



# *Pieris brassicae* (great white butterfly) eradication annual report 2014/15

Craig Phillips, Kerry Brown, Chris Green, Keith Broome,  
Richard Toft, Michael Shepherd, Simon Bayly and Jo Rees



Cover: The great white butterfly eradication team. *Photo: Nicola Gourley*

© Copyright October 2015, New Zealand Department of Conservation

Published by Whakatu/Nelson Office, Department of Conservation, Private Bag 5, Nelson 7042, New Zealand.

# CONTENTS

Executive summary	1
1. Purpose of this document	2
2. Stakeholder contributions and budget	2
3. Background	2
4. Goal, objectives and feasibility	3
4.1 Goal	3
4.2 Objectives	3
4.3 Feasibility	4
5. Temporal changes in <i>Pieris brassicae</i> distribution and detection rate	4
5.1 Distribution	4
5.2 Detection rates	4
6. Tactics and results	6
6.1 Management blocks	6
6.2 Prioritising properties	8
6.3 Property access	8
6.4 DOC surveillance effort and results	8
6.5 Passive surveillance effort and results	9
6.6 Captures of adults	9
6.7 Host plant control	10
6.8 Insecticide use	10
6.9 Delimitation	10
6.10 Enhancing natural parasitism to assist eradication	11
6.11 <i>Pieris brassicae</i> genetics	12
7. Management	12
7.1 Decision-making triggers	12
7.2 Plan for responding to detections beyond Nelson	12
7.3 DOC and MPI roles and responsibilities	13
7.4 Team structure and change in effort	13
7.5 Data management	13
7.6 Research	13
7.7 Reporting and presentations	13
8. Acknowledgements	14

9. References	14
<hr/>	
Appendix 1	
<hr/>	
Eradication programme costs for 2014/15 financial year (July to June) in New Zealand dollars	15
Appendix 2	
<hr/>	
Eradication programme costs from 19 November 2012 to 30 June 2015 in New Zealand dollars.	16
Appendix 3	
<hr/>	
<i>Pieris brassicae</i> public awareness activities August 2014 to July 2015	17

# *Pieris brassicae* (great white butterfly) eradication annual report 2014/15

Craig Phillips<sup>1</sup>, Kerry Brown<sup>2</sup>, Chris Green<sup>3</sup>, Keith Broome<sup>4</sup>, Richard Toft<sup>5</sup>,  
Michael Shepherd<sup>2</sup>, Simon Bayly<sup>2</sup> and Jo Rees<sup>2</sup>

<sup>1</sup> AgResearch, Private Bag, 4749, Christchurch 8140; Better Border Biosecurity, [www.b3nz.org](http://www.b3nz.org).

<sup>2</sup> Department of Conservation, Private Bag 5, Nelson 7042; [kbrown@doc.govt.nz](mailto:kbrown@doc.govt.nz).

<sup>3</sup> Department of Conservation, Private Bag 68908, Newtown, Auckland 1145.

<sup>4</sup> Department of Conservation, Private Bag 3072, Hamilton 3240.

<sup>5</sup> Entecol Ltd, PO Box 142, Nelson 7040.

## 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.

*Pieris brassicae* is detected in Nelson via DOC staff either searching properties, or responding to reports from the public. Nelson residents remain supportive of the programme and, of the > 30 000 properties within the operational zone, difficulty is currently being experienced accessing only three. The zone covers 9742 ha and is divided, for operational purposes, into 46 management blocks.

In 2014/15, DOC conducted 82 364 property inspections, of which 170 detected *P. brassicae*. Detection rates (number of infested properties divided by number of inspected properties) have steadily declined from 0.042 in 2012/13, to 0.019 in 2013/14, and 0.002 in 2014/15. The distribution of *P. brassicae* has also declined: in 2012/13, the maximum distance from the centre of Nelson (-41.267, 173.278) that *P. brassicae* was detected was 24.1 km, while in 2013/14 it was 14.2 km, and in 2014/15 it was 8.1 km. The number of blocks in which *P. brassicae* was detected has declined from 38 in 2012/13, to 34 in 2014/14, and 24 in 2014/15.

The last *P. brassicae* detected was an adult male captured on 16 December 2014. None were detected in autumn 2015, thus the programme arguably met its criterion for achieving mop-up (zero detections for an entire spring or autumn). However, the number of inspections conducted in autumn 2015 was only 48% of those conducted in autumn 2014 (14 487 c.f. 30 392), so confidence that mop-up has been completed is weak. Additional work is required to confirm the programme has achieved its goal of eradicating *P. brassicae* from Nelson by 30 June 2015.

© Copyright October 2015, Department of Conservation. This paper may be cited as:  
Phillips, C.; Brown, K.; Green, C.; Broome, K.; Toft, R.; Shepherd, M.; Bayly, S.; Rees, J. 2015: *Pieris brassicae* (great white butterfly) eradication annual report 2014/15. Department of Conservation, Wellington. 19 p.

# 1. Purpose of this document

This document summarises the Department of Conservation's (DOC) programme to eradicate *Pieris brassicae* L. (Lepidoptera: Pieridae), great white butterfly, from Nelson to the end of the 2014/15 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 documents listed in the references.

# 2. Stakeholder contributions and budget

In 2014/15, Vegetables NZ contributed \$40,000 to the *P. brassicae* eradication programme, and MPI contributed \$72,000 for research to support the eradication attempt. 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 locations 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](http://www.b3nz.org)).

In the 2014/15 financial year (July to June), DOC spent \$1,445,000 on the eradication programme (Appendix 1). The programme's total cost from 17 November 2012 to 30 June 2015 has been \$3,468,741 (Appendix 2).

# 3. Background

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 Hazardous Substances and New Organisms Act 1996, 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). East (2013) estimated that once *P. brassicae* had spread throughout New Zealand, it would cost the horticultural and agricultural sectors \$7.4 million/annum.

New Zealand has 79 native cress 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*.

Unlike *P. rapae*, which lays single eggs, *P. brassicae* lays eggs in batches of 50–150. The caterpillars feed in groups on a wide range of host plants, and will completely defoliate a plant before crawling >100 m to find another. Late-stage larvae pupate in sheltered locations, often on built structures, and are difficult to find. *Pieris brassicae* adults fly well.

