

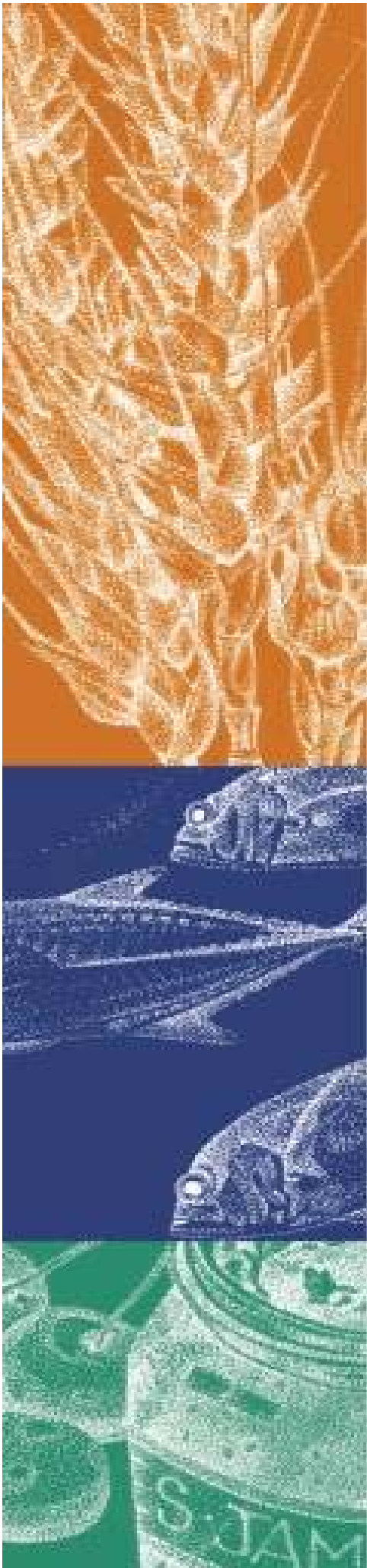


Australian Government

Department of Agriculture, Fisheries and Forestry

Australian Plague Locust Commission

Annual Activity Report 2008-2009



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Introduction

The Australian Plague Locust Commission was established in 1974 and began operations in late 1976. The Commission is financed by the States of New South Wales, Victoria, South Australia and Queensland, with a matching contribution from the Australian Government. Funding allocations from the member states are in proportion to the agreed benefit delivered to that state by APLC operations, while the Australian Government contribution reflects that national benefit derived from APLC activities. The Commission is governed by six Commissioners: one from each contributing state, one from the Department of Agriculture, Fisheries and Forestry and one from the Department of the Environment, Water, Heritage and the Arts. APLC activities are managed by a Director assisted by staff based in Canberra HQ and at three field bases in NSW and Qld, who are all Commonwealth Public Sector employees. The Commission is accountable to the Australian Government Minister for Agriculture, Fisheries and Forestry and to the relevant Minister for Primary Industries in each member state.

APLC Charter

In August 2002, a Memorandum of Understanding (MOU) was signed between the Department of Agriculture, Fisheries and Forestry (DAFF) on behalf of the Australian Government and participating member States effectively replacing the original (1974) Exchange of Letters under which the APLC was established. The MOU also incorporated a Charter that replaced the original terms of reference under which the APLC had operated since its establishment.

The purpose of the APLC, as defined in the Charter, is “to control locust populations in those situations where they have the potential to inflict significant damage to agricultural industries in more than one member state.” In fulfilling its charter the APLC is required to:

- Implement a preventive control strategy to minimise economic loss to agricultural industries caused by the Australian plague locust, spur-throated locust and migratory locust, with priority given to Australian plague locust.
- Minimise risk of locust control to the natural environment, human health and markets for Australian produce.
- Develop improved locust management practices through a targeted research program.
- Provide a monitoring and forecasting system for operations conducted by APLC and member states.
- Promote and facilitate adoption of best practice in locust control by member states.
- Participate in cooperative national and international programs for development of APLC expertise.
- Continually review APLC operations to ensure they keep pace with the expectations of industry, community and government.

Commissioners

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Executive Manager
Product Integrity, Animal and Plant Health
Department of Agriculture, Fisheries and Forestry - Australia
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Brisbane QLD 4001

Director

Mr Chris Adriaansen
Australian Plague Locust Commission
Product Integrity, Animal and Plant Health
Department of Agriculture, Fisheries and Forestry - Australia
GPO Box 858 Canberra ACT 2601

Notes: * Mr Eggleston retired from NSW DPI in March 2009 and was replaced as APLC Commissioner representing that jurisdiction by Ms Robinson.

Research Review Committee

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Principal Scientist, Plant Standards
Department of Primary Industries Victoria
Private Bag 15, Ferntree Gully DC, Vic 3156

Professor Myron Zalucki
Department of Integrative Biology
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Environment Protection Branch
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Review of 2008-2009

The congregation of adult locusts in southern NSW in autumn 2008 gave rise to an expectation of a significant locust hatching in the Southern Riverina region for spring 2008. Significant effort was applied in August and September to collective planning between APLC, relevant state agencies and local Rural Lands Protection Boards (RLPB, which changed to the Livestock Health & Pest Authority (LHPA) in January 2009) to prepare for the anticipated threat. Given the proximity of this infestation to the NSW – Victoria border and the likelihood that some egg laying had occurred in the far north of that state, this planning involved both NSW and Victorian primary industries sectors. Hatchings in the Riverina commenced in late September, with control of high density pockets of nymphs applied by APLC and local landholders coordinated through the RLPB. Hatchings in Victoria produced mostly low density nymphs and conditions became dry by November.

Some moderate size swarms resulted from those first generation locusts not controlled, and a second generation established in the same region of NSW further to the north. Limited additional control was required of this second generation of nymphs, with APLC again working in conjunction with local landholders and RLPB officers. Weather conditions intervened in some control activity in December 2008, with cool wet conditions preventing control implementation on some areas of high density infestation. Once these conditions cleared, the population had dispersed to the point that aerial control was no longer feasible.

The development of a significant locust population in the Central West region of New South Wales in January 2009 gave rise to a large nymphal population in February -March, with the population centred in the Coonamble – Nyngan – Bourke districts. The prevailing vegetation and weather conditions at that time were such that it was considered likely that adults arising from these nymphs could undertake long distance migration in search of better conditions in which to lay eggs. Consequently, APLC undertook some aerial spraying for nymphal band control at that time to supplement control being undertaken by landholders and LHPA officers. Immediately after this, significant rainfall greatly increased the likelihood that remaining locust nymphs would now complete their development, remain and lay eggs in the infested districts. For this reason, APLC determined that control of adult swarms in the Central West region in April – May 2009 was solely the responsibility of NSW agencies.

These adult swarms resulted in extensive egg laying across many parts of the NSW Central West region. Subsequent surveillance revealed extensive areas of high density egg beds, with up to 750 egg pods per square metre in some instances. Crop and pasture condition in this region generally remained very favourable, increasing the likelihood that hatching locusts will be able to complete their development before establishing a second generation in the region, undertaking long distance migration before egg laying, or possibly both. As this is the first generation of the 2009-10 locust season, effective control will be more important to ensure that an ongoing and escalating problem does not persist through until winter 2010.

While each of these generations of infestation required limited control response from APLC, the aerial surveillance and control activities undertaken did allow for training to be implemented with new and less experienced APLC staff in a situation that was not particularly high pressure. It also allowed APLC to evaluate, refresh and refine some operational procedures, including issues associated with the exclusive use of the biopesticide *Metarhizium* for the control campaign operated around Coonamble in March 2009. Given the loss of some experienced field staff during the year and the addition of several new field staff, continued focus on training and development is essential to ensure that APLC maintains both capacity and competence.

In general, 2008-09 was a period of operational and governance consolidation for APLC with the limited locust responses required allowing for focus on developing and finalising key processes. The Request for Tender process to secure a new panel of aerial contractors was completed in

February 2009, with standing offer contracts established with suitable operators. The selection of suitable operators was completed against the criteria established as part of the aerial safety review and subsequent new Aerial Operations Manual. Changes to aerial procedures documented in that manual also provided the impetus for the preparation of a new Field Operations Manual, with appropriate document quality management and control systems now in place.

A number of key governance issues were also addressed through the APLC Commissioners meetings, including management of APLC finances and the “reserve” fund for accumulation of unspent allocations. Issues associated with Commissioner liability were also addressed with appropriate legal references used.

With a degree of expectation that emerging locust populations will be significant in the coming Spring, much of the focus during the 2009 winter and early into spring will be on planning for operations. This includes liaising with state agencies and other stakeholders to ensure that all sectors are aware of and prepared for control operations as required, and delivering training to both APLC and non-APLC staff.

Chris Adriaansen
Director APLC

Locust situation

Australian plague locust

Overview

High density populations developed over three generations in NSW during 2008–09. The first generation produced a large nymphal infestation in the Riverina during spring and swarms in November and December. Breeding in early December in parts of the Riverina and southern Central West resulted in a second nymphal infestation during January and early February. Nymphs of this generation declined in the Riverina due to very dry conditions, but in the Central West swarms formed during February and northward movement extended the infestation into the Coonamble–Bourke area. Swarms laid eggs in late February and early March and in late March and April there were hopper bands of the third generation in the Coonamble–Nyngan and Bourke areas. These fledged and formed numerous swarms in April, which remained in the Central West and laid eggs during May and June. The first and second generations affected isolated parts of Northern Victoria to a limited extent.

A population also developed in parts of Southwest Qld, Far North South Australia and Far West NSW after heavy rains and adult egg laying in January. There were medium density nymphs in localised areas in these regions during February. Migrations during March brought swarms into the Broken Hill–Tibooburra and Ivanhoe–Menindee area of western NSW and the Dulkanina–Moolawatana area in Far North South Australia in late March, but only sporadic egg laying occurred as habitat conditions were mostly unfavourable in these areas.

New South Wales

Hatching of nymphs began in late September and continued during October in the Riverina (Figure 1). A large number of bands developed throughout the eastern Riverina and southern Central West in the Narrandera, Wagga, Murray, Riverina, Gundagai, Young, Forbes and Condobolin RLPB districts and a coordinated control campaign was carried out by landholders, RLPBs and the APLC. Nymphs also developed in the areas north and east of Shepparton in northern Victoria during October and November where landholders carried out some control.

