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Protecting the Booroolong Frog in the Namoi Catchment: A Cost-Benefit Analysis

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Abstract

The Booroolong frog project in the Namoi Catchment represents an environmental investment to protect the species and around 10.7 kilometres of its habitat in the catchment. The project's benefit-cost ratio (BCR) of 8.6 indicates that the benefits outweigh the costs by a significant margin. The measures introduced by landholders, at relatively low cost, should therefore result in a significant return on investment upon project completion in 10 years time. The benefits are estimated using a choice modelling study which was recently developed for the valuation of investment in natural resource management in the Namoi Catchment. As this is a largely ex ante cost-benefit analysis, the BCR is subject to uncertainty associated with assumptions which had to be made for some variables. However, sensitivity analysis indicates that the project benefits outweigh the costs by a significant margin even under conservative conditions.

Key words: Cost-benefit analysis, Benefit-cost ratio, Choice modelling, Booroolong Frog, Namoi Catchment.

1. Introduction

The Booroolong frog (*Litoria booroolongensis*) is one of fourteen critically endangered amphibian species in Australia (Frogs Australia, 2006). Surveys indicate that the species has undergone a severe decline over the past two decades across the entire breadth of its range. Estimates of the national population are in the order of 5,000 individuals (DSEWPC, 2010). The species only occurs in NSW and north-eastern Victoria but has largely disappeared from the NSW Northern Tablelands (DECCW, 2005a). However, significant remnant populations have been recorded in the Namoi Catchment.

The Namoi Catchment Management Authority (CMA) implemented a project in fiscal year 2009/2010 to protect the Booroolong frog in the catchment. The project area is located on the Peel River above the Chaffey Dam which is one of four subregions where populations are known to occur in the Namoi Catchment (the others are Eastern Nandewars, Kaputar and Walcha Plateau) (DECCW, 2005c). The aim of the project is to protect the Booroolong frog and about 10.7 kilometres of its habitat by entering in an agreement to implement a management plan with landholders where large numbers of the species are known to occur. The management actions seek to address the threats facing the species. Examples of management actions include clearing of weeds; removal of non-native riparian species; and the prevention of degradation of both river banks and water quality by restricting livestock access and fossicking activities.

The project area is comprised of four separate river facing properties. The landholders are comprised of the Livestock Stock Health & Pest Authorities (LHPA); State Water; and two private landholders (referred to as landholder A and B). Collectively these four properties represent the largest proportion of the Booroolong frog's habitat in the Namoi Catchment. The main differences between the properties include heavier weed burdens such as the presence of canopy weeds at some locations; total livestock exclusion versus seasonal river access for livestock outside the species' breeding season; and the prohibition of fossicking as opposed to restricted vehicle access to the river and signage to create public awareness about the impact of fossicking activities on the species. However, on the whole the management actions undertaken across the different sites don't vary significantly.

2. Background

2.1 Cost-Benefit Analysis

In this study the cost-benefit analysis (CBA) method is used to evaluate the efficiency of an environmental investment by determining the project's benefit-cost ratio (BCR). The goal is to find the most efficient allocation of a society's resources (Boardman et al., 2006). The BCR assists decision-makers in deciding how to allocate funding by providing a basis for comparison of different possible investments in an *ex ante* scenario. On the other hand, the decision-maker may want to evaluate an investment from an *ex post* point of view or an investment which is in the process of being made to determine if the resources already allocated delivers the expected outcomes. In this case a project which has recently commenced is evaluated for its largely future outcomes.

CBA is commonly used to evaluate investments; however its use in the environmental management realm faces significant obstacles. As most environmental assets are not traded on markets it can be difficult to determine the value of investment in the protection of environmental assets. Non-market valuation is one approach which offers an alternative route for valuing these types of investment (see section 2.2 below). Another perceived challenge to the use CBA in this context is the moral objection to the evaluation of environmental investments in economic terms. One concern relates to placement of a monetary value on endangered species. However, one should bear in mind that the aim is not to create a market for the species but to facilitate comparison of different costs and benefits (Hanley and Barbier, 2009).