The eradication programme is a world-first attempt to eradicate a butterfly, and is ecologically, socially and technically complex. Effective trapping methods have been crucial to previous

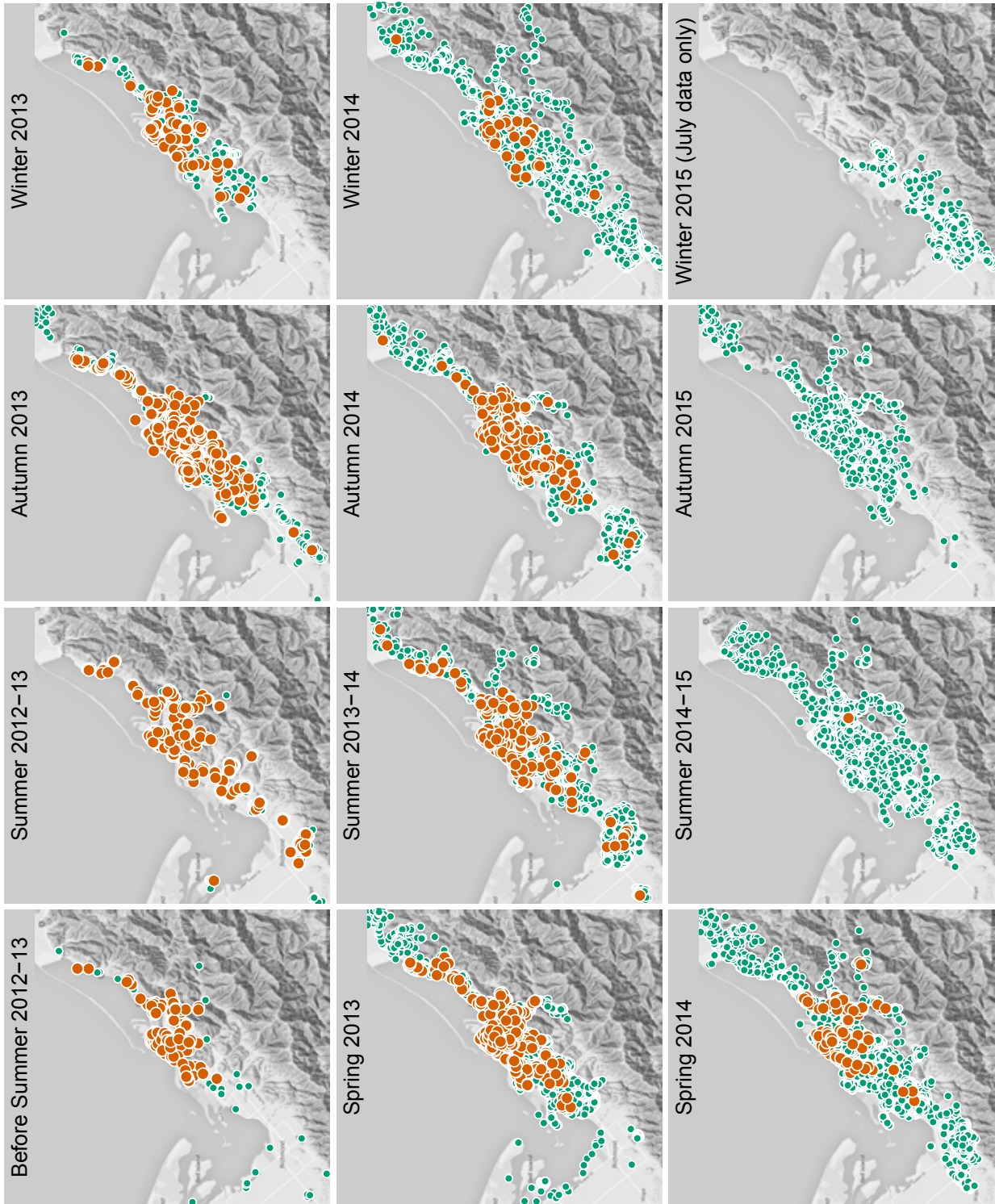


Figure 1. Spatial distribution of *Pieris brassicae* presence (orange) and absence (green) records within the Nelson eradication zone from May 2010 to June 2015, split by season, with records from before December 2012 pooled.

invertebrate eradications, but are lacking for *P. brassicae* (though a visual lure that attracts *P. brassicae* adults was developed this year). Instead, the programme depends primarily on searches by DOC staff and reports of sightings by the public. These are facilitated both by the distinctive appearance of *P. brassicae*, and by its occurrence on accessible low-growing plants that are common in home gardens. The programme fosters and receives strong support from local residents. It is based on systematic prioritised searches of the infested area and assiduous management of host plants, which demands excellent staff training, team structure, responsiveness, timeliness, communication and strategy. To assist programme management, DOC divided Nelson into 46 management blocks (section 6.1).

Due to the seasonality of *P. brassicae* in Nelson, spring and autumn are the best periods for gauging its abundance and distribution (further details are provided in section 5.2). Thus, comparisons between successive autumns and successive springs provide the most reliable indications of *P. brassicae* population trends. The abundance of *P. brassicae* is monitored by measuring the number of properties infested with *P. brassicae* divided by the number of properties searched, which is here termed 'detection rate'. The distribution of *P. brassicae* is monitored both through searches conducted by DOC staff and by public reports of sightings, which are always validated by DOC.

## 4. Goal, objectives and feasibility

### 4.1 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.

### 4.2 Objectives

For the purpose of setting goals and measuring progress, the process of eradicating *P. brassicae* has been divided into three phases:

- Contain and suppress the main population ('knock-down').
- Eliminate all remaining subpopulations and individuals ('mop-up').
- Confirm success ('surveillance').

In 2013/14, the programme was in the knock-down phase. To monitor progress, the transition from knock-down to mop-up was defined as when, for an entire spring or autumn, there is no evidence of population spread beyond the operational area, the average detection rate (properties infested divided by properties inspected) across the operational area is  $\leq 0.01$ , and when zero immature *P. brassicae* are detected in at least half of the management blocks. This last criterion seeks evidence that the population's distribution is becoming increasingly patchy within the operational area. The programme achieved knock-down by 30 November 2014

To achieve mop-up, the 2013/14 annual report (Phillips et al. 2014a) stated, the programme will have advanced from mop-up to the surveillance phase when zero *P. brassicae* have been detected for an entire spring or autumn. No *P. brassicae* were detected in autumn 2015, but the number of inspections conducted in autumn 2015 was only 48% of the number conducted in autumn 2014 (14 487 c.f. 30 392), thus it remains uncertain if mop-up has been achieved. A model that uses property inspections data to estimate the probability that *P. brassicae* is present in each Nelson management block is being developed (J.M. Kean & C. B. Phillips, AgResearch, unpubl. data). It has been designed to help evaluate progress towards mop-up and, once mop-up has been



completed, to help define the additional inspections needed to be confident that eradication has been achieved. Model results and predictions are expected by October 2015. Should there be further detections of *P. brassicae* in Nelson, the mop-up phase would start again.

