Gillespie Economics

Economic Evaluation of the Lord Howe Island Rodent Eradication Project

Final Report

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Key Points

- Investing in the Rodent Eradication Plan (REP) will create net benefits for Australia. It is justified on economic efficiency grounds.
- The REP will provide net benefits to the residents of Lord Howe Island and those living elsewhere in Australia.
- The REP will create net benefits by improving biodiversity, tourism opportunities and the profits of the Kentia Palm and fresh vegetable industry on Lord Howe Island.
- These results are robust to variations in assumptions that underpin the analysis.
- It is likely that there will be minimal or no reduction in visitation to Lord Howe island when the rodent baiting takes place. At worst, reductions will be off-set by intending tourists re-scheduling their visits..
- It is reasonable to expect that there will be minimal or no reduction in visitation at the time of the REP, or at least in the off-peak period overall (allowing for tourists rescheduling their visits in the off-peak period).
- The short term impacts of the REP on tourist demand for accommodation will be more than offset by the demand for accommodation of the REP workforce.
- Where the REP workers have similar spending patterns to tourists, then impacts on tour operators, food providers and shops will also be offset.
- Where the REP workers spending patterns are different to those of tourists, tour operators, and to a lesser extent food and shopping providers may be worse-off in the short term i.e. July 2017.
- These potential short term impacts would be offset if there was an increase in off-peak visitation by 0.4% (29 people) because of the eradication of rodents. Increases in visitor numbers due to the REP are likely to be considerably greater than this.
- Potential short term impacts of the REP on tourism operators, shops and food outlets could be reduced by:
  - promoting local purchases to the REP workers;
  - giving REP workers tour and restaurant vouchers; and,
  - mandating the use of tourist operators' vehicles and boats where required for REP operations.

Executive Summary

Introduction

The Lord Howe Island Group (Lord Howe Island (LHI) and outlying islands, islets and rocks) has outstanding natural features and values, and is on the Register of the National Estate. It is also listed as a World Heritage Area (WHA) and is located within the Lord Howe Island Marine Park (NSW) and the Lord Howe Commonwealth Marine Reserve (under Commonwealth authority).

The environmental, tourism and industry values associated with the LHIG, and in particular LHI, are being adversely impacted by introduced species of rats and mice, despite an ongoing rodent control program.

"With" and "Without" the Rodent Eradication Project

The LHI Rodent Eradication Project (REP) is a proposal to eradicate introduced rodents from LHI using cereal baits laced with the anticoagulant Brodifacoum dispersed from helicopters in the uninhabited areas, and a combination of hand broadcasting, bait stations and bait trays in the settled area.

"Without" the REP, the current rodent control program would continue with ongoing control costs, continued presence of poison in the environment, continued impacts on the Kentia Palm and nursery industry, further degradation of World Heritage values (including endemic and threatened species) and the potential for the LHIG to be inscribed on the "World Heritage in Danger List".

Cost Benefit Analysis

Cost Benefit Analysis (CBA) provides a comparison of the additional costs and benefits "with" the REP, relative to "without" the REP. Costs are measured in terms of reductions in producers' net revenues (producers' surpluses) and benefits to consumers (consumers' surpluses), while benefits are measured in terms of increases in producers' and consumer's surpluses.[1]

Provided the present value[2] of additional benefits exceed the present value of additional costs (i.e. a net present value (NPV) of greater than zero or a benefit cost ratio (BCR) of greater than one), a project is considered to improve the wellbeing of society and hence is desirable from an economic efficiency perspective.

[1] Consumer surplus is the difference between what an individual would be willing to pay (demand) for a good or service (the total benefit to the consumer) and what they have to pay (the cost to the consumer i.e. consumer expenditure or price times quantity). In the market model, it is the area between the demand curve and the price line. Producer surplus is the difference between the revenue (consumer expenditure) received for a good or service (total benefit to producer) and the costs (supply) of the inputs used in the provision of the good or service (economic cost to producer). In practical terms, it is the net revenue (before tax) that is earned by producer of goods and services (James and Gillespie 2002). In the market model, it is the area between the price line and the supply curve.

[2] The present value of a benefit or cost arising in the future takes into account the value of time through the process of 'discounting'. Discounting acts in the opposite way to 'compounding' where an amount received now is worth more in the future.

Additional Costs and Benefits of the REP

Relative to the "without" REP scenario of ongoing rodent control program, the REP would have the following additional costs and benefits to the Australian community.

Table ES1 - Potential Additional Costs and Benefits of the LHI REP

Category	Costs	Benefits
Direct costs	REP direct implementation costs	Avoided ongoing rodent control costs - LHI and residents
Biodiversity	Potential for species extinction from the REP Costs of returning extant species to LHI	Biodiversity improvements - prevention of additional extinctions - increased abundance of species - return of extant species to LHI
Tourism	Foregone tourism business during REP implementation	Additional demand for accommodation during REP implementation Additional tourism business after REP implementation
Palms and vegetables		Increased productivity for Kentia Palm and vegetable industry and avoided direct costs Increased productivity of other vegetable gardens
Health and toxicity	Potential impacts on other species, water and human health	Reduced impacts to humans, livestock and pets from constant presence of rodent poison Elimination of health impacts from rodents for residents and tourists
Wastage and amenity		Elimination of spoiled foodstuffs and the presence of rodent excrement on LHI
Research		Research benefits of the program

Estimation of the Additional Costs and Benefits of the REP[3]

Direct costs

The LHI REP has estimated capital costs of $10.6M, although approximately $1.5M of this is already spent and hence in accordance with NSW Treasury (2007) is excluded from the analysis. Incremental ongoing biodiversity monitoring costs associated with the REP are estimated at $50,000 per year for 10 years, with ongoing rodent detection (quarantine) costs of $30,000 per year. "With" the implementation of the REP, the LHIB would avoid ongoing rodent control costs of $85,000 per annum and residents would avoid private bait costs of $4,800 per annum.

[3] All values reported here are pre-discounting and pre application of probability weights.

Biodiversity

The biodiversity benefits of the REP include:

- avoiding seven additional extinctions on LHI over the next 20 years[4];
- the ability to return four species that are extant from LHI due to the predation of rats and mice such as the Kermadec petrel, White-bellied storm petrel, phasmid and wood feeding cockroach; and an
- increase in abundance of plants, birds, reptiles and insects.

Based on benefit transfer from a choice modelling study of environmental improvements (including protection of species from extinction) in three NSW catchments, a conservative value of $8M per species prevented from extinction or returned to LHI is adopted. Because of the uncertainty associated with future species outcomes, the benefit estimate was weighted by the probability of REP success (95%)[5] and the probability of species extinctions in the absence of the REP or successful reestablishment (which ranged from 50% to 100% for the individual species). The cost of reestablishment of species, subject to successful eradication of rodents, was estimated at $50,000.

In addition to benefits from protection of species, a further benefit of the REP would be an increase in abundance of flora and fauna. This benefit remains unquantified in this analysis, although studies have found that the community are willing to pay for increases in species abundance. For example, Blamey et al (2000) found that Brisbane households on average were willing to pay $1.69 each to avoid each 1% decrease in the population size of non-threatened species in the Dessert Uplands of Queensland[6].

Toxikos (2010) and Pacific Environment Limited (2015) found that the potential risks of the REP to soil, water and the marine environment were negligible because of the physical chemical properties of Brodifacoum. While there are risks to a number of species from primary and secondary poisoning, with the implementation of a range of mitigation measures, the Office of Environment and Heritage found that the likelihood of species extinctions on LHI as a result of the REP would be extremely small i.e. $1*10^{-4}$ to $1*10^{-6}$.

Tourism

Tourism supply and demand for current peak and off-peak periods visitation to LHI were estimated based on visit numbers, expenditure estimates per visit, the responsiveness of demand to changes in price (known as 'price elasticity') for places such as LHI and the proportion of expenditure likely to be net revenue based on the National Input-Output Table.

[4] A 20-year time frame is referred to here as this is the basis on which nonmarket valuation studies used in this report are based.

[5] All benefits that are contingent on the successful eradication of rodents are weighted by the probability of success of the REP, estimated at 95%. Some costs i.e. costs returning extant species, are also contingent on success of the REP and hence are weighted accordingly.

[6] Using this value estimate to estimate values for LHI was deemed inadvisable due to the differences between the ecological settings pertaining to the two cases.

"Without" the REP, further degradation of World Heritage values of LHI would occur with this potentially resulting in the LHIG being inscribed on the "World Heritage in Danger List". If this occurred, it would have the effect of 'signalling' a decline in the value of the LHI experience. This would be expected to result in a reduction in tourism demand in both the peak and off-peak periods. Whether LHIG is inscribed on the "World Heritage in Danger List" or not, the Lord Howe Island Tourism Association (2015) has identified the "potential increase in negative consumer perception of degeneration of pristine environment" as a key threat to tourism.

While some decline in tourism demand is expected to be associated with further degeneration of the environment of LHI "without" the REP, for the purpose of the analysis it has conservatively been assumed that "without" the REP demand in the peak and off-peak periods would remain constant[7] over the analysis period.

"With" the REP, two separate potential impacts were identified - short term effects during the REP and long term effects after the REP.

Short term effects include the potential for reduced tourist visitation during the REP and increased demand for accommodation from the non-local workforce.

The REP is proposed to be undertaken during the winter months when tourism is least and the group assumed to be most sensitive to knowledge of the REP i.e. families with children, visit less. Other groups are likely to be less sensitive and, in any case, have greater flexibility to adjust the time of their travel to other non-peak periods. Therefore, in the absence of any survey of prospective visitors to LHI, it is reasonable to expect that there will be minimal or no reduction in visitation at the time of the REP, or at least in the off-peak period overall (allowing for some substitution for an alternative off-peak times).

However, for the purpose of this analysis it is conservatively assumed that 50% of visitors who would otherwise have visited during the month of July (when the REP is likely to be implemented) i.e. 293 visits and 2,051 visitor nights, would not visit and would not alter the timing of their booking. This impact was represented by a reduction in off-peak demand resulting in an associated reduction in annual benefits to tourists and annual net revenues to tourism providers of $490,000 and $130,000, respectively. Offsetting this short term impact would be additional REP workforce demand for 3,050 bed nights and net revenues to accommodation providers of $122,000. If these workers have similar spending habits to tourists, then impacts on tour operators, food providers and shops will also be offset. However, to the extent that the REP workforce expenditure pattern is different to that of tourists, tour operators, and to a lesser extent food and shopping providers may be worse-off in the short term i.e. July 2017, if assumed reductions in tourists eventuate.

Consultations with the LHI community elicited a range of views on the potential long term tourism impacts of the REP. However, evidence supports an increase in tourism demand post rodent eradication and economic principles indicate benefits to tourism providers from an increase in demand, even when constraints on visitor numbers apply. While a review of case studies suggests

[7] All other things being equal (ceteris paribus).

that, conservatively, predator free status may lead to a 50-75% increase in tourism numbers, this report adopts an even more conservative assumption of a 20% increase in tourism demand, ramping up over five years. Sensitivity analysis is undertaken for different tourism demand assumptions.

In peak periods an increased demand results in no increase in visitation but an increase in the market price for accommodation on LHI with an estimated increase in the net revenue to accommodation providers[8] of $6.0m per annum.

In off-peak periods an increase in demand, results in an increase in visits which can be accommodated within the capacity constraint, and an increase in price (or average spend) per visit. The result is an increase in annual net revenue to tourism providers on LHI and benefits to tourists of $720,000 and $2.7m, respectively.

Kentia Palm and Vegetables

Kentia Fresh has identified that a successful REP would result in the following benefits to its nursery operations:

- avoided costs of $10,000 per year on rodent baiting;
- reduced seed collections costs from around $165/bushell to $50/bushell - wild seeds would be easier to collect in the absence of rodents;
- avoided loss of $50,000 worth of Kentia production per annum from current rodent predation;
- avoided loss of $25,000 of fruit and vegetable production per annum from current rodent predation.

Health and Toxicity

Toxikos (2010) and Pacific Environment Limited (2015) identified that many of the potential human exposure pathways to Brodifacoum will not occur due to the proposed management practices that are to be put in place during and after the REP e.g. removal of poultry and cattle from LHI, isolation of dairy cows from exposure. Other direct and indirect exposure pathways are concluded by Toxikos (2010) and Pacific Environment Limited (2015) to pose negligible risk for human health.

Toxikos (2010) and Pacific Environment Limited (2015) identified that the most important exposure pathway of Brodifacoum for humans is direct ingestion of bait pellets picked up off the ground. However, they concluded that the proposed REP involving the use of brodicafoum will not pose a risk to the health of the residents of Lord Howe Island. The risk management processes included in the plan will mitigate any possible risks posed by the use of Brodicafoum.

With the implementation of the mitigation measures, the risk to dogs is also considered to be negligible (Toxikos 2010).

[8] Some increased net revenue would also accrue to airlines but this is not modelled here.

Cost Benefit Analysis Results

The present value of the incremental costs and benefits of the REP[9], using a 7% discount rate and a 30 year evaluation period, consistent with NSW Treasury Guidelines, is provided in Table ES2. The REP is estimated to provide net social benefits of $142M and a benefit cost ratio of 17.0. This indicates that the aggregate welfare of the community is improved by implementing the REP i.e. the incremental benefits of the REP exceed the incremental costs.

There are incremental biodiversity benefits, incremental tourism benefits and incremental benefits to the Kentia Palm and vegetable industry from implementation of the REP.

There are benefits that remain unquantified in the analysis i.e:

- increased species abundance;
- increased productivity of private vegetable gardens;
- reduced risk to humans, livestock and pets from constant presence of rodent poison;
- elimination of potential health impact from rodents for residents and tourists;
- elimination of spoilt foodstuffs and the presence of rodent excrement on LHI;
- research benefits from the REP.

If these were able to be quantified they would increase the net benefits of the REP. However, the magnitude of these benefits is unlikely to affect the central CBA result that the REP improves the well-being of the community.

[9] With all costs and benefits that are contingent on successful eradication of rodents weighted by the probability of the REP being successful i.e. 95%.

Table ES2 - Present Value of Incremental Costs and Benefits (@7% discount rate)

Category	Costs	$	Benefits	$	Net Benefits
Direct costs	REP direct implementation costs		Avoided ongoing rodent control costs		
	Capital costs	$7,658,155	*LHIB*	$845,425	
	Ongoing costs	$620,823	*Residents*	$47,742	**($7,385,812)**
Biodiversity	Potential for species extinction from REP	$1,055	Prevention of additional extinctions	$40,599,970	
	Costs of returning extinct species to LHI	$38,774	Return of extinct species to LHI	$27,537,371	
			Increased abundance of species		**$68,098,566**
Tourism	Foregone tourism during REP implementation				
	Net revenue	$113,686	Additional accommodation during REP implementation		
	Tourist benefits	$427,457	*Accommodation net revenue*	$106,773	
			Net revenue to tours, food outlets and shops	NQ	
			Tourist benefits	NA	
			Additional tourism business after REP implementation		
			Net revenue	$57,175,022	
			Tourist benefits	$23,153,099	**$79,893,751**
Palms and vegetables			Increased productivity for Kentia Palm industry and avoided direct costs	$982,682	
			Increased productivity of other vegetable gardens	NQ	**$982,682**
Health and toxicity	Any impact to other species, water and human health	NQ	Reduced impact to humans, livestock and pets from constant presence of rodent poison	NQ	**NQ**
			Elimination of health impacts from rodents for residents and tourists	NQ	**NQ**
Wastage and amenity			Elimination of spoiled foodstuffs, rodent excrement for residents	NQ	**NQ**
Research			Research benefits of the program	NQ	**NQ**
Total	**Total costs**	**$8,859,951**	**Total benefits**	**$150,448,082**	**$141,588,132**
			Net Present Value	**$141,588,132**	
			Benefit Cost Ratio	**17.0**	

Note: Reporting of calculations should not be misconstrued as conveying false accuracy

Distribution of Costs and Benefits

The CBA was undertaken from an Australian perspective. Distributional analysis found that there are net benefits from the REP for the residents of LHI and those who do not live on LHI, with NPVs (BCRs) for these groups of $58 (80.5) and $83M (11.2), respectively. The BCR for LHI residents is considerable higher than the BCR for non-residents.

A particular focus of the distributional consideration is the impact of the REP on tourism and tourism providers i.e. net revenues.

If it assumed that there is a 50% decrease in tourists during July 2017 as a result of the REP then the reduction in net revenues to tourism providers[10] is estimated at:

- $83,000 to $308,000 to accommodation;
- $18,000 to $68,000 to tours;
- $10,000 to 42,000 to shopping; and
- $20,000 to $111,000 to meals.

These economic costs would only accrue to those operators that are normally open during July.

However, increased demand for worker accommodation as a result of the REP would more than offset the assumed reduction in accommodation demand i.e. 50%, and hence there will be a net benefit to accommodation providers. If these workers have similar spending habits to tourists, then impacts on tour operators, food providers and shops will also be offset. However, to the extent that the REP workforce expenditure pattern is different to that of tourists, tour operators, and to a lesser extent food and shopping providers may be worse-off in the short term i.e. July 2017, if the assumed reductions in tourists eventuate. However, a number of measures could be implemented to mitigate these potential impacts including promotion of local purchases to the incoming workforce; provision of tour and food vouchers to workers; and rent of tourist operators vehicles and boats where required for implementation of the REP.

Accommodation providers (and airlines), who would be no worse-off in the short term as a result of the REP, would be the main beneficiaries of any increase in peak season tourism demand. This is because benefits would mainly accrue via price increases for accommodation (and airlines)[11] rather than any increase in visitation.

An increase in off-peak tourism demand as a result of the REP would benefit all tourism service providers i.e. accommodation providers, tour operators, food outlets and shops, as it would result in both price increases and increases in visitation.

[10] It should be noted that reduced net revenue is an overstatement of financial cost as it is gross of tax. Also these estimates are based on broad industry relationships and hence should be interpreted as order of magnitude estimates rather than specific estimates of impacts to individual businesses.
[11] Price increases would only occur for services where quantity is constrained.

Sensitivity Testing

The sensitivity analysis indicates that the CBA results are not sensitive to substantive changes in key variables. The primary drivers of the CBA results are the estimated benefits from biodiversity improvements and the increased demand for tourism arising from these biodiversity improvements. Even under the extreme scenario of no increase in tourism demand, the REP would still have net benefits because of the biodiversity benefits it will provide.

Economic Activity Impacts

Any changes in expenditures (and revenue) impact economic activity on LHI. These are not measures of costs and benefits from an overall community and CBA perspective. However, changes in economic activity on LHI is of particular interest to stakeholders.

In the short term, there will be in the order of $400,000 spent on local labour to assist in the REP implementation and post REP monitoring. Reduced expenditure on tourism business is estimated at between zero and $527,000, depending on the impact of the REP implementation on visitation. The maximum estimate of reduced tourism expenditure on accommodation during the REP implementation ($307,000) is more than offset by the accommodation demand by nonlocal workers ($455,000) and if these workers have the same expenditure patterns as tourists then maximum assumed impacts on tour operators, food providers and shops will also be more than offset. Expenditure on tour operators is the expenditure category where worker expenditure is most likely to be different from tourist expenditure. Overall in the short run the REP implementation will result in an increase in expenditure in the local economy.

