



Pieris brassicae (great white butterfly) eradication annual report 2015/16

Craig B. Phillips, Kerry Brown, Chris Green, Keith Broome, Richard Toft,
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Cover: The great white butterfly team contribution to the 2014 Nelson Mask Parade. *Photo: Nicola Gourlay*

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Pieris brassicae (great white butterfly) eradication annual report 2015/16

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Executive summary

Pieris brassicae, great white butterfly, is a Northern Hemisphere species that was first found in New Zealand in Nelson in May 2010. It is a threat to New Zealand native cresses as well as to forage and vegetable brassicas, thus the Department of Conservation (DOC) launched an eradication attempt on 19 November 2012.

To find *Pieris brassicae* in Nelson during 2015/16, DOC staff either searched sites (mainly residential properties), or responded to reports from the public. Nelson residents remained supportive of the programme and DOC gained access to all of the > 30,000 sites within the operational zone. In 2015/16, DOC conducted 70106 site inspections and found no *P. brassicae*. Detection rates (number of infested sites divided by number of searched sites) steadily declined from 0.048 in 2012/13, to 0.019 in 2013/14, 0.002 in 2014/15, and 0 in 2015/16. The distribution of *P. brassicae* also declined: the maximum distance from the centre of Nelson (-41.267, 173.278) that *P. brassicae* was detected was 24.1 km in 2012/13, 14.2 km in 2013/14, and 8.1 km in 2014/15. The operational area covers 9742 ha and, for operational purposes, DOC divided it into 46 management blocks. The number of blocks in which *P. brassicae* was detected declined from 38 in 2012/13, to 34 in 2013/14, 24 in 2014/15 and zero in 2015/16.

The last *P. brassicae* detected was an adult male captured near central Nelson on 16 December 2014. Since then:

- Sufficient time has elapsed for *P. brassicae* to complete six generations.
- DOC has conducted 106,545 general surveillance inspections of 29,445 different locations (mean of 3.6 inspections per site) situated 0–20 km from central Nelson. Search emphasis was on sites where *P. brassicae* host plants occur.
- DOC has continued to encourage the public to report possible sightings, and responded to all 41 reports received.
- DOC and Plant and Food Research have conducted 55 searches of native cress populations and brassica crops at 12 sites in Nelson-Tasman.
- Modelling indicated that there is a low relative probability of *P. brassicae* presence across all Nelson management blocks.

Thus, DOC is now confident that *P. brassicae* has been eradicated and the eradication programme was discontinued on 4 June 2016.

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1. Purpose of this document

This document summarises the Department of Conservation's (DOC's) programme to eradicate *Pieris brassicae* L. (Lepidoptera: Pieridae), great white butterfly, from Nelson during the 2015/16 financial year (July to June). It has been written for senior managers in DOC and the Ministry for Primary Industries (MPI), stakeholders, staff in the *P. brassicae* eradication programme, and people attempting to eradicate other pests. Additional information is available from previous annual reports (Toft 2013; Phillips et al. 2014a, 2015) and references therein.

2. Stakeholder contributions and budget

In 2015/16, Vegetables NZ contributed \$60,000 to the *P. brassicae* eradication programme, and MPI contributed \$150,000. MPI also forwarded calls received from the public via their 0800 80 99 66 hotline. Plant and Food Research conducted fortnightly surveys at 5–7 Nelson sites outside the eradication zone to monitor for *P. brassicae*. AgResearch provided research support from its contribution to the Better Border Biosecurity research collaboration (www.b3nz.org).

In financial year 2015/16 (July to June), \$1,060,000 was spent on the eradication programme (Appendix 1). The programme's total cost from 17 November 2012 to 30 June 2016 has been \$4,972,942 (Appendix 2).

3. Background and justification

The natural distribution of *P. brassicae* is Europe and Asia. It was first detected in Nelson on 14 May 2010, has not been recorded elsewhere in New Zealand, is an Unwanted Organism under the Biosecurity Act 1993, and is likely to be a pest of forage and vegetable brassicas. In 2010, MPI responded to *P. brassicae* with a monitoring programme that aimed to slow its spread. However, DOC advocated for an eradication attempt due to the risk it posed to New Zealand native brassicas—as evidenced by the damage currently caused to native brassicas by *P. rapae* (small white butterfly)—and took over the incursion response to attempt eradication on 19 November 2012. By this time, *P. brassicae* was firmly established in Nelson and spreading (Fig. 1).

Nixon (2015) calculated that cultivated brassicas are worth \$207 million per annum to New Zealand. East (2013) estimated that eradicating *P. brassicae* would have a net present value (4% discount rate) to the horticultural and agricultural sectors in the range \$4.8 million to \$61 million per annum, depending on how quickly *P. brassicae* spread through New Zealand.

New Zealand has 79 native brassica species (3% of New Zealand's flora), of which 55 are currently threatened or at risk of extinction. A further 13 are not threatened, but are nevertheless at risk from *P. brassicae*. Many of the 68 at-risk species are represented only by small isolated populations. They also face many other threats, including browsing by mammals, habitat destruction and herbivory by *P. rapae*. After including impacts on cultivated and native brassicas in her analysis, East (2013) estimated that eradicating *P. brassicae* would have a net present value (4% discount rate) to New Zealand in the range \$43 million to \$133 million per annum, depending on how quickly *P. brassicae* spread.