### 4.3 Feasibility

Phillips et al. (2013b) developed and discussed nine criteria that should be considered when evaluating the feasibility of an eradication attempt (criteria also listed in the 2013/14 annual report). A November 2013 assessment of the *P. brassicae* programme considered two criteria were only being marginally met. These were:

- Irrespective of its density, the population can be forced to decline from one year to the next.
- Immigration and emigration can be prevented.

Criterion 1 is now being met and Criterion 2 is now being substantially fulfilled because the distribution and abundance of *P. brassicae* have been dramatically reduced (see sections 5.1 and 5.2). Thus, eradicating *P. brassicae* appears more feasible now than it did in November 2013.

Members of the *P. brassicae* Technical Advisory Group (TAG) and Dr John Kean (AgResearch) have periodically been asked to estimate the likelihood of eradication success:

- In October 2013, their mean estimate was 56% (range 50–70%).
- In November 2014, it was 80% (range 70–92%).
- In July 2015, it was 91% (range 80–98%).

## 5. Temporal changes in *Pieris brassicae* distribution and detection rate

### 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 Summer 2012/13’ (Fig. 1) arose solely from passive surveillance and would have underestimated the abundance and spatial distribution of *P. brassicae* compared to subsequent seasons when active surveillance predominated. During the course of the programme, particularly since autumn 2014, *P. brassicae* has become increasingly confined to central Nelson. This is 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 of 46 (48%) management blocks, which meant the programme had achieved its ‘knock-down’ goal. Only one *P. brassicae* was detected in Summer 2014/15, which occurred near the centre of Nelson, and none were found in autumn and June 2015.

### 5.2 Detection rates

*Pieris brassicae* eggs, larvae and adults are relatively easily detected compared to pupae. Detection rates tend to be low both in winter, when most *P. brassicae* are pupae, and in summer, when probably at least 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 2015. 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 for the rest of the 2014/15 financial year (no searches were conducted in June).

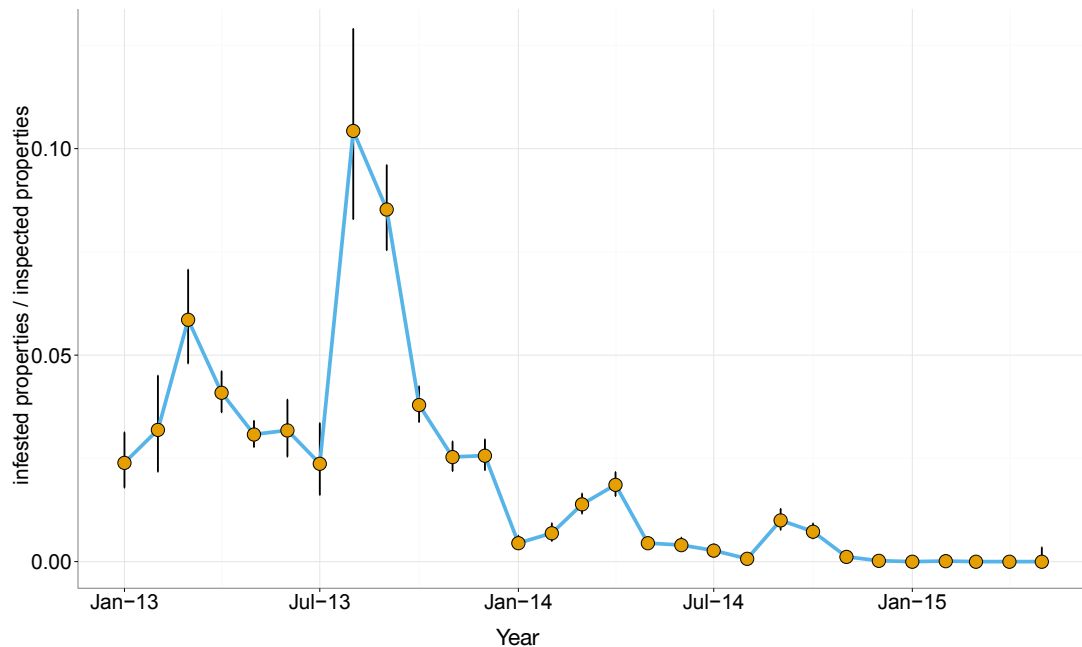


Figure 2. *Pieris brassicae* detection rates each month from February 2013 to May 2015. Error bars show 95% confidence intervals. (No searches were conducted in June 2015.)

## 6. Tactics and results

Methods for detecting and eliminating *P. brassicae* are constantly being improved. Early refinements were described by Phillips et al. (2013b) and in the 2013-14 annual report (Phillips et al. 2014a), and those made subsequently are described in the following sections, along with brief summaries of recent results.

### 6.1 Management blocks

To assist management and optimise use of staff time, the eradication zone was divided into 46 management blocks (Fig. 3), and each block was assigned a priority between 1 (high) and 4 (low) based mainly on the number of infested properties found during previous inspections, though other factors are also considered (Phillips 2014). In essence, the prioritisation constitutes an attempt to predict where *P. brassicae* will be most abundant (high priority) and least abundant (low priority). In general, block priorities are high in the Port Hills where most infested properties have been found, and decline towards the perimeter of the operational area. Low priority blocks tend to have had fewer detections longer ago. Phillips (2014) evaluated the efficacy of various block prioritisation methods by comparing their predictions with the search results that DOC subsequently obtained, and the method currently being used by DOC performed relatively well.



