Status of Weed Biological Control Agents on the West Coast of the South Island of New Zealand

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Summary

Project and Client

This report on the status of weed biological control agents on the West Coast in the South Island of New Zealand was prepared for the West Coast Regional Council by Landcare Research from December 2006 to June 2007.

Objectives

- To check the current status of the 14 species of weed biological control agents that have been released on the West Coast during the past 25 years.
- To make recommendations about how biological control programmes could best be further developed on the West Coast.

Methods

- Information from a Landcare Research database was used to compile a list of West Coast release sites and visits were made to check them between December 2006 and May 2007.
- Sites that were previously considered to have failed and very recent sites were generally not visited, but are listed for completeness. Information was also sourced from a previous report and various people associated with biocontrol on the West Coast.
- Information about control agents that have not been released on the West Coast is included where relevant.

Main Findings

- Of the 14 weed biocontrol agents that have been released during the last 25 years eight have become established (broom psyllid, broom seed beetle, gorse spider mite, gorse thrips, gorse pod moth, gorse soft shoot moth, cinnabar moth, ragwort flea beetle), three have failed to establish (Californian thistle leaf beetle, Californian thistle flea beetle, nodding thistle crown weevil), and the fate of the remaining three is currently unknown (old man's beard leaf fungus, ragwort crown-boring moth, ragwort plume moth).
- At least one weed biocontrol agent has also self-introduced (old man's beard leaf miner).
- Of the agents that are established, probably only three species are widespread (gorse pod moth, gorse spider mite, ragwort flea beetle) and no project is yet complete. Actions are required to improve the distribution of at least four agents (broom psyllid, broom seed beetle, gorse thrips, and gorse soft shoot moth) and for each weed target tackled to date there are still control agents which should be considered for release (see recommendations below).

Conclusions

- The establishment success of weed biocontrol agents on the West coast is following similar trends to the rest of New Zealand. While the climatic conditions experienced on the West Coast could make it more difficult to establish some insect agents it does not appear to have been a major obstacle so far. However, it would appear that there are some places on the West Coast, such as Otira/Aickens and south of Whataroa, where establishment is likely to be problematic, and control agents should only be released there once populations are well established and plentiful at more benign locations.

- There has been a considerable investment to date by a number of organisations on the West Coast to develop biocontrol programmes for weeds but more will be required to complete projects and reap the benefits.
- The West Coast Regional Council should consider joining the National Biocontrol Collective so it can participate in decision making about what weeds should be targeted for biocontrol and have access to new agents as soon as they are developed.

Recommendations

- Harvest and redistribute the broom psyllid, broom seed beetle, gorse soft shoot moth, and gorse thrips to areas where they are not yet present. Check the distribution of the broom twigminer and gorse pod moth and if necessary shift them around too. Check if biocontrol agents are present on St John's wort in South Westland. Monitor ragwort crown-boring moth and plume moth release sites to check for establishment and to see if any further releases or harvesting and redistribution activities are needed (Caryl Coates is contracted to do this on behalf of the West Coast Ragwort Control Trust) .
- Release the broom leaf beetle, broom shoot moth, broom gall mite, and gorse colonial hard shoot moth as soon as they are available. If *Carduus* and *Cirsium* thistles continue to be a problem on the West Coast release nodding thistle crown weevil, Scotch thistle gall fly, Californian thistle stem miner and green thistle beetle and check the status of nodding thistle receptacle weevil.
- No further action against old man's beard is required unless the current DOC weed-led control project is unsuccessful and the weed continues to be a problem.

1. Introduction

This report on the status of weed biological control agents on the West Coast in the South Island of New Zealand was prepared for the West Coast Regional Council by Landcare Research from December 2006 to June 2007.

2. Background

Weeds threaten many of the landscapes and agricultural systems in New Zealand, and the West Coast of the South Island is no exception. Biological control, where natural enemies (usually insects and fungi) are put to work against weeds, is a key strategy for managing serious widespread weeds, and may even be the only practical or sustainable approach (Williams & Hayes 2007). Consequently 14 species of weed biological control agents have been released on the West Coast by the DSIR, West Coast Regional Council (WCRC), Department of Conservation (DOC), Timberlands West Coast (TWC), and the West Coast Ragwort Control Trust (WCRCT) during the past 25 years. This report reviews progress that has been achieved in developing biological control programmes on the West Coast to date and makes recommendations about the next steps that should be taken. We did not attempt to measure the impact of the control agents as such a study would require susbstantial resources over many years and was therefore beyond the scope of this project.

3. Objectives

- To check the current status of the 14 species of weed biological control agents that have been released on the West Coast during the past 25 years.
- To make recommendations about how biological control programmes could best be further developed on the West Coast.

4. Methods and Data Sources

Landcare Research maintains a database about where weed biological control agents are released nationwide and their fate. Information from this database was used to compile a list of sites for which there was insufficient up-to-date information. Visits were made to the West Coast to check these sites in December 2006, and in February and May 2007, to correspond with suitable times for checking the various species. Information gathered during these visits was added to the database. Sites that were previously considered to have failed were usually not revisited but are listed for completeness. New sites, where agents have been released only recently and need more time before they are assessed, are likewise listed for completeness. Information about ragwort flea beetle release sites was sourced from a previous report (Smith, 2003). Information about a number of other species was sourced from various colleagues and organisations involved in biological control on the West Coast, especially

Caryl Coates who provided information about releases of the ragwort crown-boring moth and ragwort plume moth, which have been made recently as part of a West Coast Ragwort Control Trust intiative. Information about control agents that have not been released on the West Coast is also included where relevant.

5. Main Findings

5.1 Broom (*Cytisus scoparius*)

5.1.1 Broom twig miner (*Leucoptera spartifoliella*)

The broom twig miner is a stem-mining moth. Larvae damage broom by feeding on the stem tissues. When a large proportion of green material has been affected then bushes grow and flower less, and whole branches and even entire bushes may die. The twig miner is believed to have arrived in New Zealand accidentally about 50 years ago, and it is now common and widespread throughout most of New Zealand. During the last 10–15 years there have been some large outbreaks of the twig miner in the South Island that have caused noticeable damage to broom plants, especially where the plants are under stress.

The status of the broom twig miner on the West Coast is unclear. It was not observed causing obvious damage at any of the broom sites visited. Further studies are needed before we can advise whether or not it would be possible to do anything to increase the impact of this insect on broom.

