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Benefit–cost analysis of Australian plague locust control operations for 2010–11

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ABARES report prepared for the Australian Plague Locust Commission

March 2011

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Science and economics for decision-makers

Millist, N and Abdalla, A 2011, *Benefit–cost analysis of Australian plague locust control operations for 2010–11*, ABARES report prepared for the Australian Plague Locust Commission, Canberra, March.

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ABARES project 43173

The Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) was formed following the merger of the Australian Bureau of Agricultural and Resource Economics (ABARE) and the Bureau of Rural Sciences (BRS) in 2010–11.

Acknowledgments

Many people provided information, data and advice that was crucial for the analysis and production of this report. From the Australian Plague Locust Commission, Chris Adriaansen's insight and advice throughout the project and Ted Deveson's helpful and constructive comments on the draft were invaluable. Staff in the state agriculture departments provided data necessary for undertaking the analysis. Andrew Wilke, Queensland; Suzanne Robinson, New South Wales; Claire Norris, Victoria; and Lyn Chapman, South Australia, were all able to respond to our data requests quickly during a busy time. Valuable contributions were also received from Kristopher Morey and Benjamin Buetre from the ABARES Agricultural Biosecurity section.

Foreword

The Australian plague locust has the potential to damage and severely impact a number of rural industries. The Australian Plague Locust Commission (APLC) is required to monitor and manage populations of the Australian plague locust within a demarcated area of the four mainland eastern states. In addition to this, states and landholders also undertake control operations to protect agricultural enterprises.

Following favourable climatic and habitat conditions, a major infestation of Australian plague locusts developed in autumn 2010. Hatchings in September 2010 marked the commencement of control operations, with large areas treated by the APLC, state governments and landholders in 2010–11.

This report was commissioned by the APLC to determine if the benefits of the control campaigns exceeded the costs incurred by the commission, state governments and landholders in the 2010–11 plague locust outbreak.

Phillip Glyde
Executive Director
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March 2011

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Summary

Following favourable climatic and habitat conditions, a major infestation of Australian plague locusts developed in autumn 2010, and a subsequent generation of high-density nymphs developed in spring. Control operations commenced following these hatchings in September, with large areas treated by the APLC, state governments and landholders.

The APLC commissioned ABARES to conduct a benefit–cost analysis to assess the economic feasibility of the operations undertaken by the APLC, states and landholders to control the threat of a locust plague in 2010–11. The study compares the total expenditure on locust control by all parties to the overall benefits likely to be generated through the control campaign—that is, by estimating the damage to agricultural industries that could have occurred in the absence of control.

The benefits from locust control accrue from treating juvenile bands before they are able to move to and adversely affect agricultural enterprises beyond the breeding grounds. The extent of damage depends on the density of the outbreak and the quantity and value of plant matter consumed. The benefits of control were estimated using a spreadsheet model applying data on area and unit values for crops and pasture production, together with entomological assumptions on locust density and plant matter consumption obtained from the literature and confirmed by the APLC and state governments.

Locust control operations this season are estimated to have avoided potential losses of $963 million. Total expenditure by all parties was estimated to be $50 million. The net benefits of control are therefore $913 million, with an estimated ratio of benefits to costs of around 19.2:1.

Control undertaken by the APLC was found to have a benefit–cost ratio of 50.7:1, while control by the states and landholders had an average benefit–cost ratio of 18.3:1. The difference between the two ratios is largely owing to operational and logistical variations in executing locust control operations. For example, the APLC generally uses aerial treatment, which has a lower cost of treatment per hectare than the ground spraying that had to be used by states and landholders in some areas.

As insect density is one of the highly uncertain parameters in the model, sensitivity analysis was undertaken to test the effect of a lower insect density on the estimated results. This showed that if the assumed density of locust bands and swarms was halved, the ratio of benefits to costs was also halved, but still remained significantly greater than one.

Other non-market costs and benefits that may result from control of locust outbreaks—such as costs to human health from chemical use or benefits to other industries and the public—are discussed but not estimated.

The results from this study are in line with two previous studies by ABARE (now ABARES), when differences between the scale of this year's outbreak and outbreaks in previous seasons and the purpose of the study are taken into account.

1 Introduction

The Australian Plague Locust Commission (APLC) commissioned ABARES to conduct a benefit–cost analysis of the operations undertaken by the APLC, states and landholders to control the threat of a locust plague in 2010–11. To meet this objective, the study compared the total expenditure on locust control by all parties with the benefits likely to be generated through locust control operations.

In early April 2010, a large-scale locust swarm formation occurred in New South Wales, northern South Australia and northern Victoria, with reported damage to autumn fodder and crops. High-density autumn egg-laying by locust swarms produced a subsequent generation of high-density nymphs in the spring (September–October 2010).

