benefits of locust control in eastern australia

a supplementary analysis of potential second generation outbreaks

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foreword

Outbreaks of the Australian plague locust could potentially cause substantial damage to rural industries in many parts of Australia. The Australian Plague Locust Commission (APLC) is mandated to combat outbreaks or potential outbreaks in Australia's four mainland eastern states.

To determine the value of its operations and inform future policy decisions on locust control, the APLC commissioned ABARE in 2005 to analyse the benefits and costs of the commission's control activities, focusing on 2004-05. In that year the commission undertook its largest control operation since commencing operations in 1976, treating 450 000 hectares for locusts.

The current report was also commissioned by the APLC to complement the previous analysis by estimating the net benefit of control taking into account the possibility that a second generation of locust may develop in the absence of APLC operations.

In this analysis, all likely outcomes are considered assuming that the APLC did not exist and therefore no control operations would be undertaken. With no control, the likely outcomes are that locusts could migrate into an agricultural area and breed up as a large second generation, resulting in severe infestations in the following season, or the infestation could die down of its own accord or it could be anywhere between these two extremes in the following season. The 'expected' benefit–cost ratio depends critically on the probabilities assigned to each possible population trajectory.

PGlyde

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Executive Director

January 2007

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background

In August 2005 the Australian Plague Locust Commission (APLC) commissioned ABARE to undertake a benefit–cost analysis of its locust control activities in eastern Australia for the years 1999-2000 to 2004-05, with a focus on its activities in 2004-05 (Love and Riwoe 2005). Given its terms of reference, the analysis undertaken by that study did not investigate the possibility that, in the absence of APLC control operations, a second generation of locusts could develop under suitable conditions. If subsequent climatic conditions were favourable for breeding and a second generation emerged, the economic implications for agriculture could be expected to be far more serious than if the first generation had not been controlled.

The aim in the current analysis is to supplement the previous 2005 ABARE analysis by estimating the average annual benefit–cost ratio of APLC operations, taking into consideration the likelihood of a second generation emerging, assuming initial outbreaks were not controlled. The resulting potential size of an outbreak and the accompanying scale of damage are probabilistic in nature, mainly determined by the suitability of the climatic conditions (for instance, adequate spring rains to induce hatchings of eggs laid during the previous autumn).

Similar to the original ABARE study, the main benefit assumed to arise from the commission's control activities that can be measured or estimated within the framework of a formal methodology is the avoidance of the losses to agriculture that could occur if no control activities were undertaken by the commission. If not controlled, locusts can swarm through cropping areas, leaving in their wake significant damage to crops and pastures.

The major difference between the original ABARE analysis and the current one is that the former is an ex post (after the event) examination of the APLC operations in the recent past, while the latter is an ex ante (before the event) investigation with the objective of estimating an average annual benefit–cost ratio of APLC control operations. Estimating the benefit–cost ratio is achieved by estimating the expected value of annual losses from subsequent damage and other expenditure, given the likelihood of different scales of outbreak occurring in a year in the absence of control, then relating the total value of these losses to the cost of APLC operations in treating the initial area of locusts in the interior to avoid the development of second generation locust damage to crops and pastures.

2

prevalence and geographic spread

The Australian plague locust is a seasonal pest to Australian agriculture and some degree of loss from plague locust attacks is bound to occur in most seasons, mainly 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, however, suitable seasonal conditions lead to a buildup of locust numbers to plague proportions.

The area affected by a locust outbreak largely depends on where significant rain has fallen and the wind direction, which partly determines the destination of migrating swarms. Outbreaks of the Australian plague locust are particularly frequent in inland New South Wales and South Australia, reflecting the proximity of these regions to the usual source of breeding, the Channel Country of south western Queensland. In some years, swarms of the Australian plague locust can also reach cropping areas of Victoria or eastern Queensland. Separate outbreaks can also occur in Western Australia. These outbreaks tend to be less frequent than in the east (DAFF 2005).