5.1.2 Broom psyllid (*Arytainilla spartiophila*)

The broom psyllid is a sap-sucking insect. Both adults and nymphs suck sap out of the tender new growth in spring. When populations are high the damage to new growth can be severe. This agent was released widely throughout New Zealand in the mid-1990s. It has established readily and is gradually becoming common and widespread. Some damaging outbreaks have been seen in Canterbury and Southland, but overall the performance of the psyllid has not lived up to expectations. This may be due to predation, but more studies are needed. Given the relatively short time that has elapsed since this insect was first released here, and the impact it has on broom in its native range, we should not yet discount the possibility that the psyllid may still make a contribution towards broom control.

The psyllid has not managed to establish at the two sites it was released at on the West Coast, but one of these was destroyed soon afterwards (Table 1). Interestingly the broom psyllid has established near Reefton where no releases have been made that we are aware of. It seems most likely that the psyllids have dispersed from the Hanmer Springs area, which is the nearest place they are known to be well established, but this is still surprising given that this species is not thought to disperse rapidly. Further surveys would be needed to determine how widespread the psyllid is on the West Coast. As none were seen at broom sites checked further south, there is likely to be some merit in collecting and redistributing the psyllids from the Reefton area. Given the extreme climatic conditions at Otira it is likely to be difficult to establish any broom agents there and any further attempts should be a low priority at this stage.

Table 1 Broom psyllid release sites on the West Coast

Site name	Organisation responsible	Grid reference/GPS	Date released	Date checked	Comments
Otira	DOC WCRC	NZMS260 K33 923 165	18/2/96 20/11/98	4/12/06	No sign of the psyllids; likely to have failed to establish here
Rimu Tailings	TWC	NZMS260 J33 417 269	21/12/96	5/12/06	Site destroyed, but given that psyllids were seen at three broom seed beetle sites (Bonanza Rd, Compartment 7, Dirty Dam Rd) they must have dispersed from this site beforehand

5.1.3 Broom seed beetle (*Bruchidius villosus*)

The broom seed beetle is a seed-feeding insect. The larvae are the damaging stage and each larva attacks a single seed. This agent was released widely throughout New Zealand during the mid-1990s. It has established readily and is becoming common and widespread. Infestation levels have only been measured at a few sites to date, and have shown that the beetle is capable of destroying 80–90% of seeds in New Zealand. Modelling work suggests that at the very least this level of seed destruction should significantly slow the spread of broom.

The broom seed beetle appears to be establishing well on the West Coast and can now be found in good numbers at four sites (Table 2). This agent is believed to be a moderate disperser, but there would be some merit in collecting and redistributing it to other parts of the Coast where the beetle is not yet present. It has failed so far to establish at Otira, and again further attempts to establish the beetle here should be a low priority at this stage.

Table 2 Broom seed beetle release sites on the West Coast

Site name	Organisation responsible	Grid reference/GPS	Date released	Date checked	Comments
Adair Rd	TWC	NZMS260 J33 415 270 NZMS260 J33 424 268 NZMS260 J33 425 266 NZMS260 J33 427 264	13/11/98	5/12/06	Four releases made close together so treated as one site – 20 beetles were dislodged in a single beat of one plant so they are obviously well established here now
Bonanza Rd	TWC	NZMS260 L30 156 963	13/11/98	6/12/06	Many beetles found and they are obviously well established here. Beetles were found up to half a kilometre away. Psyllids also found here
Compartment 7 – Holmes Hill	TWC	NZMS260 L30158 966	13/11/98	6/12/06	Many beetles found and they are obviously well established here. Beetles were found up to several hundred metres away. Psyllids also found here
Compartment 8 – Holmes Hill	TWC	NZMS260 L30 166 971	13/11/98	6/12/06	Status unknown as unable to locate release site
Dirty Dam Rd	TWC	NZMS260 L30164 966	13/11/98	6/12/06	Many beetles found and they are obviously well established here. Beetles were found up to half a kilometre away. Psyllids also found here
Otira River	WCRC/DOC	NZMS260 K33 923 165	6/11/97	4/12/06	No sign of the beetles; likely to have failed to establish here
Upper Inangahua	DOC	NZMS260 L31 254 810	5/11/95	8/12/06	Small isolated patch of broom and no sign of the beetles here so it seems unlikely they have established here

5.1.4 New broom agents

The Environmental Risk Management Authority (ERMA) has recently approved an application by the Canterbury Broom Group to release two new broom agents in New Zealand. The first new agent is the broom leaf beetle (*Gonioctena olivacea)*. The adults feed on foliage and the larvae attack the leaves and stem tips. Newly hatched larvae are voracious feeders and their active period should coincide perfectly with broom regrowth after twig miner attack. Mass-rearing is now underway and the beetle is expected to be available for release from spring 2007.

The second new agent is the broom shoot moth (*Agonopterix assimilella*), which is a close relative of the gorse soft shoot moth (*Agonopterix ulicetella*). The larvae feed on the leaves and kill off stem tips by ring-barking them. It is hoped that this moth will be available for release from spring 2008.

A third new agent, a gall-forming mite (*Aceria genistae*), did not need ERMA approval as it has already been recorded in New Zealand, but on gorse. Recent research shows that *Aceria genistae* includes a number of distinct strains, each of which is specific to one species of plant. We are certain that the mites we are introducing will only attack broom and are unlikely to interbreed with the resident strain. The broom gall mite is so small it can't be seen with the naked eye. During winter the mites live in colonies inside the base of stem buds. In the spring, feeding by mites causes the buds to develop into green fleshy galls, about 5–30 mm across, instead of shoots. Unlike many insects that attack broom, the mite is believed to cope well with shade. It is hoped that releases of this mite will be made from spring 2008.

In their native range each of the new broom agents is known to severely affect broom plants from time to time. The moth and beetle can strip plants bare, so that no green growth remains above ground. By forming galls on successive years' growth the mites cause stunting, reduced flowering, and even kill whole bushes. We recommend that all three new agents are released on the West Coast as soon as possible. Given where these species naturally occur in their native range it would appear that the broom shoot moth has the greatest chance of being able to establish at Otira, but this should only be attempted once the moth is established at more benign sites and can be harvested and relocated from these.