This prompted a high level of coordination and preparedness by all jurisdictions, which culminated in the 2010–11 season campaign targeting the locusts after hatchings while the emerging insects were still in the nymphal or band stage. When left until they are able to fly and form swarms, these locusts become far more difficult to control.

The benefits from locust control accrue not only in breeding grounds, where control operations are carried out, but also in areas that juvenile bands and adult swarms are able to move to and adversely affect agricultural enterprises, the environment and society. As such, locust management may have considerable external impacts beyond the location where hatchings occur.

The APLC—financed by the governments of New South Wales, Victoria, South Australia and Queensland with a matching contribution from the Australian Government—was established to monitor and manage populations of the Australian plague locust that could damage rural industries in Australia's four mainland eastern states. In conjunction with control carried out by the APLC, the states and private landholders also undertook control campaigns against locusts in 2010–11.

2 Background

The Australian plague locust is a seasonal pest to Australian agriculture, with some degree of loss from locust attack occurring in most seasons, particularly in the rangelands of the interior. The plague locust is native to these areas and is already a well-established part of the existing ecosystem. From time to time, suitable seasonal conditions lead to a build-up of locust numbers, reaching plague proportions, as has occurred in the 2010–11 season.

Consumption of agricultural green plant matter by locusts can adversely affect crop yields and production. Crops can suffer from defoliation, stem-snapping and damage at head-emergence and flowering stages. For example, locusts can chew through the stem of wheat plants and sever the grain head, thereby reducing yields (ABARES 2010).

The actual impact of locusts on crop yields and production will depend on a number of factors. These include climatic factors, such as rain and wind direction (which partly determines the destination of migrating swarms), crop type and stage of growth (both of which affect the ability of the plant to regenerate) and the feeding preferences of the insect itself.

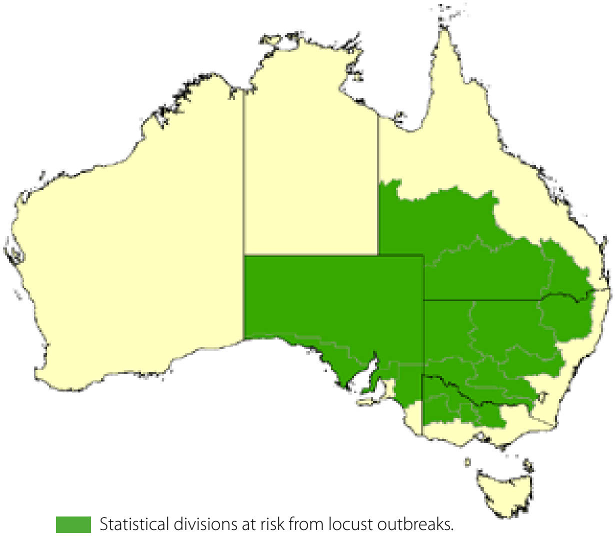
Agricultural activity in regions at risk of locust attack

In the eastern states, 17 statistical divisions have been identified as at risk from locust outbreaks based on historic locust distribution maps, published in the Annual Activity reports of the Australian Plague Locust Commission (APLC 2009) (map 1). The total area of agricultural holdings in these divisions is 172.8 million hectares, which makes up two-thirds of the agricultural holdings in the four states (ABS 2010). The 17 divisions are: Northern, North Western, Far West, Murray, Murrumbidgee and Central West in New South Wales; Central West, South West and Darling Downs in Queensland; Northern, Murray Lands, Yorke/Lower North and Eyre in South Australia; and Mallee, Wimmera, Loddon and Goulburn in Victoria.

The gross value of production for the 2010–11 season has been estimated for crop and pasture production. The value and quantity of production for each statistical division were based on the most recent ABS survey (ABS 2010), which was then updated for the current season using projected annual percentage changes generated by ABARES (2010).

Of the total holdings in the 17 divisions, 30.2 million hectares are assigned to improved pasture, while 119.2 million hectares are native pasture. Land mainly used for crops makes up 19.7 million hectares for the 17 divisions, accounting for 85 per cent of the total land used for crops across the four states. Of the cropped area in the divisions, wheat makes up 8.3 million hectares and barley 3.1 million hectares. The estimated gross value of cropping in the 17 divisions is $8.8 billion.

map 1 Map of statistical divisions historically at risk from locust attack



Statistical divisions at risk from locust outbreaks.

The inland area of south-eastern Australia that is potentially subject to attack by the Australian plague locust represents a significant proportion of the total area in the four states, both in terms of the area of crops and pastures and the value of agricultural activity. The above data are used in estimating the benefit–cost ratios for the APLC's and states' control operations. Likely impacts of widespread heavy rains and floods, unforeseen at the time of the ABARES September 2010 crop production forecasts, are not accounted for in the reported results.