In the long run, there is expected to be increased expenditure on LHI from an increase in peak and off-peak tourism expenditure. There will also be increased profitability to the Kentia Palm Nursery. Local labour will experience some reduction in direct output as wages associated with the ongoing rodent control program will no longer be spent and there will be a reduction in expenditure on labour involved in Kentia Palm seed collection. However, overall in the long run the REP implementation is expected to result in a substantial increase in expenditure in the local economy.

Conclusion

CBA of the REP indicates that it will have net benefits to Australia and hence is justified on economic efficiency grounds. It will provide net biodiversity benefits, net tourism benefits and net benefits to the Kentia Palm and fresh vegetable industry. The REP will also have net benefits to residents of LHI and net benefits to residents in the rest of Australia.

It is reasonable to expect that there will be minimal or no reduction in visitation at the time of the REP, or at least in the off-peak period overall (allowing for some substitution for an alternative off-peak times). Nevertheless, the maximum assumed short term impacts to tour operators, food outlets and shops as a result of the REP implementation would be offset in present value terms if there was a sustained increase in off-peak visitation by 0.4% (29 people) because of the eradication of rodents.

1 Introduction

1.1 Contextual Background

Lord Howe Island (LHI) is an unincorporated part of NSW that is administered by the Lord Howe Island Board (LHIB). The Island contains a small settlement of approximately 350 inhabitants that covers 15% of the Island.

LHI has outstanding natural features and values with 75% of its area, and all of the outlying islands, islets and rocks protected, under the Permanent Park Preserve, a similar status to a national park. The Lord Howe Island Group (LHIG) is on the Register of the National Estate, is listed as a World Heritage Area (WHA) and is located within the Lord Howe Island Marine Park (NSW) and the Lord Howe Commonwealth Marine Reserve (under Commonwealth authority).

In addition to its natural and heritage values, LHI also generates significant financial values through the provision of tourism accommodation and a range of tourism and recreation activities that include:

- Marine activities such as beach and reef walking, swimming, snorkelling, scuba diving, fish feeding, surfing, underwater photography, windsurfing, sea-kayaking, fishing, sightseeing cruises and eco tours, and other water sports and beach activities; and

- Terrestrial activities such as hiking, bird watching, bike riding, sightseeing, eco tours, lawn bowls and golf.

Financial values are also generated via the export and local sale of the Lord Howe Kentia Palm.

The natural, heritage, tourism and industry values identified above are being impacted by introduced species of rats and mice. Rodents have contributed to the extinction of a number of species on the Island and are a recognised threat to at least 13 bird species, 2 reptiles, 51 plant species, 12 vegetation communities and numerous threatened invertebrates on the Island (DECC 2007).

Any impact on the natural values of the Island diminishes tourism and recreation values since these are inextricably linked to the Islands unique biodiversity and World Heritage values.

Predation by rodents on Kentia Palm production reduces values associated with this commercial activity, via reduced production and added costs.

In addition, rodents impose costs to residents and tourism operators via the need to bait to reduce visual presence of rodents, the spoiling of food stuffs and potentially health impacts to residents and tourists alike.

The LHIB currently implements a limited rodent control program at a cost of $85,000 per year. However, it is not reducing the rodent population sufficiently to limit landscape scale ecological impacts and there is a risk that continuation of the current approach will result in bait shyness and/or resistance in the rodent population.

An alternative to this scenario is being proposed by the LHIB: The LHI Rodent Eradication Project (REP). This is a proposal to eradicate introduced rodents from the LHIG using cereal baits laced with the anticoagulant Brodifacoum dispersed from helicopters in the uninhabited areas, and a combination of hand broadcasting, bait stations and bait trays in the settled area.

As well as eradicating introduced rodents the introduced Masked Owl will also be eliminated.

1.2 Purpose and Scope of this Consultancy

The purpose of the consultancy is to provide a robust, plain English economic evaluation of the proposed LHI REP that will address ongoing community concerns about the potential impacts to tourism and the economy, and identify whether the proposal will provide net benefits to the Australian community.

It draws on previous specialist studies, summary results of previous community consultations relevant to the study, some additional consultations with key stakeholders, economic principles and a review of the economic valuation literature.

There are two potential frameworks available to assess the economic impacts of the proposal:

- cost benefit analysis (CBA) which examines the additional costs and benefits of the LHI REP to impacted stakeholders, relative to "without" the REP, and determines whether it is likely to have net benefits to the community;

- economic activity analysis which examines the impact of a proposal on the LHI economy in terms of economic activity indicators such as expenditure and business turnover. These indicators are not equivalent to the measures of net benefit used in CBA.

CBA is the primary way that economists evaluate the desirability of a proposal and this technique will form the core of this economic evaluation. However, consideration will also be given to the consequences of the proposal for economic activity on LHI.

2 Economic Values

2.1 Total Economic Value Framework

Economic values are anthropocentric in nature and so relate to anything from which individuals gain satisfaction (DEST et al 1995), whether or not that value can be easily determined or observed.

LHI and its associated marine resources have many economic values that can contribute to the enjoyment (or wellbeing) of society. These economic values may be associated with goods and services that are traded in markets e.g. tourism, as well as goods and services that are outside the market system e.g. biodiversity conservation, provided these contribute satisfaction to individuals in society.

Combined, all the economic values that can be obtained from a resource are often referred to as total economic value (TEV) (Young 1992).

The mechanisms that link resources to individual and community well being are direct use of the resources (for example, commercial and non commercial recreation), indirect use of a resource (i.e. ecosystem service values such as carbon sequestration) and nonuse (such as the preservation of natural ecosystems, species or special areas) (James and Gillespie 2002).

A typology of potential economic values associated with LHI and its surrounds is presented diagrammatically in Figure 2.1. Broadly, the main economic values associated with LHI can be summarised as:

- use values associated with tourism and recreation;
- use values associated with Kentia Palm and vegetable production; and
- nonuse values associated with the conservation of the natural environment.

The first two dot points are represented by use values in Figure 2.1. The latter point is represented by nonuse values in Figure 2.1.

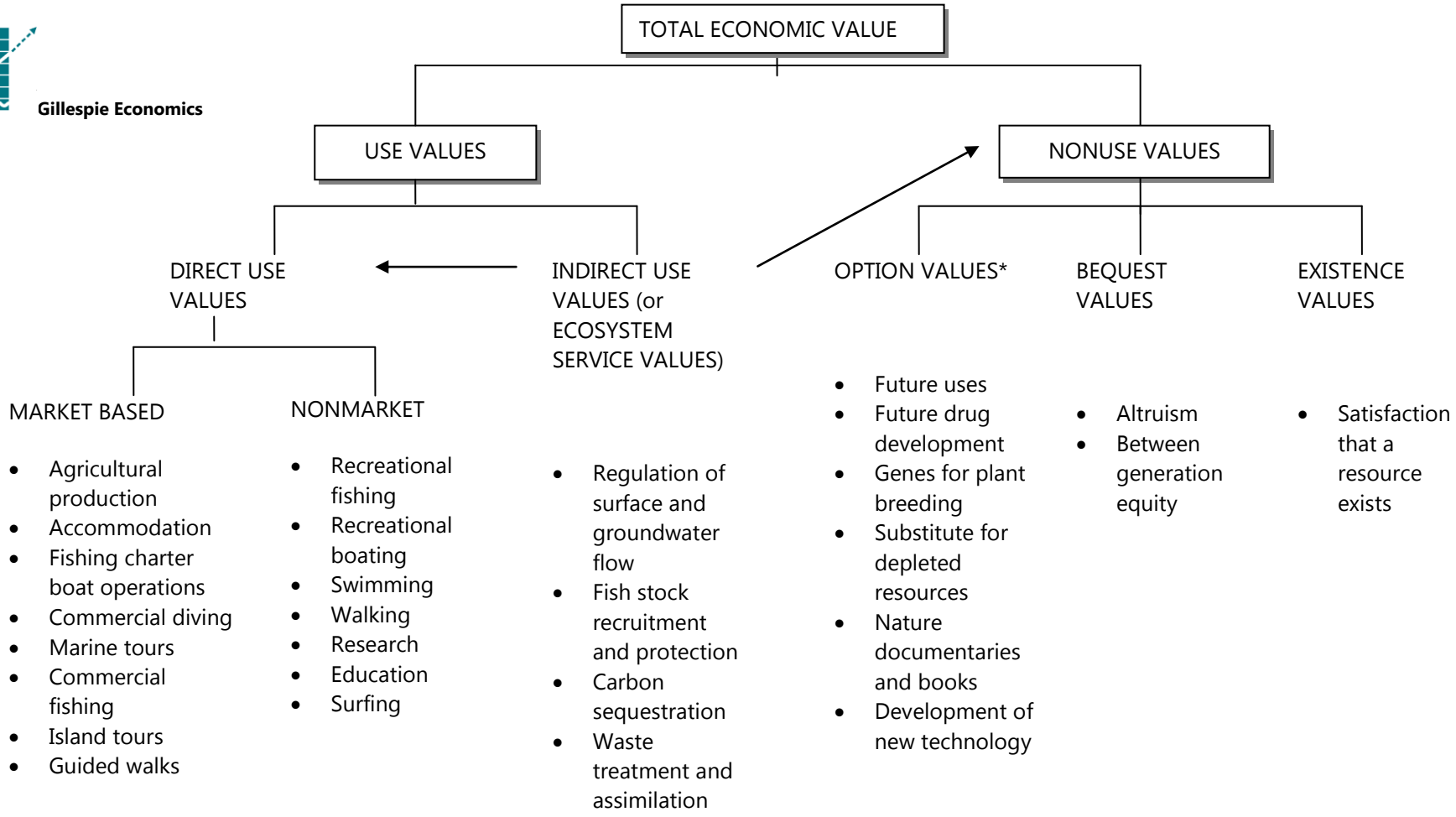


Figure 2.1 - Components of Total Economic Value of Lord Howe Island and Surrounds: Use and Nonuse Values

* includes option, vicarious and quasi-option values

Adapted from Young (1992), p. 23.

2.2 Measures of Economic Value

The conceptual framework for identifying and estimating economic values is the supply and demand, or market, model. Appendix 1 provides a detailed explanation of this framework.

The net benefits to consumers from a good or service are referred to as consumers' surplus and are estimated by the difference between what an individual would be willing to pay (WTP) (demand) for a good or service (the total benefit to the consumer) and what they have to pay (the cost to the consumer i.e. consumer expenditure or price times quantity) (Edwards 1990).

The net benefits to producers are referred to as producers' surplus and is estimated as the difference between the revenue (consumer expenditure) received for a good or service (total benefit to producer) and the costs of the inputs used in the provision of the good or service (economic cost to producer) (Edwards 1990). In practical terms, it is the net revenue (before tax) that is earned by producers of goods and services (James and Gillespie 2002).

Use values associated with tourism and recreation on LHI include:

- benefits to tourists (i.e. consumers) as measured by their WTP for the experience over and above what they actually have to pay (consumers' surplus); and
- benefits to tourism operators (i.e. producers) as measured by net revenue (producers' surplus).

Use values associated with Kentia Palm and vegetable production relate to the net revenue (producers' surplus) from production.

Nonuse values associated with the conservation of the natural environment are measured by the WTP of the community for conservation over and above what they actually have to pay.

While some studies have attempted to measure the TEV of environmental resources (e.g. Constanza et al. 1997), this is problematic since economic valuation methods for nonuse values can only be used to estimate a change in TEV as a result of a project or policy rather than total values. Also, what is relevant from a policy perspective is how components of TEV are likely to change "with" and "without" a policy. Hence, only a subset of total economic values may require investigation. This is the focus of CBA which is discussed in Section 3 and applied to the REP in Section 4.

3 Overview of Cost Benefit Analysis

3.1 Introduction

This Section provides some background information on the CBA method and key parameters used in the CBA of the REP. The application of CBA to the REP is then provided in Section 4.

3.2 CBA Method

Economic assessment is primarily concerned with identifying changes in aggregate wellbeing (consumers' and producers' surpluses) from alternative uses of resources. CBA is the standard technique applied to consider these wellbeing changes. It provides a comparison of the additional costs and benefits to society "with" a project, policy or program, relative to "without" the project, policy or program. Costs are measured in terms of reductions in producers' surplus (i.e. net revenues) and consumers' surplus (i.e. benefits to consumers), while benefits are measured in terms of increases in producers' or consumers' surpluses.

Taking into account the timing of the benefits and costs through the process of discounting, provided the present value of additional benefits exceed the present value of additional costs (i.e. a net present value (NPV) of greater than zero or a benefit cost ratio (BCR) of greater than one), a project, policy or program is considered to improve the wellbeing of society and hence is desirable from an economic efficiency perspective.

3.3 Definition of Society

CBA includes the consideration of costs and benefits to all members of society i.e. consumers, producers and the broader society as represented by the government.

The most inclusive definition of society includes all people, no matter where they live or to which government they owe their allegiance (Boardman et al. 2001). However, in practice most analysts define society at the national level[12] based on the notion that the citizens of a country share a common constitution that sets out fundamental values and rules for making collective choices and that the citizens of other countries have their own constitutions that make them distinct societies (Boardman et al. 2001).

The CBA of the REP reported here is undertaken from a national (Australian) perspective (as funding arises from both national and state sources). It is recognised that some tourism benefits of the REP accrue to international tourists, however, the international market remains a small percentage of arrivals to LHI (LHI Tourism Association 2015). While biodiversity values from the REP may accrue to households outside of NSW, the studies from which estimates for biodiversity values

[12] While most applications of CBA are performed at the national level, "to incorporate national distinctions in a CBA is far easier said than done. Thus many CBAs end up estimating the net benefits for global society, if only implicitly" (Bureau of Transport Economics 1999, p. 2).

were obtained only surveyed NSW households and it is not appropriate to extend these values outside of the population that was surveyed. Hence, only biodiversity values for NSW households are included in the analysis, implicitly and conservatively assuming that no values are held by households outside of NSW.

3.4 Valuation of Market and Nonmarket Costs and Benefits

Valuation of costs and benefits first requires quantification of the physical impacts of policies, which relies on the assessment of other experts e.g. tourism experts to identify impacts on visitation, ecologists to identify impacts on species extinctions etc. Only once the magnitudes of physical effects are identified can they be valued using market and nonmarket valuation methods. For the CBA of the REP, physical quantification of impacts relied on expert advice from the NSW Office of Environment and Heritage and the Lord Howe Island Board, consultations with affected stakeholders and review of other studies.

Valuation of all impacts is neither practical nor necessary. Only those impacts which are likely to have a material bearing on the outcome of the analysis need to be considered in CBA (NSW Government, 2012). Where benefits and costs cannot be quantified these items should be included in the analysis in a qualitative manner (NSW Treasury, 2007; NSW Government, 2015). The focus in the CBA of the REP was on the main impacts of the REP.

3.5 Risk and Uncertainty

The net present value (NPV) estimates presented in some *ex-ante* cost benefit analyses are based on future values being achieved with certainty. However, future values are subject to risk and uncertainty. In economic analysis, there is a difference between risk and uncertainty. Risk is measurable; it refers to situations with known probabilities. Uncertainty in contrast is vague; as it is characterised by a lack of information on the likelihood of occurrence of different impacts.

One way of incorporating risk into a CBA is to use expected values instead of certain values. This requires the range of potential outcomes being assigned probabilities. Expected values are the certain values multiplied by the probability of their occurrence. Where outcomes require a sequence of future events to occur, expected values will depend upon the product of the probabilities of each sequential event. The result is an expected net present value (ENPV).

When uncertainty is encountered in an economic appraisal, the most commonly applied technique is sensitivity analysis. This involves changing the values of critical variables in the analysis to determine how the overall CBA results might be affected.

For the REP CBA, where probability information was available, expected values were calculated. For these and other variables, sensitivity testing was also undertaken.

3.6 Evaluation Period

All costs and benefits attributable to a project, policy or program should be included in the CBA in the year that they occur and hence the period covered by the evaluation needs to be long enough to capture them. Due to the discounting of future costs and benefits to present values, once a project period of more than 30 years is reached, the analysis will be relatively insensitive to the choice of a longer project period (NSW Treasury 2007). The analysis period used for the REP CBA is 30 years.

3.7 Discounting

Costs and benefits occurring in different time periods require discounting to present value so that the benefits can be compared to costs on a common basis. Discounting reflects the fact that individuals and society prefers a dollar today than a dollar in the future.

There are two main approaches to determining the appropriate discount rate:

- the social time preference rate (STPR) - consumer's rate of time preference i.e. society's view of what at the margin is an appropriate tradeoff for individuals between now and the future.
- the social opportunity cost of capital (SOC) - represents real return on capital or producer's rate of discount (NSW Treasury 2007).

In NSW, the discount rate set by the NSW Treasury is 7% with sensitivity testing at 4% and 10%. The lower figure is indicative of STPR and the higher figure indicative of SOC (NSW Treasury 2007). These are the discount rates used in the REP CBA.

3.8 Consideration of the Distribution of Costs and Benefits

While CBA, undertaken at different scales, can provide qualitative and quantitative information on how costs and benefits are distributed, welfare economics and CBA are explicitly neutral on intra and intergenerational distribution of costs and benefits. There is no welfare criterion in economics for determining what constitutes a 'fair and equitable' distribution of costs and benefits. Judgments about intra and intergenerational equity are subjective and are therefore left to decision-makers.

Nevertheless, it should be noted that the costs and benefits included in a CBA are defined and valued based on the values held by individuals in the current generation. There is no way to measure the value that future generations may hold for impacts of current day projects as they are not here to express it. However, as identified by Boardman et al. (2001) this is not considered a serious problem for CBA because:

- Few policies involve impacts that only appear in the far future. Consequently, the WTP of people alive today can be used to predict how future generations will value them;
- Most people alive today care about the wellbeing of their children, grandchildren and great grandchildren, whether or not they have yet been born. They are therefore likely to include the interests of these generations to some extent in their own valuations of impacts. Because

people cannot predict with certainty the place that their future offspring will hold in society, they are likely to take a very broad view of future impacts; and
- Discounting used in CBA also reduces the influence of costs and benefits that occur a long way into the future.

Furthermore, increased wealth generated by projects that have a net benefit to the current society can be used to improve the services (e.g. health, school and community services) and the environment (e.g. protected areas) that are passed on to future generations.

As identified by the Productivity Commission (2006), a policy option that provides the highest net benefit, as indicated by CBA, would also be consistent with the principles of ecologically sustainable development.

3.9 Consideration of Other Objectives of Government

CBA does not address other objectives of governments. Decision-makers therefore need to consider the economic efficiency implications of a project, as indicated by CBA, alongside the performance of a project in meeting other often conflicting goals and objectives of government.

3.10 Key Steps in Cost Benefit Analysis

The key steps in CBA are summarised in Box 3.1.