5.2 Gorse (*Ulex europaeus*)

5.2.1 Gorse seed weevil (*Exapion ulicis*)

The gorse seed weevil attacks gorse seeds produced during spring/summer. The damage is caused by the larvae with each one attacking a single seed. The weevil was one of the first biocontrol agents to be released in New Zealand back in the 1930s. It established successfully and is now extremely common on gorse throughout most of New Zealand, except for the lower part of the West Coast (south of Hari Hari). During this survey the weevils were seen at two of the four gorse pod moth sites (Brennans Creek, Neilsons Rd), and one of the gorse thrips sites (Cementlead Rd). Given that climatic conditions appear to limit the weevils and they are already widespread, no further attempts to increase their distribution on the West Coast are warranted.

5.2.2 Gorse pod moth (*Cydia succedana*)

The gorse pod moth also damages gorse seeds and, unlike the gorse seed weevil, is able to attack seed produced during autumn/winter as well as during spring/summer. The caterpillars destroy the seeds, with each one consuming the contents of 2–3 pods. This agent was released widely throughout New Zealand during the 1990s. It has established well and is now common and widespread. Attack by the moth has augmented the effect of the seed weevil in spring. In one recent study spring seed production contributed little to the annual seed crop as a result of the activity of these two agents. However, the amount of damage caused to the autumn/winter seed crop, is not as high as hoped, typically around 10–15%. In many places seed produced at this time of the year forms the bulk of annual production, and so gorse pod moth has little overall effect. Recent research has suggested that this may be because in New Zealand the timing of the insect's life cycle (phenology) is not ideally aligned with the plant's. As time passes selection pressure may see moth populations become better synchronised with the peak occurrence of the autumn seed resource, in which case the percentage of seed attacked will rise.

The moth has also established successfully on the West Coast, and can now be found at all four release sites, although dispersal may account for half of these (Table 3). As well as the four official release sites TWC collected a large amount infested material from Canterbury in October 1998, but we are unsure where this material was released. The moth was also found at several gorse thrips release sites (Gillespies Beach, Martins) which would suggest that the moth is probably now widespread on the West Coast, but further surveys would be needed to check this. Given that this agent is considered to be a rapid disperser there may not need to be any further releases made unless areas can be found that are still free of the moth.

Table 3 Gorse pod moth release sites on the West Coast

Site name	Organisation responsible	Grid reference/GPS	Date released	Date checked	Comments
Brennans Creek	TWC	NZMS260 J33 472 287	27/10/93	5/12/06	Previously not thought to have established here but present now in low numbers and may have dispersed from a successful release site. Gorse seed weevil also present
Granville Forest	TWC	NZMS260 K31 755 965	8/11/05	6/12/06	Established but infestation rate appears low (10%).
Neilsons Rd	WCRC	NZMS260 J32 584 496	7/11/95	4/12/06	Established but infestation rate appears low (10%). Gorse seed weevil also present
Stripland Creek	DOC	NZMS260 J33 505 275	11/11/92	5/12/06	Previously not thought to have established here but present now and may have dispersed from a successful release site. Infestation rate appears low (10%).

5.2.3 Gorse soft shoot moth (*Agonopterix ulicetella*)

The gorse soft shoot moth is a foliage-feeding insect. The caterpillars are the damaging stage and they feed on the new growth buds and soft tips in the spring. Each can destroy up to five shoots. This agent was released widely throughout New Zealand during the early to mid-1990s. For many years it was thought that establishment success had been poor and that the insect was only hanging on in low numbers at a limited number of sites nationwide. In recent years large outbreaks of the moth have been noticed in Marlborough and Canterbury, giving much cause for optimism.

The moth was released at two sites on the West Coast and has established in Granville Forest (Table 4). However, the moth is currently still only present in low numbers and it will be interesting to see if they are able to outbreak in coming years. Further checks of this site should be made annually in late November/early December, when the caterpillars are most obvious, and if they are abundant it would be worth harvesting some for release in other areas. Given that the moth is now plentiful in Canterbury and Marlborough it may also be worthwhile harvesting some moths from one of these areas this coming spring.

Table 4 Gorse soft shoot moth release sites on the West Coast

Site name	Organisation responsible	Grid reference/GPS	Date released	Date checked	Comments
Granville Forest	TWC	NZMS260 K31 965 755	21/12/92 12/1/95	6/12/06	Caterpillars could be found in the area surrounding both release sites but are still in low densities
Maori Gully	WCRC	NZMS260 K32 765 544	7/12/96	4/12/06	Site has been logged; no sign of the moth

5.2.4 Gorse spider mites (*Tetranychus lintearius*)

The gorse spider mite is a foliage-feeding invertebrate. Both the adults and juveniles have sucking mouthparts that extract the cell contents. Foliage takes on a bleached and later a brown appearance. When present in large numbers the mites can cause considerable damage. Growth and flowering is reduced but they rarely stay on gorse bushes long enough to kill them. This agent was widely released throughout New Zealand, including at numerous sites on the West Coast, during the late 1980s and early 1990s. Initially the mite established well except for in warm, wet areas. As a result other strains were imported and released that were expected to be better adapted to these climatic conditions. It is unclear whether the original strain managed to adapt to these conditions or if the new strains did in fact establish better, as dispersal was rapid and once mixed the strains could not be differentiated. However, the overall outcome was that gorse spider mites did became established in all regions of New Zealand during the mid-1990s. Unfortunately gorse spider mite populations tend to be regulated by predators. Large colonies form but do not tend to persist, and the distribution of the mites tends to be patchy both temporally and spatially.

The original release sites on the West Coast were not checked during this survey because the mites are so mobile that the original release sites are now only of historical interest (Table 5). It appears that both the original strain and the new strains only established at Granville Forest, and TWC subsequently re-released the mites to other areas. They can be found sporadically on gorse from Hokitika north (Ross Jackson, pers. comm.). The mites were not commonly seen when checking sites for other gorse agents. No further efforts to try to increase their distribution are warranted and only time will tell as to whether or not gorse spider mites are able to make a contribution to gorse control.

