An Analysis of the Costs of New Zealand Threatened Species Programmes

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The New Zealand Department of Conservation has so far classified 2,373 species and subspecies of those so far assessed as being threatened with extinction. Annual expenditure for management services for protected species and island habitats was NZ$35.8 million in 2001/02. Some threatened species programmes, however, require far more funding than other programmes for species that are also at risk of extinction. Until now, the contribution of economics to threatened species conservation has focused on areas such as the value of threatened species and the opportunity costs of threatened species conservation in terms of economic development, and not the costs of management for threatened species. The aim of this research is to improve the formal understanding of the management costs by investigating the specific form of the cost function for threatened species programmes. The cost function is based on Swanson (1994) and describes the Present Value (PV) of the cost of a threatened species programme as a factor, *inter alia*, in a cost-benefit ranking criterion, which conceptualises threatened species conservation as a dynamic optimisation problem. It is proposed that the cost of a programme in a single time period is determined by the costs of the base natural resources and the management services needed to maximise

the conservation of a threatened species; and that the cost of a programme over time is determined by the costs in each time period and a species' extant population and recovery rate, which together act as a controlling mechanism on these costs. To investigate the specific form of the cost function, this research conducted a cross-case analysis of the costs of New Zealand threatened species programmes. Cost data was collected and analysed from a survey of the Department of Conservation's Recovery Group Leaders for eleven programmes from 2003 until 2012 and used to test hypotheses developed from the theorised characteristics of the cost function. Although the results of the cross-case analysis are subject to uncertainty, habitat area and a species' taxon are identified as two factors that determine the specific costs of New Zealand threatened species programmes. The results also indicate that many threatened species programmes receive minimal or partial funding and, as a consequence, the conservation of species may be delayed, which could increase the risk of further decline, or even extinction, of species and the total cost of the programme. It is recommended that estimates of costs are included in recovery plans, cost-effectiveness analysis of threatened species programmes is conducted, cost and a species' possible recovery rate are included as factors in priority ranking systems, and the costs of threatened species programmes are used in funding applications for threatened species conservation.

Keywords

New Zealand, threatened species, threatened species programme, management, conservation, economic analysis, cost, funding, budget constraint, opportunity cost, cost-benefit criterion, cost function, base resources, management services

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This thesis is dedicated to the memories of

Mabel Hunter, for her love of New Zealand's native plants,

and Kathleen and Bill Perry

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1 Introduction

1.1 Background

New Zealand has been identified as one of twenty-five global 'biodiversity hotspots' because it features a high concentration of endemic species and has experienced a significant loss of natural habitat (Myers, Mittermeier, Mittermeier, da Fonseca, and Kent, 2000). New Zealand's remaining primary vegetation is twenty-two percent of its original extent, and 1,865 of New Zealand's plant species and 136 of its vertebrate species are found nowhere else (Myers *et al.*, 2000). New Zealand's isolation from other landmasses has resulted in relatively low biological diversity (biodiversity) and the evolution of unusual characteristics in its fauna, such as gigantism and flightlessness (Conservation International, 2003). Although eight million hectares, or about thirty percent of New Zealand's land area, is officially protected in national parks and reserves, lowland habitats are under-represented and many of the protected areas are still at risk from introduced pests (Conservation International, 2003).

The New Zealand Department of Conservation (The Department, DoC) has so far classified 2,373 species and subspecies of those assessed using the New Zealand Threat Classification System (NZTCS) as being threatened with extinction (Hitchmough, 2002). For instance, five subspecies of bats, four frog species, fifty-nine reptile species and subspecies, 145 birds, 670 terrestrial invertebrates, and 890 vascular plants are classified in one of seven threat categories from 'At Risk: Range

Restricted' to 'Acutely Threatened: Nationally Critical' (Hitchmough, 2002). The decline in biodiversity is recognised as New Zealand's most pervasive environmental issue (Ministry for the Environment (MfE), 1997). The New Zealand Biodiversity Strategy (NZBS) was prepared in response to biodiversity decline and to fulfil its obligations under the Convention on Biological Diversity (CBD) 1992 (DoC and MfE, 2000). A goal of the NZBS is to halt the decline in New Zealand's native and endemic biodiversity by 2020 (DoC and MfE, 2000: 18) by doing whatever is necessary "to maintain and restore viable populations of all indigenous species and subspecies across their natural range and maintain their genetic diversity."

In 2001/02, annual expenditure for management services for protected species and island habitats was NZ$35.8 million (DoC, 2002). In 2000, the New Zealand Government committed an additional NZ$26.5 million over five years for habitat restoration on the mainland and species recovery programmes as part of funding to support the implementation of the NZBS (DoC, 2003). The additional funding included NZ$10 million to establish five Kiwi sanctuaries covering 40,000 hectares of land. The Kiwi programme now receives more government funding than any other threatened species programme. It is estimated by DoC that mean annual expenditure for the Kiwi from 2000 until 2004 will be around NZ$2.8 million (C. Carter, personal communication, October 18, 2002) (included in Appendix A). It is unclear, however, why some threatened species programmes require more funding than other programmes for species that are also at risk of extinction. The aim of this research is to improve the formal understanding of the costs of New Zealand threatened species programmes so that the conservation of threatened species can be maximised.

1.2 Structure

1.2.1 Review of literature

Chapter two reviews the economic literature on the conservation of threatened species and considers the contribution of economic theory and research to threatened species conservation as an economic problem. First, Swanson's (1994) and Weitzman's (1998) theoretical models are used to represent economic theory on threatened species conservation. Second, three general areas of interest in the economic research are reviewed: the value of threatened species, the opportunity costs of threatened species conservation, and the costs of nature reserves. Third, patterns of expenditure for threatened species and the costs of species' management are discussed as two further research areas. Finally, the problem statement for this research is presented.

1.2.2 Economic theory

Chapter three formally states the aim and objectives for this research. It then develops a model of the cost of a threatened species programme, and proposes a null hypothesis and alternative hypotheses for further investigation. Theory from ecological economics and production economics is applied to the conservation of threatened species in two stages to develop a simple conceptual model of the cost of a threatened species programme. First, how the cost of a threatened species programme fits into the wider context of threatened species conservation is outlined. Second, a threatened species programme's cost is described using a cost function. The specific

form of the cost function, however, needs to be based on empirical evidence, which is the focus of this research.

1.2.3 Research methodology

Chapter Four describes the methodology that is used to collect and analyse the empirical evidence needed to test the proposed hypotheses. This chapter outlines the background to the research method, the development of the research design, and the collection and analysis of data. In the absence of cost databases, the methodology used for this research is a multiple case study analysis of the costs of New Zealand threatened species programmes using data collected from a survey of DoC's Recovery Group Leaders. The general analytical strategy is a cross-case analysis of the data collected from the Recovery Group Leader Survey using pattern matching logic and explanation building. The chapter then previews the reporting of the analytical results and the testing of the hypotheses in Chapters Five and Six.

1.2.4 Reporting of results and discussion

Chapters Five and Six report and discuss the results of the cross-case analysis of the data collected from the Recovery Group Leader Survey. In Chapter Five, the results are presented for each of the eleven threatened species programmes for which cost data was available and the additional seven programmes for which only expenditure data was reported to highlight key points for further analysis and discussion. In Chapter Six, the results of the cross-case analysis of the eleven threatened species programmes are presented and discussed. The main body of Chapter Six is divided

into five sections: the costs of threatened species programmes, programme's annual costs, their cost-effectiveness, the projected total costs, and the budget constraint.

1.2.5 Conclusion

In the final chapter, the main findings of this research are used to review the characteristics of the cost function for New Zealand threatened species programmes, to highlight this research's contribution to the sum of knowledge on the subject, and to identify areas for further research. This chapter also considers the policy implications of this research and makes recommendations for conservation of threatened species in New Zealand.

1.3 Interpretation

This research uses terminology from economic and scientific disciplines that require interpretation. The meaning of each term is developed using relevant definitions from New Zealand and international sources.

Biological diversity or biodiversity means the variability among living organisms from all sources and the ecological complexes of which they are part, this includes diversity within species, between species and of ecosystems (CBD, 1994; DoC and MfE, 2000: 137), but particularly diversity between species.

Budget constraint means a circumstance when the amount of money set apart for a particular purpose falls short of the amount that is needed to accomplish the purpose.

Conservation means the careful preservation and protection of all kinds of living organisms for the purpose of maintaining their intrinsic values, providing for their appreciation and recreational enjoyment by the public, and safeguarding the options of future generations (Brown, 1993: 485; Conservation Act, 1987).

Conservation status means the position or rank of a species according to its risk of extinction. In New Zealand, the ranking of a threatened species is assessed as one of seven threat categories using the NZTCS[1] (listed in increasing order of risk): 'Sparse', 'Range Restricted', 'Gradual Decline', 'Serious Decline', 'Nationally Vulnerable', 'Nationally Endangered', and 'Nationally Critical'. The seven threat categories are grouped into three major divisions: 'At Risk', 'Chronically Threatened' and 'Acutely Threatened'.

Cost means the amount of money that must be given in order to accomplish a particular purpose; the price to be paid (Brown, 1993; 521). Expenditure is not equivalent to cost unless it is equal to one hundred percent of cost.

Expenditure means the action or practice of expending money; an amount of money spent or used for a particular purpose (Brown, 1993: 886).

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[1] The NZTCS was developed by Molloy, Bell, Clout, de Lange, Gibbs, Given *et al.* (2000) to complement the IUCN (World Conservation Union) Red List of Threatened Species but also consider New Zealand's relatively small land area, the period over which recent declines have occurred, and the high number of taxa with small population size and naturally restricted ranges.

Fully fund means to set an amount of money apart for a particular purpose that is equal to the amount of money that must be given to achieve a particular purpose; funding is equal to 100 percent of cost.

Funding means an amount of money set apart for a particular purpose; the amount of money at a person's disposal for a particular purpose; financial resources (Brown, 1993: 1042).

Habitat means the environment in which a particular organism naturally occurs (Brown, 1993: 1169; DoC and MfE, 2000: 140).

Immediate threat means an important present threat to a species.

K-selection means the evolutionary selection of traits that maximise population size. A K-selected species is a strategist and characteristic of constant or predictable environments. It typically has slower development, large body size, late onset of reproductive capability, low birth rates and high survival rates among offspring, long life-span, and iteroparity (Allaby, 1998; Calow, 1998; Lawrence, 1995; Lincoln Boxshall, & Clark, 1998).

Opportunity cost means the value of the most highly valued rejected alternative; the value that is given up in order to secure the higher value that the selected alternative embodies (Eatwell *et al.*, 1987: 719).

Recovery means the possibility of a threatened species being restored, the action of restoring a threatened species, and the restoration of a threatened species to a former natural state or strengthened condition (Brown, 1993: 2507)[2].

r-selection means the evolutionary selection of traits that maximise growth rate. A r-selected species is opportunistic and characteristic of variable or unpredictable environments. It typically has rapid development, small body size, early on set of reproductive capability, expends a large proportion of energy to reproduce, has efficient dispersal, short life-span, and semelparity (Allaby, 1998; Calow, 1998; Lawrence, 1995; Lincoln *et al.*, 1998).

Significant cause of decline means an important historical reason for the tendency for a species to be reduced to an inferior state or weakened condition.

Species means a taxonomic group of organisms that are distinguished from others by certain shared characteristics and are usually unable to interbreed with members of other such groupings due to such factors as genetic divergence, different behaviour and biological needs, and separate geographic locations (Brown, 1993: 2972; DoC and MfE, 2000: 137). Species is also, however, used to refer in general to lower groups of organisms, whether they are taxonomically classified as sup-species, species, subgenus or genus.

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[2] The NZBS defines restoration as the active intervention and management of degraded biotic communities, landforms and landscapes (DoC and MfE, 2000: 142).

Taxon (plural taxa) means a named biological classification unit or taxonomic group assigned to sets of species (Brown, 1993: 3230; DoC and MfE, 2000: 143), rather than organisms within such groups. This is a narrow definition because of a need to delineate sets of species at the level of order or class.

Threat means a person or thing that is regarded as a likely source of harm, injury or danger to a species (Brown, 1993: 3290).

Threatened species means a subspecies, species, subgenus or genus that is assessed as at risk of becoming extinct. In New Zealand, DoC assesses the risk of extinction for native species using status and trend criteria under the NZTCS.

Threatened species programme means the organised system of management under which actions are taken to achieve the recovery goal and objectives for a threatened species. In New Zealand, this includes all of DoC's species conservation programmes, but particularly its species recovery programmes.

2 Review of literature

> "All economic questions and problems arise from scarcity. Scarcity means that our wants exceed the resources available to satisfy them ... Economics is the science of choice - the science that explains the choices we make as we cope with scarcity."
>
> (McTaggart, Findlay and Parkin, 2003: 4)

2.1 Introduction

The purpose of this chapter is to review the economic literature on the conservation of threatened species. This chapter considers the contribution of economic theory and research to threatened species conservation as an economic problem and is divided into three sections. First, economic theory on threatened species conservation is represented by two theoretical models: Weitzman's (1998) normative model of the preservation of threatened species and biodiversity, and Swanson's (1994) positive model of the extinction of species and biodiversity loss. Second, three general areas of interest in the economic research are reviewed: the value of threatened species, the opportunity costs of threatened species conservation, and the costs of nature reserves. Third, two further areas of research to be discussed are patterns of expenditure for threatened species and the costs of management for threatened species, which is the focus of the problem statement for this research.

Many authors have argued that the need to allocate scarce natural resources between competing uses means that the conservation of threatened species is, in effect, an economic problem (for example: Souder, 1994; Swanson, 1994; Weitzman, 1998; Shogren, Tschirhart, Anderson, Whritenour, Beissinger, Brookshire *et al.*, 1999). The allocation of natural resources to threatened species conservation can have a high opportunity cost in terms of economic development (Montgomery, Brown and Adams, 1994; Lewandrowski, Darwin, Tsigas, and Raneses, 1999). Where there is a high opportunity cost of conservation then the non-market value of threatened species becomes important to support the argument for conservation (Edwards and Abivardi, 1998; Alexander, 2000). The contribution of economics to threatened species conservation has, therefore, largely focused upon the non-market value of threatened species, the opportunity costs of threatened species conservation and, to a lesser extent, the costs of supplying nature reserves.

Fewer authors appear to have recognised that threatened species conservation is also an economic problem because of the need to allocate scarce financial resources across species (examples are: Balmford, Gaston, Rodrigues and James, 2000; Restani and Marzluff, 2001; Doerksen, Leff and Simon, 1998; Hughey, Cullen and Moran, 2003). The World Conservation Union (IUCN) (2001) advised that financial resources would have to be increased by ten to one hundred times their present level to be able to ensure the survival of the 11,000 animal and plant species so far assessed as facing a high risk of extinction. Until this occurs, threatened species conservation will be dependent upon the costs of management and the budget constraint. There has been some economic analysis of patterns of expenditure for threatened species, but costs have as yet been virtually ignored.

2.2 Economic theory on threatened species conservation

There are two important theoretical models of threatened species conservation: Swanson's (1994) model of the extinction of species and biodiversity loss, which revised a model by Clark (1973a, 1973b) and, Weitzman's (1998) model of the preservation of threatened species and biodiversity. The two models represent radically different approaches to threatened species conservation. Swanson's (1994) model is an explanation of why some species become threatened or even extinct, and Weitzman's (1998) "Noah's Ark" model is intended as a guide for decision-makers when choosing priorities for which threatened species to protect. Furthermore, although both authors use the opportunity cost of threatened species conservation as a cost factor in their models, only Swanson measures opportunity cost as the cost or rent for a unit of land, which is a cost of management for a threatened species.

2.2.1 The economics of species extinction and biodiversity loss

Clark (1973a, 1973b) first modelled the economics of species extinction, building on Gordon's (1954) over-exploitation model of a fishery as a common-property resource. Clark developed a simple mathematical model for the commercial use of a species in the wild and applied it to the case of the Antarctic Blue Whale fishery. He argued that the maximisation of the present commercial value of a species could mean that the extinction of a species might appear to be the most attractive policy, especially if high private discount rates are used. Clark's model has been used as the basis for most of the economic analysis of the extinction of species over the last thirty years (Swanson, 1994).

Swanson (1994) revised Clark's (1973a, 1973b) model to build a general framework for the analysis of species extinction and biodiversity loss[1], and illustrated its use with the case of the African Elephant. He developed an investment-based model of species as productive biological assets that includes all of the natural resources that are required for the survival of a species. The model showed that there are three types of threat to a species: stock disinvestment, base resource re-allocation, and management services re-allocation. The implications of the model are that the different types of threat are all alternative routes to extinction, each driven by society's 'disinvestment' in a species because it is seen as a non-competitive asset. Swanson argued that the biological growth rate and the commercial value of a species determine whether a species will become threatened or even extinct.

2.2.2 The economics of biodiversity

In contrast to Swanson (1994), Weitzman (1998) developed a cost-benefit model to rank projects to protect different threatened species, which Metrick and Weitzman (1998) use in their discussion about the economics of biodiversity preservation. The theoretical basis of the model is to maximise biodiversity subject to a budget constraint or the natural resources available for the survival of species. The priority assigned to a project is determined by the ratio of the change in probability of a species survival to the opportunity cost of this change. This cost-effectiveness ratio is then weighted by the value of a species as calculated by its distinctiveness and utility. Weitzman concluded that the model encourages decision-makers to focus on the basic

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[1] Biodiversity loss is broader than species extinctions and refers to the potential removal of millions of virtually unknown life forms (Swanson, 1994: 800).

factors when choosing priorities for threatened species conservation, but acknowledged that it may be difficult to quantify these factors in practice.

2.3 Research into the allocation of scarce natural resources

Even though economic theory is limited, there is a growing body of research on threatened species conservation in response to the argument that conservation is an economic problem because it requires the allocation of scarce natural resources. Research on threatened species conservation has, therefore, focused upon three general areas of interest: the value of threatened species, the opportunity cost of threatened species conservation, and, to a lesser extent, the costs of supplying nature reserves.

2.3.1 The value of threatened species conservation

A general area of interest in economic research on threatened species conservation is in assessing the use, existence and contributory values of threatened species to support the argument for their conservation (for example: Van Zyl, Store, and Leiman, 1989; May, 1990; Polasky, Solow, and Broadus 1993; Humphries, Williams, and Vane-Wright, 1995; Sagoff, 1996; Pimentel, Wilson, McCullum, Huang, Dwen, Flack *et al.*, 1997; Bulte and van Kooten, 2000). Costanza, d'Arge, de Groot, Farber, Grasso, Hannon *et al.* (1997) estimated that the total economic value of the Earth's ecosystem services, which are underpinned by biodiversity, ranges from US$16 to

US$54 trillion annually[2]. In a similar exercise, Patterson and Cole (1999) estimated the total economic value of New Zealand's terrestrial ecosystem services to be almost NZ$44 billion annually[3].

Biologists Edwards and Abivardi (1998) considered the growing importance of economics in wildlife conservation and argued that economic analysis of the opportunity costs and benefits of conserving threatened species is a useful tool for conservation. The authors proposed that economics is able to show the high economic value of wildlife and can reveal the economic and social pressures that threaten wildlife. They also proposed that economic analysis has a role to play in restoring wildlife to the areas of society where it has been seriously degraded. They concluded that conservation must, however, cease to be a specialist interest dominated by scientists and naturalists and become part of mainstream activity for economic analysis to be effective.

In contrast, Bulte and van Kooten (2000) argued that while economic analysis can be used to support the argument for the conservation of species and their habitats, many biological assets are inferior investments in society's investment portfolio. They illustrated this by balancing the value of harvest to the value of preservation stock for the ancient temperate rainforest and Minke Whale to determine how much of each asset society should have in its investment portfolio. The authors found that it is only as the stock of a biological asset is depleted that its marginal non-use value increases. Economic efficiency will lead to the conservation of some stock of the biological

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[2] Measured in 1994 dollars.

[3] Measured in 1994 dollars.

asset, but there is no guarantee that this will be enough to satisfy ecologists. In conclusion, they proposed that economic analysis is important in developing tools to achieve goals but it should not be allowed to determine the goals themselves.

Alexander (2000) argued that often non-market values and, in particular, existence value must be appropriated in order to ensure the survival of a species. He revisited Swanson's model and the case of the African Elephant to develop a model of species extinction that highlighted existence value as one of the key economic factors in determining the future of a threatened species. Analysis of non-market values is, however, problematic and research has had to rely on indirect methods of valuing the conservation of threatened species, such as contingent valuation studies (for example: Loomis and White, 1996; Garrod and Willis, 1997; and Eagle and Betters, 1998).

2.3.2 The opportunity costs of threatened species conservation

The literature on the value of threatened species is balanced by research into the opportunity costs of threatened species conservation in terms of economic development (for example: Brown and Shogren, 1998; Norton-Griffiths and Southey, 1995: Haight, 1995; and van Zyl, Store and Leiman, 1998). The total annual opportunity costs of nature reserves covering ten percent of global land area to protect biodiversity has been estimated to be over US$93 billion (Lewandrowski *et al.*, 1999)[4]. In the United States, the costs of threatened species conservation are viewed as the economic effects of protecting threatened species under the Endangered Species Act (ESA) (Souder, 1993).

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[4] Measured by the value of market goods and services forgone in 1990 dollars.

A comparatively early paper is Hyde (1989), who examined the marginal opportunity costs of managing threatened species using the Red-Cockaded Woodpecker as a case study. The costs of conserving the Woodpecker were identified as only the lost timber opportunities of delayed harvests as there were no direct management costs associated with the species. Hyde concluded that outlining the costs of conserving populations of a species provides the total cost information needed for choices between management options. He noted that the analysis showed the costs of providing habitat for a species but this may not be enough to conserve a species or even individuals of a species. Finally, the author suggested that the costs of conservation for threatened species could sometimes be less than anticipated.

In an influential paper, Montgomery *et al.* (1994) linked a biological production function model with an econometric timber market model to derive a marginal opportunity cost curve for the protection of the Northern Spotted Owl. The authors argued that the question of which species to save should be a choice of the probability of survival that is wanted, rather than one of preservation or extinction. They noted as important that the United States Fish and Wildlife Service (USFWS) has limited funding to allocate to the conservation of threatened species, but they focused on the economic trade-offs associated with the protection of habitat. The costs of saving the Owl were defined as the opportunity costs of protecting Owl habitat, and were measured as the welfare loss in wood products markets. The authors reported extremely high opportunity costs of improving the certainty of Owl survival, but because this did not include any costs, such as those for fire management (Loomis and González-Cabán 1998), it does not restrict the allocation of USFWS funding to the management of other species.

Marshall, Homans and Haight (2000: 462) argue that there is no management strategy that will provide complete certainty of the survival of a species and so "it is appropriate to consider cost and benefit analysis in probabilistic rather than deterministic terms". The authors used Haight's (1995) decision framework for the choice of population size that is wanted and a stochastic simulation model to examine strategies for improving the cost-effectiveness of management for the Kirtland's Warbler. The authors, however, defined the cost of management as the opportunity cost of harvesting timber early to regenerate prime nesting habitat. They concluded that the desired population size that is selected might determine the most cost-effective combination of management techniques.

2.3.3 The costs of nature reserves

In addition to the literature on the value of threatened species and the opportunity costs of threatened species conservation, there is an increasing amount of research into the costs of supplying nature reserves (for example: Ruitenbeek, 1992; Montgomery, Pollak, Freemark, and White, 1999; Drechsler, and Wätzold, 2001). Research into the cost of nature reserves is linked to research into the opportunity costs of threatened species conservation because of issues of compensation, but it is also related to the costs of species' management to be discussed in the next section.

James, Gaston and Balmford (1999) argued that despite the value of the Earth's ecological systems, the comparatively low costs of maintaining biodiversity have been ignored. They calculated that globally, the total annual expenditure by governments and international non-governmental organisations on nature reserves,

arguably the cornerstone of conservation actions, is only US$6 billion[5]. The authors estimated that the annual cost of expanding the system of nature reserves to ten percent of global land area to take account of concerns that the existing reserves are often too small to support biodiversity, would be an additional US$16.6 billion.

James *et al.* (1999) argued that the costs of expansion must include resources for biodiversity surveys, land acquisition, and administration and management. They also proposed that effective long-term conservation is dependent on appropriate compensation being paid to local communities: the opportunity costs of expanding the system of nature reserves should be met in land prices, but compensation needs to be paid for the opportunity costs of many existing nature reserves. The authors concluded that given the key role of nature reserves for conservation, meeting those costs should be a high priority in government budgets and on the international agenda.

Balmford *et al.* (2000) developed on James *et al.* (1999) to examine the advantages of including cost information in global priority setting. They noted that as there are only scarce resources for conservation efforts, the identification of priorities for allocating resources is important, but most widely used approaches do not consider the comparative costs of conserving different areas. Further to this, James, Gaston and Balmford (2001) noted that as well as the costs of maintaining biodiversity being ignored, there are few reliable figures available: estimates range from a total global cost of U.S.$680 million to $42 billion, with most around $20 billion. They concluded that although many documents have outlined strategies and priorities for the conservation of biodiversity, none have included detailed cost estimates.

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[5] All costs are in 1996 dollars.

The cost of nature reserves has created interest in the potential for economies of scale and scope in threatened species conservation. This interest has raised the issues of single-species versus ecosystem management in threatened species conservation (for example: Simberloff, 1998; Andelman and Fagan, 2000), and the effectiveness of nature reserves in the conservation of threatened species (for example: Bruner, Gullison, Rice, da Fonesca, 2001). Ando, Camm, Polasky and Solow (1998) extended Dobson, Rodriguez, Roberts and Wilcove's (1997) model, which used the geographic distribution of threatened species in the United States to locate biodiversity 'hotspots', to include land values in the selection of nature reserves. Polasky, Camm, and Garber-Yonts (2001) applied the extended model to the nature reserve selection for land vertebrate species in Oregon and concluded that, in general, effective conservation decision-making requires integrated analysis of both biological and economic data.

2.4 Research into the allocation of financial resources

Most of the research on threatened species conservation has been in response to the argument that it is an economic problem because it requires the allocation of scarce natural resources. The argument that threatened species conservation is also an economic problem because it requires the allocation of scarce financial resources has not, however, been widely recognised. As a result, there has been some research into expenditure for threatened species, but, beyond some of the literature on the costs of nature reserves (for example: James *et al.*, 1999), there is only a limited amount of research on the costs of management for threatened species.

2.4.1 Patterns of expenditure for threatened species

A fourth area of research interest is expenditure for the threatened species (for example: Scott, Tear and Mills, 1995; Ando, 1999; Wu and Boggess, 1999). Research in this area has focussed on the relationship between the factors that determine expenditure and the policy goals for threatened species conservation. The IUCN and countries such as the United States, Australia and New Zealand have all developed priority ranking systems for threatened species, in which the key factor is the degree of threat. The literature shows, however, that the patterns of expenditure are more likely to be explained by political rather than scientific considerations.

Policy analysts, Simon, Leff and Doerksen (1995) examined the relationship between United States federal and state expenditures for threatened species and the priority ranking assigned to species by the USFWS. They found that less than nine percent of species received almost eighty-five percent of all expenditure, and about forty percent of species received no expenditure at all. They also found that there is a higher probability that mammals, birds and fish species will be allocated funding than plants and invertebrates. The authors concluded that even though there is a positive relationship between expenditure and some of the factors that determine priority ranking, such as conflict with economic development, the allocation of funding is not related to a species' priority ranking.

In the first of two influential papers on the political economy of threatened species conservation, Metrick and Weitzman (1996) also used US government expenditures to show that visceral factors, such as body size, charisma or taxonomic group, play a much greater role in determining expenditures for threatened species than more

scientific factors, such as degree of threatenedness or biological distinctiveness. Metrick and Weitzman (1998) used "revealed preference" analysis to show that charisma or utility is the key factor in decisions about the conservation of threatened species. They concluded that either society's decisions need to better reflect a reasoned cost-benefit calculation or society needs to be honest about its preference for charismatic species. In response to both papers, Dawson and Shogren (2001) found that any combination of "time invariant" factors, from charisma to historical use or habitat, could explain expenditures for threatened species.

Unlike Simon *et al.* (1995) and Metrick and Weitzman (1996), Restani and Marzluff (2001) analysed US government annual expenditures for only bird species to determine if the priority ranking system was being followed within a taxonomic group. They found that a bird species' priority ranking explained less than five percent of expenditure. They also found that ten bird species dominated expenditures, even though half of these species have a moderate or low priority ranking; and bird species with a high ability to recover, wide distributions, and captive breeding programmes received more expenditure than other species. The authors concluded that funding for threatened species conservation needs to be increased to reduce the negative consequences of having to allocate funding across species.

2.4.2 The costs of management for threatened species

Annual expenditure for a threatened species is not necessarily equivalent to the annual cost of a threatened species' management. That is, the amount of money that is actually used each year for the conservation of a threatened species may not be the same as the amount that ideally must be given each year to accomplish the

conservation of the species[6]. The cost of management for a threatened species is a fifth research area and the literature highlights three crucial points. First, adequate information on the costs of management is essential to the success of attempts to gain sufficient funding for threatened species conservation (Wilcove and Chen, 1998). Second, differences in the costs of management for threatened species means that the allocation of funding across species can be affected by alternative policy goals (Doerksen *et al.*, 1998). Third, accurate estimates of the costs are critical for cost-effectiveness analysis of the management of threatened species (Cullen, Fairburn and Hughey, 2001; Cullen, Moran and Hughey, 2002).

An important example in the literature on management costs for threatened species is Wilcove and Chen (1998), who estimated the costs of managing the habitats of species threatened by alien species or the disruption of fire regimes using published data and interviews. The authors argued that it is not surprising that the focus of efforts to ensure the survival of threatened species is on the protection of habitats, as habitat destruction is a factor in the decline of most species, but many habitats also require active management to be able to support a species. They suggested that attempts to gain enough resources for habitat management have been largely unsuccessful in the United States because of a lack of information on costs. The authors concluded that if the costs of habitat management are not met then a large proportion of threatened species in the United States could face extinction, even if their habitats are protected.

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[6] Total expenditure will be equal to total cost, however, when the conservation of a threatened species is accomplished.

Along similar lines, Main, Roka and Noss (1998) compared the costs of public ownership of priority habitat for the Florida Panther with the costs of Resource Conservation Agreements, which compensate private landowners for conserving the habitats of threatened species. The management costs of public ownership consisted of the costs of pest control, law enforcement, monitoring, and administration and were measured by annual operating budgets. They argued that the costs of public ownership of habitat must include operating or management costs as well as acquisition costs because it is counterproductive to acquire land if it is then poorly managed because of limited resources. The authors found that the costs of public ownership of land were different to the costs for privately owned land because there was greater potential for development on privately owned land.

Abitt and Scott (2001) examined the differences in management between threatened species that recover and those that continue to decline in the United States. They found that the recovering species face threats that are easier to manage or they inhabit more of their historic range, and the species that remain threatened may require much more management, and so may have higher costs in the future. More recovering species were threatened by pollution and direct human-caused mortality, while more declining species were threatened by dams, drainage or diversion, introduced predators, and economic development. Doremus and Pagel (2001) found that the lack of effective protection against the effects of human activity in the United States means that most species will remain threatened in the long term. The implication of this is that the costs of management for many threatened species may be ongoing.

In a different approach to costs, Doerksen *et al.* (1998) estimated the costs of USFWS's management actions to show how alternative policy goals affect the allocation of US$35 million annually for 575 threatened species. The average total costs of management ranged from over US$7.9 million for birds and almost US$5.9 million for mammals to under US$0.5 million for invertebrates and US$0.24 million for plants[7]. They found that a policy goal to save all species would mean that all species receive funding but only a small part of their average annual costs. They also found that a goal to only save species that have public support would mean that only eleven percent of species receive funding, but just over half of their average annual costs. Conversely, a policy goal to save the most species for the funding available would mean that sixty percent of species receive funding equal to all of their average annual costs. The authors concluded that it is important that there are clear and explicit goals for species conservation and that funding is allocated to achieve these goals.

Even if the goal of threatened species conservation is to save all species, economic analysis is useful because it shows how to be cost-effective in achieving that goal (Shogren *et al.*, 1999). Cullen *et al.* (2001) argued there has been little economic research into the cost-effectiveness of threatened species programmes because of the problem of how to quantify programme output. The authors used cost-utility analysis to evaluate the cost-effectiveness of the output for twenty-two threatened species programmes in New Zealand between 1987 and 1998. They noted that the most

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[7] The authors derived the costs using constant 1993 dollars from data contained in 292 recovery plans, which was all of the plans available to them and over fifty percent of the plans for each taxonomic

immediate threats to many New Zealand threatened species come from introduced species, and the most important management action of threatened species programmes is pest control. They found that although estimating costs[8] was the most difficult part of their research, almost seventy-five percent of total expenditure over the programmes had been allocated to just four bird species, but only two of these species had any significant improvement in conservation status.

Craig (1997) argued that there is a need to move toward more co-operative, effective and accountable management of "communal resources" including plant and animal species. Although there is research into the cost-effectiveness of threatened species conservation (for example, Moran, Pearce and Wendelaar, 1996; Macmillan, Harley, and Morrison, 1998), Hughey, Cullen and Moran (2003) found that the cost-effectiveness of threatened species programmes is not being properly considered in management decisions. The three points highlighted by the literature are the focus of the problem statement for this research. First, adequate information on the costs of management is essential for funding applications. Second, differences in the costs of management for threatened species means that alternative policy goals can affect the allocation of funding across species. Third, accurate estimates of the costs are critical for cost-effectiveness analysis but such analysis is not being conducted.