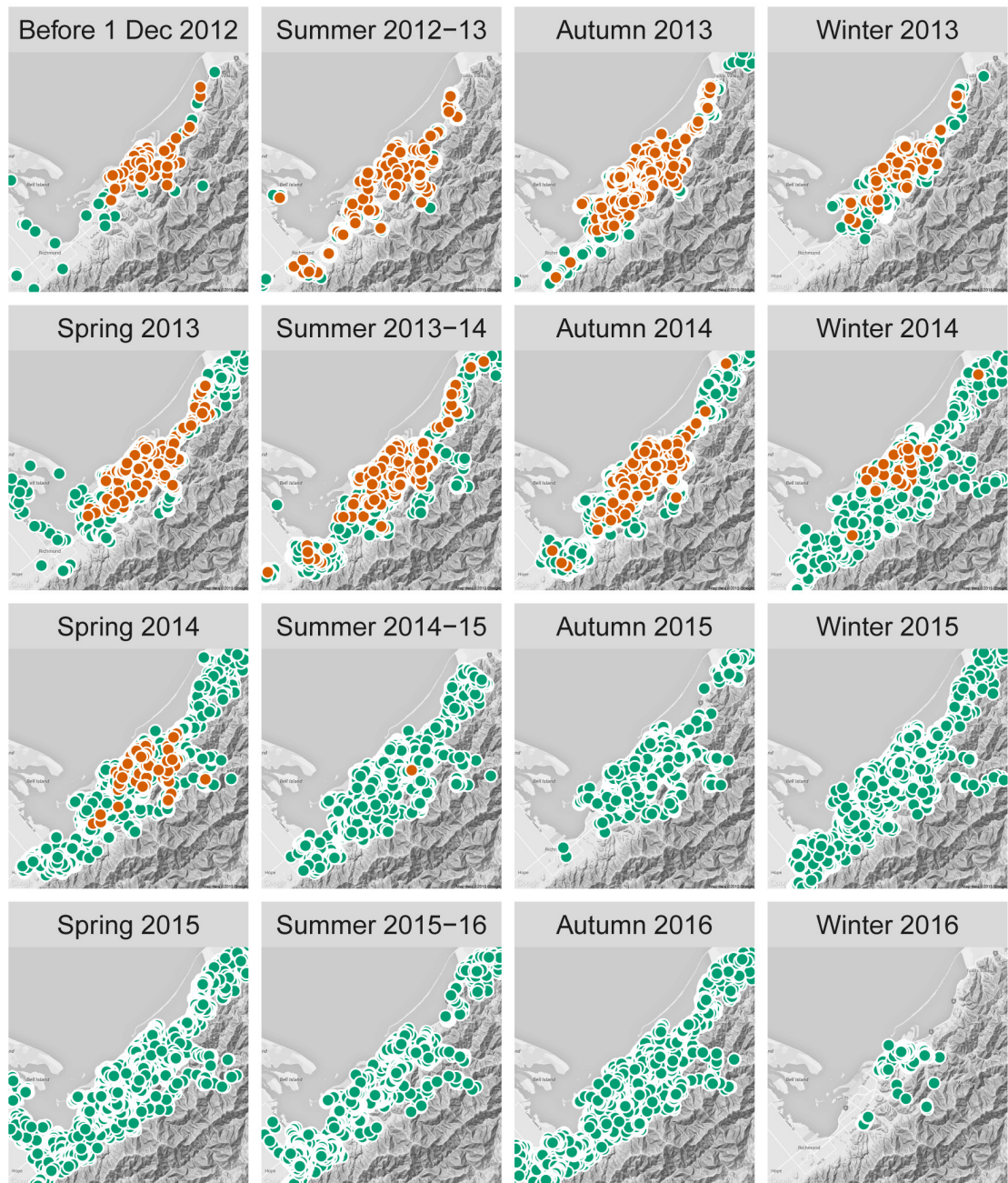


Figure 1. Spatial distribution of *Pieris brassicae* presence (red) and absence (green) records within the Nelson eradication zone from May 2010 to June 2016, split by season, with records from before 1 December 2012 pooled.

4. Programme goal

The programme aimed to eradicate *P. brassicae* from Nelson by 30 June 2015, and to confirm that eradication has been successful by 30 June 2017. The programme appears to have met its goal, but a formal declaration that *P. brassicae* has been eradicated is pending further discussion with MPI.

5. Temporal changes in *Pieris brassicae* distribution and abundance

5.1 Distribution

Figure 1 shows the spatial distribution of *P. brassicae* presence and absence records within the Nelson eradication zone from May 2010 to June 2015. Detections made 'before 1 Dec 2012' (Fig. 1) arose solely from passive surveillance and would have underestimated the abundance and spatial distribution of *P. brassicae* compared with subsequent seasons when active surveillance predominated. During the programme, particularly since autumn 2014, *P. brassicae* became increasingly confined to central Nelson. This was likely a result of the programme's strategy of eliminating small outlying populations to minimise *P. brassicae* spread, while simultaneously suppressing the larger central population to reduce butterfly emigration. During spring 2014, *P. brassicae* was detected in 22 (48%) of 46 management blocks. Only one *P. brassicae* was detected in summer 2014/15, which occurred near the centre of Nelson, and none have been found since.

