have become highly aggressive invaders of forest habitats.

Kahili ginger (*Hedychium gardnerianum*), and yellow ginger (*H. flavescens*) have proven to be extremely difficult to control in New Zealand using traditional methods, mainly because the infestations are so numerous and widespread, and biocontrol has increasingly been seen as a desirable option. The same wild ginger species plus white ginger (*H. coronarium*) are problematic in Hawai'i. White ginger is present in New Zealand but not considered a problem, yet... White and kahili ginger flowers are used for leis and other floral displays in Hawai'i – an important conflict of interest that will need to be resolved before any biocontrol agents can be released there.

Ginger cultivation enthusiasts often state that part of the appeal of growing *Hedychium* species is that they are relatively pest and disease free. Also, little information about the natural enemies of wild ginger is available in the literature. By contrast the pests of economically and culturally important species in the Zingiberaceae family, such as edible ginger (*Zingiber officinale*) and cardamom (*Elettaria cardamomum*), are well documented.

So finding out what, if any, natural enemies of wild ginger exist in its native range was therefore an essential first step in exploring the possibility of biocontrol for these

CABI Europe-UK

Kahili ginger is a well-behaved, innocuous plant in its native range.

species. Recently CABI Europe–UK has begun surveys of wild ginger in India. India is a long-standing member country of CABI, and CABI has an office in New Delhi, making them ideally placed to conduct the surveys.

"India is not the easiest place to work in, especially with recent changes in legislation," reports Djami Djeddour of CABI. New laws aimed at promoting conservation of biological diversity and equitable sharing of benefits arising out of the use of biological resources currently makes it extremely difficult to export any species, dead or alive, even for identification purposes. "This remains a major hurdle to be overcome if the project is to succeed," cautioned Djami. This type of impediment to biocontrol projects is unfortunately becoming increasingly common. In India non-nationals may not collect any material from the field without prior notification and authorisation from the National Biodiversity Authority or appropriate state institutes, so CABI has initiated communications and collaborations with a network of Indian scientists including forestry institutes, national bureaux and research centres to facilitate this and other biocontrol projects.

CABI Europe-UK

Damage caused by unknown insect on white ginger.

The initial survey in October 2008 was timed to coincide with the purported flowering period to make it easier to find and identify the plants (as the keys for this genus generally use floral characteristics), and to avoid the summer monsoon period. Identifying *Hedychium* species in the field still proved to be quite a challenge as most plants had in fact moved on to the fruiting stage and had to be identified by their leaves and stems and through local knowledge. Since *Hedychium* species also hybridise quite readily, molecular studies will be needed to clarify how the plants found in India compare with the weed populations needing to be controlled in New Zealand and Hawai'i. In particular when looking for prospective pathogens, which can be host-specific in the extreme, it may be necessary to look in places that provide a good match to find suitable strains.

The three wild ginger species of interest were located in a range of habitats from roadsides and gardens through to forests. "It was extremely heartening to see that all were being subjected to attack from a suite of natural enemies (both insects and pathogens) with damage being inflicted on all parts of the plant," reports Djami. The wild ginger was growing in equilibrium with native vegetation and not exhibiting any of the invasive traits that we see in New Zealand or Hawai'i. Close relatives, such as edible ginger and cardamom, were often growing in close proximity to the wild ginger allowing observations of the natural field host-range of the prospective control agents, and allowing some insect species to be discounted immediately for lacking sufficient specificity. However, most of the specimens collected still need to be identified and, given that they can't be taken out of India, this may take some time.

CABI Europe-UK

Pathogen having a serious impact on yellow ginger.

As well as identifying the material already collected, further surveys are needed to ensure that nothing is overlooked. Normally several surveys are needed to pick up all prospective agents and it is important to look across a wide geographic distribution as well as in different seasons. Early monsoon (June–July) has been identified as the best time for the next survey, so don't forget to pack your raincoats guys!

This project is funded by the National Weed Biocontrol Collective (New Zealand), and The Nature Conservancy of Hawai'i, the United States Geological Survey, and the Pacific Islands Ecosystem Research Centre.

A Stitch in Time?

We have been making some headway over the last 12 months in the uphill battle against Chilean needle grass (*Nassella neesiana*) in Australia and New Zealand. During this time a new infestation of this damaging grass was found in North Canterbury, confirming fears that despite comprehensive measures to contain it, it was only a matter of time before the weed became more widespread, and increasing the urgency to find better control methods.