Table 5 Gorse spider mite release sites on the West Coast

Site name	Organisation responsible	Grid reference/GPS	Date released	Strain	Date checked	Established
Aickens	DOC	NZMS1 S59 101 478	1/10/90 5/2/91 6/2/91	UK	2/10/93	N
Aickens	DOC	?	28/1/93	Spanish		
Big Totara River	WCRC	NZMS260 K29 834 263	5/3/93	Spanish	26/10/93	N
Birchfield	WCRC	NZMS260 L29 126 487	25/10/89 30/1/90	UK	3/10/91	N
Blur Spur	WCRC	NZMS260 J32 301 506	4/3/93	Spanish		
Bundi-Camerons	TWC	NZMS260 J32 612 468	5/2/90	UK	7/11/92	N
Camerons	WCRC	NZMS1 679 751	8/10/90 12/12/90	UK	3/10/91	N
Cape Terrace Rd	TWC	NZMS1 S51 702 715 NZMS1 S51 716 698	17/8/89 23/11/89 11/12/90 1/10/90	UK	7/11/92	N
Doughboy Creek	WCRC	NZMS260 M29 507 343	19/11/91	UK	?	?
Gillespies Beach	DOC	NZMS1 S70 520 702 NZM1 S70 516 696	10/12/90 11/2/91 2/10/90	UK	5/6/92	N
Granville Forest	TWC	NZMS260 K31 350 310	16/11/91	UK	19/8/92	Y
Granville Forest	TWC	NZMS260 K31 350 310	8/1/92	Spanish	7/10/97	Y
Moana	WCRC	?	28/1/93	Spanish	4/9/93	Site destroyed
Ogilvies Rd	TWC	NZMS1 S51 742 773	17/8/89 23/11/89 21/1/90	UK	7/11/92	N

5.2.5 Gorse thrips (*Sericothrips staphylinus*)

The gorse thrips is a foliage-feeding insect. Adults and juveniles have sucking mouthparts that extract the cell contents. This feeding results in small white spots that give the gorse a mottled blotchy appearance. The thrips prefer new growth, but will feed on older, harder growth during winter. When present in good numbers, growth and flowering is reduced and seedlings may be killed. This agent was released widely throughout New Zealand during the 1990s and has established well. However, dispersal appeared to be extremely slow, because winged forms appear to be produced only rarely. As a consequence another strain of the thrips, that was believed to disperse more quickly, was imported from Portugal and released in the early 2000s, and it has also established. It is not possible to tell the strains apart so we cannot confirm whether or not this strategy has paid off, but gorse thrips are now being found

over a much wider range than before. While thrips can now often be commonly found on gorse, it is less common to see gorse bushes that appear to be severely affected by them. A study in the UK found that gorse thrips could reduce the growth of seedlings, even when present in low numbers, and this may be where they have the greatest impact.

Only the original strain of thrips was released on the West Coast and it has established well (Table 6). Thrips can now be found in good numbers at six of the release sites and they have only failed to establish at two sites, one of which was destroyed. Winged forms have been seen more commonly on the West Coast than in other parts of New Zealand. Even so it seems that the thrips are still not widespread, and there would be some merit in collecting and redistributing them to areas where they are not yet present. It would be useful to undertake further surveys to assess their current distribution more fully.

Table 6 Gorse thrips release sites on the West Coast

Site name	Organisation responsible	Grid reference/GPS	Date released	Date checked	Comments
Aickens	DOC	NZMS1 S59 101 478	2/10/91 27/10/92	5/12/06	No gorse left at the release site and no sign of any thrips on few remaining bushes in the area
Brennans Creek	TWC	NZMS260 J33 302 481	8/11/95	5/12/06	Unsure of exact release site as gorse has been bulldozed but no sign of any thrips in the general area
Cement Lead Rd	TWC	NZMS1 S50/51 572 538	16/11/91	5/12/06	Thrips found in good numbers and have spread up to several kilometres away. Winged forms present. Gorse pod moth and gorse seed weevil also present
Gillespies Beach	DOC	NZMS1 S70 525 705	3/10/91	21/2/07	Thrips present in good numbers, but have not spread far yet. Gorse pod moth also present
Gladstone	WCRC	NZMS260 J32 584 496	17/3/94	4/12/06	Thrips present in good numbers, but have not spread far yet
Granville Forest	TWC	NZMS260 K31 759 974	12/1/95 8/11/95 21/12/96	6/12/06	Thrips present in good numbers, but have not spread far yet
Martins	WCRC	NZMS260 K29 917 377	29/10/92	7/12/06	Thrips present in good numbers, but have not spread far yet. Gorse pod moth also present
Rifle Range	WCRC	NZMS1 S31 691 083	3/10/91	6/12/06	Thrips present in good numbers, including many winged forms, but have not spread far yet

5.2.6 New gorse agents

The gorse colonial hard shoot moth (*Pempelia genistella*) is foliage-feeding insect. The caterpillars are the damaging stage and they feed on the spines, leaves, buds, shoots and flowers causing foliage around the web to brown off and die. When the caterpillars are small, the area damaged is usually only a few centimetres in diameter; but as the caterpillars become larger in the spring, the damaged area can extend to 20–40 cm around the web. This agent has been released at sites throughout New Zealand in recent years, but it has not been

released on the West Coast. Establishment has only been confirmed so far at two sites in Christchurch. At one of these, Redcliffs, the moth has been causing obvious damage. It would be worthwhile releasing this moth on the West Coast as soon as possible.

Surveys are currently underway overseas to check if there are any more potential control agents for gorse, including pathogens. The results from these are expected to be available later this year.

5.3 Old man's beard (*Clematis vitalba*)

5.3.1 Old man's beard leaf fungus (*Phoma clematidina*)

The old man's beard leaf fungus is a foliar pathogen. Initially it cause black spotting and slight yellowing of the leaves, and later premature leaf death, leaf fall, and reduced vigour. Younger leaves are more vulnerable than older leaves, and the stems, flowers, seed pods, and seedlings can also be affected. The fungus was released widely throughout much of New Zealand during the mid-1990s. While it has caused high levels of damage to the plant at times, overall the amount of damage and impact of this fungus has been disappointing. Studies have revealed that the fungus is able to exist inside the leaves as a symptomless endophyte. Research is currently examining whether this lack of disease symptoms is the result of the host plant developing resistance or due to limiting environmental factors, and into whether anything could be done to enhance its effects.

The fungus was released by DOC at two sites on the West Coast (Table 7). However, its status remains unknown since old man's beard has been cleared from these sites since the plant became the target of a DOC weed-led control project 3 years ago. No further activity with the fungus is warranted unless the status of old man's beard changes on the West Coast in years to come.