5.2 Detection rates

In this report, locations searched for *P. brassicae* are referred to as 'sites'. Many of the searched sites were residential properties.

Pieris brassicae eggs, larvae and adults are relatively easily detected compared with pupae (Phillips et al. 2014b). Detection rates tend to be low both in winter, when most *P. brassicae* are pupae, and in summer, when probably about half of *P. brassicae* aestivate (summer dormancy) as pupae (Kean & Phillips 2013). Detection rates tend to be high in spring because adults emerge from overwintered pupae to lay eggs, and also in autumn when there is a coincidence of second generation adults emerging from pupae that aestivated, and third and fourth generation adults emerging from pupae that did not aestivate (Kean & Phillips 2013).

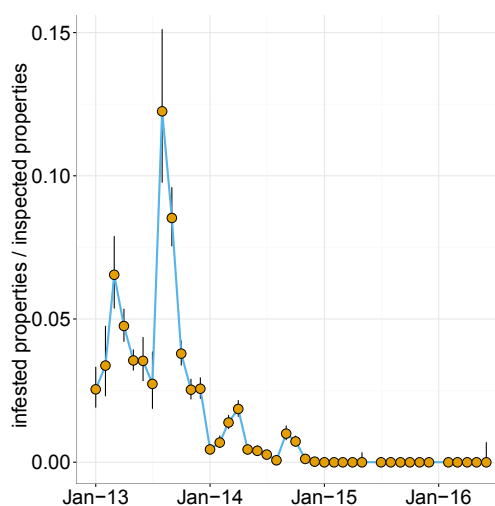


Figure 2 shows *P. brassicae* detection rates each month from February 2013 to June 2016. Rates peaked in September 2013, which coincided with a time when the eradication programme was well underway, staff were fully trained, *P. brassicae* was relatively abundant, and most of the population was exposed to control. Thereafter, rates generally declined, though they showed regular smaller peaks each autumn and spring until the end of 2014. They declined to zero in January 2015 and remained there until 4 June 2016 when searching for *P. brassicae* ended.

Figure 2. *Pieris brassicae* detection rates each month from February 2013 to June 2016. Error bars show 95% binomial confidence intervals. Note: no searches were conducted in June 2015 and three searches conducted in January 2016 were omitted.

6. Tactics and results

Methods for detecting and eliminating *P. brassicae* were refined throughout the programme. Previous improvements were described Phillips et al. (2013), and the 2013/14 and 2014/15 annual reports. In brief, the eradication zone was divided into 46 management blocks (Fig. 3), and each block was assigned a priority between 1 (high) and 4 (low). Block prioritisation was based mainly on infestation rates measured during previous searches, although other factors were also considered. Within blocks, individual sites were prioritised for searching based on previous records of *P. brassicae* detections and the presence of host plants at each site. The timing and frequency of searching were based on the seasonality of *P. brassicae*. Thus, decisions about where and when to search were made by considering *P. brassicae* seasonality, block priorities, site priorities, operational capacity and logistics. In essence, the prioritisation constituted an attempt to predict sites where *P. brassicae* would be most abundant (high priority) and least abundant (low priority).

Search tactics were modified in 2015/16 by gradually shifting emphasis to lower priority blocks. After the last detection of *P. brassicae* occurred in December 2014, continued intensive searching of high priority blocks provided increasing confidence that *P. brassicae* had been eliminated from those areas. However, given persistent potential for *P. brassicae* to disperse from high to low priority blocks, the less-intensive searching that had been conducted in low priority blocks meant there was growing uncertainty as to whether they had become infested. The change in search emphasis from higher to lower priority blocks was informed by a 'relative risk of presence' model, described in the following section. As for high priority blocks, the emphasis of searching in low priority blocks was on sites where host plants had previously been recorded.

6.1 Relative risk of *Pieris brassicae* presence

A mathematical model that estimated relative risks of *P. brassicae* presence in different management blocks was developed in consultation with DOC by Kean and Phillips (unpublished). It considered searches conducted by DOC, but not passive surveillance (i.e. it assumed blocks shared equal per-site probabilities that residents would report the possible presence of *P. brassicae*).

The relative risk of *P. brassicae* being present in a block was calculated from the proportion of sites with host plants that were searched each month, and the probability of detecting *P. brassicae* during the searches. Detection probability varied with month to account for the difficulty of finding *P. brassicae* pupae in the months they occurred.

For each month and block, if no *P. brassicae* were detected, relative risk of *P. brassicae* presence declined with the proportion of host plant sites searched. If *P. brassicae* was detected, relative risk of presence increased, though not to 100%, because DOC always controlled all *P. brassicae* found.

It was assumed *P. brassicae* could disperse between blocks, and the risk that a block had received *P. brassicae* immigrants was proportional to the overall risk of *P. brassicae* being present elsewhere in the operational area. Dispersal probability varied with month to account for the greater likelihood of dispersal in months when *P. brassicae* adults occurred.