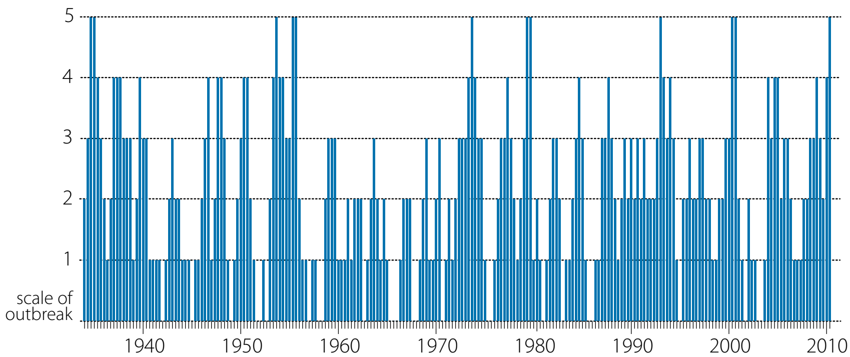
Size and frequency of outbreaks

According to APLC classification, locust outbreaks are divided into different categories ranging from zero to five, depending on the land area occupied by locusts. Different scales of locust infestations are broadly defined as follows:

- Scale 0—very low populations
- Scale 1—background population with a few bands/swarms
- Scale 2—an outbreak, with localised bands/swarms in several areas
- Scale 3—a major outbreak with many bands and swarms, some of them in dense aggregation
- Scale 4—a plague with several hundred thousands of hectares of agricultural zone affected by dense bands/swarm formations
- Scale 5—a major plague, with 500 000 hectares or more of agricultural land affected by invasion by dense bands/swarms.

A historical record of annual locust status in Australia since mid-1930s is presented in figure 1. One of the largest outbreaks recorded during this period is the current one that started in 2010, with efforts to bring it under control continuing.

1 Seasonal locust status in Australia (1934–2010)



Source: APLC 2010.

Locust situation during 2010

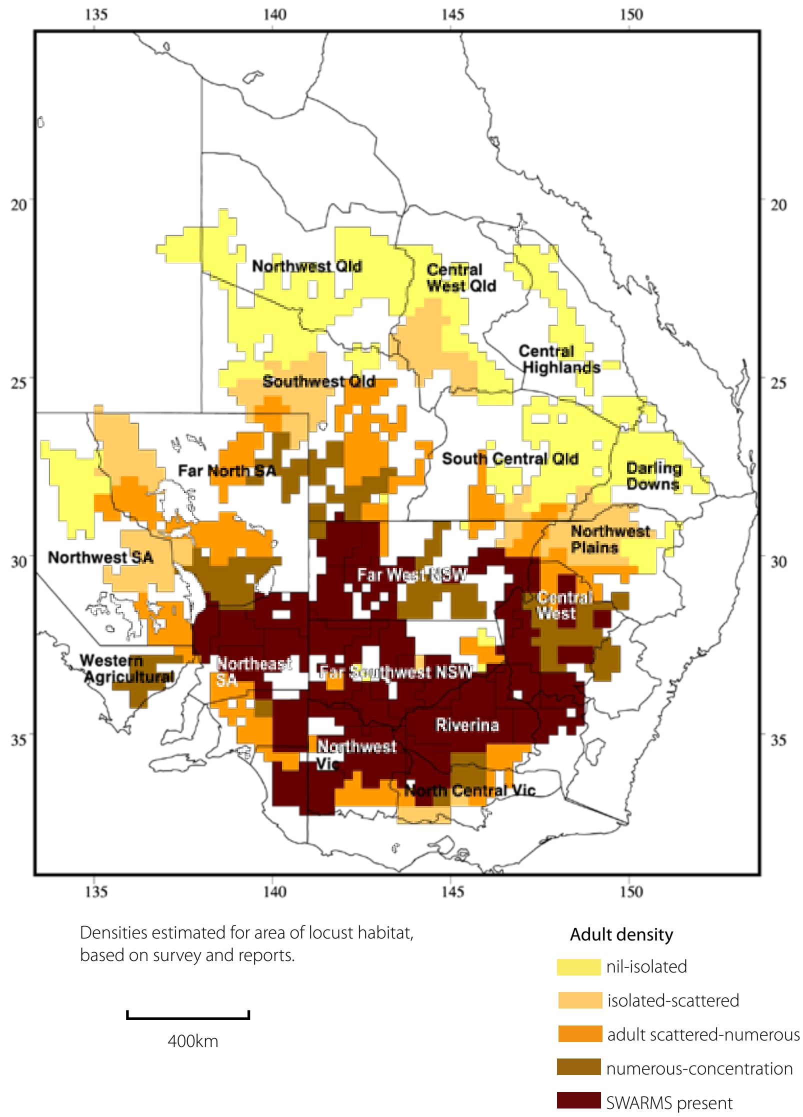
In early April 2010, large-scale locust swarm formation occurred in New South Wales, northern South Australia and northern Victoria. Despite intensive control efforts, good rainfall and favourable habitat conditions resulted in three generations of population increase in 2009–10, with reported damage to autumn fodder and crops. The APLC reported that the Australian plague locust was distributed throughout the eastern mainland states and South Australia, as shown in map 2. Spur-throated locust populations were also present, mainly in Queensland.