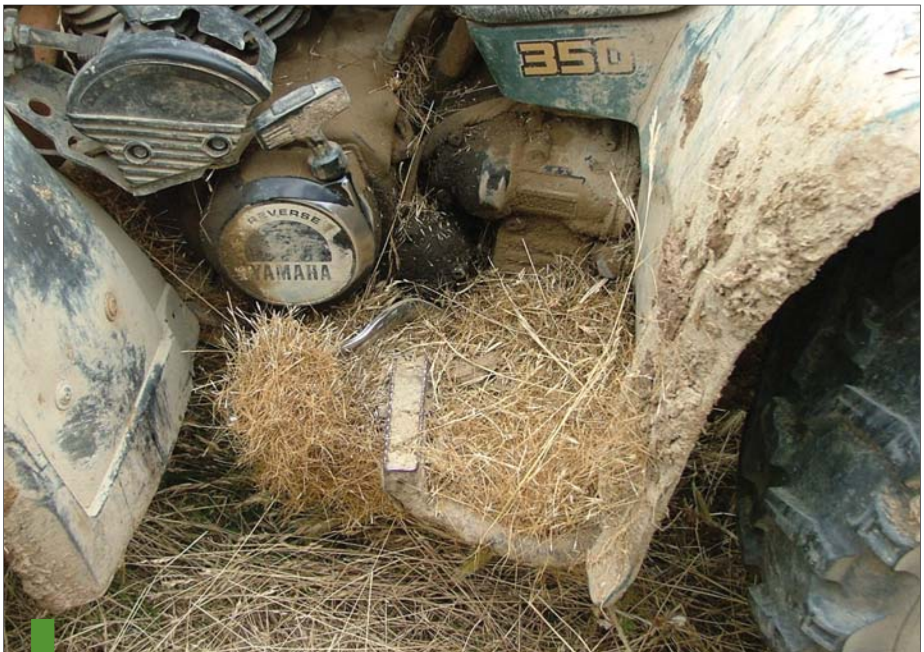
Through great perseverance David McLaren (Department of Primary Industries, Australia) has finally secured permission to import into Argentina the grass species we need to include in host range testing. This means that they can now be tested by Freda Anderson and her team of assistants (CERZOS-UNS) for their susceptibility to the most promising potential agent, a rust fungus called *Uromyces pencanus*. Unfortunately, they will need to do this testing in a plant containment facility at Castelar, a town near Buenos Aires, rather than in their own glasshouse at Bahía Blanca. Still, for a while there it looked as though host range testing would have to be done outside of Argentina. "While there will be lots of logistical difficulties with having to move ourselves and our equipment 700 km north, it is still a much better option than shifting the testing to South Africa or the UK!" observed Freda.

Further good news was received in January: David's application to the Australian Government for a further 12 months of funding, for the 2009 calendar year, was successful. Due to the delays in getting the seed to Freda she was unlikely to be able to complete the host range testing by the end of 2009, but fortunately, New Zealand was able to "step into the breach". Freda was thrilled to hear that funding pledged by the National Biocontrol Collective for the 2009/10 financial year will run until the end of June 2010. "I was having sleepless nights about getting everything finished between June (when the first test plants should be ready for inoculation) and December," said Freda, "so it is a huge relief to know we have a few more months up our sleeves."

New Zealand funding also allowed Jane Barton to visit Freda again in February to help with the project. On this trip Jane carried with her a very precious parcel: Chilean needle grass seeds from Marlborough and Auckland. Freda had found previously that the isolate of *Uromyces pencanus* that worked best against Australian Chilean needle grass did not attack populations from Auckland or the Hawke's Bay, but she had been unable to test it against material from Marlborough populations, due to the difficulties in getting seed into Argentina. "I can now get on with that task," said Freda "and we are also 'bulking up' two other rust strains to test against New Zealand plant material." Jane delivered the seed to Dr Eduardo Botto, a new and very helpful collaborator who works at the quarantine facility in Castelar.

While work with *Uromyces pencanus* has been accelerating, the second most promising candidate, the rust *Puccinia graminella*, has been extremely uncooperative. A particularly hot and dry summer was followed by an unusually cold winter and this seems to have led to the local extinction of *P. graminella* at the only field site within striking distance of Bahía Blanca; other sites are hundreds of kilometres north. This rust mostly produces a spore stage known as aeciospores, which do not store very well. Consequently, Freda has run out of spores to use for experiments and is unable to do any further work on this organism until it can be re-collected from the field. At least this will allow Freda to concentrate solely on *U. pencanus* for a while, and for once there appear to be no further obstacles to the completion of host range testing of that fungus. Touch wood!!!

