Final Report

Starlings in Western Australia

Assessing the likely cost of an incursion

Prepared for the Invasive Animals CRC

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ACIL Tasman

Economics Policy Strategy

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Contents

Figures and tables

Executive summary

This report finds that in Western Australia, the potential habitat zone of starlings is around 1 million sq km, and under full infestation and with a conservatively estimated prevalence rate of 12.5 starlings per sq km, this would mean that the Western Australian habitat zone could support *at least* 12.5 million starlings.

Such a population of starlings could consume in excess of 110,000 tonnes of food in a year, of which two-thirds would come from commercially valuable sources such as horticulture and grains. Starlings would account for a loss of 0.5 per cent of the Western Australian grains crop, and 3 per cent of the State's horticultural crop (grapes, apples, pears, etc.). The annual damage caused on this basis has been valued at $21.2 million. The plausibility of these estimates has been corroborated using existing evidence on bird damage to crops.

A range of other costs, including management of urban roost situations, damage to property, clean-up costs, weed control, and the likely cost of recovery plans for displaced native birds, takes the estimate of annual damage done by starlings under a full infestation to at least $30.0 million per year. This estimate does not include less easily verifiable costs such as threatened existence values that the community might place on native birds.

Using a range of starling population growth scenarios, we find that given the current body of evidence it is reasonable to assume that the population of starlings in Western Australia will increase to 12.5 million over the next 25 to 30 years if the infestation is not controlled. Under the worst case scenario, however, such a population could establish within 10 years from now.

Cost-benefit of control

The cost of controlling starlings effectively has been estimated at $3.8 million per annum in the first year, $3.6 million in years 2 and 3, and $1.5 million per annum thereafter. Effective control here refers to a situation in which the total starling population is returned to, and maintained, at levels no higher than in 2005/06. We note that complete eradication of starling populations has proved impossible in most countries, but believe that given the current situation in Western Australia, an early intensive control and management exercise would have a very good chance of keeping starling numbers under control.

Over a 50 year horizon, the program of controlling starlings as costed here would imply a total cost of $29.4 million in present value terms (discounted at 6 per cent per annum.). Over a 30 year horizon, it would imply costs of $26.4 million in present value terms.

The benefit-cost analysis showed:

- Cost-benefit of control (50 year horizon): the present value of conservatively estimated damage that would be done by starlings comes to $122.7 million; set against the above costs of $29.4 million, this would imply a benefit-cost ratio of 4.2:1 for the control program
- 30 year horizon: the total estimated damage done by starlings would be valued at $62.8 million in present value terms. Compared with a discounted cost of funding the control program of $26.4 million, this reduction in the planning horizon therefore implies a lower benefit-cost ratio of 2.4:1.

If the probability of the infestation is less than 25 per cent for the 50 year horizon or less than 50 per cent for the 30 year horizon – then the *probability-adjusted* benefits from starling control could be less than the costs of running the starling control program. We note however that there appears to be scientific consensus that, if left unchecked, starlings will expand.

There is also a chance that the control program, if successful, could subsequently be wound back to a less intensive program costing around $0.5 million per annum (or less).

We therefore conclude that there is a strong case for investing in an intensive control and management program as costed above.

Sensitivity analysis

Raising the discount rate at which future costs and benefits are discounted to 8 per cent and 10 per cent, respectively, reduces the benefit-cost ratio for the 50 year horizon to 2.9:1 and 1.9:1. For the 30 year horizon, the benefit-cost ratios drop to 2.0:1 (8 per cent discount rate) and 1.3:1 (10 per cent discount rate) respectively. It is noteworthy that the benefit-cost ratios do not turn negative under these assumptions.

Applying probability weights could imply that expected costs of control outweigh the benefits derived, but if one accepts that in the absence of early intervention starlings *will* spread (i.e., with certainty) then all of the cost-benefit ratios remain positive.

2 Introduction

ACIL Tasman was engaged by the Invasive Animals Cooperative Research Centre to undertake an analysis of the likely cost of a major starling incursion into Western Australia.

The European or common starling (*Sturnus vulgaris*) is one of the world's worst invasive bird species. It originated in Europe and Asia and has become established in North America, South Africa and New Zealand.

Starlings were introduced into Australia in the mid-19th century and are now widespread and firmly established in the eastern states and Tasmania. Although starlings were first sighted in Western Australia in 1936, it has only been since the early 1970s that they have been regularly sighted, predominantly on the south coast (Massam and Woolnough 2004). These populations have been largely contained due to an on-going control program conducted by the Agriculture Protection Board (APB) and other government agencies. However, since 2004 numbers of starlings in Western Australia appear to have grown, with new populations establishing along the south coast.

In response the Western Australian Government has already invested an additional one-off $2.45 million in 2006/07 for an enhanced surveillance, research and control program, bringing total annual expenditure to $2.95 million. This funding goes largely to meeting the following aims:

- Definition of the geographical limits of the current starling incursion in Western Australia;
- Establishment of a team of trained personnel capable of carrying out effective starling surveillance and control from Bremer Bay to Eucla;
- Minimisation of the risk of spread of starlings to other parts of Western Australia;
- Increased awareness amongst all stakeholders of the starling problem; and
- The preparation of an eradication strategy with estimated budget and timelines.

In addition, a Starling Reference Group has been established to guide the enhanced program. In support of this program, the Invasive Animals CRC has funded this study of the potential costs of a starling incursion to Western Australia.

This report is structured as follows:

- Section 2 describes the key uncertainties in relation to our knowledge of starlings and their likely impact on Western Australia (importantly, some of the key uncertainties described in Section 2 should be resolved by the currently funded research, surveillance and control exercise);

- Section 3 sets out the approach and methodology used in estimating the cost of a starling incursion; and
- Section 4 offers a summary and conclusion.

3 Key uncertainties

Whilst starlings are widely acclaimed as a pest, with undoubted vigour and phenomenal capacity to breed, the key issue in assessing their likely economic impact in Western Australia relates to uncertainty.