High-density autumn egg-laying in April and May 2010 resulted in a subsequent generation of high-density nymphs in the spring (September–October 2010). The APLC, using climate forecasts, provided estimates for timing of hatching, mid-instar and fledging stages of the Australian plague locust in the spring. In general, hatching and fledging occur earlier in regions located further north.

This prompted a high level of coordination and preparedness by all jurisdictions to control the locusts after hatching—while the insects are still in the nymphal or band stage. If left until able to fly and form swarms, locusts become far more difficult to control. They can invade cropping areas in large numbers, causing extensive losses in crop production and revenues.

In New South Wales, hatching occurred from early September to late October and fledging from mid-October to late November. In Victoria, hatching occurred from late September to late October and fledging from mid-November to early December. In South Australia, hatching occurred from early September to mid-October and fledging occurred from mid-October to mid-November. No significant hatching was detected or reported in Queensland.

map 2 Distribution of the Australian plague locust, 1 April to 20 May 2010



Source: APLC 2010.

The outlook to January 2011, as foreseen by the APLC in November 2010, was for a continued increase in adult densities and swarm activity in parts of New South Wales, South Australia and Victoria. However, the probability of the plague situation continuing across all potential regions diminished during the summer, as a result of reductions in the locust population in several regions. These reductions were because of a combination of control measures and high mortality rates resulting from overcrowding in dense vegetation, which prevented many insects from basking in the sun—a behaviour necessary for locust to regulate their body temperature. Although the potential summer generation is expected to be of a much smaller scale, it is likely to be significant as a result of continued widespread rainfall.

Previous assessments

To assist in planning for future outbreaks, the APLC is interested in periodically assessing the net benefits of its current/recent activities—in particular, the benefits of controlling locust populations before they reach plague proportions. To that end, the APLC engaged the former ABARE to conduct two studies estimating the benefits of its operations to limit the development of these swarms and protect the Australian economy from the potential damage locusts can cause.

In the first of those analyses, Love and Riwoe (2005) developed a spreadsheet model to estimate (ex post) the net benefits from the APLC operations to control the large 2005 outbreak of locusts. The relationships that determine the biological parameters and consequently the impacts of locusts on the economic variables in the model are highly complex. An extensive literature review and consultations with the APLC and other experts was undertaken to develop assumptions about the biological parameters of the spreadsheet model.

Love and Riwoe's (2005) results show that around 450 000 hectares of agricultural land was sprayed to control locusts in 2004–05. They estimated that, if the spraying had not been undertaken, the potential cost of the 2005 outbreak would have been around $68 million. They also concluded that the potential costs to the agriculture sector would be higher if a larger area was subject to an outbreak.

The second ABARE study (Abdalla 2007) was commissioned as a supplementary analysis aimed at addressing issues not considered in the study by Love and Riwoe (2005). This ex ante study estimated the net benefits of APLC control for different trajectories (sizes) of locust population, accounting for the possibility of future locust generations developing in the absence of APLC control. A weighted average net benefit was obtained by summing the net benefits from all trajectories after multiplying them by their likelihoods of occurrence.

Because the main concern in those two studies was to estimate the net benefit to the Australian economy of maintaining the APLC, the estimated gross benefit was compared to total annual costs to maintain the organisation. The benefit–cost ratios reported in the 2005 and 2007 studies were 8:1 and 20:1, respectively.

Present analysis

In contrast to the two previous studies undertaken by the former ABARE, the aim in the current analysis—also commissioned by the APLC—is to assess the overall economic feasibility of all operations (by the APLC, states and landholders) currently underway to control the 2010–11 locust plague. Benefits from the control campaigns by all parties are compared with costs specifically incurred in executing the control operations for the current outbreak.

The current study is neither a full ex post nor a full ex ante analysis. Rather, it has elements of both: actual data on areas so far sprayed, cost and amounts of chemicals used and some other cost items are now available. On the other hand, the control program is still in progress, particularly by the states and private landholders, and the extent and costs of the remaining operations is yet to be realised. As such, only projections or estimates of these costs could be used in the analysis at this stage.

As in the two previous studies, the present study adopts a benefit–cost approach to assess the economic feasibility of the current locust control campaign. This is achieved by relating the total expenditure on control by all parties (the APLC, states and landholders) to the overall benefits likely to be generated through the control campaign—that is, by estimating the damage to agricultural industries that could have occurred in the absence of control.

Environmental and social impacts

It is recognised that environmental and social impacts of a locust control campaign influence the suitability of implementing a control plan. Consideration should be made for the potentially negative effect of control chemicals, including the impacts on non-target fauna and flora—and the resulting effects on biodiversity in the ecosystem—the impacts on human health and the impacts on productivity and fecundity of farm animals. The recent development and use of the biological control agent Green Guard® may help to reduce these effects.