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group. The annual costs were twenty percent of the average total costs as it was assumed that on average all species could be recovered over a five-year period.

[8] The authors actually estimated expenditures for threatened species, not costs.

2.5 Problem statement

It is argued in this chapter that threatened species conservation is an economic problem because of the need for the allocation of scarce financial resources. Until now, however, the contribution of economics to threatened species conservation has focused on areas of interest, such as the value of threatened species and the opportunity costs of threatened species conservation, and not the costs of management for threatened species. Information on management costs, or the direct costs of conservation, is essential to the success of attempts to gain sufficient funding for threatened species conservation, to forecasting the outcomes of policy for the allocation of funding across species, and to analysis of the cost-effectiveness of management for threatened species.

The cost of the protection and recovery of a threatened species is a key factor in its management. Accurate estimates of costs are not, however, necessarily included in either funding applications or as a factor, *inter alia*, in priority ranking systems for the allocation of funding across species, and cost-effectiveness analysis is rarely conducted. Reasons for those omissions may be that a costing exercise requires the use of further resources, it is subject to risk and uncertainty, it may be regarded as a commitment to funding, or simply that its importance is not recognised by conservation managers. The number of species at risk of extinction underlines the urgent need for information on management costs if threatened species conservation is to be maximised.

3 Economic theory

3.1 Introduction

The review of literature showed that, although threatened species conservation is in effect an economic problem, economic analysis has yet to significantly contribute to an understanding of the costs of management for threatened species. Furthermore, accurate estimates of costs are not necessarily included in either funding applications or as a factor in priority ranking systems for threatened species, and cost-effectiveness analysis is rarely conducted. The purpose of this chapter is to formally present the research aim and objectives, to develop a model of the cost of a threatened species programme, and to propose a null hypothesis and five alternative hypotheses for further investigation.

Theory from ecological economics and production economics is applied to the conservation of threatened species to develop a simple conceptual model of the cost of a threatened species programme. The conceptual model of the cost of a threatened species programme is presented in two stages. First, threatened species conservation as a dynamic optimisation problem, is adapted from Metrick and Weitzman (1998) to outline how the cost of a threatened species programme fits into its wider context. Second, the cost factor in the dynamic optimisation problem is investigated using a cost function based on Swanson's (1994) analysis of species extinction. The cost function focuses on the relationship between the costs of allocating natural base

resources and management services, as inputs required for the survival of a species, and the cost of a threatened species programme over time. The specific form of the cost function, however, needs to be based on empirical evidence, which is the focus of this research. The model makes a number of simplifying, domain, and heuristic assumptions that could be reconsidered in further research.

3.2 Research aim and objectives

The aim of this research is to improve the formal understanding of the costs of threatened species programmes by investigating the specific form of the cost function that describes a programme's cost. If the understanding of the costs of threatened species programmes can be improved then accurate estimates of costs may be more easily included in funding applications, priority ranking systems, and cost effectiveness analysis. To achieve this aim, this research has the following three objectives:

1. To estimate the costs of threatened species programmes from the predicted costs of actions to achieve the objectives in species' recovery plans.

2. To identify key factors that determine the costs of threatened species programmes.

3. To investigate the effects of the budget constraint on the costs of threatened species programmes.

3.3 The economics of threatened species conservation

This section applies theory from ecological economics and, more generally, from production economics to the research problem to develop a simple conceptual model of the cost of a threatened species programme. First, a dynamic optimisation problem is adapted from Metrick and Weitzman (1998) to outline how the cost of a threatened species programme fits into the wider context of threatened species conservation. Second, the cost of a threatened species programme is investigated using a cost function based on Swanson (1994). Although in some ways apposite, fisheries economics is not applied because it focuses on the sustainable harvest and not the growth of a species' total population. It also does not include the natural resources, such as land, needed for the survival of a species. The logistic form of the biological growth function may, however, be useful for further research in predicting a species' rate of recovery.

3.3.1 Threatened species conservation

The aim of threatened species conservation is to ensure the survival of all threatened species. The purpose of the Endangered Species Act (ESA) (1973) in the United States is to conserve all threatened species and their habitats (USFWS, 2000). Similarly, a goal of the New Zealand Biodiversity Strategy (NZBS) is to halt the decline in New Zealand's native biodiversity by maintaining and restoring viable populations of all native species and subspecies across their natural range (DoC and MfE, 2000: 18). The decline in native biodiversity is recognised as New Zealand's most pervasive or widespread environmental issue (DoC & MfE, 1997).

The management of threatened species, however, operates under a budget constraint and decisions have to be made about which species to protect. Vane-Wright, Humphries and Williams (1991) describe such decisions as "the agony of choice". Doerksen *et al.* (1998) found that a policy goal to save the greatest number of species subject to a budget constraint would result in funding being allocated to lower cost species programmes, such as those for plants and invertebrates. Empirical research, however, shows that programmes for charismatic species, particularly birds and mammals, receive more government funding than less charismatic species (Simon *et al.*, 1995; Metrick and Weitzman, 1996). Metrick and Weitzman (1998) argued that decisions about which species to protect should either reflect a reasoned cost-benefit calculation or there should be more honesty about the preference for charismatic species.

Although a goal of the NZBS is to maintain and restore all native species, the aim of the Department of Conservation's (DoC) Statement of Intent recognises that the management of threatened species operates under a budget constraint. The aim is "to achieve the maximum conservation benefit for New Zealand with the resources available" (DoC, 2003). The cost-effectiveness of threatened species conservation, however, is ultimately dependent upon the costs of threatened species programmes, together with a species' rate of recovery, but these factors are not included in priority setting. Priority ranking systems are used to allocate funding in New Zealand and the United States that focus on the degree of threatenedness of a species (Molloy and Davis, 1994; USFWS, 1983). At present, priorities for the management of the New Zealand's threatened species are determined by assessing the following five factors

(listed in order of importance): conservation status, threats, vulnerability, human values, and taxonomic distinctiveness (Molloy and Davis, 1994).

Weitzman (1998) and Metrick and Weitzman (1998) conceived the preservation of biodiversity as a constrained optimisation problem where society's objective function is to preserve the maximum degree of biological distinctiveness and direct utility subject to a budget constraint. Metrick and Weitzman (1998) defined the cost of improving the survivability of a species as the 'space' taken up or the opportunity cost. The authors are unclear about what they mean by opportunity cost in this context but it is interpreted as being in terms of economic development because they define the budget constraint as the natural resources available for species' survival and use "conflict with development" as a proxy for cost. The authors proposed the following cost-benefit ranking criterion (Equation 1) as a solution to the problem but acknowledged that, in practise, it is not an easy task to quantify any of the four variables:

Equation 1 $$R_i = [\, D_i + U_i \,]\, (\, \delta P_i \,/\, C_i \,)$$

R_i = cost-benefit rank of project for species i

D_i = biological distinctiveness of species i

U_i = direct utility of species i[1]

δP_i = improvement in the survivability of species i.

C_i = cost of improving the survivability of species i by the δP_i.

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[1] Direct utility is defined as the commercial, recreational and emotional reactions to a particular species (Metrick and Weitzman, 1998: 24).

Unlike Metrick and Weitzman (1998), the conservation of threatened species is conceptualised in this research as a *dynamic* optimisation problem because it occurs over time and society's objective function is to conserve the maximum number of threatened species subject to the budget constraint. The budget constraint, however, is defined as the financial resources set apart for the conservation of threatened species, which falls short of the amount of resources needed to accomplish this. The cost of a threatened species programme means the cost of management for a species, or the opportunity cost in terms of the protection and recovery of other species at risk. The following cost-benefit ranking criterion (Equation 2) is offered as a solution to the problem of threatened species conservation:

Equation 2 $$P_i = [\, D_i + U_i \,] \, (\, \mathrm{PV}\delta S_i \,/\, \mathrm{PV}C_i \,)$$

P_i = cost-benefit rank of threatened species programme for species i

D_i = biological distinctiveness of species i

U_i = utility for species i

$\mathrm{PV}\delta S_i$ = PV of the change in conservation status of species i over time

$\mathrm{PV}C_i$ = PV of the cost of a threatened species programme for species i over time

The conservation status – cost ratio ($\mathrm{PV}\delta S_i$ / $\mathrm{PV}C_i$) measures the cost-effectiveness of the outcome for the conservation of a threatened species[2]. The changes in

[2] The cost-effectiveness of the outcome for a species is different to the cost-effectiveness of a programme's output, which measures the change in the conservation status of a species that occurred as a direct result of a programme and not change that may have occurred anyway (Cullen *et al.*, 2001).

conservation status and the costs are discounted to their present values to allow incidences of each factor occurring at different points in time to be directly compared across threatened species programmes. The programme's cost-effectiveness is weighted by a species' biological distinctiveness and utility, which are related to taxonomic distinctiveness and human values, but could also include other factors, such as the threats facing a species and the vulnerability of a species. The existence of input prices means that the cost of a threatened species programme (C_i) is comparatively easy to measure. Analysis of this factor will improve understanding of the costs of threatened species programmes so that cost can be more easily included in funding applications, priority ranking systems, and cost effectiveness analysis.

3.3.2 The cost of a threatened species programme

Swanson's generalised framework for species extinction and biodiversity loss (1994) brought Clark's analysis of extinction (1973a; 1973b) 'on-shore' by including all of the resources a species requires for survival. The model showed that stock disinvestment, base resources re-allocation, and management services re-allocation, are all alternative routes to the extinction of a species, but the fundamental source of a species' extinction is its exclusion from society's portfolio of assets. A natural extension of Swanson's model is that the protection and recovery of a threatened species comes from its inclusion in society's asset portfolio, and it is achieved by investment in stock, and the allocation of base resources and management services.

The proposition that stock investment, and allocations of base resource and management services are all 'routes' to the conservation of a threatened species points towards a cost function for a threatened species programme. A manager's production

decision for a programme is how to combine stock, base resources and management services as inputs so as to maximise the conservation of a threatened species, often subject to a budget constraint[3]. A programme's cost, therefore, is determined by the costs of the inputs that are needed to achieve the conservation of the species. Even though the specific form of the cost function needs empirical research, some of its characteristics can first be theorised. As will be discussed, the costs of the base natural resources and management services needed for a species' conservation determine the cost of a threatened species programme in a single time period; and the costs in each time period, the stock of a species and its recovery rate determine the cost of a threatened species programme over time.

3.3.2.1 The cost of a programme in a single time period

Swanson (1994: 814) argued that for a species to sustain itself within the natural environment there must be some allocation of biological services or base natural resources by humans and the problem for most threatened species is an unwillingness to invest in these resources. If there must be some allocation of base resource for a species to sustain itself then it will be an essential input in the cost of a threatened species programme for a single time period. Swanson summarized base resources as a species' habitat, but it also includes actions such as supplementary feeding.

Swanson defined the cost of habitat, or base resources, as the opportunity cost of the land and its natural resources, as measured by the cost or 'rent' for a unit of land. The cost must, however, include management as well as acquisition costs because many

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[3] Profit is not part of the objective function because the Convention on International Trade in

habitats require active management to be able to support the threatened species (Wilcove and Chen, 1998; Main, Roka and Noss, 1998). Indirect threats such as habitat fragmentation, competition and pollution can cause the decline of a species through the degradation of habitat. Cost is defined as the cost of supplying the base resources required for the conservation of a species, and the costs of providing the services for managing all of the threats that indirectly threaten a species within its habitat. The cost of management of indirect threats comprises of costs for institution building or the creation of a management regime, such as planning, research and advocacy, as well as all of the costs for the protection or control of the indirect threats.

If the allocation of base resources is constant, rather than gradually increasing with a growth in population numbers, then it will be a fixed input in the cost function and the marginal cost of a species conservation may decline as the species becomes less threatened. Swanson suggested that the allocation of base resources is an important factor in determining the rate of growth of a species: an increase in the amount of habitat may cause an increase in a species' growth rate. If there is either a positive relationship between base resources and a species' conservation or a declining marginal cost of allocating base resources then there will be increasing returns to scale, and so alternative cost functions will exist, for a threatened species programme.

In addition to base natural resources, Swanson (1994) argued that many threatened species require an allocation of services to manage their over-exploitation: the institution-building or creation of a management regime to prevent the decline of a species through over-exploitation. There are, however, other direct causes of the

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Endangered Species (CITES) strictly regulates trade in threatened species (http://www.cites.org/).

mortality of individuals of a species that also need management services, such as predation, disturbance, and disease. Swanson did not define the cost of allocating management services, but in this research it is defined as the costs of services for the management of all of the threats that directly threaten a species within its habitat. The cost of management of direct threats comprises of costs for the creation of a management regime, as well as all of the costs for protection or control of direct threats. The distribution of costs for creating a management regime between the management of direct and indirect threats is dependent upon the types of threats facing a species.

There will be high initial costs of managing direct and indirect threats in the cost function if there is a lack of knowledge about a threatened species because of the need for surveying and research. There will be lower costs of managing both types of threat over time for monitoring of the threatened species and surveillance of the threats. If threats can be removed completely then this may extend the period of high initial costs but will be followed by lower costs over time; if threats can only be controlled then the costs will be constant or cyclical over time. Some types of threats, however, are more difficult to remove or control than other types, and so the costs of providing services to manage such threats will be higher. Technological change may result in the use of more successful management techniques and a decline in costs. In general, the costs of managing direct and indirect threats in each time period will vary.

To summarize, the cost of a threatened species programme for a single time period (Equation 3.) is a function of the costs of allocating the base resources and management services needed to achieve the conservation of a species. In turn, the cost

of allocating base resources is the costs of supplying base resources (Equation 3a.), and providing services for the management of the indirect threats (Equation 3b.) and direct threats (Equation 3c.) facing a species. It is assumed that the quantities of inputs are fixed, the costs of conserving a species are discrete, and the most cost-effective combination of inputs is used.

Equation 3 $$C_{it} = BR_{it} + MS_{it} = (baseresources_{it} + indirect_{it}) + direct_{it}$$

C_{it} = the cost of a threatened species programme for species i in time t

BR_{it} = the cost of allocating base resources for species i in time t

MS_{it} = the cost of allocating management services for species i in time t

$baseresources_{it}$ = the cost of supplying base resources for species I in time t

$indirect_{it}$ = the cost of providing services to manage the indirect threats facing species i in time t

$direct_{it}$ = the cost of providing services to manage the direct threats facing species i in time t

Equation 3a $$baseresources_{it} = (rent_{it} * quantity_{it})$$

$rent_{it}$ = rent for one unit of the base resources required for species i in time t

$quantity_{it}$ = quantity of base resources required for species i in time t

Equation 3b $$indirect_{it} = (quantity_{it} * imgmt_{it})$$

$imgmt_{it}$ = the cost of managing the indirect threats for one unit of base resources for species i in time t

Equation 3c $direct_{it} = (quantity_{it} * dmgmt_{it})$

$dmgmt_{it}$ = the cost of managing the direct threats for one unit of base resources for species i in time t

3.3.2.2 The cost of a programme over time

In addition to allocations of base resources and management services, Swanson (1994) argued that there must be some stock or population of a threatened species retained for it to be able to regenerate itself. It is clear that an extant population of a species is essential to the conservation of a threatened species: the extant population indicates the 'distance' that a species is from being a non-threatened population, and its recovery rate sets the 'pace' with which the species covers this distance. A species' extant population and its rate of recovery, therefore, determine the timeframe, or the number of time periods, for which there are costs and influence the total cost of a threatened species programme over time. In effect, the extant population and recovery rate together act as a controlling mechanism or a 'counter' on the cost function over time.

A species' extant population can be measured by either population numbers or its conservation status. The choice of measurement has differing effects on the marginal cost of a threatened species programme because of the non-linear nature of total population size as a status criterion in threat classification systems[4]. Population numbers, however, may not always be appropriate for all species nor accurately

[4] For example, using DoC's system (Molloy *et al.*, 2002), the total population size status criterion for 'Nationally Critical' is less than or equal to 250 mature individuals, but the equivalent criterion for 'Nationally Endangered', the next threat category, is 250 to 1,000 mature individuals.

reflect a species' circumstance. Montgomery *et al.* (1994: 122) measured the probability of a species' survival[5] using population viability analysis and defined marginal cost as "the additional cost … incurred for a one percentage point increase in the probability of survival". A species' extant population is measured by its initial conservation status in the cost function, and marginal cost is defined as the additional cost incurred for a one unit of improvement in a species' conservation status.

The influence of a species' recovery rate on total cost is implicit in Swanson's (1994) proposition that certain very slow-growing species are subject to pressures for their complete disinvestment. The growth rate of many species can be described by the logistic form of the biological growth function (Perman, Ma, McGilvray and Common, 1999: 216) and the allocation of base resources to a species sets the upper limit of its growth (Swanson, 1994: 811). If a threatened species' recovery rate is affected by the allocation of more base resources, then the timeframe, and possibly the total cost of a programme, may be able to be reduced. The logistic biological growth function and the base resources allocation may be used in further research to more accurately estimate a species' recovery rate. If, however, a species remains threatened in the long term then the total cost may be open-ended.

In summary, the cost of a threatened species programme over time (Equation 4.) is a function of the cost of allocating base resources and management services for each time period (Equation 3.) and the number of time periods needed for the conservation of the species. The number of time periods is calculated from the distance between the species' extant population or initial conservation status and a non-threatened

[5] Probability of survival is a similar measure to conservation status.

population, and the pace set by its recovery rate (Equation 4a.)[6]. It is assumed that there are constant prices for inputs, the costs of inputs and the subsequent recovery of a species occur in the same time period, and technology is constant.

Equation 4 $$C_i = \sum_{t=1}^{n} (baseresources_{it} + indirect_{it}) + direct_{it}$$

C_i = cost of a threatened species programme for species i over time

n = final time period

Equation 4a $$n = \ln\left(\frac{Pop_{NTi}}{Pop_{Oi}}\right) \div \ln(1 + r_i)$$

Pop_{Oi} = extant population of species i

Pop_{NTi} = non-threatened population of species i

r_i = recovery rate of species i

The cost of a threatened species programme over time is discounted back to the initial time period to determine its present value (Equation 5.)[7]. Discounting allows a programme's cost (C_i) and its cost-benefit ranking criterion (R_i) to be directly comparable with those for other threatened species programmes.

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[6] Equation 4a is based on a compound interest equation (e.g., $100 earning 5% per year for three years is $1.05^3 * 100$ = $115.76 at the end of three years) and is $(1 + r)^n * Pop_{Oi} = Pop_{NTi}$ solved for n. It calculates the number of years that it will take the threatened species' extant population, given its growth rate, to reach the recovery goal population, and it acts as 'a counter' on Equation 4.

[7] The Net Present Value (NPV) will need to include the benefit, as well as the cost, of conserving the threatened species and is beyond the scope of this research.

Equation 5

$$PVC_i = \sum_{t=1}^{n} \frac{(baseresources_{it} + indirect_{it}) + direct_{it}}{(1+d)^t}$$

PVC_i = present value of the cost of the threatened species programme for species i over time

d = discount rate

The base resources and management services needed to conserve a species and the recovery rate of a species could be influenced by a species biological characteristics. Doerksen *et al.* (1998) demonstrated that the costs of management for threatened species vary by a species' taxonomic group. Therefore, the biological characteristics of a species may be an underlying explanatory variable in determining the costs of a threatened species programme. A species' taxon, however, provides only a general indication of the biological characteristics of a species in comparison to species of other taxa, and a more specific indicator may be a species' K-selection. K-selection indicates the evolutionary selection of traits such as slower development, body size and low birth rates, and so may have higher costs of management. A species' taxon and its' K-selection within each taxon are proposed as underlying explanatory variables in the cost function for a threatened species programme.

3.4 Hypotheses

The theorised characteristics of the cost function are used to develop the following null hypothesis and alternative hypotheses to investigate its specific form, one or more of which may be able to be supported. In general, the alternative hypotheses propose that the costs of the base natural resources and management services needed for a species' conservation determine the annual costs of a threatened species programme; and the annual costs, and the stock of a species and its recovery rate determine the total cost of a threatened species programme.

3.4.1 Null hypothesis

The costs of threatened species programmes are the same for all threatened species.

3.4.2 Alternative hypotheses

1. The annual costs of a threatened species programme are positively related to the area of habitat required for the management of the species. That is, the greater the habitat area needed the higher the costs of the programme annually.

2. The annual costs of a threatened species programme are related to the types of threats facing the species. That is, the annual costs of programmes that manage threats that are difficult to remove or control are higher than the costs of programmes managing other threats.

3. The total costs of a threatened species programme are related to the species' initial conservation status and its rate of recovery. That is, the more threatened a species is and / or the lower a species' recovery rate, the higher the total cost of the programme.

4. The annual and total costs of a threatened species programme are related to the species' taxon. That is, the costs of programmes for taxa such as birds and mammals are higher than the costs of programmes for other taxa.

5. Within each taxon, the annual and total costs of a threatened species programme are positively related to the degree to which a species is K-selected. That is, the more extreme a species' K-selection, the higher the costs of the programme.

4 Research methodology

"Recovery plans are statements of the Department's intentions for the conservation of particular plants and animals for a defined period. In focusing on goals and objectives for management, recovery plans serve to guide the Department in its allocation of resources, and to promote discussion amongst a wider section of the community."

Part of the foreword included in DoC recovery plans (for example: Reed, Murray and Butler, 1993; Newman, 1996; Townsend, 1999).

4.1 Introduction

Chapter Three used theorised characteristics of the cost function for the cost of a threatened species programme to develop hypotheses to investigate its specific form. The purpose of this chapter is to review the research methodology used to collect and analyse the empirical evidence needed to test those hypotheses. The methodology outlines the background to the research, the development of the research design, the collection of the data, and the general analytical strategy. It then previews the reporting of the analytical results and the testing of the null and alternative hypotheses in Chapters Five and Six. In general, the research methodology is based on the guidelines for case study research provided by Yin (1994).

First, the background to the research focuses on how quantitative analysis of the costs for threatened species is practicable in the United States, but similar analysis in New Zealand is more problematic because there are no existing databases. The preferred methodology, therefore, is to conduct a multiple case study analysis of the costs of threatened species programmes using primary data. Second, the development of the research design also points towards a multiple case study and the research objectives are used to identify individual threatened species as the unit of analysis and the data that are required.

Third, the collection of data section reviews the development of the Recovery Group Leader Survey for threatened species programmes, which was the main source of data for this research. Data was requested from the DoC and a pilot survey was conducted for three threatened species programmes. The Department agreed to provide cost data for a total of eleven threatened species programmes. This section outlines the criteria used to choose threatened species programmes that would give a range of results to achieve theoretical replication. Finally, the general analytical strategy is a cross-case analysis of the data collected from the Recovery Group Leaders Survey using pattern matching logic and explanation building to test the proposed hypotheses.

4.2 Background

Doerksen *et al.* (1998) used data contained in 292 USFWS recovery plans for threatened species to derive average total costs of management for each taxonomic group as part of their research into the outcomes of alternative policy goals for

threatened species in the United States. The authors stated that recovery plans are the single source of comprehensive data on the costs of management. In the United States, quantitative analysis of costs of conserving threatened species is practicable because there are existing databases on the costs of recovery plans and expenditure by species. Subsection 4:f:1:B:iii of the ESA (1973) states that recovery plans must include "estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal." (USFWS, 2000).

In addition to including estimates of costs in recovery plans, the USFWS also reports on the reasonably identifiable annual expenditures for the conservation of threatened species by Federal and State agencies, and on threatened species recovery programmes. Data published in both types of annual expenditure reports have been used for economic research into the management of threatened species. For example, Simon *et al.* (1995) used data from reports on annual expenditure to analyse the relationship between expenditure for threatened species and the priority rankings of species. Metrick and Weitzman (1996) also made use of data from expenditure reports to run a regression analysis to investigate the key factors in the government's allocation of resources.

In contrast to the United States, quantitative analysis of the costs for New Zealand threatened species is more problematic because there are no similar cost or expenditure databases available. The Department of Conservation is not obliged to include cost estimates in recovery plans, and few contain even basic budgets, even though recovery plans are statements of the Department's intentions for a species'

conservation and they serve to guide it in the allocation of resources (for example: McClelland, 1993; Creswell, 1996; Innes and Flux, 1999). Furthermore, the Department does not collect information on the costs of threatened species programmes (A. Ross, personal communication, August 12, 2002), and it reports on expenditure by output rather than by outcome. Cullen, Fairburn and Hughey (1999; 2001) found that collecting cost data[1] to estimate the costs of threatened species programmes was the most difficult part of their study.

One approach to the problem would be to study the management of threatened species in countries that have cost and expenditure databases, such as Australia or the United States, but the results would not necessarily be applicable to New Zealand. The preferred methodology was to survey Recovery Group Leaders for threatened species programmes and to conduct a multiple case study analysis of the costs for threatened species. Although case study analysis makes it more difficult than statistical analysis to test hypothetical relationships, it is less liable to be affected by reductionism and it gives the ability to explain unexpected results by examining the wider picture for each threatened species.

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[1] As discussed in Chapter Two, the authors actually collected expenditure and not cost data for threatened species programmes.

4.3 Research design

4.3.1 Research question

The question for research is why some threatened species programmes cost more than other programmes for species also threatened with extinction. The research question pointed towards a multiple case study analysis because the question is explanatory, does not require control over behavioural events, and it focuses on contemporary events (Yin, 1994). To be able to accomplish this aim, the research has three objectives that guided the research design: to estimate the costs of threatened species programmes, to identify key factors that determine these costs, and to investigate the effects of the budget constraint on the costs of threatened species programmes.

4.3.2 Data requirements

The data requirements for this research are determined by the information that is needed to achieve the three research objectives. Therefore, data is required on the costs of threatened species programmes, possible key factors that determine programme costs, and the effects of the budget constraint. The data on possible key factors is driven by the independent variables in the proposed alternative hypotheses: habitat area, types of threat, a species' taxon and K-selection, and a species' initial conservation status and its potential recovery rate. The data on the effects of the budget constraint focuses on the expected funding of threatened species programmes and species' probable recovery rate.

4.3.3 Unit of analysis

The research objectives identify a threatened species programme as the unit of analysis for this research: each case study investigates the costs of management for a New Zealand threatened species. The case studies are holistic, rather than embedded, because each case study focuses on a single threatened species programme, even though the management of other threatened species may significantly reduce the costs for the species being studied[2]. As DoC has responsibility for all threatened species programmes in New Zealand, the results may be applicable to programmes for other New Zealand threatened species. New Zealand's established system of national parks and reserves means that the additional step of calculating the costs of habitat acquisition is needed for the results to be compared with those for threatened species programmes internationally, which is an area for further research if these costs are positive.

4.4 Data collection

4.4.1 Data sources

As already discussed, there are no New Zealand databases on the costs of species recovery plans, or expenditures by species, and the main source of data for this research was a survey of DoC's Recovery Group Leaders for threatened species programmes. Data was requested from the Department under the Official Information

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[2] The exception is the Otago and Grand skinks programme: the two species are considered together in their recovery plan because they have so much in common (Whitaker and Loh, 1995).

Act, 1982, which required a pilot survey to be conducted of the Recovery Groups Leaders for three threatened species programmes. The experience of the pilot survey was used to develop the final Recovery Group Leader Survey of a further fifteen programmes. Data collected from the Recovery Group Leaders survey was enhanced with information contained in the published and unpublished recovery plans for the threatened species studied.

4.4.1.1 Request for data

General species information on the independent variables, such as habitat area, types of threats, and K-selection, and financial data was requested from DoC for one or more of the threatened species covered by each of the forty-six published recovery plans[3]. In response to discussions with members of the Department's Biodiversity Recovery Unit, this request was revised to data for twelve threatened species programmes. The Department agreed to provide the general species information and data on annual expenditure for threatened species over the previous ten years, as this part of the request was considered to be under the Official Information Act, 1982 (A. Ross, personal communication, August 12, 2002). Data on the costs of the threatened species programmes over the next ten years was, however, to be at the discretion of the Regional Conservators who manage each Recovery Group Leader because this was not information held by the Department[4] (A. Ross, personal communication, August 12, 2002).

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[3] DoC had published forty-nine species recovery plans (forty-eight as a series) by the end of 2002, but three of these updated earlier plans for the Kakapo, the North Island Kokako, and the Tuatara.

[4] A "back of an envelope" exercise in a Recovery Group Leaders workshop in 2001 used "guestimates" of the costs of achieving the recovery plan objectives for 73 threatened species to calculate the mean annual cost per species and the total annual cost for 403 species. The exercise was designed to show the

DoC decided to charge for the time taken to provide the data because it held the view that the information is only likely to confirm what managers already know intuitively, and the costs of threatened species programmes would not be of interest to the general public (A. Ross, personal communication, August 12, 2002). The Department's decision to charge for providing data severely limited the number of threatened species programmes able to be studied. In particular, its decision to separate the request into two parts meant that research funding was used collecting expenditure data for programmes where no cost data was available. The Department's response to the request for data is included in Appendix A.

4.4.1.2 Pilot survey

In considering the request, DoC required that a pilot survey of the Recovery Group Leaders for three threatened species programme be undertaken to ensure that the data could be easily provided and to confirm that it would provide information of use to the author. It was recommended that the author meet with the Leaders of the Recovery Groups for three single species programmes proposed by the Department to investigate what data they are able to supply and to review the survey on that basis. The Department also required that the Recovery Group Leaders estimate the time it would take to complete the survey and comment on the exercise (P. Cromarty, personal communication, August 29, 2002).

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gap in funding, but it was not realised until later that significant errors had been made in calculating the results, which reduced the value of this information (P. Cromarty, personal communication, August 14, 2002).

1. Black Stilt programme

The Black Stilt is a bird species that exists within a single conservancy during its breeding season. The Recovery Group Leader commented that he had already collated expenditure data for previous requests and had also estimated cost data, so the information was readily available. The time taken to complete the survey was 30 minutes.

2. South Island Long-tailed Bat programme

The South Island Long-tailed Bat is a species of mammal that is found in multiple conservancies. The Recovery Group Leader commented that he had to contact other conservancies to get expenditure data and it took time to get estimates of cost data. The time taken to complete the survey for the Long-tailed bat was 8 hours.

3. Kakapo programme

The Kakapo is a bird species that usually exists in a single conservancy and has a centrally co-ordinated threatened species programme. The Recovery Group Leader noted that the costs for this species are very discrete and one funding allocation covers operating costs and salaries. The time taken to complete the survey was 2 hours.

4.4.2 Recovery Group Leader Survey

The survey sent to the Recovery Group Leaders by email consisted of a letter of introduction, a questionnaire, a completed example of the questionnaire for the Black Stilt, and a copy of the Conservation Status Continuum developed by Cullen, Moran and Hughey (2002). A letter of explanation from the Biodiversity Recovery Unit accompanied the survey documents. The survey documents and accompanying letter

are included as Appendix B. As well as completion of the questionnaire, the Recovery Group Leaders were also invited to provide any additional information that may help with interpretation of the results and to include comments on the research. The additional information and comments provided by the Recovery Group Leaders are reported in the analysis and discussion of the results in Chapter Six.

In the first part of the questionnaire, the Recovery Group Leaders were asked to note the main conservancies where the species is found and provide information on the degree to which a species is K-selected, the habitat area required for its management, and its causes of decline and immediate threats. A K-selected species is a species that typically has slower development, large body size, late reproduction, low birth rates and high survival rates among offspring, long life span, and iteroparity (Allaby, 1998; Calow, 1998; Lawrence, 1995; Lincoln *et al.*, 1998). The opposite end of the spectrum is a r-selected species, which is one that typically has rapid development, small body size, early reproduction, expends a large proportion of energy to reproduce, has efficient dispersal, short life-span, and semelparity (Allaby, 1998; Calow, 1998; Lawrence, 1995; Lincoln *et al.*, 1998).

In the second part, Recovery Group Leaders were asked to estimate the following financial data to the nearest NZ$10,000: annual expenditure for the species from the year the recovery plan was published until 2002, predicted annual costs by objective from 2003 until 2012, and expected annual funding over the same timeframe, given present budgets and patterns of expenditure. As well as financial data, they were also asked to assess the species' conservation status for each year up to and including 2002, its possible conservation status for each year from 2003 to 2012 if the

programme is fully funded, and its probable conservation status over the same timeframe if the expected level of funding is received.

Annual expenditure was defined as the total expenditure each year from DoC's Output Class D5: Management Services: Protected Species and Island Habitats[5] for actions incurred as the direct result of the decision to recover a species. The Recovery Group Leaders estimated expenditure data up to and including 2002 in current year New Zealand dollars. Predicted annual costs were derived from the sum of the estimated annual costs of the actions that need to be taken to achieve each objective developed for a species for Output Class D5. Estimating cost by objective is based on the method used by the USFWS, and is similar to the budgets in the Kiwi, Native Frog and Chevron Skink recovery plans and a "back of an envelope" exercise used in the Recovery Group Leader's workshop. The Recovery Group Leaders estimated cost data from 2003 until 2012 in constant December 2002 New Zealand dollars.