2.2 Choice Modelling

The valuation method used in this assessment to estimate the non-market environmental benefits associated with protecting the Booroolong frog is Choice Modelling (CM), a stated preference technique. In a CM study conducted by Mazur and Bennett (2009), New South Wales (NSW) households were asked about their preferences regarding investment in natural resource management in the Lachlan Catchment. The availability of this economic model to determine the benefit of environmental investment in the Lachlan Catchment is fortunate because finding values for 'non-market goods' is often difficult or costly to determine through surveying. Therefore this presented an ideal opportunity to evaluate the Booroolong frog conservation project in the Namoi Catchment.

In the Namoi CM survey the respondents were asked about their preferences regarding four attributes: native species; native vegetation; healthy waterways; and agricultural employment. These attributes were presented to the respondents in the form of choice sets which each contain different scenarios where the four attributes are set to different levels. For example, one scenario provided 6,000 square kilometres of native vegetation; 2,130 native species; 2,700 km of healthy waterways and 5,100 people working in agriculture at a cost of $50 per household per year paid over 5 years (Mazur & Bennett, 2009). In each choice set the respondent was asked to compare three of these scenarios including the status quo scenario which provided the level of the four attributes within the catchment that would occur in 20 years time if there were no new natural resource management investments made. By choosing one of the scenarios a respondent reveals her relative preferences for the four attributes. The implicit price of each of the attributes can then be determined by examining the respondents' average willingness to pay to secure more of each environmental attribute, all else remaining constant.

The implicit prices of the attributes from this CM study are presented in table 1. A benefit estimate for improvements in each of the attributes can be calculated from these implicit prices by multiplying the implicit price with the change in the level of the attribute achieved, the number of households in NSW and the response rate. In this particular CBA only the implicit prices of native species and healthy waterways are relevant.

Table 1: NPV of implicit prices for the CM attributes

Attribute	Units	Namoi	Sydney	Rural NSW
Native Vegetation	$ per sq. km. per household	-	0.09	0.09
Native Species	$ per species per household	10.82	10.52	-
Healthy Waterways	$ per km. per household	0.48	-	-
Agricultural Employment	$ per person per household	-	0.82*	-

*Significant only at the 10 per cent level.
All values discounted at a rate of 5 per cent over 5 years.

3. Cost-Benefit Analysis

3.1 Benefits

3.1.1 Native species

The benefit of protecting the Booroolong frog in the Namoi Catchment is estimated to be $4,462,153. This is the net present value (NPV) of NSW households' willingness to pay over a period of 5 years for the protection of the species in the Namoi Catchment. The NPV is based on an annual interest rate of 5 per cent; response rates of 30 per cent for the Sydney region and 60 per cent each for the local rural and distant rural regions; and NSW household numbers as recorded in the 2006 census.

However, this benefit estimate must be scaled down to account for the fact that the project only accounts for a proportion of the total population of the species in the Namoi Catchment. A 2009 study (North West Ecological Services, 2009) of the Booroolong frog in the Namoi Catchment provide the basis for an estimation of this distribution. The study documented 647 sightings in the project area out of a total of 690 sightings in the entire catchment. As the methodology employed across the catchment was consistent and the entire catchment where the species is known to occur was surveyed, the percentage of the population within the project area can be estimated to be in the order of 94 per cent. Therefore the final native species benefit estimate for the Booroolong frog project is $4,194,424. Due to the uncertainty associated with the distribution estimate it is included in a sensitivity analysis in section 4. This highlights the sensitivity of the BCA to this variable.

3.1.2 Healthy waterways

As an obligate stream dweller, protection of the Booroolong frog's natural habitat is crucial to its survival (North West Ecological Services, 2009). Apart from helping secure the protection of the species, this environmental investment delivers a benefit in its own right. As indicated in table 1, households in the Namoi Catchment value healthy waterways at $0.48 per kilometre. The total length of river which is included within the project area is around 10.7 kilometres (21.3 kilometres of stream bank). The estimated benefit of the protection of this length of healthy waterways is $101,578.

3.1.3 Risk and uncertainty

The estimated benefit derived from the protection of the species and the establishment of healthy waterways is based on the projected benefits upon completion of the project in 9 years' time. The fact that the project has only completed its first full year means that the evaluation is largely *ex ante*. This introduces uncertainty about the outcome of the project which translates into a risk that the project will not achieve its aim of protecting the Booroolong frog and the associated waterways. Usually this risk is accommodated in the analysis by introducing probability factors into the benefit calculation (see equation 1 below). In effect the benefits derived by the investment is weighted by the probability associated with each benefit being realised (Hanley and Barbier, 2009, Campbell and Brown, 2003).