Box 3.1 - Steps in Cost Benefit Analysis

- determination of the scope and objectives of the analysis;
- identification of the constraints (financial, distributional, environmental and so forth) on meeting the objectives to ensure that all alternatives examined in the analysis are feasible;
- identification of the "without" proposal case (base case or counterfactual) as well as alternatives to be examined;
- identification of incremental costs (capital expenditures, operating and maintenance costs, labour costs, opportunity costs, harmful effects on other parties and so forth) and incremental benefits (value of outputs, avoided costs, productivity savings, health, social or environmental benefits and so forth) of alternatives relative to the "without" proposal case;
- quantification/valuation of costs and benefits, including adjustment of private costs and benefits into social ones; that is, costs and benefits that reflect losses and benefits to the economy as a whole, rather than to individual persons or groups. For example, estimates of 'shadow' prices may be required when market prices do not reflect the true opportunity cost of using a resource, and taxes on outputs would be included as a benefit;
- calculation of net present value; that is, total benefits less total costs occurring in each time period, discounted to present values or other decision criteria such as benefit cost ratio and internal rate of return;
- application of sensitivity analysis; that is, calculating the net present value or other decision criteria using different assumptions about key determinants of costs and benefits;
- consideration of equity issues (identification of groups or communities which loses or gain from the project or program) and 'intangibles' (costs and benefits which cannot be assessed in monetary terms).

Source: Adapted from RAC 1992, p. 36.

4 Cost Benefit Analysis of the Rodent Eradication Project

4.1 Scope and Objectives of the Analysis

The objective of this CBA is to examine whether the LHI REP improves or reduces the aggregate well-being of the Australian society and hence whether it is desirable from an economic efficiency perspective. In doing this, it is also an objective of this analysis to identify the specific costs and benefits to the residents of LHI.

4.2 Constraints

If the benefits of the LHI REP exceed the costs, then on economic efficiency grounds, it is desirable to go ahead with the investment. However, it is understood that if the REP poses an unacceptable health risk to the people of LHI or the environment then it will not proceed. In this respect, a Human Health Risk Assessment has been prepared by Toxikos (2010) and reviewed by Pacific Environment Limited (2015), and the results of these reports have been relied on in this CBA. However, an additional Human Health Risk Assessment is currently being undertaken under the guidance of the NSW Government Chief Scientist. Environmental risks are considered in various Commonwealth and State environmental approvals processes.

4.3 Specification of the "With" and "Without" Rodent Eradication Project[13]

A starting point for the CBA of the LHI REP is the specification of the base case or "without" REP scenario and the "with" REP scenario. The former is necessary because the costs and benefits of the "with" REP scenario are additional to what would have happened had the REP not gone ahead.

4.3.1 The "Without" Rodent Eradication Project Scenario.

The base case or 'without' REP scenario for this analysis is the continuation of the current rodent control program. Control is distinct from eradication. It aims to keep the negative effects of rodents within acceptable limits, but its ongoing nature brings with it a continuing financial cost. It also brings an increased potential for negative impacts to the environment and on human health caused by the ongoing presence of poison in the environment (LHIB 2009). This is because even with the rodent control program (covering approximately 10% of the island) in place, neither the rat or mouse population is being reduced to a level that reduces landscape scale ecological impacts. Rodent population estimates from the entire island range from 63,000 to 150,000 rats and 140, 000- 210,000 mice (30 -74 rats per hectare and 67-100 mice per hectare) (LHIB 2016e).

[13] The description of the "with" and "without" scenarios is based on LHIB (2016d).

Since the 1920s numerous methods of control have been tried on LHI including a bounty on rat tails, hunting with dogs, introduction of cats and owls and the use of various poisons including barium chloride, diphacinone, warfarin. The prolonged use of warfarin has led to house mice becoming resistant to this poison (LHIB 2009).

Over time, the bait that the LHIB has used for rodent control has changed from warfarin to coumatetralyl, largely due to the LHIB being unable to source commercial quantities of warfarin as a consequence of rodents being largely resistant to it on the mainland. The coumatetralyl based bait currently used (in the product Ratex at a concentration of 0.38g/kg) is a first generation anticoagulant that has similar mode of action as warfarin. The LHIB has an Australian Pesticides and Veterinary Medicines Authority Minor Use Permit to apply the bait in stations with 200gm of bait which is replenished five times per annum (approximately every 10 weeks) in order to reduce resistance build up in rodent populations. The LHIB rodent control baiting contract covers the servicing of 1,400 stations over 30 baiting areas across the island.

In addition to the LHIB rodent control contract, coumatetralyl is also supplied by the LHIB to residents who wish to use it on their properties. In 2015, the Board purchased 192 x 15 kg buckets (total of 2880kg) of Ratex grain bait containing coumatetralyl for use in its rodent control program to be used by both Board and leaseholders on the Island for rodent control. In the 6 months from January to the beginning of July 2016, the Board has used and provided to residents approximately 700kg of Ratex grain bait for rodent control on Lord Howe Island.

In addition, many Island residents also purchase Brodifacoum based rodenticides such as Talon™ and Tomcat™ (generally at concentrations of 50 mg/kg) to control rats and mice around their properties. As residents can purchase this locally or directly from the mainland, exact quantities used are unknown but it is estimated to be around 400kg per year over the 54 ha residential area. This equates to approximately 7.4kg/ha per year of Brodifacoum based products alone.

Anecdotal evidence suggests that a large percentage of residents in the settlement areas use commercially available Brodifacoum based rodenticides in off label situations (i.e. not in accordance with product label conditions) for their individual rodent control programs. This includes the use of Brodifacoum products in the open, away from buildings, in gardens or in combination with other products. Project Staff assisting with baiting through the settlement areas during the LHIB's scheduled baiting program have shown that as many as 1 in 3 residents are using Brodifacoum products such as Talon™ and Tomcat™ (50ppm Brodifacoum) exclusively or in conjunction with LHIB provided bait, Ratex- coumatetralyl. The main reason given by residents for this supplementary baiting is the perceived view that the bait provided by the LHIB is not as effective at controlling rodents, particularly mice, as the Brodifacoum based commercially available products.

The present control baiting program is primarily limited to the settlement area. It does not occur in the other parts of the Island with the exception of small areas of high conservation value. Widespread control is simply not practical given the large area and rugged terrain. There is also a significant risk that through ongoing control (and the continuous presence of poison baits) the island group's rodent populations will develop bait shyness or a resistance to current rodenticides.

Mice have already developed a resistance to warfarin. The suite of second-generation anticoagulants, which includes Brodifacoum, is the only tool currently available for effectively eradicating rodents from islands. Resistance to these poisons, if it develops, will make eradication impossible and will greatly restrict control. Studies show that within benign laboratory conditions, rats succumb to the bait as expected while mice currently take approximately three weeks.

If eradication is not attempted, the above ongoing rodent control will be required, although the rodenticide used may change periodically. Continued rodent control program will be associated with:

- ongoing impacts to biodiversity including population declines and potential extinctions as a result of rodent predation and competition;
- the continuous presence of poison baits in the environment, essentially in perpetuity. This presents ongoing risks of poisoning for non-target species and high probability that rodents will develop a resistance to poison;
- potential further degradation of World Heritage values (including endemic and threatened species) and the potential for the LHIG to be inscribed on the "World Heritage in Danger List"; and
- ongoing socio-economic impacts associated with rodents (LHIB 2016e).

4.3.2 The "With" Rodent Eradication Project Scenario

The "with" REP scenario is as follows.

Baiting Protocol

The Pestoff 20R bait (20mg/kg Brodifacoum) will be distributed at a total nominal dose rate of 20 kg/ha (12kg first application + 8kg/ha second application) of bait. This equates to 0.4 g of Brodifacoum/ ha. At this application rate, approximately 42 tonnes of cereal based bait (containing a total of 840 g of Brodifacoum) will be required to cover the total island group's three dimensional surface area of 2,100 ha.

Area to be baited

Rats and mice occur throughout LHI, including the settlement. LHI is the only island in the LHIG that is known to contain rodents. However, ship rats are able to swim over 500 m and both rats and mice are difficult to detect at low densities. It is therefore possible that either species occur on offshore islands and islets close to the main island. To minimise the risks of operational failure, the main island and all nearby islands and islets, other than Balls Pyramid and its associated islets, will be baited. The 23 km distance between Balls Pyramid and the main island renders the chances of invasion by rodents very low.

Number of bait applications

The proposal is for aerial and hand baiting to be carried out twice, with the applications separated by about 14 -21 days (depending on the weather) although the number of applications in and around dwellings may be more as it is dependent on the rate of removal by rodents of distributed baits. This will maximise the exposure of rodents to the bait. The proposed application rate for the first bait application is 12 kg of bait per hectare, and 8 kg per hectare for the second application.

Most rodents will be killed by bait from the first bait application, however it is beneficial to carry out a second bait application to eliminate the likelihood of any gaps in the distribution of baits, ensure bait is available long enough to ensure that all individuals receive a lethal dose and to target:

- individuals that may have been denied access to bait distributed in the first application (by more dominant individuals that will now be dead), and
- any surviving young that have recently emerged from the nest.

The operation is programmed to take place in winter 2017 (June-August), when the availability of natural food for rodents is low and breeding is greatly reduced or absent. This is also a period when most seabirds are absent from the LHIG. Bait application will be timed to avoid periods of predicted heavy rainfall (as this may prematurely dissolve the bait) and therefore weather will influence the actual timing of the two bait applications.

Weather forecasts of rainfall and wind speeds will be obtained from the Bureau of Meteorology station on LHI from June onwards. A forecast of less than 15 knots and four fine days (three fine nights) without significant rainfall (less than 6 mm daily) is preferred for each application. Operational wind speeds to cease operations will be developed in conjunction with the helicopter operator and any permit conditions issued by the Australian Pesticides and Veterinary Medicines Authority. The NZ Code of Practice requirement is that no aerial baiting will occur on buffer boundaries in winds greater than 20 km/h.

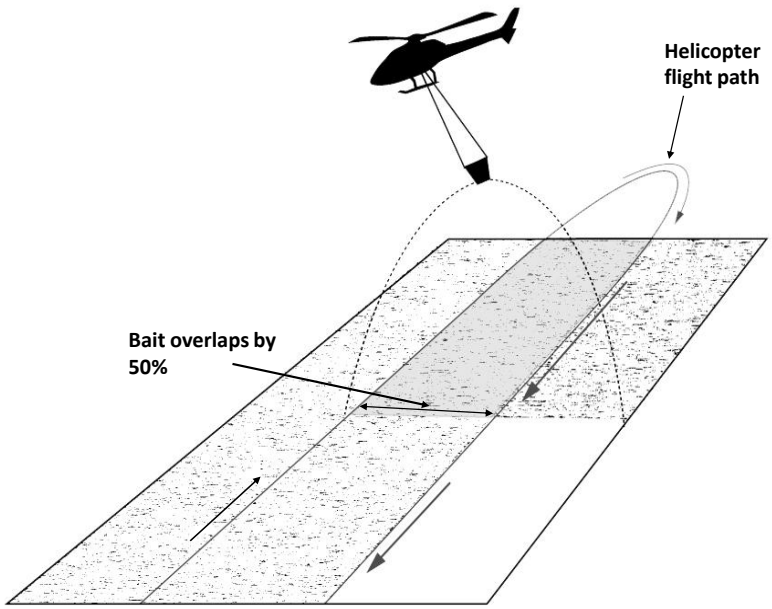
Aerial baiting

Aerial baiting will be conducted throughout the LHI Permanent Park Preserve and other areas of the main island excluding the settlement area and identified buffer zones which will be baited by hand or bait stations. In all areas baited aerially, 10 mm baits (approximately 2g each) will be broadcast at a density of 12 kg/ha (one bait every two square metres) for the first application and 8kg/ha for the second application.

The bait will be dispersed using a purpose built spreader bucket slung below a helicopter. A rotating disc throws the bait 360^{o}consistently to 35 m (note outlier pellets may be thrown to 45 m); enabling a swathe of up to 70 m to be baited in a single pass.

Overlapping (50%) each swathe will ensure that there are no gaps in the distribution of baits. Application rates are adjusted to account for the 50% overlap (i.e. for the first application 6kg/ha on each swathe with 50% overlap will be applied to achieve a 12kg/ha application rate) (see Figure 4.1).

Figure 4.1 - Aerial Application Method



2

Each bait application will take approximately two days to complete dependent on weather.
In order to achieve the required baiting density on the cliffs and steep slopes (particularly around Mt Gower and Mt Lidgbird) several horizontal flight lines will be flown at approximately 50m vertical spacing along these areas to ensure adequate bait coverage. Baiting around the coast line will occur above the mean high water mark to minimise bait entry into the marine environment. A deflector arm can be attached to the spreader bucket to restrict the arc of the swathe to 180^{o}and will be used particularly when baiting the edge of buffer zones and to minimise bait entry into the marine environment when baiting coastal areas. The dose rate, bait direction and swathe width can all be controlled within set limits and will be adjusted as required for specific requirements for different types of flight lines (inland, coastal or buffer zone). Other aerial dispersal options include the turning off or removal of the spinning motor on the spreader bucket which will result in bait trickling vertically below the helicopter for narrow areas if required. The combination of techniques will enable all terrains on the LHIG to be effectively baited. The exact method of distributing bait aerially on LHI will be finalised in consultation with the helicopter contractors.

Buffer zones for aerial application to individual properties will be agreed with the relevant occupiers and in accordance with relevant regulations and considering outliers from the bait swath. The LHIB has committed that aerial baiting would be no closer than 30m to dwellings. In these buffer zones bait will either be applied by hand or if agreement to the contrary is not reached, then the buffer zone will extend to 150 m, and will be baited by hand. This will be covered in a Property Management Plan for each property. 30m buffer zones will also be established around containment areas for the dairy herd.

GPS will be used to guide the helicopter along a set of pre-determined flight lines designed to ensure that all areas are adequately baited. Computer-generated plots of the actual path flown will be inspected after the flight to confirm that this has been done. Any identified gaps will be treated. Flight-path height will be set at an altitude that ensures effective and safe baiting. It will be determined in discussion with the helicopter operator, and take into account topography, weather conditions, aircraft safety and the need to avoid significant disturbance to roosting birds. This baiting technique is similar to (and is based on) established techniques for other island pest eradications undertaken worldwide. In Australia this technique has been used on islands such as Montague and Broughton islands in New South Wales and Hermite Island in Western Australia. It was also used on World Heritage listed Macquarie Island in Tasmania over autumn and winter 2011.

The aerial baiting technique has been trialled on LHI with non toxic bait and a custom built spreader bucket (LHIB, 2007). The trials have shown aerial baiting to be an effective technique that could be utilised in an operation on Lord Howe Island. The trial provided an opportunity to establish the correct flight configuration: air speed and settings to produce the required flow rate to achieve the on grounds density of bait during operations. Methodologies for loading procedures, and determination of bait usage on flight runs were developed for use in future baiting operations.

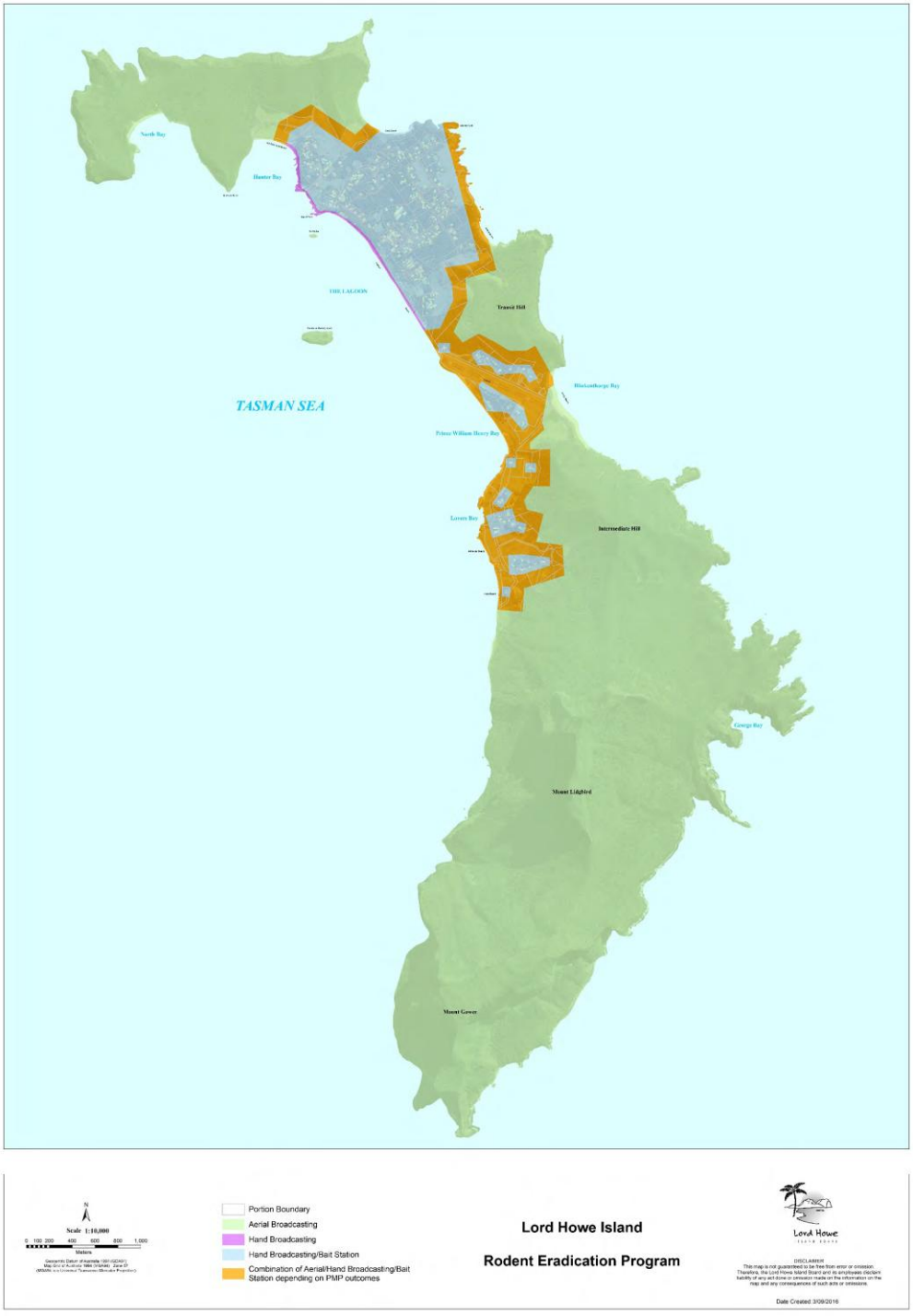
Further detailed calibration of the equipment with non toxic baits (i.e. helicopter, spreader bucket, GPS equipment etc) will be undertaken immediately prior to the operation as part of an operational readiness check overseen by an international eradication expert from the New Zealand Department of Conservation's Island Eradication Advisory Group.

Hand broadcasting of bait

Hand broadcasting of bait will be conducted concurrently with aerial baiting. It will be undertaken throughout the settlement area where agreed by residents under individual Property Management Plans and in buffer and exclusion zones (i.e. the lagoon foreshore and Ned's Beach). In the settlement area, either 10mm (2g each) or 5.5 mm Pestoff baits (0.6 g each) will be hand-broadcast at a density of 12 kg/ha for the first application of bait and at 8kg/ha for the second application (one pellet every 2 square metres for 10 mm pellets or one pellet every half square metre for 5.5 mm pellets).

Provisional areas to be hand-baited are shown in Figure 4.2 however this is subject to completion of individual Property Management Plans.