The species' conservation status was assessed using the Conservation Status Continuum, which allows for more accuracy and flexibility than systems based on categories, and places a higher weighting on the conservation of endangered species than that of less threatened species (Cullen *et al.*, 2002). Recovery Group Leaders first identified the species' conservation status category for each year using the NZTCS (Molloy *et al.*, 2002). They then selected a number from the range of numbers on the

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[5] Output class D5: Management Services: Protected Species and Island Habitats covers "all species conservation programmes including: distribution and habitat surveys, species recovery programmes, captive breeding programmes, transfers and introduction of species, control of predators and competitors, manipulation of habitats, habitat enhancement programmes, population monitoring and associated permitting and all related research" (DoC, 2003: 71).

continuum for that category that reflected the extent to which the species either fitted, or will possibly fit, the category's criteria. Assessments of a species' annual conservation status were collected to indicate the possible recovery rate of a species and the projected total cost of the programme.

4.4.3 The threatened species programmes

The threatened species programmes were chosen for the study using a set of criteria that would give a range of results to achieve theoretical replication. In general order of importance, the criteria used were:

1. Species programmes that have a draft or published recovery plan.
2. Programmes for species that are representative of different taxa.
3. Programmes for species within each taxon that require different habitat types.
4. Programmes for species that occur within one or two conservancies, rather than multiple conservancies.
5. Programmes for species that have a high threat classification, such as 'Nationally Critically Endangered', 'Nationally Endangered', or 'Nationally Vulnerable'.
6. Programmes for species that have a clear and undisputed taxonomy.
7. Species programmes that are of particular interest for research.

If the Regional Conservator for a Recovery Group Leader declined the request for data on the costs of a particular threatened species programme then an alternative programme, preferably for a species from the same taxon, was chosen. For example, the Pygmy button daisy (*Leptinella nana*) was replaced with the Climbing Everlasting Daisy (*Helichrysum dimorphum*), and the Mercury Island Tusked Weta (*Motuweta*

isolata) was replaced with the Flax Snail (*Placostylus ambagiosus*). Efforts were made to choose an equal number of species from each taxon, but this was problematic because there are only seven native terrestrial mammal species and four native amphibian species in New Zealand. Furthermore, a disproportionate number of threatened bird species have recovery programmes.

The completion of the survey was co-ordinated by the Biodiversity Recovery Unit, and the author was unable to contact the Recovery Group Leaders directly unless they had queries or required more information. In total, data was eventually requested for twenty threatened species programmes: cost data was available for eleven programmes, expenditure data was reported for an additional seven programmes[6], and no data was able to be provided for two other species programmes (Table 5.1). Data on costs or expenditure was not requested for the Kiwi programme as the Recovery Group Leader had already indicated that this would be an extremely large task (A. Ross, personal communication, August 12, 2002). Unfortunately, all requests for data on the costs of reptile or freshwater fish programmes were rejected. The reasons for not providing cost data for the additional seven threatened species programmes are recorded in Appendix C.

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[6] One questionnaire was completed for both the Otago and Grand skinks and they are discussed as one species programme. The two species are considered together in their recovery plan and their management is regarded as complementary because they have so much in common (DoC, 1995).

Table 1: Recovery Group Leader Survey

Taxon	Common name	Species	Data collected
Plants	*Pittosporum patulum*	*Pittosporum patulum*	Expenditure and cost data
	Climbing Everlasting Daisy	*Helichrysum dimorphum*	Expenditure and cost data
	Pygmy Button Daisy	*Leptinella nana*	Expenditure data
Invertebrates	Stephens Island Ground Beetle	*Mecodema costellum costellum*	Expenditure and cost data
	Flax Snail	*Placostylus ambagiosus*	Expenditure and cost data
	Mercury Island Tusked Weta	*Motuweta isolata*	Expenditure data
Reptiles	Otago Skink and Grand Skink	*Oligosoma Otagense and Oligosoma grande*	Expenditure data
	Brothers Island Tuatara	*Sphenodon guntheri*	Expenditure data
	Chevron Skink	*Oligosoma homalonotum*	Expenditure data
Amphibians	Stephens Island Frog	*Leiopelma hamiltoni*	Expenditure and cost data
Freshwater fish	Canterbury Mudfish	*Neochanna burrowsius*	Expenditure data
	Otago Galaxid	*Galaxias anomalus*	No data
Mammals	South Island Long-tailed Bat	*Chalinolobus tuberculata*	Expenditure and cost data
Birds	Black Stilt	*Himantopus novaezelandiae*	Expenditure and cost data
	Kakapo	*Strigops habroptilus*	Expenditure and cost data
	North Island Kokako	*Callaeas cinerea wilsoni*	Expenditure and cost data
	Mohua	*Mohoua ochrocephala*	Expenditure and cost data
	Campbell Island Teal	*Anas nesiotis*	Expenditure and cost data
	Yellow-eyed Penguin	*Megadyptes antipodes*	Expenditure data

4.5 Analysis and reporting of results

4.5.1 Analytical strategy

The general analytical strategy is a cross-case analysis of the data collected for each of the eleven threatened species programmes from the Recovery Group Leader Survey to test the hypotheses proposed in Chapter Three. The analysis focuses on the relationships between the dependent cost variables and the hypothesised independent variables: habitat area, type of threats, degree of threatenedness, recovery rate, taxon, and K or r-selection. The analytical techniques used to investigate the relationships between the dependent and independent variables are pattern matching logic and explanation-building. Before conducting any analysis, however, the expenditure data is inflation adjusted and all of the financial and data for species conservation status is discounted back to its present values.

The expenditure data was adjusted for inflation to constant December 2002 dollars using the Producers Price Index, Inputs for All Industries, which measures price changes in costs of production, excluding labour and depreciation costs (Statistics New Zealand, 2003). The cost and funding data are the predicted real costs or funding of threatened species programmes over the next ten years and so do not need to be inflation adjusted. All expenditures, costs, funding and changes in species' conservation status were discounted to their present values using the same constant exponential discount rate of six percent to allow incidences of each one occurring at different points in time to be directly compared across threatened species programmes.

The use of a positive discount rate also reflects the public's preference for the conservation of a threatened species earlier rather than later. The discount rate of six percent is based on the real cost of government borrowing in New Zealand (Cullen *et al.*, 2001: 59), which is lower than the public sector discount rate of ten percent used in New Zealand since the 1980s. A prescriptive approach to determining the discount rate is sometimes applied to intergenerational issues, such as the preservation of biodiversity (Arrow, Cline, Mäler, Squitieri and Stiglitz, 1996), but because recovery plans are usually short-term and threatened species programmes tend to be for the medium term, and not the far distant future, a descriptive approach was used in this research.

4.5.1.1 Pattern matching logic

Pattern matching in explanatory research compares empirically based patterns relating to the dependent and independent variables, with expected theoretical patterns (Yin, 1994). If the patterns correspond, then the results will help strengthen the internal validity of the case studies. The first step is to decide whether to accept or reject the null hypothesis by comparing the pattern of the costs of the eleven threatened species programmes with the theoretical pattern that the cost of threatened species programmes are specific for most threatened species. If the null hypothesis is rejected then the second step is to test the alternative hypotheses by comparing patterns in the results for the independent variables with the following theoretical patterns:

1. The annual costs of threatened species programmes that require large areas of habitat for the management of a species are higher than the annual costs for programmes that need smaller areas of habitat.

2. The annual costs of programmes for threatened species facing particular types of threats are higher than the annual costs of programmes for species facing other types of threats.

3. The total costs of programmes for species that are more threatened and / or have a low rate of recovery will be higher than the total costs of programmes for species that are less threatened and / or have a higher recovery rate.

4. The annual and total costs of programmes for threatened bird or mammal species are higher or will be higher than the costs of programmes for reptile, amphibian, invertebrate, or plant species.

5. Within each taxon, the annual and total costs of programmes for threatened species that are extremely K-selected are higher than the costs of programmes for species that are less K-selected.

4.5.1.2 Explanation-building

Explanation-building creates a cross-case analysis for multiple case studies, rather than being limited to an analysis of each individual case. The gradual building of an explanation is similar to the refining of a set of ideas, and as part of this, each hypothesis, or sets of hypotheses, are considered as a plausible explanation for the costs of threatened species programmes (Yin, 1994). The process is to make a theoretical statement, compare the results of the first case study against the statement, revise the statement, compare other details of the case against the revision, and revise the statement again (Yin, 1994). By comparing other details of each case study,

explanation-building is used to explain any unexpected results from the pattern matching logic. The process is repeated with the results of the second, third or more case studies, repeating the process as many times as is necessary to build an explanation. The results from the additional seven threatened species programmes are used as supporting evidence in this process.

4.5.2 Reporting of results

Chapters Five and Six focus on the reporting and discussion of the results of the cross-case analysis of the data collected from the Recovery Group Leader Survey, and not detailed descriptions of the individual case studies as this would unnecessarily repeat information that can be found in species' recovery plans. The results of the analysis of the data collected for each of the eighteen threatened species programmes are presented in Chapter Five to highlight key points for further analysis and discussion. The Recovery Group Leaders originally surveyed were given the opportunity to check and comment on the final draft of Chapter Five to ensure accuracy in the reporting of results. The results of the cross-case analysis of the eleven threatened species programmes are presented and discussed in Chapter Six.

5 Results of the Recovery Group Leader Survey

5.1 Introduction

The research methodology in Chapter Four reviewed the research design, the collection of data, and the general analytical strategy used to investigate the specific form of the cost function. The purpose of this chapter is to present the results of analysis of data collected from the Recovery Group Leader Survey for each of the eighteen threatened species programmes to highlight key points for cross-case analysis and discussion in Chapter Six. The results presented focus on the costs of achieving the objectives of a threatened species programme and key factors that determine these costs. The results of the effects of both the budget constraint and relaxing the budget constraint on the costs of threatened species programmes are presented in Chapter Six.

The main body of this chapter is divided into two sections. First, the contents of the results are explained, two commentaries are provided to illustrate how to interpret the results, and the budget constraint and effect of discounting are outlined. Second, two pages of results are presented for each of the eleven threatened species programmes for which cost data was available, and one page is presented for each of the additional seven threatened species programmes for which only expenditure data was reported. Without the costs, the data collected for the additional seven programmes is of limited use in this research, but the costs of these programmes could be estimated in further

research. In both parts of this section, the threatened species are listed in taxa in order of least costly to conserve to most costly to conserve, based upon Doerksen *et al.*'s, (1998) taxonomic rankings: plants, invertebrates, reptiles, amphibians, fish, mammals, and birds.

5.2 The results of the Recovery Group Leader Survey

5.2.1 The content of the results

The following general information is presented for all of the threatened species programmes: the threatened species and any other 'complementary species'[1] that benefit from the programme; the key conservancies where the species is to be found[2] and the species' major habitat type; causes of decline and immediate threats, which are both listed in order of importance; and the species' conservation status category in 2001 using DoC's Threat Classification System (Molloy *et al.*, 2001). For the eleven threatened species programmes, the recovery plan's goal and objectives[3] for the species programme, and the Present Value[4] (PV) of the predicted total annual cost of achieving each objective from 2003 until 2012, which is summed to give the PV of the total annual cost of the programme, are also detailed.

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[1] Complementary species are defined as those species that the direct conservation of would significantly reduce the costs of conserving the species in question.

[2] The Department of Conservation has a decentralised organisational structure that divides New Zealand into thirteen conservancies or management areas.

[3] Only objectives with positive costs for 2003 until 2012 are recorded.

[4] All present values are calculated using a discount rate of six percent. Discounting and the discount rate are discussed in Section 5.2.3 The budget constraint and discounting.

As well as general information, the following species and financial information is presented in a series of tables (Tables 2 to 19). Only items 1 to 5 are reported for the additional seven species programmes for which only expenditure data was reported:

1. The degree to which the species is either r-selected (10) or K-selected (1) on a decreasing scale from 10 to 1. A r-selected species maximises its growth rate and is opportunistic and characteristic of variable or unpredictable environments; a K-selected species maximises population size and is a strategist and characteristic of constant or predictable environments (Allaby, 1998; Calow, 1998; Lawrence, 1995; Lincoln *et al.*, 1998)[5].

2. The mean area of habitat required for the management of an individual or breeding pair of the species, on an increasing quadratic scale from ≤0.1 to ≤25 hectares.

3. The conservation status of the species either in 1989 or in the first year of recorded expenditure (whichever is most recent) ***and*** the PV of the actual change in species' conservation status[6] until 2002, on a decreasing quadratic scale from ≤1.00 (Not Threatened) to 0.00 (Extinct). An arrow shows the overall direction of the change in conservation status for a species: an arrow pointing towards 1.00

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[5] K- and r-selected species are defined in full in Chapter 4: Section 4.4.2: 54.

[6] The PV of the change in species' conservation status is calculated as the sum of the incremental changes in species' status from one year to the next discounted to the present. If only one result is recorded there is thought to be no significant change in species' status over the time period. A one-unit change in the species' conservation status is equal to 0.01.

indicates an improvement in conservation status and an arrow pointing towards 0.00 indicates a further decline. This item is a measure of the recovery rate of a species over recent years.

4. The PV of the total annual expenditure for the programme from the first year of recorded expenditure until 2002 in December 2002 dollars, on an increasing quadratic scale from New Zealand (NZ) ≤$0.1 million to ≤$10 million. This item records the level of financial resources used for the management of a species. It also is a record of the cost for the Stephens Island Ground Beetle[7], the Stephens Island Frog, and the Kakapo programmes because expenditure for these programmes was equal to cost.

5. The PV of the programme's total annual expenditure per conservation unit, or the PV of the average expenditure for a one unit change in the species' conservation status, until 2002 on an increasing quadratic scale from NZ ≤$10,000 to ≤$1 million. This item can be used to forecast what the eventual total cost of a programme may be if funding continues at present levels.

6. The species' conservation status in 2003 ***and*** the PV of the possible change in species' status until 2012[8] if annual funding is equal to annual cost, on a decreasing quadratic scale from ≤1.00 (Not Threatened) to 0.00 (Extinct). An

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[7] The Stephens Island Ground Beetle programme is allocated funding indirectly from the general Stephens Island management operating budget (C. McGuinness, personal communication, September 17, 2002).

[8] This is equivalent to PV of the change in conservation status of species i (PVδS_i) in Equation 2 from Chapter Three over a timeframe of ten years.

arrow as described for item 3 shows the overall direction of the change in status for a species. This item measures the possible recovery rate of a species if the programme is fully funded.

7. The PV of the predicted total annual cost of the programme from 2003 until 2012[9], calculated as the sum of the PV of the total annual costs of achieving each objective in the species' recovery plan, on an increasing quadratic scale from NZ ≤\$0.1 million to ≤\$10 million[10]. This item reflects the estimated annual costs of a threatened species programme.

8. The PV of the programme's predicted total annual cost per conservation status unit from 2003 until 2012[11], on an increasing quadratic scale from NZ ≤\$10,000 to ≤\$1 million. This item is the PV of the mean cost of improving a species' conservation status by one unit.

The results are highlighted (shaded) within their associated ranges to make it easier for the reader to compare the results across species and to indicate how well they match the expected theoretical patterns. For example, given the species' taxon, the more a species' r or K-selection (item 1) is 'in line' with a programme's PV of predicted total annual cost and its PV of predicted total annual cost per conservation unit (items 7 and 8) then the closer this matches the expected pattern that programmes

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[9] This item is equivalent to the PV of the cost of a threatened species programme for species i (PVC_i) in Equation 2 over a ten-year timeframe.

[10] The specific figure is reported on the first page of the results for each programme.

[11] The inverse of this ratio is equivalent to the cost-effectiveness ratio of a threatened species programme for species i ($PV\delta S_i / PVC_i$) in Equation 2 over a ten year timeframe.

for species that are extremely K-selected have higher annual and total costs than species that are less K-selected within each taxon. Similarly, the more the mean habitat area (item 2) is 'in line' with a programme's PV of predicted total annual cost (item 7) then the closer this result matches the expected pattern that programmes that require large areas of habitat for the management of a species have higher annual costs than programmes that need smaller areas of habitat.

5.2.2 Interpretation of the results

The following two commentaries are provided to illustrate how to interpret the species and financial results:

The Flax Snail (refer to Section 5.2.4: 78) is moderately K-selected for an invertebrate species (item 1 or row 1) and needs a small average habitat area per individual (row 2). The species' conservation status, or degree of threatenedness, was extreme in 1990 (row 3), and had further declined by 2002 (indicated by the arrow pointing towards 0.00 for row 3), but the PV of total expenditure for the species was moderate during this time period (row 4). That is reflected in a negative PV of total expenditure per unit change in conservation status (row 5). The Flax Snail's conservation status in 2003 (row 6), however, could improve quickly by 2012 if the programme is fully funded, even though the PV of predicted total annual cost of the programme is comparatively low (row 7). This result is reflected by a low PV of predicted total annual cost per unit change in conservation status during this time period (row 8).

The Kakapo (refer to Section 5.2.8: 86) is extremely K-selected[12] for a bird species (row 1) and needs a large average habitat area per individual (row 2). The species' conservation status was extreme in 1989 (row 3) and had not improved significantly by 2002 (indicated by only one result recorded for row 3), but the PV of total expenditure for the species was extremely high during this time period (row 4). That is reflected by the PV of total expenditure per unit change in conservation status of more than NZ$1 million (row 5). The Kakapo's conservation status in 2003 (row 6) should slowly improve by 2012, even though the PV of total annual cost of the programme is predicted to be lower than past expenditure (row 7). This result is reflected by a PV of total annual cost per unit change in status during this time period of less than or equal to NZ$1 million (row 8).

5.2.3 The budget constraint and discounting

All of the financial results are estimated to the nearest NZ$10,000 and are for Output Class D5: Management Services: Protected Species and Island Habitats, which had a total annual budget of about NZ$35.8 million for the year ending June 2002 (DoC, 2002). Expenditure in 2001/02 on the eleven species was over $2.5 million, or seven percent of the annual budget, even though they represent less than one percent of the total number of New Zealand species classified as Acutely Threatened. The major items in Output Class D5 are: species conservation programmes, mainland island sites, island management and restoration. The results generally do not include expenditure or costs from Output Class D4: Management Services: Conservation

[12] To resolve problems with the collection of data, the author referred to Merton (2002) to estimate the Kakapo's K-selection, and annual total population numbers to assess its annual conservation status from 1989 until 2012, which was confirmed by the Recovery Group Leader.

Estate, which focuses on fire and pest control, or other budgets. The predicted cost of the North Island Kokako programme, however, is not directly comparable with the predicted costs of programmes for other threatened species because almost all management of the species occurs as part of ecosystem restoration projects (J. Hudson, personal communication, September 20, 2002).

The expenditure data is inflation adjusted and all data for expenditure, cost, funding and change in species' conservation status are discounted back to their present values using a discount rate of six percent, based on the real cost of government borrowing. Discounting allows incidences of expenditures, costs, funding and changes in species' conservation status occurring in different time periods to be directly compared across threatened species programmes and the use of a positive discount rate reflects the public's preference for the timely conservation of threatened species.

The effect of discounting is to reduce the predicted total annual cost of programmes but it does not alter their ordinal rank or position because the incidence of costs over time are similar for all of the single species programmes studied. The highest estimated annual costs are at the start of the ten-year timeframe for the eleven threatened species programmes: an average of fifty-one percent of the total annual costs of programmes occur in the first three years. For the remainder of the timeframe, estimated annual costs decline to lower constant costs for eight programmes (less than fifty percent of the cost in 2003 for seven species); continually decline for two programmes, and decline to lower cyclical costs for the last programme. Discounting may, however, reduce the total costs of some programmes enough to alter their positions and it marginally reduces improvements in species' conservation status.

5.3 The results for the eighteen threatened species programmes

5.3.1 Pittosporum patulum

Species	*Pittosporum patulum*
Complementary species	Mistletoes, *Peraxilla tetrapetala* and *Alepis flavida*
Key conservancies	Nelson / Marlborough, Canterbury
Habitat type	Sub-alpine scrub and gaps in mountain beech fest
Causes of decline	Possum and maybe deer browsing
Immediate threats	Predation
Conservation status	Nationally Endangered (range: 0.44 to 0.24)
Recovery goal	Self-sustaining populations of *P. patulum* occur in the wild throughout the natural range of the species.

Recovery objectives	**PV of total annual cost 2003 – 2012**
Promote public and iwi interest and involvement in the recovery of the species.	$4,401
Determine more precisely the distribution, abundance and agents of threat of the species.	$44,008
Promote adaptive management and research that address the information deficiencies in the species' ecology and threats.	$22,326
Mitigate threats at sites representative of the ecological range of the species.	$314,745
PV of total annual cost 2003 – 2012	**$385,480**

Table 2: Results for the *Pittosporum patulum*

Item	Results (the results for the species are shaded within the range for each item)									
1. r selected (10) or K-selected (1)	10	9	8	7	6	**5**	4	3	2	1
2. Habitat area per individual (hectares)	≤ 0.10	≤ 0.42	**≤ 1.41**	≤ 3.00	≤ 5.19	≤ 7.96	≤ 11.33	≤ 15.30	≤ 19.85	≤ 25.00
3. PV of Δ in status 1999 – 2002 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90	≤ 0.80	≤ 0.70	≤ 0.60	≤ 0.50	**≤ 0.40** ←	**≤ 0.30**	≤ 0.20	≤ 0.10
4. PV of expenditure 1999 – 2002 (millions New Zealand $)	**≤ $0.1**	≤ $0.4	≤ $0.9	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
5. PV of expend. / Δ in status (thousands New Zealand $)	**≤ $10**	≤ $40	≤ $90	≤ $160	≤ $250	≤ $360	≤ $490	≤ $640	≤ 810	≤ $1,000
6. PV of Δ in status 2003 – 2012 (Not Threatened to Extinct)	**≤ 1.00**	←					**≤ 0.40**	≤ 0.30	≤ 0.20	≤ 0.10
7. PV of cost 2003 – 2012 (millions New Zealand $)	≤ $0.1	**≤ $0.4**	≤ $0.9	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
8. PV of cost / Δ in status (thousands New Zealand $)	**≤ $10**	≤ $40	≤ $90	≤ $160	≤ $250	≤ $360	≤ $490	≤ $640	≤ $810	≤ $1,000

5.3.2 Climbing Everlasting Daisy

Species	*Helichrysum dimorphum*
Complementary species	*Carmichaelia kirkii* and *Coprosma wallii*
Key conservancies	Canterbury
Habitat type	Matagouri and coprosma shrublands
Causes of decline	Habitat loss, fire, weed competition, stock browsing
Immediate threats	Habitat loss, fire, weed competition, stock browsing
Conservation status	Nationally Endangered (range: 0.44 to 0.24)
Recovery goal	Vision: viable, representative, self-sustaining populations of the Climbing Everlasting Daisy occurring throughout its natural range. This will be achieved though the species becoming 'Range Restricted' over the next fifty years.

Recovery objectives	**PV of total annual cost 2003 – 2012**
Create awareness among stakeholders for the opportunities for conserving the species by June 2003.	$2,016
Determine distribution and trends in population size, fitness and recruitment by 2005.	$7,802
Legally and physically protect representative examples of the species' habitat by 2011.	$66,802
Establish a research programme that provides relevant information for management decisions to be made by June 2003.	$12,679
Establish a restoration programme that enhances representative examples of species' habitat selected under the objective to protect examples of habitat by June 2007.	$78,017
PV of total annual cost 2003 – 2012	**$167,315**

Table 3: Results for the Climbing Everlasting daisy

Item	**Results** (the results for the species are shaded within the range for each item)									
1. r selected (10) or K-selected (1)	10	9	8	**7**	6	5	4	3	2	1
2. Habitat area per individual (hectares)	≤ 0.10	≤ 0.42	**≤ 1.41**	≤ 3.00	≤ 5.19	≤ 7.96	≤ 11.33	≤ 15.30	≤ 19.85	≤ 25.00
3. PV of Δ in status 1990 – 2002 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90	≤ 0.80	≤ 0.70	≤ 0.60	≤ 0.50	≤ 0.40	**≤ 0.30**	≤ 0.20	≤ 0.10
4. PV of expenditure 1990 – 2002 (millions New Zealand $)	**≤ $0.1**	≤ $0.4	≤ $0.9	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
5. PV of expend. / Δ in status (thousands New Zealand $)	Decline in conservation status 1990 – 2002									
6. PV of Δ in status 2003 – 2012 (Not Threatened to Extinct)	≤ 1.00	**≤ 0.90**	←					**≤ 0.30**	≤ 0.20	≤ 0.10
7. PV of cost 2003 – 2012 (millions New Zealand $)	≤ $0.1	**≤ $0.4**	≤ $0.9	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
8. PV of cost / Δ in status (thousands New Zealand $)	**≤ $10**	≤ $40	≤ $90	≤ $160	≤ $250	≤ $360	≤ $490	≤ $640	≤ $810	≤ $1,000

5.3.3 Stephens Island Ground Beetle

Species	*Mecodema costellum costellum*
Complementary species	None
Key conservancies	Nelson / Marlborough
Habitat type	Under large ngaio and *Coprosma repens* logs
Causes of decline	Habitat loss (mature forest and logs for refugia)
Immediate threats	Lack of suitable sized logs for refugia
Conservation status	Nationally Endangered (range 0.44 to 0.24)
Recovery goal	A self-sustaining population of the Stephens Island Ground Beetle secured at a density that enables transfers to other islands to be a sustainable option.

Recovery objectives	**PV of total annual cost 2003 - 2012**
Improve the population size of the species.	$11,802
PV of total annual cost 2003 – 2012	**$11,802**

Table 4: Results for the Stephens Island Ground Beetle

Item	**Results** (the results for the species are shaded within the range for each item)									
1. r selected (10) or K-selected (1)	10	9	8	7	6	5	4	3	2	1
2. Habitat area per individual (hectares)	≤ 0.10	≤ 0.42	≤ 1.41	≤ 3.00	≤ 5.19	≤ 7.96	≤ 11.33	≤ 15.30	≤ 19.85	≤ 25.00
3. PV of Δ in status 1990 – 2002 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90	≤ 0.80	≤ 0.70	≤ 0.60	≤ 0.50	≤ 0.40	≤ 0.30	≤ 0.20	≤ 0.10
4. PV of expenditure 1990 – 2002 (millions New Zealand $)	≤ $0.1	≤ $0.4	≤ $0.9	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
5. PV of expend. / Δ in status (thousands New Zealand $)	≤ $10	≤ $40	≤ $90	≤ $160	≤ $250	≤ $360	≤ $490	≤ $640	≤ 810	≤ $1,000
6. PV of Δ in status 2003 – 2012 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90	≤ 0.80	←			≤ 0.40	≤ 0.30	≤ 0.20	≤ 0.10
7. PV of cost 2003 – 2012 (millions New Zealand $)	≤ $0.1	≤ $0.4	≤ $0.9	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
8. PV of cost / Δ in status (thousands New Zealand $)	≤ $10	≤ $40	≤ $90	≤ $160	≤ $250	≤ $360	≤ $490	≤ $640	≤ $810	≤ $1,000

5.3.4 Flax Snail (Te Paki species)

Species	*Placostylus ambagiosus*
Complementary species	None
Key conservancies	Northland
Habitat type	Coastal broadleaf forest and scrub
Causes of decline	Predation, habitat loss, and fragmentation
Immediate threats	Predation, habitat loss
Conservation status	Nationally Critical (range: 0.23 to 0.01)

Recovery goal Long-term goal: to preserve and enhance populations of the Flax Snail in their natural range with emphasis on directing management towards the most genetically diverse and viable populations. Short-term goal: to prevent the extinction of most of the recognised subspecies or genetically distinct populations.

Recovery objectives (These were provided by the Recovery Group Leader and differ from those in the recovery plan)	**PV of total annual cost 2003 - 2012**
Control or eradicate predators within colonies of the species.	$1,170,254
Build and maintain pig and stock-proof fences around colonies of the species.	$198,017
Survey species' colonies to determine status and management requirements	$10,000
Re-vegetate selected colonies of the species.	$28,334
Carry out research on predator impacts, and population dynamics.	$234,051
PV of total annual cost 2003 – 2012	**$1,640,655**

Table 5: Results for the Flax Snail

Item	Results (the results for the species are shaded within the range for each item)									
1. r selected (10) or K-selected (1)	10	9	8	7	6	5	4	**3**	2	1
2. Habitat area per individual (hectares)	**≤ 0.10**	≤ 0.42	≤ 1.41	≤ 3.00	≤ 5.19	≤ 7.96	≤ 11.33	≤ 15.30	≤ 19.85	≤ 25.00
3. PV of Δ in status 1993 – 2002 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90	≤ 0.80	≤ 0.70	≤ 0.60	≤ 0.50	≤ 0.40	≤ 0.30	**≤ 0.20** →	**≤ 0.10**
4. PV of expenditure 1993 – 2002 (millions New Zealand $)	≤ $0.1	**≤ $0.4**	≤ $0.9	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
5. PV of expend. / Δ in status (thousands New Zealand $)	Decline in conservation status 1993 – 2002									
6. PV of Δ in status 2003 – 2012 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90	≤ 0.80	**≤ 0.70**	←					**≤ 0.10**
7. PV of cost 2003 – 2012 (millions New Zealand $)	≤ $0.1	≤ $0.4	≤ $0.9	≤ $1.6	**≤ $2.5**	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
8. PV of cost / Δ in status (thousands New Zealand $)	≤ $10	**≤ $40**	≤ $90	≤ $160	≤ $250	≤ $360	≤ $490	≤ $640	≤ $810	≤ $1,000

5.3.5 Stephens Island (Hamilton's) frog

Species	*Leiopelma hamiltoni*
Complementary species	None
Key conservancies	Nelson / Marlborough
Habitat type	Rock banks and forest floor
Causes of decline	Habitat loss and degradation, predation, disturbance
Immediate threats	Small population, predation, invasive alien species, pathogens and parasites, natural events *et al.*
Conservation status	Nationally Critical (range: 0.23 to 0.01)
Recovery goal	The long-term (fifty-year) goal is to maintain and enhance, in the wild, existing genetic stocks of Stephens Island Frog.

Recovery objectives	**PV of total annual cost 2003 – 2012**
Maintain the known population of the species and protect it from adverse human impacts.	$39,008
Work towards establishing two new wild populations of the species (one on Stephens Island and a second on another predator-free island).	$28,082
Establish long-term monitoring at selected sites to determine population trends.	$39,008
PV of total annual cost 2003 – 2012	**$106,099**

Table 6: Results for the Stephens Island Frog

Item	Results (the results for the species are shaded within the range for each item)									
1. r selected (10) or K-selected (1)	10	9	8	7	6	5	4	3	2	1
2. Habitat area per individual (hectares)	≤ 0.10	≤ 0.42	≤ 1.41	≤ 3.00	≤ 5.19	≤ 7.96	≤ 11.33	≤ 15.30	≤ 19.85	≤ 25.00
3. PV of Δ in status 1996 – 2002 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90	≤ 0.80	≤ 0.70	≤ 0.60	≤ 0.50	≤ 0.40	≤ 0.30	≤ 0.20	≤ 0.10
4. PV of expenditure 1996 – 2002 (millions New Zealand $)	≤ $0.1	≤ $0.4	≤ $0.9	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
5. PV of expend. / Δ in status (thousands New Zealand $)	≤ $10	≤ $40	≤ $90	≤ $160	≤ $250	≤ $360	≤ $490	≤ $640	≤ 810	≤ $1,000
6. PV of Δ in status 2003 – 2012 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90	≤ 0.80	≤ 0.70	≤ 0.60	≤ 0.50	≤ 0.40	≤ 0.30	←	≤ 0.10
7. PV of cost 2003 – 2012 (millions New Zealand $)	≤ $0.1	≤ $0.4	≤ $0.9	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
8. PV of cost / Δ in status (thousands New Zealand $)	≤ $10	≤ $40	≤ $90	≤ $160	≤ $250	≤ $360	≤ $490	≤ $640	≤ $810	≤ $1,000

5.3.6 South Island Long-tailed Bat

Species	*Chalinolobus tuberculata*
Complementary species	Mohua, Kaka, other bat species
Key conservancies	All South Island Conservancies
Habitat type	Forest edges
Causes of decline	Habitat loss, predation
Immediate threats	Predation, habitat loss
Conservation status	Nationally Endangered (range: 0.44 to 0.24)

Recovery goal To ensure the perpetuation of the South Island Long-tailed Bat throughout its present ranges, and where feasible establish new populations within its historical range. It is thought that this needs to be amended to be more realistic recovery goal, and it is suggested that there be at least twelve sites where management is undertaken to specifically protect bats (J. Lyall, personal communication, August 2002).

Recovery objectives	**PV of total annual cost 2003 - 2012**
Undertake or promote research on the species that will assist in its management.	$773,698
Evaluate the status of the species.	$2,151,988
Select, protect and monitor populations of the species throughout their geographic range.	$2,830,721
Raise public awareness of the species and involve the public in its conservation.	$118,346
PV of total annual cost 2003 – 2012	**$5,874,754**

Table 7: Results for the South Island Long-tailed Bat

Item	Results (the results for the species are shaded within the range for each item)									
1. r selected (10) or K-selected (1)	10	9	8	7	6	5	4	3	2	1
2. Habitat area per individual (hectares)	Unknown									
3. PV of Δ in status 1995 – 2002 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90	≤ 0.80	≤ 0.70	≤ 0.60	≤ 0.50	≤ 0.40	≤ 0.30	≤ 0.20	≤ 0.10
4. PV of expenditure 1995 – 2002 (millions New Zealand $)	≤ $0.1	≤ $0.4	≤ $0.9	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
5. PV of expend. / Δ in status (thousands New Zealand $)	No change in conservation status 1990 – 2002									
6. PV of Δ in status 2003 – 2009 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90	≤ 0.80	≤ 0.70	≤ 0.60	≤ 0.50	≤ 0.40	≤ 0.30	≤ 0.20	≤ 0.10
7. PV of cost 2003 – 2009 (millions New Zealand $)	≤ $0.1	≤ $0.4	≤ $0.9	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
8. PV of cost / Δ in status (thousands New Zealand $)	No possible change in conservation status 2003 – 2012									

5.3.7 Black Stilt (Kakī)

Species	*Himantopus novaezelandiae*
Complementary species	None
Key conservancies	Canterbury
Habitat type	Braided riverbeds
Causes of decline	Predation, habitat loss
Immediate threats	Predation, habitat loss
Conservation status	Nationally Critical (range: 0.23 to 0.01)
Recovery goal	Establish self-sustaining populations of the Black Stilt to ensure the species' survival in the wild without a continuing need for intervention.