The key question is what are the probabilities that the project will achieve success in protecting the Booroolong frog and the targeted length of river? The answer will depend on a number of factors including:

- What is the financial security of the project?
- What are the threats facing the species and its habitat?
- Do the management actions address most of the threats?
- Have similar projects succeeded elsewhere?
- What do recent population trends and the state of the associated waterways tell us about the condition of the species and its environment?

The project is financially reasonably secure because the Namoi CMA has entered into an agreement with the landholders, whereby the landholders will receive project funding in the form of a grant. The landholders also committed a significant proportion of the projected funds needed in the form of their own in-kind contribution over the 10 year lifetime of the project. The contributions of the landholders make up roughly half of the projected funding needed to implement the management actions but ultimately the landholders are responsible under the agreement to implement the management actions. In the event of the project expenditure exceeding the agreed funding the onus will nonetheless be on the landholder to implement the actions.

The main threats facing the species include the chytrid fungus, feral predation, habitat loss, water extraction and drought (North West Ecological Services, 2009; DECCW, 2005a). Other threats which have been identified include water quality (e.g. sedimentation, chemicals, nutrient emissions) and invasive weeds. DECCW (2005b) developed a list of 10 priority actions for the recovery of the Booroolong frog which seek to address the threats faced by the species (see table 2).

Table 2: Priority management actions to address threats

No.	Management Action
1	Captive Husbandry or ex-situ collection/propagation
2	Community and land-holder liaison/ awareness and/or education
3	Disease and pathogens
4	Habitat management: Feral Control
5	Habitat Protection
6	Habitat Rehabilitation/Restoration and/or Regeneration
7	Monitoring
8	Research
9	Survey/Mapping and Habitat assessment
10	Translocation and/or reintroduction

Source: DECCW, 2005b.

The project management actions address the majority of these threats with the exception of the first and last actions. Also, action no. 8 (Research), is beyond the scope of the project. The threat that stands out as possibly the greatest relates to the third action – disease and pathogens. The Booroolong frog is known to be susceptible to *Chytridiomycosis*, an infectious disease affecting many amphibian species worldwide (DSEWPC, 2010; Speare & Berger, 2005). There is relatively little that can be done to prevent its spread as it is waterborne and the species is an obligate streamdweller (North West Ecological Services, 2009). However, the project population is not known to be infected with the fungus. Furthermore, the removal of heavy weeds to reduce heavy shading, which has been reported to reduce the prevalence of the chytrid fungus, is being implemented in the project (A. Cronin, Personal Communication, 28 February 2011).

The decline of the species has been rapid on a national scale and the species is now rare throughout the majority of its range (DSEWPC, 2010). Though population trends cannot be developed due to the scarcity of population records, the species' range has clearly contracted and population densities have declined noticeably within the past 20 years. A comparison of the national population estimates (around 5,000 individuals) with the population in the project area (647 sightings in the most recent survey) indicates the significance of the project not only on a regional scale but also within the national context (DSEWPC, 2010; North West Ecological Services, 2009). Given the rapid speed of the species' decline across its entire range it is likely that the population in the project area will eventually suffer extinction if no action is taken. However, the majority of the threats facing the species relate to its environment which is also the focal point of the management actions.

Based on the threats and corresponding management actions taken in the project, the probability of the protection the native species is assumed to be around 70 per cent. The probability of the restoration and protection of health to the 10.7 kilometres of waterways is assumed to be around 80 per cent. As these assumptions have a bearing on the outcome of the CBA they are included in a sensitivity analysis in section 4.

3.1.4 Total estimated benefits

The above benefits and probability factors are combined in the form of equation one as follows.

$$B_{Tot.} = \left(PV_{NS} \times P_{NS} \right) + \left(PV_{HW} \times P_{HW} \right) \qquad (1)$$

where $B_{Tot.}$ ≡ Total benefit (NPV);

PV_{NS} ≡ Present value of estimated benefit of protecting the Booroolong frog;

P_{NS} ≡ Probability of Booroolong frog protection;

PV_{HW} ≡ Present value of estimated benefit of protecting the target length of waterways;

P_{HW} ≡ Probability of protecting targeted waterways.

Substitution of the benefit values and their associated probability factors results in a total benefit of $3,027,517.