Uncertainty still exists on a number of levels – including biology and ecology as well as economics and policy making. Unfortunately, some of these levels of uncertainty interact with one another. To illustrate relevant issues encountered in dealing with this issue, and that have informed the thinking behind the current report, consider the following:

- It is not known for certain whether the starling populations that were most recently discovered in Western Australia (see Section 4.3) are new and growing populations or whether they are populations that have been long established but only recently spotted;
- The long-term determinants of starling populations are subject to scientific debate – in many countries where the bird was introduced over the past two centuries, starling populations grew rapidly. However, in the bird's original habitats such as the UK and Sweden, starlings have been declining for at least the past three decades:
  - The likely *shapes* of the long term population growth curves are thus largely unknown; and
  - It cannot be said with any precision where on the likely population growth curve Western Australia currently sits;
- Amongst invasive species specialists, reference is made to 'sleepers' or 'timebombs' – small populations of invasive species that may be triggered into exponential growth by an unpredictable one-off event (e.g., bushfires, unexpected cold, warm, dry or wet periods, etc.):
  - The above considerations indicate that it is unclear whether an increase in the numbers of starlings is likely to occur imminently;
- The total number of starlings in Western Australia and the current range of their habitat is also subject to some uncertainty:
  - Consequently the likely cost of an eradication program and the chances of its success are not known with certainty;

- Much of the South West of Western Australia would appear to present potential habitat for starlings, suggesting that a rapid increase in numbers could be expected once starlings take a foothold:
  - However, actual rates of growth and likely geographic paths for dispersal cannot be predicted with certainty, and optimal response strategies (e.g., containment, early warning systems, trapping strategies, etc.) can therefore be difficult to determine;
  - Western Australia's 'carrying capacity' of starlings has not been determined;
- If recent increases in numbers are confirmed as "new growth" and if total numbers reach 10,000 or so, and with dispersal already having reached some 3,000 sq km in Western Australia, then it is also relevant to note that most, if not all, attempts at reducing starling numbers in other countries were unsuccessful in affecting long term populations:
  - If 'the horse has already bolted', as it were, then attempts at eradication could be off the mark and thinking would have to shift towards management of starlings rather than eradication (e.g., control at the 'frontier');
- Even if the current bird population could be eradicated, there is always the potential for new populations to emerge every year due to the migration of starlings across the Nullarbor Plain:
  - It is therefore uncertain for how long the benefits of an intensive eradication program would be enjoyed; a new flock could arrive and establish the very next year or not for many years to come;
- The role of climate in affecting starling numbers in Western Australia has not been fully explored. It has been speculated that the recent growth in numbers was linked to the series of 'wet' years across the Nullarbor (or, conversely, relative dryness in South Australia). If local climate change dynamics favour more 'wet' years across (patches of) the Nullarbor in future then this could significantly increase the probability that starlings will enter Western Australia from South Australia:
  - On the other hand, if more dry years are to be expected in Western Australia, then bushfires may help control numbers of starlings in areas where colonies are known to exist at the moment. Conversely, if South Australia comes out of drought more quickly, fewer birds may attempt the journey to Western Australia;
- Interaction with native species might also lead to 'perverse' outcomes: if starlings were to displace birds such as cockatoos, lorikeets, parrots and rosellas – all 'high-risk' species identified by WWF – then in some cases agricultural losses attributable to starlings might be counterbalanced, possibly outweighed, by fewer losses from other species:
  - Unfortunately there is not much starling-specific information on species interaction, with most studies in eastern Australia focussing on

the Common or Indian Mynah and starling together. It is not certain that one can extrapolate from the Mynah to starlings;

- Another potential 'perverse' outcome relates to insect control. In the past, introduction of starlings has in part been influenced by the consideration that starlings could act as a biological control (e.g., in New Zealand and Russia). Recurring threats of locust infestations in Western Australia spring to mind in particular, but ecosystem services that might consequently be provided by starlings should be counted as benefits and not costs:
  - Similarly, during consultation it was commented by one informed observer that whilst starlings cause damage to grape crops, in years of plenty, when grapes fall to the ground, starlings could in fact be *preventing* spread of disease by removing fallen fruit;
- Any valuation of the environmental impact of starlings needs to address the issue of competition with native species. People and communities have a demonstrated willingness to pay (WTP) for action that prevents species from becoming extinct, and keeping the starling out of Western Australia can in one sense be seen as providing this service:
  - It is not clear, however, that starlings would actually cause extinctions – it appears more likely that they would cause *reductions* in numbers – and hence it is extremely difficult to place a dollar figure on this service. Estimates of WTP for different population levels of native birds simply do not exist. Also, no attempts have ever been made to estimate WTP to make a species extinct (the aim of invasive species eradication programs);
- Finally, and this is partly due to the informational constraints outlined here, existing estimates of the economic impact of starlings range enormously. In the case of the USA, for example, estimates range from $1.5 million per year (US Department of Agriculture) to $800 million annually (Pimentel *et al.* 2000). The only Australian estimate so far puts annual damage at 'at least $10 million' for the whole of Australia (Pimentel 2002).

In summary, we note the comments made by Johnson and Glahn (1994) in their briefing paper on starlings:

> (1) Starlings are difficult to monitor because they often move long distances daily from roost to feeding areas, and many migrate. (2) Effectiveness of controls, particularly in relation to the total population in an area, is difficult to document. For example, does population reduction in a particular situation reduce the problem or merely allow an influx of starlings from other areas, and how does this vary seasonally or annually? In addition, does lethal control just substitute for natural mortality or is it additive? (3) The economics of interactions with other species are difficult to measure. For example, how much is a bluebird or flicker worth, and what net benefits occur when starling interference with native cavity-nesting birds is considered? (4) Other factors such as weather and variation among problem situations complicate accurate evaluation of damage and the overall or long-term effectiveness of controls. These points … are examples of factors that must be considered in assessing the total

> economic impact of starlings. Clearly, to minimize starling-human conflicts we need a better understanding of starlings and their interactions with various habitats and control measures (pp. 118-119).

The discovery of the true extent of the uncertainties surrounding starlings has, two major implications for the methodology used to estimate their economic impact:

- There is a need to avoid the temptation to produce estimates that contain a level of spurious accuracy; and perhaps more importantly
- There is value simply in *reducing* the level of uncertainty.

We have therefore used defensible conservative estimates that were derived by applying balanced judgment to the available information.