Recovery aims	**PV of total annual cost 2003 – 2012**
Increase the productivity of breeding pairs in the wild on the mainland.	$2,509,514
Increase the breeding population in the wild on the mainland from the current level of ten pairs.	$2,218,577
Maintain a captive population and improve its productivity to provide the maximum number of birds for release into the wild.	$1,702,796
Establish a self-sustaining population on a predator-free island.	$82,574
Encourage public interest in, and support for, the recovery programme through advocacy and education.	$633,249
PV of total annual cost 2003 – 2012	**$7,146,709**

Table 8: Results for the Black Stilt

Item	**Results** (the results for the species are shaded within the range for each item)									
1. r selected (10) or K-selected (1)	10	9	8	7	6	5	4	**3**	2	1
2. Habitat area per individual (hectares)	≤ 0.10	≤ 0.42	≤ 1.41	≤ 3.00	**≤ 5.19**	≤ 7.96	≤ 11.33	≤ 15.30	≤ 19.85	≤ 25.00
3. PV of Δ in status 1993 – 2002 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90	≤ 0.80	≤ 0.70	≤ 0.60	≤ 0.50	≤ 0.40	≤ 0.30	**≤ 0.20** ←	**≤ 0.10**
4. PV of expenditure 1993 – 2002 (millions New Zealand $)	≤ $0.1	≤ $0.4	≤ $0.9	≤ $1.6	≤ $2.5	**≤ $3.6**	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
5. PV of expend. / Δ in status (thousands New Zealand $)	≤ $10	≤ $40	≤ $90	≤ $160	≤ $250	≤ $360	≤ $490	**≤ $640**	≤ 810	≤ $1,000
6. PV of Δ in status 2003 – 2012 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90	≤ 0.80	≤ 0.70	≤ 0.60	≤ 0.50	**≤ 0.40**	←	**≤ 0.20**	≤ 0.10
7. PV of cost 2003 – 2012 (millions New Zealand $)	≤ $0.1	≤ $0.4	≤ $0.9	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	**≤ $8.1**	≤ $10
8. PV of cost / Δ in status (thousands New Zealand $)	≤ $10	≤ $40	≤ $90	≤ $160	≤ $250	**≤ $360**	≤ $490	≤ $640	≤ $810	≤ $1,000

5.3.8 Kakapo

Species	*Strigops habroptilus*
Complementary species	None
Key conservancies	Southland
Habitat type	A range of terrestrial habitats (but not alpine)
Causes of decline	Predation at all life stages
Immediate threats	Small population size
Conservation status	Nationally Critical (range: 0.23 to 0.01)

Recovery goal Vision: at least one viable, self-sustaining, unmanaged population of Kakapo as a functional component of the ecosystem in a protected habitat and to establish two or more other populations that may require ongoing management.

Recovery objectives	**PV of total annual cost 2003 – 2012**
Maximise egg and chick survival by minimising mortality from predation, starvation, disease, parasites, inadequate hygiene, natural events (e.g. flooding), and poor parenting.	$601,754
Maintain and increase the breeding life of the species.	$1,665,111
Identify ways of increasing the species' breeding frequency.	$375,009
Determine where productivity is being lost.	$60,000
Work with the Conservancies to manage islands for the species.	$466,679
Increase public awareness of the species conservation.	$123,336
Collect, store and publish information on the species.	$38,334
PV of total annual cost 2003 - 2012	**$3,330,223**

Table 9: Results for the Kakapo

Item	Results (the results for the species are shaded within the range for each item)									
1. r selected (10) or K-selected (1)	10	9	8	7	6	5	4	3	2	1
2. Habitat area per individual (hectares)	≤ 0.10	≤ 0.42	≤ 1.41	≤ 3.00	≤ 5.19	≤ 7.96	≤ 11.33	≤ 15.30	≤ 19.85	≤ 25.00
3. PV of Δ in status 1989 – 2002 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90	≤ 0.80	≤ 0.70	≤ 0.60	≤ 0.50	≤ 0.40	≤ 0.30	≤ 0.20	≤ 0.10
4. PV of expenditure 1989 – 2002 (millions New Zealand $)	≤ $0.1	≤ $0.4	≤ $0.9	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
5. PV of expend. / Δ in status (thousands New Zealand $)	≤ $10	≤ $40	≤ $90	≤ $160	≤ $250	≤ $360	≤ $490	≤ $640	≤ 810	≤$1,000+
6. PV of Δ in status 2003 – 2012 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90	≤ 0.80	≤ 0.70	≤ 0.60	≤ 0.50	≤ 0.40	≤ 0.30	≤ 0.20 ←	≤ 0.10
7. PV of cost 2003 – 2012 (millions New Zealand $)	≤ $0.1	≤ $0.4	≤ $0.9	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
8. PV of cost / Δ in status (thousands New Zealand $)	≤ $10	≤ $40	≤ $90	≤ $160	≤ $250	≤ $360	≤ $490	≤ $640	≤ $810	≤ $1,000

5.3.9 North Island Kokako

Species	*Callaeas cinerea wilsoni*
Complementary species	All North Island threatened bird and plant species present in the 16 managed forest tracts
Key conservancies	All North Island Conservancies
Habitat type	Mature podocarp-broadleaf forest dominated by tawa
Causes of decline	Habitat loss, predation by rats, possums and stoats, competition from possums, deer and goats
Immediate threats	Predation by rats, possums and stoats, competition from possums, deer and goats
Conservation status	Nationally Endangered (range: 0.44 to 0.24)
Recovery goal	Improve the status of North Island Kokako from Endangered, by restoring its total population to around 1,000 pairs by 2020, in sustainable communities throughout the North Island.

Recovery objectives	**PV of total annual cost 2003 – 2012**
Determine the relative importance of the causes of the current decline of the species.	$1,926,608
Determine successful management techniques and strategies for the conservation of the species.	$5,710,110
Establish viable populations of the species on islands.	$429,093
Develop rearing techniques for the species in captivity.	$936,203
Survey potentially important but poorly known populations.	$312,068
PV of total annual cost 2003 – 2012	**$9,314,082**

Table 10: Results for the North Island Kokako

Item	**Results** (the results for the species are shaded within the range for each item)								
1. r selected (10) or K-selected (1)	10	9	8	7	6	5	4	3	2	1
2. Habitat area per individual (hectares)	≤ 0.10	≤ 0.42	≤ 1.41	≤ 3.00	≤ 5.19	≤ 7.96	≤ 11.33	≤ 15.30	≤ 19.85	≤ 25.00
3. PV of Δ in status 1993 – 2002 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90	≤ 0.80	≤ 0.70	≤ 0.60	≤ 0.50	≤ 0.40	≤ 0.30	≤ 0.20	≤ 0.10
4. PV of expenditure 1993 – 2002 (millions New Zealand $)	≤ $0.1	≤ $0.4	≤ $0.9	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
5. PV of expend. / Δ in status (thousands New Zealand $)	≤ $10	≤ $40	≤ $90	≤ $160	≤ $250	≤ $360	≤ $490	≤ $640	≤ 810	≤ $1,000
6. PV of Δ in status 2003 – 2012 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90					≤ 0.40	≤ 0.30	≤ 0.20	≤ 0.10
7. PV of cost 2003 – 2012 (millions New Zealand $)	≤ $0.1	≤ $0.4	≤ $0.9	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
8. PV of cost / Δ in status (thousands New Zealand $)	≤ $10	≤ $40	≤ $90	≤ $160	≤ $250	≤ $360	≤ $490	≤ $640	≤ $810	≤ $1,000

5.3.10 Mohua (Yellowhead)

Species	*Mohoua ochrocephala*
Complementary species	Orange-fronted parakeet, bat species, blue duck, kiwi spp., weka, kaka, kakariki, and robin
Key conservancies	All South Island Conservancies
Habitat type	South Island beech forests
Causes of decline	Predation, natural events, habitat (quality) loss
Immediate threats	Predation, natural events, habitat (quality) loss
Conservation status	Nationally Endangered (range: 0.44 to 0.24)
Recovery goal	Maintain and enhance Mohua populations throughout the present range and beyond, by halting and reversing the degradation of the forest ecosystem.

Recovery objectives	**PV of total annual cost 2003 - 2012**
Manage wild populations of the species within key mainland forests throughout their range.	$2,742,796
Improve management techniques so they are effective over large geographic areas.	$1,087,680
Search for new populations of the species.	$76,102
Establish populations of the species on suitable predator-free islands.	$71,811
Improve our understanding of factors that impact on populations of the species.	$1,303,904
Continue to develop a captive management capability.	$28,852
PV of total annual cost 2003 – 2012	**$5,311,145**

Table 11: Results for the Mohua

Item	**Results** (the results for the species are shaded within the range for each item)									
1. r selected (10) or K-selected (1)	10	9	8	7	6	5	4	**3**	2	1
2. Habitat area per individual (hectares)	≤ 0.10	≤ 0.42	≤ 1.41	**≤ 3.00**	≤ 5.19	≤ 7.96	≤ 11.33	≤ 15.30	≤ 19.85	≤ 25.00
3. PV of Δ in status 1992 – 2002 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90	≤ 0.80	≤ 0.70	≤ 0.60	**≤ 0.50**	≤ 0.40	≤ 0.30	≤ 0.20	≤ 0.10
4. PV of expenditure 1992 – 2002 (millions New Zealand $)	≤ $0.1	≤ $0.4	≤ $0.9	≤ $1.6	**≤ $2.5**	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
5. PV of expend. / Δ in status (thousands New Zealand $)	Decline in conservation status 1992 - 2002									
6. PV of Δ in status 2003 – 2012 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90	≤ 0.80	**≤ 0.70**	←	**≤ 0.50**	≤ 0.40	≤ 0.30	≤ 0.20	≤ 0.10
7. PV of cost 2003 – 2012 (millions New Zealand $)	≤ $0.1	≤ $0.4	≤ $0.9	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	**≤ $6.4**	≤ $8.1	≤ $10
8. PV of cost / Δ in status (thousands New Zealand $)	≤ $10	≤ $40	≤ $90	≤ $160	≤ $250	**≤ $360**	≤ $490	≤ $640	≤ $810	≤ $1,000

5.3.11 Campbell Island Teal

Species	*Anas nesiotis*
Complementary species	None
Key conservancies	Wellington (captive population), Southland
Habitat type	Wetland vegetation on sub-Antarctic islands
Causes of decline	Predation
Immediate threats	Predation, disease
Conservation status	Nationally Critical (range: 0.23 to 0.01)
Recovery goal	Improve the conservation status of the Campbell Island Teal from Endangered to Rare by re-establishing it in its former ranges so that further intensive management is no longer required.

Recovery objectives	**PV of total annual cost 2003 – 2012**
Establish a captive breeding population of the species.	$295,009
Establish an additional wild population of the species.	$114,066
PV of total annual cost 2003 – 2012	**$409,075**

Table 12: Results for the Campbell Island Teal

Item	**Results** (the results for the species are shaded within the range for each item)									
1. r selected (10) or K-selected (1)	10	9	8	**7**	6	5	4	3	2	1
2. Habitat area per individual (hectares)	**≤ 0.10**	≤ 0.42	≤ 1.41	≤ 3.00	≤ 5.19	≤ 7.96	≤ 11.33	≤ 15.30	≤ 19.85	≤ 25.00
3. PV of Δ in status 1990 – 2002 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90	≤ 0.80	≤ 0.70	≤ 0.60	≤ 0.50	≤ 0.40	**≤ 0.30**	←	**≤ 0.10**
4. PV of expenditure 1990 – 2002 (millions New Zealand $)	≤ $0.1	≤ $0.4	**≤ $0.9**	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
5. PV of expend. / Δ in status (thousands New Zealand $)	≤ $10	**≤ $40**	≤ $90	≤ $160	≤ $250	≤ $360	≤ $490	≤ $640	≤ 810	≤ $1,000
6. PV of Δ in status 2003 – 2012 (Not Threatened to Extinct)	≤ 1.00	**≤ 0.90**	←					**≤ 0.30**	≤ 0.20	≤ 0.10
7. PV of cost 2003 – 2012 (millions New Zealand $)	≤ $0.1	≤ $0.4	**≤ $0.9**	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
8. PV of cost / Δ in status (thousands New Zealand $)	**≤ $10**	≤ $40	≤ $90	≤ $160	≤ $250	≤ $360	≤ $490	≤ $640	≤ $810	≤ $1,000

5.3.12 Pygmy Button Daisy

Species *Leptinella nana*

Key conservancies Wellington, Nelson / Marlborough, Canterbury

Causes of decline Habitat loss, weed competition

Conservation status Nationally Endangered (range: 0.44 to 0.24)

Complement species None

Habitat type Varies from forest to cliff-top grassland

Immediate threats Weed competition, habitat degradation

Recovery goal status At Risk or Not Threatened

Table 13: Results for the Pygmy Button Daisy

Item	Results									
1. r selected (10) or K-selected (1)	10	**9**	8	7	6	5	4	3	2	1
2. Habitat area per individual (hectares)	≤ 0.10	≤ 0.42	**≤ 1.41**	≤ 3.00	≤ 5.19	≤ 7.96	≤ 11.33	≤ 15.30	≤ 19.85	≤ 25.00
3. PV of Δ in status 1990 – 2002 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90	≤ 0.80	≤ 0.70	≤ 0.60	≤ 0.50	**≤ 0.40** ←	**≤ 0.30**	≤ 0.20	≤ 0.10
4. PV of expenditure 1990 – 2002 (millions New Zealand $)	**≤ $0.1**	≤ $0.4	≤ $0.9	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
5. PV of expend. / Δ in status (thousands New Zealand $)	**≤ $10**	≤ $40	≤ $90	≤ $160	≤ $250	≤ $360	≤ $490	≤ $640	≤ 810	≤ $1,000

5.3.13 Mercury Island (Middle Island) Tusked Weta

Species Motuweta isolata

Key conservancies Waikato

Causes of decline Predation, habitat loss

Conservation status Nationally Critical (range: 0.23 to 0.01)

Complement species None

Habitat type Open ground amongst sea-bird burrows and under mixed broadleaf forest

Immediate threats Reintroduction of rodents to predator-free habitats

Recovery goal status Range Restricted – 0.94 to 0.87

Table 14: Results for the Mercury Island Tusked Weta

Item	Results									
1. r selected (10) or K-selected (1)	10	9	8	7	6	5	4	3	2	1
2. Habitat area per individual (hectares)	≤ 0.10	≤ 0.42	≤ 1.41	≤ 3.00	≤ 5.19	≤ 7.96	≤ 11.33	≤ 15.30	≤ 19.85	≤ 25.00
3. PV of Δ in status 1993 – 2002 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90	≤ 0.80	≤ 0.70	≤ 0.60	≤ 0.50	≤ 0.40	≤ 0.30	≤ 0.20	≤ 0.10
4. PV of expenditure 1993 – 2002 (millions New Zealand $)	≤ $0.1	≤ $0.4	≤ $0.9	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
5. PV of expend. / Δ in status (thousands New Zealand $)	≤ $10	≤ $40	≤ $90	≤ $160	≤ $250	≤ $360	≤ $490	≤ $640	≤ 810	≤ $1,000

5.3.14 Otago and Grand Skinks

Species	*Oligosoma Otagense* and *Oligosoma grande*	**Complement species**	None other than each other
Key conservancies	Otago	**Habitat type**	Large, well-creviced rock outcrops
Causes of decline	Predation, habitat loss	**Immediate threats**	Predation, habitat loss
Conservation status	Nationally Endangered (range: 0.44 to 0.24)	**Recovery goal status**	Range Restricted – 0.94 to 0.87

Table 15: Results for the Otago and Grand Skinks

Item	**Results**									
1. r selected (10) or K-selected (1)	10	9	8	7	6	5	4	3	2	1
2. Habitat area per individual (hectares)	≤ 0.10	≤ 0.42	≤ 1.41	≤ 3.00	≤ 5.19	≤ 7.96	≤ 11.33	≤ 15.30	≤ 19.85	≤ 25.00
3. PV of Δ in status 1992 – 2002 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90	≤ 0.80	≤ 0.70	≤ 0.60	≤ 0.50	≤ 0.40	≤ 0.30	≤ 0.20	≤ 0.10
4. PV of expenditure 1992 – 2002 (millions New Zealand $)	≤ $0.1	≤ $0.4	≤ $0.9	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
5. PV of expend. / Δ in status (thousands New Zealand $)	Decline in conservation status 1992 – 2002									

5.3.15 Chevron Skink

Species	*Oligosoma homalonotum*	**Complement species**	Tuatara on Little Barrier Island
Key conservancies	Auckland	**Habitat type**	Forested areas along streams
Causes of decline	Predation, habitat loss	**Immediate threats**	Predation
Conservation status	Nationally Endangered (range: 0.44 to 0.24)	**Recovery goal status**	Not Threatened – 1.00 to 0.99

Table 16: Results for the Chevron Skink

Item	**Results**									
1. r selected (10) or K-selected (1)	10	9	8	7	6	5	4	3	2	1
2. Habitat area per individual (hectares)	≤ 0.10	≤ 0.42	≤ 1.41	≤ 3.00	≤ 5.19	≤ 7.96	≤ 11.33	≤ 15.30	≤ 19.85	≤ 25.00
3. PV of Δ in status 1996 – 2001 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90	≤ 0.80	≤ 0.70	≤ 0.60	≤ 0.50	≤ 0.40	≤ 0.30	≤ 0.20	≤ 0.10
4. PV of expenditure 1996 – 2001 (millions New Zealand $)	≤ $0.1	≤ $0.4	≤ $0.9	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
5. PV of expend. / Δ in status (thousands New Zealand $)	No change in conservation status 1996 – 2001									

5.3.16 Brothers Island Tuatara (Gunther's Tuatara)

Species	*Sphenodon guntheri*	**Complement species**	None
Key conservancies	Wellington, Nelson / Marlborough	**Habitat type**	Coastal forest and scrub
Causes of decline	Predation, habitat loss	**Immediate threats**	Reduced to remnant population
Conservation status	Nationally Endangered (range: 0.44 to 0.24)	**Recovery goal status**	Range Restricted – 0.94 to 0.87

Table 17: Results for the Brothers Island Tuatara

Item	Results									
1. r selected (10) or K-selected (1)	10	9	8	7	6	5	4	3	2	1
2. Habitat area per individual (hectares)	≤ 0.10	≤ 0.42	≤ 1.41	≤ 3.00	≤ 5.19	≤ 7.96	≤ 11.33	≤ 15.30	≤ 19.85	≤ 25.00
3. PV of Δ in status 1990 – 2002 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90	≤ 0.80	≤ 0.70	≤ 0.60	≤ 0.50	≤ 0.40	≤ 0.30	≤ 0.20	≤ 0.10
4. PV of expenditure 1990 – 2002 (millions New Zealand $)	≤ $0.1	≤ $0.4	≤ $0.9	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
5. PV of expend. / Δ in status (thousands New Zealand $)	≤ $10	≤ $40	≤ $90	≤ $160	≤ $250	≤ $360	≤ $490	≤ $640	≤ 810	≤ $1,000

5.3.17 Canterbury Mudfish

Species	*Neochanna burrowsius*	**Complement species**	None
Key conservancies	Canterbury	**Habitat type**	Freshwater streams
Causes of decline	Habitat loss and destruction, stock encroachment, invasive fish species, estrangement of wetlands	**Immediate threats**	Habitat loss and destruction, stock encroachment, invasive fish species, estrangement of wetlands
Conservation status	Nationally Endangered (range: 0.44 to 0.24)	**Recovery goal status**	Serious Decline – 0.75 to 0.62

Table 18: Results for the Canterbury Mudfish

Item	**Results**									
1. r selected (10) or K-selected (1)	10	9	8	7	6	5	4	3	2	1
2. Habitat area per individual (hectares)	≤ 0.10	≤ 0.42	≤ 1.41	≤ 3.00	≤ 5.19	≤ 7.96	≤ 11.33	≤ 15.30	≤ 19.85	≤ 25.00
3. PV of Δ in status 1990 – 2002 (Not Threatened to Extinct)	≤ 1.00	≤ 0.90	≤ 0.80	≤ 0.70	≤ 0.60	≤ 0.50	≤ 0.40 ←	≤ 0.30	≤ 0.20	≤ 0.10
4. PV of expenditure 1990 – 2002 (millions New Zealand $)	≤ $0.1	≤ $0.4	≤ $0.9	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
5. PV of expend. / Δ in status (thousands New Zealand $)	≤ $10	≤ $40	≤ $90	≤ $160	≤ $250	≤ $360	≤ $490	≤ $640	≤ 810	≤ $1,000

5.3.18 Yellow-eyed Penguin

Species *Megadyptes antipodes*

Key conservancies Canterbury, Otago, Southland

Causes of decline Habitat loss, predation, poaching

Conservation status Nationally Vulnerable (range: 0.61 to 0.45)

Complement species None

Habitat type Marine and terrestrial - was coastal forest, shrub margins, now from native forest to grazed pasture

Immediate threats Predation, habitat loss, collapse of food supply

Recovery goal status Range Restricted – 0.94 to 0.87

Table 19: Results for the Yellow-eyed Penguin

Item	**Results**									
1. r selected (10) or K-selected (1)	10	9	8	7	6	5	4	3	2	1
2. Habitat area per individual (hectares)	≤ 0.10	≤ 0.42	≤ 1.41	≤ 3.00	≤ 5.19	≤ 7.96	≤ 11.33	≤ 15.30	≤ 19.85	≤ 25.00
3. PV of Δ in status 1991 – 2002 (Not Threatened to Extinct)	Change in conservation status unknown									
4. PV of expenditure 1991 – 2002 (millions New Zealand $)	≤ $0.1	≤ $0.4	≤ $0.9	≤ $1.6	≤ $2.5	≤ $3.6	≤ $4.9	≤ $6.4	≤ $8.1	≤ $10
5. PV of expend. / Δ in status (thousands New Zealand $)	Change in conservation status unknown									

6 Results of cross-case analysis and discussion

6.1 Introduction

Chapter Five presented the results of the analysis of data from the Recovery Group Leader Survey for each of the selected threatened species programmes to highlight points for cross-case analysis and discussion. The purpose of this chapter is to present and discuss the results of the cross-case analysis of the eleven threatened species programmes for which cost data was available. The cross-case analysis used pattern matching logic and explanation building to test the proposed null and alternative hypotheses for each of the eleven threatened species programmes. All of the results discussed in this chapter are the Recovery Group Leaders' best estimates and assessments based on their knowledge when surveyed and they should be treated as such even if this caution is not always repeated.

The main body of this chapter is divided into five sections: the costs of threatened species programmes, the annual costs of programmes, the mean cost of recovery for a species, the projected total cost of a programme, and the budget constraint. The central point highlighted by the results in Chapter Five is that the eleven threatened species programmes have specific costs. The first section of this chapter outlines six reasons for the complexity of the task of estimating costs and then analyses and discusses the total annual costs of the eleven threatened species programmes from 2003 until 2012.

The results also highlight the point that the costs of programmes are dependent upon the set of objectives developed for the conservation of a species. The second section of this chapter categorises the objectives for the eleven threatened species programmes to show the structure of each programme's annual costs. It then considers habitat area and types of threat in turn as possible key factors in determining the annual costs of a programme. A further point that was clearly evident in the results is that there is a range of costs between programmes. In the third section, the mean cost per conservation status unit for the eleven threatened species programmes is used to consider a species' taxon and its K-selection within each taxon as underlying explanatory factors.

The results presented in Chapter Five also highlight the variation in both a species' conservation status in 2003 and its possible change in conservation status from 2003 until 2012. The fourth section of this chapter uses the projected total costs of the eleven programmes to illustrate how a species' initial conservation status and its rate of recovery are possible key factors, in addition to habitat area and types of threats, that determine a programme's total cost. In the fifth section the results of the likely effects of both the budget constraint and relaxing the budget constraint on the costs of threatened species programmes are presented for analysis and discussion. Finally, the findings from the hypotheses testing are drawn together and summarised in the conclusion.

The cross-case analysis focuses on a series of graphs (Figures 1 to 14) that illustrate the results for the eleven threatened species programmes presented in Chapter Five. In all of the graphs, the threatened species programmes are ordered by the dependent

variable. Similar colours are used to display results for related concepts across the graphs. Costs and funding are in shades of purple; costs and funding per conservation unit are coloured in reds. Results for knowledge about species are shaded yellow; results relating to habitat are in greens; results for the management of threats and predators are shaded blue; those relating to breeding programmes and K-selection are in oranges; and results for conservation status and recovery rate are shaded in grey. The analysis and discussion is also supported by the additional information and comments provided by the Recovery Group Leaders.

6.2 The costs of threatened species programmes

6.2.1 The task of estimating costs

The results for each threatened species programme indicate that New Zealand threatened species programmes have specific costs. Before the results of the cross-case analysis are presented and discussed, however, six main reasons are outlined for why the task of estimating the costs of programmes is complex. First, projects for particular populations of a threatened species may have multiple objectives or the programme may share resources at certain sites (J. Hudson, personal communication, September 5, 2002). As already noted, the cost of the North Island Kokako programme is not directly comparable with the costs of other species programmes because almost all management of the species occurs as part of ecosystem restoration projects. Conversely, much of the actual cost of the Campbell Island Teal programme

is hidden, for example, by the use of New Zealand Navy transport ships for visits (P. McClelland, personal communication, September 17, 2002).

The second reason for the complexity of the task is the costs of threatened species programmes may be partly met by sponsorship from other public or private organisations. As well as not being directly comparable, part of the reported cost of the North Island Kokako programme is funded by other agencies, such as Regional Councils and community groups. Those agencies are expected to take a greater share of costs in the future (J. Hudson, personal communication, September 20, 2002). The Kakapo programme is sponsored by Comalco New Zealand and the Royal Forest and Bird Protection Society. Third, threatened species programmes may benefit from voluntary community involvement. The Yellow-eyed Penguin Trust is actively involved in habitat restoration and predator control for the Yellow-eyed penguin. If any of these costs are not easily quantified then the task will be complicated.

The fourth reason is there may be a lack of knowledge about a species if existing management is limited, as is the case for the South Island Long-tailed Bat and the Canterbury Mudfish. Estimates of the costs of research for the Mohua or the Takahe programmes when these programmes were in their research phase may have been much higher than they are now for the South Island Long-Tailed Bat programme (C. O'Donnell and J. Lyall, personal communication, March 20, 2003). Fifth, even when knowledge does exist, management may depend upon a complex range of endogenous and exogenous factors. The results for the Mohua programme, and those for many

other threatened species, are dependent upon sets of factors relating to threats from predators (A. Roberts, personal communication, October 3, 2002)[1].

Finally, the cost may also change over time through the application of knowledge gained either from the use of adaptive management strategies[2] or the management of other threatened species. A strategy using large-scale pest control in an experiment for the North Island Kokako at Mapara and other sites showed that predation is the immediate factor responsible for the present decline of the species (Innes, Hay, Flux, Bradfield, Speed, and Jansen, 1999). The total number of years for which there is control of pests was found to be the key factor in determining population size of the Kokako (Basse, Flux, and Innes, 2003). Innes *et al.* (1999) note that there is potential for adaptive management strategies in most species programmes. Research into the control of stoats as part of the Mohua programme has been used to benefit threatened species such as the Kaka (*Nestor meridionalis*) (C. O'Donnell and J. Lyall, personal communication, March 20, 2003).

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[1] The first set of factors is the number of years the beech forest mast seeds followed by a stoat irruption, the success of stoat control, and the number of Mohua populations for which stoat control is carried out. Stoat control is carried out for eight out of about thirty populations, and if successful then only about twenty percent of nests are lost in a stoat irruption year. The second set is the number of winters following a beech mast that are mild enough for ship rats to persist, the ability of managers to predict such winters, and the success of rat control. Beech masts and mild winters seem to occur together about one in every four beech mast events and they cause the population to decline by about sixty percent. The results are also dependent upon the number of Mohua populations established on suitable offshore islands, and the ability of managers to keep these islands free of predators.

[2] Adaptive management is based on the proposition that management involves a continual learning process that cannot be easily separated into functions, such as research, and may never have full knowledge and optimal productivity (Walters, 1986: 8).

6.2.2 The specific costs of threatened species programmes

Null hypothesis: The costs of threatened species programmes are the same for all threatened species.

Theoretical pattern: The costs of threatened species programmes are specific for most threatened species.

The six reasons outlined in the previous section mean that the results are subject to uncertainty but they also underline the central point that the costs are not the same for all threatened species programmes. Each of the eleven threatened species programmes has a specific PV of total annual costs from 2003 until 2012, which matches the expected theoretical pattern (Figure 1). The results show that the variations in the costs of programmes are marked: the PV of total annual costs increases at a rate indicated by the power trendline from almost $12,000 for the Stephens Island Ground Beetle to over $9 million for the North Island Kokako. The rate of increase in the PV of total annual costs means that there are more programmes that have lower costs and a few programmes that have higher costs over the timeframe. This is also reflected in the difference between the median PV of total annual cost of just over $1.6 million and the mean PV of total annual cost of around $3 million.

As well as the eleven threatened species programmes having specific PV of total annual costs, all eighteen species programmes also have specific PV of total expenditures up to and including 2002. The results do not, however, discount the possibility that complementary programmes for closely related threatened species

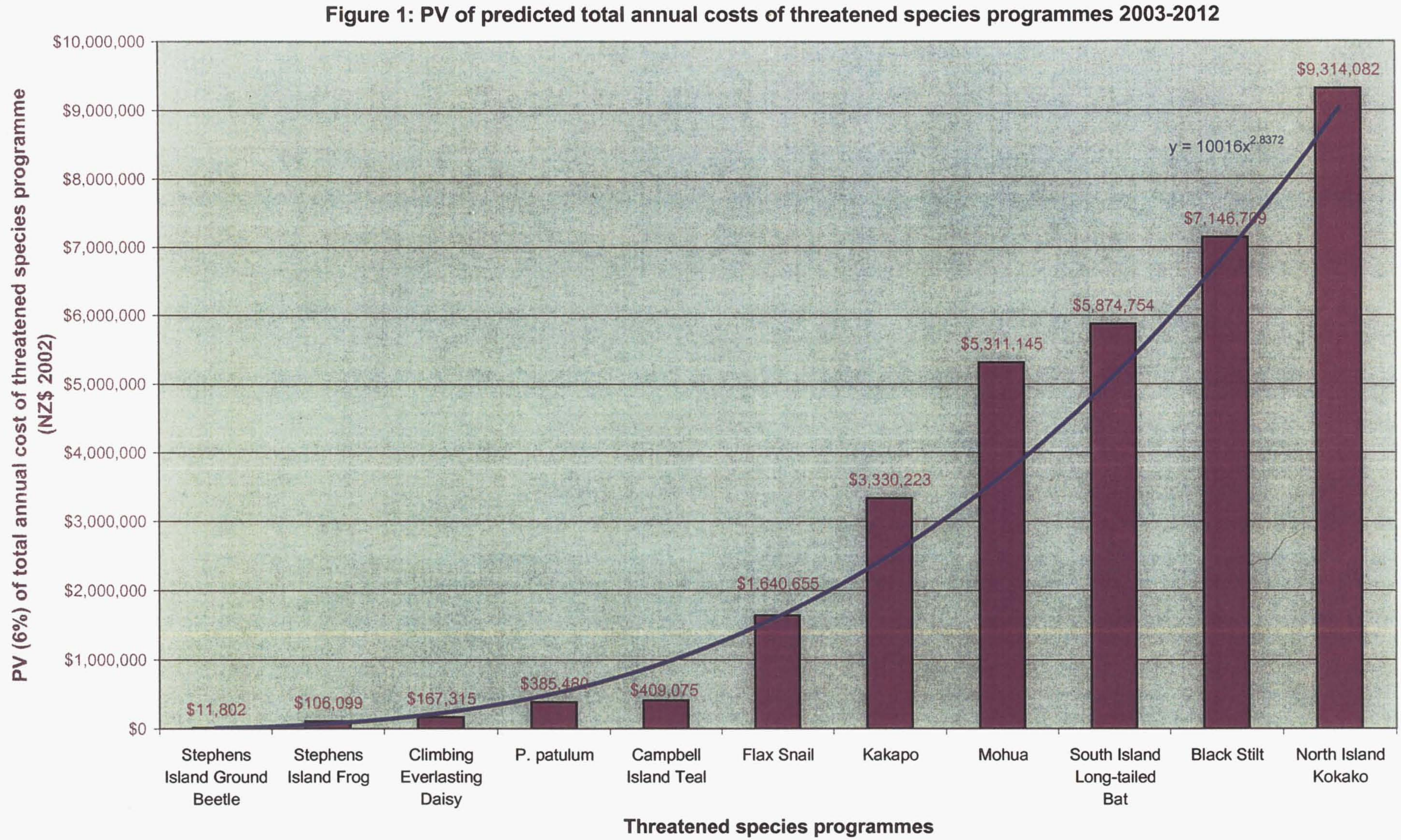
Figure 1: PV of predicted total annual costs of threatened species programmes 2003-2012
PV (6%) of total annual cost of threatened species programme (NZ$ 2002)
$10,000,000
$9,000,000
$8,000,000
$7,000,000
$6,000,000
$5,000,000
$4,000,000
$3,000,000
$2,000,000
$1,000,000
$0
$11,802
$106,099
$167,315
$385,480
$409,075
$1,640,655
$3,330,223
$5,311,145
$5,874,754
$7,146,709
$9,314,082
y = 10016x^2.8372
Stephens Island Ground Beetle
Stephens Island Frog
Climbing Everlasting Daisy
P. patulum
Campbell Island Teal
Flax Snail
Kakapo
Mohua
South Island Long-tailed Bat
Black Stilt
North Island Kokako
Threatened species programmes

may have similar costs. For example, expenditure data was provided for the Otago and Grand skinks together because they have almost the same distribution, similar habitats, and appear to face the same threats (TSU, 1995). On this basis, therefore, the null hypothesis is rejected and the five alternative hypotheses are tested in the following three sections to identify factors that determine the annual and total costs of programmes. The uncertainty of the results could be addressed in further research by the use of a more accurate funding model (A. Roberts, personal communication, February 28, 2003).