3.2 Costs

The main costs incurred include construction materials such as fencing; weed control; predator control; and labour costs. The potential opportunity costs of restricted access for fossicking and restricted river access for livestock on the four properties are also taken into consideration. Cost estimates for the 10 year project are based on the project expenditures of the four landholders during the first year. Though expenditures can be expected to fluctuate during the project life, the annual expenditures are assumed to remain constant. Note that this assumption is included in a sensitivity analysis in section 4. All costs are reported in terms of 2011 dollars by calculating the present values at an interest rate of 5 per cent.

3.2.1 Opportunity cost of fossicking

The area around Nundle is a popular location for fossicking. However, the detrimental impact that fossicking activities have on the stream banks and in-stream habitat of the species means that restrictions have to be enforced within the project area. It is important to note that fossicking may only be undertaken for recreational and educational purposes (DPI NSW, 2010). In fact, limits apply to the amount of mineral-bearing material or recovered minerals or gemstones which may be removed. This means that the opportunity cost is limited to the tourism industry as opposed to possible impacts on mineral production.

Though by no means the only tourist activity in Nundle, fossicking is nonetheless an important contributor to the local tourism industry (Tourism Nundle, 2010). Other activities include fishing, bush walking and the Nundle Woollen Mill. Furthermore, the project area isn't the only fossicking area in the region (A. Cronin, Personal communication, 16 March 2010). The opportunity cost from restricted access for fossicking in this particular part of the Peel River is therefore not included in this analysis as it is unlikely to result in a significant opportunity cost.

3.2.2 State Water

The State Water Corporation is NSW's state-owned rural water supplier (State Water Corporation, n.d.). It not only holds investment in infrastructure for bulk delivery of water to its customers but also acts as an important manager of water resources in the region. State Water has committed a total of 2.88 kilometres of river habitat for protection and restoration. The estimated NPV of this cost over the 10 year life of the project is $84,395. A significant proportion of these costs are associated with capital expenditures to establish the project. As State Water does not engage in livestock production there was no opportunity cost from foregone production.

3.2.3 Livestock Health & Pest Authority

The LHPA is involved in the project through the equivalent of 5.3 kilometres of riverbank which is under its management on the Peel River in the proximity of the Booroolong frog population. The NPV of the costs to protect the species and its habitat along this stretch is $50,364. This reflects the cost of fencing, weed control, predator control, labour and foregone grazing from a proportion of land which would normally be leased for grazing.

3.2.4 Landholder A

The initial costs of Landholder A were greater than projected largely due to earthworks and capital expenditures. Other costs incurred during the first year of the project include fencing and weed control. Landholder A did not incur opportunity costs in the form of foregone grazing. The estimated NPV of the cost to protect a total of 2.5 kilometres of stream bank (equivalent of 1.25 kilometres of river) is $102,105.

3.2.5 Landholder B

Landholder B committed to the protection of around 1.3 kilometres of river. The main sources of expenditure during the first year were associated with fencing, weed control and foregone livestock production. The estimated NPV of the cost of protecting this length of the river is $115,505.

3.2.6 Total estimated costs

The sum of the estimated NPVs yield the total estimated costs of the project over its 10 year life:

$$C_{Tot.} = PV_{SW} + PV_{LSPH} + PV_{LA} + PV_{LB} \tag{2}$$

where $C_{Tot.} \equiv$ Total cost (NPV);

$PV_{SW} \equiv$ NPV of cost to State Water;

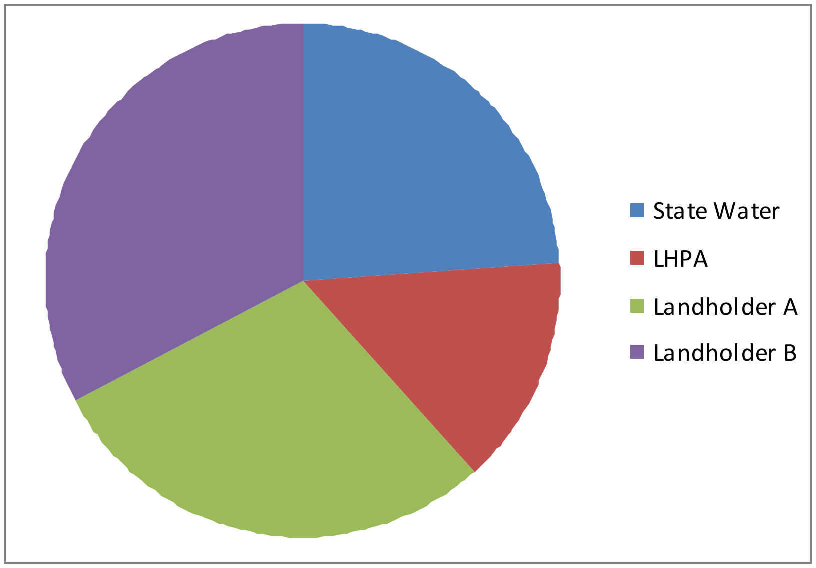
$PV_{LSPH} \equiv$ NPV of cost to Livestock Health & Pest Authorities;