In blocks that received few or no searches, relative risk of *P. brassicae* presence increased with time due to the possibility of *P. brassicae* immigrating from other blocks. Thus, relative risk of presence per block and month were calculated using *P. brassicae* seasonality, dispersal risks, and records of host plant sites and sites searched.

The model enabled DOC to construct preliminary plans for future searches, then to ascertain the influence the plans would have on relative between-block risks of *P. brassicae* being present.

Thus, it provided guidance on how to target search activities to maximise confidence that *P. brassicae* was absent from the entire operational area. However, search plans were always further informed by logistical considerations, and knowledge and experience of operational staff.

Figure 4 shows model estimates of relative probability of *P. brassicae* presence for June of 2015 and 2016. In June 2015, the model indicated that several blocks had relatively high probabilities of *P. brassicae* presence because they had received few or no recent searches. During 2015/16,

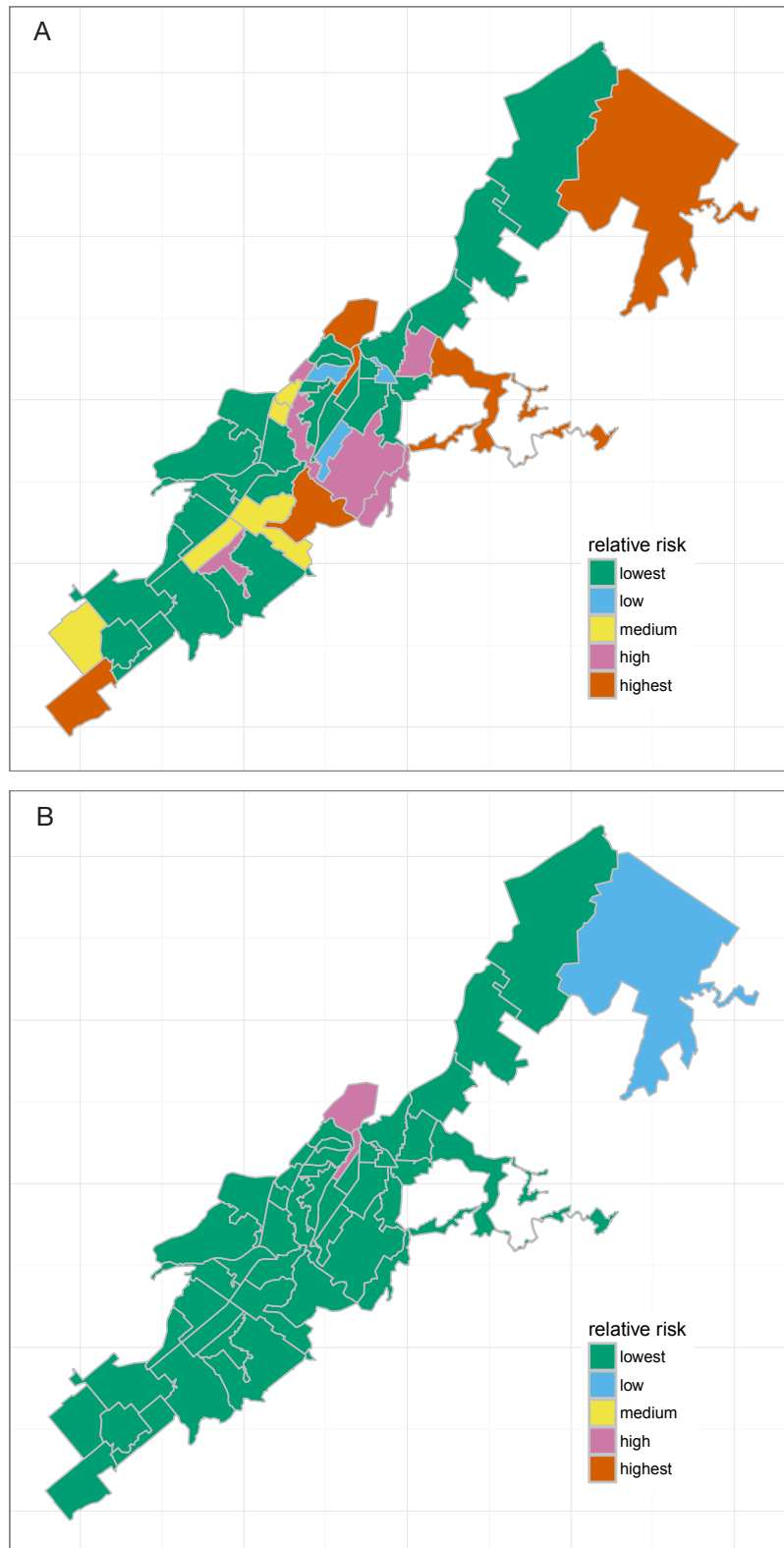


Figure 4. Relative between-block risks of *Pieris brassicae* presence in June of 2015 (A) and June 2016 (B).