6.3 The annual costs of threatened species programmes

6.3.1 The PV of total annual costs by objective

The PV of predicted total annual costs of a threatened species programme from 2003 until 2012 are derived from estimates of the annual costs of the actions that need to be taken to achieve the set of individual objectives developed for a species. The workplan of actions represents the Recovery Group's production decision for a threatened species programme. The predicted cost of a programme is, therefore, dependent upon both the set of objectives developed for a species and the estimated costs of achieving those objectives for the species in question. The structure of the costs of the eleven threatened species programmes provides a starting point for testing the alternative hypotheses. The individual objectives for the eleven programmes are categorised as follows: advocacy and/or public education, research, survey and

monitoring, translocation, habitat restoration, protection from threats, control of threats, breeding programme in the wild, and breeding programme in captivity.

The types of objectives can be characterised as either allocations of base resources or management services to a threatened species that were discussed in Chapter Three. Habitat restoration and translocation indicates the supply of additional base resources to a species. The remaining types of objectives indicate services for the management of either indirect or direct threats and their characterisation depends upon the type of threat facing a species. For example, if the threat being controlled is a predator then the objective indicates services for the management of direct threats, but if the threat is a competitor then this points towards services for managing indirect threats. Advocacy and education, research, and surveying and monitoring objectives point towards the creation of a management regime for a threatened species. Using the typology, the PV of the predicted total annual costs is displayed by objective (Figure 2) and the PV of the estimated cost of the objectives is presented as a percentage of the PV of predicted total annual cost (Figure 3).

The results show that the three most common objectives for which there are recorded costs from 2003 until 2012 are survey and monitoring, research, and translocation. All of the non-bird species programmes have survey and monitoring costs except for the programme for the Stephens Island Ground Beetle. The Mohua, Black Stilt, and North Island Kokako programmes have survey and monitoring costs, but only the Mohua and the Black Stilt programmes have significant research costs[3]. The costs for survey

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[3] The cost of research for the Kakapo programme has a PV NZ$38,334, or about one percent of the programme's PV of total annual costs from 2003 until 2012.

Figure 2: PV of predicted total annual costs of programmes by objective 2003-2012

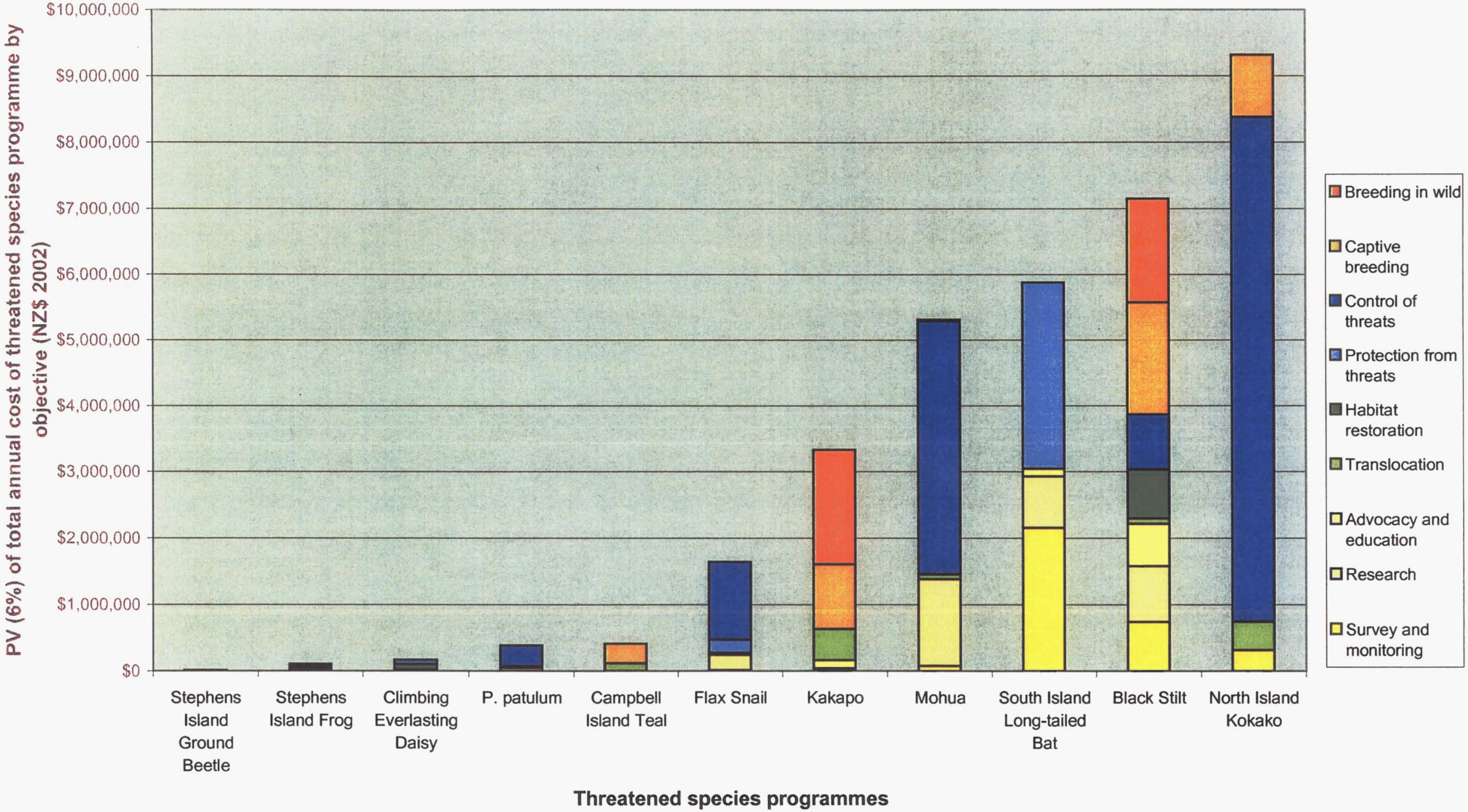
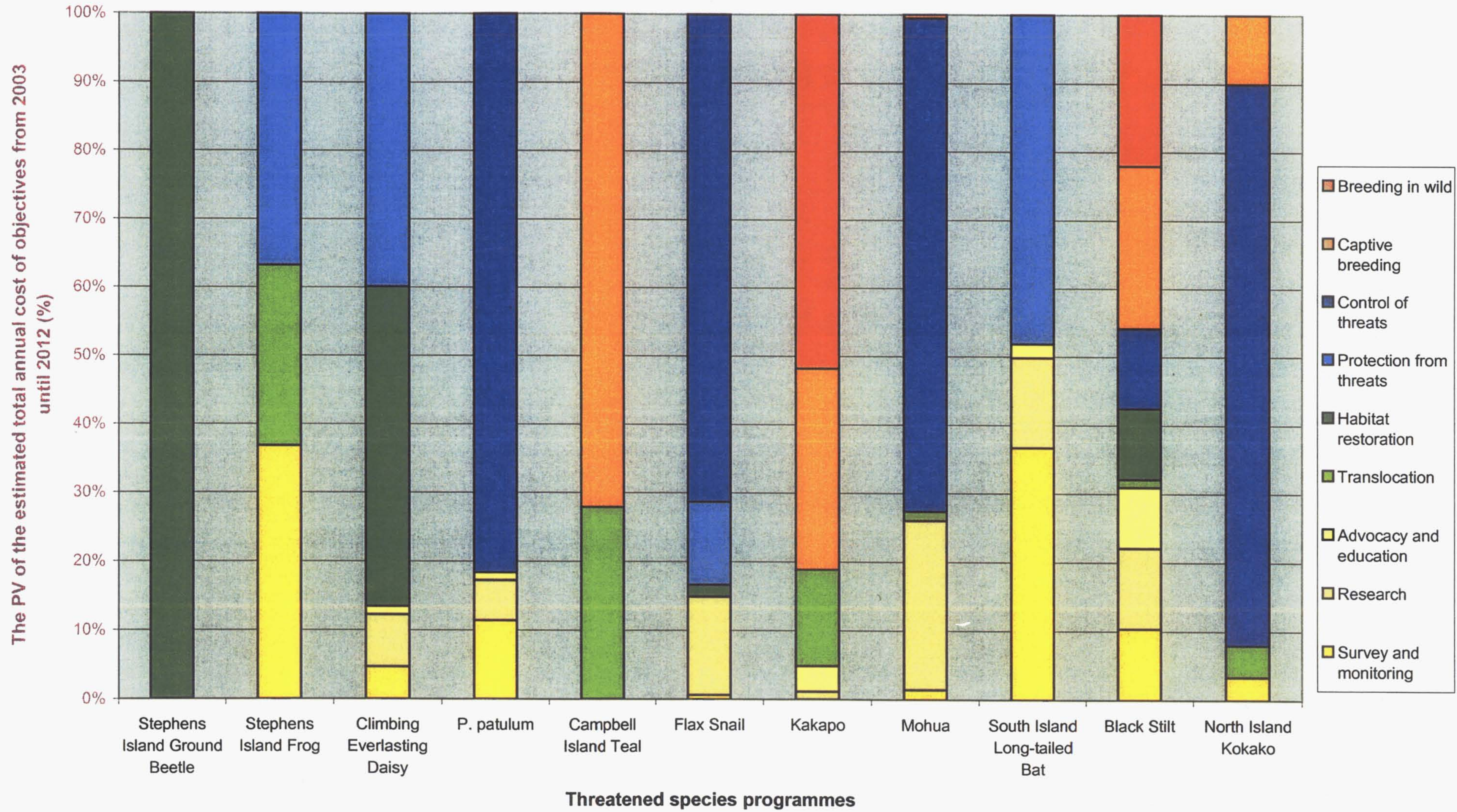


Figure 3: PV of the estimated cost of objectives as a percentage of the PV of predicted total annual costs 2003-2012



and monitoring, and research for the South Island Long-tailed Bat, Mohua, Black Stilt[4] and Stephens Island Frog account for over twenty percent of the PV of total annual cost of each programme. The Stephens Island Frog programme and all five bird programmes have costs for translocation[5], ranging from a PV of $28,082 for the Stephens Island Frog to a PV of $466,679 for the Kakapo. The costs for advocacy and/or public education range from a PV of $2,016, for the Climbing Everlasting Daisy to a PV of $633,249 for the Black Stilt, and are less than ten percent of any programme's PV of total annual cost.

The costs for survey and monitoring and research objectives appear to be affected by the level of existing knowledge about a species. The Kakapo programme had a PV of total annual expenditure[6] of $7,837,244 from 1989 to 2002 and it has a PV of total annual cost of $3,330,233 from 2003 until 2012, of which one percent is for survey and monitoring, or research objectives. By comparison, the South Island Long-tailed Bat programme has a PV of total annual expenditure of $367,723 from 1995 until 2002 and has a predicted PV of total annual cost of $5,874,753 from 2003 until 2012, of which fifty percent is for survey and monitoring, and research. The conservation status of the South Island Long-tailed Bat is unlikely to improve through management until those objectives are accomplished (J. Lyall, personal communication, July 2002).

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[4] The annual costs for the Black Stilt programme were estimated by aim and not by objective, and so the PV of the predicted total annual cost of achieving each aim is divided equally between the objectives under that aim.

[5] Translocation means to establish additional populations of a species at alternative sites.

In total, the lowest cost objective over all eleven threatened species programmes is habitat restoration. Much of the costs for habitat restoration for threatened species may, however, be hidden in Output Class D4: Management Services: Conservation Estate. The programme for the Stephens Island Ground Beetle has only a cost for habitat restoration, which focuses on the placement of recycled fence posts as refugia[7]. The intensive management objectives are the highest cost: the control of threats, and breeding programmes in the wild, followed by breeding in captivity and then protection from threats. Over seventy percent of the PV of total annual cost for *P. patulum*, the Flax Snail, Mohua and North Island Kokako are for the control of threats. Part of the costs for the control of pests, however, may also be hidden in Output Class D4.

With the exception of the Stephens Island Ground Beetle programme, the programmes can be divided into those for non-bird species, which have costs for managing threats, and those for bird species, which have costs for breeding programmes[8] either in addition to or instead of costs for the management of threats. The Stephens Island Frog, Climbing Everlasting Daisy, and the South Island Long-tailed Bat have costs for protection from threats, *P. patulum* has a cost for the control of threats, and the Flax Snail has costs for both types of objectives. The five bird species have costs for captive breeding programmes, and the Black Stilt and the

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[6] Unlike many other threatened species programmes, the Kakapo programme has 100 percent of its annual cost funded, which means that expenditure is equal to cost.

[7] The cost of the placement of fence posts is minimal because the fences were being removed as part of the management of Stephens Island (C. McGuinness, personal communication, September 2002).

[8] Although none of the other species studied have formal breeding programmes, such programmes are not exclusive to bird species. For example, the Tuatara and the Mercury Island Tusked Weta both have breeding programmes involving external organisations.

Kakapo also have costs for breeding programmes in the wild. Together, the mean PV of total annual cost of breeding programmes is of $2,078,565, but this ranges from $28,852 for the Mohua to $6,430,886 for the Black Stilt. The cost for the Black Stilt programme is a "best case scenario", focusing on providing three new aviaries for the captive breeding programme and an extensive predator control regime (A. Grant, personal communication, July 2002). For the Mohua, the Black Stilt, and the North Island Kokako, the costs for breeding programmes are in addition to costs of controlling threats.

The cost structure for the eleven threatened species programmes raises three points to consider in testing the five alternative hypotheses. First, most programmes have costs for the creation of a management regime, such as survey and monitoring or research, but these costs appear to be affected by the level of existing knowledge about the species. Second, the costs of habitat restoration and the control of threats may not have been fully reported because the Recovery Group Leader Survey was limited to Output Class D4: Management Services: Protected Species and Island Habitats. Third, intensive management objectives, such as control of threats and breeding programmes, are comparatively high cost and may more commonly be developed for bird species. The level of existing knowledge and intensive management may be two factors that determine the costs of threatened species programmes for further research.

6.3.2 The habitat area required for the management of a species

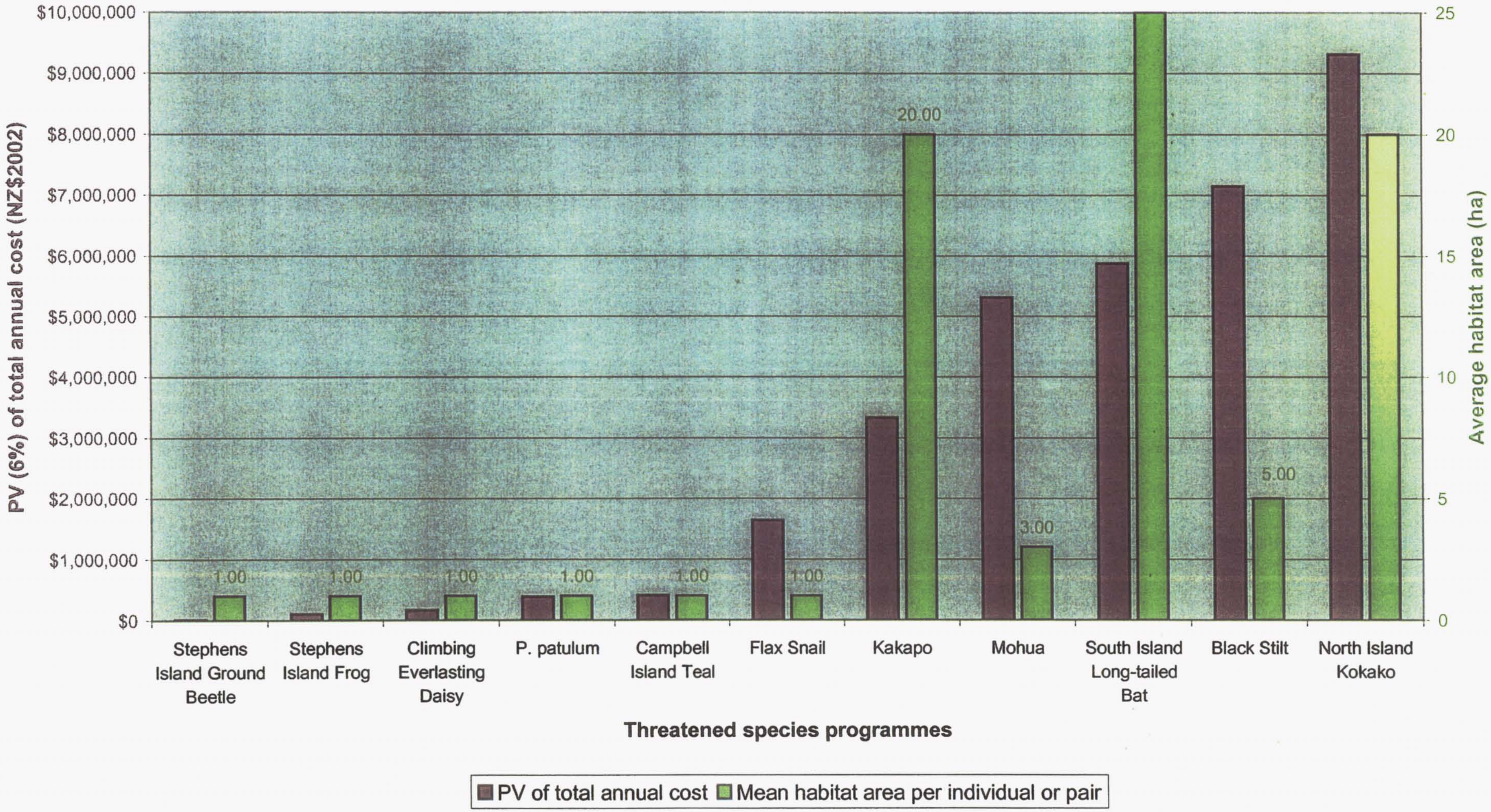
Hypothesis: The annual costs of a threatened species programme are positively related to the area of habitat required for the management of the species.

Theoretical pattern: The annual costs of threatened species programmes that require large areas of habitat for the management of a species are higher than the annual costs for programmes that need smaller areas of habitat.

New Zealand's existing system of national parks and reserves means that the cost of habitat acquisition was not included in the estimates of the annual costs of threatened species programmes. The area of habitat, therefore, can only determine annual costs by influencing the costs of managing threats that cause either the degradation of a species' habitat or the direct mortality of individuals of a species, but all of these costs may not be included in the results. The results show, however, that the habitat area required for the management of a species still appears to be a key factor in determining the PV of total annual costs of the eleven threatened species programmes from 2003 until 2012 (Figure 4), which matches the theoretical pattern.

All of the programmes for species that require a mean habitat area of less than or equal to one hectare per individual or pair of individuals have a PV of total annual cost of less than $500,000 from 2003 until 2012, except for the Flax Snail programme. In contrast, the PV of total annual costs of the bird species programmes, , progressively increase as the mean habitat area increases, with the exception of the Kakapo programme. The mean habitat area per individual required for the management of the North Island Kokako is shaded from dark to light because it varies from between five and twenty hectares depending upon the site. The mean area of habitat required for the management of the South Island Long-tailed Bat is unknown because the species is difficult to observe, but it has a large range in comparison with

Figure 4: PV of predicted total annual costs and mean habitat area required for management of individual or pair



other species[9]. This is also the case with the Mercury Island Tusked Weta, which is a ground dweller. The results for the Flax Snail, the Kakapo and the South Island Long-tailed Bat indicate that additional key factors, such as K-selection, or the level of existing knowledge about a species, may also be significant in determining the annual costs of these programmes. They also, however, indicate problems with mean habitat area as a measure of area of habitat used in determining programme cost.

Three problems became evident with mean habitat area during the collection of data: the measure implicitly assumed that the area of habitat is within a larger reserve, that a species is territorial, and that a species has a reasonably constant range. The measure did not take into consideration any differences in the habitat area arising from colonial species, the foraging ranges of a species, or the quantity and quality of habitat at a site. Mean habitat area may overstate habitat area for a colonial species, such as the South Island Long-Tailed Bat, because areas for individuals will overlap. It may also understate the area of habitat if a site is a fragment. For example, an individual Stephens Island Ground Beetle can be supported by about five square metres but if a site is less than one hectare then it is unsuitable as habitat (C. McGuinness, personal communication, September 16, 2002). Similarly, an individual *P. patulum* or Climbing Everlasting Daisy needs a minimum habitat area of one hectare but as a species in the landscape they require hundreds of hectares of habitat (N. Head, personal communication, February 25, 2003)[10].

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[9] A colony of South Island Long-tailed Bats in the Eglington Valley ranges over 11,700 hectares but the foraging ranges of individuals vary depending on the age and sex of the bats (J. Lyall, personal communication, December 19, 2002).

[10] Many plant populations are not viable because of the small size and fragmentation of habitat (N. Head, personal communication, February 25, 2003). For example, a population of about eighty *Olearia*

As well, mean habitat area may not accurately reflect habitat area if a species has a comparatively large foraging range. The mean habitat area reported for the Campbell Island Teal is $200m^2$ per breeding pair and does not take into account the large foraging range of the species (P. McClelland, personal communication, September 17, 2002). The roosting and breeding sites for the South Island Long-tailed Bat are known to be small but an individual can range up to fifty-six square kilometres to forage (C. O'Donnell and J. Lyall, personal communication, March 20, 2003). The effect of differences in a species' breeding and foraging ranges on the annual costs of programmes may, however, depend upon whether the species tends to forage on land or out to sea. The breeding and foraging ranges of the South Island Long-tailed Bat appear to be similar to the Yellow-eyed Penguin (C. O'Donnell and J. Lyall, personal communication, March 20, 2003) but further research may show that the Yellow-eyed Penguin programme has a lower cost because its foraging range is marine.

The distribution of sites where populations occur and the total area of habitat being managed at any one site may affect the significance of habitat area as a factor in determining the annual costs of a species programme. A programme's annual costs may increase if populations occur at widely distributed sites, rather than within a particular geographic region, because there is less potential for economies of scale. All eleven threatened species, however, are now restricted to only one or two key conservancies, except for the North Island Kokako, which occurs at sites throughout the North Island, and the Mohua and the South Island Long-tailed Bat, which are both

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hectorii exists in around 0.25 of a hectare of habitat but this area is not large enough to support the required ecosystem processes, such as disturbance needed for recruitment, and so the population will become locally extinct. (N. Head, personal communication, February 25, 2003).

found throughout the South Island of New Zealand. Similarly, a programme's annual costs may decrease as the total area of habitat being managed at a site increases. For *P. patulum*, it is more cost effective to manage an entire site containing a number of discrete populations of the species than it is to manage each population separately (N. Head, personal communication, February 25, 2003)[11].

Based on the results, the hypothesis that the annual costs of a threatened species programme are positively related to the area of habitat required for management of the species is accepted. The results for programmes, such as that for the Kakapo, indicate that additional factors may also be significant. As well, a more encompassing measure of habitat area needs to be developed, such as the minimum area of habitat needed to support a viable population of a species (K. Hughey, personal communication, June 12, 2003). The inclusion of the costs of habitat acquisition and all of the costs for habitat restoration and control of threats may increase the significance of habitat area as a key factor, and these are areas for further research.

6.3.3 The types of threats facing a species

Hypothesis: The annual costs of a threatened species programme are related to the types of threats facing the species.

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[11] The improved health of the ecosystem will also have flow on effects for the species, such as increased opportunities for seedling establishment throughout the site (N. Head, personal communication, February 25, 2003).

Theoretical pattern: The annual costs of programmes for threatened species facing particular types of threats are higher than the annual costs of programmes for species facing other types of threats.

The set of individual objectives developed for the conservation of a threatened species and, therefore, the estimated annual costs of the programme are dependent upon the threats facing a species. As with the set of objectives, the immediate threats known to be facing the eleven species can also be grouped together as follows: loss of habitat[12], predation, competition, small population, natural events (for example, flooding or fire), and disease. Additional types of threats for other species may include disturbance, pollution, over-use, or accidental take[13]. Using the threat typology the results show that, although threats determine a programme's cost, the most immediate threat (Figure 5) and significant cause of decline (Figure 6) do not explain the range of PV of total annual costs across the eleven programmes from 2003 until 2012.

The results show that predation and habitat loss are either one or both of the two most immediate threats and the two most significant causes of decline for each of the eleven threatened species. Other less common threats facing threatened species are the effects of a small population, competition, hybridisation, natural events, disease and

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[12] Habitat loss is in terms of quantity and quality, and includes habitat degradation and fragmentation.

[13] Habitat loss, competition, fragmentation, and pollution can be characterised as indirect threats to a species, and so theoretically require the allocation of additional base resources to a species, either through the supply of habitat or the provision of management services. Predation, over-use, accidental take, and disease are direct threats to a species, therefore in theory requiring the allocation of management services. Natural events may be either an indirect or a direct threat and its characterisation is dependent on the effect of the threat on the species.

Figure 5: PV of predicted total annual costs of programmes and most immediate threat in 2002

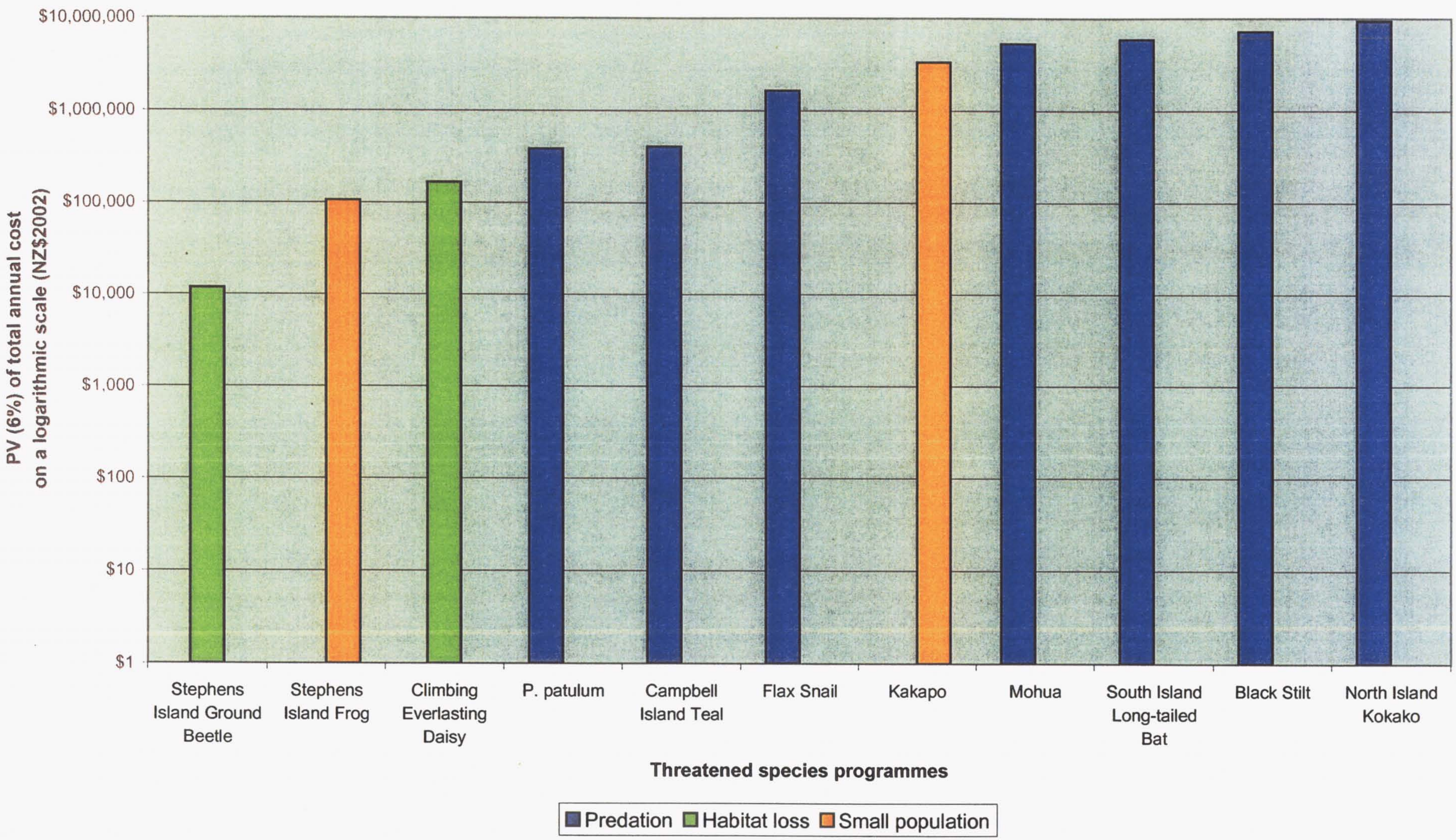
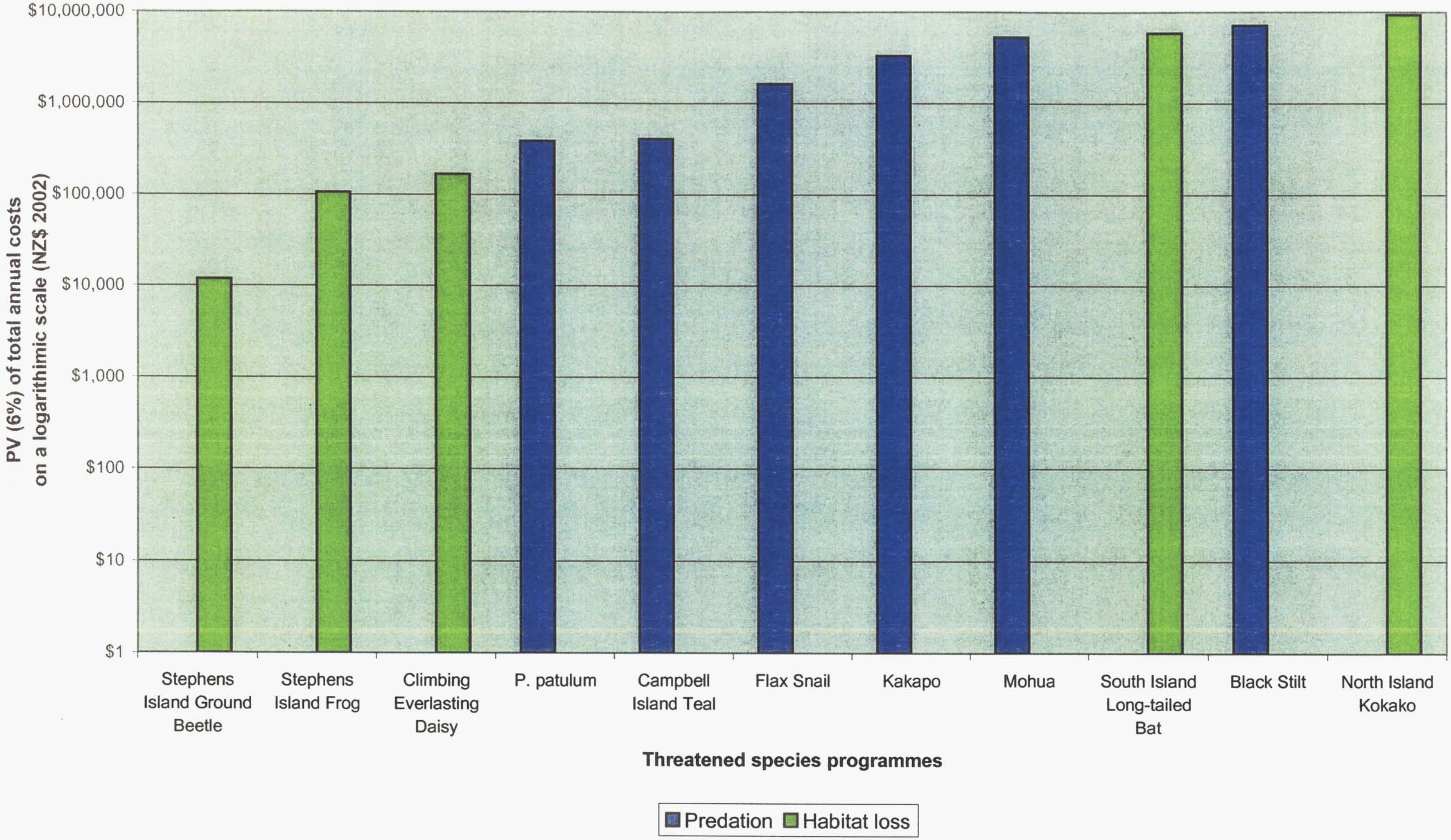


Figure 6: PV of predicted total annual costs of programmes and most significant known cause of decline



pollution. The effects of a small population is the most immediate threat to Stephens Island Frog and the Kakapo but habitat loss and predation are the most significant causes of decline for both species. Those species and the Campbell Island Teal also face the threat of disease, and the South Island Long-tailed Bat is affected by toxins. In addition to habitat loss, the Black Stilt faces the threat of hybridisation with the Pied Stilt (*Himantopus himantopus leucocephalus*), and the Climbing Everlasting Daisy is threatened by fire.