Jane Barton is a contractor to Landcare Research.



Marlborough District Council

Chilean needle grass seed on a quad bike that has gone through infested paddocks in the Blind River area of Marlborough.

Farewell to Helen

In February Helen Harman left to work for the Ministry of Agriculture and Forestry in Wellington. Helen first arrived on the scene in 1985, where as a new BSc graduate she worked with Pauline Syrett at Lincoln on biocontrol of ragwort (*Jacobaea vulgaris*, formerly *Senecio jacobaea*). This work involved importing the now famous and highly successful ragwort flea beetle (*Longitarsus jacobaeae*), and efforts to increase the distribution of the cinnabar moth, which was only present in the lower North Island at that time. Later Helen and Pauline worked on biocontrol of broom (*Cytisus scoparius*), culminating in the release of the broom seed beetle (*Bruchidius villosus*) and broom psyllid (*Arytainilla spartiophila*). Helen was also involved in some landmark projects with Jane Memmott (Bristol University) to understand why broom is invasive outside its native range, and develop optimal release strategies for biocontrol agents.

Helen, and former colleague Nick Waipara, looking for pathogens on old man's beard in France in 2007.

Helen was briefly involved in the biocontrol of hawkweeds project (*Hieracium* spp.) before taking some time out for further study. Based at Lincoln University, Helen gained a doctorate for her thesis about the likely origins of the broom twig miner (*Leucoptera spartiofoliella*) in New Zealand, which involved learning many new molecular ecology skills. By studying the twig miner's DNA Helen was able to determine that this insect probably established as the result of a single introduction of only a few individuals. Helen then shifted to Auckland in 2002 to be with others at Landcare Research undertaking molecular studies and applied her new skills to projects involving heather beetle (*Lochmaea suturalis*), bridal creeper rust (*Puccinia myrsiphylli*), old man's beard fungus (*Phoma clematidina*) and tradescantia (*Tradescantia fluminensis*). As a result we know that our heather beetle populations were severely genetically bottlenecked during line-rearing to remove a microsporidian disease, which may at least partly explain why our beetles are smaller than they should be. Also that bridal creeper rust probably arrived here from Australia, and that the strain of old man's beard leaf fungus that was released here has probably died out.

"Working in weed biocontrol has given me the opportunity to work on some fascinating projects with interesting and inspiring colleagues from around the world," concluded Helen.

After devoting nearly 25 years to biocontrol of weeds in New Zealand it was time for a change and in her new role Helen is working in a team that assesses the risks to New Zealand from importing plant commodities. We thank Helen for all her hard work and dedication over so many years and wish her all the best for the future.

Helen can now be contacted at : helen.harman@maf.govt.nz

Hot off the Press

Recently the Environmental Risk Management Authority (ERMA) granted us permission to import six prospective **Japanese honeysuckle** (*Lonicera japonica*) agents into containment at Lincoln for further testing. They include two species of white admiral butterfly (*Limenitis camilla*, *L. glorifica*), a moth whose larvae commonly destroy stem tips in the spring (*Bhadorcosma lonicerae*), another moth which has very large fluffy larvae (*Apha aequalis*), a sawfly (*Zaraea lewisii*), and a longhorn beetle (*Oberea mixta*). Quentin Paynter is travelling to Japan in late June to uplift some of these species so testing can get underway.

An application to release the first agent for biocontrol of **woolly nightshade** (*Solanum mauritianum*) was lodged with ERMA in April. We expect to have an answer, as to whether or not we will be able to release a lacebug (*Gargaphia decoris*), before Christmas.