Figure 4.2 - Indicative Treatment Areas by Method



Source: LHIB (2016e)

Trained personnel will move through such areas and apply bait at the designated rate. All personnel will carry a GPS unit capable of continuously tracking their path. Computer-generated plots of their paths will be used to check baiting coverage. The aim will be to distribute baits in

garden beds and other areas of vegetation around dwellings, rather than broadcast on lawns. These details will be contained in the individual property management plans which will be established between property occupiers and the LHIB.

It is essential that all hand-broadcast bait be out in the open so it is subject to degradation by weathering. No bait will be hand-broadcast directly in or under buildings where it will not be subject to weathering.

Bait stations

Commercially available or specifically designed bait stations will be used where aerial or hand broadcasting cannot be undertaken. Bait stations will also be placed within all areas containing livestock (i.e. dairy herd, horses and goats). These bait stations used in livestock areas will be designed specifically to be able to withstand interference and trampling by stock. Where practicable, and with the agreement of householders, small amounts of bait in open containers ('bait trays') similar to commercial products currently available, will be placed within buildings including kitchens, pantries, pet food storage areas etc. Where possible, bait trays will also be put in accessible roof spaces and under-floor cavities.[14]

All bait trays and bait stations will be monitored regularly and bait replenished as necessary for approximately 100 days after the second baiting (this could be longer if surviving rats or mice are detected). Bait take will provide an indication of rodent activity. Bait in these locations will not be exposed to weathering, and so any remaining bait will be removed after approximately 100 days or after mice or rats are no longer detected.

When using bait stations or trays it is important that they are set close enough together that individual rats and mice come across at least one station during their nightly movements. Rats are wide-ranging and can be eradicated using a grid spacing of 25 m. Mice, however, are not as wide-ranging, and require a grid spacing as close as 10 m.

It is expected that the combination of hand broadcasting and setting and arming of bait stations will take approximately 5 days each application (coinciding with the aerial application) dependant on results of the property management plan process and actual staff numbers.

Property Management Plans

The Property Management Plans include the agreed baiting methods for each lease on the Island, including the settlement area. They are discussed and negotiated with the leaseholders / residents individually and consider mitigation of specific risks and areas of concern on individual properties (such as presence of children, pets, drinking water and vegetable gardens). The property management plans include details of where and how hand baiting or baits would occur on the individual property.

[14] There is a potential for currently registered Brodifacoum products to be used in accordance with label conditions by residents in some dwellings. This will be considered on a case by case basis assessing higher palatability of pellets vs. higher dosage, quality control and resident acceptability.

Elimination of survivors

The settlement area and other selected areas of LHI will be monitored for the presence of rodents throughout the 100-day period of the baiting operation. Detection of surviving rodents will be evidenced by bait take from bait trays and bait stations and observations of droppings or rodent activity. Residents will be asked to report any such evidence to the project team. In addition, trained detector dogs will be deployed throughout the settlement area to find and locate any surviving rodents. In the unlikely event that rodents are detected, action will be taken to eliminate them. A Contingency Plan will be developed prior to the REP to guide selection of appropriate actions in the event that surviving rodents are detected. This could include targeted hand baiting or bait stations.

Ongoing Monitoring

Monitoring of the rodent-free status of LHI following the eradication of rats and mice will be achieved by monitoring for rodent activity at bait stations, in tracking tunnels strategically placed at stratified locations across the island and with the use of rodent detector dogs. This will form part of the island's permanent rodent detection and prevention system initiated as an integral part of the island's biosecurity program which will be upgraded in parallel with the REP.

4.3.3 Comparison

A fundamental starting point for the CBA is that "with" the REP, rodents will be eliminated from Lord Howe Island. "Without" the REP the control program will need to continue with periodic changing of poison due to increasing bait shyness and resistance over time. However, under the "without" REP scenario the rodent population is likely to remain unchanged in the long run. If alternative poisons do not become available over time to counteract bait shyness and resistance, adverse impacts on the environment, tourists and residents would escalate over time as the control program becomes less effective in controlling rodent populations.

4.4 Identification of Incremental Costs and Benefits

Relative to the "without" scenario of continuing the control program, the REP is likely to have a range of potential incremental costs and benefits as shown in Table 4.1.

The main potential economic benefits of the REP relate to avoided ongoing rodent control costs, biodiversity improvements, tourism benefits and benefits to the Kentia Palm and vegetable industry. The main potential costs are the direct costs of implementing the REP, any reductions in tourism (short term) as a result of the REP and any risks to non-target species and human health.

Each of the potential incremental costs and benefits identified in Table 4.1 are investigated, quantified and, where possible, valued in the following subsection.

Table 4.1 - Potential Incremental Costs and Benefits of the LHI REP

Category	Costs	Benefits
Direct costs	REP direct implementation costs	Avoided ongoing rodent control costs - LHI and residents
Biodiversity	Potential for species extinction from the REP Costs of returning extant species to LHI	Biodiversity improvements - prevention of additional extinctions - increased abundance of species - return of extant species to LHI
Tourism	Foregone tourism business during REP implementation	Additional demand for accommodation during REP implementation Additional tourism business after REP implementation
Palms and vegetables		Increased productivity for Kentia Palm and vegetable industry and avoided direct costs Increased productivity of other vegetable gardens
Health and toxicity	Potential impacts on other species, water and human health	Reduced impacts to humans, livestock and pets from constant presence of rodent poison Elimination of health impacts from rodents for residents and tourists
Wastage and amenity		Elimination of spoiled foodstuffs and the presence of rodent excrement on LHI
Research		Research benefits of the program

4.5 Quantification and Valuation of the Costs and Benefits

4.5.1 Direct Costs

Without the REP, the current rodent control will continue at an annual cost to LHIB of approximately $85,000. In addition, many Island residents also purchase Brodifacoum based rodenticides such as Talon™ and Tomcat™. The quantity purchased by residents is estimated to be around 400kg per year (LHIB 2009). The cost of this rodenticide is assumed to be $12/kg (based on sales price from www.easypestsupplies.com.au). These costs to LHIB and residents would be avoided with the implementation of the REP and hence are a benefit of the REP.

The REP direct implementation costs include:

- future planning costs;
- bait purchase and distribution;
- building enclosures and capture and management of species during baiting;
- destocking and restocking (beef cattle and fowl);

- dog boarding or muzzling;
- dairy cows separated from bait and milk tested prior to human consumption;
- preparation and implementation of property plans;
- additional quarantine measures for incoming boats and planes;
- additional research as part of environmental approvals;
- administration costs;
- ongoing monitoring.

All costs will be borne by LHIB (funded from Government grants), including preparation and implementation of property plans. LHI estimate capital costs at $10.6M, although approximately $1.5M of this has already been spent and hence in accordance with NSW Treasury (2007) is excluded from the analysis.[15] Incremental ongoing biodiversity monitoring costs associated with the REP are estimated at $50,000 per year for 10 years, with ongoing rodent detection (quarantine) costs of $30,000 per year. In this respect, LHIB have resolved to implement an improved Biosecurity Strategy for LHI, regardless of whether the REP is implemented. Only incremental rodent quarantine costs as a result of the REP are therefore included in the CBA.

4.5.2 Biodiversity

The population of rodents on LHI is estimated at around 63,000 to 150,000 for rats and 140,000 to 210,000 for mice (LHIB 2016e). Both species have had, and continue to have, significant adverse impacts on the biodiversity of LHI. Ship rats are implicated in the extinction of at least five endemic birds and at least 13 invertebrates. They are also a recognised threat to at least 13 other bird species, 2 reptiles, 51 plant species, 12 vegetation communities and numerous threatened invertebrates (LHIB 2009).

The impact of house mice on biodiversity of LHI is not as well understood, however, evidence elsewhere shows that they eat eggs of small birds, reduce seedling recruitment of some plants, and compete with native seed-eating fauna. On other islands, mice have been implicated in declines of invertebrates, and in some cases this has greatly affected nutrient recycling processes (LHIB 2009).

Continuation of the current control program is anticipated to result in additional extinctions on LHI over the next 20 years, particularly of invertebrates (LHIB 2016e). The OEH estimate additional extinctions of five land snails and two plants species over the next 20 years[16] under the base case. The practice of using off-label rodenticide by residents has also been demonstrated to indiscriminately poison birdlife on the Island as a secondary poison occurrence.

The biodiversity benefits of implementing the REP therefore include:

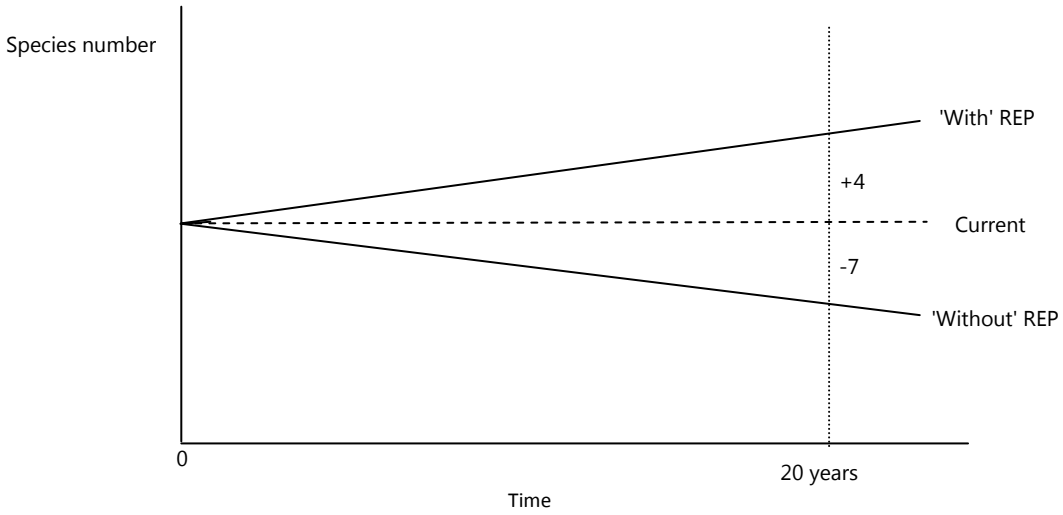
- avoiding additional extinctions on LHI;
- the ability to return extant species (due to the predation of rats and mice) such as the Kermadec petrel, White-bellied storm petrel, phasmid and wood feeding cockroach;

[15] In accordance with normal practice those costs are sunk costs and are omitted from the analysis as they cannot now be avoided or changed and therefore do not influence the net benefits of the alternatives being evaluated.
[16] 20 years is used here as the choice modelling study from which WTP values are transferred was based on this time frame.

- a marked increase in the abundance of plants, birds, reptiles and insects.

The net impact on species numbers is illustrated in Figure 4.3.

Figure 4.3 - Native Species on LHI 'With' and 'Without' the REP



Economic benefits of species conservation are reflected in the experience of people who visit LHI and observe the biodiversity (use values) and by those who obtain an increase in their wellbeing from knowing that there has been an improvement in biodiversity (non-use values). The former category of values is discussed under Tourism in Section 4.5.3 below.

Non-use values are measured by people's willingness to Pay (WTP) to obtain that biodiversity outcome and can be estimate via stated preference methods such as choice modelling (CM). In the absence of specific study for LHI, benefit transfer (BT) is used to provide an indication of the possible non-use values arising from the REP.

The use of BT means that valuation is limited to those attributes and species that have been included in other studies. Pandit et al (2015) undertook a global review of nonmarket valuation studies of threatened species and ecological communities. They reviewed 76 papers and found that there is strong evidence that the broader community does support and is WTP for protection and recovery of threatened species. However, the values of threatened species and ecological communities varied considerably based on species valued and the sample population. In a meta analysis covering 31 studies, Richardson and Loomis (2009) found a WTP for species range from $8 per household per year to a maximum of $311 per household per year. Of the 76 studies examined by Pandit et al (2015), 89 were overseas studies and therefore are not ideally suited to BT to Australia. The Australian studies examined are also not well suitable for BT to the current study since they related to specific species such as the Northern Hairy Nose Wombat, Tree Kangaroo etc and used methods (such as the contingent valuation method) that are difficult to use for BT.

Two Australian studies using a state of the art non-market valuation method (i.e. Choice Modelling - CM) and including a protection (from extinction) of native species attribute are those by Van Beuren and Bennett (2000) and Mazur and Bennett (2009).

Van Beuren and Bennett (2000) in a survey of Australian households found an average WTP of $0.68/household/year (for 20 years) i.e. $7.20 per household (present value), per species protected from extinction. Aggregating per household benefits to the community requires adjustment for the survey response rate since not all the originally targeted respondents participated in the survey and it is difficult to determine the preferences of non-respondents. A conservative approach is therefore to assumed that non-respondents were unwilling to pay for environmental improvements (Greyling and Bennett 2012).

The response rate for the questionnaire was 16%. Adopting a conservative approach and aggregating to this percentage of Australian households gives an economic value estimate of $8.5M per species protected from extinction in Australia.

Mazur and Bennett (2009) undertook a CM study to acquire information about different NSW community (local resident, distance rural and distance urban) attitudes and preferences for environmental improvements provided by a range of potential natural resource management (NRM) strategies in three NSW catchments (Lachlan, Namoi and Hawkesbury-Nepean).

The attributes used to describe different environmental improvements included an attribute for the number of native species protected (from extinction in each of the catchment). The context for elicitation for these values was a decline in native species numbers from the status quo over a 20-year period without any natural resource management (NRM) actions and an increase in native species numbers relative to the status quo with NRM actions. This is the same as the context for the LHI REP. Community average WTP (implicit prices) estimates per household per annum for five years per species protected are provided in Table 4.2. Households from three different community types were sampled: Rural communities near the areas where the species lived, urban communities distant from the areas and rural communities located at a distance. Statistically significant values range from $2.43 to $6.97 per household per annum for five years.

Table 4.2 - Implicit Prices Per Household Per Annum for Five Years for Protection of a Native Species

Catchment	Community Type		
	Local Rural	Distant Urban	Distant Rural
Hawkesbury-Nepean	$6.97**	$5.25**	$4.97**
Lachlan	$4.51*	$8.11**	$7.45**
Namoi	$2.50*	$2.43*	$1.79

*Statistically significantly different from zero at the 5% level

** Statistically significantly different from zero at the 1% level

Source: Mazur and Bennett (2009) and Greyling and Bennett (2012).

Response rates for the questionnaires varied from 30% for Sydney households to 60% for rural households (Greyling and Bennett 2012). Conservatively, aggregating the lowest value per species across NSW households using the lowest response rate gives an economic value of $8M per species protected from extinction in the region. This is the value used in this analysis.

However, there is risk and uncertainty associated with the future species outcomes from implementation of the REP. One way that this can be addressed is to weight the certain benefit estimate by the probability of it being realised (Greyling and Bennett 2012) to estimate the expected benefit. For example, a certain benefit estimate of $8M for native species protection from actions with a 50% probability of success results in an expected benefit estimate of $4M.

The probability of re-establishing species post REP or avoiding additional extinctions has two components, the probability that the REP will eliminate rodents and the probability that once this occurs species can be re-established. These probabilities are multiplicative.

Probabilities assumed in this analysis are based on experience of other island eradication projects and expert judgements of OEH ecologists. They are identified in the following table.

Table 4.3 - Probability Assumptions

Event	Probability
Success of REP in eradicating rodents	95%
Success of reintroducing species	
LHI Phasmid - *Dryococelus australis*	100%
LHI Wood-feeding Cockroach - *Panesthia lata*	100%
Kermadec Petrel - *Pterodroma neglecta*	95%*
White Bellied Storm Petrel - *Fregetta grallaria*	95%*
Additional Extinctions "without" the REP	
Four species of land snails -Whitelegge's land snail - *Pseudocharopa whiteleggei* -Masters' charopid land snail - *Mystivagor mastersi* -Mt Lidgbird charopid land snail - *Pseudocharopa lidgbirdi* -Magnificient Helicarionid land snail - *Gudeoconcha sophiae magnica*	100%
One species of land snail - Lord Howe placostylus - *Placostylus bivaricosus*	50%
Phillip Island Wheat Grass - *Elymus multiflorus var. Kingianus*	75%
LHI Passionfruit - *Passiflora herbertiana* ssp. *insulae-howe*i	50%

*If actions are taken to actively attract this species. Hence a cost of these actions is included in the CBA.

The cost of reestablishment of species, subject to successful eradication of rodents, was estimated at $50,000 (OEH ecologists, pers. comms).

In addition to benefits from protection of species, a further benefit of the REP would be an increase in species abundance including:

- a marked increase in birds, reptiles and insect density, diversity and distribution - this boost in diversity will increase food resources for predatory terrestrial vertebrates and potentially lead to population increases which will enrich the experience of both island residents and tourists; and
- increases in the abundance of plants, seeds and seedlings, thereby enhancing the process of forest regeneration (LHIB 2016e).

This benefit remains unquantified in this analysis, although studies have found that the community are WTP for increases in species abundance. For example, Blamey et al (2000) found that Brisbane households were WTP $1.69 each to avoid each 1% decrease in the population size of non-threatened species in the Dessert Uplands of Queensland. This value is not readily transferable to LHI.

Notwithstanding the potential species benefits of the REP, concern has been raised in relation to the potential impacts on soil, water, the marine environment and impact on non-target species. Each of these is considered in below.

The Brodifacoum bait is cereal based and designed to rapidly breakdown following the absorption of water, or after rain. Because of the physical chemical properties of Brodifacoum, it is unable to contaminate groundwater. When Brodifacoum breaks down it binds strongly and rapidly to soil particles with very slow desorption. It doesn't leach from the soil. It is non-toxic to plants, because it is not transported from water or soil into the plant (Toxicos 2010). Soil residual concentrations decline rapidly over time. After aerial application of Talon 20P (0.002% Brodifacoum) over an island off New Zeland, Brodifacoum was not detected in soil when randomly sampled 2, 12, 34 or 210 days post application (Toxicos 2010). Other studies have also found rapid reduction in residual soil concentrations. Notwithstanding, additional tests on LHI will be conducted to test Brodifacoum residues in soil (LHIB 2009).

The REP is designed to ensure that the bait is directed onto land. Nevertheless, it is inevitable that a small amount of bait will enter the marine environment, particularly where cliffs come right to the shoreline. Most of this bait will fall within a few metres of the shoreline and will be subjected to the mechanical effects of wave actions, resulting in disintegration within a few minutes. This, together with the high dilution factor, and the insolubility of Brodifacoum in salt water, means that the potential risk to marine organisms is negligible. The amount of Brodifacoum assimilated into the marine environment will be many orders of magnitude lower than the concentrations known to be toxic to fish (Toxicos 2010).

Research indicates that the LHI woodhen will ingest baits and poisoned rodents in amounts that would be fatal and LHI pied currawongs consume rodents and so would be susceptible to secondary poisoning. To minimise the impact on these two threatened species, a substantial proportion[17] of each population will be taken into captivity on LH and will remain there until baits have disintegrated and pose no further risk (LHIB 2009). Consequently, the likelihood of extinction of the LHI woodhen and LHI pied currawong is considered by LHIB and OEH to be highly

[17] 80-85-% and 50-60%, respectively.

improbable and very unlikely, respectively. (Refer to the probabilities attached to these likelihoods in Appendix 2).