When inspecting properties, it is possible that *P. brassicae* females will lay eggs on host plants soon after they have been searched. DOC manages this risk by endeavouring to return to the property and search it again before those eggs could reach the pupal stage, which is more difficult to detect than other *P. brassicae* life stages. The frequencies with which properties need to be searched at different times of year to minimise the risk that *P. brassicae* will reach the pupal stage were defined by a *P. brassicae* phenology model (Kean & Phillips 2013), and are referred to as 'return intervals'. Inspecting a property twice within a return interval gives approximately 95% confidence that it is not infested (Phillips et al. 2014b). DOC has insufficient staff to search all of the properties in high priority blocks within specified return intervals, so must prioritise properties for inspection.

## 6.2 Prioritising properties

Each property is prioritised for inspection based on its surveillance records, which indicate if *P. brassicae* host plants have been found on the property and if any *P. brassicae* have been detected. Prioritising individual properties supports efficient use of staff time and effective control of *P. brassicae* within the block-ranking framework by enabling the number of properties to search to be adjusted according to the resources and time available. Thus, decisions about which properties to search, and when to search them, are made by considering *P. brassicae* seasonality, block priorities, property priorities, operational capacity and logistics.

During summer and winter, many *P. brassicae* are in the pupal stage, which are difficult to detect and control. Therefore, these periods are used to survey properties for host plants so that property-prioritisation can be effectively implemented in autumn and spring when *P. brassicae* is exposed to control.

## 6.3 Property access

Property inspections have sometimes been inhibited by factors such as locked gates, dangerous dogs, and absent occupants. A few residents have refused access, occasionally aggressively. Members of DOC staff have training in law enforcement and conflict resolution, and have legal rights to search properties as authorised persons under the Biosecurity Act 1993. Their expertise has usually enabled them to negotiate access directly, thus minimising the time spent on formal compliance correspondence. Staff have often visited blocked-access properties on Saturdays to conduct negotiations. This approach has kept the number of properties with blocked access at any one time to less than 20. Currently there are only three properties in Nelson of 30 808 (0.0001%) where aggressive occupants mean police assistance may be required to gain access.

## 6.4 DOC surveillance effort and results

Table 1 provides an overview of the inspections data by financial year to 30 June 2015. The number of inspections markedly increased following the start of the eradication programme in late 2012, with approximately equal numbers of inspections being conducted in 2013/14 and 2014/15. However, in 2014/15 the number of infested sites declined by 89% compared with 2013/14; every *P. brassicae* life stage was detected at fewer sites (Table 1).

Table 1. Sites inspected, sites infested with *Pieris brassicae*, proportion infested (%), and numbers of sites where eggs, larvae, pupae or adults were detected, by financial year (July to June).

YEAR	SITES INSPECTED	SITES INFESTED	DETECTION RATE	SITES WITH EGGS	SITES WITH LARVAE	SITES WITH PUPAE	SITES WITH ADULTS
2009/10	3	3	1.000	0	3	1	0
2010/11	88	30	0.341	0	25	4	4
2011/12	76	71	0.934	3	60	2	5
2012/13	27 112	1122	0.041	231	732	34	54
2013/14	80 547	1490	0.018	645	684	43	249
2014/15	83 156	170	0.002	48	49	16	62
Total	190 982	2886	0.015*	927	1553	100	374

\* Average, not total?

## 6.5 Passive surveillance effort and results

Passive surveillance involves reporting of *P. brassicae* by the public, and is supported by a public awareness campaign. The public are asked to report *P. brassicae* via an 0800 number that is constantly monitored. Staff respond to a passive surveillance report within 48 hours and usually also visit the property to verify it.

A variety of methods was used during 2013/14 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* is most conspicuous.

The 2013/14 *P. brassicae* annual report (Phillips et al. 2014a) presented evidence that both the number of passive reports, and the proportion of reports that were confirmed as *P. brassicae*, significantly declined between autumn 2013 and autumn 2014; this was consistent with a reduced abundance of *P. brassicae* in Nelson.

Between financial years 2013/14 and 2014/15, the declines continued both in the number of passive reports and the proportion confirmed as *P. brassicae* (Table 2). In 2013/14, 33% of a total of 782 passive reports were found to be *P. brassicae*, but in 2014/15 only 9% of 277 reports were *P. brassicae*. Thus, passive surveillance results corroborate evidence from general surveillance that the abundance of *P. brassicae* has declined.

Table 2. Total number of passive surveillance reports and the number confirmed to be *Pieris brassicae* in financial years 2013/14 and 2014/15.

FINANCIAL YEAR	TOTAL REPORTS	REPORTS CONFIRMED TO BE <i>Pieris brassicae</i>	DETECTION RATE
2013/14	782	258	0.33
2014/15	277	25	0.09

## 6.6 Captures of adults

The eradication programme endeavours to minimise *P. brassicae* reproduction, partly by capturing adults with nets. This is difficult and time consuming, but became easier when a DOC staff member, William Wragg, developed model butterflies that are attractive to adults of *P. brassicae* and *P. rapae*, particularly males. Their attractiveness arises from ultraviolet reflectivity near 370 nm, and the reflectivity of different materials has been measured to optimise lure efficacy (Phillips et al. 2015).

Capturing adults is extremely valuable to the eradication attempt. Capturing a female minimises the number of offspring she will produce (potentially 500) and thus the number of eggs, larvae and pupae that the programme would otherwise have to detect and control across widely dispersed locations. Capturing males should inhibit mate-finding and reduce female fertility, particularly when *P. brassicae* abundance is low.

In 2014/15, 70 *P. brassicae* adults (46 males and 24 females) were captured at 62 sites (Table 1). Forty-two were caught between August and December 2014 during periods of dedicated hunting that together comprised 2036 person-hours. During the same period, a further 20 adults were caught while conducting general surveillance, and eight were captured by the public. In the first half of 2015, dedicated hunting comprising an additional 383 person-hours captured zero *P. brassicae* adults.

## 6.7 Host plant control

Host plant control was described in the 2013/14 annual report (Phillips et al. 2014a). In 2014/15, surveillance teams controlled host plants on 1929 properties, and the host plant control team treated an additional 227 properties that had large infestations, primarily of nasturtium (155 manually and 72 with herbicide). Four host plant patches were managed by a contractor (NELMAC) due to their relative inaccessibility and/or large size. In November 2014, the DOC Golden Bay abseiling team conducted 12 cliff inspections, and herbicide-treated patches of wallflowers (total of c. 100 m<sup>2</sup>) and removed nasturtium (c. 20 m<sup>2</sup>).