DOC increasingly allocated its search effort to minimise relative probability of presence across all blocks, rather than emphasising blocks where detections had most recently occurred. By June 2016, relative probability of presence was uniformly low throughout the operational zone. Minor exceptions were Lud Valley (Fig. 4, blue fill), Vanguard and Port Nelson (Fig. 4, pink fill). These blocks showed slightly higher relative probabilities because they contained few host plant sites and the frequent repeated searches needed to drive further reductions in model estimates of their relative probabilities of *P. brassicae* presence were impractical and unjustified.

6.2 Site access and public support

In previous years, site searches were occasionally inhibited by factors such as locked gates, dangerous dogs, or absent or uncooperative occupants. However, DOC staff usually negotiated access without needing to assert their legal rights to search sites as authorised persons under the Biosecurity Act 1993. Data for 2015/16 indicate the value of this negotiating expertise because, of a total of 30,443 sites in the Nelson eradication zone, none had blocked access.

Before the eradication programme, DOC enjoyed an excellent reputation in Nelson-Tasman, and subsequently maintained strong public support throughout it. This was evidenced by the few sites with blocked access before 2015/16, their absence in 2015/16, ongoing public reports of possible *P. brassicae* sightings (Section 6.4), positive media articles, and informal unsolicited positive feedback from Nelson residents.

DOC rangers were consistently friendly, professional and courteous, and their searches of residential properties were always tolerated and usually well received. However, a few residents objected to or resented frequent visits to their properties. Such responses increased in early 2016, probably due to DOC's increased emphasis on searching residential properties within lower-priority blocks that were unaccustomed to high visit frequencies.

6.3 DOC surveillance effort and results

Table 1 provides an overview of the site search data by financial year to 30 June 2016. The number of sites searched markedly increased following the start of the eradication programme in late 2012, with approximately equal numbers of searches being conducted from 2013/14 until 2015/16. However, compared with the previous year, the number of infested sites declined by 89% in 2014/15 and 100% in 2015/16.

Table 1. Sites searched, sites infested with *Pieris brassicae* and proportion infested by financial year* (July to June).

YEAR	SITES SEARCHED	SITES INFESTED	PROPORTION OF SITES INFESTED (%)
2009/10	3	3	100.0
2010/11	88	30	34.1
2011/12	76	71	93.4
2012/13	23923	1121	4.7
2013/14	80263	1490	1.9
2014/15	83118	170	0.2
2015/16	76507	0	0.0
Total	263978	2885	1.5

* Figures for some years prior to 2015/16 given in earlier annual reports differ slightly from those shown in Table 1; those given here are more accurate.

6.4 Passive surveillance effort and results

Passive surveillance involves reporting of *P. brassicae* by the public, and was supported by a public awareness campaign. The public were asked to report *P. brassicae* via a toll-free 0800 phone number that was monitored 24/7 by MPI. Staff responded to a passive surveillance report within 48 hours and usually also visited the site to verify it. Throughout the programme, 76% of possible sightings were reported via the toll-free number, and most of the remainder were reported by phone to DOC's office in Nelson.

A variety of methods were used during 2015/16 to communicate with the public about the eradication programme (Appendix 3). To support passive surveillance, communication was emphasised during spring and autumn when *P. brassicae* was most conspicuous.

Table 2 summarises sightings reported by the public, and the proportion that were *P. brassicae*, by financial year. Total sightings for financial years prior to 2015/16 (Table 2) are slightly higher than those given in previous annual reports because they include sightings reported from both outside and within the operational area; previously stated figures were just from within it. The proportion of reported sightings that arose from within the operational area steadily increased from 46% in 2012/13 to 87% in 2015/16, perhaps indicating that, as the programme proceeded, public awareness of *P. brassicae* remained higher within the operational area than beyond it.

Thirty percent of all reported sightings were confirmed to be *P. brassicae* (Table 2). Of reports made via the 0800 number, 35% were confirmed to be *P. brassicae* in 2012/13 and this steadily declined to 0% in 2015/16. In contrast, the proportion of sightings reported via DOC's phone that was confirmed to be *P. brassicae* remained low throughout the programme (mean 4%). Reasons for this apparent difference are unknown.

Table 2. Number of passive surveillance reports and the number confirmed to be *Pieris brassicae* by financial year from 19 November 2012 to 30 June 2016.

YEAR	TOTAL REPORTS	REPORTS CONFIRMED TO BE <i>Pieris brassicae</i>	PROPORTION <i>Pieris brassicae</i> (%)
2012/13	698	305	44
2013/14	823	256	31
2014/15	288	25	9
2015/16	127	0	0
Total	1936	586	30

6.5 Host plant control

In 2015/16, host plants were controlled at 2537 sites during general surveillance; this usually involved manually removing some or all host plants.

A further 37 sites were visited specifically to control host plants; 10 to control nasturtium and 27 to control wild brassicas. Many of these sites had also received host plant control in previous years, and in 2015/16 were visited up to three times to manage regrowth. Herbicide was usually applied to areas of host plants that ranged from 1 m² to 504 m².

6.6 Insecticide use

The programme's use of insecticide was described in the 2013/14 annual report. No insecticide was used in 2015/16 due to the absence of *P. brassicae* detections.