Based on detailed maps produced by the APLC of the areas affected by locust outbreaks in recent years, there are seventeen statistical divisions in the eastern states in which moderate to major locust activity occurs, or had the potential to occur. These seventeen 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. According to ABS Agricultural Statistics, the total area of agricultural holdings in these divisions averaged about 183 million hectares in the three years to 2002-03. This represented two-thirds of the total area of agricultural holdings in New South Wales, Victoria, Queensland and South Australia.

Of this, the average annual area grown to crops was 14.1 million hectares, which represented 86 per cent of total crop area in the four states. In terms of individual crops, average areas of 6.7 million hectares of wheat, 2.4 million hectares of barley, 122 000 hectares of rice and 88 000 hectares of grapes were grown in the seventeen divisions. These divisions also had 10.7 million hectares of sown pastures and 96.7 million hectares of native pastures.

Over the three years to 2002-03, the average annual value of crops was $10.3 billion (in 2005-06 dollars), or 65 per cent of the total value of crops produced in the four states. The average gross unit values of the main crops were: $214 a tonne for wheat, $276 a tonne for barley, and $242 a tonne for pasture cut for hay (in 2005-06 dollars).

The above data are used directly in estimating the benefit–cost ratios for APLC control operations.

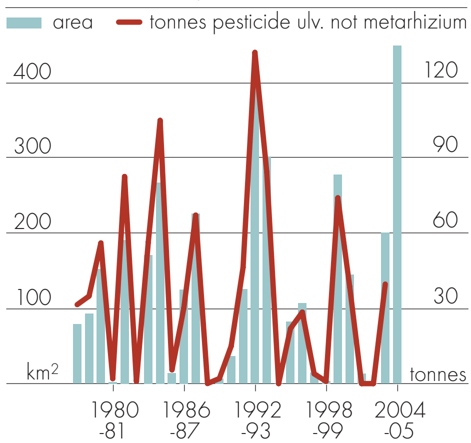
3

control costs

An examination of the APLC's expenses over the six years 1999-2000 to 2004-05 shows that the cost of staffing, field operations and office and other expenses tends to be relatively constant in real terms. However, costs of control operations have shown high variability, in line with the required scale of operations to control locust infections at various scales.

Over the six-years from 1999-2000 to 2004-05, the cost of staffing, field operations and office and other expenses varied between $2.7 million and $3.2 million a year, with an average of $2.9 million in 2005-06 dollars. In years of extensive operations the main additional expenses incurred have been for pesticides and aircraft hire. Pesticide expenses and aircraft hire varied with the level of the control operations undertaken, reaching $3.8 million in 2004-05. The average cost of these additional operations over the six year period was $1.8 million a year or $947 per square kilometre sprayed. In real terms, total APLC expenditure over the six years to 2004-05 averaged around $4.7 million a year. Figure A depicts the high correlation between the size of outbreak and the use of pesticides over an extended time period.

fig A **area treated and insecticide used**
Australian Plague Locust Commission



4

potential cost of damage

Juvenile locust nymphs (hoppers) have the ability to aggregate in dense formations – called bands – that may extend over several kilometres. Adults aggregate in highly mobile formations, called swarms. A swarm may consist of millions of adult insects.

Damage by bands and early swarms is mostly confined to areas of comparatively low returns. Subsequently, the highly mobile nature of swarms and their ability to migrate over large distances distributes the damage potential over a wide area of much higher returns. Moreover, if the initial outbreak is not treated, and subsequent climatic conditions are favourable to significant hatchings of eggs laid by the initial generation, there is a likelihood that far greater crop damage could occur. This means that virtually all agricultural areas in Australia – perhaps except coastal areas of eastern Australia and areas of regularly higher rainfall – are at risk of being attacked by locusts (DAFF 2005).

A combination of biological factors could also determine the extent of damage caused by locusts. First, the suitability of the habitat provided by a particular area of crop or pasture could vary, affecting the probability of the area being heavily infested and damaged. Second, the extent to which locusts prefer particular crops or pastures as a food source could also affect the vulnerability of these plants to attack. Third, the amount of vegetation lost per unit area could also vary depending on the time that the locust population is in contact with it. Finally, the vegetation's response to this loss could vary, depending on its stage in the plant cycle, and subsequent seasonal conditions.

frequency of outbreaks, by size

The scale of outbreaks of Australian plague locust since 1934 is shown in figure B. Outbreaks have been divided into different categories ranging from zero to five, depending on the land area infested by locusts. Different scales of a locust infestation 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 under dense bands/swarm formations
- scale 5 – a major plague, with 500 000 hectares or more of agricultural land under invasion by dense bands/swarms.