Table 7 Old man's beard fungus release sites on the West Coast

Site name	Organisation responsible	Grid reference/GPS	Date released	Date checked	Comments
Dunollie	DOC	NZMS260 J31 672 668	23/3/99	5/12/06	No old man's beard present
Tarapuhi St	DOC	NZMS260 J32 631 599	23/3/99	5/12/06	No old man's beard present

5.3.2 Old man's beard leaf miner (*Phytomyza vitalbae*)

The old man's beard leaf miner is a foliage-feeding insect. Larval feeding disrupts the flow of nutrients around the leaves by mining through the veins. Heavily scarred leaves turn brown, shrivel up, and fall off the plant. Both the larval mines and the adults' feeding punctures can also allow fungal pathogens to invade the plant. This agent was released widely throughout much of New Zealand during the mid-1990s. Although high levels of damage have occasionally been seen, overall the infestation levels have remained low, and this may be due to attack by native leaf miner parasites.

The leaf miner was not released on the West Coast, but is an extremely rapidly disperser and has found it own way to the West Coast. It was first noticed there in 1999 when the old man's beard fungus was released. It is likely to still be present on any infestations that have not been

controlled by DOC. No further action is warranted unless the status of the plant changes on the West Coast in years to come.

5.3.3 New old man's beard agents

The old man's sawfly is a foliage-feeding insect. The larvae are the damaging stage and each larva may eat several leaves, sometimes leaving only the central vein intact. This agent was released at a limited number of sites throughout New Zealand during the late 1990s – early 2000s. The sawfly has not been seen again at any of the 16 release sites nationwide and establishment is looking increasingly unlikely. In the event that the sawfly has definitely failed to establish then another attempt may be made to import and release the sawfly because of the severity of the old man's beard problem in many regions.

Research is underway to determine whether a beetle (*Xylocleptes bispinus*) that mines beneath the bark and can ring-barks and kill whole vines might be suitable for release in New Zealand. If the beetle is unsuitable then it is possible that the potential for any other agents may be explored further. Further work is also likely to be undertaken on pathogens that attack old man's beard. Whether or not any further agents should be released to attack old man's beard on the West Coast will depend on the success of the current DOC weed-led control project.

5.4 Ragwort (*Senecio jacobaea*)

5.4.1 Cinnabar moth (*Tyria jacobaeae*)

The cinnabar moth is a foliage-feeding insect. The caterpillars are the damaging stage and they feed on the leaves and flowers. The severity of the attack depends on the number of caterpillars, and can vary from a few damaged leaves to bare stalks. This moth was one of the first biocontrol agents to be released in New Zealand, from the late 1920s to the early 1930s. However, the moth only established successfully in the lower North Island, so from the 1980s to early 1990s fresh attempts to increase its distribution were made. As a result the moth has established in all regions of New Zealand, but its distribution still tends to be patchy temporally and spatially. While the caterpillars can heavily defoliate ragwort, in New Zealand the plant is often able to subsequently regrow. Cinnabar moth is thought to be an effective agent in cold regions of Canada where there is no opportunity for regrowth following defoliation.

Attempts to establish the cinnabar moth on the West Coast seem to have followed a similar pattern. Even though caterpillars have previously been seen at more than half of the release sites, none were seen this year, although in some cases there is no ragwort now at the site for them to feed on (Table 8). However, we have had a report of a healthy population of caterpillars at high altitude (1200 m) near Granity Pass Hutt (Pauline Syrett, pers. comm.) and also at Murchison (Graeme Bourdôt, pers. comm.) this autumn. In 2004 they were also seen at high altitude in the Spenser Mountains (just north of Lewis Pass) in the snow (Pauline Syrett, pers. comm.), so there must have been a healthy population somewhere in the area that they had originated from. Given that the cinnabar moth seems to be difficult to establish at many sites and is of limited usefulness, no further effort to increase its distribution appears to be warranted, especially when more-promising ragwort control agents are available.

Table 8 Cinnabar moth release sites on the West Coast

Site name	Organisation responsible	Grid reference/GPS	Date released	Date checked	Comments
Barrytown	DSIR	NZMS262 10 883 372	30/10/90	15/1/92	Not checked as previously considered to have failed
Cook River Flats	DOC	NZMS1 S70 555 626	14/10/91	21/2/07	Caterpillars were seen here in 1993, but now no ragwort at the site or nearby
Hokitika River	DOC	NZMS1 S50/51 515 548	20/11/90 13/12/90	21/2/07	Caterpillars were seen here in 1993, but now no ragwort at the site or nearby
Karamea Bluff	DSIR	NZMS1 S18 494 045	15/2/82 10/1/84	20/2/07	Caterpillars seen here from 1988 to 1991 but now no ragwort here
Mitchells	DSIR	NZMS1 S51 878 664	3/2/84	9/1/86	Not checked as previously considered to have failed
Seargeants Hill	DSIR	NZMS260 K29 992 361	24/10/91	20/2/07	Caterpillars were seen here in 1993/94 but none present now
Te Taho	WCRC	NZMS1 S63 051 915	8/11/90 2/10/91	21/2/07	Caterpillars were seen here in 1993 but none present now
Whataroa River	DSIR DOC	NZMS1 S71 047 824	20/12/83 8/10/91	21/2/07	No caterpillars seen here previously and now there is no ragwort here

5.4.2 Ragwort flea beetle (*Longitarsus jacobaeae*)

The ragwort flea beetle damages the roots and crowns of ragwort rosettes. Heavily infested plants die, and plants that are not killed produce fewer flowering stems. The beetles have established extremely well nationwide and are now successfully controlling ragwort in many places, with no other control measures required.

A recent survey (Smith 2003) has confirmed that the flea beetle has established at many sites on the West Coast (Table 9), but the plant has continued to be a problem. An intensive study (Gourlay et al. 2006) has recently explained why the flea beetles are unable to control ragwort on the West Coast. Overseas studies have shown that ragwort populations do best when there is high rainfall and ground disturbance. Both these events are common on the West Coast, and ragwort does indeed grow extremely well there At the same time high rainfall probably has a negative effect on flea beetle populations as beetle density appears to be lower at higher-rainfall sites. The level of beetles per plant was lower at West Coast sites than at some East Coast sites where control has been achieved. Previous work has suggested that you need at least four beetles per rosette in order to get control. On average during the West Coast survey there were never more than three beetles counted. The highest number of beetles recorded on a single rosette was only 10 whereas as many as 50 have been recorded from a single rosette in Auckland. Unlike in other parts of New Zealand the beetle is only able to complete one life cycle a year on the West Coast. So it seems that West Coast conditions allow ragwort to do very well but the same is not true for the beetles. For this reason efforts have been made to release two new ragwort agents, the plume moth and crown-boring moth. Efforts should now be put into establishing these two new agents and no further efforts to increase the distribution of the ragwort flea beetle are warranted.