$PV_{LA} \equiv$ NPV of cost to Landholder A;

$PV_{LB} \equiv$ NPV of cost to Landholder B.

The value of $C_{Tot.}$ comes to $352,369. This cost is distributed across the four properties as illustrated in figure 1.

Figure 1: Distribution of project costs (2011 dollars)



3.3 Benefit-Cost Ratio

The costs and benefits are summarised in table 3. As indicated, the BCR is 8.56, which indicates that the benefits outweigh the costs and that the project is a worthwhile investment.

Table 3: Summary of costs and benefits (NPV in 2011 dollars)

<table>
<tr><th>Costs</th><th>Dollars ($)</th><th>Benefits</th><th>Dollars ($)</th></tr>
<tr><td>State Water</td><td>84,395</td><td rowspan="2">Native Species</td><td rowspan="2">2,936,097</td></tr>
<tr><td>LHPA</td><td>50,364</td></tr>
<tr><td>Landholder A</td><td>102,105</td><td rowspan="2">Healthy Waterways</td><td rowspan="2">81,262</td></tr>
<tr><td>Landholder B</td><td>115,505</td></tr>
<tr><td>Total Costs</td><td>352,369</td><td>Total Benefits</td><td>3,017,359</td></tr>
<tr><td colspan="2">Benefit Cost Ratio</td><td colspan="2">8.56</td></tr>
</table>

4. Sensitivity Analysis

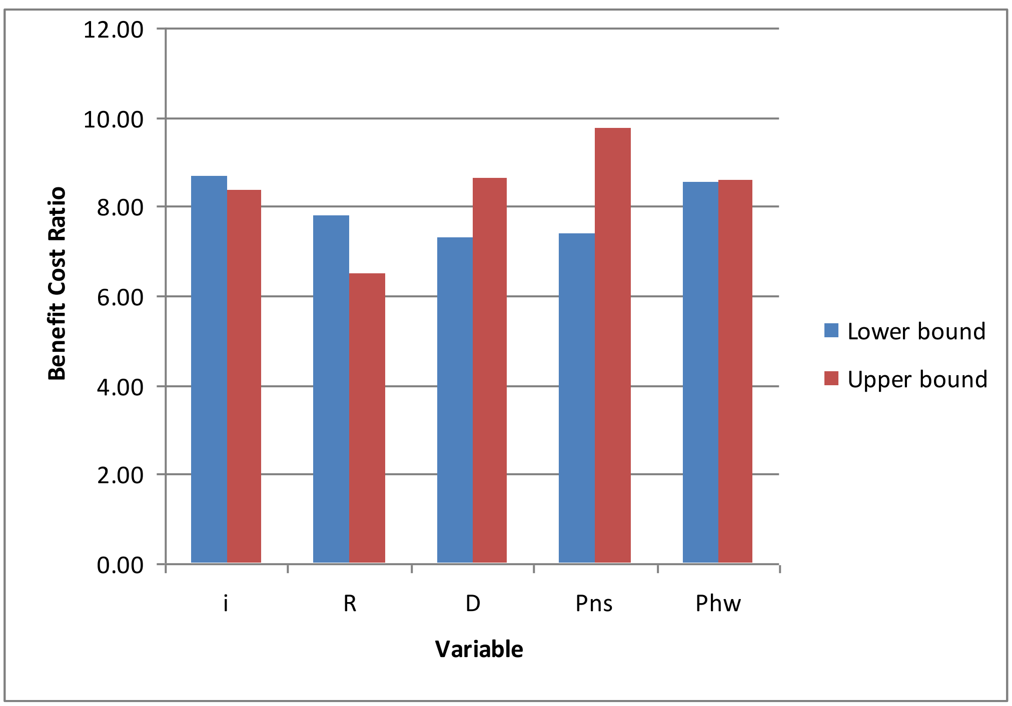
A number of assumptions have to be made about variables for which there is uncertainty about the value they may take. These variables are included in a sensitivity analysis to test how sensitive the CBA is to changes in these values. The possible ranges that these values may take are listed in table 4.