On examining past records of Australian plague locust activity back to 1844, Bullen (1975) concluded that a plague of similar extent to the 1934-35 and 1973-74 plagues had occurred in 1889-91. Based on the historical trends Bullen concluded that severe plagues of the Australian plague locust appeared likely to occur once in about every forty years, while moderate to very extensive plagues appeared likely once in about every twenty years, with local population upsurges occurring every two to three years.

For this analysis, the frequency distribution of different scales of an outbreak has been generated based on evidence from recent history of outbreaks depicted in figure B and table 1. The generated frequency distribution is broadly consistent with Bullen (1975).

For the purposes of this analysis, a major locust outbreak (scale 3) was assumed to affect a remote rangeland area, with the locust population comprising an area of 1000 square kilometres of bands and 500 square kilometres of swarms that would

fig B **scale of Australian plague locust outbreaks**
Australian Plague Locust Commission

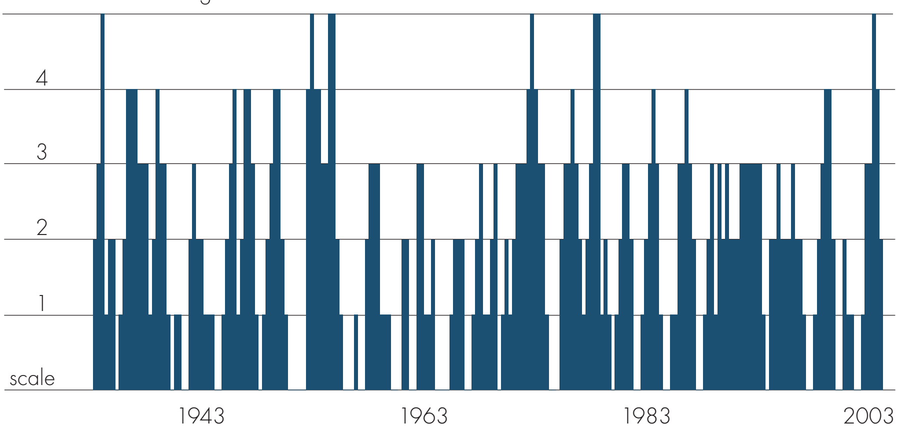
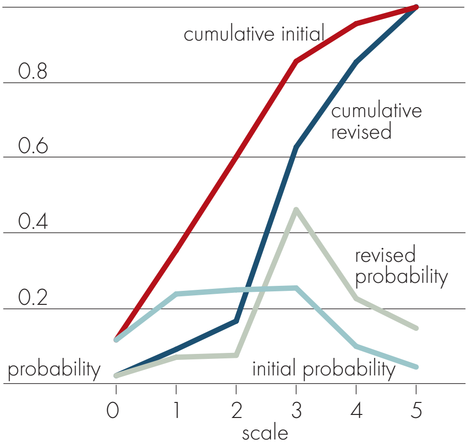


fig C **probability of different scale outbreaks**



require control. This represents the likely scale of a major locust outbreak in the remote interior according to the APLC. The initial probabilities of the size of a locust outbreak in a given year were estimated based on the actual occurrence of outbreaks over an extended time horizon – that is, there are no assumptions of an initial level of outbreak within a year. Since the incursion in this analysis is assumed to be already at scale 3, it would be expected that long run probabilities of outbreaks below scale 3 would decrease while those at or above this level would increase.