Table 9 Ragwort flea beetle release sites on the West Coast checked in May 2003

Site name	Organisation responsible	Grid reference/GPS	Date released	Comments
Barrytown	WCRC	E2371346 N5885747	15/3/95	No beetles found but feeding damage seen. Herbicides have been used here
Bradshaws Road	WCRC	E2388945 N5938503	23/3/89	No beetles found but feeding damage seen. Herbicides have been used here and ragwort is now scarce
Charleston	DSIR	E2382083 N5925328	22/5/85	No beetles or feeding damage seen. Sheep are grazing the site
Cook River Flat	DOC	E2256670 N5743842	4/3/91	Beetles present in low numbers
Haast River	DOC	E2221002 N5682600	7/3/95	Beetles present in large numbers
Howard Valley	WCRC	E2482182 N5940632	7/4/88	Beetles present in good numbers
Inangahua	DSIR	E2427840 N5931433	7/4/86	No beetles or feeding damage seen. Ragwort now scarce
Inchbonnie	DSIR	E2384366 N5831130	20/4/83 9/5/84	Beetles present in low numbers. Herbicides have been used here
Kamaka	WCRC	E2378156 N5863573	13/4/94	No beetles or feeding damage seen
Rotomanu	WCRC	E2390999 N5840724	15/3/95	No beetles found but feeding damage seen
Tauranga Bay	Sourced by landowner	E2381961 N5932893	1997?	Beetles present in large numbers
Te Kua	WCRC	E2397321 N5929766	7/4/93	Feeding damage seen and beetles found 800 m beyond release point
Whataroa River	DOC	E2301238 N5762524	5/3/91	No beetles found but feeding damage seen

5.4.3 Ragwort crown-boring moth (*Cochylis atricapitana*)

The ragwort crown-boring moth is a foliage-feeder. The caterpillars are the damaging stage. Their mining thickens young stems and suppresses flowering, and tends to kill older stems and the root crowns of rosette plants. Releases of this agent have been made at a limited number of sites nationwide since autumn 2006, and it is too soon yet to know how well they are establishing or what impact they will be able to have.

A good number of releases of the crown-boring moth have been made on the West Coast already, due to a rearing programme being initiated by the WCRCT (Table 10), and further releases are planned. Sites are being monitored by the WCRCT to check for establishment and to see if any further releases or harvesting and redistribution will be needed.

Table 10 Ragwort crown-boring moth release sites on the West Coast

Site name	Organisation responsible	Grid reference/GPS	Date released	Date checked	Comments
Arahura	WCRCT	?	13/2/07		
Atarau	WCRCT	?	20/1/07		
Barrytown	WCRCT	?	7/1/07		
Bell Hill	WCRCT	?	6/1/07		
Bradshaws Farm	WCRCT	E2389040 N5936750	16/3/06		
Cape Foulwind	WCRCT	E2387450 N5931375	16/3/06		
Coal Creek	WCRCT	E2365078 N5860424, E2365074 N5860500 ?	16/3/06 6/1/07		
Haupiri	WCRCT		6/1/07		
Hobson Creek Farm	WCRCT	NZMS260 H36 538 384	21/4/06		
Hokitika	WCRCT		28/3/07		
Ikamatua	WCRCT		20/1/07		
Inchbonnie	WCRCT	E2385130 N5831485 ?	31/3/06 30/3/07		
Kaniere	WCRCT	?	28/3/07		
Mai Mai Valley	WCRCT	?	20/1/07		
Notown	WCRCT	?	6/1/07		
Reefton	WCRCT	?	23/3/06 6/1/07		
Taramakua	WCRCT	?	7/2/07		
Whataroa	WCRCT	E2297103 N5778187, E2297103 N5778187	16/3/06 4/5/06	5/12/06	No sign, but early days yet

5.4.4 Ragwort plume moth (*Platyptilia isodactyla*)

The ragwort plume moth is a foliage feeder. The caterpillars are the damaging stage and can severely harm the crown and roots of ragwort plants. Attack by as few as 2–3 larvae can kill a plant. If plants are not killed then they produce fewer flowers and seeds. This agent has been released at a limited number of sites nationwide since autumn 2006, and it is too soon yet to know how well the moths are establishing or what impact they will be able to have.

A good number of releases of the plume moth have been made on the West Coast already, due to a rearing programme being initiated by the WCRCT (Table 11), and further releases are planned. A number of sites have been checked but it is still too early to judge establishment success. However, the fact that signs of the moth have been seen at Reefton

after they would have completed several generations and survived a winter suggests that establishment of the moth at this site a least looks likely. All release sites are being monitored by the WCRCT to check for establishment and to see if any further releases or harvesting and redistribution will be needed.

Table 11 Ragwort plume moth release sites on the West Coast

Site name	Organisation responsible	Grid reference/GPS	Date released	Date checked	Comments
Coal Creek	WCRCT	?	22/3/06	20/1/07	No sign, but early days yet
Fox Glacier	WCRCT	?	9/3/06		
Hobson Creek Farm	WCRCT	NZMS260 H36 538 384	21/4/06		
Ikamatua	WCRCT	?	6/4/06 22/3/06		
Inchbonnie	WCRCT	E2384150 N5830950 E23805040 N5831160 ? ?	16/3/06 16/3/06 17/3/06 18/12/06	5/12/06 5/12/06 4/1/06 30/3/07	No sign, but early days yet No sign, but early days yet No sign, but early days yet Signs of the moth seen here apparently
Kumara	WCRCT	?	10/3/06		
Reefton	WCRCT	?	22/3/06 29/3/06	20/1/07	Pupae found here apparently
Westport	WCRCT	?	17/3/06		
Whataroa	WCRCT	NZMS260 I34 955 740 ?	23/3/06 29/3/06		

5.5 St John's wort (*Hypericum perforatum*)

We were asked to look at a patch of St John's wort in the Nine Mile Rd – Victoria Rd area south-east of Westport. Upon inspection we discovered that the plant was not St John's wort but Sumatran fleabane (*Conyza* spp.) There was also a lot of ragwort present in this area. However, St John's wort is increasingly turning up at sites in South Westland (Tom Belton, pers. comm.) and it would be worth surveying the plant to see if the St John's wort beetles (*Chrysolina* spp.) are present. These beetles have helped to successfully control this plant in many other parts of New Zealand.