6.7 Monitoring for *Pieris brassicae* outside the operational area

Monitoring for *P. brassicae* outside the operational area occurred via passive surveillance, general surveillance by DOC, monitoring of native cress populations by DOC, and searching of brassica crops by Plant and Food Research.

In 2015/16, passive surveillance outside the operational area was supported by delivering letters and pamphlets to residences in Brightwater and Upper Moutere (October 2015), and Hope (November 2015). None of the 17 public reports of *P. brassicae* sightings received from outside the operational area in 2015/16 were of *P. brassicae*.

Sites outside the operational area searched for *P. brassicae* by Department of Conservation and Plant and Food Research in 2015/16 are shown in Fig. 5. These included 759 general surveillance searches conducted by DOC between 21 August 2015 and 3 June 2016, many in Bronte, Cable Bay, and Mapua (Fig. 5). The general surveillance included three forage brassica crops in Upper Moutere, Delaware Bay and Brightwater, which were searched in May 2016. DOC also searched native cress populations for *P. brassicae* on 10 occasions at five sites between 6 July 2015 and 21 April 2016, including on Noman, Saxton and Tonga Islands (Fig. 5). Plant and Food Research searched brassica crops at seven sites on 30 occasions between 7 January 2016 and 20 April 2016 (Fig. 5). None of the searches detected *P. brassicae*.

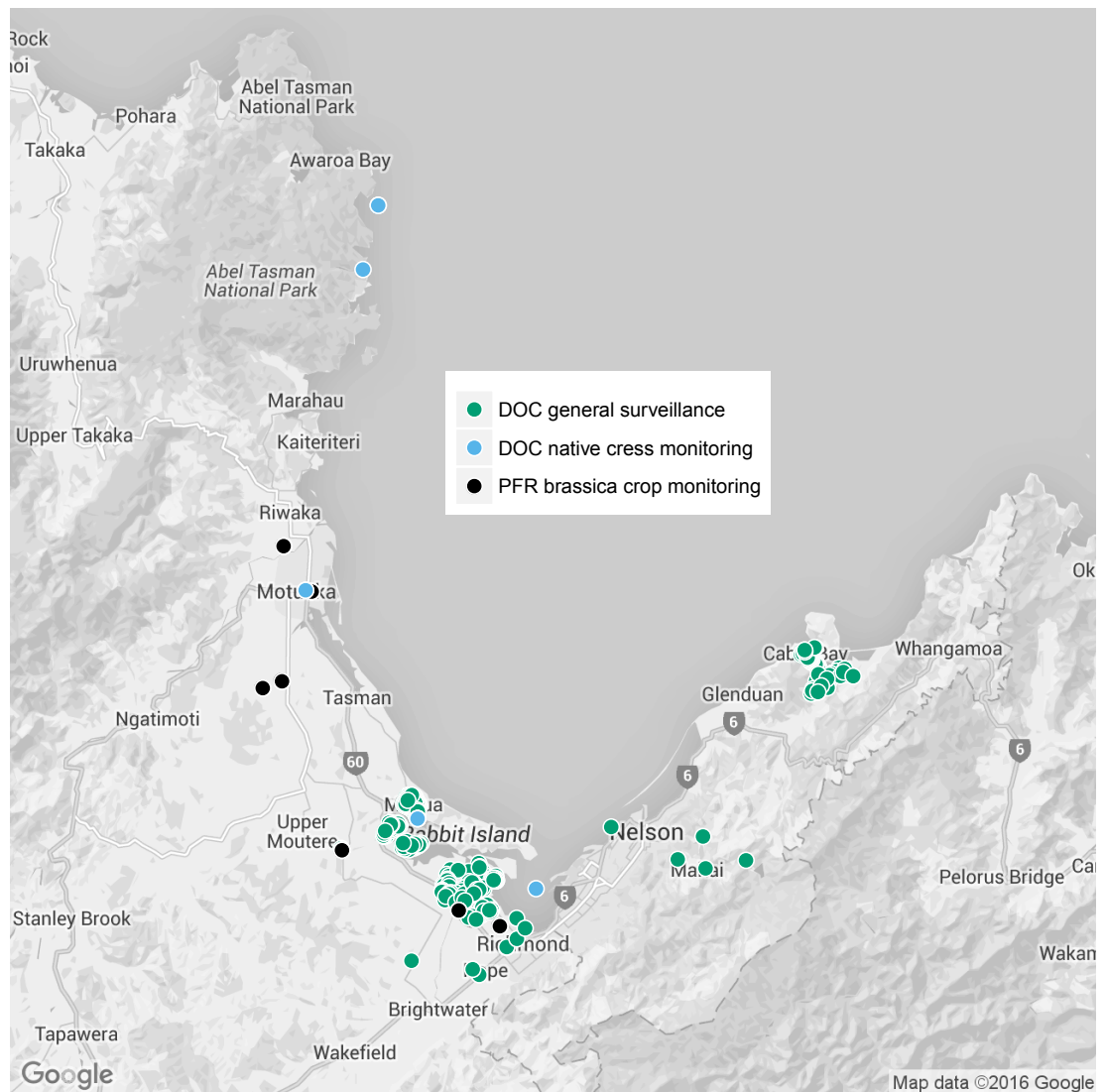


Figure 5. Sites outside the operational area searched for *Pieris brassicae* by Department of Conservation and Plant and Food Research staff.