This being the case, the initial probability distribution of different scales of outbreak has been calibrated to generate a new probability distribution, taking into account that a major outbreak is already under way. Two conditions need to be satisfied in the calibration process. First, the downward revised probabilities of small outbreaks and the upward revised probabilities of large outbreaks must be highly correlated with the corresponding initial probabilities. Second, the cumulative probability in the revised distribution must add up to 1. The revised probabilities are given in the last two columns of table 1 and a graphic depiction of the initial and the revised probabilities is shown in figure C.

table 1 **probability of occurrence of different scale outbreaks**

scale	**indicative area requiring control** km^2	**initial probability**	**cumulative probability**	**revised probability**	**revised cumulative probability**
0	0	0.116	0.116	0.021	0.021
1	75	0.238	0.354	0.069	0.090
2	225	0.249	0.603	0.075	0.165
3	1 500	0.254	0.857	0.462	0.627
4	3 000	0.099	0.956	0.226	0.853
5	> 5 000	0.044	1.000	0.147	1.000

Based on data from APLC.

5

framework of analysis

Similar to the original analysis by Love and Riwoe (2005), the primary notion in the current analysis is that, because some of the green plant matter consumed by locust bands and swarms has an economic value, then allowing locusts to reach plague numbers rather than controlling them could potentially cause losses in agricultural production and returns in south eastern Australia. Avoiding these losses represents an economic benefit obtainable by allocating resources to locust control – that is, by treating bands and swarms while they are still confined to relatively small numbers in grazing areas rather than waiting until they multiply and 'swarm' into the cropping belt in plague proportions. The current estimates, however, differ from earlier studies by incorporating the possibility that locusts, if not controlled early, could breed a second generation, with additional consequences to agricultural production.

Since the current study is an extension to the original ABARE report by Love and Riwoe (2005), the analysis has been undertaken using the same methodology and assumptions adopted in that report. For the analysis to be independently coherent, without the need for frequent reference to the original report, the adopted method is presented below and a summary of the main assumptions is given in appendix A.

method

Various methodologies have been developed to assess the benefits and costs of locust control. Choosing which methodology to use will depend on the objective of the benefit–cost analysis. Some methodologies are oriented toward the detailed spatial assessment of the risk of locust attack in particular seasons and areas. Others rely on more indirect means of arriving at an estimate of the level of damage and economic loss. A literature review of various studies employing different methods of assessing the benefit and cost of locust control is provided in the original ABARE report (Love and Riwoe 2005).

The method adopted by Love and Riwoe based the estimate of potential damage on the actual area treated. This method was applied to a series of years for which actual treated areas were known, without requiring a detailed assessment of the potential locust threat in each particular season. This rests on the argument that bands, if not treated, could have developed into new swarms that could have caused further damage to crops and pastures.

Love and Riwoe introduced some broad elements of spatial analysis by allowing for separate proportions of green matter in grazing and cropping areas. This was done on the argument that if locusts are not controlled early in years of potential plagues (while bands and swarms are still mainly in the grazing areas), then the bulk of any further damage to crops and pastures would be likely to occur in cropping areas, where the value of the green matter consumed by locusts would be higher than in grazing areas. In the original study, it was assumed that the APLC treated the locusts within the season so that none of them survived to constitute a problem in the next season. A benefit–cost ratio of around 8:1 was estimated in that analysis.

In this analysis, all likely outcomes are considered assuming that the APLC did not exist and therefore no control operations would be undertaken against a major locust outbreak in remote rangeland areas. If no control was undertaken against the scale 3 outbreak, the likely outcomes are: locusts could migrate into an agricultural area and breed up as a large second generation, resulting in a severe infestation in the following season, or the infestation could die down of its own accord or result in an infestation level anywhere between these two extremes in the following season. The 'expected' benefit–cost ratio depends critically on the probabilities assigned to each possible population trajectory.

The same approach used in the original study to estimate the damage is adopted in this analysis. The main calculations for estimating the cost of damage are as follows:

$$GMC = A_b * D_b * dgm_b * T_b + A_s * D_s * dgm_s * T_s$$

where

GMC	tonnes of green matter consumed per season
A_b and A_s	area occupied by bands and swarms respectively
D_b and D_s	insect densities for bands and swarms
dgm_b and dgm_s	daily green plant matter consumption of bands and swarms
T_b and T_s	number of days the insects are eating before being treated.

$$\text{Loss to agriculture} = GMC * V$$

where, V is the value of damage per tonne of green matter consumed, calculated as the weighted average of the different types of green matter attacked and their unit values.