On the benefit side, locust control may reduce social costs for communities affected by swarms in residential areas and public roads, resulting in widespread public discomfort, obstructing visibility for motorists and potentially contributing to traffic accidents. Further, the savings in potential clean-up bills, by preventing swarms, should also be considered for both residential property owners and motorists.

As in previous studies, the gross benefits to agriculture of controlling plague locusts are found to be considerably higher than control expenditure. In addition, Love and Riwoe (2005) concluded that the general public would appear to receive a net benefit, including the social and environmental impacts, from the avoidance of locust plagues. If the environmental and social benefits were estimated and included, it is unlikely that the addition of these would alter the study's conclusions. Because of this, and the inherent difficulty and considerable time and effort required to monetise these non-market impacts, they have not been quantified in this analysis.

Industry flow-on effects of control

There are also likely to be flow-on effects of locust control to other sectors linked to the cropping and grazing resources. For instance, reductions in supply of feed grains and pastures—as a result of locust attack—could raise costs of production in the livestock sector, with an increase in costs passed through the supply chain to livestock processing industries and consumers. The flow-on effects of locust control to other sectors are likely to be small, given that prices of major commodities such as grains and livestock products are largely determined on the world market. For this reason, coupled with a commensurate research effort required to identify forward and backward sectoral linkages and fit them within a computable general equilibrium modelling technique, the flow-on effects have not been quantified in this analysis.

3 Methodology

Model

The green plant matter (GPM) consumed by locust bands and swarms has an economic value. Control of locust bands suppresses population development and reduces consumption peaks. Where bands are not treated, they can develop into new swarms causing further damage to crops and pastures in both the current and subsequent generations. For the present analysis, only one generation of locusts was considered. The additional losses from potential subsequent generations are not investigated. The net benefits of control are therefore the value of avoided losses to crops and pastures from GPM consumption by potential new swarms, less the cost of control operations.

The potential damage with and without control measures has been estimated using a spreadsheet model, based on that of Love and Riwoe (2005) and Abdalla (2007) and underpinned by entomological assumptions. The total value of plant matter consumed by bands and swarms with and without control depends on a number of factors, including: the size of the area occupied by the locusts; the tonnage of GPM consumed; the type and value of GPM consumed; and the proportion of crop loss this translates to. The main calculations for estimating the cost of damage to agriculture are as follows:

$$\mathit{Cost\ of\ damage} = \mathit{GPMC} * V$$

$$\mathit{GPMC} = (A_b * D_b * \mathit{dgpm}_b * T_b) + (A_s * D_s * \mathit{dgpm}_s * T_s)$$

where:

GPMC	total volume of green plant matter consumed per season (tonnes)
V	value of damage per tonne of green plant matter consumed
A_b, A_s	total area occupied by bands and swarms, respectively
D_b, D_s	average insect densities for bands and swarms, respectively, per area
dgpm_b, dgpm_s	daily green plant matter consumption of bands and swarms, respectively
T_b, T_s	number of eating days of bands and swarms, respectively, before being treated.

Data and assumptions

The assumptions developed and used for the estimation of the 2005 and 2007 studies by ABARE are adopted for the present analysis. Consultation with the APLC (C Adriaansen 2010, pers. comm., 16 November) confirmed that there have been no significant developments—such as new scientific research findings—to alter the original biological assumptions. To ensure comprehensiveness of this report, those assumptions are briefly described below.

Consumption of GPM by bands of locusts is assumed to occur in extensive grazing areas, with the highly mobile swarms assumed to move into intensive cropping areas. The size of the area occupied by insects per day is based on the actual area treated for locusts in 2010–11. The area treated is assumed to correspond to the size of the locust outbreak because, for a district, around 70 per cent of locusts are found in the sprayed area where bands are targeted, with the remaining 30 per cent in isolated areas that are not viable to treat (C Adriaansen [APLC] 2010, pers. comm., 16 November).

Past studies have shown that only 15 per cent of the area treated for bands by fixed wing aircraft is actually occupied by juvenile locusts in a band. This provides an estimated area of 1332 km^2 that has been fully occupied by bands across the four states in spring 2010.

Before reaching the adult stage, locusts pass through five developmental stages, referred to as instars. Since the current outbreak is considered by the APLC to be a level 5 (see table 1), it is assumed that the juveniles in a band are present in an average density of 4000 insects of instar IV equivalent per square metre.

The density of swarms produced by instar IV bands is assumed to be determined by a band–swarm ratio of around 16:1—that is, one adult locust will occupy an area equivalent to the area occupied by 16 instar IV juveniles. If bands of instar IV are not treated, they are expected to develop into swarms with densities of 125 insects per square metre.