Fledging and swarm formation began in mid-November in the Riverina and southern Central West and egg laying began at the end of November. There was some migratory activity during December. Swarms moved from Forbes into the Parkes area and a southward movement in the Riverina resulting in an accumulation of swarms along the Murray River. Some swarms entered Victoria near Echuca. Egg laying by swarms in December produced second generation bands in several areas, although more restricted than the area infested in spring, including Griffith-Darlington Point, Jerilderie–Berrigan and Moama–Mathoura, in the new amalgamated Riverina Livestock Health and Pest Authority (LHPA) area, and Parkes–Forbes in the Lachlan LHPA (Figure 2.). However, dry conditions in the Riverina and northern Victoria during summer led to slow development and significant mortality of nymphs and although swarm density adults formed in some areas, the population substantially declined in autumn.

The Central West population continued to increase and there were many reports of bands in the Parkes–Forbes area and widespread nymphs in the Nyngan–Coonamble area in early February (Figure 3).

Fledging of second generation nymphs in early February was followed by migrations to the north associated with rain periods during the month. In late February laying swarms were reported in the Nyngan–Coonamble and Bourke–Engonnia areas and this produced a third generation of nymphs and many bands in these areas (Figure 4). Control was carried out by landholders, LHPA, APLC and NSW DPI on this generation during April. Fledging and swarm formation occurred in April when swarms remained in the Central West and laid eggs during May and June.

In the far west the population increased significantly in late March, following the immigration of swarms, although locust numbers had increased during summer as a result of local breeding in a number of locations. Bands had developed in the Gum Lake area, near Menindee during spring, and at Owen Downs near Tibooburra and Fowlers Gap in February. Swarms arrived in the Ivanhoe–Pooncarie and the Tibooburra–Broken Hill area from 24 March. Wind directions in the preceding week were generally from the east, so it is likely much of the immigration was from the Bourke area and Central West. On 24 March some immigration from Southwest Qld could have contributed to the population in the Tibooburra area. Swarms in the Ivanhoe area had developed eggs and laid in several locations, while those to the north of Broken Hill showed no egg development in late March, and conditions were generally unsuitable for breeding.

Queensland

Surveys during spring identified a low density population in most regions, although there were medium density adults in the Windorah–Quilpie area in mid-November. There were reports of migrating locusts in the Cunnamulla and Thargomindah areas in early December, but surveys continued to detect only low density adults and few nymphs.

The situation changed in January when there was redistribution of adults with aggregation and egg laying in favourable habitats after heavy rainfall in the southwest. The Birdsville light trap caught high numbers of locusts during the second half of January. In February nymphs were widespread in the Birdsville area with some bands in the Quilpie–Eromanga area. APLC aerial survey of these areas in early March did not detect any significant band development. Fledging and some swarm development occurred in these areas during March with some migration of adults from the Birdsville area into the Far North of South Australia likely in late March.

Victoria

There were widespread hatchings in the area bounded by Wodonga, Wangaratta, Rushworth, Eltham, Kerang and the Murray River in North Central Victoria during October. By November there had been over 400 reports of locusts, many of which were from the area north and east of Shepparton. Bands formed in some locations and control was carried out by landholders.

In mid-December limited swarms entered Victoria from NSW near Echuca and Yarrawonga and egg laying occurred in the Echuca–Torrumbarry area. The adult population declined in the infestation area during January, but there were reports of

occasional locusts from over a wide area of northern Victoria. Hatching of second generation nymphs began in early January and some small bands developed in the Echuca area. Very dry conditions during summer, however, resulted in slow development and significant mortality of nymphs. Fledging extended throughout February, but the population declined to low levels during March.

South Australia

Locust densities remained very low in South Australia during spring. Locusts were recorded at the Oodnadatta light trap in late December after heavy rains in that region, and were also reported near Nundroo in the Western Agricultural region. Subsequent surveys identified only low density adults in the Northwest region.

In late January immigration into the Innaminka–Cordillo Downs area of the Far North region, associated with the population increase in Southwest Qld, was followed by sporadic egg laying and localised nymphs were identified in early March. On 25 March a significant migration from this area and from the Birdsville area in Qld brought adult locusts to the Marree–Moolwatana area of the northern Flinders Ranges. The light trap at Dulkaninna recorded high numbers of locusts during 25–27 March. Some localised egg laying was likely in this area, but conditions were generally too dry for successful breeding.

Western Australia

Low numbers of locusts were identified in parts of the Central Agricultural area in January and February. Densities increased to noticeable levels during March and surveys in April identified localised medium and high density locusts in a number of Shires of the Central and Western Agricultural regions.