5.6 Thistles (*Carduus* spp., *Cirsium* spp.)

5.6.1 Californian thistle flea beetle (*Altica carduorum*)

The Californian thistle flea beetle is a foliage feeder. Both adults and larvae feed on the leaves and stems. It was released widely throughout New Zealand in the early 1990s, and after doing well initially at a number of sites appears to have died out. The reasons for the beetle failing to establish are not understood.

The beetle was released by DOC at one site at Karamea, which showed exactly the same trend as mentioned above (Table 12). Given that the beetle has not established in New

Zealand and better agents will be coming on stream soon, no further efforts to try to establish this beetle appear to be warranted.

Table 12 Californian thistle flea beetle release sites on the West Coast

Site name	Organisation responsible	Grid Reference/GPS	Date Released	Date Checked	Comments
Karamea Bridge Farm	DOC	NZMS260 L27 371 938	2/11/94 3/3/95	6/12/07	Good numbers seen in December 1995 but no sign of then now so site can be considered a failure

5.6.2 Californian thistle leaf beetle (*Lema cyanella*)

The Californian thistle leaf beetle is also a foliage feeder. Both adults and larvae feed on the leaves and stems. It was released widely throughout New Zealand in the early 1990s, but is thought to have established only at one site near Auckland. Numbers of beetles at this site have remained low but there were some promising signs this summer that they may be starting to build. The reasons for the poor establishment of the beetle are not understood.

The beetle was released by the WCRC at one site, Burton Rd, which was flooded soon afterwards (Table 13). Given the poor track record of the beetle elsewhere in New Zealand and that better agents will be coming on stream soon, no further efforts efforts to try to establish this beetle appear to be warranted, unless the beetle begins to show more promise at the Auckland site.

Table 13 Californian thistle flea beetle release sites on the West Coast

Site name	Organisation responsible	Grid reference/GPS	Date released	Date checked	Comments
Burton Rd	WCRC	NZMS260 K31 035 887	31/1/92	6/12/07	Site was flooded following release and no beetles have ever been seen here so site can be considered a failure

5.6.3 Nodding thistle crown weevil (*Trichosirocalus horridus*)

The nodding thistle crown weevil damages the crowns and roots of thistle rosettes. Plants that are not killed are stunted with fewer flowering stems, and any lateral regrowth may be attacked. Plants of all sizes are attacked. While nodding thistle (*Carduus nutans*) is believed to be the preferred host, the weevil attacks a number of thistle species: plumeless (*Carduus acanthoides*), winged (*Carduus tenuiflorus*), slender-winged (*Carduus pynocephalus*), Scotch (*Cirsium vulgare*), marsh (*Cirsium palustre*), and cotton (*Onopordum acanthium*) thistles. It was released widely throughout New Zealand in the late 1980s and early 1990s, and establishment has been excellent. The weevil is believed to have contributed to a decline in nodding thistles in many regions.

The weevil was released by the WCRC at one site, Rotomanu, to attack marsh thistle (*Cirsium palustre*) but failed to establish (Table 14). If *Carduus* and *Cirsium* thistles continue to be a problem on the West Coast then it would be worth making further efforts to establish this weevil.

Table 14 Nodding thistle crown weevil release sites on the West Coast

Site name	Organisation responsible	Grid reference/GPS	Date released	Date checked	Comments
Rotomanu	WCRC	NZMS1 S52 024 658	13/4/90	5/12/06	Unable to access release site due to river. Checked Scotch thistles nearby but no sign of the weevil

5.6.4 Nodding thistle receptacle weevil (*Rhinocyllus conicus*)

The nodding thistle receptacle weevil attacks the flowerheads of nodding thistles and a number of other thistle species to a lesser degree (plumeless, winged, slender-winged, Californian, and Scotch thistles). The weevil was released widely throughout New Zealand in the 1970s and 1980s and established well. It is now commonly found on nodding thistle and is believed to have contributed to a decline in nodding thistles in many regions.

It is believed that no official releases of the weevil were made on the West Coast because its preferred host was not a problem there. However, given that other less preferred hosts are present on the West Coast, the dispersal abilities of the weevil and the time that has elapsed, there is a chance that the weevil has subsequently made its own way over there. No signs of the weevil were seen when checking for other thistle agents, but further surveys would be needed to confirm whether the weevil is established there or not. If *Carduus* and *Cirsium* thistles continue to be a problem on the West Coast then it would be worth making further efforts to establish this weevil.

5.6.5 New thistle agents

A fly (*Urophora stylata*) that attacks the flowerheads of Scotch thistle, reducing seed production, is established in New Zealand, as is another fly (*Urophora solstitialis*) that attacks the flowerheads of nodding thistle and plumeless thistle and reduces seed production in these species. A third fly (*Urophora cardui*) that attacks Californian thistle stems is also established in New Zealand. Larval feeding tricks the plant into diverting valuable nutrients (which would normally be used for plant growth and increasing root reserves) into forming galls to feed the developing larvae. None of these flies have been released on the West Coast and are unlikely to have found their own way there yet. Given that the Californian thistle gall fly is limited in its usefulness by stock eating the galls and nodding and plumeless thistles are not major pests on the West Coast, possibly only the Scotch thistle gall fly should be considered for release on the West Coast, if in fact Scotch thistle is considered a serious enough problem to warrant any intervention.

ERMA has just given permission to release two new thistle agents. The Californian thistle stem miner (*Ceratapion onopordi*) feeds on thistle stems and roots and acts as a vector for the Californian thistle rust (*Puccinia punctiformis*). This rust is present in New Zealand but is limited in its ability to disperse and infect Californian thistles. The rust benefits from improved dispersal by the weevil, which in turn does better on rust-infected thistle stems than uninfected ones. The weevil prefers Scotch thistle and Californian thistle (if rust-infected) but is likely to also attack other thistle species to a lesser extent. The green thistle beetle (*Cassida rubiginosa*) is a foliage feeder. It prefers Californian thistle but is likely to attack most species of thistles. It is hoped that releases of both species will be available in 2008. If thistles are considered to be a serious enough problem on the West Coast then efforts to release the Californian thistle stem miner and green thistle beetle should be made.