Total damage to crops and pastures under each incursion level is determined by the combined effect of two factors: the total area affected and the insect density under that level. The assumed values for insect density, insect daily GPM consumption, and number of feeding days are shown in table 1.

The economic value for GPM was based on the areas of crops, sown pastures and native pastures in the 17 statistical divisions. Data were obtained from the Australian Bureau of Statistics for the 2008–09 season and updated to better reflect the situation in the 2010–11 season. This update was undertaken by applying estimated annual percentage changes reported in the Australian crop report (ABARE–BRS 2010) at the state level, with all values expressed in 2010–11 dollars.

The grazing regions in the study cover 132 million hectares, while the cropping regions constitute 41 million hectares. The value of GPM consumed in grazing and cropping regions is based on the weighted value of GPM per tonne—calculated as the real gross value of production for crops and pastures weighted by area shares, as shown in table 2. In the table, as recorded in the ABS data, there were only minor differences in the unit values between the grazing and cropping divisions for each vegetation category.

1 Entomological and other assumptions

Scale of locust outbreak		1	2	3	4	5
Insect density	unit					
Band (Instar IV)	no./m^2	50	150	1 000	2 000	4 000
(Instar V equivalent)	no./m^2	25	75	500	1 000	2 000
Adults	no./m^2	2	5	31	63	125
Other						
Band–swarm ratio	ratio	16	16	16	16	16
Daily GPM consumption						
Juvenile (Instar IV)	gm/day	0.04	0.04	0.04	0.04	0.04
Adult (female)	gm/day	0.2	0.2	0.2	0.2	0.2
Insect eating days						
Treated band	no.	18	18	18	18	18
Treated swarm	no.	30	30	30	30	30
Potential new swarm	no.	30	30	30	30	30

Source: Abdalla 2007.

2 Green plant matter (GPM) – composition and unit values

	grazing		cropping	
	area share	value	area share	value
	%	2010–11$/t	%	2010–11$/t
Vegetation category				
Wheat	1.8	265	18.20	268
Barley	0.4	226	8.5	228
Other crops	0.4	433	6.7	429
Sown pasture	15.4	310	29.3	354
Native pasture	82.1	103	37.3	118
Total/average	100	140	100	245

Sources: ABS 2010; ABARES 2010.

The average percentage loss in yield or unit value after locust attack is assumed to be 10 per cent in the grazing divisions and 20 per cent in the cropping divisions, based on plants of higher unit value in the cropping areas occurring in more geographically dense concentrations than in the grazing areas. The loss in potential harvest can be seen as the total loss of part of the crop, the partial loss from all crops or a downgrading in the price received for the crop because of the presence of insect debris (Love and Riwoe 2005).

Using the assumed proportion of GPM eaten in each sector, the average value of the financial loss to agriculture per tonne of GPM consumed by locusts is estimated to be $49.93 a tonne in cropping areas and $14.00 a tonne in grazing lands.

box 1 **Parameter uncertainty**

Of the variables and parameters used in the study, the two that are most uncertain are:

- the density of the hatched nymphs (and consequently of potential adults) per unit area
- the extent to which a given concentration of locusts, feeding on green plant matter, would translate to losses in crop production and revenues.

For the first variable, and given that the amount of green matter consumed is directly proportional to locust numbers per unit area, it would be expected that the higher the density is the greater the potential loss in production and, consequently, in financial revenues.

For the second variable, the difficulty in translating the amount of green plant matter consumed into losses in the potential harvest is underpinned by more than one factor. Among these are the stage of growth in the life cycle of a plant at the time of the insect attack (which determine the ability of the plant to recover and produce yield), likely difference in the ability of different types of plants to rejuvenate after an attack, and the feeding preferences of locusts.

For both these variables, assumptions were made based on previous research. Concerning the likely density of instars, Love and Riwoe (2005), after consultations with the APLC, considered that 2000 instars per square metre would represent a typical density for scale 4 outbreaks. They subsequently used this figure in their analysis to estimate potential consumption of green matter.

Smith (2005) undertook sensitivity analysis to discern the impacts of variation in locust density on the benefit–cost ratio estimates (with all other factors remaining unchanged). The results of the sensitivity analysis indicated that a given percentage change in density would translate directly into a similar percentage change in the benefit–cost ratio. For example, doubling the density of locusts would double the estimated benefit component of the benefit–cost ratio. As presented later, similar results were obtained in this analysis.

Costs of control

The areas treated and expenditure for the current season's control operations shown in table 3 were provided to ABARES by the APLC and the four states.