4.5.3 Tourism

Background

Tourism is the main industry on LHI, and is estimated to account for some 90% of total visitation. The industry on LHI is comprised of the accommodation sector, tour operators, and other service providers (Lord Howe Island Tourism Association 2015). There are 22 licensed tourist accommodation properties ranging in size and standard and around 14 tour operators catering for a range of activities from fishing, diving, walking, to more specialist areas such as bird watching and environmental regeneration. Services include bike and water sports hire, retail, transport and food and beverage (Lord Howe Island Tourism Association 2015). Individual operators will have interests in various sectors including accommodation and tour operations, with considerable cross-over of the type of services supplied (Lord Howe Island Tourism Association 2015). However, the majority of tourism operators don't provide accommodation (Bill Monks pers. coms.).

There is also a small core of LHI specialists, who facilitate direct bookings with the public, and in some cases wholesale to the trade (see Table 4.4).

Table 4.4 - Special LHI Distribution Partners.

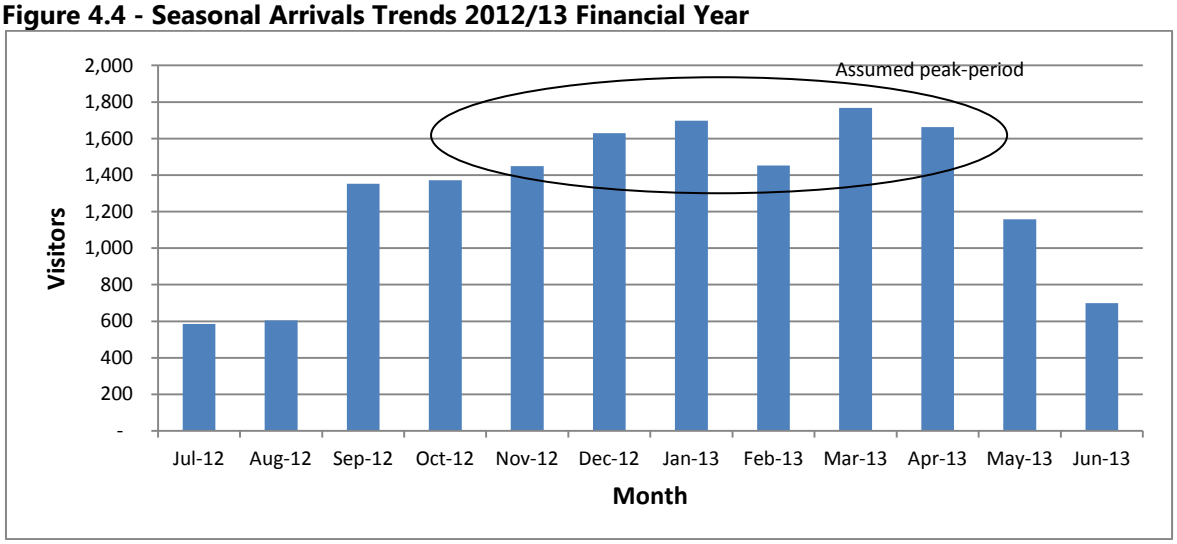
Specialist LHI distributors.	
Oxley Travel	Qantas Holidays
SPACIFICA Travel	All About Travel
Norfolk- Pacific Holidays	Pinetrees Travel Agency
Traveldale Holidays.	
Plus any major group with whom the wholesalers have preferred agreements.	

Source: Lord Howe Island Tourism Association (2015).

The island attracts approximately 15,500 visitors per year consisting of leisure, visiting friends and relatives and business travellers (Lord Howe Island Tourism Association 2015).

The maximum number of tourists on the Island at any one time is constrained to 400 (excluding children under 5) (although bed numbers are higher at about 500) (Lord Howe Island Tourism Association 2015). In this analysis, it is assumed that this constraint is reached in the peak periods of November to April. The remaining months are collectively referred to as the off-peak period in the remainder of this analysis.

Figure 4.4 - Seasonal Arrivals Trends 2012/13 Financial Year



Source: Lord Howe Island Tourism Association (2015)

The attraction of the island is derived from both the natural beauty and the relaxed and peaceful lifestyle that benefits from limited motorized traffic, with bicycles being the main form of transport for visitors, no mobile phone reception, and an absence of security concerns which sees most accommodation properties having no keys to their rooms (Lord Howe Island Tourism Association 2015).

The natural environment, both terrestrial and marine, is however the primary attraction of the island. Extensive fauna, particularly marine life and birdlife, provide a unique and spectacular experience (Lord Howe Island Tourism Association 2015).

The LHIG became a World Heritage site in 1982. In 1999, the waters surrounding LHI and Balls Pyramid were declared a NSW Marine Park, with the waters extending from three to 12 nautical miles offshore becoming a Commonwealth Marine Park in 2000. Around 70% of the Island is incorporated in a Permanent Park Preserve (Lord Howe Island Tourism Association 2015).

The main motivations when deciding to visit LHI are:

- to experience the natural surroundings;
- LHI is undeveloped and unspoilt; and
- there is a range of activities for all ages (Lord Howe Island Tourism Association 2015).

Economics of Tourism on LHI

The conceptual supply and demand framework for peak period tourism and off-peak period tourism on LHI is provided in Appendix 3.

In both peak and off-peak periods there is:

- a benefit to tourists as indicated by their WTP for a visit above their actual expenditure; and
- a benefit to tourism providers by way of normal net revenue (producer surplus).

However, in peak periods where demand exceeds the capacity constraint on accommodation, additional revenue can be earned by accommodation suppliers (with no additional cost) via increased prices.[18]

These values of tourism to LHI are estimated in Appendix 3 based on a variety of data sources.

The net economic benefits of the current levels of tourism on LHI during peak periods are estimated at $16.7m per annum, comprising:

- normal net revenue of $2.9m:
  - $2.2m to accommodation
  - $252,000 to tours
  - $142,000 to shopping
  - $283,000 to meals

- additional revenue from price increases of $3.1m; and
- benefits to tourists of $10.7m per annum.

The net economic benefits of current levels of tourism on LHI during off-peak periods is estimated at $7.8m per annum, comprising:

- normal net revenue of $1.6m:
  - $1.0m to accommodation;
  - $222,000 to tours;
  - $125,000 to shopping; and
  - $249,000 to meals.

- benefits to tourists of $6.2m per annum

[18] Price effects would only occur for services where quantity is constrained.

Impact of the 'With' and 'Without' REP Scenarios

"Without" REP Scenario

A key motivation for visits to LHI is to experience the natural, undeveloped and unspoilt surroundings, as epitomised by its WHA listing, Marine Park declarations of surrounding waters and incorporation of around 70% of the Island in a Permanent Park Preserve.

Rodents are identified as a threat to LHIs Outstanding Universal WH values. Rodents have resulted in a reduction in biodiversity via extinctions on LHI and a reduction in species abundance.

Under the 'without' REP scenario further degradation of World Heritage values could potentially result in the LHIG being inscribed on the "World Heritage in Danger List". This would have a 'signalling' effect to the tourism market of a decline in values and tourism experience and would be expected to result in a reduction in tourism demand in both the peak and off-peak periods. Whether LHIG is inscribed on the "World Heritage in Danger List" or not, the Lord Howe Island Tourism Association (2015) has identified the "potential increase in negative consumer perception of degeneration of pristine environment" as a key threat to tourism.

While some decline in tourism demand is expected to be associated with further degeneration of the environment of LHI, for the purpose of the analysis it has conservatively been assumed that "without" the REP, demand in the peak and off-peak periods remains constant[19] over the analysis period i.e. 30 years. Hence, the values reported above for current visitation levels are assumed to continue.

"With" REP Scenario

'With' the REP, two separate potential impacts have been identified - short term effects during the REP implementation and long term effects after the REP implementation.

Short Run Effects

a) Reduced Tourism Demand

The REP is proposed to be undertaken during the winter months when tourism is least. Accommodation providers will be obliged to inform prospective tourists at the time of taking their booking or when a decision to proceed is made (for those who already hold a booking).

The LHIB has suggested the following simple statement to inform guests that book for a holiday during the proposed project period (June – August 2017) about the REP. This will be refined down to the proposed month of REP implementation in the near future:

[19] All other things being equal (ceteris paribus).

"The eradication would help to retain Lord Howe Island's position as a unique paradise and World Heritage listed island destination. It is currently planned over two blocks of 2-5 days in winter of 2017 but a final decision has not yet been made. If it goes ahead it will be safe for people and the environment and there will be minimal disruptions for guests. A confirmed scheduled can be provided closer to the time" (LHIB 2016b).

With the above information provided to prospective tourists, the empirical question is the sensitivity of tourist bookings to this information.

The most sensitive group is likely to be families with children, particularly small children. However, the Lord Howe Island Tourism Association (2015) identifies that family groups predominate in the peak seasons of Christmas, Easter and September school holiday periods. At other times, there are larger proportions of younger and older couples. These groups are likely to be least sensitive to the knowledge that the REP may occur while they are present. These groups are also likely to have greater flexibility in the time of year that they visit LHI. If they are sensitive to the information provided they could change the off-peak time of year that they visit, to an off-peak time when the REP is not occurring at little or no costs.

Therefore, in the absence of any survey of prospective visitors to LHI, there is a reasonable argument to support minimal or no reduction in visitation at the time of the REP, or at least in the off-peak period overall (allowing for some substitution for an alternative off-peak times). However, for the purpose of this analysis it is conservatively assumed that 50% of visitors who would otherwise have visited during the month of July (when the REP is likely to be implemented) i.e. 293 visits and 2,051 visitor nights (Lord Howe Island Tourism Association 2015), would not visit and would not alter the timing of their booking.

This can be represented by a reduction in demand and an associated reduction in the average spend per visitor. Refer to Appendix 3 for detailed calculations. The result is a decrease in both normal net revenue to tourism providers and benefits to tourists in the off-peak period, estimated at:

- $130,000 foregone normal net revenue
  - $83,000 to accommodation;
  - $18,000 to tours;
  - $10,000 to shopping; and
  - $20,000 to meals.

- $489,000 foregone benefits to tourists.

A caveat on the estimation of foregone normal net revenue to tourism providers is that it is based on a fixed ratio of net revenue to revenue for each sector impacted. While this is reasonable for large changes in demand for sectors such as accommodation and tours, for small changes in revenue there may be no or very little change in costs i.e. most costs in the short run are fixed. Hence, the change in net revenue may approximate the change in revenue. This is less likely for

shopping and meals where costs are likely to vary proportionally with revenue. Nevertheless, on this basis, an upper limit estimate of foregone net revenue would be $527,494, comprising:

- $308,000 to accommodation;
- $68,000 to tours;
- $42,000 to shopping;
- $111,000 to meals.

b) Increased REP Worker Demand for Accommodation

The LHIB is expecting demand for accommodation from the non-local workforce required at the time of the eradication. While there is uncertainty over the exact size and makeup of the project workforce it is expected that up to 3,050 bed nights will be required during implementation of the REP (LHIB 2016a). Table 4.5 indicates historic demand for beds from May to August and the estimated demand from the REP workforce over this time period. The REP workforce demand will be equivalent to an increase demand for bed nights of 15% over May to August. In total the REP demand for bed nights is 74% of the bed nights in July, when any impacts of the REP implementation on tourism would occur.

Table 4.5 - May to August Demand for Beds (2012/13) and Demand from the REP

	May	June	July	August	Total May to August	Total REP Bed Nights as a % of July Bed Nights
Historic Visitors	1,158	699	586	605	3,048	586
Historic Bed Nights*	8,106	4,893	4,102	4,235	21,336	4,102
REP Bed Nights	600	900	930	620	3,050	3,050
REP Bed Nights as a % of Historic Bed Nights	7%	18%	23%	15%	15%	74%

Source: Historic data based on Lord Howe Island Tourism Association (2015) and excludes locals.

* This relates to occupied beds assuming an average stay of 7 nights per visitor.

**Qantas data for July visitation in 2014, 2015 and 2016 is 730, 641 and 639. This is higher than reported in Lord Howe Island Tourism Association (2015) however includes locals.

Assuming the same ratio of net revenue to revenue as for foregone tourism, REP demand for accommodation will result in an increase in net revenue to accommodation providers of between $122,000 (based on a fixed ratio of producer surplus to revenue) and $455,000 (based on revenue approximating net revenue). Consequently, the assumed decline in tourism demand for accommodation during July as a result of implementation of the REP ($83,000 to $308,000) is more than offset by the increased demand for accommodation from the non-local REP workforce, between May and August ($122,000 to $455,000) i.e. there will be a net benefit to accommodation providers.

If these workers have similar spending habits to tourists, then impacts on tour operators, food providers and shops will also be more than offset. However, to the extent that the REP workforce expenditure pattern is different to that of tourist, tour operators, and to a lesser extent food and shopping providers may be worse-off in the short term i.e. July 2017, if assumed reductions in tourists eventuate.

Long Run Effects

Consultations with the LHI community elicited a range of views on the potential tourism impacts of the REP including that it would have:

- ongoing negative impacts from negative community perceptions around poisoning and/or actual negative impacts on fauna from poisoning;
- positive impacts on tourism as a result of being rodent free and improved biodiversity and abundance;
- no impacts on tourism due to the constraints on tourism numbers.

However, evidence supports an increase in tourism demand post rodent eradication and economic principles indicate benefits to tourism providers from an increase in demand even when constraints on visitor numbers apply.

Morgan and Simmons (2014) review the evidence of the impact of eradication on Tourism. They find that on Ulva Island, New Zealand, tourism post rodent eradication has been consistently 2-3 times the level prior to predator eradication, although this also coincided with the upgrade and opening of walking tracks. Visitation to Tiritiri Matangi, a small island of Auckland, New Zealand, trebled from 13,000 in 1995 to 37,000 in 2014 post predator eradication. However, this also coincided with track upgrades, tree planting, school visits from Auckland and animal relocations. These may not have occurred without the predator eradication.

Zealandia, where predators in valley in Karori, Wellington were eliminated in 1999 and new species have been introduced, has had visitor numbers double since 2002 to over 80,000.

Maungatutari, a forested mountain in the Waikato, where predators were eliminated in 2006 experienced visitation 50% higher than the far more established walking destination of Mt Pirongia, and this is expected to grow two and a half times as many visitors. Again, the increase in visitation is at least partly associated with the provision of infrastructure.

Morgan and Simmons (2014) identify that there is a growing demand for predator-free tourist destinations as part of a growing demand for unique eco-tourist experiences. The ecotourism market segment is growing far faster than tourism generally. Evidence from eradications around the world indicates that removing predators improves the lot of native fauna and flora (Jones 2010, St Clair et al 2010, Croll et al 2016), and this can potentially provide a stimulus for the tourism industry.

A particular segment that that has been growing quickly and is now one of the dominant sectors in the world tourism market is bird watching (Jones and Buckley 2001). This segment is where places with bird diversity and abundance and hence is attracted to predator free locations (Jones and Buckley 2001). Lord Howe Island is recognised internationally as one of nine Endemic Bird Areas in Australia (Jones and Buckley 2001).

Morgan and Simmons (2014) undertook an online survey to test whether "Predator-Free" status would alter the likelihood of people visiting Stewart Island/Rakiura. The survey was circulated through local and international birding communities and other tourism networks. It asked local and international respondents whether they had previously visited Stewart Island/Rakiura. It then explained the predator free status, and asked whether that would change their likelihood of visiting. The purpose of the questions was to estimate the proportionate increase in tourism that predator-free status would generate. The results indicated that predator free status would increase the likelihood of visiting from 36% to 87% i.e. more than double.

Conservatively Morgan and Simmons (2014) suggest that predator-free status would lead to a 50-75% increase in tourism numbers, although the time frame over which this would occur is not identified.

The Lord Howe Island Tourism Association (2015) states that the LHI destination will not grow if it depends on the existing visitor profile and that growth in the future needs to come from new segments, requiring and effective new brand campaign to reposition the destination. The new positioning has to be cognisant of the key attributes that provides the unique selling points for LHI.

"A pristine, stress free natural environment, which is safe, unpolluted, unrushed, and where you can enjoy simple pleasures that leave you relaxed and refreshed. And is reinforced by the supporting evidence of ***Abundant flora and fauna, world class diving, and many adventure activities to challenge, where everything is easily accessed on the island, and you have the ability to escape from the modern day pressures of traffic, high-rise and mobiles*.** Messaged well, and consistently, this is a powerful and compelling argument for experiential seekers to prefer LHI. It does however require to be told well, and frequently" (Lord Howe Island Tourism Association 2015, p. 6)

The REP provides an opportunity to add significantly to tourism marketing for LHI and reinforce one of the Islands key selling points - abundant flora and fauna. With adjustment of existing marketing efforts to emphasis the rodent free status of LHI, there would seem to be compelling evidence that tourism demand for LHI would increase relative to the base case of continued control, although the exact magnitude and timing is uncertain. For the purpose of analysis, conservatively, a growth in demand of 20% in both peak and off-peak periods is assumed, ramping up over a 5-year time frame. This is considerable less than suggested by the analysis of Morgan and Simmons (2014). Section 4.8 considers the sensitivity of the analysis results this assumption and identifies the threshold level i.e. the level of increased tourism demand, required to offset assumed short term impacts.

An increase in demand in both peak and off-peak periods can be represented by shifts in the respective demand curves. Refer to Appendix 3 for detailed calculations. In peak periods an increased demand results in no increase in visitation but an increase in the market price for a visit from an increase in accommodation prices. The additional net revenue to accommodation providers[20] estimated at $6.0m per annum.

In off-peak periods an increase in demand, results in increase visits which can be accommodated within the capacity constraint, and an increase in price (or average spend) per visit.

The result is an increase in both the annual net revenue and benefits to tourists during off-peak to:

- $2.4m net revenue to producers comprising:
  - $1.5m to accommodation;
  - $320,000 to tours;
  - $179,000 to shopping; and
  - $359,000 to meals.

- $8.9m in benefits to tourist.

The additional benefits of a 20% increase in off-peak tourist are:

- $719,000 net revenue to producers comprising:
  - $457,000 to accommodation;
  - $98,000 to tours;
  - $55,000 to shopping; and
  - $110,000 to meals.

- $2.7m in benefits to tourists.

4.5.4 Palms and Vegetables[21]

Kentia Fresh acquired the former Kentia Palm Nursery from the LHIB in May 2014 under a 25 year lease arrangement. It has been rebuilding the infrastructure of the Nursery with the dual objective of:

- Rekindling the production and sale (domestic and export) of kentia seedlings, which was discontinued when the LHIB ceased operations at the Nursery in 2012. This enterprise includes:

  - collection of seeds from the Kentia Palm forests on LHI;
  - planting kentia seeds in boxes using plastic bags as an internal liner with approximately 600 seeds planted in between layers of peat/perlite growing mix. These are stored in a darkened shed for approximately four months; and

[20] Some increased net revenue would also accrue to airlines but this is not modelled here.
[21] This section is based on Maxwell (2016).

  - moving boxes to igloos for a further six months or so during the germination phase.

- Establishing a fruit and vegetable growing operation to supply the demands on the Island and reduce the need to import supplies by both sea and air transport. Kentia Fresh has built approximately 1000m2 of covered growing spaces (poly-houses and a glasshouse) to grow tomatoes, cucumbers, eggplants, capsicums and various fruits and herbs for the local shops, restaurants and residents. It has also restored an organic garden to complement covered growing spaces with the capacity to produce vegetables in the rich, volcanic, island soil.