4 Approach and methodology

Starlings potentially pose a serious threat, as evidenced by their rapid spread across other land masses (e.g., North America) and in the eastern states of Australia. In order to understand the extent of potential impact in Western Australia, however, it is crucial to have some understanding of the size of the potential starling population in Western Australia.

4.1 Approach to modelling starling population growth

Starlings from South Australia have migrated to Western Australia for some time now – but recent investigations suggest the numbers that have established in Western Australia are larger than previously thought. As indicated above, however, this may be because of a recent increase in numbers or because these birds were not previously spotted – colonies may have been resident for thirty years or more. Either way, total numbers in Western Australia are still thought to be relatively low at around 1,000 birds. The supporting documentation provided for this consultancy refers to a range of 1,000 to 10,000 birds. In Section 4.4.2, we therefore assume three starting populations – 1,000 birds, 5,000 birds and 10,000 birds. Feedback from our presentation to the Starling Reference Group on 31 October 2006, however, indicated that a figure of 10,000 would be very much at the 'top end' of current population estimates.

In the USA, starling numbers grew from an initial population of 100 in 1890 to an estimated 150 to 200 million now. Whilst precise growth dynamics are unknown, it appears that most of this growth in numbers occurred during the first 50 years after introduction (see, for example, Davis 1950). Curiously, in contrast to the USA, starling populations have been undergoing a long term decline in their traditional habitats in the UK, Sweden and Finland (see Crick *et al.* 2002, Svensson 2004, and Rintala 2003).

The investigation by Crick and colleagues into the decline of the starlings and sparrows in Britain put the current British breeding population of starlings at approximately 8.5 million birds – down by over 50 per cent over the last two decades alone, and likely following a longer term trend that it is speculated may have begun around the middle of the 20th century. The decline in farmland bird populations in the UK has been attributed to agricultural intensification (see Wretenberg *et al.* 2006).

Expert opinion also suggests that it is possible that starling populations can, under 'favourable' circumstances, quadruple in a year, for example, due to low winter mortality (Woolnough, A. (WA Department of Agriculture and Food), *pers comm.*, confirmed by Tracey, J. (NSW Department of Primary Industries), *pers comm.* and Lindenmayer, D. (ANU), *pers comm.*). Such an event could, for example, be triggered by an unusually warm and wet winter. As mentioned earlier, this is why starlings can be referred to as sleepers that might be triggered to 'go off' at any point in time, given a suitable shock to their environment. Discussions with invasive species specialists confirmed that it is indeed almost certain that this will eventually happen – in particular given the experience with starlings in other regions and countries (Bomford, M. (Bureau of Rural Sciences) and Lindenmayer, D. (ANU), *pers comm.*).

Our approach is to assume:

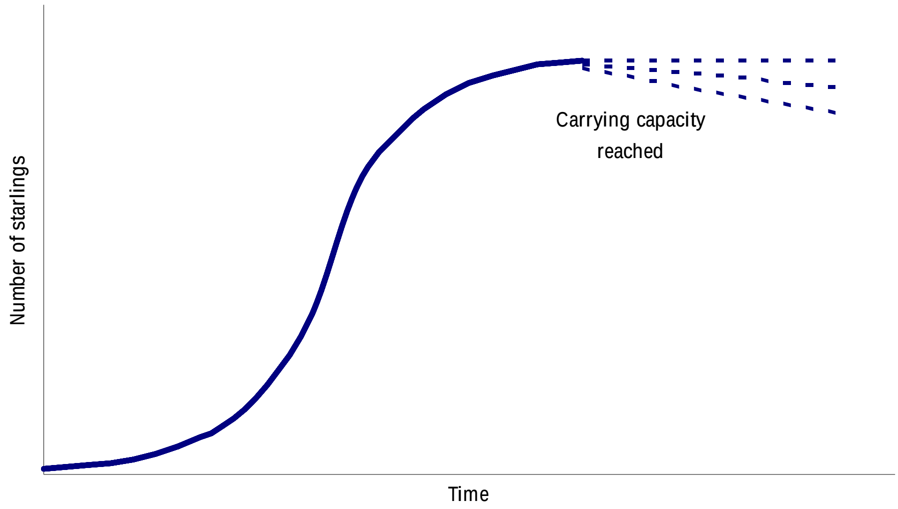
- A relevant timeframe of 30 to 50 years;
- The shape of the starling population growth curve is sigmoidal up until carrying capacity is reached (see Figure 1).

In other words, we ignore minor year-to-year fluctuations, and we do not speculate on starling populations in the *extremely* long term (beyond 50 years), when a number of other factors may change population growth dynamics in Western Australia (e.g., climate change, changes in cultivation methods or human habitation).

Once carrying capacity is reached, it would clearly be feasible, on the above evidence, that starling numbers could decline again, but we suggest that consideration of this is beyond the timeframes proposed. We also note that as the stream of effects are discounted in the analysis– say, by 6 per cent per annum –effects that are felt 50 or more years from now would be negligible in *present value* terms. Limiting the analysis to 50 years should therefore not affect the conclusions of this report.

We discuss our approach to modelling possible population growth scenarios in the Western Australian context in further detail in Section 4.4.2.

Figure 1 **Basic starling population growth illustrative dynamics**



4.2 Previous findings

Most of the work on estimating economic impacts of starlings has been carried out in the USA. The AgNIC Wildlife Damage Management Web site, a cooperative project between the National Wildlife Research Center and Colorado State University, for example, provides the following information:

> Invasive European starlings were reported to the USDA's Wildlife Services program as causing damage in every state except North Dakota and Alaska. … Over the 8-year period, 1990-1997, starlings accounted for more than $13.5 million in damage to all resources, ranging from $235,067 to $4,137,119, with an average of $1,694,170 and a median of $1,457,014 per year. Pimentel et al. (2000) estimated that yearly starling damage to agriculture was $800 million in damages per year to agriculture crops based on a figure of $5/ha (AgNIC Wildlife Damage Management Website).

There is therefore at present a very large variation in the estimates of economic losses due to starlings. We would point out however, that farmers typically would not *report* damage to any authorities – bird damage and associated losses are a fact of life to horticulturists and are priced into the final product. Also, some of the literature on bird damage suggests that horticulturalists are often unaware of the true extent of damage done by birds (Tracey, J. (NSW Department of Primary Industries), *pers comm.*). Such considerations imply that reported damage is likely to underestimate damage done by starlings.