## 6.8 Insecticide use

Insecticide use was described in the 2013/14 annual report (Phillips et al. 2014a). Table 3 summarises the treatments used on the 93 properties where eggs and/or larvae were detected. Most were sprayed with Entrust, which is an organically approved insecticide. In the remaining cases, occupants did not want Entrust to be sprayed and either host plant removal, regular host plant checks (without applying further treatments), or *Bacillus thuringiensis* (Bt; another organically approved insecticide) was used.

Table 3. Summary of treatments used on 93 properties where *Pieris brassicae* eggs and/ or larvae were detected.

TREATMENT	NUMBER OF PROPERTIES	PROPORTION (%)
Entrust	65	70
Host plant removal	19	20
Regular host plant checks	5	5
<i>Bacillus thuringiensis</i>	4	4

## 6.9 Delimitation

Monitoring for the presence of *P. brassicae* outside the eradication zone depends mainly on passive surveillance, and regular monitoring at sites in the Tasman region by Plant and Food Research and DOC. No passive reports from 31 locations outside the Nelson eradication zone resulted in detections. Plant and Food Research staff surveyed brassica crops at eight locations outside the perimeter of the eradication zone (Fig. 4). Six were checked seven times between 22 September 2014 and 8 December 2014, and all eight were checked 13 times between 2 March 2015 and 13 May 2015. DOC surveyed five native cress populations situated near Nelson 2–5 times during 2014/15 (Fig. 4). None of the monitoring detected *P. brassicae*.

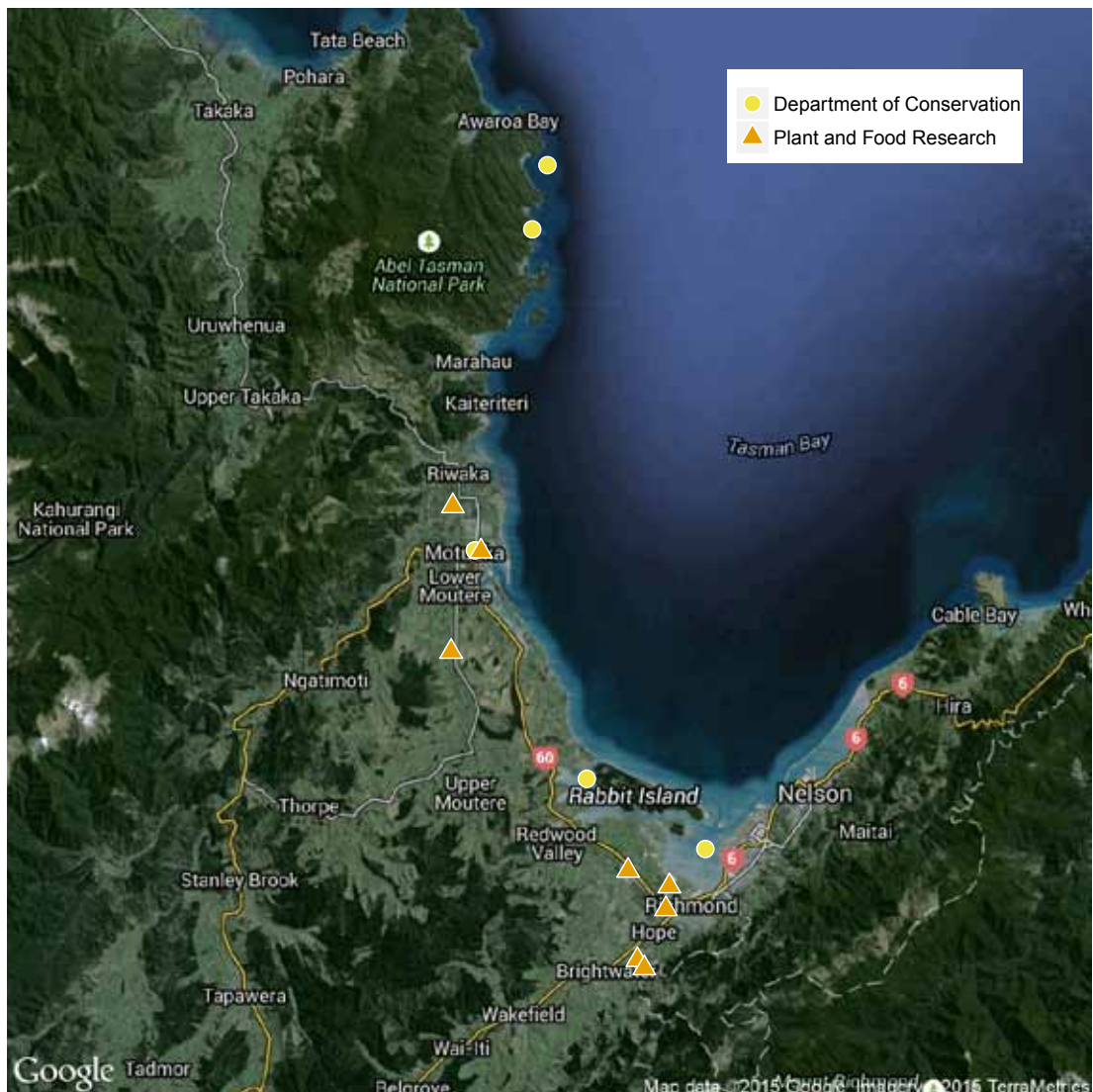


Figure 4. Locations regularly monitored for *Pieris brassicae*, both in native cress populations by Department of Conservation and in brassica crops by Plant and Food Research.

## 6.10 Enhancing natural parasitism to assist eradication

Two parasitic wasp species (*Cotesia glomerata* L. (Hymenoptera: Braconidae) and *Pteromalus puparum* L. (Hymenoptera: Pteromalidae)) that were introduced to New Zealand in the early 1930s for biological control of *P. rapae* also parasitise *P. brassicae*. Larvae of both butterfly species are parasitised by *C. glomerata* and late-stage larvae and pupae of both butterflies are parasitised by *P. puparum*. Parasitic wasps are well known for their remarkable ability to find their host insects, even when hosts are scarce. Therefore, the eradication programme has been supplementing populations of *C. glomerata* and *P. puparum* in Nelson by releasing additional individuals in locations where *P. brassicae* is present.