6. Conclusions

The establishment success of weed biocontrol agents on the West coast is following similar trends to the rest of New Zealand. Of the 14 weed biocontrol agents that have been released during the last 25 years eight have become established, three have failed to establish, and the fate of the remaining three is currently unknown. At least one has also self-introduced (Table 15). While the climatic conditions experienced on the West Coast could make it more difficult to establish some insect agents, it does not appear to have been a major obstacle so far. However, it would appear that there are some places on the West Coast, such as Otira/Aickens and south of Whataroa, that are problematic for establishing control agents, and they should only be released there once populations are well established and plentiful at more benign locations.

Table 15 Status of weed biocontrol agents on the West Coast

Target	Species	Status on West Coast
Broom	Broom psyllid	Established
	Broom seed beetle	Established
	Broom twigminer	Unknown (self-introduced)
Gorse	Gorse pod moth	Established
	Gorse seed weevil	Established
	Gorse soft shoot moth	Established
	Gorse spider mite	Established
	Gorse thrips	Established
Old Man's Beard	Old man's beard leaf fungus	Unknown
	Old man's beard leaf miner	Established (self-introduced)
Ragwort	Cinnabar moth	Established
	Ragwort crown-boring moth	Unknown
	Ragwort flea beetle	Established
	Ragwort plume moth	Unknown
Thistles (*Carduus* spp. and *Cirsium* spp.)	Californian thistle flea beetle	Failed
	Californian thistle leaf beetle	Failed
	Nodding thistle crown weevil	Failed

No project is yet complete. Of the agents which are established, probably only three species (gorse pod moth, gorse spider mite, ragwort flea beetle) are widespread. For each weed target tackled to date there are still control agents which should be considered for release on the West Coast (Table 16). For advice on how to source biocontrol agents that are not available yet on the West Coast please contact the authors. For information about how best to harvest and redistribute biocontrol agents from existing sites see www.landcareresearch.co.nz/research/biocons/weeds/ or contact the authors.

Biological control is a very long term approach and it may take 50 years or longer to see changes in the distribution of long-lived weeds. Experience has shown that not all projects attempted will be successful, but that the successful ones more than pay for the failures (Page & Lacey 2006). There has been a considerable investment to date by a number of organisations on the West Coast to develop biocontrol programmes for weeds but more will be required to complete projects and reap the benefits.

Table 16 Possible new weed biocontrol agents for the West Coast

Target	Agents still to be released or established
Broom	Broom gall mite Broom leaf beetle Broom shoot moth
Gorse	Gorse colonial hard shoot moth
Old man's beard	Old man's beard bark beetle? Old man's beard sawfly?
Thistles	Californian thistle stem miner? Green thistle beetle? Nodding thistle crown weevil? Nodding thistle receptacle weevil? Scotch thistle gall fly?

Biocontrol programmes are continually being developed in New Zealand and some of these new targets are likely to be of interest to the West Coast. The National Biocontrol Collective, which includes all regional councils and unitary authorities (except the West Coast Regional Council) plus the Department of Conservation, funds most current and new biocontrol programmes. Collective decision-making is undertaken annually to decide which weeds to target and how best to progress current projects. There would be no barrier to the West Coast Regional Council joining the National Biocontrol Collective, if it so desired, provided it could contribute some funding. By joining the National Biocontrol Collective the West Coast Regional Council would then be able to participate in decision making about what weeds should be targeted for biocontrol and have access to new agents as soon as they are developed.

7. Recommendations

7.1 Broom

- Harvest and redistribute the broom psyllid to areas where it is not yet present.
- Harvest and redistribute the broom seed beetle to areas where it is not yet present.
- Determine the status of the broom twig miner on the West Coast.
- Release the broom leaf beetle, broom shoot moth, and broom gall mite as soon as they are available.
- Attempting to establish broom agents at Otira should be a low priority. Of the agents available the broom shoot moth is most likely to be able to cope with the conditions at

Otira, and a release should be attempted once the moth is established elsewhere on the West Coast in harvestable numbers.

7.2 Gorse

- Check if the gorse pod moth is present throughout the West Coast and if areas remain free of the moth shift infested pods to them.
- Further checks of Granville Forest should be made in coming years in late November – early December, and if the soft shoot moth becomes abundant it would be worth harvesting some and shifting them to other areas. Given that the moth is now plentiful in Canterbury and Marlborough it may also be worthwhile to harvest some moths from one of these areas this coming spring.
- Harvest gorse thrips from well-established sites and shift them to areas where they are not yet present.
- Release the gorse colonial hard shoot moth as soon as possible.
- Attempting to establish gorse agents at Aickens or South of Whataroa should be a low priority as conditions in these places are more difficult for them.

7.3 Old man's beard

No further action is required unless the current DOC weed-led control project is unsuccessful and the weed continues to be a problem.

7.4 Ragwort

- Ragwort crown-boring moth release sites should be monitored in future years to check for establishment and to see if any futher releases or harvesting and redistribution is needed. Caryl Coates is contracted to do this on behalf of the West Coast Ragwort Control Trust .
- Ragwort plume moth release sites should be monitored in future years to check for establishment and to see if any futher releases or harvesting and redistribution is needed.

7.5 St John's wort

Check the plant in South Westland to see if any biocontrol agents are present.

7.6 Thistles

- If *Carduus* and *Cirsium* thistles continue to be a problem on the West Coast then it would be worth making further efforts to establish the nodding thistle crown weevil, and check the status of the nodding thistle receptacle weevil.
- If Scotch thistle is considered a serious enough nuisance on the West Coast then efforts to release the Scotch thistle gall fly should be made.
- If thistles are considered to be a serious enough nuisance on the West Coast then efforts to release the Californian thistle stem miner and green thistle beetle should be made.

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9. References

Gourlay AH, Fowler SV, Rattray G 2006. Abundance of ragwort flea beetle (*Longitarsus jacobaeae*) at five sites on the West Coast, South Island, New Zealand. Landcare Research Contract Report LC0405/131 prepared for the West Coast Ragwort Control Trust. 20 p.

Williams PA, Hayes LM 2007. Emerging weed issues for the West Coast Regional Council and their prospects for biocontrol. Landcare Research Contract Report LC0607/109 prepared for the West Coast Regional Council. 41 p.

Page AR, Lacey KL 2006. Economic impact assessment of Australian weed biological control. CRC for Australian Weed Management Technical Series #10. 151 p.

Smith LA 2003. Investigation of ragwort flea beetle (*Longitarsus jacobaeae* Coleoptera: Chrysomelidae) establishment success in Westland and Tasman. Landcare Research Contract Report LC0203/181 prepared for the West Coast Ragwort Control Trust. 15 p.