The study by Crick *et al.* (2002) investigated the issue of starling damage in the UK. It should be noted that despite the recent decline in numbers, starlings remain the UK's commonest garden bird, with huge roosts found in plantations, reed beds and city centres. Nevertheless, Crick *et al.* (2002) found that:

> Neither species [starling and sparrow] currently appears to pose a widespread or serious pest problem; only 3% of owner/occupiers reported starling damage so severe that farm income was affected (0.5% for house sparrows), and 5% of responding Local Authorities reported starling problems severe enough to affect budgets (pp. xi-xii).

Given the variability in estimates and the paucity of recent research on the topic, our overall approach is therefore to try to build credible estimates for Western Australia, as far as possible, from the bottom up. These can then be compared to other estimates found in the literature.

A number of studies on the economic impact of starlings were summarised by Johnson and Glahn (1994) in their briefing paper on starlings, and these are reviewed below.

Consumption of livestock feed

Starlings consuming livestock feed can be a substantial economic consideration, and Johnson and Glahn (1994) mention several studies from the US and UK with field data from the 1960s to 1980s:

- A 1978 study in England estimated that the food eaten by starlings in a calf-rearing unit over three winters was 6 per cent to 12 per cent of the food presented to the calves; and
- Two other studies in England since then found 4 per cent losses and negligible damage, respectively.

An interesting finding reported by Johnson and Glahn (1994) was that feed contamination from starling excreta may not cause economic loss in cattle or pig operations. Tests carried out at Western Kentucky University over two years showed that neither pigs nor cattle were adversely affected by long-term exposure to feed heavily contaminated with starling excreta.

Damage to horticultural crops

Johnson and Glahn (1994) report that bird damage to grapes in the USA was estimated to be at least $4.4 million in 1972 and that starlings were one of the species causing the most damage. A 1972 study in Michigan found 17.4 per cent of a total crop lost to birds. A 1975 study in England estimated damage at 14 per cent (lower branches) to 21 per cent (tree canopy) of the crop. However, similar data for 1976 showed less damage.

Recent information from Australia estimates bird damage in horticulture, in particular grapes, at around 15 per cent of the crop (e.g., Tracey and Saunders

2003) – with starlings likely accounting for around one-fifth of the damage from all birds (Tracey and Saunders 2003). John Tracey confirmed that his team at the Vertebrate Pest Research Unit, NSW Department of Primary Industries is at present in the process of analysing results of the first national bird damage survey, which was carried out over the past two years, but that first results of perceived losses in regard to starlings are broadly along the lines suggested here (Tracey, J. (NSW Department of Primary Industries), *pers comm.*). We therefore assume that a starling infestation in Western Australia could potentially cause total losses amounting to some 3 per cent of the horticultural crop (that is, 20 per cent or one-fifth of all bird damage).

Damage to crops in the field

Johnson and Glahn (1994) refer to a study of 218 fields of winter wheat in three regions in Kentucky and Tennessee. In this study, losses attributed to starling damage averaged 3.8 per cent, 0.5 per cent, and 0.4 per cent respectively, with the most serious losses (more than 14 per cent) occurring where wheat was planted late and fields were within 11 miles (16 km) of a large starling roost. More recently, the USDA confirmed that bird damage to crops in the field can be serious:

> …birds can cause severe damage to a whole host of agricultural crops, including sunflowers, rice, corn, winter wheat, fruits, and nuts. Crops are especially vulnerable to bird damage because they are exposed throughout the entire growing season without any covering or protection. In many cases, such crops are the best food source available for miles and serve as a buffet for migrating or roosting birds. The extent of damage, however, can vary dramatically from one location to the next. In any given year, one producer may experience devastating losses while another nearby producer harvests a record crop (USDA 2003, p. 4).

Feare (1980) reports that in grain fields, starlings can consume grain worth about US$6/ha. Starlings have been recorded removing grain from newly sown wheat fields, with a 91 per cent probability of grain loss at depths of 21-30 mm (Boyce 1979). Damage to sprouting wheat has also been reported (Stickley Jr, *et al.* 1976). Starlings feed on ripening corn, prising into husks to gain access to the grains (Bernhardt *et al.* 1987). In Canada, starlings are common in corn fields of Ontario (Boutin *et al.* 1999); losses are also reported by Woronecki and Dolbeer (1983) and Woronecki *et al.* (1988).

Spread of livestock disease

The costs associated with starlings in the spread of livestock disease can be substantial. As an example, Johnson and Glahn (1994) refer to a transmissible gastro enteritis (TGE) outbreak in southeast Nebraska, which occurred during the severe winter of 1978-1979, and during which over 10,000 pigs were lost in one month in Gage County alone. Starlings were implicated because the TGE outbreak was concurrent with large flocks of starlings feeding at the same facilities.

Human health and safety problems

These problems are mainly associated with large urban starling roosts, and include concerns about the disease histoplasmosis and aircraft-bird collisions. It is the tendency of starlings to congregate and move in large flocks that leads to special risks around airports. Well kept grassy areas around landing strips are attractive places for starlings to seek out invertebrates in an urban setting, and warehouses around airports often provide good roosting sites. The airline industry in the United States incurs significant costs as a result of bird strikes:

> Wildlife collisions with aircraft cost U.S. civil aviation more than $470 million annually and pose a serious safety hazard as well. From 1990 to 2002, 46,000 bird strikes were reported at U.S. airports, but experts estimate that only about 20 percent of all strikes are reported (USDA 2003).

As a result of an accident involving starlings that led to a loss of 62 lives in 1960 (Boston Harbor crash), action was initiated to develop minimum bird ingestion standards for turbine-powered engines. The risk of further loss of life has thus likely been reduced, but if starlings did spread in Western Australia – in particular, if the infestation spread to Perth – costs would be implied by the need to better understand and more intensively manage urban roost situations.