Plant & Food Research staff collected *C. glomerata* cocoons from *P. rapae* infestations in several New Zealand locations, and DOC and Entecol collected them from *P. brassicae* infestations in Nelson. Cocoons were maintained until adult wasps emerged, which mated soon afterwards. The wasps were provided with sugar water, then released. In autumn 2015, c. 6600 *C. glomerata* were released at 14 Nelson locations.

In 2013/14, AgResearch (Lincoln) developed methods for laboratory culturing *P. rapae* and *P. puparum*, and in 2014/15 sent mass-reared *P. puparum* to Entecol in Nelson for release at locations where there was a high risk of *P. brassicae* pupae being present. Approximately 17 000 *P. puparum* were released at 14 Nelson locations (Richards et al. 2015).

## 6.11 *Pieris brassicae* genetics

The Nelson population can be divided into three genetic types based on minor variation in the cytochrome oxidase I mitochondrial gene (Hiszczyńska-Sawicka & Phillips 2014; Phillips & Sawicka 2014). An analysis of the spatial and temporal distributions of genetic types in 460 *P. brassicae* collected in Nelson suggested that the maximum distance between egg batches laid by the same female were typically in the range 2–5 km (C.B. Phillips, J.M. Kean and E. Hiszczyńska-Sawicka, AgResearch, unpubl. data). The conclusion that a *P. brassicae* female may traverse much of Nelson city while laying eggs was consistent with an earlier result, based on an analysis of detections that occurred between January 2013 and May 2014, which indicated that infested properties were seldom clustered at the scale of a management block (Phillips & van Koten 2014). These preliminary indications of *P. brassicae* female movements indicate that an effective response to a *P. brassicae* detection needs sufficient resources to search several management blocks before any of the female's offspring can reach the pupal stage.

# 7. Management

## 7.1 Decision-making triggers

The feasibility and benefit of continuing the eradication programme would be reviewed if:

- Established *P. brassicae* populations are detected outside the Nelson operational area.
- *Pieris brassicae* is clearly expanding its distribution around Nelson.
- *Pieris brassicae* is still present in Nelson by 30 November 2015.
- Despite active searching, *P. brassicae* has not been detected for two consecutive years, or for a period statistically defined as providing high confidence that it has been eradicated.

## 7.2 Plan for responding to detections beyond Nelson

DOC regularly responds to pest detections in unexpected locations. For example, mice were detected on Maud Island in October 2013, advice was obtained, an eradication attempt was planned, then in July 2014 it was implemented. DOC's procedures for responding to such events are documented in its Island Biosecurity Standard Operating Procedure (oldDM-763784) and Island Biosecurity Best Practice Manual (DOCDM-20171). A response to a detection of *P. brassicae* beyond Nelson would follow the same guidelines. Once the Project Leader (Mike Shepherd) and TAG Leader (Kerry Brown) are informed of the suspected detection:

- Staff will be directed to confirm the identity of the specimens and obtain all possible information by interview and site visit.
- The Project Leader will keep a written record of all relevant information.
- If the detection is confirmed, then the Conservation Services Director (Jo Gould—acting) and MPI will be informed.
- The TAG Leader will seek advice from the TAG, then convey that advice to the Project Leader.
- The Project Leader will call for an invasion incident debrief and response planning meeting.
- A response plan will be developed, signed off by the Conservation Services Manager, implemented, then reviewed and reported as necessary.



### 7.3 DOC and MPI roles and responsibilities

MPI is New Zealand's lead biosecurity agency with responsibilities to protect environmental, economic and health values under the Biosecurity Act 1993, while DOC has a responsibility to protect native biodiversity under the Conservation Act 1987. MPI handed over the *P. brassicae* incursion response to DOC on 19 November 2012. DOC immediately initiated the eradication attempt and remains the lead agency. MPI supports DOC by providing research funding of \$72,000 per year until 30 June 2015 and by maintaining the New Zealand biosecurity hotline (0800 80 99 66).

### 7.4 Team structure and change in effort

The team structure is described in Phillips et al. (2014a). Field team effort increased to a maximum of 150 person days per week in spring 2014. This increased effort facilitated *P. brassicae* population knock-down, but also exceeded budget. Effort was maintained at 140 person days per week until February 2015 when it was reduced to 80 person days per week. In April 2015, effort was further reduced to 40 person days per week, and searching ceased on 8 May 2015 due to financial constraints. This reduced search effort prevented the programme from gaining confidence that mop-up had been achieved, despite an absence of detections since mid December 2014. The intention is to maintain a search effort of 125 person days per week from July 2015 to November 2015.

### 7.5 Data management

The data management system was described in Phillips et al. (2014a). In 2014/15, a spatial data analyst was employed who refined data entry, capture, storage, analysis and application. Models were developed that allowed reports to be easily accessed by field staff on blocked access, safety (e.g. aggressive dogs), surveillance results, host plant control and missed properties. Property and block boundaries were refined, and land parcels (a subset of properties and other land) were given unique identification numbers. Maps were made more accurate and accessible. The changes increased operational and analytical efficiency.

### 7.6 Research

In 2014/15, MPI and AgResearch (via B3) supported the following research:

- AgResearch (Phillips and Kean)—Using surveillance records to support eradication of *Pieris brassicae* from Nelson.
- AgResearch (Richards)—Enhancing parasitism of *Pieris brassicae* pupae.
- AgResearch (Phillips)—*Pieris brassicae* genetics to assist eradication.
- Entecol (Toft)—Refine the *P. brassicae* lure.

### 7.7 Reporting and presentations

MPI produced a Great White Butterfly 2012 Response Assessment Report (Bates & Krejcek 2015) that described lessons learned during the MPI-led phase of the *P. brassicae* response (May 2010 to November 2012).

The following presentations were made to the following audiences in 2014/15:

- 1 August 2014: Biosecurity Institute NETS Conference, New Plymouth (C. Green, DOC)

- 25 September 2014: Auckland Branch of the NZ Entomological Society (C. Green, DOC)
- 8 April 2015: NZ Entomological Society Conference, Auckland (C. Green, DOC)
- 6 May 2015: National DOC TATs Team Hui, Silverstream (C. Green, DOC)
- 6 May 2015: Better Border Biosecurity Science Partnership Forum, Lincoln (C. Phillips, AgResearch).