6.8 Summary of search effort since *Pieris brassicae* was last detected

The last *P. brassicae* detected was an adult male captured on 16 December 2014. Since then:

- Sufficient time has elapsed for *P. brassicae* to complete six generations in Nelson.
- DOC has continued to encourage the public to report possible sightings, and responded to all 41 reports received.
- DOC and Plant and Food Research have conducted 55 searches of native cress populations and brassica crops at 12 sites situated 8–45 km from central Nelson (Fig. 5).
- DOC has conducted 106,545 general surveillance searches of 29,445 different sites (mean of 3.6 searches per site) distributed 0–20 km from central Nelson. Search emphasis was on sites where *P. brassicae* host plants occur.
- Modelling has indicated that there is a low relative probability of *P. brassicae* presence across all Nelson management blocks.

The 29,557 sites searched since *P. brassicae* was last detected are shown in Fig. 6.

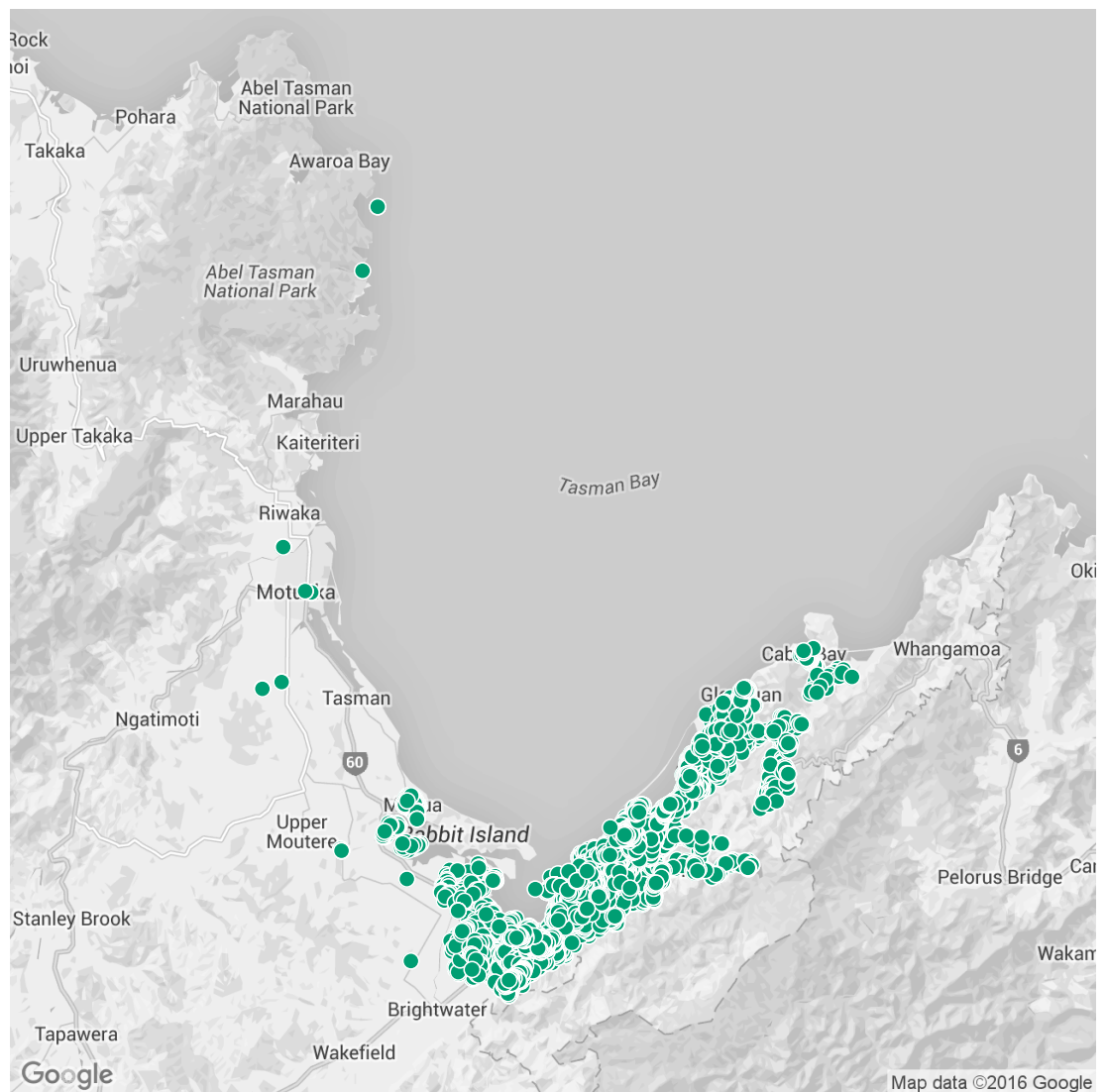


Figure 6. Summary of all sites searched for *Pieris brassicae* after it was last detected near central Nelson on 16 December 2014.