Competition with native species and other biodiversity impacts

Whilst starlings are generally believed to be responsible for a decline in native cavity-nesting bird populations, a recent US study found few actual effects on populations of 27 native species (Koenig 2003). Only sapsuckers showed declines because of starlings, and other species appeared to be holding their own against the invaders. Also, Adeney (2001) states that:

> Studies documenting these effects have produced differing results, depending on the species examined. For example, Vierling (1998) found that Lewis Woodpeckers (Melanerpes lewis) in Colorado were not out competed for nest sites by European Starlings. Two other studies found that European Starlings did usurp significant numbers of nest site cavities from Northern Flickers (Colaptes auratus) and Red Bellied Woodpeckers (Melanerpes carolinus), and that the presence of additional nest boxes near Flicker nest cavities did not alleviate the problems (Ingold 1998 and 1994).

We recognise therefore that the impact of starlings on native bird population is likely to differ regionally and will at least partly depend on the resilience or vulnerability characteristics of native birds. In the Western Australian context, expert opinion has recently been summarised in a WWF report (Brown and Miller 2006), which concluded that:

> The risks posed by starlings to native birds in Western Australia are significant. Potential key threatening impacts of starlings in Southwest Australia include competition with hollow-nesting birds and mammals, weed dispersal, defoliation, and fouling of wetlands…In Western Australia, over 90% of the native woodlands have already cleared, and what remains is highly fragmented. Although many native bird species persist despite these pressures, many are declining and/or threatened. The severity of impact of the potential additional pressure of starlings in the highly fragmented landscape of the agricultural region, which has an abundance of food and watering points, is likely to be high. Species likely to be most affected include Muir's Corella (Cacatua pastinator), Carnaby's Black Cockatoo (Calyptorhynchus latirostris), Purple Crowned Lorikeet (Glossopsitta porphyrocephala), Red-capped Parrot (Purpureicephalus spurious), Western Rosella (Platycercus icterotis), Elegant Parrot (Neophema elegans) and Blue Bonnet (Northiella haematogaster) (p. 6).

Other costs/damage

The above discussion followed the categories of damage identified by Johnson and Glahn (1994), but there are a number of other costs that starlings can cause. These include damage to property (e.g., surfaces such as car finishes and white goods stored in warehouses), costs of cleaning up defiled walkways, noise pollution and unsightliness, the possibility that defiled lots of grain may have to be downgraded and subsequent loss of (export) premium and earnings, damage to seedlings in plant nurseries, and 'defensive' costs of control incurred such as the cost of netting (discussed further in the Western Australian context in Section 4.4.5 below).

Benefits of starlings

The literature also reports some benefits of starlings, for example, that fact that they consume large quantities of insects and other invertebrates (control of locusts springs to mind in the Western Australian context). There are references to starlings having been introduced as a biological control agent by authorities in the former USSR as well as in New Zealand. We have not been able to identify any literature that quantifies the benefits actually obtained. Johnson and Glahn (1994) comment that:

> Research is needed to further understand potential positive impacts of starlings and to learn how to maximize potential benefits while minimizing problems (p. 118).

4.3 The 'state-of-play' in Western Australia

We understand from discussion with various scientists and stakeholders, as well as considering the literature on pest birds, that unless very definite action is taken to reduce starling populations, starlings will indeed spread across much of the south western corner of Western Australia (Bomford, M. (Bureau of Rural Sciences), *pers comm.* and Lindenmayer, D. (ANU), *pers comm.*).

In response to a parliamentary question to the Minister for Agriculture and Food in Western Australia, the Hon Kim Chance replied on 14 March 2006:

> 'Starlings are an invasive species in south eastern Western Australia. They have been in Western Australia for, I think, some 34 years and control has been adequate. However, we have been unable to eliminate the species because new infestations continue to enter the state from across the Nullarbor. As a result of the extraordinarily good wet season on the Nullarbor this summer, a number of additional invasions have occurred. It is a serious problem…. Starlings tend to inhabit swampy areas. They are very difficult places in which to work because tiger snakes also inhabit that type of country. The people employed to control the starling population are generally up to their elbows in all kinds of difficult material. However, the new outbreak widens the area of alert for starlings by about 300 per cent. Two new colonies have been found, which is sufficient reason to be concerned. I have spoken to the department since the alert went out and I am not convinced that we have sufficiently funded the campaign to eradicate starlings, even though we have almost doubled the budget in that area. I am very concerned to at least pull back the area of infestation to the point at which it was prior to this recent outbreak.'

4.3.1 Cost considerations

A Cabinet submission dated 22 May 2006 states that:

> 'It is currently estimated that an effective response to the current known infestations and ongoing management of the starling incursion could cost between $15 and $20 million over three years with a need for an ongoing annual commitment thereafter of $1 to 1.5 million. …DAFWA does not consider it prudent to commit to such a costly program without detailed surveillance, emergency control of major populations and collation of Australasia's best starling expertise in developing a long-term strategy. Therefore, it is recommended that an initial project be implemented to define the limits of the starling incursion and to enhance containment activities, with an estimated cost of $2.5 million in 2006/2007.'

As pointed out above, the $2.5 million allocated in the 2006/07 year will go towards reducing some key uncertainties. The analysis provided in the remainder of the current report looks beyond 2006/07, asking what the impact of starlings might be if they are not controlled effectively.

For the purposes of this exercise we adopt a cost estimate for effective control based on the above statement, i.e., $3.8 million in the first year, $3.6 million in years 2 and 3, and $1.5 million in each year thereafter.

4.4 ACIL Tasman impact scenario

We considered the following two approaches to assessing the impact of a starling plague in Western Australia:

- A 'top level' approach; and
- A 'bottom up' approach.

4.4.1 Top level approach - transfer of existing $/ha estimates

One top level approach would be to use the US$5/ha *damage* cost estimate attributable to starlings suggested by Pimentel *et al.* (2005, 2000). If we make an allowance for inflation and exchange rates and assume the same level of infestation as in the United States we would arrive at a representative Western Australian cost per hectare figure of around $10 for 2006.

Given that roughly 8 million hectares of land are planted to grains and horticulture in Western Australia, this top level estimate would suggest a potential annual total cost of $80 million to the Western Australian economy. Clearly such damage could only be caused by a very large number of birds, i.e., this estimate might give an indication of the worst-case scenario in Western Australia once starlings had established across the maximum possible range in the State.