Deciding Which Weeds to Target for Biocontrol

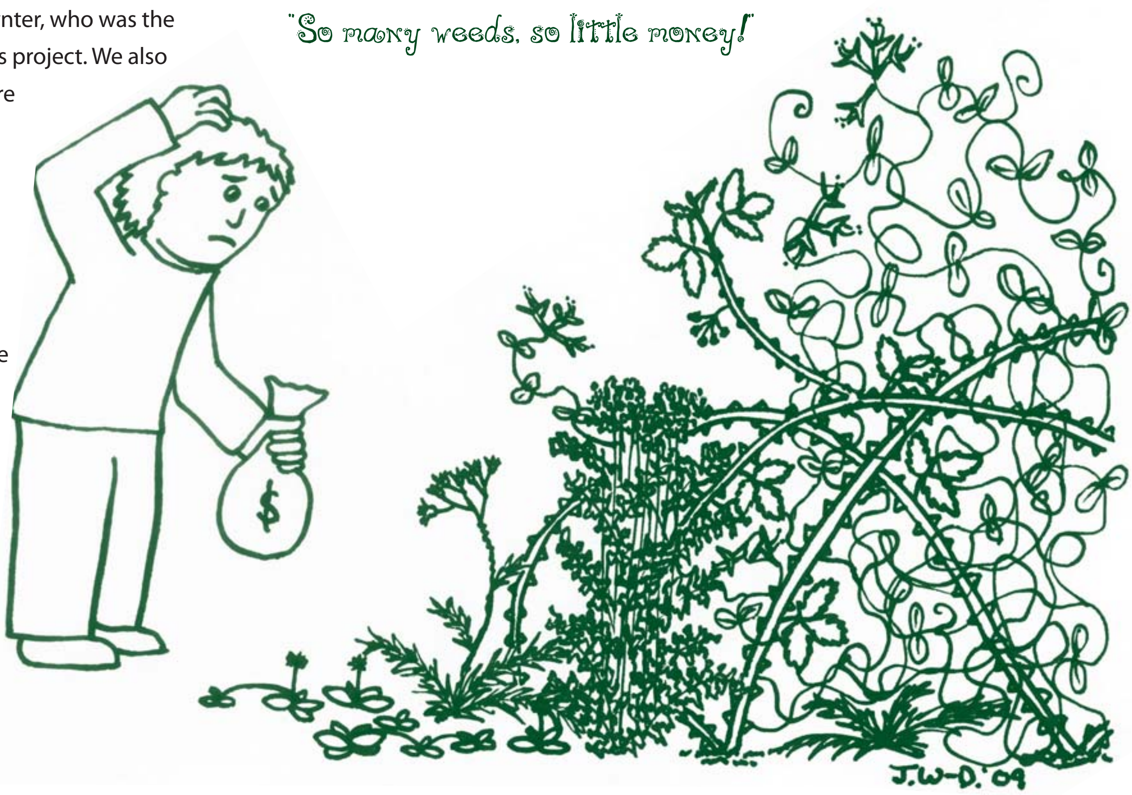
Weeds are undoubtedly a growing problem. Typically the worst affected counties already have hundreds of species to manage, many sleeper weeds gradually beginning to wake up, and new species continually escaping from cultivation. Biocontrol is likely to be the only feasible way of managing widespread weeds, but, with so many species to tackle and inevitably limited resources, we need to find better ways of prioritising where to direct our efforts. Recently our team undertook a project for the Australian Government to come up with a framework for prioritising which weeds to target for biocontrol.

First of all we reviewed all the ranking processes that have been used before in Australia, Canada, New Zealand, South Africa and the USA, the countries that have been most active in developing biocontrol programmes for weeds. "All of the systems used previously appeared to have limitations in that they relied too heavily on subjective judgements without adequate supporting justification," concluded Quentin Paynter, who was the mastermind behind this project. We also delved into the literature for papers that related biocontrol success to plant attributes and then had a major brainstorming session to decide on the best approach. As a result we identified three factors that we believed needed to be taken into account.

The first factor to consider is the ***importance of the weed target***. Things like how invasive is the weed, what impacts does it have, how fast is it spreading, how much land is at risk of invasion, and are other effective control methods available? This information was readily available for more than 70 Australian weeds that had been assigned scores for these kinds of attributes through the Weeds of National Significance (WoNS) ranking scheme undertaken a decade ago. Our project, therefore, concentrated on the remaining two factors.

The second factor to consider is the ***effort*** required to undertake a project. For example if agents are not already well known, the native range is not friendly and accessible, and there are likely to be major conflicts of interest, a project is likely to have a lesser chance of succeeding. It is unfortunately a fact of life that very difficult and expensive projects are more likely fall by the wayside.

The third factor to consider is the likely *impact or success of biocontrol*. At present the best predictor of the success of a biocontrol programme is what has happened in countries that have attempted it. However, for novel targets obviously we don't have the luxury of a precedent, so we need another way of predicting success. In our literature search we collated all the hypotheses that people had proposed as to how various plant traits affect the likelihood of success. We made a list of these and then looked for evidence to back them up by studying published information about the success of biocontrol programmes completed in South Africa and the USA (see Table 1). Data on the impact of biocontrol had been collected in a variety of ways, so to allow comparison Quent converted these data into an "impact index", defined as the proportional reduction in weed density (e.g. percentage cover; stems/m^2; weed biomass) due to biocontrol. The impact indices were then correlated with the range of factors that have been proposed as determinants of biocontrol success, to identify the important ones.