Kentia Fresh has identified a number of impacts on its operations from rodents that would continue "without" the REP:

- cost of $10,000 per year on baiting;
- additional costs of seed collection due to low seed levels across all the collection areas as a result of predation of rodents. Costs of collection are in the order of $165/bushell when in the absence of predation it is estimated that they would be approximately $50/bushell. It is assumed that 120 bushells/year are collected.
- loss of 25% of potential Kentia production from rodent predation equating to foregone revenue of $50,000 per year[22];
- loss of 25% of fruit and vegetable production from rodent predation equating to foregone revenue of $25,000 per year[23]

The costs would be avoided "with" successful implementation of the REP.

These are costs associated with the current production levels and enterprises and to the extent that planned expansions occur they will understate the impacts of the "without" REP scenario. Other unquantified impacts include disruption to the vegetable planting program, damage to irrigation equipment during dryer period and psychological impacts of losses. If rodents ultimately effect the viability of Kentia Fresh then economic costs of the "without" REP scenario will be even greater.

4.5.5 Health and Toxicity

Human health

Theoretical exposure pathways for humans are identified below, along with consideration of potential impacts:

- direct ingestion of rodent bait - the amount of bait required to be ingested by a child at one time to cause health effects is quite large i.e. 200 pellets would need to ingested to reach the No Observed Effect Level (NOEL) i.e. the dose that has no effect on the body. Over a 4-5 week period that the bait will be in a physical form able to picked up by a child (4-5 weeks), it would require ingestion of 6-7 small pellets every day by a small child to acquire a dose equivalent to the 42 days of exposure NOEL (Toxicos 2010). A recalculation by Pacific Environment Limited

[22] It is assumed that the marginal cost savings associated with the loss of production is minimal.

[23] It is assumed that the marginal cost saving associated with lost production is minimal since vegetables are sold on LHI only and losses primarily occurs as the vegetables ripen.

(2015) using the Acceptable Exposure Levels (AEL) changes these estimates to 20 pellets/day for the single acute exposure and <1 pellet per day, every day, for the repeated exposure. These are conservative calculations and give a 10-fold safety margin when compared to the NOELs. As noted by Toxikos, while intoxication seems unlikely, the presence of an indicator dye in the bait which will stain lips and mouth, in conjunction with an education campaign and parental supervision will minimise risk from the direct ingestion of bait. Furthermore, human studies have demonstrated the complete efficacy of antidote treatment (Vit K) for cases of human intoxication by Brodifacoum (Pacific Environment Limited 2015);

- inhalation of dust containing Brodifacoum - a reasonable maximum estimate of the amount of Brodifacoum that might be inhaled during the REP is 5 million times less that the dose that does not affect the body (Toxicos 2010). Pacific Environment Limited (2015) identified an error in Toxicos's assumed concentration of Broadifacoum in the air. However, adjusting the calculations for the correct value, the estimated exposure to a 2-3 year old child would be 25,000 times less than the acute AEL.
- ingestion of soil contaminated by Brodifacoum from bait - it is unlikely that all soil incidentally ingested would be contaminated soil. Soil residue data from New Zealand when incorporated into the intake calculations results in negligible doses of Brodifacoum. Furthermore, Brodifacoum is tightly bound to organic carbon in soil which significantly lowers the amount that may be absorbed by the body (Toxicos 2010). Conservative assumptions used by Toxikos for soil ingestion, soil concentrations of Broadifacoum and estimates of child ingestion of Broadifacoum are insignificant when compared to the 42-day AEL (Pacific Environment Limited 2015);
- dermal exposure to bait and contaminated soil - potential for dermal absorption of Brodifacoum is low. When it is bound to soil the potential for dermal absorption is even lower (Toxicos 2010). Pacific Environment Limited (2015) found that the conservative assumptions used by Toxikos for soil contamination of the hands of a child and dermal absorption result in insignificant effects compared to the 42 day AEL.
- ingestion of water (groundwater and tank water) that may become contaminated by bait - because of its physical chemical properties, Brodifacoum is unable to contaminate groundwater and in any case groundwater on LHI is not used for drinking. Contamination of tank water is unlikely due to hand broadcasting in the settlement area. Birds eating bait and depositing droppings on roofs and gutters, or birds picking baitup and discarding it onto roofs are unlikely to place significant amounts of Brodifacoum onto the roof to the extent that tank water would be unsafe to drink (Toxicos 2010). Pacific Environment Limited (2015) found that Toxikos's estimates of the amount of Broadifacoum a child might ingest through drinking tank water is insignificant compared to the 42 day AEL.
- consumption of :
  - vegetables and fruit - Brodifacoum does not contaminate vegetables and fruit because it is not transported from water or soil into the plant. The surface of a plant could become contaminated if the bait was physically broadcast onto the plant, however, this should not occur as bait will be hand broadcast in the settlement areas. Even if the surface of plants were contaminated bait particles can be easily washed off during food preparation (Toxicos 2015). Pacific Environment Limited (2015) confirmed that uptake into plants is considered to be negligible.
  - poultry produce - will be removed from LHI prior to the REP.

- fish that have ingested bait inadvertently distributed to shore waters - it is unlikely that fish will have much of an opportunity to eat bait that might fall into the ocean before it disintegrates and it is also unlikely that humans will catch such fish in numbers where it may become a health issue. In New Zealand there has been a very large accidental spill of Brodifacoum into the sea with no measurable levels in fish flesh (Toxicos 2010). Pacific Environment Limited (2015) considered that all the assumptions used by Toxicos in its analysis are conservative and appear reasonable. The estimated daily dose of Brodifacoum from high end consumption of fish is insignificant compared to the 42 day AEL.
- meat and dairy produce - beef cows will be removed from LHI prior to the REP. Dairy cows will be isolated and protected from ingestion of Brodifacoum.
- wild ducks - these are not consumed by residents of LHI (Toxikos 2010).

Toxikos (2010) identified that many of the potential human exposure pathways to the proposed bait will not occur because they are hypothetical due to the proposed management practices that are to be put in place during and after the REP e.g. removal of poultry and cattle from LHI, isolation of dairy cows from exposure. Toxikos (2010) identifies that other direct and indirect exposure pathways pose negligible risk for human health.

Toxicos (2010) identify that the most important exposure pathway is direct ingestion of bait pellets picked up off the ground. However, substantially quantities would need to be ingested to have any impacts and with toxic signs apparent several days before the onset of any life threatening effects the toxicity of Brodifacoum is easily treated with Vitamin K. As identified by Pacific Environment Limitied (2015) the proposed REP involving the use of Brodicafoum will not pose a risk to the health of the residents of Lord Howe Island. The risk management processes included in the plan will mitigate any possible risks posed by the use of Brodicafoum.

Livestock

Having livestock present during the eradication poses a substantial risk to the success of the operations. Stock feed provides an ideal harbour and food source for rodents. If rodents have access to this feed or any spillage they may not take baits. There is also a risk that livestock may consume baits. Consequently, the proposal is to, as far as possible, destock LHI prior to the eradiation (LHIB 2009).

This will be done largely through orderly culling and butchering. Replacement breeding stock will then be brought to the island when the breakdown of bait in the paddocks is complete (LHIB 2009). This imposes a cost on stock owners which will be compensated for by the LHIB. The cost of destocking and compensation is included in the costs of the REP and hence no addition costs require inclusion in the CBA.

Dogs

Dogs are at risk from both primary and secondary poisoning from Brodifacoum. This a risk that under the "without" REP scenario will continue into the future, although there are no known incidences of anticoagulant poisoning from the current control operations. However, this may be partly due to ongoing management of dogs by their owners.

Under the "with" REP scenario, the risk will be heightened for a period of up to 100 days due to the more extensive bait distribution, and then all risks to dogs will be eliminated. To assess this heightened by short term risk to each dog, owners will be provided with a sample of non-toxic bait many months prior to the operations. Any dogs that have a propensity to eat baits may need to be muzzled and/or kept on a leash during the period that bait is present on the ground. The option of removing the dogs from LHI for the duration of the risk period and housing them in boarding kennels on the mainland will be available to any concerned residents, at no cost to them (LHIB 2009). The cost of these mitigation actions that reduce the risk of harm to dogs to a negligible level[24] will be borne by the LHIB and are included in the direct costs of the REP.

With the implementation of the mitigation measures, the risk to dogs over the 100 days is considered negligible while under the base case the risk is also considered negligible but ongoing.

4.5.6 Wastage and Amenity

Rodents can lead to spoilage and destruction of stored food products and result in a reduction in residential amenity through dispersal of rodent excrement. These costs of the "without" scenario are avoided with implementation of the REP. While these impacts can potentially be estimated via methods such as the value of spoiled goods, no quantitative information on this was available. Consequently, this benefit (avoided cost) of the REP remains unquantified in the analysis.

4.5.7 Research

The benefits of research associated with the REP can be thought of in terms of reducing the costs of future Island REPs. Alternatively, it may improve the likelihood of success of future Island REPs. This benefit may accrue in NSW, the rest of Australia or in other parts of the World.

The magnitude of this benefit to Australia is difficult to estimate and remains unquantified in this analysis.

4.6 Results

The present value of the additional costs and benefits of the REP is provided in Table 4.6. The REP is estimated to have net social benefits of around $142m and a benefit cost ratio of 17.0 This indicates that the aggregate welfare of the community is improved by implementing the REP i.e. the incremental benefits of the REP exceed the incremental costs.

There are incremental biodiversity benefits, incremental tourism benefits and incremental benefits to the Kentia Palm and vegetable industry from implementation of the REP.

There are benefits that remain unquantified in the analysis i.e:

[24] Particularly, because in the unlikely event of poisoning, the affected dog will be treated with a course of vitamin K injections administered under veterinarian supervision.

- increased species abundance;
- increased productivity of private vegetable gardens;
- reduced risk to humans, livestock and pets from constant presence of rodent poison;
- elimination of health impact from rodents for residents and tourists;
- elimination of spoilt foodstuffs and presence of rodent excrement on LHI;
- research benefits from the REP.

If these were able to be quantified they would increase the net benefits of the REP. However, the magnitudes of the benefits are unlikely to be material to the CBA results.

The main potential unquantified cost of the REP relates to toxicity risks to humans, dogs and aquatic species.[25] However, expert reports on toxicity (Toxikos 2010; Pacific Environment Limited 2015) examined all the theoretical exposure pathways for humans and found that many were theoretical due to the proposed management practices during the REP and others pose negligible risk for human health. The studies also found that the risk to marine organisms is negligible. The risk to dogs will heighten for a period of up to 100 days with implementation of the REP but then all risks to dogs will be eliminated.

[25] Toxicity risk to terrestrial species has be explicitly addressed.

Table 4.6 - Present Value of Incremental Costs and Benefits (@7% discount rate)

Category	Costs	$	Benefits	$	Net Benefits
Direct costs	REP direct implementation costs		Avoided ongoing rodent control costs		
	Capital costs	$7,658,155	*LHIB*	$845,425	
	Ongoing costs	$620,823	*Residents*	$47,742	**($7,385,812)**
Biodiversity	Potential for species extinction from REP	$1,055	Prevention of additional extinctions	$40,599,970	
	Costs of returning extinct species to LHI	$38,774	Return of extinct species to LHI	$27,537,371	
			Increased abundance of species		**$68,098,566**
Tourism	Foregone tourism during REP implementation				
	Net revenue	$113,686	Additional accommodation during REP implementation		
	Tourist benefits	$427,457	*Accommodation net revenue*	$106,773	
			Net revenue to tours, food outlets and shops	NQ	
			Tourist benefits	NA	
			Additional tourism business after REP implementation		
			Net revenue	$57,175,022	
			Tourist benefits	$23,153,099	**$79,893,751**
Palms and vegetables			Increased productivity for Kentia Palm industry and avoided direct costs	$982,682	
			Increased productivity of other vegetable gardens	NQ	**$982,682**
Health and toxicity	Any impact to other species, water and human health	NQ	Reduced impact to humans, livestock and pets from constant presence of rodent poison	NQ	**NQ**
			Elimination of health impacts from rodents for residents and tourists	NQ	**NQ**
Wastage and amenity			Elimination of spoiled foodstuffs, rodent excrement for residents	NQ	**NQ**
Research			Research benefits of the program	NQ	**NQ**
Total	**Total costs**	**$8,859,951**	**Total benefits**	**$150,448,082**	**$141,588,132**
			Net Present Value	**$141,588,132**	
			Benefit Cost Ratio	**17.0**	

Note: NA = not applicable, NQ = not quantified

Reporting of calculations should not be misconstrued as conveying false accuracy

4.7 Distribution of Costs and Benefits

As identified in Section 3.1, CBA is only concerned with the single objective of economic efficiency. CBA and welfare economics provide no guidance on what is a 'fair, equitable' or 'preferable' distribution of costs and benefits. Nevertheless, CBA can provide qualitative and quantitative information for the decision-maker on how economic efficiency costs and benefits are distributed.

Table 4.6 above is reproduced below for Australians residing off LHI and those residing on LHI.

From Table 4.8 it can be seen that the main costs and benefits that accrue to non-residents of LHI are:

- the capital cost of the REP which is funded by various government grants and ultimately tax payers of NSW and Australia;
- the costs of returning species to LHI which is assumed to be funded by the OEH and ultimately tax payers of NSW and Australia;
- the benefits of avoided extinctions, return of species and increased species abundance which accrues to households of NSW that are WTP to for this biodiversity outcome; and
- benefits to tourists associated with additional tourists to LHI during off-peak periods.

From Table 4.9 it can be seen that the main costs and benefits that accrue to residents of LHI are:

- ongoing costs of biodiversity monitoring and rodent detection which are assumed to be funded by the LHIB and ultimately LHI residents;
- avoided ongoing costs of rodent control which accrue to both the LHIB (and ultimately LHI residents) and residents directly;
- decreased net revenues to tourism providers during the REP - if there is a reduction in tourist demand.
- increased net revenues to tourism providers from increased demand for worker accommodation;
- increased net revenues to tourism providers from additional tourism demand after the REP implementation; and
- increased net revenues to the Kentia Palm and vegetable growing industry.

For both groups of stakeholders, those resident on LHI and those outside of LHI, there are net benefits from the REP.

A particular focus of the distributional consideration is the impact of the REP on tourism and tourism providers i.e. net revenues to tourism providers.

As identified in Section 4.5.3, there is a reasonable argument to support minimal or no reduction in visitation at the time of the REP, or at least in the off-peak period overall (allowing for some substitution for an alternative off-peak times). However, if it assumed that there is a 50% decrease

in tourists during July 2017 as a result of the REP then the reduced net revenues to tourism providers[26] is estimated at:

- $83,000 to $308,000 to accommodation;
- $18,000 to $68,000 to tours;
- $10,000 to 42,000 to shopping; and
- $20,000 to $111,000 to meals.

These economic costs would only accrue to those operators that are normally open during July. Refer to Table 4.7.

Table 4.7 - Tour Operators and Shops that are Normally Open in July

Accommodation	Open in July (Yes/No)
Leanda Lei	Open
Blue Peter (part of Arajilla)	Open but can vary yearly
Ocean View	Open
Lorhiti	Open
Arajilla	Closed
Pine Trees	Closed
Blue Lagoon	Closed
Pandanus	Closed for redevelopment. Expected reopening in Sep 17
Ebb Tide	Open
Waimarie	Open
Treehouse	Open
Admiralty	Open
Beachcomber	Open
Banyan	Open
Bowker Beach House	Open
Lagoon Landing	Open
Hideaway	Open
Earls Anchorage	Open
Capella	Closed
Somerset	Open
Milky Way	Open
Howena	Open
Tours	
Fish Lord Howe	Generally closed for ~6 weeks
Sea to Summit	Open
Oblivienne	Open
LHI Environmental Tours	Open
Pro Dive	Closed
Howea divers	Closed

[26] It should be noted that reduced net revenue is an overstatement of financial cost as it is gross of tax. Also these estimates are based on broad industry relationships and hence should be interpreted as order of magnitude estimates rather than specific estimates of impacts to individual businesses.

Marine Adventure	Closed
LHI Nature Tours	Open
Islander Cruises	Closed
Divine Seafoods	Unclear
Blue Billy	Closed
Chasing Thyme	Open
Wilson's Tours	Open
Ron's Ramble	Open
Shops / Galleries	
Iskland Showcase	Open
Izaak's Studio	Open
Ginny's Shed	Open
Abemama	Open
Beach Boutique	Open

However, increased demand for accommodation would arise from REP workforce and this demand would more and offset the reduction in accommodation demand if there was a 50% decline in tourist demand. Net beneficiaries would be those accommodation providers normally open in winter or who choose to be open due to the net increase in demand.

If these workers have similar spending habits to tourists, then impacts on tour operators, food providers and shops will also be more than offset. However, to the extent that the REP workforce expenditure pattern is different to that of tourist, tour operators, and to a lesser extent food[27] and shopping providers may be worse-off in the short term i.e. July 2017, if assumed reductions in tourists eventuate. However, a number of mitigation measures discussed in Section 5 should ensure minimal short term impacts for tour operators, food providers and shops.

Based on the supply and demand models presented in Appendix 3, accommodation providers (and airlines), who would be no worse-off in the short term as a result of the REP, would be the main beneficiaries of any increase in peak season demand. This is because benefits would mainly accrue via price effects for accommodation rather than any increase in visitation.

An increase in off-peak increase in tourism demand as a result of the REP would benefit all tourism service providers as it would result in both price effects and increases in visitation.

The 20% increase in off-peak visitation levels modelled in Appendix 3 does not reach the capacity constraint. However, if this level of demand were to be reached either in the off-peak period as a whole or individual months then benefits from increases in demand past this point would accrue to accommodation providers only.

[27] Workers will still need to purchase food but may not frequent restaurants as often as tourists.

