Prioritising and evaluating biodiversity projects

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Engaging Society in Conservation ● Te Whenua, Te Moana, Te Papa Atawhai Whakamaua ki Tina

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The Challenge in New Zealand

33 documented extinctions in 100 years (including 16 birds, 9 terrestrial invertebrates, 6 vascular plants)

About 2000 threatened species and 3000 data deficient out of 90,000 indigenous species

Department of Conservation budget to improve the status of threatened species NZ$32 million per year, 2006.

Joseph, Maloney, Possingham, 2008

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Beyond opportunism

The need for biodiversity conservation has been recognised for at least 25 years

Conserving biodiversity is a big challenge

‘*We cannot preserve everything ... The laws of economics apply to diversity*’ Weitzman 1992

Opportunism may explain many reserve choices, but the case for systematic approaches to prioritisation is at least 20 years old

More recently, concern with evaluation of projects

Many project prioritisation options...

- Most at risk threatened species
- Most charismatic threatened species
- Most genetically important threatened species
- Most ecologically important species
- Lowest cost threatened species projects
- Equal expenditures on all threatened species
- Most cost-effective biodiversity projects ...

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Key questions in Project Prioritisation

- What Objective Function to pursue?
- Which Variables in the Objective Function?
- What are the Constraints to actions?
- What Method used to select projects to pursue the Objective Function
- What Data types and Sources to use
- What are the Strengths and Limitations of each prioritisation approach?

Foci

- Reserves, and reserve selection
- Species, and ranking species for the Ark
- Projects to manage species
- Ecological functioning and ranking species for the Ark

Reserves

Are the unit of choice for in situ protection

Goal – ‘separate elements of biodiversity from processes that threaten their existence in the wild’ Margules and Pressey 2000

- Select reserves based on their characteristics, including complementarity of sites
- Data from biophysical databases, and use of surrogates to represent biodiversity

A four stage process – Sarkar *et al,* 2002

Surrogates are selected to represent the conservation *target* - species, vegetation type, ecosystem type, environmental parameters...

Using lists of the surrogates, places are *ordered* according to their biodiversity *content*

For each place, the *projected futures* of the surrogates - populations, species - is estimated and places are reordered based on their *biodiversity value*

Devise *management practices* for each place ‘starting with highest valued places’

Where *and how* to manage

Multiple actions are possible at sites

$ are limited, and actions are costly

Need to determine where and what actions to apply to maximize conservation benefits

An algorithm with benefit functions (effects of actions on species) needed to identify most beneficial actions at each site, given a cost constraint – Zonation

Biophysical, socio-econ data incl. expert opinion

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Species ranking

Metrick and Weitzman 1998 - we can rank projects to achieve highest payoff /$ available

$R_i = [D_i + U_i] \times (\Delta P_i / C_i)$

- Di – distinctiveness
- Ui - utility
- Pi - Present value of change in conservation status
- Ci - Present value of costs

Allocate budget $ on highest ranked projects – fill the Ark

Noah's problem

The Noah's Ark framework ranks species or species projects on the basis of ranking criterion, R, which is a cost-efficiency metric:

$$R_i = \frac{W_i \times \Delta p_i}{C_i}, \qquad (6)$$

where Δp is analogous to our biodiversity benefits, B, and is defined as the change in survivability of a species i and W is the sum of distinctiveness and species utility.

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We modified the cost-efficiency measure to include the likelihood of success of a project and called the modified metric the project efficiency, E, of project i. The E_i was calculated as:

$$E_\mathrm{i} = \frac{W_i \times B_i \times S_i}{C_i}, \qquad (7)$$

where W_i is the species weights, B_i is the biodiversity benefits, S_i is probability of success, and C_i is the cost of project i.

Project Prioritisation Protocol *Joseph et al, 2008*

1. Define objectives
2. List biodiversity assets (threatened species)
3. Weight assets
4. List management projects
5. Calculate cost of each project
6. Predict benefits to species of each project
7. Estimate likelihood of success
8. State constraints
9. Combine info on costs, values, benefits, likelihood of success, rank projects on benefits/$, choose

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Pragamatism

- Considered only distinctiveness and assumed utility of all species was equal (i.e. = 0)
- Wi – taxonomic distinctiveness – inversely related to number of related species – inverse of product of the number of branches at genus, family and order nodes
- Benefits – the difference between probability of the species being secure in 50 years with and without management
- Present value (r=.01) of project costs 50 years
- Success – expert judgment of estimated likelihood of securing the species in 50 years

Returns from $20m expenditure using 5 priority-setting methods

Table 3. The returns on the spending of $20,269,096 over 50 years for each of the 5 priority-setting methods.*