We have not based our analysis on the assumption that the above dollar-per-hectare estimate can be applied to Western Australia because:

- We are not aware of the detail of the work underpinning this estimate; and
- We believe that Western Australia has certain distinguishing features that could mean that applying such a top-level figure would lead to an overestimate of impact.

To produce an independent estimate 'from the bottom up', we began by asking how many birds there may conceivably be once starlings became firmly established across Western Australia. We then estimated how much damage such a bird population could do – by estimating (using data from the literature review) how much the birds could eat and how much of their diet might come from sources where economic losses might be implied (e.g., horticulture, etc.).

4.4.2 Carrying capacity and starling population growth rates

Very few estimates of starling population numbers appear to exist in the literature. Conversations with leading researchers on the subject in Australia revealed that no credible estimates of the total number of starlings in Australia exist to date.

Some readily accessible estimates on starling populations exist for the UK (Crick *et al* 2002) and the USA (e.g., Adeney 2001). As starlings are endemic in these countries, we believe they give a good indication of possible prevalence rates at a generalised level, i.e., if averaged across large land masses. For the UK, at current starling population levels, such an average prevalence rate calculation (number of starlings divided by land mass) results in an estimate of 35 starlings per sq km. For the USA a similar exercise shows that prevalence rates may be around 20 starlings per sq km (see Table 1).

Given that the starling population in the UK has declined by over 66 per cent since 1965 (Crick *et al* 2002), average prevalence rates of up to 100 starlings per sq km might have occurred historically in the UK. Moore (1980) also states that prevalence rates of *over* 100 starlings per sq km are possible in agricultural areas.

While starlings inhabit most areas of the UK and the USA, many parts of Western Australia will be too dry, too low in woodland or other suitable nesting sites – such as those associated with human habitation (e.g., under roofs) – and too remote from food sources to allow for colonisation by starlings. Climate matching models (e.g., Duncan *et al* 2001) coupled with an examination of the spread and location of agricultural areas across the state suggest that perhaps up to 40 per cent of the land mass in Western Australia could present starling habitat. This would suggest that up to one million square kilometres of land might be available for settlement by starlings in Western Australia.

Table 1 **Starling populations and current prevalence rates per hectare**

	Land mass (sq km)	No of starlings	Rate / sq km
UK	250,000	8.5 million	35.2
USA	9,200,000	150 million to 200 million	16.4 to 21.8
WA	2,500,000	1,000 to 10,000	0.0004 to 0.004

Data sources: Robinson *et al* (2005), WA Starling Reference Group supporting documentation, and various internet sources.

The next difficulty was to come to a determination on a relevant 'prevalence rate' – along the lines discussed above – that might apply in the context of Western Australia, if a serious starling infestation were to occur. Clearly, the UK reality is far removed in climatic (especially rainfall) terms from Western Australia. An average rate of 35 starlings per sq km across the entire potential habitat area in WA would therefore likely result in a gross overestimate.

Next, consider the USA – whilst parts of the USA might resemble the Western Australian climatic and settlement patterns, there are significant differences. For example, some 18 per cent of the US land mass is categorised as arable land (CIA fact book, accessed online). In Western Australia only about 8 million hectares are planted to various crops (i.e., around 80,000 sq km). This represents some 8 per cent of the one million sq km area identified by climate matching models as potential starling habitat. Given that starling numbers are likely to be much higher, on average, in the agricultural areas with good food and water sources, near human habitation, etc., the US representative average prevalence rate of 20 starlings per sq km would therefore once again seem too high in the Western Australian context.

We therefore began by positing a potential range of 10 to 15 starlings per sq km in Western Australia. Feedback from experts has indicated that this prevalence rate would not be unreasonable (Tracey, J. (NSW Department of Primary Industries), *pers comm.*). Applied to a habitat of one million sq km, this would yield a potential starling population of 10 to 15 million birds.

Another approach is to consider what would happen if agricultural areas suffered a severe infestation along the lines suggested by White (1980), i.e., with 100 starlings per sq km or more in the agricultural areas. If we assumed that such a severe infestation might occur across the 80,000 sq km (8 million hectares) planted to various crops in Western Australia, this would imply a bird population of over 8 million birds. But as pointed out above, this area represents only 8 per cent of the potential starling habitat in Western Australia. It is of course more likely that a less severe infestation across the areas planted to crops would be accompanied by some infestation of the other 92 per cent of suitable habitat.

A third way of arriving at a potential starling population for Western Australia is to divide up the (suitable) land mass of one million square kilometres into 500 parcels of 2,000 square kilometres each. The literature suggests that a roost of 25,000 starlings should easily support itself on such a parcel of land – a 2,000 square kilometre parcel of land implies a 25 km radius around a central roost site, and with normal distances travelled from roost for feeding being less than 2 km, a 25 km radius would appear adequate. Using this approach, we can say that 500 parcels supporting 25,000 starlings each is entirely feasible, and this yields a potential starling population of 12.5 million birds in Western Australia.

We therefore believe that a range of 10 to 15 starlings per sq km of potential habitat is not unreasonable in the Western Australian context, and we adopt a rate of 12.5 starlings per hectare as a representative rate for the potential Western Australian habitat. This prevalence rate implies that the potential starling infestation could involve 12.5 million birds, which in our analysis will be assumed as the Western Australian starling carrying capacity.

The next important question is, how long would it take for the starling population to grow to this level in Western Australia? International evidence suggests that initial population growth rates can be extremely rapid for avian species. In the US, the starling population 'took off' over a 50 year period from the early 1890s to around 1940 (see, for example, Davis 1950). Over this initial 50 year phase of their establishment, the annual growth rate in the population of starlings could thus have been around 33 per cent.

Certainly the more recent (and highly relevant) example of growth in the number of rainbow lorikeets in Perth would confirm this possibility. Since their introduction in the mid-1980s they have grown at an annual rate of around 34 per cent (Lamont and Massam 2005; quoted in WWF 2006).

So how long would it take for the population of starlings to reach 12.5 million? The answer to this depends partly on how many birds there are at present. Table 2 illustrates what could happen to the starling population given three different starting populations, i.e., 1,000, 5,000 or 10,000 birds respectively in 2006.