## 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](http://www.b3nz.org).

## 9. References

- Bates, S.; Krejcek S. 2015: Response Assessment Report: Great White Butterfly 2012. Ministry for Primary Industries Report, Wellington. 27 p.
- East, M. 2013: A benefit cost analysis for the great white butterfly incursion in New Zealand. University of New England (Australia) Institute of Rural Futures Report for Department of Conservation. 25 p.
- Hiszczynska-Sawicka, E.; Phillips, C.B. 2014: Mitochondrial cytochrome c oxidase subunit 1 sequence variation in New Zealand and overseas specimens of *Pieris brassicae* (Lepidoptera: Pieridae). *New Zealand Plant Protection* 67: 8-12.
- Kean, J.M.; Phillips, C.B. 2013. Phenology and diapause research for great white butterfly (*Pieris brassicae*). Milestone 4: Detailed spreadsheet model for phenology. Unpublished AgResearch report RE400/2013/481 prepared for Ministry for Primary Industries. October 2013. 15 p.
- Phillips, C.B.; Brown, K.; Green, C.; Walker, G.; Broome, K.; Toft, R.; Vander Lee, B.; King M. 2013a: Great white butterfly interim report. Prepared for Ministry for Primary Industries External Technical Advisory Group, December 2013. Unpublished report, Department of Conservation, Wellington. 32 p.
- Phillips, C.B.; Brown, K.; Green, C.; Walker, G.; Broome, K.; Toft, R.; Vander Lee, B.; Shepherd, M.; Bayly, S.; Rees, J. 2014a: *Pieris brassicae* (great white butterfly) eradication annual report 2013/14. Unpublished report, Department of Conservation, Wellington. 37 p.
- Phillips, C.B.; Green, C.; Walker, G.; Broome, K.; Brown K. 2013b: Great white butterfly eradication feasibility assessment November 2013. Unpublished report, Department of Conservation, Wellington. 15 p.
- Phillips, C.B.; Kean, J.M.; Van Koten, C. 2014b: Estimating detection rates of *Pieris brassicae* eggs and larvae. Unpublished AgResearch report RE400/2014/589 prepared for Ministry for Primary Industries. September 2014. 18 p.
- Phillips, C.B.; Novoselov, M.A.; Toft, R. 2015: Ultraviolet reflectivity of *Pieris brassicae* wings and of materials used for *Pieris* lures. Unpublished Entecol report ENT-043 prepared for Ministry for Primary Industries. June 2015. 9 p.
- Phillips, C.B.; Sawicka, E. 2014: Genetic variation within the Nelson population of *Pieris brassicae*. Unpublished AgResearch report RE400/2014/578 prepared for Ministry for Primary Industries. July 2014. 15 p.
- Phillips, C.B.; Van Koten, C. 2014L: What search radius around an infested property will optimise search efficiency for *Pieris brassicae*? Unpublished AgResearch report 884 prepared for Ministry for Primary Industries. September 2014. 116 p.
- Phillips, C.B. 2014. Prioritising GWB management blocks. Unpublished AgResearch report RE400/2014/607 prepared for Ministry for Primary Industries. March 2014. 13 p.
- Richards, N.R.; Hardwick, S.; Toft, R.; Phillips, C.B. 2015. Enhancing parasitism of *Pieris brassicae* pupae by *Pteromalus puparum*. Unpublished AgResearch report 3072 prepared for Ministry for Primary Industries.

# Appendix 1

## *Pieris brassicae* eradication programme costs for 2014/15 financial year (July to June) in New Zealand dollars

BUDGET ITEM	COST (\$)
Salaries	119,700
Wages	1,111,100
Uniforms	14,500
Travel	5,500
Vehicles	14,200
Contractors / Consultants	57,900
Printing / Publication	3,300
Other Operating	47,000
<b>Total DOC Expenses</b>	<b>1373,200</b>
<b>External contributions*</b>	<b>302,000</b>
<b>Total budget</b>	<b>1,675,200</b>

\* External contributions were from: Vegetables NZ (\$60,000) for operational activities; MPI (\$72,000) for research; and AgResearch (\$150,000) for research.

## Appendix 2

### *Pieris brassicae* eradication programme costs from 19 November 2012 to 30 June 2015 in New Zealand dollars

YEAR	AGENCY	COST (NZ\$)
2012/13	DOC	486,834
	AGR (via B3)	50,000
	Vegetables NZ	40,000
	PFR	*
	MPI	27,000
	<b>2012/13 total</b>	<b>603,834</b>
2013/14	DOC	1,327,908
	AGR (via B3)	100,000
	PFR	*
	MPI	76,000
	Vegetables NZ	40,000
	TR Ellet Agricultural Research Trust (to AGR)	25,000
	Dairy NZ	10,000
	<b>2013/14 total</b>	<b>1,578,908</b>
2014/15	DOC	1,373,200
	AGR via B3	150,000
	MPI	72,000
	Vegetables NZ	60,000
	<b>2014/15 total</b>	<b>1,655,200</b>
	<b>Grand total to date</b>	<b>3,837,942</b>

\* Costs to be advised.

# Appendix 3

## *Pieris brassicae* public awareness activities August 2014 to July 2015

TIME	ACTIVITY	COMMENT
May 2015	Intranet story on GIS.	Story for internal DOC staff explaining the essential role of GIS to the project.
15 May 2015	Winter eNews distributed to public.	Electronic newsletter for interested members of the public. Distributed seasonally.
12 May 2015	Federated Farmers talk.	Overview on the project to date.
Mid May 2015	Media release.	Update public on early winter wind down and asking the public to consider planting non-brassica cover crops.
17 April 2015	Public talk at All Saints Church (Vanguard St) for Super Seniors group.	
10 April 2015	Article in Golden Bay Times.	Update on progress of the project.
27 March 2015	Media release.	Promoting the tag line 'Help us get to zero' and updating the public on the project.
20 March 2015	School monitor kits delivered to Nelson Intermediate and Victory Primary School.	Kits included: ID guide, instruction guide, Butterfly Hunter stickers and GWB magnets. School monitors are a point of contact for families with little to no English (to report GWB finds).
10 March 2015	Advert in North West Nelson News.	Advert asking the citizens of North Nelson to continue to search for GWB on brassica plants, especially as rangers may not be able to search that area this season.
3 March 2015	Autumn eNews distributed to the public.	
1 March 2015	Race Unity Day stall	To raise awareness of our 'Help us get to zero' message and to maintain GWB awareness in the community.
Autumn 2015 March–May	Autumn Campaign communications used: <ul style="list-style-type: none"> <li>• Radio ad on More FM, The Edge, The Sound and the Breeze. Ads placed Thurs to Mon every fortnight for six weeks.</li> <li>• Newspaper adverts in the Nelson Mail, Nelson and Tasman Leaders and Nelson and Waimea Weeklies.</li> <li>• Posters put up on various notice boards from Hira to Richmond.</li> </ul>	Campaign based around the phrases 'Help us get to zero', 'Find the last butterfly', 'Find the last caterpillar', 'Find the last eggs' and 'Find the last pupa'.
February 2015	Start of Autumn campaign with an editorial and adverts in the Nelson and Waimea Weeklies.	
February 2015	Information for New Zealand Plant Conservation Network.	
January 2015	Introduced self as Advocacy ranger on Monarch Trust forum to answer questions.	Also known as Moths and Butterflies of NZ Trust (MBNZT).
24 December 2014	eNews distributed to the public.	
December 2014	Annual report sent out by Kerry and Mike.	
19 December 2014	Thank you cards sent to supportive members of the public.	
12 December 2014	Media release explaining that we were entering 'mop-up' and reminding holiday makers to search their vehicles for pupae.	
16 December 2014	Talk delivered to interested realtors at Stoke Summit office.	