7. Management

7.1 Research

In 2015/16, the \$72,000 p.a. contribution that MPI had made to *P. brassicae* eradication research in previous years was instead invested in the operational programme because the operation was critically short of money. The only research contributions were from AgResearch (via B3) and Plant and Food Research (Appendix 2). These comprised:

- AgResearch further developed the model of *P. brassicae* relative probability of presence (Section 6.1) and used it to assist DOC to develop its search plans throughout 2015/16.
- AgResearch continued to help DOC to define its priorities for searching blocks and sites (Phillips 2014), and helped plan how it should respond if *P. brassicae* was detected during the final stages of the programme.
- AgResearch used PCR melt curve analysis to rapidly determine if Lepidoptera eggs and young larvae, not identifiable morphologically, detected on brassicas in Nelson were *P. brassicae* (Hiszczynska-Sawicka & Phillips 2014 and unpublished data April 2016)
- AgResearch reported to MPI and published research conducted in 2014/15 to mass rear and release the parasitic wasp *Pteromalus puparum* to help control *P. brassicae* pupae (Richards et al. 2015, in press)
- Plant and Food Research continued to collect the parasitic wasp *Cotesia glomerata*, which attacks *P. brassicae* larvae, from outside the operational area and provide them to DOC for release within the operational area.
- Plant and Food Research continued to conduct surveillance for *P. brassicae* in brassica crops outside the operational area (Section 6.7).

7.2 Presentations

Table 3 summarises presentations about *P. brassicae* made in 2015/16.

Table 3. Presentations about *Pieris brassicae* made in 2015/16. All presenters were from DOC.

PRESENTER	MEETING	DATE	LOCATION
C. Green	B3 Maori Engagement Hui	7 Aug 2015	Auckland
	Biosecurity Institute NETS Conference	26 Aug 2015	Dunedin
	NZ Ecological Society Conference	17 Nov 2015	Christchurch
	B3 Conference	9 May 2016	Wellington
J. Murphy	Senior class at Nelson Central School	Nov 2015	Nelson
M. Shepherd	New Zealand Conservation Authority	5 Apr 2016	Nelson
K. Henderson	Top Of The South GIS Group (Nelson)	8 Apr 2016	Nelson

8. Acknowledgements

We thank the many DOC staff involved who have shown continued dedication, commitment and enthusiasm during a difficult period of restructuring, high workloads and funding shortfalls. We also acknowledge the many people from outside DOC who have generously provided their time, advice, support and expertise, including researchers in the Better Border Biosecurity research collaboration, www.b3nz.org.

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Appendix 1

Eradication programme costs for 2015/16 financial year (July to June) in New Zealand dollars

BUDGET ITEM	COST
Salaries	\$29,000
Wages	\$920,000
Uniforms	-
Travel	\$4,200
Vehicles	\$500
Contractors/consultants	\$700
Printing/publication	\$4,200
Other operating	\$16,400
Total expenses	\$975,000
External contributions*	\$210,000
Total DOC Contribution	\$765,000

* External contributions to operational costs were from Vegetables NZ (\$60,000) and MPI (\$150,000).

Appendix 2

Eradication programme costs from 19 November 2012 to 30 June 2016 in New Zealand dollars

YEAR	AGENCY	COST (NZ\$)
2012/13	DOC	486,834
	AGR (via B3)	50,000
	Vegetables NZ	40,000
	PFR	50,000
	MPI	27,000
	2012/13 total	653,834
2013/14	DOC	1,327,908
	AGR (via B3)	100,000
	PFR	60,000
	MPI	76,000
	Vegetables NZ	40,000
	TR Ellet Agricultural Research Trust (to AGR)	25,000
	Dairy NZ	10,000
	2013/14 total	1,638,908
2014/15	DOC	1,313,200
	AGR via B3	150,000
	PFR	25,000
	MPI	72,000
	Vegetables NZ	60,000
	2014/15 total	1,620,200
2015/16	DOC	765,000
	AGR via B3	70,000
	MPI	150,000
	PFR	15,000
	Vegetables NZ	60,000
	2015/16 total	1,060,000
Grand total to date		4,972,942

Appendix 3

Pieris brassicae public awareness activities in 2015/16

TIME	ACTIVITY	COMMENT
October–November 2015	Help us get to zero public campaign	Campaign started in March 2015. Weekly advertisements in Nelson Mail and Waimea Weekly
October 2015	Letter drops	Letters and pamphlets delivered to houses in Upper Moutere
November 2015	Letter drops	Letters and pamphlets delivered to houses in Brightwater and Hope
15 February 2016	Media release	Programme update published on Nelson Mail section of stuff.co.nz (T. Grant)
29 February 2016	Intranet story	Programme update provided on internal DOC website (T. Grant)
20 March 2016	Display describing Help us get to zero campaign	Race Unity Day at Victory Square, Nelson (J. Cronin)
April 2016	Help us get to zero public campaign	Weekly advertisements in Nelson Mail and Waimea Weekly (M. Shepherd)
11 May 2016	Article in Waimea Weekly	Article about the training DOC staff receive for dealing with dogs during site searches (J. Bergman)
13 June 2016	DOC blog story by the Director General of DOC	Update about the eradication programme (L. Sanson)