Predation is the most immediate threat for seven of the eleven species, and the second most immediate threat for another three species. The programmes for five of those seven species are the programmes that have the control of threats as an objective. Predation is also the most significant cause of decline for six species, and the second most important cause for another three species. All of the animal species with predation as an immediate threat and a significant cause of decline face a similar suite of introduced mammalian predators, and particularly Australian Brush-tailed Possums (*Trichosurus vulpecula*), Pacific, Norway and Ship Rats (*Rattus exulans; R. norvegicus; R. rattus*), and Stoats (*Mustela ermina*). Similarly, *P. patulum* is threatened by predation through browsing from Brush-tailed Possums and species of deer and goats.

The two species for whom predation is not an immediate threat or significant cause of decline are Stephens Island Ground Beetle and the Climbing-everlasting Daisy. A loss of habitat is the most immediate threat for those species and the second most immediate threat for another three species. The programmes for the Stephens Island Ground Beetle and the Climbing-everlasting Daisy are the programmes that focus on

the restoration of habitat. Habitat loss is also the most significant cause of decline for five species, and the second for another three species. Although the Stephens Island Ground Beetle and the Climbing-everlasting Daisy programmes have low predicted PV of total annual costs, the programmes for the five species for whom habitat loss is the most significant cause of decline have the lowest and the highest predicted PV of total annual costs.

As well as the type of threat, the number of threats facing a species also does not explain the range of the PV of total annual costs. The highest number of recorded threats was for Stephens Island Frog, whose programme is predicted to have a low PV of total annual cost from 2003 until 2012. The threats facing Stephens Island Frog included invasive alien species, predators, pathogens/parasites, natural disasters, drought, temperature extremes, wildfire, changes in native species dynamics, intrinsic factors, limited dispersal, poor recruitment & reproduction, inbreeding, low densities, slow growth rates, population fluctuations, and restricted range. In contrast, two threats were recorded for the South Island Long-tailed Bat and the Black Stilt, and one threat was recorded for the Kakapo, whose programmes are predicted to have high PV of total annual costs.

Although the estimated annual costs are dependent upon the threats facing a species, the results do not match the theoretical pattern. The results are not unexpected, however, for New Zealand species as insufficient and fragmented habitat and introduced invasive species are the main threats to native species on land identified in the NZBS (DoC and MfE, 2000). Based on the results, the hypothesis that the annual costs of a threatened species programme are related to the types of threats facing a

species is rejected for terrestrial threatened species in New Zealand. It may, however, provide an explanation for differences that may exist between the costs of those programmes and the costs of programmes for other species. In the next section, two alternative hypotheses are tested to identify possible underlying explanatory factors for both the annual costs and total costs of threatened species programmes, which are to be considered in the following section (Section 6.5).

6.4 The mean cost of improving a species' conservation status

6.4.1 The PV of total annual costs per conservation status unit

The total annual costs of the eleven threatened species programmes from 2003 until 2012 provide a picture of the funding that is needed in the short-term, but they give no indication of the total cost of a programme. As the task of estimating costs is subject to uncertainty and the objectives for a species are usually developed for a five to ten-year timeframe, attempts to accurately estimate the annual costs of the programmes beyond 2012 may be unrealistic. An alternative approach is to calculate the mean cost of improving a species' conservation status by one unit from 2003 until 2012 by dividing the PV of total annual costs of each programme by the PV of improvements in the conservation status of the species. This approach indicates how costly it will be to recover a threatened species and it includes any improvements in a species' conservation status that may occur without the programme. It is used in considering a species' taxon and its K-selection within each taxon as underlying explanatory factors for a programme's annual and total costs.

The approach measures the programmes' mean cost of a one-unit improvement in the conservation status of a species but, as can be seen with the South Island Long-tailed Bat programme, many objectives do not in themselves necessarily bring about any improvement, even though they are essential for its management. The intermediate outputs of a threatened species programme, such as research, have an instrumental value for the species in question[14]. Expenditure on the preparation of a recovery plan for the Climbing Everlasting Daisy did not improve the species' conservation status because no extra funding was received for actions to achieve the plan's objectives (N. Head, personal communication, September 19, 2002). Similarly, one year's biodiversity funding for *P. patulum* enabled a full survey of historical sites to determine the best example of habitat for protection but it did not allow for any mitigation of threats (N. Head, personal communication, September 12, 2002).

6.4.2 A species' taxon

Hypothesis: The annual and total costs of a threatened species programme are related to the species' taxon.

Theoretical pattern: The annual and total costs of programmes for threatened bird or mammal species are higher or will be higher than the costs of programmes for reptile, amphibian, invertebrate, or plant species.

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[14] Instrumental value is the value of an object or an action in serving as a means to accomplish a goal which has intrinsic or inherent value (Armstrong and Botzler, 1993: 53)

The results show that the PV of total annual cost for a one-unit improvement in a species conservation status for the eleven threatened species programmes appear to be related to a species' taxon (Figure 7) and the results match the expected theoretical pattern. The mean cost alters the positions of four of the threatened species programmes from their order by total annual cost. The Stephens Island Frog, the Kakapo, and possibly the South Island Long-tailed Bat programmes have higher total annual costs per conservation status unit when compared to other programmes, and the North Island Kokako programme's cost per conservation status unit is comparatively lower. The result for the South Island Long-tailed Bat programme is uncertain because the species is not expected to improve its conservation status over the next ten years even if funding equals 100 percent of annual cost.

The PV of total annual costs per conservation status unit for the plant and invertebrate programmes, except for the programme for the Flax Snail, is lower than for any of the amphibian, mammal or bird species. The mean cost of the Flax Snail programme may be subject to more uncertainty than that for the other programmes because the Flax Snail is the only species of Northern giant land snails that is being actively managed by DoC (A. Booth, personal communication, September 10, 2002). The annual costs for the Flax Snail programme may also be somewhat overstated because they are estimated for all of the 'Endangered' and 'Critically Endangered' sub-species[15], but the conservation status of the species is only assessed for the twelve Critically Endangered sub-species (A. Booth, personal communication, September 10, 2002).

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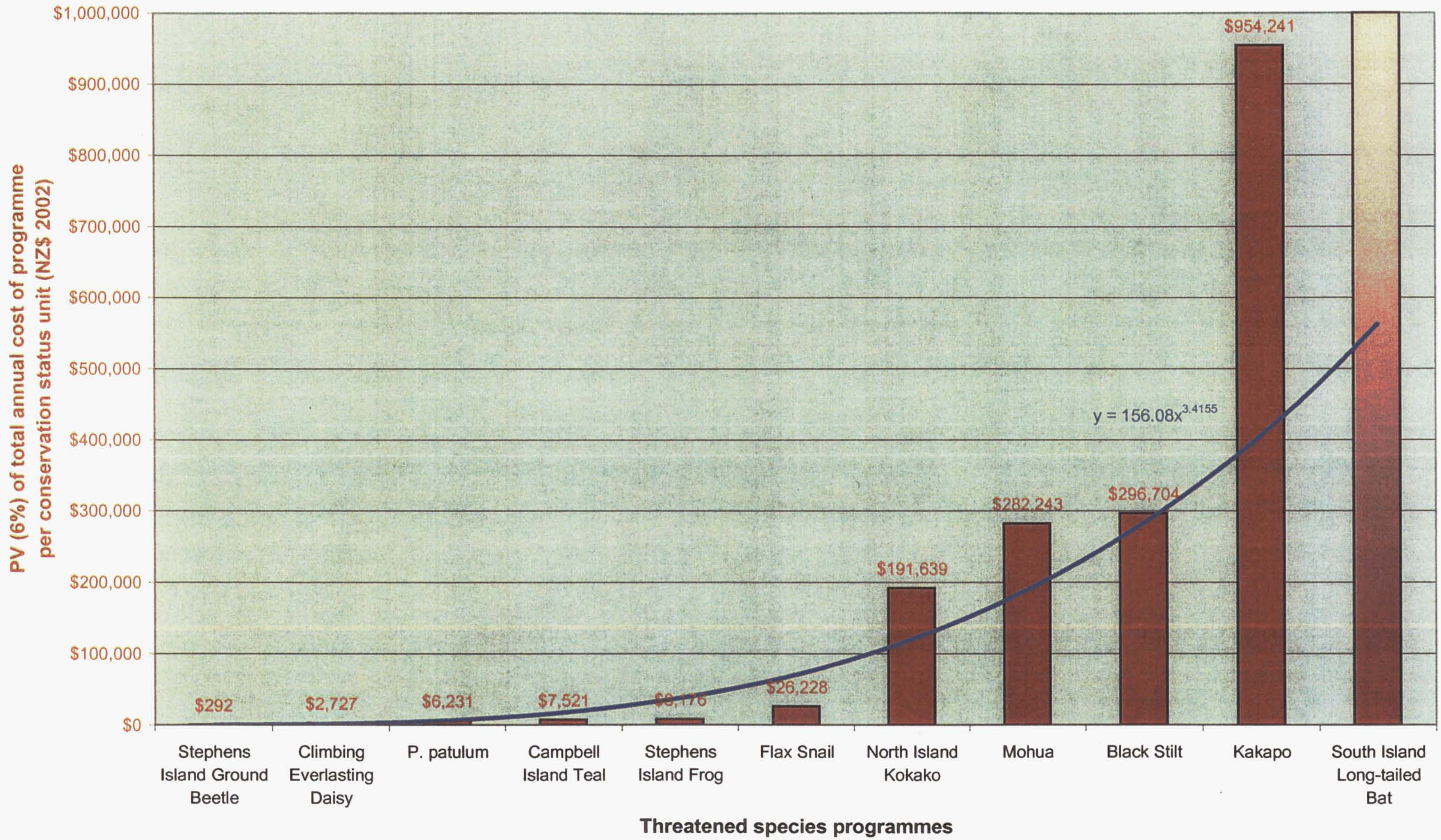
[15] A total of eighteen populations, some of which are undescribed.

Figure 7: PV of predicted total annual cost of threatened species programmes per conservation status unit 2003-2012



The Stephens Island Frog programme has a similar PV of total annual costs per conservation status unit to the four plant and invertebrate species. If expenditure data is used to indicate the region of costs for a programme then reptiles may have a higher PV of total cost per unit than invertebrate and plant species. The Chevron skink programme had a PV of total annual expenditure from 1996 until 2001 of almost $300,000 but no improvement in its conservation status. The Otago and Grand Skinks programme had a PV of total annual expenditure of over $1.8 million from 1992 until 2002, even though the conservation status of the species continued to decline. In contrast, the Brothers Island Tuatara, which is a member of the same subclass as the skink species, had a PV of total annual expenditure of just over $54,000 from 1990 until 2002, and a small improvement in its conservation status[16].

The Campbell Island Teal programme has significantly lower PV of total annual cost per conservation status unit than the other four bird programmes. The programme's annual costs may stop after 2006 if it is fully funded and, as already noted, much of the actual costs of the programme are hidden. The cost of feeding for the captive breeding programme is included in the overheads for the Mt Bruce National Wildlife Centre, and the cost of maintaining wild populations is covered by the Southland Conservancy's quarantine budget (P. McClelland, personal communication, September 17, 2002). The PV of total annual costs per conservation status unit for the other four bird programmes is higher than for any species except for possibly the South Island Long-tailed Bat. Bats are the only land mammal species native to New Zealand and their management is expected to be effective at the sites that are

[16] The Tuatara's PV of total annual expenditure per conservation status unit over this timeframe was about NZ$13,000.

managed, which is similar to the management of forest bird species, such as the Mohua and the Kokako (J. Lyall, personal communication, December 2002).

Observations from the Recovery Group Leader Survey suggest that patterns of expenditure or expectations of funding for different taxa could influence the estimates of annual costs, and possibly the development of objectives, and these may be other factors for further research. Based on the results, the hypothesis that the annual and total costs of a threatened species programme are related to the species' taxon is accepted. As with habitat area, the results for some programmes indicate that additional factors may also be significant. For example, the programme for the Campbell Island Teal may have a low PV of total annual cost per conservation status unit because the level of existing knowledge about the species may be high or the species is less K-selected in comparison to the other bird species.

6.4.3 A species' K-selection within each taxon

Hypothesis: Within each taxon, the annual and total costs of a threatened species programme are positively related to the degree to which a species is K-selected.

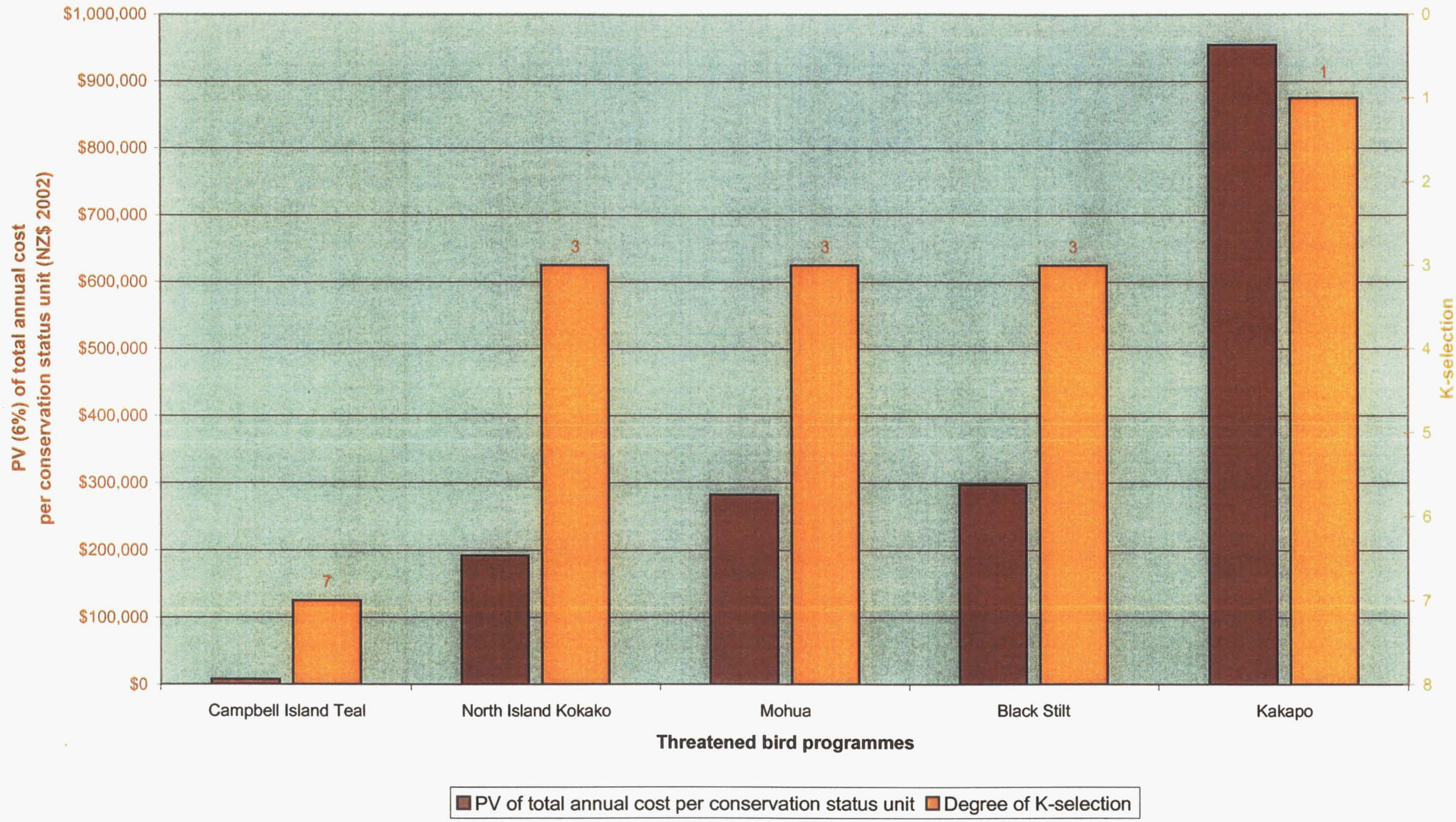
Theoretical pattern: Within each taxon, the annual and total costs of programmes for threatened species that are extremely K-selected are higher than the costs of programmes for species that are less K-selected.

In a theoretical assessment of the ability of bird species to recover from a reduction in numbers, Spurr (1979) argued that a species' ability to recover can be predicted by

considering its capacity for reproduction and dispersal. He suggested that a species with low reproduction and poor dispersal has a high risk of not recovering; a species with either low reproduction or poor dispersal has a medium risk; and a species with good reproduction and dispersal capacities has a low risk of non-recovery. Spurr identified the Kakapo, the Mohua, and the North Island Kokako as being amongst species with low reproduction and poor dispersal, and so have a high risk of not recovering after being heavily reduced. In this research, a species' K-selection, or the evolutionary selection of traits such as slower development, large body size and low birth rates, within each taxa is considered as an underlying explanatory factor for a programme's cost. The limited number of programmes for which cost data was available, however, means that K-selection can only be considered as a factor in determining the costs of programmes for bird species.

The results for the five bird programmes point towards a species' K-selection possibly being an explanatory factor in the PV of total annual costs per conservation status unit (Figure 8), which matches the expected theoretical pattern. The Kakapo is the most extremely K-selected species, with breeding programmes in the wild and in captivity, and its programme has a high PV of total annual cost per conservation unit. In contrast, the Campbell Island Teal is far less K-selected and its programme has a low PV of total annual cost per conservation unit. The remaining three bird species are more K-selected than the Campbell Island Teal but not as K-selected as the Kakapo or the Black Stilt, which also has breeding programmes in the wild and in captivity. The Black Stilt and the Kakapo may, however, require breeding programmes in the wild and captivity because of their 'Critically Endangered' conservation status. The initial

Figure 8: PV of predicted total annual cost per conservation status unit 2003-2012 and estimated K-selection for threatened bird species



conservation status of a species may affect the level of intensive management as a factor for further research on the costs of threatened species programmes.

The value for a species' K-selection was dependent upon the assessment made by Recovery Group Leaders. Sensitivity analysis showed that, in the case of the five bird species, the use of more pessimistic or optimistic values for K-selection did not change the ordinal ranking of the programmes. As only one taxon could be considered, it is unclear whether to accept or reject the hypothesis that the annual and total costs of a threatened species programme are positively related to a species' K-selection within each taxon. Further research on other taxa needs to use population viability analysis to determine the K-selection of a species (J. Innes, personal communication, March 10, 2003). The next section will illustrate how key factors may determine the total costs of threatened species programmes by influencing the timeframe over which the annual costs of a programme occur.

6.5 The total costs of threatened species programmes

6.5.1 The projected total costs

Key factors that determine the annual costs of a threatened species programme will also determine a programme's total costs. For example, all of the programmes for species that require less than or equal to one hectare of habitat per individual have a PV of total annual cost per conservation status unit of under $30,000. There may be additional key factors, however, that determine the total cost of a programme by

controlling the incidence of annual costs. Although the mean cost of a threatened species programme gives an indication of a programme's total cost, it is not possible to investigate the additional key factors without total cost data. As no DoC recovery group has ever been disbanded (P. Jansen, personal communication, June 3, 2003), there is not yet a total cost for any New Zealand threatened species programme.

Although no total cost data exists, it is possible to calculate the projected total costs of the eleven threatened species programmes from the total annual cost from 2003 until 2012 and the predicted further cost from 2013 onwards. Further cost is predicted from the mean estimated annual cost from 2010 until 2012[17] multiplied by the additional number of years it may take for a species to reach 'Not Threatened'. The number of additional years is derived from the species' probable conservation status in 2012 and its mean annual rate of recovery from 2003 until 2012 if the programme is fully funded. Consequently, the projected total cost of a programme is dependent upon both the estimated annual costs of achieving the objectives developed for a species, the timeframe over which these costs occur, and that the programme is fully funded. The projected total cost is used to illustrate how a species' initial conservation status and its rate of recovery may be additional key factors in determining the total costs of a programme.

The projected total cost does ***not*** forecast the total cost of any threatened species programme because it is based on at least three simplifying assumptions. First, it assumes that the recovery rate of a species is constant, which may not be realistic for

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[17] The estimated annual costs of objectives appear to be constant for all programmes by 2010, and this occurs for many programmes by 2008.

any threatened species. A species' recovery rate is non-linear and it may be able to be described by a biological growth function, which is another area for further research. Second, it assumes that there is no timelag between the timing of annual costs and any subsequent improvement in the conservation status of a species. Active management may be able to be halted before a species reaches 'Not Threatened', which will reduce the total cost of a programme. For example, the estimated annual costs for the Campbell Island Teal could cease after 2006 if the programme is fully funded but the conservation status of the species could improve from 'Serious Decline' to 'Range Restricted' over the following three years.

Third, the projected total cost assumes that a threatened species is able to recover to the point where self-sustaining populations occur throughout its natural range, which may be unrealistic for all species because of permanent loss of habitat and persistent threats from introduced pests. The Kakapo programme's recovery goal in 1989 was to increase its numbers to more than 500 individuals on at least two predator free islands, which was later revised to establishing one unmanaged population in a protected habitat and two or more other populations that may require ongoing management. The total population of the Kakapo in 2002 numbered sixty-two adults and twenty-four chicks located on Codfish and Chalky Islands. Unless a species recovers to 'At Risk' or 'Not Threatened' the costs of a programme are likely to continue. For example, the North Island Kokako will still be management dependent even when it has reached the recovery goal of restoring the total population to around 2,500 by 2020 (J. Hudson, personal communication, September 20, 2002).

6.5.2 A species' initial conservation status and recovery rate

Hypothesis: The total costs of a threatened species programme are related to the species' initial conservation status and its rate of recovery.

Theoretical pattern: The total costs of programmes for species that are more threatened and / or have a low rate of recovery will be higher than the total costs of programmes for species that are less threatened and / or have a higher recovery rate.

The projected total costs of the eleven threatened species programmes shows how a species' initial conservation status and its rate of recovery may be additional key factors in determining the total costs of a programme (Figure 9). All of the eleven threatened species were 'Acutely Threatened'[18] in 2002. The number of years from 2002 that it would theoretically take for each species to improve from either 'Critically Endangered' 'Endangered' or 'Vulnerable' to 'Not Threatened' are recorded above each result. The projected total costs for the Stephens Island Frog, Mohua, Black Stilt and Kakapo are shaded from dark to light to reflect increasing uncertainty in the medium to long-term. The projected total cost of the South Island Long-tailed Bat programme is not presented because the recovery rate of the species from 2003 until 2012 is unknown.

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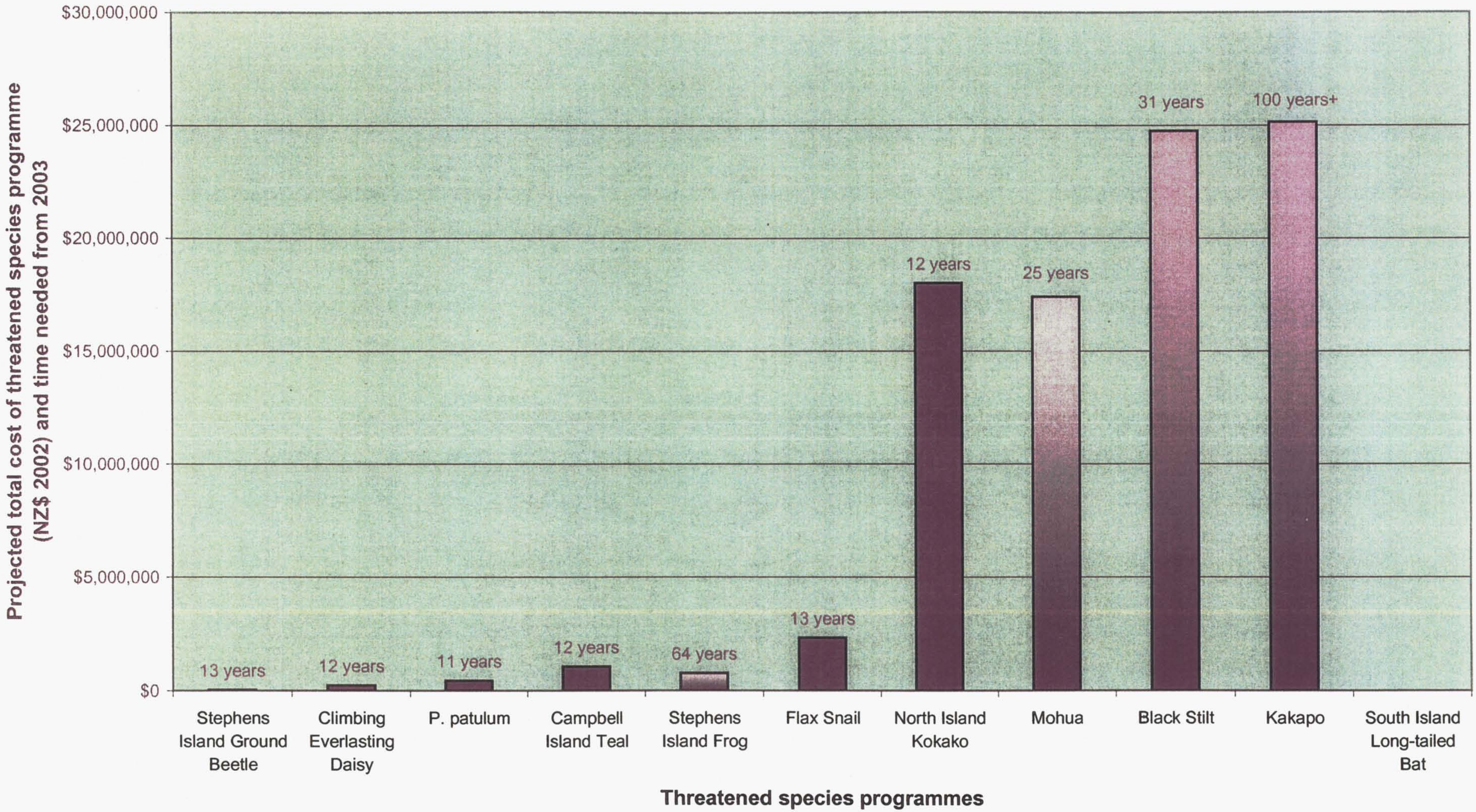
[18] The threat categories in 'Acutely Threatened' are 'Vulnerable', 'Endangered' and 'Critically Endangered' (Molloy *et al.*, 2002: 11).

Figure 9: Projected total costs of threatened species programmes from 2003



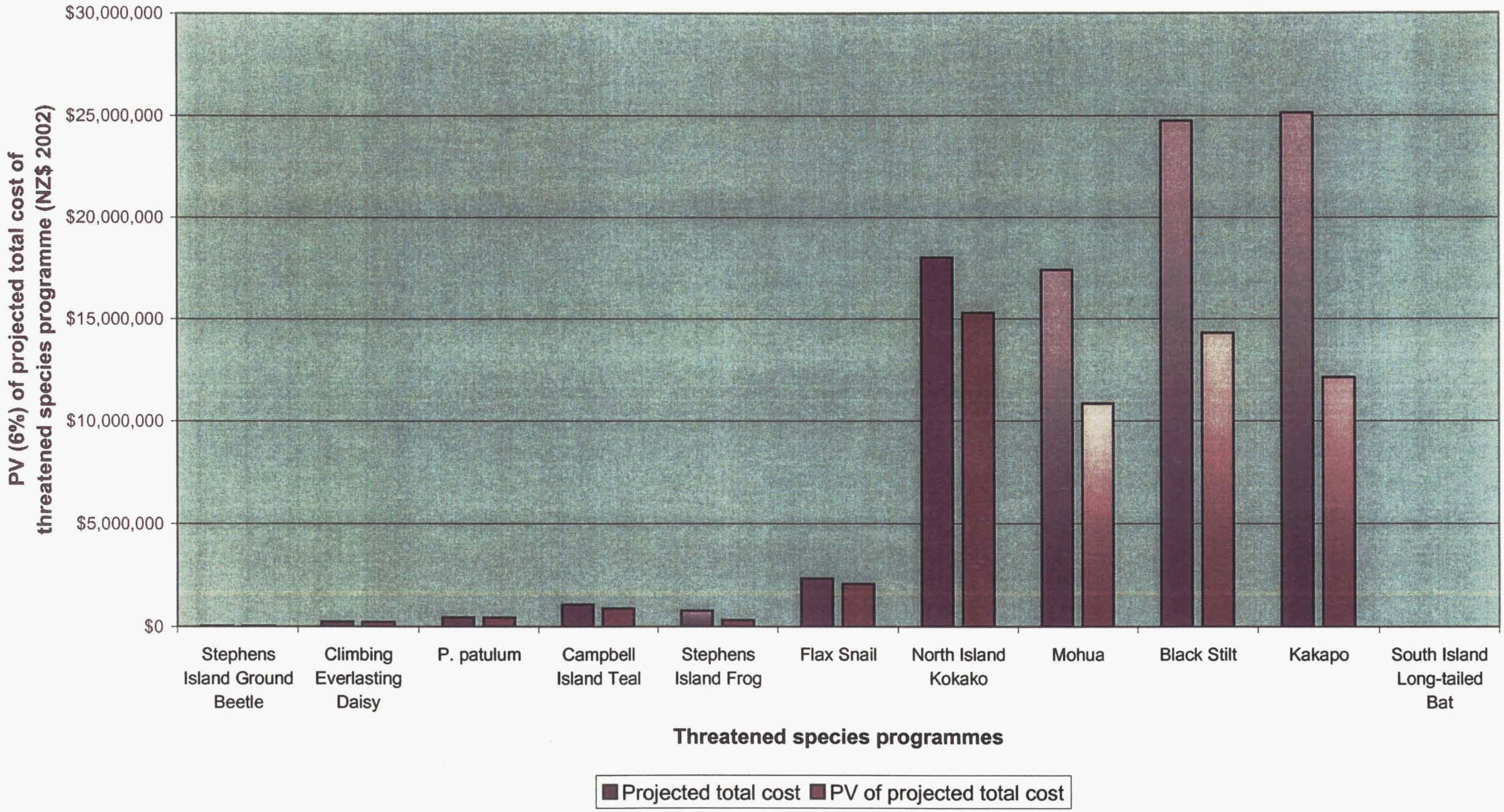
The effect of the timeframe can be seen by comparing the projected total costs for different threatened species programmes. The Stephens Island Frog was more threatened than the Campbell Island Teal and less threatened than the Flax Snail in 2002 but its programme has a similar projected total cost because it has lower estimated annual costs and a lower predicted rate of recovery. The North Island Kokako was more threatened than the Mohua in 2002 but its programme has a similar projected total cost, even though its estimated annual costs are higher, because it has a higher predicted recovery rate. The Black Stilt and the Kakapo were both Critically Endangered in 2002 and have similar projected total costs, even though estimated annual costs for the Black Stilt programme are higher, because the species has a higher predicted rate of recovery than the Kakapo.

6.5.3 The PV of projected total costs

The PV of projected total costs of the eleven threatened species programmes are lower than the programmes' undiscounted projected total costs (Figure 10). The effect of discounting, however, is uneven across the programmes because of differences particularly in the timeframes needed for the conservation of the species. Discounting alters the positions of programmes that may have extremely long timeframes. The PV of projected total cost for the Stephens Island Frog programme is lower than that for the *P. patulum* programme, and the PV of projected total cost for the Mohua, Black Stilt and Kakapo programmes are lower than that for the North Island Kokako programme.