Australian Plague Locust Distribution

1 October to 31 October 2008

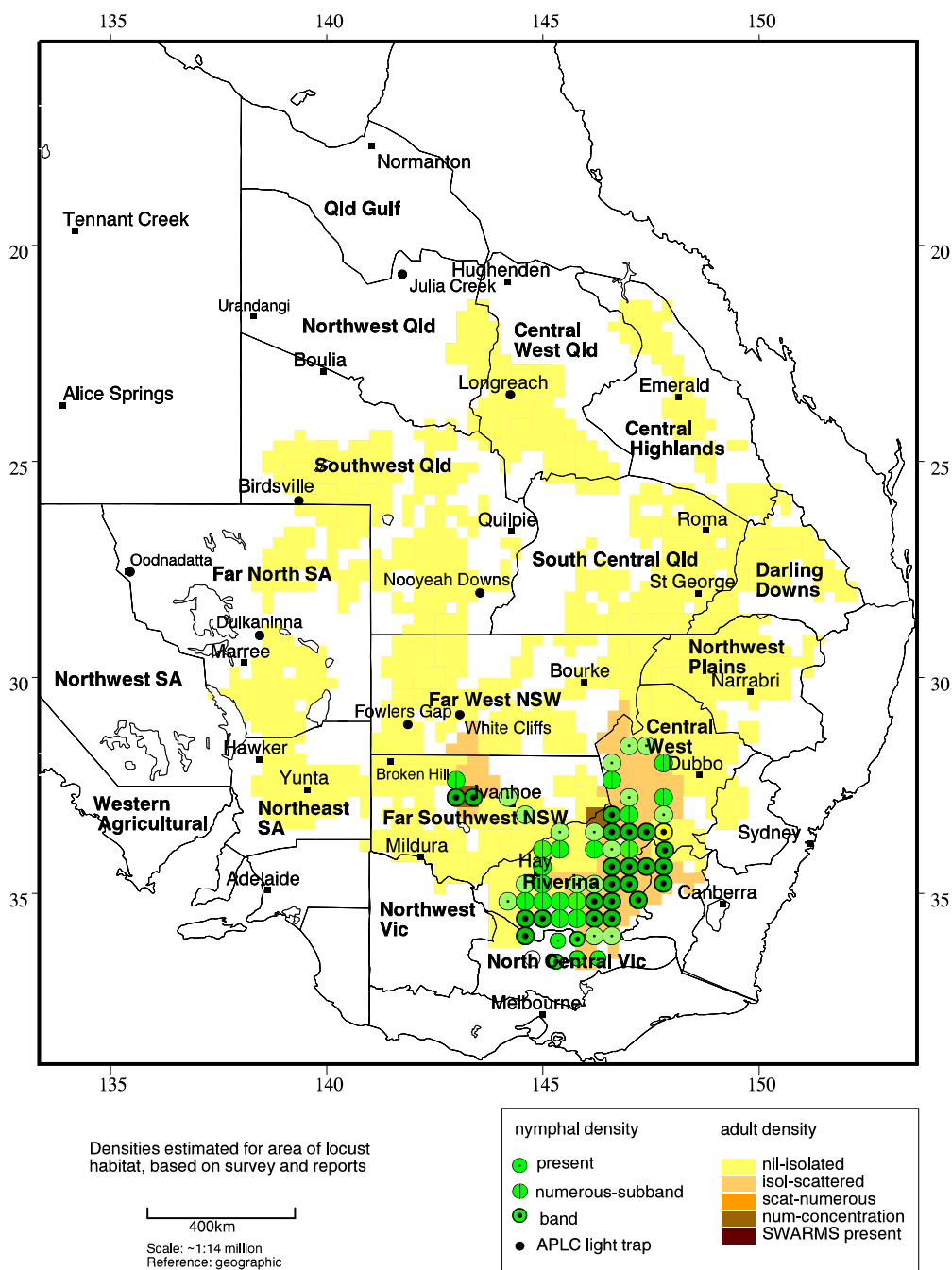


Figure 1 : Australian plague locust distribution: October 2008

Australian Plague Locust Distribution

1 January to 31 January 2009

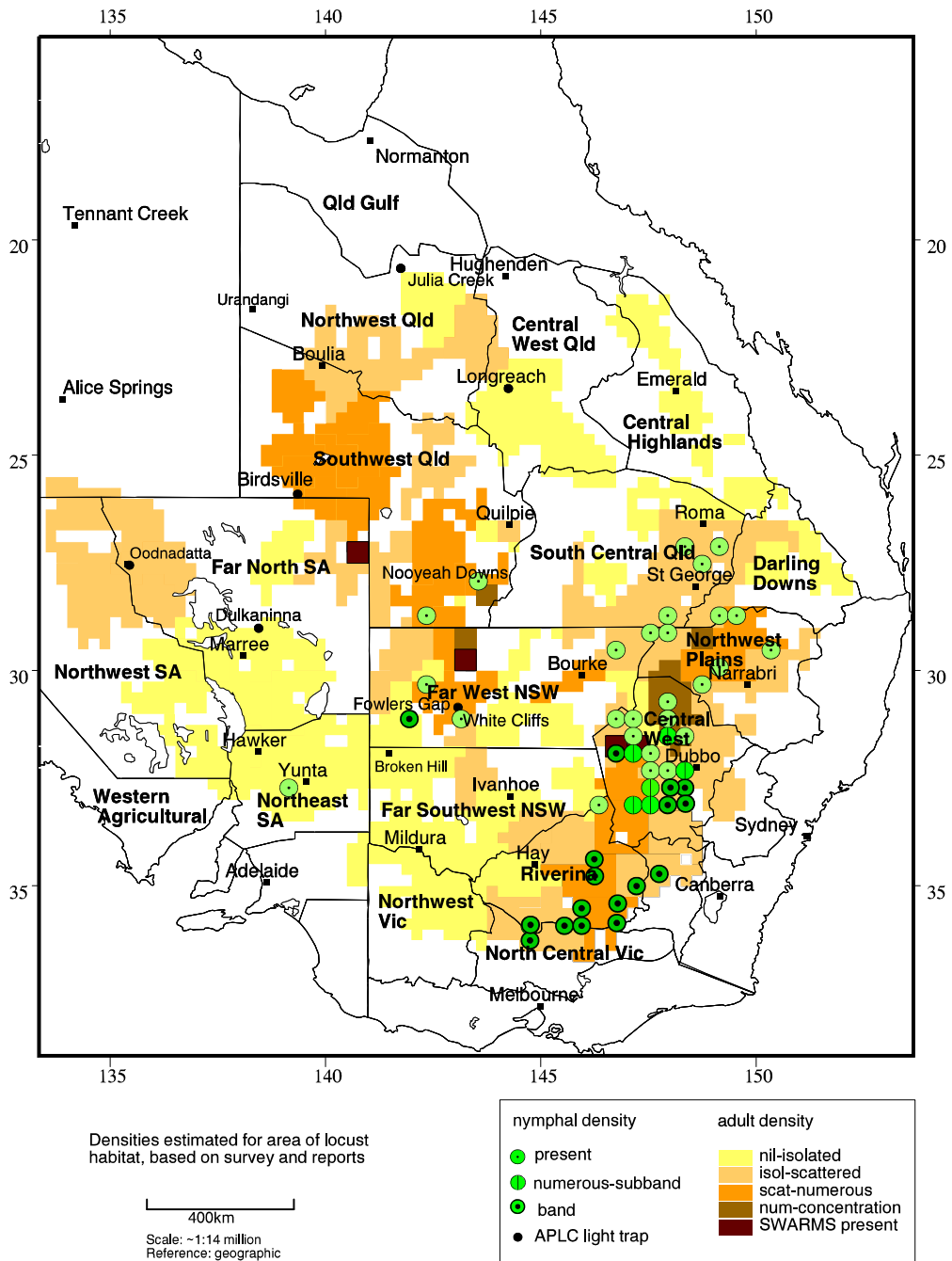


Figure 2 : Australian plague locust distribution: January 2009

Australian Plague Locust Distribution

1 February to 28 February 2009

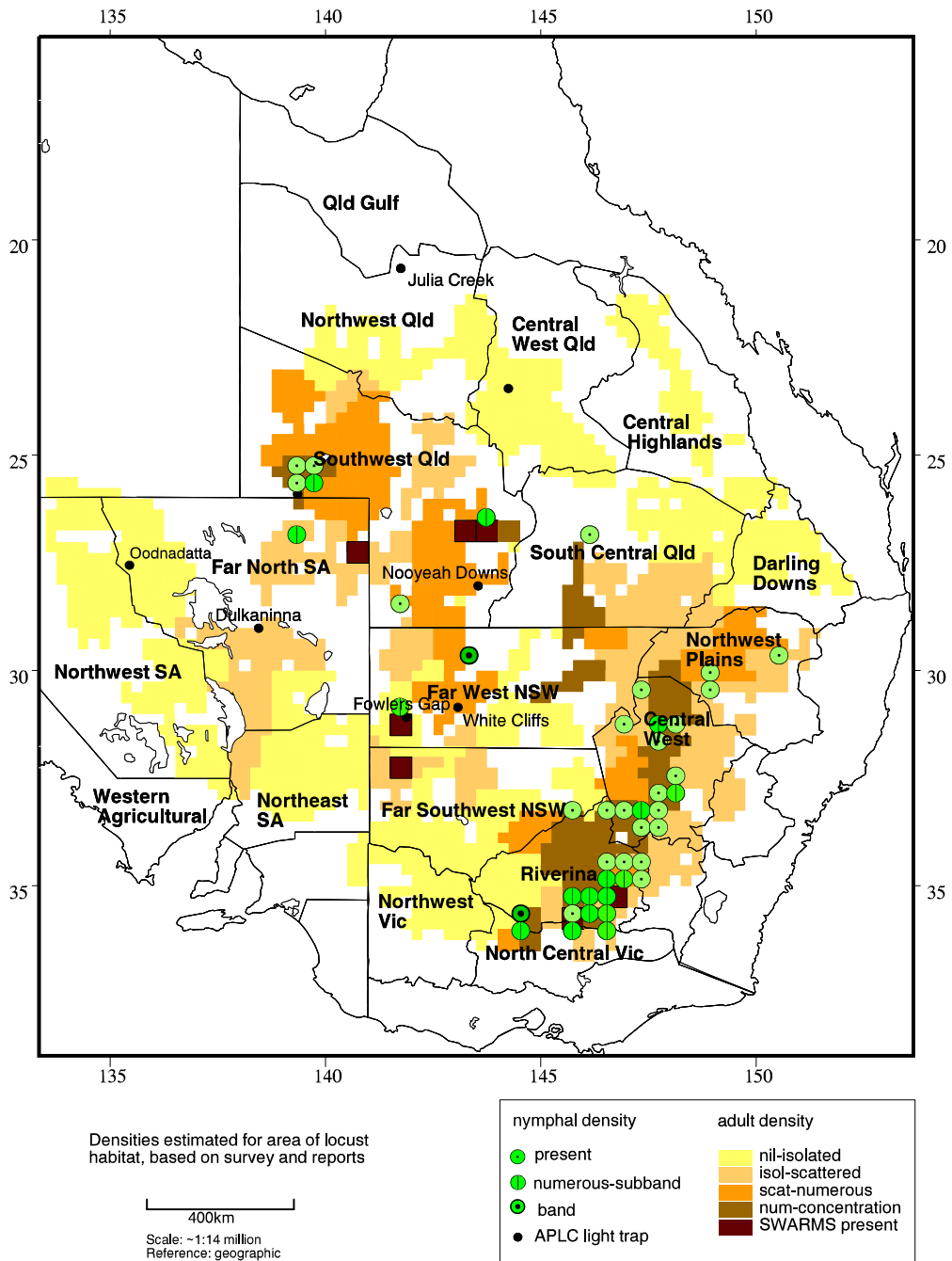


Figure 3 : Australian plague locust distribution: February 2009

Australian Plague Locust Distribution

1 March to 31 March 2009

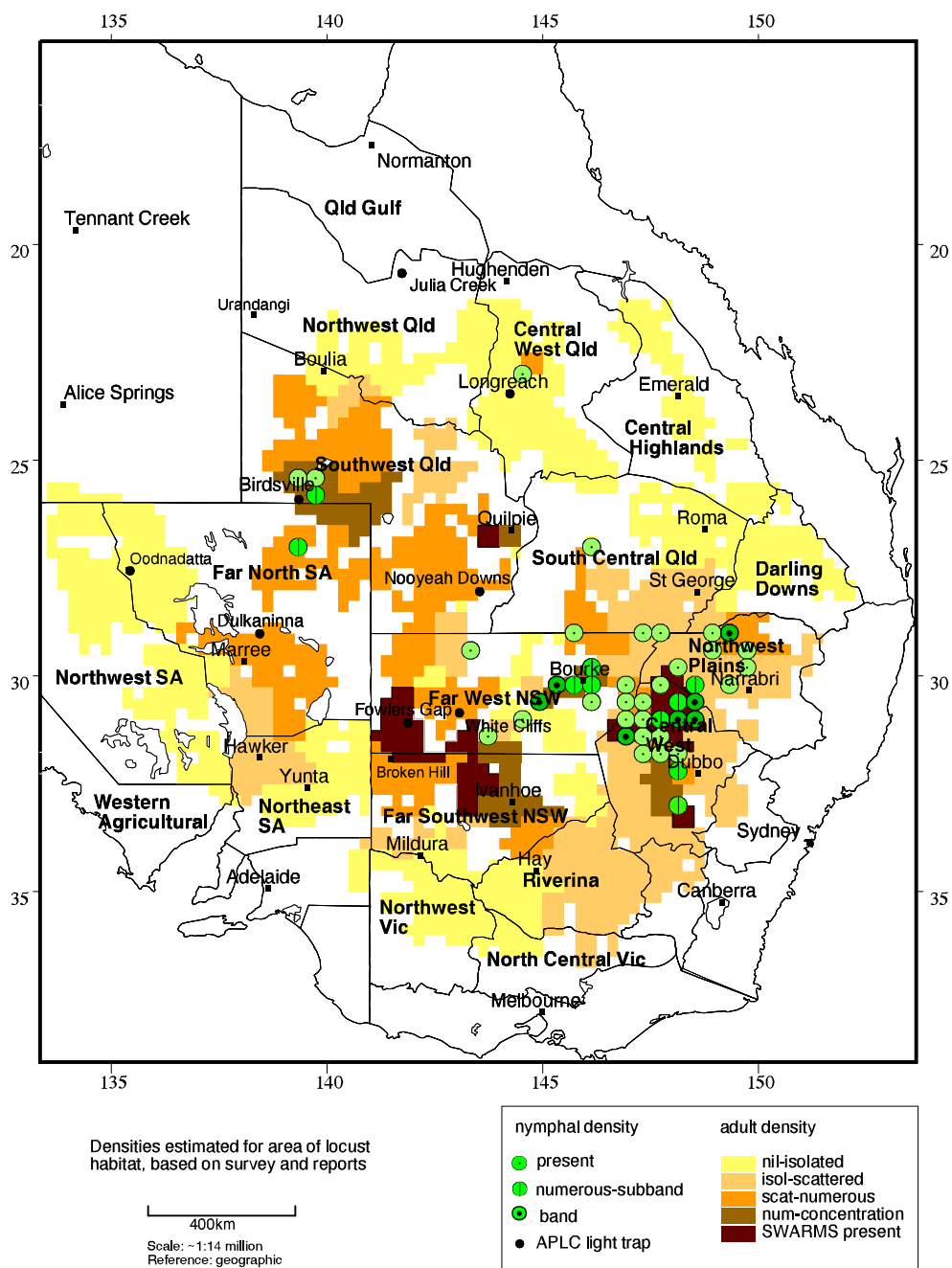


Figure 4 : Australian plague locust distribution: March 2009

Spur-throated locust

In spring there was a widespread population of immature adults throughout most regions of inland Queensland and northern NSW. A number of overwintering swarms were identified in the Aramac area during August and several swarms near Laglan, west of Clermont, were controlled by Biosecurity Qld staff in October. There was a report of high density locusts in a crop area near Goodooga in October.

Surveys in November and December identified widespread medium density adults in South Central Queensland and the NSW Northwest Plains and there were reports of high numbers of adults and breeding in the Alice Springs in December. At the end of January high density fledgling adults and late instar nymphs were reported from several locations in the Walgett–Narrabri area, indicating some breeding had taken place in northern NSW as early as November.