Efficiency metrics	*Weighted efficiency*	*Unweighted efficiency*	*Cost*	*Taxonomic distinctiveness*	*Threat status*
Number of species managed	11	16	20	8	11
Expected benefit gained (B^*S)	6.09	7.39	6.86	4.18	4.02
Uniqueness of species managed (W)	0.96	0.82	0.83	0.95	0.31
Expected uniqueness gained (W^*B^*S)	0.61	0.42	0.38	0.59	0.15

**Returns are measured as number of species managed; expected benefit gained by managing the set of species (i.e., the summed product of benefit, B and probability of success, S); uniqueness of the set of species managed (i.e., summed taxonomic distinctiveness, W); and expected uniqueness gained by managing the set of species (i.e., the summed product of the benefit, B; probability of success, S; and taxonomic distinctiveness, W).*

Application of PPP

Systematic, transparent, and repeatable method for prioritizing actions to minimize the number of extinctions.

DoC assessed management projects & generated rank-ordered list for senior managers in resource allocation for > 2000 projects

<1.5 years, 105 experts consulted

‘By incorporating, management costs, benefits, likelihood of success, ROI substantially improved.’

‘Number of species managed and expected overall benefit to threatened species is remarkably improved.’

Perry 2010, *Functional diversity*

- Species are units but new Objective Function
- Rank species by their contributions to *ecological functioning*
- Noah's Ark is filled with most useful species to ensure functional ecosystem rather than an optimal zoo
- The cost of saving species and the impact of each $ spent determine their importance
- Reformulate law, target *ecological interactions*

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Project Evaluation

"Few well designed empirical analyses assess even the most common biodiversity conservation measures" (Millennium Ecosystem Assessment, 2005)

"If any progress is to be made in stemming the global decline of biodiversity, the field of conservation policy must adopt state-of-the-art program evaluation methods to determine what works and when." (Ferraro & Pattanayak, 2006)

Knowing which conservation actions are effective and cost-effective will enable us to steer conservation resources toward effective uses, and may attract new resources

Challenges to evaluation

- ‘No objective independent or dependent variable’ (Abbitt and Scott, 2001)
- ‘No data on biological outcome’ (Kiesecker *et al*, 2007)
- Cost data (un)availability
- ‘BACIP is ideal way to test effectiveness of conservation’ (Stewart-Oaten *et al*, 1986)
- Ex post studies are often the default situation

Some evaluations

Owl habitat protection, Montgomery *et al*, 1994

U.S. Endangered Species Act Abbitt and Scott, 2001; Ferraro *et al*, 2007

Predator control, Engeman *et al*, 2002; Shwiff *et al*, 2005

NZ endangered species projects, Cullen *et al*, 2001; Cullen *et al*, 2005

UK species projects, Laycock *et al* 2009, 2011

YEP protection actions, Busch and Cullen 2010

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Cost Utility Analysis

Need a technique to determine which programmes are providing the best payoff from resources invested.

Programmes vary in duration, species face differing threats, recover at differing rates.

Need a measure of output that can capture variations in output across the species.

Cost Utility Analysis compares status of a species '*with management*' to a counterfactual - its status '*without management*.'

Cost Utility Analysis

Can we compare a species status, to what would have happened if there was no species management?