The use of a positive discount rate, therefore, may decrease the significance of a species' initial conservation status and its recovery rate as possible key factors in

Figure 10: Projected total costs of threatened species programmes and the PV of projected total costs using a discount rate of six percent

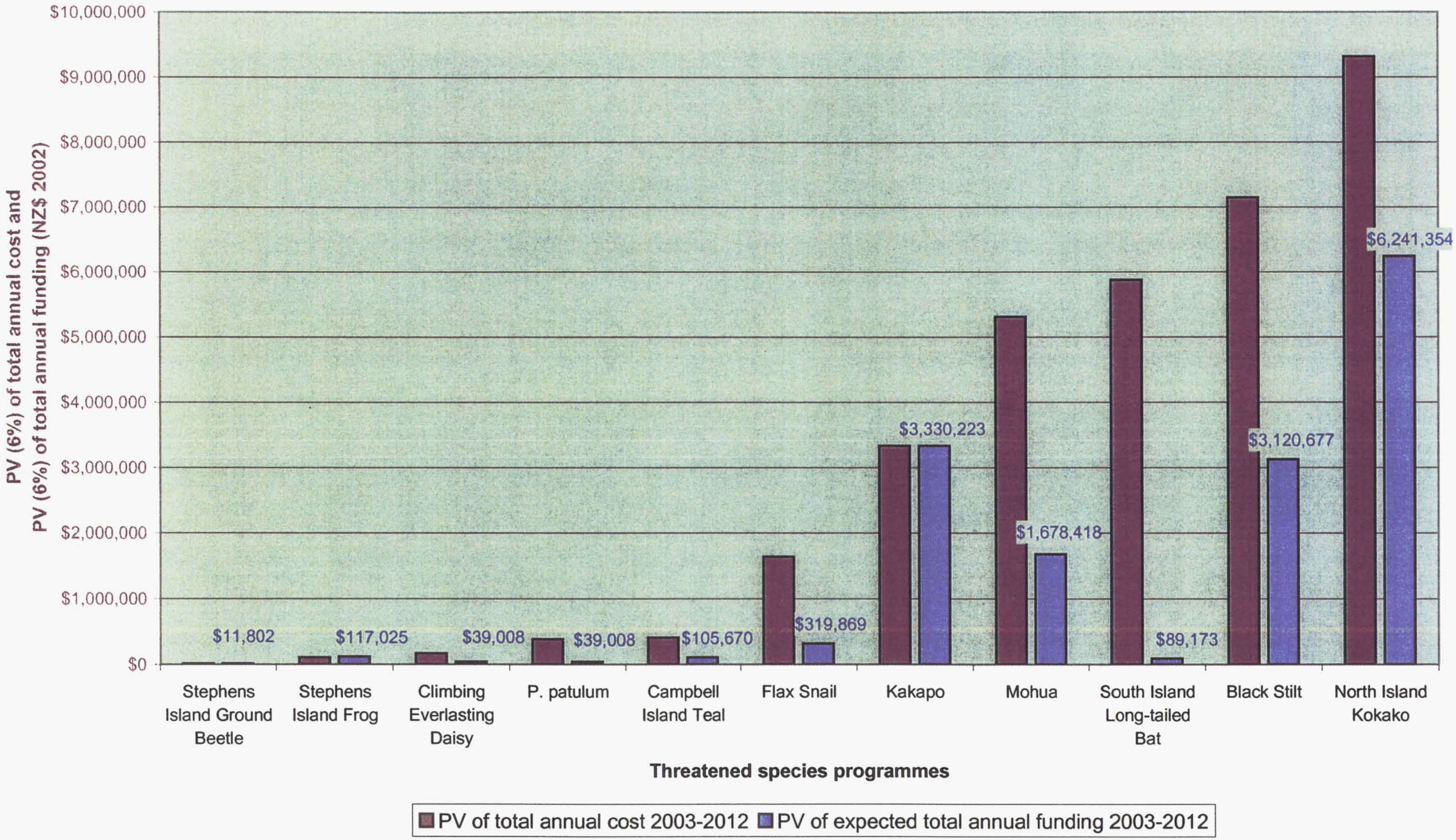


determining the costs of threatened species programmes. How much their significance is reduced is dependent upon the choice of discount rate. Any existing budgets in recovery plans for threatened species either in New Zealand or overseas, however, do not discount the costs of programmes. The hypothesis that the total costs of a threatened species programme are related to the species' initial conservation status and its rate of recovery needs to be investigated in further research when total cost data is available. The next section presents the results of the potential effects of the budget constraint and relaxing the budget constraint on the costs of threatened species programmes.

6.6 The budget constraint

The PV of predicted total annual costs of the eleven threatened species programmes from 2003 until 2012 is NZ$33.7 million, compared to the PV of expected total annual funding of NZ$15.1 million indicates that threatened species conservation in New Zealand will operate under a budget constraint (Figure 11). The evaluation of the budget constraint for the eleven threatened species programmes over the timeframe is the difference between the PV of funding and the PV of cost, or NZ$18.6 million. The budget constraint means that a decision to allocate funding to a threatened species programme will have an opportunity cost in terms of the protection of other species at risk. To identify the opportunity cost, however, it is necessary to prove that an alternative species programme (or programmes) has been denied funding as a direct result of such a decision.

Figure 11: PV of predicted total annual costs and PV of expected total annual funding of threatened species programmes 2003-2012



The results show that the programmes for the Stephens Island Ground Beetle[19], Climbing Everlasting Daisy, *P. Patulum*, Campbell Island Teal, and Flax Snail need comparatively few resources to improve the species' conservation status but are allocated minimal funding, sometimes on an irregular basis, or have to source funding from general budgets. They also show that the programmes for the Mohua, South Island Long-tailed Bat, Black Stilt, and North Island Kokako need comparatively more resources but are only allocated partial funding. In particular, the South Island Long-tailed Bat programme appears to be critically underfunded: it expects to receive 1.5 percent of the cost of achieving the species' objectives. The Stephens Island Frog[20] and the Kakapo programmes are expected to continue to be fully funded.

For the programmes that receive minimal or partial funding, the mean expected funding is equal to twenty-eight percent of costs. As a consequence, the conservation of species may be delayed, which could in turn increase both the risk of further decline, or even extinction, of species and the total cost of the programmes. The issue is similar to that which can exist in the health sector, where under-funding can create waiting lists for treatment that may delay a patient's recovery, and ultimately increase the risk to the well-being of the patient and the total cost of healthcare.

The PV of costs per conservation status unit compared to the PV of funding per conservation status unit indicates that the mean cost of most of the programmes that

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[19] The Stephens Island Ground Beetle programme receives all of the funding that it requires from the general Stephens Island management operating budget (C. McGuinness, personal communication, September 17, 2002

receive minimal or partial funding could be significantly reduced and the conservation of the species hastened if fully funded (Figures 12 and 13). The mean cost of the programmes for the Climbing Everlasting Daisy, *P. Patulum*, North Island Kokako, Mohua and Black Stilt may decrease if the programmes are allocated funding equal to 100 percent of costs. The mean cost of the Campbell Island Teal and Flax Snail programmes may marginally increase if the programmes are fully funded, but the value of a possibly more rapid recovery of the Flax Snail may outweigh the additional cost per conservation status unit for this programme.

The estimated cost of achieving the objectives for each of the programmes in 2003/04 ranges from NZ$5,000 for the Stephens Island Ground Beetle to NZ$1.53 million for the North Island Kokako. Together, the total cost of the eleven programmes is NZ$5.97 million, which is equivalent to 16.7 percent of the expenditure on Output Class D5: Management Services: Protected Species and Island Habitats in 2001/02, which is the latest year for reported expenditure (DoC, 2002). In contrast, the total expected funding for the eleven programmes is NZ$2.86 million, or 8.0 percent of expenditure on Output Class D5 in 2002/02. Overall, the eleven threatened species programmes appear to be allocated about half of the funding that is needed to achieve the species' recovery objectives. Extra funding, over and above the $16.5 million provided as part of the NZBS funding package for mainland habitat restoration and species recovery programmes, is needed to achieve Goal Three in the New Zealand Biodiversity Strategy.

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[20] Expected annual funding is higher than annual cost for the Stephens Island Frog programme because extra funding is to be allocated in case of disease (F. Begley, personal communication, November 7, 2002).

Figure 12: PV of predicted total annual cost per conservation status unit and expected total annual funding per conservation status unit for lower cost programmes 2003-2012

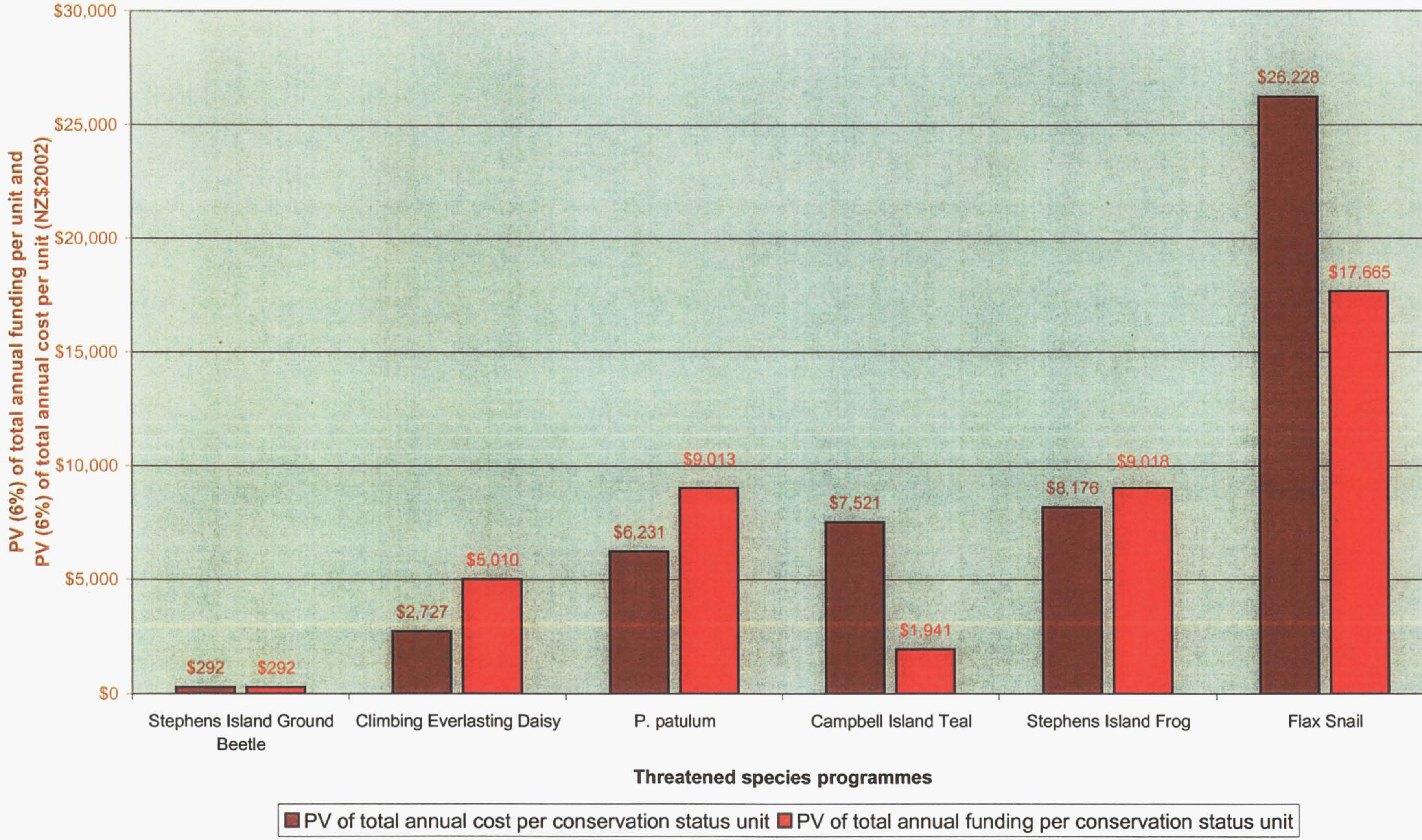
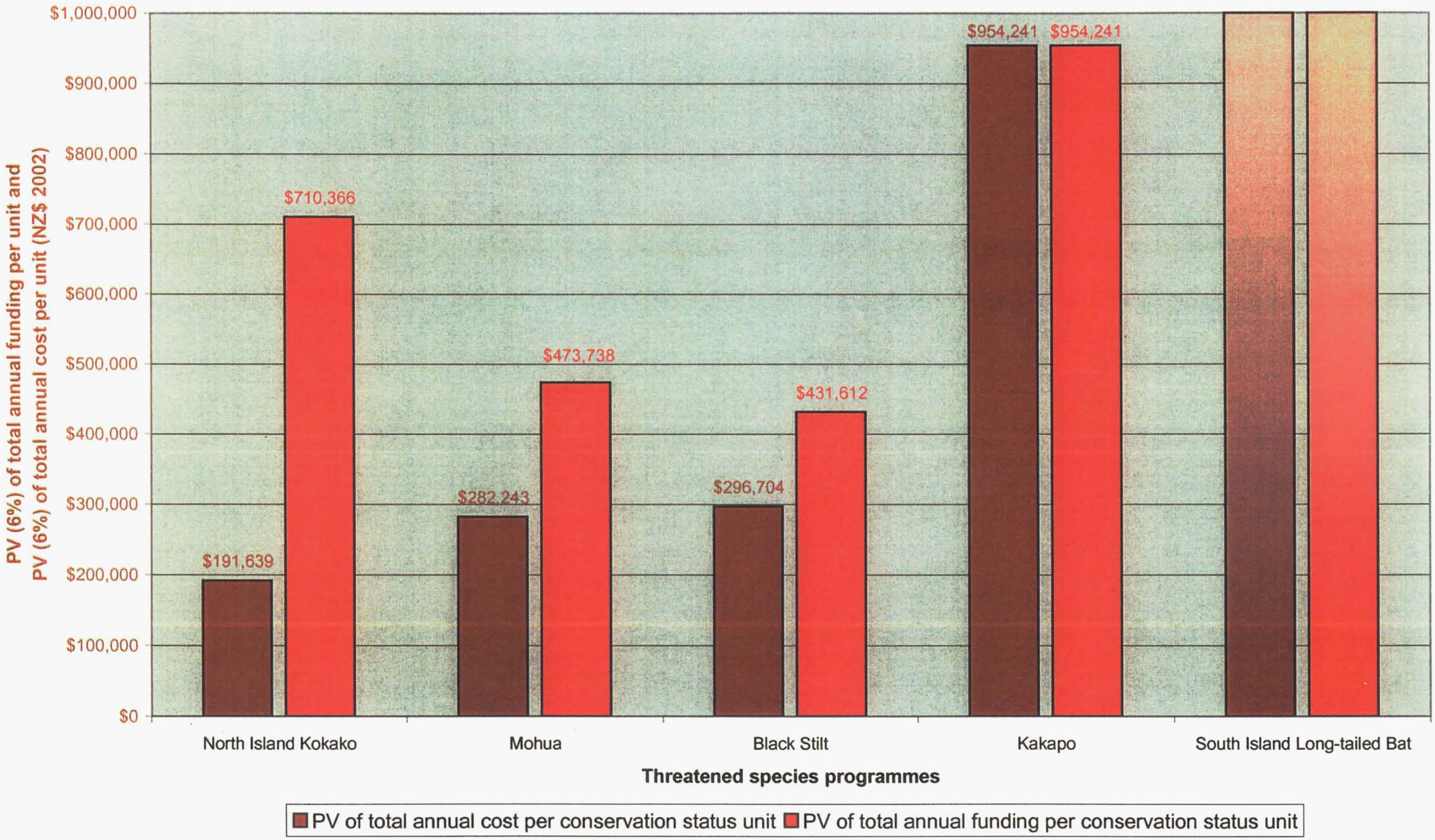


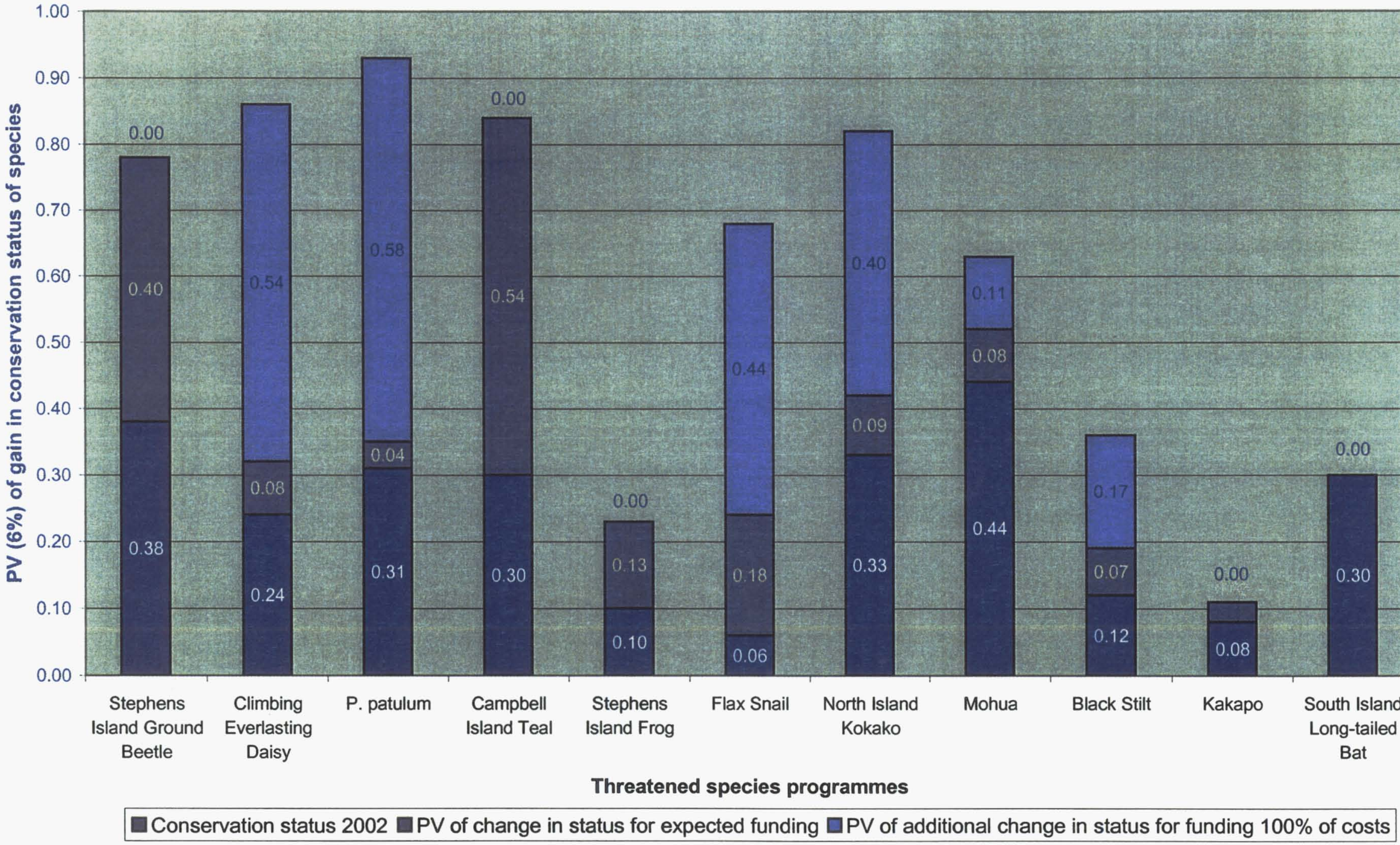
Figure 13: PV of predicted total annual cost per conservation status unit and expected total annual funding per conservation status unit for higher cost programmes 2003-2012



If extra funding equivalent to a PV of $18.6 million is allocated to the eleven threatened species programmes from 2003 until 2012 then additional improvements in the conservation status of the species may be achieved by the end of the timeframe (Figure 14). Fully funding the programmes could improve the conservation status of *P. patulum* to 'Range Restricted'; the Climbing Everlasting Daisy and North Island Kokakos' conservation status to 'Gradual Decline'; the Flax Snail and Mohua to 'Serious Decline'; and the conservation status of the Black Stilt from 'Critically Endangered' to 'Endangered'. Fully funding the Campbell Island Teal programme is not expected to improve the conservation status of the species beyond that which the expected funding could achieve by 2012. It is also not expected to improve the conservation status of the South Island Long-tailed Bat but it could make improvements in the species' conservation status possible after 2012.

The eleven programmes directly represent 1.8 percent of the 603 New Zealand species classified as 'Acutely Threatened' (Hitchmough, 2002). Although this is a small proportion of New Zealand's threatened species, other species benefit from the programmes, which creates the potential for economies of scope. *P. patulum*, the Climbing Everlasting Daisy, and the South Island Long-tailed Bat have 'complementary species', and the Kakapo, North Island Kokako, Mohua, and Black Stilt all act as umbrella species. For example, the protection of large tracts of habitat for the Black Stilt automatically protects the Wrybill (*Anarbynchus frontalis*), the Black-fronted Tern (*Sterna albostriata*), and the Robust Grasshopper (*Brachaspis robustus*). The effectiveness of an umbrella species as a 'short-cut' in threatened species conservation is, however, yet to be proved (Simberloff, 1998; Caro and O'Doherty, 1999; Andelman and Fagan, 2000). The eleven programmes may also

Figure 14: PV of possible improvements in species' conservation status for expected funding and additional improvements if fully funded 2003-2012



include a disproportionate number of higher cost programmes, such as that for the Kakapo, but they do not include the Kiwi programme, which receives more funding than any other programme (C. Carter, personal communication, October 18, 2002).

6.7 Conclusion

The task of estimating the costs of threatened species programmes is complex and the results of this research are, therefore, subject to uncertainty. The complexity of the task, however, underlines the central point that programmes have specific costs. Variations in the costs of threatened species programmes are marked but it appears that, comparatively, there are more lower cost programmes and a few that are higher cost. A cross-case analysis of the results identified habitat area as a key factor in determining the annual costs of a threatened species programme, and a species' taxon as an underlying explanatory factor that determines a programme's annual costs, and possibly its total cost. As a consequence, New Zealand threatened species programmes that require large tracts of habitat and are for bird or mammal species are likely to have higher costs than programmes that require less habitat or are for other taxa, such as plants and invertebrates. A proper understanding of this is important if the conservation of threatened species is to be maximised.

The cross-case analysis also indicated that K-selection may possibly be an underlying explanatory factor in determining the annual and total cost of a programme for threatened bird species, although further research is needed on the costs of programmes for other taxa to confirm this. The type of threat facing a species does not

appear to be a key factor, however, but further research is needed into programmes for species that face immediate threats other than predation and habitat loss. The cross-case analysis illustrated how the initial conservation status of a species and its recovery rate may determine the total cost of a programme but it was unable to investigate these factors because there is not yet a total cost for any New Zealand threatened species programme. The results of this research indicate that there may be correlations between the factors that are influenced by the biological characteristics of a threatened species, such as habitat area and a species' taxon, or K-selection and recovery rate. If more data of these or other factors becomes available in further research then a formal multivariate analysis could be conducted.

The projected costs of the eleven threatened species programmes from 2003 until 2012 are more than twice the expected level of funding for these programmes. Some programmes for species such as plants and invertebrates need comparatively few resources but are allocated minimal funding or have to source funding from general budgets. Other programmes for species such as birds need more resources but are only allocated partial funding. The effects of the budget constraint on many of these threatened species programmes are to inflate the cost of the programmes over time and to delay the possible conservation of the species. The shortfall in funding means that a decision to allocate funding between programmes will have an opportunity cost in terms of the protection of other species at risk of extinction. An allocation of funding to a programme that has a high cost and / or is for a species with a low possible recovery rate means it will be necessary to forego funding to a programme(s) that is low cost and / or is for a species with a high possible recovery rate. This will reduce the number of threatened species that can be conserved for a given budget.

7 Conclusion

The aim of this research was to improve the formal understanding of the costs of threatened species programmes by investigating the specific form of the cost function. To achieve this aim, a multiple case study analysis was conducted of the costs of New Zealand threatened species programmes. Data was collected and analysed from a survey of the Department of Conservation's Recovery Group Leaders for eighteen threatened species programmes: cost and expenditure data was available for eleven programmes, and expenditure data was provided for an additional seven programmes. A cross-case analysis of the results for the eleven programmes was then used to test hypotheses developed from the theorised characteristics of the cost function. Although the results are subject to uncertainty, habitat area and a species' taxon were identified as two factors that determine the specific costs of New Zealand threatened species programmes. The results also indicated the effects of the budget constraint on those costs.

The purpose of this chapter is to use the main findings of this research to review the characteristics of the cost function for New Zealand threatened species programmes, to highlight the contribution of this research to the sum of knowledge on the subject, and to identify areas for further research. It will also consider the policy implications of this research and make recommendations for conservation of threatened species in New Zealand. The cost function was based on Swanson (1994) and described the PV of the cost of a threatened species programme over time as a factor, *inter alia*, in a

cost-benefit ranking criterion adapted from Metrick and Weitzman (1998). It was proposed that the cost of a programme in a single time period is determined by the costs of the base natural resources and the management services needed to maximise the conservation of a threatened species. The cost function also stated that a programme's cost over time is determined by the costs in each time period and a species' extant population and recovery rate, which together acts as a controlling mechanism on these costs.

First, it was found that the area of habitat required for management of a threatened species appears to be positively related to the annual cost of the eleven threatened species programmes. This indicates that the quantity of base resources required for the survival of New Zealand threatened species is a variable in the costs of providing services to manage the indirect and direct threats facing the species (Equations 3b and 3c). The minimum habitat area needed by an individual *P. patulum* and the Climbing Everlasting Daisy underlined that a supply of base natural resources is an essential input in the cost function, although a more encompassing measure of the quantity of base resources than mean habitat area needs to be developed. The finding supports both Wilcove and Chen's (1998) conclusion that the costs of managing species' habitats are significant and Main, Roka and Noss' (1998) proposition that the costs of public ownership of habitat must include operating or management costs.

The quantity of base resources may also be a variable in the cost of their supply to a species in a certain time period (Equation 3a). The cost of supplying base resources, however, was not investigated because New Zealand's existing system of national parks and reserves means that the costs or 'rent' for base resources are not usually

included in the cost of a threatened species programme. It is concluded that the quantity of base resources is a variable in the cost function for a threatened species programme in a single time period (Equation 3). The costs of habitat acquisition need to be calculated for the results to be able to be compared with those for threatened species programmes internationally. If the costs are positive then the significance of base resource quantity as a variable may increase, although this may not necessarily be true for the costs of freshwater and marine species programmes. Its significance may also increase if all of the costs of habitat restoration and control of threats from other conservation budgets are included in the results.

Second, it was found that the types of threats and the numbers of threats facing a species do not appear to be closely related to the annual costs of the eleven threatened species programmes. All of the threatened species studied face either predation, habitat loss, or have a small population as a result of decline caused by predation and habitat loss, as their most immediate threats. This indicates that the costs of management for both indirect and direct threats (Equations 3b and 3c) for New Zealand threatened species are determined by factors other than the type of threat. The finding raises questions whether Abitt and Scott's (2001) discussion about differences in management between threatened species in the United States is relevant in the New Zealand context.

A possible alternative factor to types of threats may be the level of existing knowledge about a species, which appears to influence the costs of achieving survey, monitoring, and research objectives in the creation of a management regime.

Third, the research illustrated how the initial conservation status of a species and its recovery rate may determine the total costs of the eleven programmes. It also illustrated how the use of a positive discount rate in calculating the PV of the total cost reduces the possible importance of these two variables. A species' extant population and recovery rate were not investigated as variables in the mechanism controlling the cost of a threatened species programme over time (Equation 4a) because there is not yet a total cost for any New Zealand threatened species programme. The research supports Doremus and Pagel's (2001) conclusion that most species will remain threatened in the long term. Despite the lack of total cost data, identification of a small population as the most immediate threat for the Kakapo and the Stephens Island Frog underlined that an extant population is an essential input in the cost function for a threatened species programme.

Fourth, it was found that a species' taxon is related to the annual costs and possibly the total costs of the eleven threatened species programmes. The costs of programmes for plant and invertebrate species are comparatively low, while the costs of programmes for bird species are higher. The only land mammal species native to New Zealand are bats and their management is expected to be similar to that for forest bird species. This finding indicates that a species' taxon is a background variable in the cost function for New Zealand threatened species. It also confirms Doerksen et al.'s (1998) findings that there is a wide range in the average total costs of management for different taxa.

Fifth, a species' K-selection within each taxon was investigated as a variable only for bird species because of the limited number of programmes studied, but it appears to

be positively related to annual and possibly total costs. This finding supports Spurr's (1979) argument that a species' ability to recover can theoretically be predicted by considering its capacity for reproduction and dispersal. A species' K-selection may, therefore, be a background variable, although population viability analysis needs to be used as a measure of the variable.

Finally, the research also found that the projected costs of the eleven threatened species programmes from 2003 until 2012 are more than twice the expected level of funding. This finding confirms that a manager's production decision is often subject to a budget constraint and that funding allocation decisions will have an opportunity cost in terms of the protection of other species at risk. Some programmes need comparatively few resources but are allocated minimal funding or have to source funding from general budgets, while other programmes need comparatively more resources but are only allocated partial funding. If fully funded then the costs of those programmes could be reduced and the recovery of species could be hastened. It is not anticipated, however, that any of the eleven threatened species could reach 'Not Threatened" by 2012, which challenges Doerksen et al.'s (1998) assumption that species could be recovered over a five-year period.

This research represents the first time that economic theory and empirical evidence have been used to develop a model of the costs of management for threatened species. By investigating the specific form of the cost function, this research has provided the basis for a formal understanding of the costs of threatened species programmes. Further research may reconsider the assumptions used in the cost function. For the cost of a programme in a single time period it was assumed that the quantities of

inputs are fixed, the costs of the inputs are discrete, and the most cost-effective combination of inputs is used. For a programme's cost over time it was also assumed that the prices of inputs are constant, expenditure on inputs and a species' recovery occur in the same time period, and technology is constant. For example, the results for the Campbell Island Teal highlighted that there may be a timelag between the costs of inputs and a species' recovery. Also, the North Island Kokako and the Mohua programmes have shown that adaptive management strategies and knowledge gained from the management of other species can create technological change.

Three other areas for further research revolve around the remaining variables in the model, other possible variables, and the costs of other species programmes. First, a threatened species' K-selection, initial conservation status and recovery rate need to be investigated as variables in the cost function. Second, the level of existing knowledge about a species, intensive management, patterns of expenditure or expectations of funding for different taxa need to be explored as other possible variables. Third, research is also needed into the costs of the additional seven threatened species programmes, the costs of programmes for species facing different types of threats, the costs of programmes for freshwater and marine species, and the costs of threatened species programmes internationally. If this research is completed then the results could be used to specify a single equation model that is statistically estimated to explain the cost of threatened species programmes.

This research has important implications for threatened species conservation in New Zealand. It has shown that it is possible to collect information on the costs of New Zealand threatened species programmes. Furthermore, it has demonstrated that if

information on the costs of threatened species programmes is collected then it could be used to conduct cost-effectiveness analysis (Cullen *et al.*, 2001: Cullen *et al.*, 2002). This would be useful in indicating how successful the Department of Conservation is in achieving the aim of its Statement of Intent in terms of the conservation of threatened species. Cost information could also be useful for forecasting the possible outcomes of different policy goals for the allocation of funding (Doerksen *et al.*, 1998), and in gaining sufficient funding for threatened species conservation (Wilcove and Chen, 1998). Overall, there is an urgent need for information on costs if the conservation of New Zealand's threatened species is to be maximised.

Recovery plans state the DoC's intentions for the conservation of a species and serve to guide the Department in the allocation of resources. It is recommended that estimates of the annual costs of achieving the objectives developed for a threatened species are included in the preparation of recovery plans. Cost estimates are not necessarily a commitment to funding for a programme, but they encourage understanding of the resources that are needed to accomplish the recovery goal for a threatened species. It is recommended that cost-effectiveness analysis of threatened species programmes is conducted and the cost of a programme and a species' possible recovery rate is included as factors in priority ranking systems for the allocation of funding to threatened species programmes. Finally, it is recommended that the costs of threatened species programmes are included in funding applications for threatened species conservation.

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Appendices

Appendix A

Office of Hon Chris Carter
MP for Te Atatu
Minister of Conservation
Minister of Local Government
Minister for Ethnic Affairs

1 8 OCT 2002

Emma Moran
Commerce Division
Lincoln University
P O Box 84
LINCOLN

Dear Emma

Thank you for your email of 17 June 2002 asking about expenditure patterns on kiwi conservation relative to other species. I am sorry it has taken time to reply but I understand that you have been in direct contact with my department on your thesis requirements.

I can confirm that kiwi recovery work is funded through the Department of Conservation's base allocation and through a special allocation of New Zealand Biodiversity Strategy funding. In addition, funding is received through sponsorship. It is estimated that approximately $2.7 million per annum is spent on kiwi work compared with $0.9 - $1 million per annum on kakapo work. Appendix 1 contains the information on which these estimates were made. Kiwi and kakapo are considered to be the two best funded species recovery programmes operated by the department.

I hope you are now conversant with the way the department organises its financial information on conservation projects and its expenditure on species recovery work. I hope your thesis is proceeding well.

Yours sincerely

Hon Chris Carter
Minister of Conservation

Kiwi

Base allocation and sponsorship for kiwi work are estimated to be worth approximately $800, 000.

New Zealand Biodiversity Funding For The Five Kiwi Sanctuaries (GST exclusive)

2000/01	2001/02	2002/03	2003/04	2004/05
1, 636, 000	1, 590, 000	1, 573, 000	1, 572, 000	2, 107, 000

Other New Zealand biodiversity Funding allocations for kiwi work (GST exclusive)

2000/01	2001/02	2002/03	2003/04	2004/05
223, 974	267, 910	279, 600	280, 000	308, 000

Kakapo

A total of between $900, 000 and $1, 000, 000 is spent on kakapo per annum. With larger amounts being spent in the years when kakapo breed. This is made up of:

- c. $740, 000 base allocation for kakapo work - since 1996/97. All work on kakapo is organised through the kakapo team.
- $175, 000 on average from sponsorship - draw down depends on breeding.