If today's population is 1,000 birds and if the starling population grew at 34 per cent per year then there could be 12.5 million starlings in Western Australia in 33 years (see Table 2) However, if there are currently 5,000 starlings in WA, then at a 34 per cent growth rate the population could grow to 12.5 million in 27 years, and if there are currently 10,000 birds, then 12.5 million birds could be reached in 25 years.

Further, the possibility that there are circumstances under which a starling population may quadruple in size in a given year should not be discounted (Woolnough, A. (WA Department of Agriculture and Food), *pers comm.*). If for some reason winter mortality is low in one year, so that the number of starlings quadruples and then returns to a 34 per cent per annum grow rate the starling population could reach 12.5 million within 19 years from now, depending on the starting population. Two 'low mortality' years with a quadrupling in starlings would imply that a figure 12.5 million could be reached in 15 years, and three 'low mortality' years mean this could happen within 10 years from now (see Table 2). We conclude from these estimates that a population of 12.5 million starlings could quite realistically be arrived at within 25 years.

Table 2 **Number of years until 12.5 million starlings in WA, different scenarios**

	Current WA starling population (i.e., 2006)		
	1,000 birds	5,000 birds	10,000 birds
Starling population exceeds 12.5 million in …			
Growing at 34% p.a.	33 years	27 years	25 years
- quadruples once	27 years	21 years	19 years
- quadruples twice	22 years	17 years	15 years
- quadruples thrice	18 years	12 years	10 years

Source: ACIL Tasman.

4.4.3 Potential food intake of future WA starling populations

How much damage could 12.5 million starlings do? We began by examining the bird's biological 'capacity to consume'. The following information was obtained from the AgNIC website:

> Individual starlings, which weigh approximately 3 ounces, can each eat up to 1 ounce of food per day.

This would suggest a capacity to consume up to 28 grams of food per day. Trials with caged birds (e.g., White 1980) show that this is indeed possible but that the average amount consumed would be closer to 25 grams per day.

The 'representative' diet

Using an estimate of 25g/day, 12.5 million birds could consume over 114,000 tonnes of food per year. Not all of this intake would consist of commercially valuable products such as horticultural produce or grains – the papers by White (1980) and Williams & Jackson (1981), for example, suggest that animal matter typically represents one-third of the starling's diet. This animal matter includes invertebrates, slugs, etc., that the birds pluck from the ground.

Section 4.2 suggests that bird damage to horticultural crops such as grapes might amount to 15 per cent of the total crop and that starlings may be responsible for one-fifth of this total. Western Australian output of grapes, apples, apricots, pears, cherries, nectarines, peaches, plums and prunes in 2004/05 came to some 142,360 tonnes (grapes accounted for 60 per cent of this total, and apples for another 25 per cent). If we assume that birds took 15 per cent of potential output this means that total production without bird damage could have been as high as 163,000 tonnes.

If starlings were to account for a loss of 3 per cent of the Western Australian horticultural crop, this loss would amount to slightly under 5,000 tonnes in volume terms. Note that this loss would represent 4.3 per cent of the diet of 12.5 million starlings if total intake was 114,000 tonnes as discussed above.

Finally, we allocated the rest of the starling's dietary intake to crops in the field, i.e., to grains – with animal matter allocated 33 per cent of the total diet and horticultural produce accounting for a further 4.3 per cent, this leaves 62.7 per cent of the total for grains. Given a total annual food intake of 114,000 tonnes from all sources, this means that some 71,500 tonnes of grains would be taken per annum (i.e., 62.7 per cent of 114,000 tonnes).

We note that this would equate to slightly over 0.5 per cent of the Western Australian grain crop in 2004/05 (barley, oats, wheat, field peas, lupins and canola), and this is entirely plausible given the range of damage results presented in Section 4.2.

4.4.4 Estimates of crop damage

Estimates of the value of the damage done are summarised in Table 3. As the table shows, total crop damage done by 12.5 million starlings is estimated at $21.2 million per annum (using 2004/05 average product prices; based on ABARE and ABS statistics).

Table 3 **Diet of 12.5 million starlings and value of crop damage**

	Share in diet	Value
Animal matter	33.0% (37,641 tonnes)	-
Horticultural produce	4.3% (4911 tonnes)	$6.6 million
Grains	62.7% (71,510 tonnes)	$14.6 million
Totals	**100% (114,063 tonnes)**	**$21.2 million**

Note that these costs equate to roughly $2.7 per hectare of land planted to crops and horticulture in WA. As pointed out earlier in this report, Pimentel *et al.* (2005, 2000), drawing on Feare (1980), suggest a figure of around US$5/ha. It needs to be remembered, however, that the earlier estimates of Feare and Pimentel *et al.* would have been based on typical damage by starlings given overall UK and/or US starling prevalence rates, which – as we have already pointed out – are two to three times of what we have assumed for Western Australia.

If we had assumed higher starling prevalence rates, our dollar-per-hectare could clearly have been at similar levels to those reported by these experts, but as we have argued the situation in Western Australia is significantly different from the US and UK, thus leading to the lower estimate of likely damage per hectare.

4.4.5 Other costs

There are a range of other costs that we have not attempted to quantify due to a lack of readily available data:

- Other industry losses, e.g., plant nurseries and vegetable growers. Whilst impact of starlings has not been considered significant or major, some losses would likely be incurred;
- The full cost of livestock feed taken – the last section included a partial estimate (the volume of grain taken by the birds) but the cost of the ration to the livestock farmer is more than just the value of the grain (i.e., in our dollar estimate above we have simply used grain commodity prices, rather than trying to estimate the proportion of grains that is taken in the form of livestock feed – and for which the much higher price of the feed ration would have been relevant);
- Feedlot contamination – the potential cost of cleanup or downgrading and loss of competitive advantage to Western Australia (e.g., inability to load and ship grains as quickly as is currently the case);
- Other public and private costs – droppings can damage the finish on automobiles as well as being unsightly. When birds occupy warehouses and defecate on stored goods, retailers may refuse to accept contaminated goods, thus affecting warehouse management. Large, gregarious and noisy flocks of starlings can also be a serious public nuisance:
  - Costs to the Western Australian 'urban environment' have been estimated at $8 million in the supporting documentation provided by the Starling Reference Group;
- Infrastructure costs – preventative/defensive expenditure incurred on a one-off basis by farmers and industry (e.g., covering feedlots, netting):
  - This depends on risk perception and the level of risk-averseness of individual economic agents; it is also likely that only a small proportion of producers will incur preventative costs *solely* due to starlings;
- Potential costs of changing management practices to deal with starlings (e.g., pruning trees, methods for ensuring exclusion in the field, trapping, etc.);
- Weed control – starlings are known to disperse olives and other weeds and the costs of dealing with dispersal of weeds may increase;
- Disease – starlings are known disease vectors (e.g., mites, transmissible gastro enteritis or TGE in pigs, Newcastle disease, etc.) and could increase the risk of disease outbreaks; one-off costs of dealing with these could run into millions of dollars;
- Cost of extinction threats and biodiversity impacts:
  - Several species are at threat but it is believed that establishment of the starling in Western Australia would likely result in the extinction of wheat belt subspecies of the Western Rosella;
  - Flocks of thousands of birds in traditional roosts damaging trees:
    - Associated annual costs (e.g., cost of implementing recovery plans for protection of key threatened species for the western rosella