Nymphs over a range of ages were widespread throughout the South Central, Central West, Northwest and Central Highlands regions of Queensland during January and February indicating several phases of egg laying in early summer. Fledging of nymphs was reported in the Alice Springs area during February. Surveys in Northwest and Central West Qld identified consistent counts of medium density locusts and some small swarms in Flinders, Winton, Barcaldine, Longreach and Paroo Shires during March. There were still some late instar nymphs in the Longreach area during April indicating breeding continued in that area during February.

Young adults redistribute during autumn and form over-wintering swarms which often roost in trees. Swarms of young adults were reported from the Winton–Boulia area during April, and swarm reports from Northwest Queensland continued during winter. Reports of occasional adults of this species were received from as far south as Melbourne during March and April, indicating considerable migratory displacement of immature adults during autumn.

Migratory locust

Very few adults of this species were identified on survey throughout the 2008-2009 season. Occasional adults were found in the Brewarrina-Goodooga area of the NSW Northwest Plains and in the St George area of southern Queensland during September–November 2008. In January 2009 and February 2009 there were low numbers of adults in these regions and in the Queensland Central Highlands. The Longreach and Julia Creek light traps recorded low numbers of Migratory locusts during February and early March, indicating a population in Central West Queensland.

Operations

The 2008-09 APLC Operational Plan was endorsed by Commissioners at the 62nd Commissioners Meeting, held in April 2008. This plan defined expected outcomes to be achieved by APLC for 2008-09, together with identified outputs and risks.

Forecasting, information and survey

Eight Locust Bulletins were released during the period October 2008 to May 2009. Bulletins were simultaneously released via the APLC website and through direct delivery to stakeholders.

The UNSW's Insect Monitoring Radar (IMR) at the Bourke airport was damaged by very strong wind during the Christmas period of 2008 and ceased operation at that time. However, it has provided useful information about locust movements in that region in the past and proved valuable for guidance of field survey and forecasting of locust distribution. The unit was taken back to Canberra base and has been fully repaired and tested, ready for deployment in the coming season.

The portable automatic weather station purchased by APLC in 2007-08 was deployed at a *Metarhizium* control site in Coonamble in March-April 2009 to record field conditions during spray. The data collected was also used to model locust body temperatures and development rate of the *Metarhizium* fungus to validate the simulated duration of infection to death in field conditions.

APLC was also fully engaged in the process of developing a surveillance and reporting template to be used in the national BioSIRT program. Analysis of many years of accumulated survey and report data identified the most appropriate format and fields for this template. Continued development of this BioSIRT template is being undertaken by Industry & Investment NSW (formerly NSW Department of Primary Industries) under contract to the national BioSIRT program. It is anticipated that this template will be trialled during the 2009-10 locust season.

A full review of the structure and content of APLC's web pages was commenced in 2008-09 and will be concluded in the first half of 2009-10. This revision will ensure that the content and structure of information remains contemporary and accurate.

Pesticide evaluation and application management

Improved use of the biological pesticide Green Guard® remains a priority for the APLC. At band control operations in Coonamble during autumn 2009 an increased application volume (0.7 L/ha) and dose (35 g of *Metarhizium anisopliae* spores/ha) was evaluated as a viable technique for use with dense vegetation and cooler temperature conditions. This campaign also highlighted the difficulties still associated with mixing the OF formulation currently used in operations (refer Research 1.2).

Involvement in the FAO funded bio-control operation in Tanzania targeting Red locust (May-June 2009) and using the African isolate of *Metarhizium anisopliae* provided valuable first hand operational experience with the new formulation of Green Muscle TC® (Technical Concentrate, a wettable powder formulation produced by Biological Control Products South Africa). This formulation has logistical advantages for field operations in that large quantities of the vacuum packed dry spore concentrate can be stored and transported easily, it is relatively easy to mix with a spray oil prior to application and the dry spores have a long shelf life (>80% of spores remain viable for 24 months at a constant temperature of 40⁰C – by comparison viability for Green Guard® OF is 6 months at 25⁰C). Such a formulation would be ideal for Australian conditions and discussions with the producer of Green Guard® (Becker Underwood) are proceeding.

Control operations and pesticide use

APLC mounted four small to moderate campaigns to manage infestations of the Australian plague locust (*Chortoicetes terminifera*) in NSW during 2008-09 (Table 1). Two were conducted in the Riverina region of NSW in spring 2008 and two in the central west region of NSW in autumn.

Owing to the nature and location of the populations controlled, Fipronil was not employed during 2008-09. However, a substantial proportion of the biological pesticide Green Guard® was used during the year (Table 2) – particularly in the central west region of NSW where the entire Coonamble campaign was conducted using only this material. The relatively high use of Green Guard was due to the need to control infestations present in proximity to a higher incidence of sensitive sites (i.e. dwellings, dams, etc.). This use of Green Guard facilitated control of a higher proportion of the infestation than would have been possible with the constraints associated with use of chemical pesticide.

As infestations requiring intervention extended across and beyond APLC's area of operation, APLC and NSW DPI collaborated closely to effectively manage populations that met respective threat criteria. The close proximity of infestations to areas of agricultural production in Victoria also required close liaison with counterpart authorities in that state.

Although not large, these campaigns provided a valuable opportunity for relatively new field staff to gain sound basic experience in locust control.

Table 1: Control operations 2008-09

<i>Control Base</i>	<i>Type</i>	<i>Period</i>	<i>Number of targets</i>	<i>Area Treated (km²)</i>
Narrandera, NSW	Band	20-25/12/2008	21	26.62
Deniliquin, NSW	Swarm	2-3/12/2008	4	6.43
Coonamble, NSW	Band	29/3-6/4/2009	22	40.26
Bourke, NSW	Band	31/3-2/4/2009	8	24.43
Total area 2008-09				97.74

Table 2: Area treated (km²) by pesticide type 2008-09

<i>Fenitrothion</i>	<i>Fipronil</i>	<i>Green Guard</i>
52.87 km ²	0 km ²	44.87 km ²
(54.1 %)	(0 %)	(45.9 %)

Table 3 : Locust control agent stocks

	<i>Fenitrothion [Sumithion®] (tonnes)</i>	<i>Fipronil [Adonis 3®] (litres)</i>	<i>Metarhizium [Green Guard®] (containers)</i>	<i>Malathion [Fyfanon®] (litres)</i>
On Hand 1 July 2008	46.55	14,200	129	800
Purchased 2008-2009	Nil	Nil	Nil	Nil
Sold - NSW Department of Primary Industries	2.8	Nil	Nil	Nil
Used 2008-2009	1.65	Nil	36	Nil
Inventory @ 30 June 2009	42.10	14,200	93	800
Approx. equivalent area (hectares)	149,000	115,000	15,000	Trial only
Inventory Value 30 June 2009	\$570,000	\$253,000	\$191,000	\$6,000

The total inventory value of the APLC pesticide stocks held at 30 June 2009 is approximately \$1.02 million. The above figures do not include the 10 tonnes of fenitrothion held by APLC on behalf of Queensland.

Small quantities of pesticide are held at APLC field bases. The remainder (with the exception of the Green Guard stocks) is held in commercial premises in Dubbo, NSW. Some 7,200 litres of the carrying agent for Green Guard (Summer Spray Oil) held in store are not included in the above figures.

Stocks of Green Guard include both formulated product and dry spore material. The quantities of Green Guard stock listed above are expressed in 14 litre container equivalents.

Green Guard stocks are held by the supplier, Becker Underwood. The shelf-life of Green Guard stored by the manufacturer [@ 4°C] is guaranteed for 2 years but is only guaranteed for approximately 6 months in the field [@ 25°C]. Stored inventory is turned over and replaced when practicable.

Environmental Management System

A report of the progress made by the APLC in meeting the objectives of its Environmental Management System (EMS) is provided at Annex 1.

Overall progress against the targets established under the EMS was sound, but was limited in some areas due to the limited locust control activities undertaken during the season. This particularly impacted targets relating to managing changes to control agents applied, and the in-field implementation of changes to operating procedures which reflect the outcomes of various research projects.

Occupational Health & Safety

No accidents involving APLC vehicles or staff occurred in 2008-09. No aircraft safety incidents were reported..

The 2008-09 season saw the full implementation of the APLC's Aviation Procedures Manual for both fixed wing and helicopter work. A review of the new manual and related documents during the season lead to some minor changes and a final version has been made available on the APLC's website as part of APLC's continuous improvement program. The APLC's Operations Manual, Training Documents, and Information to Pilots were modified to reflect the new aviation procedures. Training which reflected these new documented procedures was provided to all operational staff

A complete revision of the APLC's OH&S Manual was commenced during 2008-09 and is expected to be completed by early 2010.

Australian Health and Safety Services Pty Ltd was contracted to undertake a review of the APLC's Occupational Health and Safety Management System (OHSMS) during 2009. All 46 recommendations of this review were accepted and immediately addressed. A few recommendations are still awaiting additional information from the consultant prior to implementation of further corrective action. A full list of the recommendations and the corrective action taken / planned are provided at Annex 2.

Competency based training and assessment

Four APLC field staff (Scott Mander, Clare Mulcahy, Lucas Scales and Laurie Sanchez) continued to progress through their 1st and 2nd year competency training programs. There was opportunity during the 2008-09 season to conduct competency training in aerial spotting, control and campaign management with both fixed wing and helicopter aircraft and all new staff had exposure to training in both. Follow-up competency assessment will be required in 2009/10.

International linkages

Haikou Wang attended the 23rd International Congress of Entomology held in Durban, South Africa during 6-12 July 2008, presenting two papers on “The 1999-2001 Australian Plague Locust Outbreak in Eastern Australia from the Perspective of Insect Monitoring Radar” in the Ecology Section, and “Estimation of Insect Migration Trajectories with Flight Parameters Measured by Insect Monitoring Radar” in the Physiology & Biochemistry Section.

Peter Spurgin and Haikou Wang were invited and funded by the National Animal Husbandry Service, Chinese Ministry of Agriculture for the visit to government organisations in Beijing and the locust/grasshopper control vicinities in Inner Mongolia during 16-24 July 2008 to evaluate their aerial control procedures (up to 2,000,000 ha treated annually). Both APLC staff presented several seminars on the locust forecasting and control technologies and techniques employed by the APLC to the audience in the Ministry and the Institute of Plant Protection, Chinese Academy of Agricultural Sciences. Several discussions were held on the information and technical exchange and potential cooperation between the two governments in the future.

Dr Pierre Mineau (Research Scientist and Program Leader, Pesticides Section, Environment Canada, Adjunct Professor – Carleton University) spent three weeks at the APLC in August, 2008 working with the APLC's Environment Officer, Paul Story to develop comparative risk assessment for locust control pesticides used world wide.