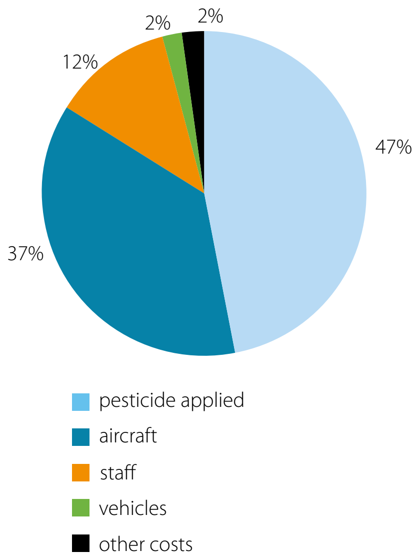
Costs are reported in aggregate as ABARES is bound by a confidentiality undertaking not to reveal the states' detailed cost sources. However, from the data provided, the control costs per hectare were found to vary markedly between jurisdictions. A number of factors could explain some of the variability in unit costs of control among the states, which are discussed below.

3 Control expenditure for the expected treated area in 2010–11

	area treated for bands	expenditure	cost per hectare
	km^2	\$m	\$/ha
APLC	798	1.4	17.36
States and landholders	10 139	48.9	48.19
Total/average	10 937	50.2	45.94

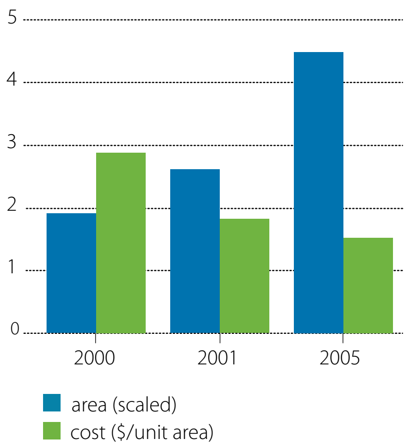
Sources: APLC, state governments of NSW, Vic, SA and Qld.

2 APLC expenditure on control for 2010–11



Source: APLC 2010.

3 APLC cost of control and area controlled for selected years



Source: APLC, Annual Activity reports (various issues).

First, a different mix of chemicals or techniques may have been used as dictated by the nature of the area to be treated. For instance, areas adjacent to sensitive environmental reservoirs would require application of a higher priced biological agent, or the use of on-ground spot spraying. On-ground spraying, if well executed, can be more intensive and targeted than aerial spraying, but at a higher cost per hectare. A breakdown of the costs of control for the APLC is shown in figure 2 and could indicate the corresponding cost shares in the states.

Second, there appears to be a strong negative relationship between the cost of treatment per hectare and the total area treated. That is, as the total area treated increases economies of size will be realised and the cost of treatment per hectare declines. This relationship is clear for the APLC, as seen in figure 3, and seems to hold for the states for this season's control, with those treating larger areas experiencing lower costs of treatment per hectare.

Third, logistic and operational difficulties—for instance the topography of the land to be treated—may hinder the execution of control operations, leading to larger unit costs in some regions than in others.

The size of the estimated net benefit or, alternatively, the benefit–cost ratio would crucially depend on the combined effect of three variables: the volume of GPM saved from locust consumption; the unit value of GPM saved from locust consumption; and the average cost spent on control so as to save one tonne of GPM. The size of the area treated, the weighted average value of GPM for the area and the cost of treatment per unit area are taken as a proxy for these variables in the present analysis.

4 Results

A number of assumptions are made to estimate the physical and financial damage in the spreadsheet model. GPM consumption and losses to agriculture were calculated for 2010–11 (table 4).

4 Estimated quantity of commercial green plant matter potentially consumed by plague locusts for 2010–11

	unit	value
Area treated		
For bands	km^2	10 937
For swarms	km^2	50
Area occupied by insects per day		
Bands	km^2	1 641
Original swarms	km^2	50
Potential new swarms	km^2	26 249
GPM consumed per km^2 per day		
Bands	$t/km^2/day$	160
Swarms	$t/km^2/day$	25
GPM consumed per day		
Bands	t/day	262 490
Original swarms	t/day	1 250
Potential swarms	t/day	656 225
Total GPM consumed		
Bands	t	4 724 820
Original swarms	t	37 500
Potential swarms	t	19 686 753
Value of GPM consumed		
Bands	$m	66.13
Original swarms	$m	0.52
Potential swarms	$m	963.25

If bands are not treated and develop into swarms, 19.7 million tonnes of GPM could be consumed, with an estimated value of $963.3 million (table 4). The avoided loss of this GPM represents the potential benefits of undertaking control.

Based on the simulations undertaken in the model, GPM consumed by bands and original swarms before and during the control campaign is simulated to be $66.7 million in the area treated.

Benefit–cost estimates

The benefits and costs of locust control are presented in table 5. Gross benefits represent the avoided loss in agricultural production—that is, the reduction in the value of GPM consumed as a result of control. The costs represent the expenditure associated with undertaking control operations. In addition to the value of gross benefits and costs, the table also presents the net benefit (total avoided losses less total cost of control) and the benefit–cost ratio (gross benefits divided by costs).