Department of Conservation
Te Papa Atawbai

File ref: LCO-01 and SPP:0004

Emma Moran
Commerce Division
Lincoln University
P O Box 84
Canterbury 8150

12 August 2002

Dear Emma

I have considered your request for the data to assist with your Master's thesis topic, specifically for data on 12 threatened species recovery programmes which involves completion of a questionnaire on annual expenditure on the species over the past 10 years, and predicting the cost of funding all the objectives in the recovery plan over the next 10 years. This would be carried out with recovery group leaders collating and calculating the information required to complete the questionnaire. In considering your request I have taken into account the time estimates and comments from the trial where three recovery group leaders completed the questionnaire.

1. The Department will provide information on annual expenditure on 12 species over the past 10 years with the request being treated as an Official Information Act Request. There will be a charge for providing this information and the Department does not consider it appropriate to provide any remission in charges in this case. It is estimated that it will take between approximately 12.5 – 27 hours for recovery group leaders to collate this information for 12 species (Refer to Appendix 2). Chargeable hours have been calculated to cost approximately $874 - $1,976 (including GST) [Refer to Appendix 4]. It will be necessary for you to pay a deposit of $800 (including GST).

2. I am enclosing copies of the information put together by recovery group leaders for an exercise in the Recovery Group Leaders workshop held in May 2001. The exercise was a Guestimate of Species Recovery Expenditure. While this information does not match the precise requirements of your questionnaire, it may be of use to you as it gives a ball park guess of what it would take to recover various species.

3. The Department does not hold information that predicts the cost of funding individual objectives in recovery plans over the next 10 years and would have to create it. This work is not within the scope of the Official Information Act (it is not information held by the Department). You can put your request for this

information to individual recovery group leaders Conservators, who have the ability to decline the request for recovery group leaders to provide new information. As the request would impose a fairly substantial burden of work on staff whose time is already committed. Where Conservators agree to provide this information there will be charge for the time spent on the request. The charge will be $38 (GST inc.) for every half hour or part. It is estimated that it will take between approximately 12.5 – 27 hours for recovery group leaders to collate this information for 12 species (Refer to Appendix 2), this would cost approximately $950 - $2, 052 (GST inc.) [Refer to Appendix 4].

Please confirm whether you wish to proceed with your request. Contact Pam Cromarty to finalise the list of species which you are requesting data on. If you proceed with your request she will also contact Conservators over the request for information on past expenditure and will provide you with contact details for the Conservators responsible for the Recovery Group Leaders you want to provide new information.

Yours sincerely

Allan Ross
Acting Regional General Manager, Central

Appendix 1: Trial of Questionnaire

Species	Recovery Group Leader	Features of the recovery programme	Time to fill in questionnaire	Comments
black stilt	Andrew Grant	Single species, conservancy species	½ hour	Had already collated past expenditure for other requests & had forecast future costs, so information readily available
bats	John Lyall and Colin O'Donnell	Multiple species and multiple conservancies	8 hours	Still took time to get rough estimates. Had to contact other conservancies to get past expenditure figures.
kakapo	Paul Jansen	Single species – centrally co-ordinated programme	2 hours	Kakapo costs very discrete, one allocation covers operating and salaries. Would be a huge task for kiwi.

Appendix 2. Estimate of Time to complete request

Species (requires confirmation with Emma)	Recovery Group Leader	Features of the recovery programme	Time to fill in questionnaire
New Zealand Sealion	No recovery group, this plan is not used – suggest it is replaced with a plant		
1 weta species	Ian Miller	single species, may be multiple conservancies	1-4 hours
2 frog species – Archy's and Hochstetter's	Avi Holzapfel	Multiple species, multiple conservancies plus SRU input	8 hours including input from other conservancies
1 species (Otago or Giant?) skink	Dave Houston	single species, single conservancy plus SRU input	1-4 hours
1 tuatara species	Peter Gaze	single species, single conservancy plus SRU input or multiple species, multiple conservancies	1 hour or 8 hours
1 coastal cress species	Phil Knightbridge	Single species, mostly multiple conservancies	2-4 hours
Pittosporum patulum	Nick Head	Single species, multiple conservancies	2-4 hours
1 tree daisy species (*Olearia*)	Brian Rance – suggested replacement for NZ sealion	multiple species, mostly multiple conservancies	2-8 hours
1 invertebrate species (Carabid species?)	Carl McGuiness	?	2 hours

Black Robin or Chatham Island Taiko	Hilary Aikman	Single species, single conservancy and NGO	2-4 hours
Saddleback or Subantarctic Teal (Campbell?)	Pete McClelland	Single species, single conservancy & Mt Bruce	2 hours
Yellow-eyed Penguin	Bruce McKinlay	Single species and multiple conservancies	2-8 hours
		Estimate of Total Time	25-54 hours

Appendix 3 Remission of Charges

Factors to consider in remission of charges	Student's view	The Department's view
Payment might cause the applicant hardship	Emma has indicated that payment is likely to cause her hardship as it is likely to be in excess of her masters budget. Estimated charges $874 - $1,976	The charges may cause hardship.
Remission or reduction of the charge would facilitate good relations with the public or assist the department in its work	Emma's view is that her use of the information would be of use to the department	It's the department's view that this information will be of limited value. The ball park/ rough estimate nature of the information that recovery group leaders will be able to provide and the disclaimers associated with the estimates mean that the information at best can be used to provide another view on how to set priorities for species recovery planning. It is very unlikely that it will provide brilliant new insights on the issue. Rather it is likely to confirm what threatened species managers already know intuitively. Returns on the time investment of recovery group leaders are expected to be low (25 – 54 hours work). The department is undertaking a wider exercise relating to how it undertakes its business under the NHMS project (which includes the Measurement of Conservation Achievement project).
Remission or reduction of the charge would be in the public interest because it is likely to contribute significantly to public	Emma's view is that the information is likely to contribute significantly to public understanding of the activities of	It is the Department's view that the information would be of interest to the requester and a narrow segment of interested

understanding or, or effective participation in, the operations or activities of the government, and the disclosure of the information is not primarily in the commercial interest of the requester.	the government as it will be published.	people, rather than the public at large.

Appendix 4. Estimate of charges

Official Information Act Charges:

1st hour is free.
First chargeable ½ hour or part $38
Each additional half hour or part $38

Charges for new information

$38 for each half hour or part spent preparing new information

	Total time estimate	Estimate for Exiting information	Estimate for New Information
Estimate of hours	25-54	12.5 – 27	12.5 -27
Chargeable hours (total hours less 1 hr)		11.5 - 26	12.5 - 27
Estimate of Charges ($38 per 30 mins)		$874 - $1,976 (GST inc.)	$950 - $2, 052 (GST inc.)

Appendix B

The Recovery Group Leader Survey

Letter of introduction

PO Box 84
Lincoln University
Phone (03) 325 2811 - 8354
morane@lincoln.ac.nz
30/06/02

Dear ??Recovery Group Leader???,

I am writing to you as part of my thesis research on threatened species programmes. My research aim is to investigate the costs of recovery for New Zealand threatened species. About 1,400 native species are classified by the Department of Conservation as having a conservation status from Critically Endangered to Range Restricted. The Department, however, was only able to spend $35 million on management services for protected species and island habitats in 2000/01. Information on recovery costs is important for the success of attempts to gain enough resources for conservation, and for the setting of priorities to allocate these resources between threatened species.

I am sending a one-page questionnaire (as an excel document) by email to each of the Recovery Team Leaders to obtain data on the threatened species that have a draft or published recovery plan. The questionnaire is based on the approach used by the U.S. Fish and Wildlife Service, which is required to include the estimated costs of actions in its recovery plans. It is also similar to the budgets in the Kiwi, Native Frog and Chevron Skink recovery plans. The questionnaire uses quick estimates of the costs of achieving the objectives in the recovery plan to calculate the recovery cost for a species. The estimates will also be useful for highlighting the key factors that determine the relative recovery costs for threatened species.

I would appreciate it if you could complete and return the questionnaire for the ??species??? by 30 September 2002. An example of a completed questionnaire for the Black Stilt, and a continuum for estimating the conservation status of the species are included with this letter. The excel document will have further explanations attached as 'comments' to the question cells. This research is funded through Lincoln University and a scholarship from Massey University. My thesis supervisors are Dr. Ross Cullen and Dr. Ken Hughey. If you have any comments or you would like more information then please contact me, and thank you in advance for your help with my research.

Yours sincerely,

Emma Moran

Questionnaire

Species
Conservancies
Reciprocal species
K or r-selected
Habitat area
Causes of decline
Current threats
Current status
Recovery goal
Recovery status
Estimated recovery year
Estimated recovery cost

Annual past expenditure (to nearest NZ$10,000)

Financial year	1990/1	1991/2	1992/3	1993/4	1994/5	1995/6	1996/7	1997/8	1998/9	1999/0
Total expenditure										
Conservation status										

Annual future funding and costs of objectives (to nearest NZ$10,000)

Financial year	2003/4	2004/5	2005/6	2006/7	2007/8	2008/9	2009/0	2010/1	2011/2	2012/3
Total funding										
Conservation status										
Recovery objective 1										
Recovery objective 2										
Recovery objective 3										
Recovery objective 4										
Recovery objective 5										
Recovery objective 6										
Recovery objective 7										
Recovery objective 8										
Recovery objective 9										
Recovery objective 10										
Recovery objective 11										
Recovery objective 12										
Total recovery cost										
Conservation status										

Explanations attached to cells as comments

Species	Common name(s) and species.
Conservancies	The key conservancies for this species.
Reciprocal species	Any other species that management actions for would significantly reduce the costs of recovery of this species.
K or r-selected	A number between 1 (extremely K-selected) and 10 (extremely r-selected) that reflects the biological characteristics of the species. **K-selected species** (selection that operates to maximise population size) – a species that is a strategist and characteristic of constant or predictable environments, typically with relatively slow development, large body size, late reproduction, low birth rates, and high survival rates among offspring, long life-span, and iteroparity. **r-selected species** (selection that operates to maximise the rate of increase) – a species that is opportunistic and characteristic of variable or unpredictable environments, typically with relatively rapid development, small body size, early reproduction, spends a large proportion of energy to reproduction, efficient dispersal, short life-span, and semelparity.
Habitat area	The average area of suitable habitat required to support an individual or pair of individuals, as appropriate (please specify).
Causes of decline	One or more of the following options in order of importance: habitat loss, predation, competition, natural events, disturbance, fragmentation, disease, pollution, over-use, accidental take, other (please specify).
Current threats	One or more of the following options in order of importance: habitat loss, predation, competition, natural events, disturbance, fragmentation, disease, pollution, over-use, accidental take, other (please specify).
Current status	The conservation status category of the species **in 2001** using the Department of Conservation's Threat Classification System (2001).
Recovery goal	The recovery goal for the species as stated in the recovery plan or draft recovery plan.
Recovery status	The conservation status category of the species **when the recovery goal is achieved** using the Department of Conservation's Threat Classification System (2001).
	The recovery goal is to establish at least one viable, self-sustaining, unmanaged population of kakapo as a functional component of the ecosystem in a protected habitat, and to establish two or more other populations that may require ongoing management.
Estimated recovery year	The estimated earliest year that the recovery status could be achieved by if total funding equalled estimated total cost.

Estimated recovery cost	The estimated total cost of achieving the recovery goal (from year of publication of recovery plan to earliest year recovery goal could be achieved by).
Total expenditure	The estimated total expenditure on actions that has been incurred as the direct result of the decision to recover this species from Output Class D5: Management Services: Protected Species and Island Habitats (cells are formatted to "currency" style).
Conservation status	Estimate the numerical value of the **actual** conservation status of the species for each year by: Identifying the conservation status category of the species using the Department of Conservation's Threat Classification System (2001). Identifying the range of numbers on the Conservation Status Continuum that apply to this category. Choosing a number within this range that reflects the degree to which the species fits the criteria for this category.
Total funding	The estimated total funding that could reasonably be expected for each year from Output Class D5 given present budgets and past patterns of expenditure (cells are formatted to "currency" style).
Conservation status	Estimate the numerical value of the **predicted** conservation status of the species **for the level of total funding** for each year by: 1. Identifying the conservation status category of the species using the Department of Conservation's Threat Classification System (2001). 2. Identifying the range of numbers on the Conservation Status Continuum that apply to this category. Choosing a number within this range that reflects the degree to which the real conservation status of the species fits the criteria for this category.
Total cost	The estimated total cost of taking all of the actions that are required to achieve the objective for each year from Output Class D5 (cells are formatted to "currency" style).
Conservation status	Estimate the numerical value of the **possible** conservation status of the species **for a level of funding equal to 100 percent of cost** for each year by: 1. Identifying the conservation status category of the species using the Department of Conservation's Threat Classification System (2001). 2. Identifying the range of numbers on the Conservation Status Continuum that apply to this category. 3. Choosing a number within this range that reflects the degree to which the species fits the criteria for this category.

Conservation Status Continuum

0.99 – 1.00 **Not Threatened**
A taxon that does not fit any of the threatened or at risk categories. This includes any that may have declined historically but are now considered secure due to widespread distribution, abundance, and stable or increasing populations.

0.95 – 0.98 **At Risk – Sparse**
A taxon is not currently in decline, but whose population characteristics mean a new threat could rapidly deplete their population(s). It has very small, widely scattered populations and is either naturally sparse or has become sparse as a result of human activities.

0.87 – 0.94 **At Risk – Range Restricted**
A taxon is not currently in decline, but whose population characteristics mean a new threat could rapidly deplete their population(s). It occurs either in a small geographic area (e.g. Three Kings Islands), is restricted to a particular habitat (e.g. geothermal areas) or requires very specific substrates (e.g. ultramafic rock). It is either naturally restricted or has become restricted as a result of human activities. The area of occupancy is less than 100km^2 for a terrestrial and a freshwater taxon and less than 1,000 km^2 for a marine taxon.

0.76 – 0.86 **Chronically Threatened – Gradual Decline**
Moderate-large population and small-moderate decline
A taxon fits at least one status criterion and the trend criterion:
Status criteria
1. Total population size is > 5,000 mature individuals.
2. There are > 15 sub-populations ***and either***:
   a. 500 mature individuals in the largest sub-population, ***or***
   b. Total area of occupancy is > 100 ha (1km^2).

Trend criterion
A predicted decline of 5-30% in total population in the next 10 years due to existing threats ***and*** the decline is predicted to continue beyond the next 10 years.

0.62 – 0.75 **Chronically Threatened – Serious Decline**
A. Moderate-large population *and* moderate-large predicted decline
A taxon fits one status criterion ***and*** the trend criterion:
Status criteria
1. Total population size is > 5,000 mature individuals.
2. There are ≤ 15 sub-populations ***and either***:
   a. 500 mature individuals in the largest sub-population, ***or***
   b. Total area of occupancy is > 100 ha (1km^2).

Trend criterion
Predicted decline of 30-60% in total population in the next 10 years due to existing threats.

B. Small-moderate population *and* small-moderate predicted decline
A taxon fits one status criterion ***and*** the trend criterion:
Status criteria
1. Total population size is < 5,000 mature individuals.

2. There are ≤ 15 sub-populations ***and either***:
    a. 500 mature individuals in the largest sub-population, ***or***
    b. Total area of occupancy is ≤ 100 ha ($1km^2$).

Trend criterion

Predicted decline of 5-30% in total population in the next 10 years due to existing threats.

0.45 – 0.61

Acutely Threatened – Nationally Vulnerable

Small-moderate population *and* moderate recent predicted decline

A taxon fits at least one status criterion *and* one trend criterion:

Status criteria

1. Total population size is 1,000 - 5,000 mature individuals.
2. There are ≤ 15 sub-populations ***and either***:
    a. 300-500 mature individuals in the largest sub-population, ***or***
    b. Total area of occupancy is 10 - 100 ha (0.1 - $1km^2$).

Trend criteria

A decline of 30-60% in total population or habitat area in the last 100 years *and* the total population *or* habitat is still in decline.

1. A predicted decline of 30-60% in total population in the next 10 years due to existing threats.

0.24 – 0.44

Acutely Threatened – Nationally Endangered

A. Small population *and* moderate-high recent predicted decline

A taxon fits at least one status criterion ***and*** one trend criterion:

Status criteria

1. Total population size is 250-1,000 mature individuals.
2. There are ≤ 5 sub-populations ***and either***:
    a. 300 mature individuals in the largest sub-population, ***or***
    b. Total area of occupancy is ≤ 10 ha ($0.1km^2$).

Trend criteria

1. A decline of ≥ 30% in total population ***or*** habitat area in the last 100 years.
2. A predicted decline of ≥ 30% in the next 10 years due to existing threats.

B. Small-moderate population and high recent or predicted decline

A taxon fits one status criterion ***and*** one trend criterion:

Status criteria

1. Total population size is 1,000 - 5,000 mature individuals.
2. There are ≤ 15 sub-populations ***and either***:
    a. 300 - 500 mature individuals in the largest sub-population, ***or***
    b. Total area of occupancy is 10 - 100 ha (0.1 - $1km^2$).

Trend criteria

1. A decline of ≥ 60% in total population ***or*** habitat area in the last 100 years.
2. A predicted decline of ≥ 60% in the next 10 years due to existing threats.

0.01 – 0.23

Acutely Threatened – Nationally Critical

Very small population *or* a very high predicted decline

A taxon meets any of the following three criteria:

1. Total population size is ≤ 250 mature individuals.
2. Human influences have resulted in ≤ 2 sub-populations ***and either***:
    a. 200 mature individuals in the largest sub-population, ***or***
    b. Total area of occupancy is ≤ 1ha ($0.01km^2$);

3. A predicted decline of $\geq$ 80% in total population in the next 10 years due to existing threats.

0.00 **Extinct**

A taxon where there is no reasonable doubt, after repeated surveys in known or expected habitats at appropriate times (diurnal, seasonal and annual) and throughout the taxon's historic range, that the last individual has died. A taxon that is extinct in the wild but occur in captivity or cultivation are as Nationally Critical and are qualified with the letters EW (Extinct in the Wild).

Completed example for the Black Stilt

Species	Black stilt (Himantopus novaezelandiae)
Conservancies	Canterbury
Reciprocal species	None
K or r-selected	5
Habitat area	3-5 ha
Causes of decline	predation, habitat loss
Current threats	predation, habitat loss
Current status	Nationally critical
Recovery goal	To establish self-sustaining populations of black stilt to ensure the species' survival in the wild without a continuing need for intervention.
Recovery status	Nationally endangered
Estimated recovery year	2011
Estimated recovery cost	$9,560,000

Annual past expenditure (to nearest $10,000)

Financial year	1993/4	1994/5	1995/6	1996/7	1997/8	1998/9	1999/0	2000/1	2001/2	2002/3
Total expenditure	$120,000	$120,000	$180,000	$22,000	$450,000	$450,000	$430,000	$380,000	$400,000	$400,000
Conservation status	0.06	0.06	0.06	0.06	0.07	0.08	0.09	0.10	0.12	0.12

Annual future funding and costs of objectives (to nearest $10,000)

Financial year	2003/4	2004/5	2005/6	2006/7	2007/8	2008/9	2009/0	2010/1	2011/2	2012/3
Total funding	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000
Conservation status	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.20	0.21
Cost of Objective 1	$300,000	$300,000	$300,000	$300,000	$400,000	$400,000	$400,000	$400,000	$200,000	$200,000
Cost of Objective 2	$300,000	$300,000	$300,000	$300,000	$300,000	$300,000	$300,000	$300,000	$200,000	$200,000
Cost of Objective 3	$600,000	$300,000	$300,000	$300,000	$100,000	$100,000	$100,000	$50,000	$50,000	$20,000
Cost of Objective 4	$0	$0	$0	$0	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Cost of Objective 5	$60,000	$60,000	$60,000	$60,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000
Total recovery cost	$1,260,000	$960,000	$960,000	$960,000	$920,000	$920,000	$920,000	$870,000	$570,000	$540,000
Conservation status	0.14	0.16	0.18	0.20	0.24	0.26	0.28	0.32	0.36	0.40

Letter accompanying the Recovery Group Leader Survey

Department of Conservation
Te Papa Atawhai

Internal Correspondence

Our file ref.: SPP:0004

To: ????Conservator??????
????Conservator??????

From: John Ombler, Regional General Manager (Central)
c.c. Peter Lawless, Regional General Manager (Northern)
John Cumberpatch, Regional General Manager (Southern)

Date: 21 August 2002

Subject: REQUEST FOR RECOVERY GROUP LEADER INPUT

Background

Emma Moran is researching the recovery of threatened species for her Masters thesis of Applied Science at Lincoln University. The topic of her thesis is: "An analysis of the costs of conserving threatened species in New Zealand" She argues that information on recovery costs is important for the success of attempts to gain enough resources for conservation, and for the setting of priorities to allocate these resources between threatened species. As part of this research, she would like the assistance of **nine Recovery Group Leaders** to collect data on a range of threatened species with recovery plans. Recovery Group Leaders would be asked to complete a questionnaire for the species they are currently the leader for. The focus of the questionnaire is on annual expenditure on the species over the past 10 years, and estimating the cost of achieving all the objectives in the recovery plan for the species over the next 10 years. To be of use in her research, Emma would like information on both past expenditure and estimates of future costs for each species.

RGM's Decision on This Request

The Regional General Manager Central has considered Emma's request and made the following decision:

- The request for information on past expenditure will be treated as an official information request and there will be a charge for the time spent on the request (i.e. it is compulsory to responds to this request).
- The request to predict the cost of funding objectives in the recovery plan over the next 10 years is discretionary and there will be a charge for time spent on the request. Conservators have the ability to decline the request for recovery group leaders to provide new information.

It is estimated that it will take between 1 – 8 hours (but probably about 4 hours) for each recovery group leader to complete these two requests (based on the trial where three recovery group leaders completed the questionnaire).

Request for Recovery Group Leaders Input

This is a request for Recovery Group Leaders identified in Table 1., to provide information on:

1. Past expenditure (last 10 years) on species recovery – this is **an Official Information request** and must be completed.
2. Predictions of the cost of funding all the objectives in the recovery plan over the next 10 years – this request is **discretionary**.

Action Required

1. Pass on the request for information on past expenditure to recovery group leaders to action using the instructions in Appendix 1. This request is to be completed within 20 working days from payment of the deposit as this is an Official Information Request.
2. Accept or decline the request for new information by emailing Fran Begley fbegley@doc.govt.nz
3. If you accept the request for new information, pass it on to recovery group leaders to action using the instructions in Appendix 2. This request is to be **completed within 20 working days of you accepting it.**

Table 1: Recovery Group Leaders and Species

Recovery Group Leader	**Species (requires confirmation with Emma)**	**Features of the recovery programme**
Dave Houston, Oamaru Field Centre	Otago or Giant skink	If it is easier to do both species then do both otherwise do a single species. Single conservancy plus SRU input
Peter Gaze, Nelson/Marlborough Conservancy	Cooks Strait or Brother's Island tuatara	If it is easier to do both species then do both otherwise do a single species. Multiple conservancies plus SRU input
Pete McClelland, Southland Conservancy	Campbell Island teal	Single species, single conservancy & Mt Bruce
Carl McGuiness, Biodiversity Recovery Unit	1 Carabid species	?
Ian Miller, Nelson/Marlborough Conservancy	1 weta species - preferably one that a reasonable amount of recovery work has been undertaken on	single species, may be multiple conservancies
Nick Head, Canterbury Conservancy	*Pittosporum patulum*	Single species, multiple conservancies
Geoff Hudson, Opotiki Area Office	North Island kokako	Single species and multiple conservancies
Richard Allibone	Otago galaxiid complex (select either the group or one species whatever works at a practical level) – non migratory galaxiids	Single or multiple species
John Sawyer, Wellington Conservancy Office	Pygmy button daisy *Leptinella nana*	

Appendix 1 Request for Information on Past expenditure (last 10 years) on the species

1. Attached are a covering letter from Emma Moran explaining her request, an excel spreadsheet questionnaire, an explanation on conservation status, and a worked example of the questionnaire. Key definitions are:

   "Cost" is the financial resources required to achieve the recovery goal of a species in a timely way.

   "Funding" is the financial resources allocated to achieve the recovery goal of a species.

   "Expenditure" is the financial resources actually utilised to achieve the recovery goal of a species.

   Both funding and expenditure may be equal to, or only a part of, cost. It is important when estimating cost not to be restricted by past funding or expenditure.
2. Save a copy of the questionnaire.
4. Complete the **part of the questionnaire on past expenditure** for your species within 20 working days from payment of the deposit as this is an Official Information Request.
3. The spreadsheet contains "Comments" indicated by a triangle in the top right hand corner of a cell. The comments provide explanation on the terms used in the spreadsheet. Read them through before completing the spreadsheet. You can print them out by going into page setup, sheet, comments, select 'at end of sheet', also select 'row and column headings'.
4. If you have any questions or require clarification about the questionnaire contact Emma Moran at morane@lincoln.ac.nz or phone (03) 768 5986.
5. Record the time you take to answer this part of the questionnaire to the nearest half hour and email this information to Fran Begley fbegley@doc.govt.nz
6. Email the completed questionnaire to Emma Moran morane@lincoln.ac.nz
7. Email a copy of the completed questionnaire to Fran Begley fbegley@doc.govt.nz

Appendix 2 Request for Information predicting the cost of funding all the objectives in the recovery plan over the next 10 years

1. Attached are a covering letter from Emma Moran explaining her request, an excel spreadsheet questionnaire, an explanation on conservation status, and a worked example of the questionnaire. Key definitions are:
   "Cost" is the financial resources required to achieve the recovery goal of a species in a timely way.

   "Funding" is the financial resources allocated to achieve the recovery goal of a species.

   "Expenditure" is the financial resources actually utilised to achieve the recovery goal of a species.

   Both funding and expenditure may be equal to, or only a part of, cost. It is important when estimating cost not to be restricted by past funding or expenditure.
2. Save a copy of the questionnaire.

3. Complete the **part of the questionnaire on predicting the cost** of funding all objectives in the recovery plan for your species over the next 10 years **within 20 working days** of your Conservator **accepting** this request.
4. The spreadsheet contains "Comments" indicated by a triangle in the top right hand corner of a cell. The comments provide explanation on the terms used in the spreadsheet. Read them through before completing the spreadsheet. You can print them out by going into page setup, sheet, comments, select 'at end of sheet', also select 'row and column headings'.
5. If you have any questions or require clarification about the questionnaire contact Emma Moran at morane@lincoln.ac.nz or phone (03) 768 5986.
6. Record the time you take to answer this part of the questionnaire to the nearest half hour and email this information to Fran Begley fbegley@doc.govt.nz
7. Email the completed questionnaire to Emma Moran morane@lincoln.ac.nz
8. Email a copy of the completed questionnaire to Fran Begley fbegley@doc.govt.nz

Appendix C

Pygmy Button Daisy

J. Sawyer (personal communication, September 17, 2002)
Our senior managers were given the option of not completing the spreadsheet of expected costs over the next 10 years so my instructions were to just do past expenditure. Most of our expenditure is in staff time monitoring and maintaining populations annually (including negotiating legal protection). There are small costs involved in fencing and planting. The largest cost was a survey in Nelson/Marlborough which resulted in more of the plant being discovered.

Mercury Island Tusked Weta

No reason provided.

Otago Skink and Grand Skink

D. Wakelin (personal communication, September 17, 2002)
I am assisting with your request for information on the costs of protecting giant skinks. I gather it is not going to be possible to answer part two of your request re costs for the next 10 years. I assume you want salary costs as well. So far, we have not been able to find these as we only moved to a financial system that allocated staff hours to projects in recent years. There has also been significant volunteer input to the giant skink programme and that won't be able to be quantified.

Forwarded by F. Begley (personal communication, September 4, 2002)
I am declining to provide an estimate of the cost of implementing the Giant Skink Recovery Plan over the next ten years. That is because there are gross uncertainties in relation to the Lindis populations of Otago and Grand skink. These populations have not been comprehensively surveyed in recent years. Until more recent surveys are conducted, we will not know which are the prime habitats requiring protection or how many of them there might be. We therefore cannot begin to estimate the cost of negotiated habitat protection nor the cost of ongoing management. The cost of habitat protection and ongoing management of the Macreas habitats is known, but this cannot necessarily be extrapolated to the Lindis.

Brothers Island Tuatara

I. Miller (personal communication, September 11, 2002)

I've had to do this in the absence of Peter Gaze (RGL) who is on extended leave. I've worked with tuatara in the past but not in recent years. I've stuck with Brothers tuatara for the questionnaire as that's the species of the two selected on which most active management has occurred and whose costs are easiest to estimate. Estimating costs to nearest $10,000 would have meant $0 for most years. I've therefore given a more indicative figure - "<$5,000" for most years (it would probably have been about $2000-2500). Two island transfers have been made (Titi in 1995; Somes in 1998) which pushed up costs and conservation status (as defined here) by small amounts. HOWEVER......... both of these transfers have received a significant boost by the removal from the wild and captive incubation of eggs by Victoria University, with subsequent raising of hatchlings to about 5 years old by Nga Manu Wildlife Centre in Waikanae. The removals were initially for research purposes but with the likelihood of island introductions as an end-use for the juveniles. The continued involvement of both institutions therefore gave us a considerable head-start for these transfers at no cost to the department. I do not know what the costs would have been for the institutions, but in some years they would have been quite substantial. So their costs are not included in the table. (The transfers never involved more than 20 adult animals from the very limited original population; the bulk of 'transferees' were these captive bred juveniles.) In addition, some DoC costs to do with island security and some ongoing monitoring will be absorbed within island management budgets, making it difficult to isolate these.

It is uncertain to me at this stage what recovery effort lies ahead for this species. I understand that one more transfer is in the wind (within Marlborough Sounds) but do not know if or when this is likely to occur. Also, the debate as to this species' original range has never been settled (and may never be settled?) so there is no clear idea of how many more sites, if any, the species could be transferred to. For this reason I have declined to fill in the section on future expenditures and outcomes. For what it's worth I would guess that total direct expenditure on the species over the next 10 years will remain at or below $5,000 per year (cost of ongoing monitoring, etc.), unless a further transfer goes ahead. With such a transfer the 'conservation status' estimate would rise to around 4.2. The beast doesn't reproduce frantically fast so you're probably looking at a couple of decades down the track to when the payoff starts to come in.

Chevron Skink

N. Peet (personal communication, September 20, 2002)
I have spoken with my conservator and I regret that I will be unable to make predictions for costs associated with the recovery of North Island Oligosoma species for the next 10 years. This sort of information is not available and any estimates that might be made could be hugely inaccurate. In many cases we have not got enough information to know exactly what recovery actions will be required and in others recovery actions are part of wider restoration schemes not specifically aimed at skinks e.g. pest eradication. I will do my best to get you costs for one of the Oligosoma skinks for the last ten years. Again this is difficult to identify and time consuming as budgets for species programmes do not always identify costs associated with skinks as

opposed to other species. In addition these budgets are not held by recovery groups so I will need to contact colleagues elsewhere in the country.

Canterbury Mudfish

R. Miller (personal communication, October 22, 2002)
The estimates for expenditure for the last 10 years are just that, estimates ! I note though that the sheet requests it to the nearest 10K !!! (I've used smaller units !!). I have not been able to cost out the carrying out the actions for the next 10 years, for the simple reason that its all a bit arbituary really !!! (i.e. how long is a piece of string !!). However, the first priority for the key sites is to fill in a register containing information about each site (including if its protected etc), so that will obtain the sort of information that might then help us to determine how much it might cost to achieve the action of protecting each site (e.g. a willing landowner may just protect it anyway, a more reluctant one might require us to purchase it etc). Costs for the second objective are mainly planner's time, and as that isn't split up into what species they're advocating for, it's a bit difficult to factor in. Objective 4 (monitoring) is likely to be covered by existing resources whereas objective 5 (addressing research needs) will require either specific science bids, or piggybacking on other agencies research. Objective 6 (involvemnet of iwi) probably wont be hugely expensive, unless they decide to create wetlands (action 6.3). Sorry I can't be more helpful than that. This is the first year of the recovery group, so I think we can be excused for not having everything sorted straight away.

Otago Galaxid

F. Begley (personal communication, September 2, 2002)
I have just received word that the Biodiversity Research Unit Manager has just declined the offer for the Galaxids. I understand that this is an Official information request, but the managers can still turn it down regarding many different matters, e.g. work load of the Recovery Group Leaders. The BRU manager is the Recovery Group Leader's manager and makes the call from what the leader tells her. I talked to the galaxid leader and he said that it would take around a week and a half to get just the past expenditure information due to the fact that it is not kept with him, but scattered around the country and there are a lot of bills that haven't been sent out to them regarding past legal battles over land use, etc.

Forward by F. Begley (personal communication, September 4, 2002)
I have replied to Fran that I will not be doing any of the future cost estimates. Partly as I just don't have a clue what we will be spending over the next ten years. I also am going to have to ask for help through the line to get estimates of what has been spent on galaxids in the last ten years. Money has come from S&R, head Office legal budgets, Otago Conservancy budgets, the old NPP funds, I have none of these figures at hand. I had a brief chat with Murray Neilson in Otago as Murray has run a lot of these projects and he says we will have Marcus Simons (his manager) for some of his time to track down what he has received and spent on various projects. Murray (like

myself) is working on the Contact Energy Clutha River consents and Project Aqua on the Waitaki and hasn't spare time, he thinks Marcus will say no at present. We both also think this is a job that will take a lot more than four hours.

Yellow-eyed Penguin

No reason provided.