*Continued on next page*

Appendix 3 continued

TIME	ACTIVITY	COMMENT
December 2014	Contacted real estate agents and property managers.	Provided with a GWB ID guide and an information letter for people moving into the area.
December 2014	Visited VTNZ, VINZ, AA, Dollar Save Auto and Muritai Motors.	Key message: check for pupae on vehicles; caravans, campervans, trailers before leaving town and report finds to the MPI Hotline.
4 December 2014	Butterfly News #14 emailed to key stakeholders.	
November 2014	Joined Moths and Butterflies of NZ Trust (MBNZT).	MBNZT Used to be Monarch Butterfly Trust. Monitor forum weekly for any discussions re GWB.
November 2014	Spring Explorer.	Initiative between Sports Tasman and Nature Land for children to hunt great white butterflies during the Spring Explorer Challenge. Successful hunters to be given a free pass to Nature Land. No GWB were reported.
29 & 30 November 2014	Stall at Heslop's Motorhome Show.	Key Message— search vehicles (campervans etc.) for pupae and report any finds to the MPI Hotline.
21 November 2014	Presentation to the Tasman Biodiversity Forum.	
17 November 2014	Signed up as an organisation to Neighbourly.co.nz.	A website that will allow us to target local neighbourhoods with GWB information.
16 November 2014	Growables/Ecofest Fair.	Focus on host plants.
14 November 2014	Host plant guide prepared for public.	
13 November 2014	Editorial in the Nelson Mail.	
12 November 2014	Golden Bay abseilers appear front page of Nelson Mail removing nasturtium from Rocks Road cliffs.	The online line version included a live video interview with Mike Shepherd, project manager and Derek Walker, team leader of host plant control. <a href="http://www.stuff.co.nz/nelson-mail/news/63115807/Butterfly-battle-on-the-cliffs">http://www.stuff.co.nz/nelson-mail/news/63115807/Butterfly-battle-on-the-cliffs</a> .
11 November 2014	Advert in the Nelson Weekly for the Growables/Ecofest Fair.	
29 October 2014	Thank you cards sent to sponsors of Spring Campaign.	
23 October 2014	TOTSEE meeting at DOC Nelson Office.	Networking with other environmental educators in the Top of the South.
23 October 2014	NZ Grower Magazine article.	
21 October 2014	School talk for syndicate of four classes at Waimea Intermediate.	Syndicate doing 'Survival and surviving' unit.
17 October 2014	Nelson Mask Parade. End of Spring Campaign.	
17 October 2014	Winner of Garden Hunt drawn at More FM.	Jasmine Wayman of Stoke won the Garden Hunt with a family trip to Hanmer Springs.
1 September to 17 October 2014	Spring Campaign communications used: <ul style="list-style-type: none"> <li>• Additions to the great white butterfly web page for the School Hunt, Fun Day and Garden Hunt.</li> <li>• Radio ad on More FM, The Edge, The Sound and the Breeze and 3 x 60 interviews with the GWB project manager and an interview with Advocacy Ranger to announce the winner of the Garden Hunt.</li> <li>• Newspaper ad in the Nelson Mail.</li> <li>• Media release in the middle of the campaign.</li> <li>• E news sent out to interested parties.</li> <li>• Nelson Saturday market display.</li> <li>• Flyers, Fun Day and Garden Hunt flyers dropped in letter boxes.</li> </ul>	Campaign consisted of School Hunt (encouraging school children to hunt for butterflies), Fun Day (to raise our profile and say thank you to the community), Garden Hunt (to encourage people to search their gardens for eggs and caterpillars) and the Nelson Masked Parade (to raise our profile and thank the community for their support). CB Marketing was contracted to help with this campaign, giving advice on communication methods etc.

Continued on next page

Appendix 3 continued

TIME	ACTIVITY	COMMENT
13 October 2014	2nd and 3rd place getters of School Hunt informed and Thank you cards to students sent out.	Classes not at Fun Day (middle of holidays). First day of Term 4.
5 October 2014	Family Fun Day.	Original date was 28 Sept which was postponed because of rain. Winners of School Hunt prizes announced.
26 September 2014	Presentation to Nelson Rotary Group.	
24 September 2014	eNews (electronic newsletter) sent out to members of public and interested parties.	Distributed seasonally.
23-24 September 2014	School Hunt presentations short listed and judged.	Short listing by two team leaders. Final judging done by two independent judges from More Fm and the GWB Project Manager.
20 September 2014	Saturday Market Stall.	Advertising Fun Day and Garden Hunt.
9 September 2014	Facebook Page set up.	
3 September 2014	Presentation to Nelson Bee Keepers Association.	
1 September 2014	Start of Great White Butterfly School Hunt.	51 classes from 8 schools from 15 (Atawhai to Richmond) registered for the hunt. Registered classes delivered education kits including 10 nets per class.
18 August 2014	Butterfly News No. 13 emailed out to key stakeholders.	
13 August 2014	Media release stating the importance of spring for the eradication programme.	
August 2014	Schools and classes canvassed for interest in the Great White Butterfly School Hunt and delivered talks to registered classes.	