The benefit–cost ratio is calculated as the sum of the expected benefits from early control (avoided further losses to agriculture plus avoided costs of late treatment, if required) divided by the cost of early control (APLC expenditure).

6

results and discussion

Inevitably there is likely to be some losses to agriculture from an outbreak of locusts prior to the commencement of or during treatment by the APLC. Using the estimated and assumed values in the previous chapter, the annual loss to agriculture from locust attacks in the affected areas prior to control is estimated to be minor ($0.2 million), as it would be mainly confined to the rangeland areas of the initial outbreak. Under all circumstances, this damage is unavoidable (sunk cost). Hence, it does not enter in the benefit–cost analysis.

However, if these initial areas of incursion are not treated and a second generation of locusts emerges, further losses could occur. The extent of the losses is mainly determined by the scale of the outbreak. These additional losses are estimated to be as high as $465 million in years when outbreaks are most severe (table 2). In table 2, the estimated costs resulting from losses to agriculture and the cost of likely control under each level of outbreak represent actual costs that would have been incurred if that level of incursion were to occur.

In contrast, APLC expenditure is the same under each level of outbreak. It simply represents the amount that could have been spent to control the initial outbreak, thus preventing a second generation outbreak. Based on actual costs of area treatment by the commission in the recent past, the total cost of treating the initial outbreak area is estimated to be $4.12 million in 2005-06 dollars. In years when there are no or very small numbers of locusts, APLC will still incur overhead and running costs of the organisation, at an average of around $2.9 million in 2005-06 dollars (table 2).

To estimate the average expected costs of locust outbreaks over an extended time horizon, estimated actual losses under each outbreak level (table 2) would need to be discounted by the chance that that level of outbreak may not occur. This is equivalent to multiplying the actual losses and late costs of control under each level (reported in table 2) by the revised probability of occurrence of that level (reported in table 3).

Thus estimated, expected costs from further damage to agriculture under each scale of incursion are presented in table 3. The sum of the expected costs under all outbreak scales gives a total expected cost of a locust incursion of $85.1 million table 2 **APLC control cost and actual costs avoided under different scales of outbreak** in 2005-06 dollars

		scale of outbreak					
		0	1	2	3	4	5
affected area							
bands	km^2	0	50	150	1 000	2 000	4 000
swarms	km^2	0	25	75	500	1 000	2 000
APLC early control							
APLC costs	$m	2.85	2.85	2.85	4.12	4.12	4.12
no APLC control							
loss to agriculture from							
second generation **a**	$m	0.0	0.0	0.0	7.3	58.2	465.5
cost of likely late control **b**	$m	0.0	0.2	0.7	4.8	9.6	19.2
total	$m	0.0	0.2	0.7	12.1	67.8	484.7
value of early intervention							
benefit–cost ratio		0.0	0.1	0.3	2.9	16.5	117.7

a Crop damage is based on the area affected and insect density under each scale. **b** Likely control is based on area sprayed regardless of insect densities using APLC costs per square kilometre.

table 3 **APLC control cost, expected costs avoided (benefits), and the estimated average benefit–cost ratio** in 2005-06 dollars

		scale of outbreak						average expected value
		0	1	2	3	4	5	
probability of outbreak		0.021	0.070	0.075	0.462	0.226	0.147	
APLC early control								
APLC costs	$m	2.85	2.85	2.85	4.12	4.12	4.12	4.12
no APLC control								
expected additional								
loss to agriculture	$m	0.0	0.0	0.0	3.4	13.2	68.6	85.1
expected cost of likely								
late control	$m	0.0	0.0	0.1	2.2	2.2	2.8	7.3
total expected cost	$m	0.0	0.0	0.1	5.6	15.3	71.4	92.4
value of early intervention								
benefit–cost ratio		0.0	0.0	0.0	1.4	3.7	17.3	22.4

(table 3). In addition to avoiding the potential damage to agriculture, APLC control activities would also avoid an estimated $7.3 million in terms of late control costs that are likely to be incurred.