All locust control operations undertaken by the states and the APLC for the 2010 spring are estimated to have a net present value of $913 million, where the avoided losses and costs of control are those accruing across the eastern states. The benefit–cost ratio for all the control campaigns is estimated at 19.2:1, indicating that every dollar invested in locust control generates $19.20 in avoided losses (table 5).

5 Benefits and costs of locust control by the APLC and states in 2010–11

	costs $m	gross benefits $m	net benefit $m	benefit–cost ratio
APLC	1.4	70	69	50.7
States and landholders	49	893	844	18.3
Total/average	50	963	913	19.2

The benefits of control for the states and the APLC represent the contribution to total benefits of the parties' control operations—that is, the total value of avoided potential damage to agriculture. The estimated costs and benefits for the states do not include benefits generated as a result of APLC operations, nor do the estimated costs include the states' contribution to maintain the APLC. These benefits and costs, which are additional to those resulting directly from the states' control operations, are subsumed in the estimated economic indicators resulting from the control operations undertaken by the APLC itself.

The aggregate contribution of New South Wales, Victoria and South Australia to the total net benefit is estimated at about $844 million, with an estimated benefit–cost ratio of 18.3:1. For Queensland, no control operations were undertaken for plague locust as no significant Australian plague locust population was present in that state.

The aggregate net benefit as a result of locust control operations being undertaken by the APLC is estimated at $69 million, with a benefit–cost ratio of around 50.7:1. This implies that each dollar spent by the APLC during the course of the control campaign generated about $50 in avoided damages. The difference in benefit–cost ratios between operators is driven by the cost of control, as discussed in the previous chapter.

Sensitivity analysis

Since insect density is one of the parameters subject to the greatest uncertainty, a sensitivity analysis was conducted. Insect densities are related to the scale of outbreak, such that with larger outbreaks locusts are found in denser formations (table 1). In turn, the benefit–cost ratio is found to increase proportionately with the density (box 1). However, it is possible that the relationship between the scale and density of outbreaks may weaken or cease once several hundred thousands of hectares of agricultural land are under dense bands/swarm formations (as in a scale 4 outbreak). For the sensitivity analysis, locust densities were reduced by 50 per cent—similar to those assumed by Love and Riwoe (2005) for the 2005 scale 4 outbreak—as shown in table 6.

As expected, halving the locust density would result in a 50 per cent reduction in the potential GPM consumption that could have occurred in the absence of control (gross benefit or avoided costs). With the costs of control operations (the denominator of the ratio) remaining unchanged, any percentage change in benefits (the numerator) will result in a corresponding change in the same direction in the benefit–cost ratio. The estimated benefit–cost ratio is therefore reduced from 19.2:1 for the high density to 9.6:1 for lower density.

6 Benefits and costs of locust control for differing outbreak scales

Instar IV density	4000/m²		2000/m²	
	net benefit $m	benefit–cost ratio	net benefit $m	benefit–cost ratio
APLC	69	50.7	34	25.4
States and landholders	844	18.3	398	9.1
Total/average	913	19.2	431	9.6

Comparison of results with previous studies

Love and Riwoe (2005) quantified the benefit of the 'presence' of the APLC during the 2005 outbreak (level 4), while the current analysis examines the benefit of control operations by all parties in the larger (level 5) 2010–11 outbreak. The estimated benefit–cost ratio of 8:1 in the former study is in line with the benefit–cost ratio of 9.6:1 in the current analysis for a similar lower density (see table 6).

There are other factors explaining a higher benefit–cost ratio estimate in the current analysis. First, the annual total cost of running the APLC plus the cost of its control operations were used in the previous study, whereas the present analysis only considers the costs incurred by the APLC in conducting its control operations.

Second, a much larger area was treated in the current season, compared with 2005. Given a strong negative correlation between the area treated and cost of treatment per unit area (figure 3), it would be expected that the larger the area treated the higher the overall net benefit of treatment.

Third, ABS data in recent years have shown a rising trend in the production of higher value crops and pastures—both a higher proportion of area sown to crops relative to pasture and to improved pastures relative to native ones. There is, therefore, a higher unit value of GPM saved from consumption with control, increasing the benefit of undertaking control relative to that noted in Love and Riwoe (2005).

The analysis of Abdalla (2007) examined the expected net present value of the APLC's operations, based on the probability of the size of an outbreak occurring. The expected benefit–cost ratio for APLC control was estimated at 22.4:1. The 2007 analysis also calculated the benefit–cost ratio of APLC operations for a level 5 outbreak at 117.7:1, and 16.5:1 for a level 4. Although the APLC cost in the current analysis is lower than the 2007 analysis—since it only includes operational costs for the first generation of the 2010–11 locust season rather than the total annual cost of maintaining the APLC—the benefit–cost ratio is lower. However, unlike in the previous study, the current analysis does not estimate the benefits resulting from avoidance of subsequent generations of plague locusts.

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