Gillespie Economics

Table 4.8 - Present Value of Incremental Costs and Benefits Outside LHI (@7% discount rate)

Category	Costs	$	Benefits	$	Net Benefits
Direct costs	REP direct implementation costs		Avoided ongoing rodent control costs		
	Capital costs	$7,658,155	*LHIB*	LHI	
	Ongoing costs	LHI	*Residents*	LHI	**($7,658,155)**
Biodiversity	Potential for species extinction from REP	$1,055	Prevention of additional extinctions	$40,599,970	
	Costs of returning extinct species to LHI	$38,774	Return of extinct species to LHI	$27,537,371	
			Increased abundance of species	NQ	**$68,098,566**
Tourism	Foregone tourism during REP implementation				
	Net revenue	LHI	Additional accommodation during REP implementation		
	Tourist benefits	$427,457	*Accommodation net revenue*	LHI	
			Net revenue to tours, food outlets and shops	NQ	
			Tourist benefits	NA	
			Additional tourism business after REP implementation		
			Net revenue	LHI	
			Tourist benefits	$23,153,099	**$22,725,642**
Palms and vegetables			Increased productivity for Kentia Palm industry and avoided direct costs	LHI	
			Increased productivity of other vegetable gardens	LHI	
Health and toxicity	Any impact to other species, water and human health	NQ	Reduced impact to humans, livestock and pets from constant presence of rodent poison	LHI	
			Elimination of health impacts from rodents for residents and tourists	LHI	
Wastage and amenity			Elimination of spoiled foodstuffs, rodent excrement for residents	LHI	
Research			Research benefits of the program	NQ	
Total	**Total costs**	**$8,125,442**	**Total benefits**	**$91,290,439**	**$83,164,998**
			Net Present Value	**$83,164,998**	
			Benefit Cost Ratio	**11.2**	

Note: NA = not applicable, NQ = not quantified

Reporting of calculations should not be misconstrued as conveying false accuracy

Table 4.9 - Present Value of Incremental Costs and Benefits to LHI Residents (@7% discount rate)

Category	Costs	$	Benefits	$	Net Benefits
Direct costs	REP direct implementation costs		Avoided ongoing rodent control costs		
	Capital costs	Rest of NSW	*LHIB*	$845,425	
	Ongoing costs	$620,823	*Residents*	$47,742	**$272,343**
Biodiversity	Potential for species extinction from REP	Rest of NSW	Prevention of additional extinctions	Rest of NSW	
	Costs of returning extinct species to LHI	Rest of NSW	Return of extinct species to LHI	Rest of NSW	
			Increased abundance of species	Rest of NSW	
Tourism	Foregone tourism during REP implementation				
			Additional accommodation during REP implementation		
	Net revenue	$113,686	*Accommodation net revenue*	$106,773	
	Tourist benefits	Tourists	*Net revenue to tours, food outlets and shops*	NQ	
			Tourist benefits		
			Additional tourism business after REP implementation		
			Net revenue	$57,175,022	
			Tourist benefits	Tourists	**$57,168,108**
Palms and vegetables			Increased productivity for Kentia Palm industry and avoided direct costs	$982,682	
			Increased productivity of other vegetable gardens	NQ	**$982,682**
Health and toxicity	Any impact to other species, water and human health	LHI and Rest of NSW	Reduced impact to humans, livestock and pets from constant presence of rodent poison	NQ	
			Elimination of health impacts from rodents for residents and tourists	NQ	
Wastage and amenity			Elimination of spoiled foodstuffs, rodent excrement for residents	NQ	
Research			Research benefits of the program	Rest of NSW and World	
Total	**Total costs**	**$734,509**	**Total benefits**	**$59,157,643**	**$58,423,134**
			Net Present Value	**$58,423,134**	
			Benefit Cost Ratio	**80.5**	

Note: While the direct biodiversity benefits of the REP i.e. the WTP of the community for conservation outcomes, largely accrue to the households of NSW, these outcomes are directly linked to tourism benefits for LHI residents.

NA = not applicable, NQ = not quantified

Reporting of calculations should not be misconstrued as conveying false accuracy

4.8 Sensitivity analysis

The CBA results reported in Section 4.6 are based on the assumptions outlined in Section 4.5. There is uncertainty surrounding the likelihood of events specified with probabilities and the values attributed to different outcomes. This Section tests the sensitivity of the results to changes in values of critical variables. The results under different scenarios are summarised in the following Table.

Table 4.10 - CBA Sensitivity Testing (Present Value $Millions and Benefit Cost Ratio)

	4% Discount Rate	7% Discount Rate	10% Discount Rate
CENTRAL ANALYSIS	$285 17.6	$142 17.0	$116 15.2
Increases by 50%			
REP costs	$278 12.3	$138 11.9	$112 10.6
Avoided ongoing rodent control costs	$286 17.7	$142 17.0	$116 15.2
Biodiversity costs	$285 17.6	$142 16.9	$116 15.1
Biodiversity benefits	$351 21.4	$176 20.8	$149 19.2
Tourism costs (short term impacts)	$285 17.1	$141 16.5	$116 14.7
Tourism benefits i.e. increased demand by 30%	$369 22.5	$182 21.5	$144 18.6
Kentia Palm Benefits	$286 17.7	$142 17.0	$116 15.2
Decrease by 50%			
REP costs	$292 31.0	$145 29.9	$119 26.9
Avoided ongoing rodent control costs	$284 17.6	$141 16.9	$116 15.1
Biodiversity costs	$285 17.7	$142 17.0	$116 15.2
Biodiversity benefits	$219 13.8	$108 13.1	$83 11.1
Tourism costs (short term impacts)	$286 18.2	$142 17.5	$116 15.7
Tourism benefits i.e. increase demand by 10%	$202 12.8	$101 12.4	$88 11.7
Kentia Palm Benefits	$284 17.6	$141 16.9	$115 15.1
Additional scenario			
Tourism benefits i.e. increase demand by 5%	$160 10.3	$81 10.2	$74 10.0

The sensitivity analysis indicates that the CBA results are not sensitive to substantive changes in key variables. The primary drivers of the CBA results are the estimated benefits from biodiversity improvements and increased demand for tourism arising from the REP.

The biodiversity benefits are based on BT of values from a study of catchments in NSW. The most conservatively low value from this study was applied to the CBA of the REP. These values also related to local extinction or presence of species rather than global extinction of species and hence to the extent that the REP would avoid global extinction of species this approach would understate benefits. The estimate of biodiversity benefits also conservatively excluded the benefit of increase abundance of species.

Tourism benefits were based on an assumption of a 20% increase in demand post REP, which was considerably less than the conservatively low estimate of tourism increases post eradication suggested by case studies. However, even if it were assumed that there would be no tourism benefits, the REP would still provide net benefits to the Australian community because of the level of biodiversity benefits.

A sustained increase in off-peak demand of 0.4% (29 visitors) post REP would be required to offset the maximum assumed short term impacts to tour operators, shops and meal providers.

5 Impacts of the Rodent Eradication Project on the Lord Howe Island Economy

5.1 Introduction

CBA of the LHI REP is concerned with the costs and benefits to stakeholders in the community, including those residing off the Island. Cost and benefits are in terms of changes in first round producer and consumer surpluses with secondary impacts assumed in aggregate to be zero across the Australian community. In this framework, reductions in expenditure are benefits e.g. avoided costs of the ongoing rodent control, while increases in expenditures are costs e.g. costs of implementing the REP.

However, changes in expenditures and revenue impact economic activity on LHI. These are not measures of costs and benefits from an overall community and CBA perspective. However, changes in economic activity on LHI is of particular interest to stakeholders.

5.2 Economic Activity Impacts

All activities associated with the REP that involve changes in short term and long term impacts on economic activity on LHI are summarised in Tables 5.1 and 5.2, respectively.

In the short term, there will be in the order of $400,000 spent on local labour to assist in the REP implementation and post REP monitoring. Reduced expenditure on tourism business is estimated at between zero and $527,000, depending on the impact of the REP implementation on visitation. The maximum estimate of reduced tourism expenditure on accommodation during the REP implementation ($307,000) is more than offset by the accommodation demand by nonlocal workers ($454,689) and if these workers have the same expenditure patterns as tourists then maximum assumed impacts on tour operators, food providers and shops will also be more than offset. Expenditure on tour operators is the expenditure category where worker expenditure is most likely to be different from tourist expenditure.

Overall in the short run the REP implementation will result in an increase in expenditure in the local economy.

Table 5.1 - Changes in Short Term Economic Activity on LHI as a result of the REP

	Reductions in Economic Activity	$	Increases in Economic Activity	$
LHI Labour Force			REP direct implementation expenditure on LHI e.g. local labour	$300,000 for local labour * $100,000 for monitoring**
Tourism operators	Reduced tourism business output during REP implementation	$0 to $527,494 comprising: - $307,780 to accommodation - $67,589 to tours - $41,506 to shopping - $110,619 to meals	Additional output for accommodation during REP implementation Additional output for tour operators, food providers and shops	$454,689 NQ
Total Short Term Impacts		**$0 to $527,000**		**$854,689 plus**

*50% local labour for implementation - wage @ $30/hr
**$50,000 pa for two years

In the long run, there is expected to be increased expenditure on LHI from an increase in peak and off-peak tourism expenditure. There will also be increased profitability to the Kentia Palm Nursery. Local labour will experience some reduction in direct output as wages associated with the ongoing rodent control program will no longer be spent and there will be a reduction in expenditure on labour involved in Kentia Palm seed collection. However, overall in the long run the REP implementation is expected to result in a substantial increase in expenditure in the local economy.

Table 5.2 - Changes in Long Term Economic Activity on LHI as a result of the REP

	Reductions in Economic Activity	$	Increases in Economic Activity	$
LHI labour	Reduced ongoing rodent control output	$50,000 pa		
	Reduced expenditure on Kentia Palm seed collection	$13,110 pa		
Tourism operators			Additional off-peak tourism business output after REP implementation	$2,765,556 pa - $1,613,636 to accommodation - $354,355 to tours - $217,610 to shopping - $579,954 to meals
			Increased peak period output to accommodation providers tourism business after REP implementation	$6,024,058 pa
Kentia Palm Nursery			Increased output of Kentia Palms and Vegetables	$75,000 pa
Long Term Impacts		**$63,110 pa**		**$8,864,61 pa**

Where changes in economic activity involve expenditure there would also be some flow-on economic activity impacts. For example, additional off-peak tourism as a result of the REP would flow to accommodation providers which would also created additional demand for employees, who would spend some of their additional income on the island etc. Other types of economic activity may have little flow-on effects e.g. increased tourism accommodation output in peak periods, which is essentially additional profit, and requires no additional expenditure to realise.

5.3 Mitigation Measures

In both the short term and long term the economic activity impacts on the LHI economy from the REP are likely to be positive.

Notwithstanding, should impacts arise from reduced tourism visitation at the time of REP implementation these are most likely to felt by tourism operators and to a lesser extent food providers (mainly restaurants) and shops.

Short term impacts on tourism operators, shops and food outlets could be minimised through:

- promotion of local purchases to the incoming workforce;
- provision of tour and restaurant vouchers to workers;

- mandating the rental of tourist operators' vehicles and boats where required for implementation of the REP.

Reduced ongoing expenditure on LHI labour from cessation of the rodent control program and decreased expenditure on seed collection may be able to be offset through provision of alternative employment opportunities that arise from increased tourism demand and productivity of the Kentia Palm nursery.

6 Conclusion

The CBA of the REP reported here indicates that the project will provide net benefits to the people of Australia and hence is justified on economic efficiency grounds. It will provide net biodiversity benefits, net tourism benefits and net benefits to the Kentia Palm and fresh vegetable industry. The REP will also provide net benefits to residents of LHI and net benefits to residents in the rest of Australia.

It is reasonable to expect that there will be minimal or no reduction in visitation at the time of the REP, or at least in the off-peak period overall (allowing for some substitution for an alternative off-peak times). Nevertheless, the conservatively high assumed reduction in visitation as a result of the REP implementation would be offset in present value terms by a sustained 0.4% (29 people) increase in off-peak demand because of the eradication of rodents. This is far short of the 50-75% increase in demand following eradications programs suggested by case studies.

A key driver of the CBA results is the estimated value for biodiversity benefits. This was based on BT from another study undertaken in another context. Future similar studies of Island rodent eradication programs would gain from undertaking a primary nonmarket valuation study e.g. choice modelling study, to estimate community WTP for the specific biodiversity benefits of specific rodent eradication programs. The results of a primary travel cost method study would also provide information relating to the demand curve for visits that could be used to inform the demand and supply models for tourism.

7 References

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8 Appendices

Appendix 1 - Measures of Economic Value

The economic values of market goods and services to the community are measured by consumers' and producers' surplus. The conceptual framework for providing an understanding of consumers' and producers' surplus is the supply and demand, or market, model. (Refer to Figure A1.1.)

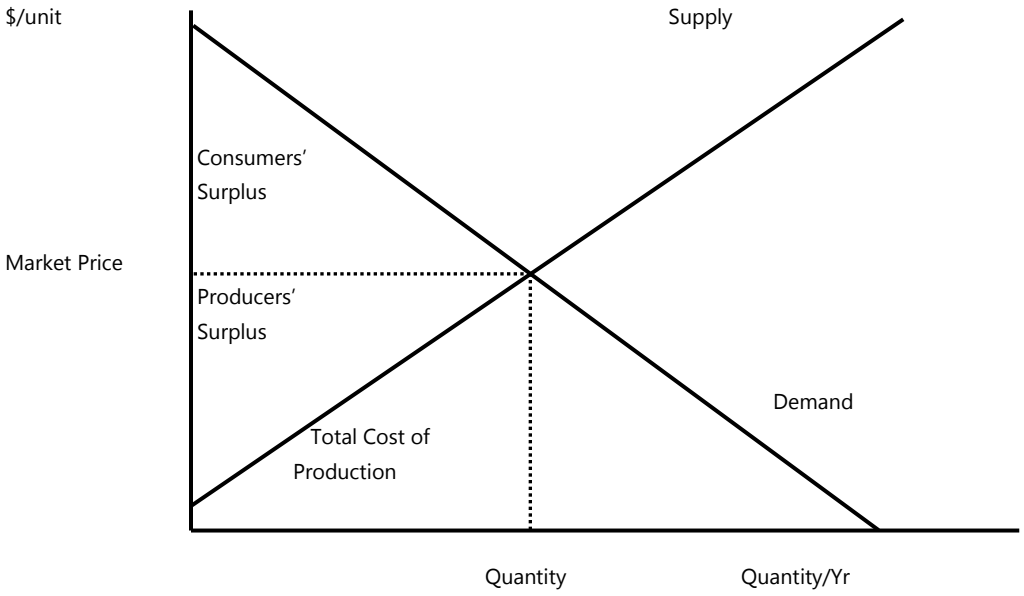


Figure A1.1 - Measures of Economic Value

The market supply curve (which comprises the summation of individual firm's supply curves) indicates the costs of extra production i.e. the costs to society of producing an extra unit of a good or service. Firms aim to operate on the upward sloping part of their marginal cost curve above the minimum average variable cost, this upward slope reflecting diminishing returns to inputs, and hence that it costs more to produce each additional unit of output[28]. The area under the supply curve is the total cost of production (Edwards 1990).

The market demand curve (which comprises the summation of individual's demand curves) indicates the maximum amount that consumers are willing to pay for incremental increases in the quantity of the good or services. The demand curve is normally downward sloping because the more someone consumes of a good, the less they are willing to pay for an extra unit of the good. This concept is generally known as diminishing marginal utility. The area under the demand curve is the total willingness to pay for a good (Edwards 1990).

[28] Provided the marginal cost of producing an extra unit of output is less than the market price then it is still profitable to produce.

The interaction of demand and supply in a competitive market determines the price for a good and the quantity that is produced and consumed in any given time period.

This market model provides the basis for identifying and estimating the net economic values to consumers and the net economic values to producers, referred to as consumers' surplus and producers' surplus, respectively.

Consumers' surplus is the difference between what an individual would be willing to pay (demand) for a good or service (the total benefit to the consumer) and what they have to pay (the cost to the consumer i.e. consumer expenditure or price times quantity) (Edwards 1990). In Figure A1.1 it is the area between the demand curve and the market price.

Producers' surplus is the difference between the revenue (consumer expenditure) received for a good or service (total benefit to producer) and the costs (supply) of the inputs used in the provision of the good or service (economic cost to producer) (Edwards 1990). In practical terms, it is the net revenue (before tax) that is earned by producers of goods and services (James and Gillespie 2002). In Figure A1.1 it is the area between the market price and the supply curve.

The market model presented in Figure A1.1 indicates the potential for the presence of both producers' and consumers' surpluses for market goods and services. However, the existence of consumer surplus for market goods will depend on how responsive demand is to changes in its price. This is known as price elasticity of demand. Where demand is perfectly elastic the demand curve is horizontal and there will be no consumers' surplus associated with the good. However, where demand is not perfectly elastic i.e. there is some slope to the demand curve, then it will be relevant to measure both producers' surplus and consumers' surplus.[29]

A key determinant of price elasticity of demand is the presence of close substitutes. Goods and services with close substitutes have higher price elasticity of demand and hence lower levels of consumers' surplus.

Even where goods and services are provided outside a market, the concepts of demand and supply can still be conceptualised and provide the basis for modelling and estimating economic values. For nonmarket use values, such as recreational fishing, swimming, snorkelling etc., and nonuse values such as protection of biodiveristy, the concept of a demand curve exists as if it were a market good (Driml 1994). The only difference is that the demand curve is not readily identifiable from market transactions and therefore needs to be derived from observing consumer behaviour using nonmarket valuation methods. These are listed in Table A1.1. For nonmarket use and nonuse values the relevant measure of net benefit is consumers' surplus only.

[29] Elasticity is also a relevant concept for supply, with higher price elasticity of supply resulting in a smaller producer surplus.

Table A1.1 - Main Types of Environmental Valuation Techniques

Market based	Revealed preference (or surrogate market)	Stated preference (or survey technique)
Productivity method	Travel cost method	Contingent valuation
Human capital approach	Wage differential method	Choice modelling
Defensive expenditures method	Property valuation method	
Replacement/repair cost method		
Shadow projects		
Opportunity cost method		

Source: BDA Group and Gillespie Economics (2007)

Consequently, the total economic value of LHI and surrounds relates to the:

- Producers' surplus, and where relevant consumers' surplus, associated with each market based activity or the entire tourism experience;
- Consumers' surplus associated with each nonmarket use activity or the entire tourism experience;
- Producers' surplus and consumers' surplus (both market and nonmarket use values and nonuse values) associated with any ecosystem function values;
- Net costs to government; and
- Consumers' surplus associated with nonuse values.

While some studies have attempted to measure the TEV of environmental resources (e.g. Constanza et al. 1997), this is problematic since economic valuation methods for non-use values can only be used to estimate a change in TEV as a result of a project or policy rather than total values. Also, what is relevant from a policy perspective is how components of TEV are likely to change "with" and "without" a policy. Hence, only a subset of total economic values may require investigation. This is the focus of CBA which is discussed in Section 3 and applied to the REP in Section 4.