Mr Paul Story and Dr Pierre Mineau developed and chaired a workshop session on the terrestrial risk assessment of pesticides at the 2008 World Congress of the Society for Environmental Toxicology and Chemistry, Sydney in August 2008.

Mr Peter Spurgin was invited by FAO to attend the Second International workshop on Biopesticide use for Desert locust management in Rome (10-12 February) to report on the biocontrol operation undertaken in Timor Leste during 2007 to contain an outbreak of Migratory locust using Green Guard. FAO considered the Timor Leste operation an important success story and a demonstration of how a biopesticide could be used effectively.

Chris Adriaansen was invited by the UN-FAO locust management group to attend the 39th international Desert Locust Control Committee (DLCC) meeting in Rome in March 2009. While APLC is obviously not directly affected by desert locust or the associated management operations in Africa and the Middle East, continued engagement in this forum

is worthwhile. At this meeting, considerable input was provided to the development of the 2009-10 DLCC plan, while valuable insight was gained into a possible pesticides stock management system developed by FAO to track and manage pesticide stocks for locust management and other operations. Further investigation will determine if this system can be employed by APLC.

Heath McRae was contracted by FAO for a one-week locust mission to Timor Leste in March 2009 as a follow up on the September 2007 migratory locust control operations and capacity building training. Assistance and expert advice was provided to the Ministry of Agriculture and Forestry staff during a joint Timor Leste – Indonesian transboundary agreement on cross border locust control.

Peter Spurgin was contracted by FAO for a two-month period in May and June 2009 to assist the International Red Locust Control Organisation with the implementation of a major red locust control campaign in Tanzania, Africa. Mr Spurgin's expertise was particularly sought as this campaign made exclusive use of the *Metarhizium* biopesticide to treat locusts in sensitive national parks and wetlands areas (the first major operational use of this biopesticide in Africa with 10,000 ha treated), and reflected APLC's extensive experience in the development and use of this biopesticide.

Administration

APLC Commissioners' meetings were held on 18 November 2008 (63rd APLC meeting) and 30 April 2009 (64th APLC meeting). In accordance with the APLC Memorandum of Understanding, the 2008-09 APLC Operational Plan was the main focus of the November meeting, while the 2009-10 Budget and 2008-09 Financial performance were key topics for the April meeting. The April meeting also received the report from the preceding Research Review Committee meeting.

Staffing

Dr James Woodman commenced employment with APLC in February 2009 to fill the vacant Entomologist position, which had been restructured to place greater emphasis on population ecology and dynamics issues.

Mr Glen Wilshire resigned from his position as Field Officer based at Longreach in January 2009 to return to his family in NSW.

Mr Matt Dowle, who had been recruited as a temporary Field Officer based at Broken Hill, worked with APLC from July until November 2008.

Mr Laurie McCulloch, former APLC Director, was employed temporarily from January to March 2009 to assist in the tendering process associated with establishing a new panel of aircraft operator suppliers.

Table 4 : Staffing position at 30 June 2009 and days away from base 2008-09

<i>Officer</i>	<i>Position</i>	<i>Period Employed</i>	<i>Weekdays away from Base</i>	<i>Sat, Sun & public holidays away from Base</i>	<i>Total Days away from Base*</i>
C. Adriaansen	Director	Throughout	31	2	33
W. Spratt	Deputy Director	Throughout	7	0	7
E. Deveson	Forecasting & Information Officer	Throughout	15	1	16
P. Spurgin	Control Officer	Throughout	39	10	49
P. Story	Environmental Officer	Throughout	30	8	38
H. Wang	GIS Officer	Throughout	28	10	38
H. McRae	OH&S/Training Officer	Throughout	33	7	40
I. Wright	Administration Officer	Throughout	4	0	4
R. Graham	OIC Broken Hill	Throughout	67	18	85

<i>Officer</i>	<i>Position</i>	<i>Period Employed</i>	<i>Weekdays away from Base</i>	<i>Sat, Sun & public holidays away from Base</i>	<i>Total Days away from Base*</i>
J. Nolan	OIC Narromine	Throughout	91	13	104
A. Coleman	OIC Longreach	Throughout	91	23	114
L. Sanchez	Field Officer	Throughout	78	15	93
L. Scales	Field Officer	Throughout	41	9	50
S. Mander	Field Officer	Throughout	99	14	113
C. Mulcahy	Field Officer	Throughout	110	13	123
M. Dowle	Field Officer	1/7/2008 – 28/11/2008	28	2	30
J. Woodman	Entomologist	From 23/2/2009	4	0	4
G. Wilshire	Field Officer	To 21/1/2009	46	10	56
L. McCulloch	Temporary Project Officer	16/1/09 – 25/3/2009	0	0	0

* Note that these figures do not include time when officers were contracted by FAO or other organisations.

Finance

Total revenue in 2008-09 amounted to \$4.569 million. Expenses recorded in the 2008-09 financial report (Annex 3) amounted to \$3.690 million resulting in a net operating surplus of \$0.878 million. The surplus was carried over to the 2009-10 financial year as part of the accumulated reserve, as shown in the 2009-10 Budget (Annex 4). This accumulation of surplus into a reserve fund is in accordance with the Memorandum of Understanding, a position that was reconfirmed by decision of the 62nd Commissioners Meeting in April 2008.

The addition of this net operating surplus to that carried forward into 2008-09 raises the level of total accumulated reserve to \$1.908 million as at 30 June 2009. This fund would be drawn upon should the cost of control activities in any year exceed the annual allocation for control activities. The 62nd Commissioners Meeting also established a review “cap” for the reserve fund of \$3 million, above which the application of accumulated reserves would be decided by Commissioners (either as a reduction in the following year’s contributions or invested for a specific agreed purpose).

The surplus of income over expenditure for 2008-09 was delivered principally as a consequence of limited control operations expenditure occurring during the year. Staff vacancies at various times during the year also contributed to this result.

Key Performance Indicators

The 2005 external review of the APLC suggested a number of Key Performance Indicators (KPIs) against which the future performance of the APLC could be measured. These KPIs have been adopted, with some modifications to provide additional semi quantitative measures, for reporting on an annual basis. Details of the KPIs and performance measures together with an assessment of the APLC's performance in 2008-09 against these are summarised in Table 5.

Table 5 : APLC 2008-09 Performance against KPI measures

Key Performance Indicator	KPI Measures	Assessment/comments (2008-09)
Effectiveness of monitoring, prediction and control of locust populations	<ul style="list-style-type: none"> - Significant populations detected at early-mid instar stage - Accuracy of forecasts of population scale, timing and location - Majority of control measures against nymphal stage - No adverse aerial spraying incidents 	<p>Significant plague locust populations in several New South Wales locations and across three generations were detected at early life stage through targeted ground and aerial surveillance, which utilised forecasts prepared for each generation.</p> <p>98% of area subjected to control activities undertaken in 2008-09 was completed during the nymphal stage.</p> <p>No adverse incidents were reported or were known to have occurred.</p>
Availability and effectiveness of control agents	<ul style="list-style-type: none"> - Availability of existing agents - Replacement agents identified and application rates/techniques verified 	<p>No change to availability of current control agents.</p> <p>Issues raised in APVMA fenitrothion review were identified and responses prepared to address impacts upon APLC patterns of use. Further investigations identified as needed to address drift buffer issues raised in review.</p> <p>A comprehensive Pesticides Strategy was developed and presented to the 64th Commissioners Meeting to address medium and longer term control agent issues.</p> <p>Small quantity of new Malathion formulation retained for evaluation, but no suitable locust populations present to enable trial.</p> <p>Initial engagement with NZ researchers regarding possible new biocontrol agent. Laboratory-based evaluation may be undertaken in 2009-10 for effectiveness against <i>Chortoicetes terminifera</i>.</p>

Key Performance Indicator	KPI Measures	Assessment/comments (2008-09)
Environmental impact of control	- No reported/observed significant adverse impacts	No adverse impacts observed or reported consequent to APLC control activities in 2008-09.
Trade risks minimised	- No adverse trade (residue) impacts	No adverse trade impacts resulted from APLC operations. Comprehensive advice was provided to state and local agencies to minimise the residue and trade risk of their locust control activities.
Cooperation with environmental, OH&S and other relevant agencies in developing and implementing plans for control programs	- Plans developed and agreed and reviewed on regular basis.	Current policy on locust control in habitat areas of endangered species and in other environmentally restricted areas was applied where appropriate. Facilitated and collaborated with member state agencies in the preparation of state locust response plans for 2008-09, and the post-season review of these plans as the initial phase of planning for the 2009-10 season.
Ensuring OH&S of APLC staff, including aerial safety	- No significant OH&S incidents	No safety incidents reported in 2008-09. Revised Aerial Operations Safety Manual implemented and new panel of aircraft operators engaged, with tender specifications reflection revised Manual. External OH&S review undertaken, with corrective actions implemented where required. Review of OH&S Manual commenced to reflect outcomes of external review.
Improved management practices developed through a targeted research program	- Research findings incorporated into APLC control strategy and operations	Limited research activity undertaken due to absence of suitable locust populations. Various Operational Procedures revised to adopt previous research outcomes. Substantial environmental research progress was made with several collaborative projects completed and now being prepared for publication. Continued write-up of previous collaborative research work is progressing well. The extrapolation of previous laboratory-based research into the field has commenced with the preparation of funding applications with research collaborators.

Key Performance Indicator	KPI Measures	Assessment/comments (2008-09)
APLC staff participation in national and international programs/scientific conferences	- APLC staff invited to participate in appropriate programs and conferences	National and international scientific and technical conferences and meetings were attended and addressed. APLC staff were invited to participate in FAO-sponsored activities, including the International Desert Locust Control Committee and the Indonesia-Timor Leste locust planning workshop.
Development of effective strategic, operational and communication plans	- Plans developed, endorsed and implemented - Plans published	APLC Business Cycle presented to and endorsed by Commissioners, establishing an ongoing process for planning and review at all levels. 2008-09 Operational Plan endorsed by Commissioners and released via APLC website.
Training of member state staff	- APLC training course developed and core of trained member state staff available	Training delivered to state agency staff prior to commencement of 2008 season. In-field training and development provided to NSW department and LHPA staff during response activities.

Research

Research Review Committee

The committee comprising Dr Andrew Tomkins (Chair), Professor Myron Zalucki and Mr Phil Sinclair met to review APLC research on 28 – 29 August 2008. Extracts from the Recommendations contained in the 2008-09 Annual Research Review Report of this meeting are provided below. A full list of the report recommendations are provided at Annex 5. Dr Alexander Latchinsky, President of the USA National Grasshopper Management Board, who was present in Australia at that time, was invited to observe the meeting and provide input.