Working under a tight time frame, we were not able to track down enough information to support or discount a number of hypotheses, such as the importance of host plant quality, genetic variability and susceptibility to secondary infection. Further research into the significance of these factors is needed. However, our analysis did reveal that biocontrol impacts have, on average, been greater against biennial and perennial versus annual weeds, plants capable of vegetative reproduction versus those that reproduce solely by seed or spores, aquatic and wetland weeds versus terrestrial weeds, and plants that are not reported to be weedy in the native range versus those which are known to be weedy in the native range.

Having sorted out the key factors, we developed a prototype scoring-framework, and ran examples of South African and US biocontrol targets through it. "To validate our framework we compared our likely impact of biocontrol scores with the impact index scores we had calculated earlier and found that there was a good correlation between the two, so we were comfortable that our framework was on the right track," explained Quent.

Table 1: Plant traits that might affect biocontrol success

Hypothesis	Our analysis
Plants that are weeds in their native range are harder to control.	There was some evidence from the USA to support this.
Weeds with closely related non-target plants are harder to control.	No, but non-target attack on native plants was a minor consideration in the past. We consider this to be an important factor because many past programmes would not be able to proceed under today's regulations.
Annuals are more difficult to control than biennial and perennial weeds.	Yes for the USA, data not available for South Africa where only one annual weed has been targeted for biocontrol.
Clonal weeds that reproduce solely vegetatively are easier to control.	There was evidence from South Africa to support this
Terrestrial weeds are harder to control than aquatic/wetland weeds.	There was some evidence from South Africa and the USA to support this.
Success is more likely for weeds that belong to a genus with many species (i.e. more agents available).	No evidence was found to support this.
Host plant quality affects success.	Not enough information was available to assess this.
Biocontrol is more difficult if there is differential susceptibility due to genetic variability (e.g. lantana).	This appears to be important, but there was not enough information available to assess this statistically.
Plants that are susceptible to secondary infections are more susceptible to biocontrol.	There was not enough information available to assess this.
Success is greater against environmental weeds than agricultural weeds.	We did not attempt to assess this because many weeds do not fall neatly into one or other category.

We presented our preliminary framework at a workshop in Canberra to obtain feedback on the proposed scheme and seek further information about Australian weeds. Following the workshop we further refined the scoring system by incorporating data from Australian weed biocontrol programmes and undertaking a sensitivity analysis to ensure questions were weighted appropriately (see Table 2). We then ran all 112 Australian weeds nominated as targets for biocontrol through the framework. Next we excluded species for which biocontrol programmes were considered completed and prepared a prioritised list of the remaining 75 species (see Table 3).

While the framework appears to be robust and useful, as always there is room for improvement: "While we can now identify programmes that are likely to be 'winners' or the most difficult targets, with a fair degree of confidence, there are still many intermediate scoring weeds, where predicting success or failure is still a bit of a lottery," said Quent. Our analysis only explains about half the variation in the success of past biocontrol programmes. If we can identify further factors that affect biocontrol success and modify the scoring system accordingly, we should be able to make significant improvements to the predictive power of the framework. For example, the relevance of criteria that authors have suggested are important, such as food quality, but which we were unable to include due to a lack of data should be investigated. For this reason, we have recommended that the framework is expanded and reviewed regularly and revised as more weed biocontrol impact

Table 2: Excerpt from framework

9. Habitat		Score	Weight
Aquatic/wetland	Higher probability of success.	10	3.5
Terrestrial	Lower probability of success.	4	3.5