With the cost of operations by APLC estimated at $4.12 million in 2005-06 prices, the expected benefit–cost ratio for APLC control operations is estimated to be 22.4 to 1 – that is, for every dollar spent by the APLC on locust control a benefit of more than $22 dollars is realised from the avoidance of subsequent crop damage and inflated late control costs. However, this estimate of the benefit–cost ratio may need to be discounted for the following two factors:

- First, it is likely that a proportion of the estimated damage to agriculture may occur in the following season, making it necessary to discount these costs to their present value. For example, if it is assumed that half of the expected future losses from no control would be incurred in the following season, then at an annual discount rate of 5 per cent, the revised benefit–cost ratio would be slightly lower, at 21.9 to 1.
- Second, late control by state governments may not always be required against the original outbreak. With the expected cost of late control operations estimated at $7.3 million, omitting this cost from the benefit–cost analysis would reduce the estimate of the benefit–cost ratio to 20.7 to 1.

Taking into account the combined effect of the two factors – discounted benefits and no control costs incurred later – the benefit–cost ratio is estimated at 20.2 to 1.

Some environmental and social considerations could also potentially influence the cost and benefit estimates and consequently policy decisions on both the level of investment on control and on choosing among different management and control strategies. On the cost side, such impacts may include the potential costs of chemical effect on nontarget fauna and flora in the ecosystem, while, on the benefit side they may include the avoidance of social costs stemming from swarms of locust in residential areas and public roads, resulting in a widespread discomfort and perhaps constituting a traffic hazard.

Production losses from locust outbreaks may also indirectly influence other industries. For example, the grain industry provides feed grains to the intensive livestock industries. A contraction in supply of feed grains caused by locust damage could result in higher grain prices, raising production costs in the livestock sector. Higher livestock production costs are also likely to impact on downstream livestock processing industries.

The environmental and social implications of locust control constitute costs and benefits that are not easily quantifiable and would require far greater research effort and time for them to be appropriately determined. Similarly, the estimation of the flow-on effects of locust outbreaks to other economic activities is only possible through an economywide approach to modelling, which requires detailed data on quantities and prices and on supply and demand parameters that determine the relationships between these economic activities. Because of these reasons, both environmental and social implications and the flow-on effects are not addressed in this analysis.

A appendix

assumptions and input data

assumptions

The area occupied by swarms of locusts is assumed to be the area that would have been treated for swarms by the APLC, on the assumption that the swarms are relatively large and their density is relatively uniform. In contrast, the area occupied by bands of locusts is assumed to be only a fraction of the area that would have been treated. This is based on an indication in past studies that bands physically occupy only around 15 per cent of the area aerially treated.

Before they reach adulthood, locusts pass through five developmental stages, termed Instars. It is assumed that the juveniles in a band are mostly members of Instar IV, present in densities ranging from 50 to 4000 insects per square metre, depending on the scale of the outbreak. The density of swarms produced by Instar V juveniles is assumed to be determined by a band to swarm ratio of around 16:1. If bands of Instar IV were not treated, they would develop into swarms with densities of between 2 and 125 insect per square metre, depending on the scale of the outbreak. Total damage to crops and pastures under each level of incursion is, therefore, determined by the combined effect of two factors: the area affected and the insect density under that level. The assumed values for insect density, insect daily consumption of green plant matter, and number of feeding days are shown in table 4.

The weighted average value of green plant matter per tonne is based on the estimated real unit gross values of production for crops, sown pastures and native pastures and the area shares of each type of green plant matter in both range-lands and crop areas. The likely percentage loss in the value of green plant matter attacked is specified and is scaled relative to the size of the outbreak. The likely percentage loss in the value of crops and pastures is highly uncertain but, based broadly on figures reported in the literature, is assumed to vary with the scale of the outbreak – from 0.25 to 20 per cent in grazing areas and from 0.5 to 40 per cent in cropping areas.