As well as reviewing current research, the committee provided input into the restructure of the vacant Entomologist position to assist with refocussing this position more towards population ecology and dynamics.

“While APLC continues to conduct a considerable amount of valuable research which is enabling greater understanding of locust biology and control and the effects of control operations, it is clear that APLC’s ability is limited by the scope of it’s ‘business’ and the relatively small limited number of staff and resources it can commit to research. It is therefore essential that APLC maintains and develops collaboration with other agencies. Universities will play a significant role especially where basic studies are required and/or access to specialised skills and resources or a larger team where this is required for a larger area of research. In the past, ARC projects have often been used, largely reflecting the high proportion of university involvement. However, for some areas of research such as the IMR studies, new sources of funding may be required and APLC should help to persuade these funding bodies by co-investment and lobbying to support research proposals to these bodies. It should also be noted that the state departments involved with locust management in their jurisdictions have been major beneficiaries from the research conducted solely or collaboratively by APLC and, while these state agencies are financial contributors to the APLC, they should also consider making further contribution to locust research either by additional co-investment or by encouraging their researchers, where appropriate, to work with those of the APLC.”

Extract from RRC Annual Research Review Report, April 2009

Research Collaborations

The value of the collaborative research strategy adopted by APLC is demonstrated clearly by the figures contained in Table 7 below. In addition to the significant intellectual power which is being harnessed from (in particular) the university sector to undertake locust research, APLC investment through Australian Research Council (ARC) linkage projects is securing a total value of research in excess of \$2.2 million for the investment of \$180,000 over the project life of the two current ARC funded projects. This represents a research investment leverage of greater than 12 : 1.

Table 6 : APLC contribution to collaborative research projects

Project	Collaborator	APLC Contribution				Total project value - All investors
		2008-09	Life of Project investment			
			Total in-kind	Total cash	Total	
Locust Band Behaviour Study	Sydney University	\$40,000	\$516,204	\$90,000	\$606,204	\$1,159,209
Locust Population Genetics	Sydney University	\$25,600	\$447,977	\$90,000	\$537,977	\$1,080,251
Totals		\$65,600	\$964,181	\$180,000	\$1,144,181	\$2,239,460

Summaries of research in progress

The following research summaries provide an overview of current research activities being undertaken by the Australian Plague Locust Commission. The research summaries are not considered to constitute publication as the investigations are often incomplete and any results presented tentative.

(1) Control agents and application technology

1.1: Barrier treatment

No opportunities to use this technique arose during 2008/09 control operations. However, the Department of Primary Industries Victoria, expressed interest in evaluating the technique for possible use during future aerial band control activities in that state (specifically evaluating the long term effects of strip spraying of fipronil on non-target invertebrate species). In February 2009 a field trial was carried out by APLC and DPI Vic. Near Bendigo. A 1 km² block (wheat stubble) was treated with Adonis 3UL using a helicopter fitted with Micronair rotary atomiser spraying equipment. Spray runs were made at 200 m intervals parallel to the prevailing wind, creating treated strips approximately 75 m wide (determined using spray droplet deposited on oil sensitive papers). The fipronil dose within these strips (or barriers) ranged up to ca. 1.0 g a.i./ha. Insects within the target area and in an adjoining untreated area were collected using a variety of sampling methods (sweep netting, pitfall traps etc.) prior to treatment and then for up to 6 months following spraying. Analysis of the insect collection data by DPI Vic is continuing.

1.2: Metarhizium

During late March and early April 2009, a band control operation in the Coonamble area was carried out using the biopesticide Green Guard ULV as the sole control agent. Twenty

target areas (3,875 ha) were treated by air at a dose of circa 35 g of *M. anisopliae* spores/ha applied in 0.7 L of carrier oil/ha. This increased dose and application volume (standard application rate used is 25 g/ha at 0.5L/ha) was used due to the dense vegetation and cooler day & night temperatures prevalent in the area at the time of control. Nymphs from one of the treated areas were collected 3 days after spraying and monitored in field cages for a total of 25 days post treatment. Dead locusts showing definite signs of infection due to *M. anisopliae* were observed 15-21 days after spraying. This timing agreed with mortality predictions from the simulation program (developed by H.Wang, refer to section 3.9) suggesting that these locusts received a dose of 2,000-5,000 spores/insect. This further confirmed that the increased application volume of 0.7 L/ha gave excellent coverage of vegetation and locusts within the target (providing both direct impact of spore laden droplets on locusts and indirect pickup by contact with treated vegetation). Droplet counts on oil sensitive papers in target areas confirmed spray droplet coverage at 30-50 droplets/cm² (size ca. 100 microns).

Previous control with the standard rate of *M. anisopliae* under ideal conditions (warm day & night conditions and short vegetation) indicated that the 25g/ha dose is adequate against dense bands of Australian plague locust. An increase in application volume (0.7 L/ha) combined with this dose may prove as effective as the 35 g/ha dose (and more cost effective).

This control operation also highlighted the problems caused during mixing when the ULV formulation is allowed to settle out due to long term storage or prolonged travel (sedimentation & compaction of spores due to vibration). To maximise mixing efficiency, the formulation should be relatively fresh or recently resuspended (no more than 1-2 months since formulation or re-suspension).

2. Environmental impact

2.1 Quantifying the effects of pesticides used for locust control on Australian native vertebrates.

With the completion of previous collaborative research between the APLC, University of Wollongong, Texas Tech University and the National Research Centre for Environmental Toxicology (see APLC Annual Activity Statement 2007-2008) research effort has been focussed on the submission of manuscripts stemming from this research effort for publication to various peer-reviewed journals. Lab-based research outlined in the APLC's previous Annual Activity Statement (2007-2008) will now be developed further to incorporate field-based effects. To this end, additional funding applications are being prepared for submission in early 2009 to evaluate the ecological impacts of pesticides used for locust control in arid and semi-arid ecosystems.

2.2 Comparative risk assessments of pesticide used for locust control throughout the world.

Several methods exist for building species sensitivity distributions (SSDs) using data relevant to several toxicity end points allowing the estimation of the probability of lethality as a result of pesticide exposure. The APLC's Environmental Officer, Mr Paul Story, is currently working with Dr Pierre Mineau (Research Scientist and Program Leader,

Pesticides Section, Environment Canada and Adjunct Professor at Carleton University) on the development of comparative risk assessments for pesticides used throughout the world for locust control. Pesticides registered in Australia, USA, Canada, European Union as well as those on the World Food and Agriculture Groups (FAO) approved list will be evaluated.

An appeal for new and updated research data, specifically as it relates to pesticide residue values on either insects or vegetation, has been extended to the world-wide scientific community through various key researchers and research agencies. It is envisaged that the incorporation of this data with new, more probabilistic risk assessment methods, will enable risk assessments for insecticides currently used for locust control to be updated and compared. Risk assessments derived within this research project will potentially be more protective because we will first look for the influence of body-weight scaling on toxicity and use that as covariate before developing pesticide specific species sensitivity distributions. Benefits to locust control agencies, such as the APLC, will flow from these improved comparative risk assessments, enabling improvements in their environmental performance through the selection of "environmentally softer" pesticides for spray operations.

2.3: The impact of fipronil on ants and termites

This collaborative project was led by former APLC entomologist, Dr Martin Steinbauer. Data collection was concluded in November 2008 by APLC field staff and subsequent analysis and interpretation was led by James Woodman in collaboration with Martin and statisticians at BRS. This work targeted ants and termites due to Fipronil being a marketed termiticide that has previously shown severe, long-lasting impacts on termites from high dosage applications in Madagascar.

The results of this work are currently being evaluated in light of experimental design limitations identified during analysis and interpretation. As such, this work is presently being used to inform the planning of a successive research project. This work will quantify the off-target impacts of fipronil applied using current APLC application rates and barrier intervals (as opposed to blanket applications which have not been used since 2002-03) for a greater number of invertebrate study species. This new study will also have a greater focus on the functional significance of these species to arid Australian ecology.

3. Population Ecology and Dynamics

Research activity during 2008-09 was affected by the interval between the departure of previous APLC entomologist, Dr Martin Steinbauer, in March 2008 and the subsequent employment of Dr James Woodman to assume the position in late February 2009.

3.1: Egg survival

This work was commenced by former APLC entomologist, Dr Martin Steinbauer to assess the effects of soil type, moisture content, and moisture retention on egg survival. This study was to build on available data for the temperature-dependence of egg development and the known capacity of eggs to imbibe moisture against external suction gradients.

While this area of research remains relatively poorly understood, this particular project has been discontinued with little resulting data or significant progress.

3.2: Body size, fat content, and habitat condition

This work was commenced by former APLC entomologist, Dr Martin Steinbauer. Body size, fat content, and habitat condition are assumed to be interrelated and are expected to have an impact on the capacity of *Chortoicetes terminifera* to survive and reproduce. It is therefore important to establish the actual importance or otherwise of body fat to survival and reproduction. Data collection for this work is now complete and the analysis and interpretation of results is underway.

3.3: Egg distribution and frequency of parasitism from dense late season oviposition

This work was planned in May 2009 in response to unusually heavy late season swarm oviposition reports around Coonamble, New South Wales. The specific objectives of the study are to (i) sample the density, distribution, morphology and orientation of egg pods within an egg bed, (ii) determine the number of eggs laid per pod, and (iii) determine the proportion of parasitised and dead eggs per pod.

Field work was conducted successfully during July 2009, however it is too early to report results. It is anticipated that this study will provide new data quantifying late season reproductive output for *C. terminifera* as well as providing an effective sampling protocol for quantifying egg bed population parameters in the future.

3.4: Cold tolerance of first-instar nymphs of the Australian plague locust

Whether sub-zero temperatures and frost can cause mortality in first instar *C. terminifera* nymphs has been a long standing question for locust monitoring and forecasting in Australia, as well as among concerned agricultural landholders. This is not surprising given that large variation in first instar nymphal survival is relatively poorly understood and yet undoubtedly important to the extent of aggregated band formation and likely crop and pasture losses. This work attempts to answer this question by evaluating the extent to which cold and frosty nights may contribute to nymphal mortality in the field. Planning for this work has only very recently commenced and it is too early to report any results.

3.5: Development of migration trajectory analysis for estimating migration

In order to locate possible emigration sources and immigration destinations, and provide early warnings for possible infestations and outbreaks, the migratory trajectories of plague locusts were estimated from the flight parameters derived from IMR measurements in the past. Due to the lack of IMR operation for much of 2008 – 2009 season, the possible migration events (when the adult locusts were present in the vicinities of favourable weather system) were evaluated by trajectories derived from the Australian Bureau of Meteorology Limited Area Prediction System (LAPS). Two occasions of expected locust migration were confirmed associated with tropical trough system.