alone would be $0.5 million per annum over 20 years). An annual cost of $1 million to the natural environment has also been posited in the supporting documentation provided by the Starling Reference Group).

Overall estimate of 'other costs'

Whilst the total costs identified here vary significantly in nature and estimates can not be made with much accuracy (some of the benefits of not having starlings, for example, include events that may or may not occur, such as disease outbreaks, etc.), we believe that the Starling Reference Group's total estimate of costs of around $9 million per annum ($8 million for urban environment and $1 million for biodiversity impacts) for a starling population of 12.5 million birds would be a conservative 'lower end' estimate. It would imply 'other costs' totalling less than one dollar per bird per year.

We note that the environmental costs in particular may be underestimates, and that this partly depends on the perspective taken. From the conservationist's perspective, the damage to the ecosystem from having introduced a new aggressive species would be enormous and, in particular where extinction threats are credible (as appears to be the case in at least one instance with starlings in Western Australia), the loss to the community may be a multiple of the estimate assumed here.

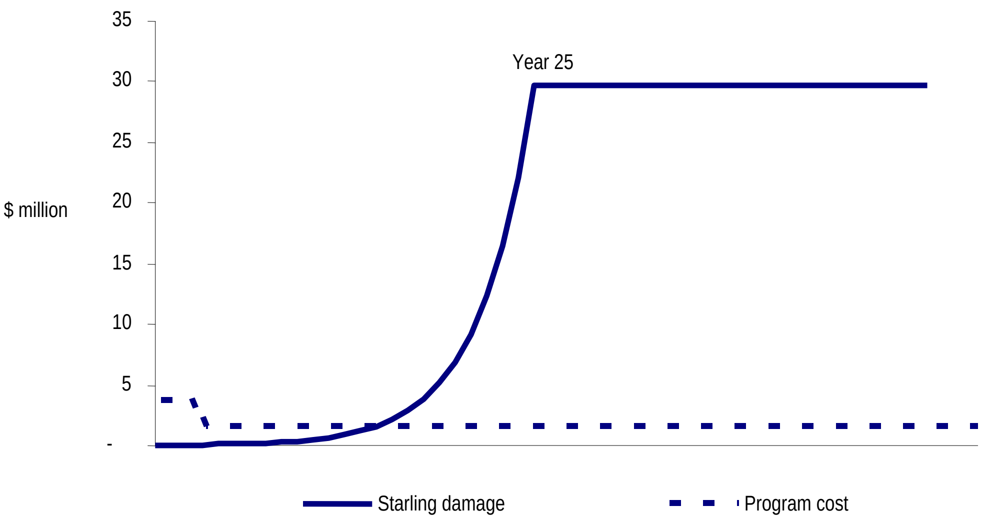
4.5 Estimate of total costs

If we now add together our estimates for crop damage and other costs, we estimate an annual cost to the Western Australian economy of about $30 million once starlings reach the assumed capacity level of 12.5 million birds. We believe that this is a conservative estimate.

This cost would only be incurred when the starling infestation has fully established, and we have suggested that a reasonable timeframe in which this could occur is 25 years from now. Figure 2 consequently shows starling damage increasing up to Year 25, when carrying capacity is reached. After this, the $30 million cost is incurred in each year.

Figure 2 also illustrates the costs of an effective response to the incursion as postulated in Section 4.3.1 above (based on previous costings submitted to the Western Australian government) – this requires $3.8 million to be spent in the first year, $3.6 million in years 2 and 3, and $1.5 million in each year thereafter.[1]

Figure 2 **Projected damage caused by starlings and cost of control**



Data source: ACIL Tasman estimates.

4.6 Cost-benefit calculations (net present values)

Given the estimates presented above, for a 50 year horizon and using a discount rate of 6 per cent per annum, the total starling control program is estimated to cost $29.4 million in present value terms. By contrast, the present value of starling damage that would be incurred if no intervention occurred comes to $122.7 million. This implies a benefit-cost ratio of 4.2:1 for the damage control program.

If we use a 30 year horizon instead, the present value of the costs of running the control program would come to $26.4 million, whilst the damage done by starlings would be valued at $62.8 million in present value terms. Reducing the horizon by twenty years thus implies a lower benefit-cost ratio of 2.4:1.

Dealing with uncertainty

The above benefit-cost ratios imply that if the probability of the infestation is thought to be low – less than 25 per cent for the 50 year horizon, or less than 50 per cent for the 30 year horizon – then the *probability-adjusted* benefits from control could be less than the costs of running the starling control program.

[1] The notional breakdown of costs is expected to be: project management and administration (5%), education and awareness (5%), research (10%), surveillance (50%) and control (30%) (Collopy, D, (WA Department of Agriculture and Food), *pers comm.*).

We note however that there appears to be scientific consensus that, if left unchecked, starlings will expand (i.e., without doubt), and if this is the case, we reiterate that our damage estimates could be on the conservative side.

5 Conclusion

The results of our analysis show benefit-cost ratios ranging from 2.4:1 to4.2:1, depending on the timeframe of the analysis. On the basis of these numbers and the conservative assumptions under-pinning the analysis, we conclude that there is a sound case for the planned program of control as costed above.

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