Appendix 2 - Probability of Species Extinctions from the REP

Table A2.1 - Probability of Species Extinctions From the REP

Species	Probability description	Comment
Woodhen	G	Some woodhens have died from secondary Brodifacoum poisoning (control program) on LHI and they have been shown to consume non toxic PestOff in trials. Weka (a similar species in NZ) deaths from poisoning during eradications have been recorded in the low to very high range but no local extinctions. There are some recorded individual deaths of NZ Kiwis from poisoning during eradications but generally no observable impacts. With mitigation (captive management) in place, extinction is highly improbable. No woodhen deaths or illness were recorded during the captive trial. Woodhens have been bred extensively in captivity thereby further reducing likelihood of extinction
Currawongs	F	No currawong deaths or illness from secondary Brodifacoum poisoning have been recorded on the island. There are records of currawongs eating rodents but only a small component of the diet for some individuals. With mitigation (captive management) in place, extinction is very unlikely. No currawong deaths or illness were recorded during the captive trial No captive breeding known
Golden Whistler	H	Several NZ studies show no observable impacts from poisoning to similar (surrogate) insectivorous species during eradications.
Silvereye	G	Several NZ studies show no observable impact from poisoning to NZ Silvereyes (a similar species). Individual deaths from poisoning have been recorded during eradications.
LHI Gecko	G	The Gecko is currently not considered endemic as it also occurs on Norfolk Island. However there is some current genetic work underway that suggests the two island populations are distinct species. Some other studies of other species of geckoes during eradications have shown some individual deaths but no extinctions Balls Pyramid will not be baited so there is an insurance population
LHI Skink	G	The Skink is currently not considered endemic as it also occurs on Norfolk Island. However there is some current genetic work underway that suggests the two island populations are distinct species. Some other studies of other species of skinks during eradications have shown some individual skink deaths but no extinctions Balls Pyramid will not be baited so there is an insurance population
LHI woodfeeding Cockroach	H	Some evidence that other cockroach species consume baits but are not susceptible to poisoning. Balls Pyramid will not be baited so there is an insurance population

Table A2.2 - Risk Table

Qualitative Description	Order of Magnitude Annual Probability	Basis
A. Certain	1 (or 0.999, 99.9%)	Certain, or as near to as makes no difference
B. Almost certain	0.2-0.9	One or more incidents of a similar nature has occurred here
C. Highly probable	0.1	A previous incident of a similar nature has occurred here
D. Possible	0.01	Could have occurred already without intervention
E. Unlikely	0.001	Recorded recently elsewhere
F. Very unlikely	1×10^{-4}	It has happened elsewhere
G. Highly improbable	1×10^{-5}	Published information exists, but in a slightly different context
H. Almost impossible	1×10^{-6}	No published information on a similar case

Appendix 3- Tourism Economics for Lord Howe Island

Economics of Current Tourism on LHI

Figure A3.1 - Annual Demand and Supply for LHI Tourism Visitation in Peak and Off-Peak Periods[30]

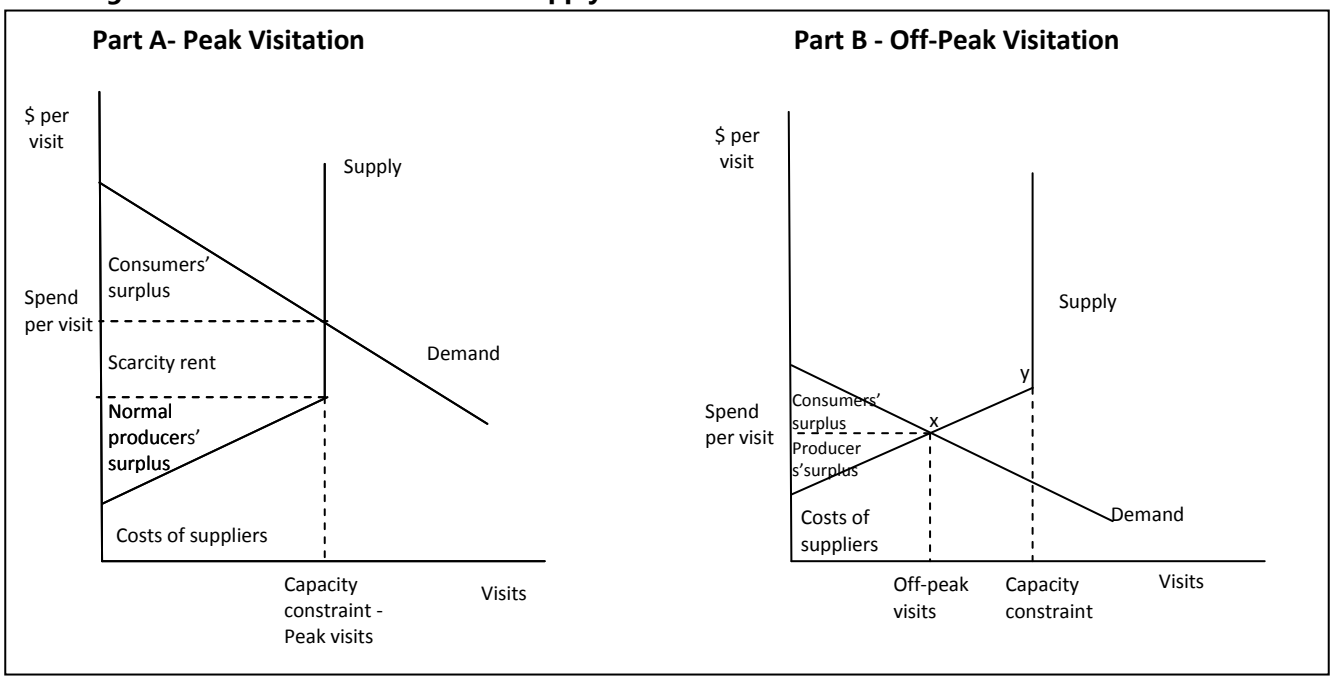


Figure A3.1 depicts the supply and demand for current visitation to LHI. The models are used to estimate the economic values associated with current levels of tourist visitation. They are then used to derive how economic values will change "with" and "without" the REP.

The current economic benefits of tourism relate to both consumers' surplus and producers' surplus associated with visits, as identified conceptually in Appendix 1.[31]

Figure A3.1 depicts the demand and supply for visits to LHI in peak (Part A) and off-peak (Part B) periods. The demand (or WTP curve) for tourism visits is downward sloping, indicating that the higher the price per visit the less quantity will be demanded. The supply curve (or marginal cost curve) is upward sloping reflecting the increasing costs of suppliers of the tourism experience and that as the price per visit increases more will be supplied as more producers find it profitable to sell.

However, with a supply constraint in peak periods there is a vertical portion of the supply curve when bed capacity is reached. In peak periods, where demand intersects with the vertical part of the supply curve (Part A of Figure A3.1), price per visit is higher than marginal costs of providing the additional tourism

[30] In this analysis, the peak period is defined as November to April and the off-peak period is defined as all other months.
[31] In this section, demand is conceptualised for the entire LHI experience and hence the supply curve relates to all costs associated with a LHI trip i.e. an amalgam of travel, accommodation, tours, foods, shopping etc.

experience. Hence, in addition to a normal producer surplus there is a scarcity rent (an extra producer surplus that does not induce increased production). However, this scarcity rent only accrues to operations that lack competition or have capacity constraints applied to it e.g. accommodation providers[32] and airlines. It is assumed that no scarcity rent accrues to tour operators as there are no capacity limits or limits on new entrants and minimal costs of entry for new participants.[33]

The net benefit of visits in peak periods therefore comprises:

- normal producer surplus to suppliers i.e. accommodation providers, tour operators, shops and restaurants. This is estimated based on visitor expenditure on these items[34] using a fixed ratio of producer surplus to revenue for these sectors sourced from the National Input-Output Table[35].
- scarcity rent that accrues from the provision of accommodation in peak periods. This is estimated by the sum of the annual bed tax levied by LHIB i.e. $750 per bed per annum ($300,000 per annum in total), and the annualised value that beds trade for in the market i.e. $7,000 per bed per annum based on a trade value of $100,000 per bed and a discount rate of 7%[36].
- consumer surplus to tourists. This is estimated on the basis of an assumed price elasticity of demand of -0.8.[37]

Refer to Appendix 4 for more detail on the estimation process.

In off-peak periods, demand intersects with the supply curve to the left of the vertical section of the supply curve and hence normal producer surplus is generated across all suppliers of the tourism experience, that supply services during this time. A segment of higher cost suppliers represented by the portion of the supply curve between x and y (in Figure A3.1) close down during this period. Normal producer surplus is estimated in the same way as outlined above for peak periods.

On this basis, the current net economic benefits of tourism on LHI during peak periods is estimated at $16,692,035 per annum, comprising:

- normal producer surplus of $2,911,673:
  - $2,234,311 to accommodation
  - $252,395 to tours

[32] The scarcity rent that accrues to accommodation providers in peak periods is implicitly recognised by the LHIB via its bed tax, which is essentially a scarcity rent tax

[33] It should be noted that some scarcity rent may potentially accrue to tour operators to the extent that the restriction on the number of Island residents provides a de facto restriction on competition in the tour operator market.

[34] This is based on annual average tourist expenditure on the Island of $27M with accommodation share of expenditure adjusted upwards in peak periods and downwards in off-peak periods based on the relationship between peak and off-peak rates for accommodation published on the LHI website.

[35] Gross operating surplus in the National Input-Output Table has been used as a proxy for producer surplus.

[36] Tourism expenditure information was based on expenditure on the Island and so excluded expenditure on airfares. Also, no information was available on potential scarcity rent accruing to airlines. Consequently, the producer surplus and scarcity rent accruing to the airline was excluded from the analysis. This has the effect of understating the benefits of tourism and the REP and the short term costs of the REP.

[37] Price elasticity of demand would be expected to be less than 1 given the uniqueness of LHI and the limited substitutes. In addition, studies (e.g. Crouch (1994) suggest an average price elasticity of demand for international tourism (which is likely to be a better indicator for LHI than domestic tourism) of around -0.6 to -0.8.

  - $141,711 to shopping
  - $283,256 to meals

- scarcity rent of $3,099,729; and
- consumer surplus of $10,680,633 per annum.

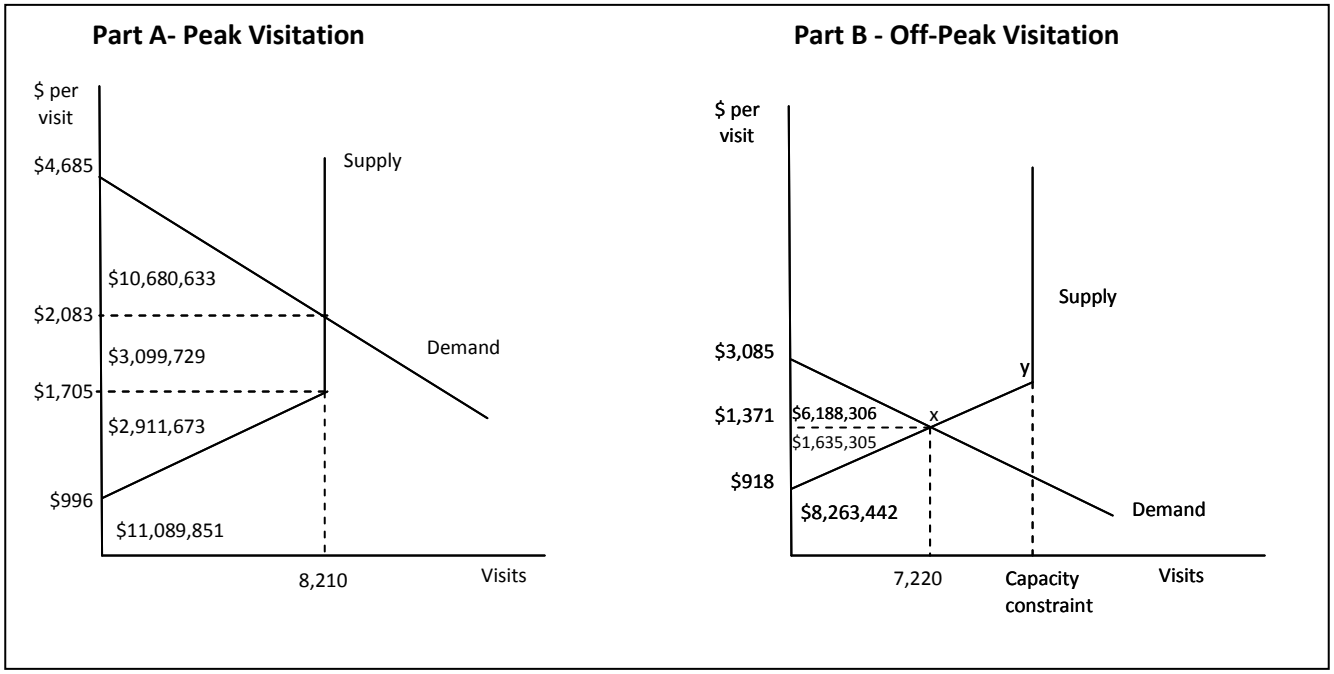
The current net economic benefits of tourism on LHI during off-peak periods is estimated at $7,823,611 per annum, comprising:

- normal producer surplus of $1,635,305:
  - $1,039,623 to accommodation;
  - $221,960 to tours;
  - $124,623 to shopping; and
  - $249,099 to meals.

- consumer surplus of $6,188,306 per annum

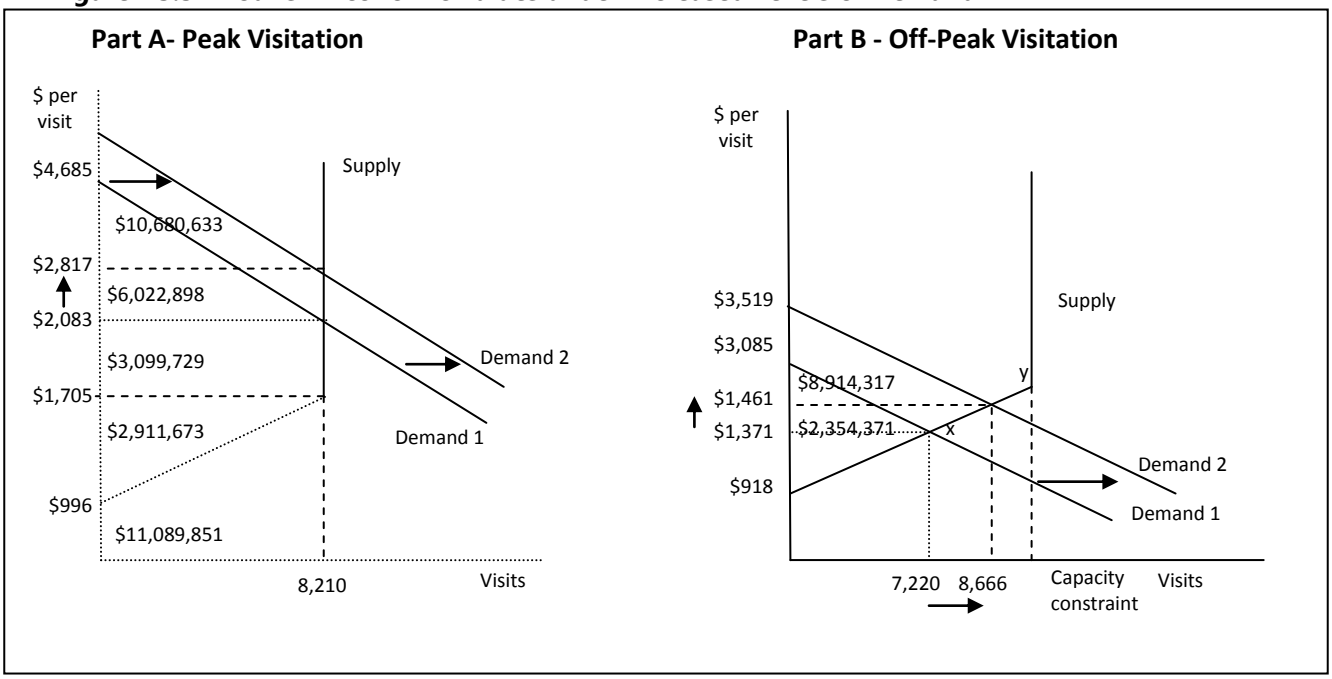
These values are represented diagrammatically in Figure A3.2.

Figure A3.2 - Tourism Economic Values under Base Levels of Demand



Impact of the 'With' REP Scenarios

Figure A3.3 - Tourism Economic Values under Increased Levels of Demand



Increased demand in both peak and off-peak periods can be represented by a parallel rightward shift in the respective demand curves. From Figure A3.3, it can be seen that in peak periods an increased demand results in no increase in visitation but an increase in the market price from $2,083 to $2,817, per visitor. This represents an increase in the annual scarcity rent to accommodation providers[38] of $6,022,898.

In off-peak periods and increase in demand, results in increase visits from 7,220 to 8,666, which can be accommodated within the capacity constraint, and an increase in price (or average spend) per visit from $1,371 to $1,461.

The result is an increase in both the annual producer surplus and consumer surplus during off-peak to:

- $2,354,341 producer surplus
  - $1,496,759 to accommodation;
  - $319,559 to tours;
  - $179,421 to shopping; and
  - $358,632 to meals.

- $8,914,317 consumer surplus.

[38] Some scarcity rent would also accrue to airlines but this is not modelled here.

The additional benefits are:

- $719,066 producer surplus
  - $457,136 to accommodation;
  - $97,599 to tours;
  - $54,798 to shopping; and
  - $109,532 to meals.

- $2,726,012 consumer surplus.

Appendix 4 - Estimation of Demand and Supply Curves for LHI Tourism

Tourism data suggest approximately $27M in annual tourist expenditure on the Island, comprising expenditure on accommodation, tour operators, meals and shopping.

Based on monthly visit estimates and an average spend per visit, average tourism expenditure was allocated across each month. This monthly expenditure was broken down by accommodation, tour operators, meals and shopping based on the LHI Visitor Experience data. In recognition that accommodation is more expensive in peak periods than non-peak periods, accommodation expenditure was adjusted upwards in peak periods and downwards in off-peak periods based on the relationship between peak and off-peak rates for accommodation published on the LHI website.

The result was $17M of expenditure for the 8,210 visits in peak periods at an average spend of $2,083 per visit. For off-peak visitation the result was $10M of expenditure for the 7,220 visits at an average spend of $1,371 per visit.

The price per visit and quantity of visits for peak and off-peak periods was therefore identified and a linear demand curve with a price elasticity of -0.8[39] was fitted through this equilibrium point.

The scarcity rent that accrues from the provision of accommodation in peak periods was estimated by the sum of the annual bed tax levied by LHIB i.e. $750 per bed per annum and $300,000 per annum in total, and the annualised value that beds trade for in the market i.e. $7,000 per bed per annum based on a trade value of $100,000 per bed and a discount rate of 7%[40].

Normal producer surplus to suppliers i.e. accommodation providers, tour operators, shops and restaurants was estimated based on visitor expenditure on these items using a fixed ratio of producer surplus to revenue for these sectors sourced from the National Input-Output Table[41].

A linear supply curve that generated the estimated level of producer surplus was then fitted through the equilibrium point for the off-peak period.

For the peak period, a linear supply curve that generated the estimated level of normal producer surplus was fitted through the appropriate point on the vertical part of the supply curve i.e. the average spend per visit less spend per visit attributable to the scarcity rent.

To estimate the impact of changes in demand on normal producer surplus, scarcity rent and consumer surplus, the demand curves were shifted horizontally by changing the demand curve constant so that the

[39] Price elasticity of demand would be expected to be less than 1 given the uniqueness of LHI and limited substitutes. In addition, studies (e.g. Crouch (1994) suggest an average price elasticity of demand for international tourism (which is likely to be a better indicator for LHI than domestic tourism) of around -0.6 to -0.8.

[40] Tourism expenditure information was based on expenditure on the Island and so excluded expenditure on airfares. Also, no information was available on potential scarcity rent accruing to airlines. Consequently, the producer surplus and scarcity rent accruing to the airline was excluded from the analysis. This has the effect of understating the benefits of tourism and the REP and the short term costs of the REP.

[41] Gross operating surplus in the National Input-Output Table has been used as a proxy for producer surplus.

new equilibrium number of visits (for the off-peak period this was the equilibrium if the visitor restriction did not apply) resulted in the appropriate percentage increase or decrease in visitors.

The new area of producers surplus, scarcity rent and consumer surplus were them measured and compared to the values under the "without" REP scenario.