The previous study on estimation of migration trajectory with IMR detected flight parameters was presented to the 23rd International Congress of Entomology, Durban, South Africa, 6-12 July 2008, as an oral presentation.

3.6: Genetic diversity at the continental scale

The population genetics program at the University of Sydney has finalised the process of identifying genetic markers in *Chortoicetes terminifera* and comparing populations collected from 92 sites across the continent. Statistical analysis indicates that there is no significant genotypic differentiation between the samples from different locations suggesting that the distribution of the *Chortoicetes terminifera* is panmictic. (A panmictic population is one where all individuals are potential partners – i.e. there are no mating restrictions on the population and no localised geographic variation).

While this does not prove that east-west and west-east migration is common, it does suggest that such migration has occurred recently. Continent wide migration may therefore be a contributing factor to the development of outbreaks. This work is currently in preparation for publication in the peer-reviewed scientific literature.

3.7: Band movement and nutrition

The research strategy identifies that further understanding of the factors influencing band formation and movement is critical to improving the implementation of barrier spraying techniques, particularly in relation to determining the width and separation of spray barriers in the field. Ideally, some form of model would be available to operational staff that would allow them to determine the width and spacing of spray barriers based on factors such as vegetation type, stage of development of hoppers, their nutrient requirements, and other environmental conditions.

The University of Sydney has commenced a project to begin to understand the factors involved in band formation and movement. The APLC is providing in-kind support.

Initial work shows that band formation can be simulated using a model of self moving particles, if it is assumed that the proximity of individual particles to each other influences the behaviour of individual particles. Initial field observations show that at hopper densities in excess of 50 per square metre, locusts are highly aligned and band direction is stable. At densities below 50 per square metre, alignment of individuals is variable and bands change direction frequently.

Future work will evaluate the effects of density, vegetation patterns, weather, and nutritional status on the formation and movement of bands.

Research on other species of Orthoptera has shown that nutritional requirements for protein, carbohydrates, and/or water can significantly influence behaviour to the point that it may be possible to design different types of bait for Orthoptera in different nutritional states. The outcome of this work is likely to be of significant benefit to APLC control activities.

3.8: Behavioural phase change

Many species of Orthoptera exhibit distinctive behavioural phases, often with colouration differences accompanying the phase change. For example, adult males of *Austroicetes cruciata* can change colour to yellow when they begin to swarm. *Chortoicetes terminifera* does not show colour changes associated with apparent phase changes and it had therefore been assumed by some that phase changes do not occur.

Recent work at the University of Sydney illustrates that *Chortoicetes terminifera* adults exhibit a phase change from solitary to gregarious behaviour with no obvious associated morphological changes. *Chortoicetes terminifera* reared solitarily over many generations will exhibit gregarious behaviour when exposed to other adults for 72 hours and vice versa.

This has relevance to APLC surveillance and forecasting. If a low density but widespread population of *Chortoicetes terminifera* exhibiting solitary behaviour is brought together by wind patterns or aggregation to remnant vegetation, gregarious behaviour could develop leading to swarms. APLC surveillance techniques are unlikely to detect all low-level populations exhibiting solitary behaviour. This phase change mechanism could explain the unexpected appearance on occasions of swarms in areas where locusts were thought not to exist.

3.9: Simulation of Metarhizium development with locust body temperature variation

In order to evaluate the effectiveness of Green Guard® on locust control, a simulation model was reconstructed from published references, for estimating the locust body temperature in association with air temperature and the Metarhizium fungus development in the locust body. The initial evaluation in the band control during late March to early April 2009 in Coonamble region revealed that the Metarhizium is also effective at moderate temperatures and the duration from infestation to killing was much longer than expected. This warranted a further development of this model.

The program was developed under the freeware R environment. Geographic location (latitude and longitude) is used to calculate day length (sun rise and sun set time), which is then used to estimate the daily temperature variation regime (assuming the daily temperature minimum occurs right before sun rise). Daily temperature maxima and minima are used to simulation hourly temperatures in 24-hr period with non-symmetric sine wave. The locust body temperature is estimated from the ambient temperature with a nonlinear sigmoid model, with the consideration of behavioural fever generated by the locust after infection. Instead of using the 4-parameter exponential model published, a much more sophisticated biophysical model was fitted and the 6 parameters are used to calculate the temperature-dependent development rate of Metarhizium fungus. Also, the number of fungus spores deposited onto a single locust is introduced into the calculation of the duration of 50% and 90% mortality.

This model was first validated with observations from Coonamble and the results showed the behavioural fever generated by the infected locusts are obvious and slow down the fungus development dramatically during daytime at moderate temperatures, and the dosage used (35 g/ha) is sufficient to kill more than 50% population within two weeks of application. The model also indicated the number of spores captured by individual locust nymph was about 2000 - 5000 with vegetation under 50cm height. The model was also

tested during the Red locust control program in Tanzania. With the higher and denser vegetation (about 2m tall) encountered there, the number of fungal spores of Green Muscle® deposited onto individual locust bodies was significantly less (estimated at ca. 600) than in Coonamble. However, even at that low dosage, the locust majority showed infection after about 50 days. The observations on both occasions illustrated the model can be used to estimate the control effect with a proper estimate of spore collection by locust.

Further validation of this model for locust control at higher temperatures may need to improve the model performance for less or no influence from locust behavioural fever.

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Story PG, Buttemer WA, Hooper MJ, Fildes K and Astheimer LB (2008). The sensitivity of native Australian marsupials to fenitrothion and the consequences of sublethal exposure. Proceedings of the 8th World Congress of the Society for Environmental Toxicology and Chemistry, Sydney, Australia August 2008. <http://www.setac2008.com/>

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Annex 1: Environmental Management System conformance

Program	Sub-project	Progress (2008-09)
1. Excellence in all operational areas	Staff trained to full field competence	<i>New staff progressed through all of their seasonal training requirements, with good opportunities arising during band control activities. New aviation and operational safety requirements under the Aviation Procedures Manual were included in the competency training program.</i>
	DGPS used in all aircraft	<i>dGPS is mandatory in spray aircraft to provide detailed record of spraying operations, and was a core criteria in the tendering process for the new panel of spray aircraft providers.</i>
	Improved control efficiency	<i>Control effectiveness assessment undertaken on Metarhizium under cooler conditions at a higher rate. Varied effectiveness and final results difficult to assess.</i>
2. All waste managed appropriately	Waste management contract	<i>No waste disposal required in 2008-09</i>
3. Minimise the intensity, extent and duration of disturbance to native flora and fauna	Incidents effectively managed	<i>55 targets covering 39 properties and 97.7 km² were treated for locusts, with no aerial spraying incidents known to have occurred.</i>
	Reduce the proportional use of fenitrothion in control ops	<i>54% of the area treated in 2008-09 was with fenitrothion and 46% with Metarhizium. This is a significant increase over the long-term average percentage treated with biopesticide, and reflects a stated objective to raise APLC use of Metarhizium to average at least 20%.</i>
	Increased successful use of fipronil and larger track spacing	<i>No further trials with Fipronil conducted as target sizes were generally too small for barrier treatment.</i>
4. Contribute to our understanding of natural and managed ecosystems	Develop risk assessment process for APLC pesticides, based on outcomes of environmental research.	<i>Bioassay procedures for locust control pesticides have been developed in collaboration with ExTox in Qld, and are ready to be applied during future control activities. International collaboration is ongoing to establish a risk assessment of all locust control agents used or listed for use worldwide.</i>
	Develop field protocols based on research	<i>Interim field procedures established to limit the use of fipronil in areas where termite activity is evident. Further analysis of data collected from specific research project will determine validity of these procedures or if variation is appropriate.</i>
5. Avoid disturbance to protected sites/areas	Development of the GIS, OpsManager® and PDA handhelds sensitive area maps and database	<i>Updated bush-stone curlew data provided by NSW DEC and added to sensitive areas database. Mapping database used operationally during Riverina and Central West campaigns.</i>
	Procedures and buffers developed to avoid disturbance	<i>Current buffers for fenitrothion and fipronil remain the same. Metarhizium buffer for water bodies reduced to 100m upwind for aerial ULV application. Established buffer zones for sensitive areas were complied with and no issues arose during the season.</i>
6. Ensure stakeholders are aware of all environmental obligations and they assist APLC achieve these.	Develop environmental aspect into APLC stakeholder training course.	<i>Training conducted with NSW DPI and RLPB staff in Wagga and Forbes through September and October.</i>
	Landholder consultation prior to and after pesticide application	<i>Extensive landholder consultation conducted during the four control campaigns. Post control advice issued within 2 weeks to all property owners.</i>

Annex 2: Occupational Health and Safety Management System (OHSMS) Review 2008-09 – Progress on Recommendations

Recommendations		Status/Progress
OHSMS		
1	Put in place ongoing review (annual basis) of OHSMS	Accepted. Established as part of annual planning & review cycle
2	Review structure and appropriateness of DAFF OHS policy to operations of APLC	Awaiting clarification prior to identifying action
3	Consider framework for replacement OHS Agreement if required.	Awaiting clarification prior to identifying action
4	Set Objectives and Targets for OHSMS performance	Accepted. OHSMS will be revised to incorporate
5	Review clear statement of responsibilities and accountabilities	Accepted. OHSMS will be revised to incorporate
6	Strengthen formality of reporting arrangements in relation to OHSMS	Awaiting clarification prior to identifying action
7	Update OHS Policy Manual to same status as Operations Manual	Completed
8	Review currency of documentation	Completed
9	Establish consistent Risk Scoring template and more robust Risk Assessment process	Awaiting clarification prior to identifying action
10	Implement more rigorous Electrical Testing and Tagging framework	Completed
11	Formalise risk evaluation process	Awaiting clarification prior to identifying action
12	Review Emergency Preparedness particularly in relation to vehicle based remote procedures	Awaiting clarification prior to identifying action
13	Improve the comprehensiveness of the reporting arrangements in relation to the OHSMS	Accepted. OHSMS will be revised to incorporate
14	Develop a more comprehensive approach to internal audit and inspection process at both systems and facility level	Accepted. Established as part of annual planning & review cycle
15	Develop a more formalised Management Review process	Accepted. Established as part of annual planning & review cycle
Physical Operations		
16	That the safe work limit (SWL) markings on the tail gate lifter fitted to the truck be converted to metric and expressed in equivalent maximum number 100 L drums to be loaded at any time.	Completed
17	Signage adjacent to the main gate needs to be refreshed so that it is clearly visible.	Completed
18	Warning tape on either side of the recess channel for the doors to the sheds needs to be renewed.	Completed
19	Safety operating instructions for the drill press and bench grinder need to be established and displayed with appropriate PPE being available.	Completed
20	Regular checks of the first aid kit need to be conducted to ensure that no out of date contents are left in the kits.	Accepted. Procedures amended to implement scheduled checks
21	Instructions for the Weed Hornet and the incubators need to be updated. The security of fire extinguishers in the vehicle cabins needs to be reviewed.	Accepted. Corrective measures established.