Table 4: Distribution of variables subject to major assumptions

Variable	**Distribution**	**Units**
Interest rate (*i*)	3 to 8	%
Growth in annual expenditures (*R*)	10 to 20	%
Population distribution factor (D)	80 to 95	%
Probability of protection of the native species (Pns)	60 to 80	%
Probability of protection of healthy waterways (Phw)	70 to 90	%

The CBA can then be adjusted using the upper and lower boundaries of the value ranges in table 4. The corresponding values of the BCR serve as an indication of the sensitivity of the analysis to that particular variable. The adjusted BCR values for the upper and lower bound values are illustrated in figure 2 for comparison (see values listed in the appendix).

Figure 2: Upper and lower bounds of BCR for variables subject to major assumptions



Changes in the interest rate (*i*) and the probability factor for native vegetation (P_{HW}) don't have a large impact on the outcome of the CBA as indicated by the relatively small change in the CBR with a change in either of these variables. The main reasons are that the interest rate affects both the cost and the benefit side of the ratio and due to the relatively small contribution of the healthy waterways benefit to the overall benefit in comparison to the benefit of protecting native species.

The CBA displays greater sensitivity to the population distribution (R), annual growth in project expenditures (D) and the probability factor for the protection of native species (P_{NS}). The BCR corresponding to the lower and upper bounds for these three variables cover a larger range of values (7.8-6.5; 7.3-8.7; and 7.4-9.8, respectively). This reflects the influence of the population distribution and probability of protection of native species factors on the benefit estimate due to the large contribution of the native species benefit to the total benefits of the project. As expected, a growth in the annual expenditures would create downward pressure on the BCR.

5. Conclusion

The BCR of 8.56 suggests that there is significant value in the Booroolong frog project. Two important factors help deliver this outcome. First, the high value attached by residents in NSW to investment in the protection of native species in the Namoi results in a significant benefit. Second, the fact that a large proportion of the known Booroolong frog population occurs within a relatively small area (around 10.7 kilometres of river habitat) means that the benefits can be delivered at relatively low cost.

The contribution of the investment in the protection of healthy waterways delivered a much smaller contribution to the total benefits than that of the investment in the protection of the Booroolong frog. The main categories of costs include weed and predator control, erection of fencing and alternative water sources for livestock, labour and the opportunity cost from foregone livestock production. Two of the four landholders incurred greater initial capital expenditures due to the nature of the management of the affected properties prior to the project which resulted in a greater need for earthworks and infrastructure to protect the river habitat in the target area.

As this is a largely *ex ante* analysis, the CBA is subject to a number of assumptions which introduces uncertainty into the outcome. However, the sensitivity analysis indicates that even at low BCR values the benefits outweigh the costs by a significant margin. In years to come there ought to be greater certainty, in particular regarding the costs and the probability of successful protection. The analysis would benefit from having at least another couple of years of data for project expenditures which would remove much of the uncertainty associated with the decoupling of the capital and operating expenditures during the initial period and enable observation of cost fluctuation across different management conditions. For instance, in times of heavy rainfall fencing may be washed away and need to be replaced at additional cost. Another cost which warrants greater analysis is the potential impact of restricted fossicking on tourism. However, it would probably be difficult to gain an understanding of its impact on the local economy without a dedicated in-depth study.

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Appendix: Upper and lower bounds of the BCR for variables subject to major assumptions

Variable	**Value**	**BCR**
Interest rate: Lower bound	3%	8.68
Interest rate: Upper bound	8%	8.36
Growth in annual expenditures: Lower bound	10%	7.78
Growth in annual expenditures: Upper bound	20%	6.49
Population distribution factor: Lower bound	80%	7.32
Population distribution factor: Upper bound	95%	8.65
Probability of protection of the native species: Lower bound	60%	7.37
Probability of protection of the native species: Upper bound	80%	9.75
Probability of protection of healthy waterways: Lower bound	70%	8.53
Probability of protection of healthy waterways: Upper bound	90%	8.59