Further losses are taken to be those that could occur if the bands in the affected area were not treated. These bands would then develop into swarms invading the cropping areas. The green plant matter composition, unit value and likely percentage losses used in this part of the calculation are those specified for the cropping belt.

table 4 **entomological and other assumptions**

		scale of outbreak				
		1	2	3	4	5
insect density						
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 to swarm ratio	ratio	16	16	16	16	16
daily green plant matter 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
expected percentage loss in unit GVP						
grazing areas	%	0.25	0.75	5	10	20
cropping areas	%	0.50	1.50	10	20	40
cost of late operations						
cost per square kilometre	\$/km^2	1 651	1 651	1 651	1 651	1 651

It is also likely that state departments of agriculture would incur a cost in treating the new locust bands and swarms when they are in the cropping belt irrespective of the potential damage that is likely to occur to crops and pastures. The cost of this late treatment, where required, is calculated by multiplying the area of original and new swarms by a treatment cost per square kilometre based on cost estimates provided by the APLC. The assumed cost of late operations of around $1650 per square kilometre is based on known APLC aircraft and pesticide costs of $825 per square kilometre plus an allowance for staff, travel and other costs.

other input data

The areas treated each season by the APLC and the APLC's annual expenditures are published in its annual activity reports. The APLC cost of control for the initial area of infestation assumed in this analysis was estimated based on areas and expenditure in past operations (table 5).

table 5 **areas treated by the APLC and APLC costs**

		1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	current a
treated area								
band	km^2	1 310	1 177	133	0	1 476	1 878	1 000
swarm	km^2	1 306	732	0	0	529	2 615	500
total	km^2	2 616	1 908	133	0	2 005	4 493	1 500
real expenditure								
(2005-06 dollars)	$'000	5 502	4 766	2 741	2 911	4 402	6 835	4 118

a Initial area of outbreak.
Sources: APLC annual activity reports.

The composition of GPM of economic value (crops and pastures) was based on the areas of crops, sown pastures and native pastures for the three seasons to 2002-03 for 17 Statistical Divisions in inland south east Australia obtained from Australian Bureau of Statistics (table 6). All values were expressed in 2005-06 dollars.

The real unit gross value of sown pastures was taken to be the real unit gross value of pastures cut for hay. The real unit gross value of native pasture was assumed to be one third of that for sown pasture, on the basis that average stocking rates on sown pasture are typically around three times higher than those on native pasture (table 6).

table 6 **green plant matter – composition and real unit value**
average 2000-01 to 2002-03

	grazing areas		cropping areas	
	share of area %	**real unit value** $/t	**share of area** %	**real unit value** $/t
wheat	2.0	263	14.4	279
barley	0.4	233	6.0	244
rice	0.1	275	0.2	292
other crops	1.0	310	11.2	310
sown pasture	3.7	215	21.7	214
native pasture	92.8	71	46.5	71
total/average	100.0	84	100.0	167

Unit values are in 2005-06 dollars.
Source: Calculated from ABS Agricultural Statistics.

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10.6

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Australian Government Department of Industry, Tourism and Resources
Australian Government Department of Prime Minister and Cabinet
Australian Government Department of Transport and Regional Services
Australian Wool Innovation Limited
CRC – Plant Biosecurity
CSIRO (Commonwealth Scientific and Industrial Research Organisation)
Dairy Australia
Department of Business, Economic and Regional Development, Northern Territory
Department of Premier and Cabinet, Western Australia
Department of Primary Industries, New South Wales
Department of Primary Industries, Victoria
East Gippsland Horticultural Group
Fisheries Research and Development Corporation
Fisheries Resources Research Fund
Forest and Wood Products Research and Development Corporation
Grains Research and Development Corporation
Grape and Wine Research and Development Corporation
GHD Services
Independent Pricing and Regulatory Tribunal
International Food Policy Research Institute
Land and Water Australia
Meat and Livestock Australia
Minerals Council of Australia
Ministry for the Environment, New Zealand
National Australia Bank
Newcastle Port Corporation
NSW Sugar
Rio Tinto
Rural Industries Research and Development Corporation
Snowy Mountains Engineering Corporation
University of Queensland
US Environmental Protection Agency
Wheat Export Authority
Woolmark Company