Recommendations		Status/Progress
22	The emergency procedures guide relating to radio procedures and dangerous goods spills need to be urgently reviewed and updated.	Accepted. Documents to be updated immediately.
23	A warning sign should be placed on the stairs to the raised storage area indicating that there is low headroom.	Accepted. Corrective measure determined and will be implemented.
24	The formal operating instructions for the high-pressure water wash should be developed.	Accepted. Corrective measure determined and will be implemented.
25	The water tank and water drums on site should be clearly labelled as to the potable status of their contents.	Completed
26	The emergency shower needs to be regularly tested to ensure that water runs freely if required and the eye wash bottles located in the chemical store need to be kept up to date.	Completed
27	The trip hazard located adjacent to the toilet access needs to be ground down to make this safer.	Completed
28	Install additional power outlets in the Laboratory area for the freezers and mark these "Do not unplug"	Request with building owners
29	Bring Testing and Tagging up to date across the whole organisation	Request with DAFF property section
30	Develop formal operating instructions for ovens, fume cupboards and CRYO cylinder	Accepted. Corrective measure determined and will be implemented.
31	Consider supplementary ventilation separate from air conditioning to enable fume evacuation from laboratory in emergency	Completed
32	Replace broken chair in laboratory	Accepted. Replacement chair ordered.
33	Consider range of cleaning products used in laboratory and obtain MSDS for each one confirmed as being required	Completed
34	Label cupboards as to contents in laboratory	Completed
35	Create record of testing of Eye Wash station	Accepted. Test record to be posted adjacent to station.
36	Implement quarterly safety checklist for laboratory	Completed
37	Update all MSDS (highlight expiry date to make this more obvious)	Completed
38	Move recycling bin from in front of fire extinguisher	Completed
39	Dispose of surplus and out of date equipment in store room, including old first aid kit	Accepted. Review & disposal task allocated.
40	Develop signage for large containers current in store room	Accepted. Signage in preparation
41	Reinforce correct storage of chemicals in Flammable Substances Cupboard	Completed
42	Secure equipment in workshop so that it can be used and provide appropriate instructions and PPE	Accepted. Corrective measure determined and will be implemented.
43	Replace all first aid kits in field vehicles with up to date ones and place them on regular review cycle.	Completed
44	Rewrite emergency evacuation plan for building	Department Progressing
45	Have landlord bring testing and tagging of all fire appliances into line with relevant Australian Standard	Completed
46	Review all indicated documents as per observations.	Accepted.

Annex 3: Financial Performance and Revenue Report 2008-09

	Budget 2008-09. At 1/7/2008	Result 2008-09
Expenses		
Employee Remuneration	1,241,526	1,183,358
Superannuation	213,649	224,920
Leave Expense	135,117	191,819
Other Employee On Costs	47,600	93,302
Staff Training And Development	9,000	7,863
Total Employee Expenses	1,646,892	1,701,262
Insecticide Expensed	425,000	22,176
Bio-Insecticide Expensed	77,000	72,576
Helicopter Charter	337,000	67,400
Fixed Wing Aircraft Charter	86,000	115,482
Aerial Spray Aircraft Charter	265,000	68,683
Aviation Fuel	43,000	13,097
Control Ops: Equipment & Freight	73,000	36,359
Sub-Total: Control Operations	1,306,000	395,773
Light Trap Operations	8,000	9,695
Other Technical & Field Expenses	22,000	44,527
Vehicles	333,000	316,810
Travel	183,000	191,791
IT, Communications & Office Equipment	164,000	162,664
Contractors & Research Grants	26,000	66,327
Human Resources Services	14,000	13,863
Internal Business Overhead Allocation	138,000	124,636
Other Administrative	9,103	3,226
Official Hospitality	1,000	2,297
General Office Supplies	15,000	20,055
Purchase Publications & Data	8,500	8,019
Production Of Publications	8,000	5,686
Property & Accommodation	242,000	172,823
Memberships & Conferences	3,500	2,508
Consultancy Services	15,000	35,071
Public Relations & Marketing	1,000	3,960
Legal	7,000	7,724
Total Supplier Expenses	2,504,103	1,587,455
Sub-Total: Salaries Plus Supplier Expenses	4,150,995	3,288,717
Depreciation & Amortisation	52,773	41,043
Corporate Expenses (Funded)	325,674	325,674
Corporate Expenses (UnFunded)	30,576	30,577
Interest Expense	-	4,930
Total Other Expenses	409,023	402,224
Total Expenses	4,560,018	3,690,941
Revenue		
Commonwealth	2,101,884	2,101,885
Member States	2,101,884	2,101,885
Commonwealth: Additional Funding For Overheads	325,674	325,674
Member States Additional Charge - Overheads	30,576	30,576
Misc Revenue		8,981
Total Revenue	4,560,018	4,569,001
Reserves At Start Of Financial Year		1,030,060
Net Operating Result - Surplus Or Loss		878,060

Annex 4: 2009-10 Budget

	2009-10 Budget
Expenses	
Employee Remuneration	1,328,542
Superannuation	237,560
Leave Expense	134,172
Other Employee On Costs	57,768
Staff Training And Development	9,000
Total Employee Expenses	1,767,042
Insecticide Expensed	316,000
Bio-Insecticide Expensed	73,800
Helicopter Charter	292,000
Fixed Wing Aircraft Charter	107,000
Aerial Spray Aircraft Charter	214,000
Aviation Fuel	28,000
Control Ops: Equipment & Freight	59,900
Control Ops: Travel	79,000
Sub-Total: Control Operations	1,169,700
Light Trap Operations	10,000
Other Technical & Field Expenses	62,715
Vehicles	326,997
Travel	134,000
IT, Communications & Office Equipment	157,091
Contractors & Research Grants	55,000
Human Resources Services	14,000
Internal Business Overhead Allocation	94,710
Other Administrative	9,015
Official Hospitality	1,000
General Office Supplies	18,445
Purchase Publications & Data	9,350
Production Of Publications	6,750
Property & Accommodation	197,000
Memberships & Conferences	9,000
Consultancy Services	38,000
Public Relations & Marketing	2,000
Legal	7,000
Total Supplier Expenses	2,321,773
Sub-Total: Salaries Plus Supplier Expenses	4,088,815
Depreciation & Amortisation	43,185
Corporate Expenses (Funded)	431,101
Corporate Expenses (UnFunded)	48,736
Total Other Expenses	523,022
Total Expenses	4,611,837
Revenue	
Commonwealth	2,066,000
Member States	2,066,000
Commonwealth: Additional Funding For Overheads	431,101
Member States Additional Charge - Overheads	48,736
Total Revenue	4,611,837

Annex 5: 2008 Research Review Committee recommendations

Extract from RRC Annual Research Review Report, April 2009

Issues that need addressing under research strategy objectives

At the completion of the review, the longest serving and most experienced member of the panel was asked to sum up and provide comment on areas where further investigation was needed. In addition, Dr Latchinsky provided some further comments and suggestions based on US experience with grasshopper management in US grasslands. The following is a summary of suggested areas/issues from Professor Zalucki and Dr Latchinsky, with the latter's suggestions identified with (AL).

Control agents and application technology

- Activity of *Metarhizium* under lower temperatures – needs to be investigated if this has not been adequately investigated previously
- Relationship between behavioural and control studies of APL - need a longer term link between movement data (theory) (Simpson team) and field/application side of things
- Effect of long term/repeated history of APLC control operations – need to determine whether there are any consequences. This may possibly require a consortium of people and agencies. For example, 2 blocks in QLD were heavily sprayed with fipronil in early days of evaluating the insecticides – consideration should be given to revisiting and conducting further studies at these sites
- Literature review for Annual Review of Entomology on biology/ecology/management of APL – this might be a task for the replacement APLC scientist
- Determining egg laying history/status of adult female APL under field conditions - a rough method is needed so that field officers can tell whether a female has laid eggs before (and insects the number of previous egg laying events)
- Use of untreated strips/refugia in areas being treated for locust control in order to conserve/enable faster recolonisation of treated areas, by non-target invertebrates that may have been adversely affected by sprays applied for locust control - need to go through Paul Walker data set first before considering further R&D of effects on non-target invertebrates and to help identify target groups for potential future research. When conducting these types of studies need to consider 'singleton' species. This involves caution of sampling techniques and interpretation of sampling data. For example, 90% of insects collected may be from only 1 or 2 specimens with the remaining 10% belonging to multiple species. If these less common species are then classed as rare, that can result in many areas being classed as containing rare species. This would then have consequences for interpretation of effects on non-target invertebrates.
- Ground spraying – should R&D be considered to assist states who make greater use of this method of spray application (AL)
- New pesticide chemistry – may wish to consider evaluation of Juvenile Hormone Analogues for control (AL)
- Non target effects of spraying – could include effects on locust natural enemies (AL)

Environmental impact

- Focus on sub-lethal effects affects is important as these (and other factors) may then have population effects
- Next year's R&D session – start with Population Ecology

Population dynamics

- Need to improve understanding of fecundity & mortality, as this will enable improved prediction
- Use of radar – there is potential to use radar to enable improved selectivity for surveillance. Investment in development and proof of concept for field radar should continue.
- Relationship between rainfall events and regional incidence of APL – need to develop/improve methodology for improving prediction of regional incidence, considering rainfall in relation to previous and current populations
- Effects of soil type on oviposition is not clearly understood
- Effects of frost are not completely understood – for example, frost does not appear to kill eggs but may kill 1st instars
- Relationship between egg beds and hopper bands – appears that where you have egg beds you will get bands. Perhaps this should be investigated to prove/disprove.
- Egg hatching from egg beds – quite often second hatchings occur from a bed (& some people will dig down and see if there is a further hatching). Need for more understanding of why/when 'secondary' hatchings occur. This could be a project for new field staff to work on in conjunction with the replacement scientist.
- Developing and maintaining long term monitoring sites e.g. sentinel sites, to enable analysis of historical data (AL)