Table 3: Top 20 Australian weed targets for biocontrol

Rank	Weed	Likely Biocontrol Impact	Weed Importance	Effort	Total Impact × Importance × 1/Effort
1	*Spartina anglica*	90.00	62.34	21.00	267.16
2	*Alternanthera philoxeroides*	100.00	67.53	26.00	259.74
3	*Cabomba caroliniana*	100.00	79.65	38.00	209.61
4	*Chrysanthemoides monilifera*	64.00	84.85	26.00	208.86
5	*Solanum elaeagnifolium*	100.00	51.08	25.00	204.33
6	*Macfadyena unguis-cati*	77.00	64.94	26.00	192.31
7	*Prosopis* spp.	50.00	99.13	26.00	190.64
8	*Ulex europaeus*	56.00	70.13	21.00	187.01
9	*Tamarix aphylla*	59.00	77.92	26.00	176.82
10	*Schinus terebinthifolia*	76.00	59.74	26.00	174.63
11	*Parkinsonia aculeata*	62.00	100.00	38.00	163.16
12	*Nassella neesiana*	52.00	78.35	26.00	156.71
13	*Nassella trichotoma*	52.00	77.06	26.00	154.11
14	*Genista monspessulana*	59.00	52.38	21.00	147.17
15	*Hymenachne amplexicaulis*	85.00	82.68	48.00	146.42
16	*Rubus fruticosus* agg.	48.00	93.07	31.00	144.11
17	*Anredera cordifolia*	76.00	50.65	28.00	137.48
18	*Salix* spp.	75.00	77.49	43.00	135.16
19	*Argemone ochroleuca*	59.00	35.50	17.00	123.20
20	*Thunbergia grandiflora*	76.00	64.50	40.00	122.55

data become available. Methods for ranking weed importance also need further debate. Should new weeds of currently limited importance, that are known to be serious weeds in other countries, be attibuted a higher weighting compared with widespread medium-inportance weeds that have been around for ages? Also, how do we factor in the likely influences of climate change on weed distribution and abundance?

While it is helpful to have tools like this framework to guide us in our decision making, we believe that some pragmatic decision making should also always be used when deciding on a portfolio of targets for biocontrol. While it is tempting and sensible to pick off some of the easier targets first, there may be good reasons for embarking on some higher risk projects, such as when other effective control methods are lacking for a very serious invader. "After all, a 5% reduction in a really important weed doesn't sound like much, but can result in economic or environmental benefits that outweigh the complete control of a minor weed," added Quent.

While developed initially for Australia this framework could be used to rank weed biocontrol targets for New Zealand or any other country. However, before this could happen a lot of data would need to be collated, especially on the importance of each weed and the likely ease of undertaking a biocontrol project.

This project was funded by Land and Water Australia as part of the Australian Government's Defeating the Weed Menace Programme. A full report on this project is available from www.lwa.gov.au/weeds

Things To Do This Winter

As most biocontrol agents hide away or become dormant during the next few months, winter is a quiet time of year. However, you can still:

- Check nodding thistle crown weevil (*Trichosirocalus horridus*) release sites. While some weevils lay eggs all year around, most begin to lay in the autumn and the damage they cause becomes most apparent later in the winter. Look for black frass in the crown and for leaves that have lost their prickliness. Although nodding thistle (*Carduus nutans*) is the preferred host you may find that the beetles attack other species of thistles too, especially Scotch (*Cirsium vulgare*) and cotton (*Onopordum acanthium*) thistles. Crown weevil adults can often be successfully harvested and shifted around as late as June; to find them look carefully on the undersides of leaves.
- Shift ragwort flea beetles (*Longitarsus jacobaeae*) around, provided they are present in good numbers.
- Make sure all the paperwork relating to release sites is up to date. If you have been shifting agents around, we would be interested to know about this (send information to Lynley Hayes: hayesl@landcareresearch.co.nz).
- Come to our Wellington workshop (see below).

Wellington Workshop

We are running a one-day workshop at the Brentwood Hotel, 16 Kemp St, Kilbirnie, Wellington, on 18 June. This is so we can share with you the latest on biocontrol of weeds and other related research being undertaken in New Zealand at Landcare Research, AgResearch and Scion. Topics to be covered include:

- Biocontrol of boneseed, broom, buddleia, Darwin's barberry, heather, ragwort, thistles and tradescantia.
- Are any weed biocontrol agents misbehaving or getting knobbled by parasites?
- Prospects of biocontrol for tutsan.
- The value of current tradescantia control in forest remnants.
- Advances in wilding conifer control.
- Why New Zealand needs a national weeds distribution database.
- Uncommon and unwanted plant species in the Manawatu–Wanganui Region.

The workshop is limited to 100 people on a first in, first served basis. There is no cost to attend the workshop and morning and afternoon tea will be provided. Lunch will be available at a cost of $19.50 per head. The workshop will begin with a cuppa at 9.30 a.m. and will finish no later than 4.00 p.m.

Please register for this workshop by contacting Lynley Hayes (hayesl@landcareresearch.co.nz or ph 03 321 9694). It would be great to see you there!

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