Expert assessment required

Quantify the gain from management

$$COPYi = \sum_t (Si_{tw} - Si_{tw/o})$$

Si_{tw} is species' i conservation status in year t with management

$Si_{tw/o}$ is species i conservation status in year t without management

Measure the cost of management

Calculate amount of conservation gain per $ cost

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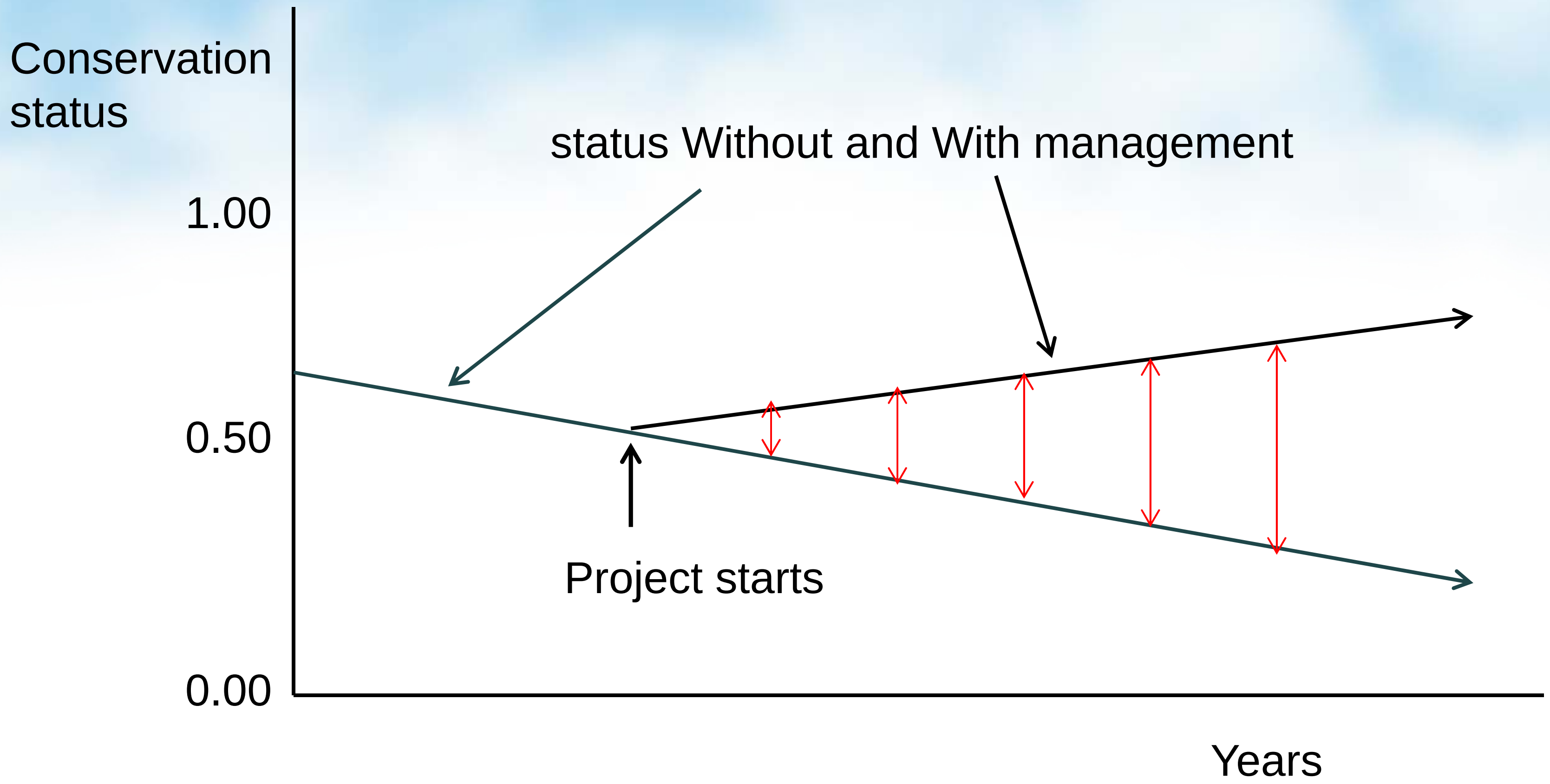
Cost Utility Analysis



Productivity of single species recovery programmes

Species recovery programme	Present value of total cost d = 6%	Present value of COPY produced d=6%	Present Value cost per present value of COPY*
Brothers Island tuatara *Sphenodon guntheri*	13,694	0.33	40,780
Cook Strait tuatara *Sphenodon punctatus*	13,694	0.18	76,457
Campbell Island teal *Anas anas nesietis*	39,940	0.39	103,178
Short tailed bat *Mystacina tuberculata*	318,938	1.73	184,570
Yellow-eyed penguin *Megadyptes anipodes*	603,013	1.97	305,344
Hector's dolphin *Cephalorynchus hectori*	773,844	0.74	1,048,245
Black stilt *Himantopus novaezelandiae*	2,441,822	2.26	1,077,724
Takahe *Porphyrio hochstetteri*	3,278,178	1.41	2,327,560
Mean	935,390	1.23	645,482

Regression analysis, test treatment effectiveness

Busch and Cullen 2009

Yellow-eyed penguin conservation program

- Stationary, observable species
- Nest counts across 48 sites, 15 years

Three conservation measures used at different sites at different times:

- Trapping
- Revegetation
- Intensive Management

Econometric analysis of panel data

$$\ln \lambda_{it} = \beta_0 + X'_{it}\,\beta_1 + \beta_2 \ln \delta_{it-1} + \beta_3 y_t + \varepsilon_{it}$$

- $\lambda_{it} = n_t / n_{t-1}$ – change in nests at site *i* between year *t-1* and year *t*
- X – conservation measures taken
- δ – nest density
- y – year dummy

Results - Intensive management is effective,

- 5.4% average increase in growth rate
- $68,000 per additional nest

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Summary

To maximize gain from biodiversity investments, within a budget, need systematic prioritisation of actions

Predicting impacts of actions is essential, tricky, but increasingly completed

To determine if investments have been effective need to assess payoff from biodiversity actions

Data availability a challenge

Cost effectiveness measures provide useful information for decision makers

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