Biodiversity Protection: Measurement of Output

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The term biodiversity conservation can be applied to efforts to conserve genetic diversity, species diversity and ecosystem diversity. This paper focuses on efforts to conserve species and ecosystem diversity. Efforts to reduce, or halt this rapid loss of species and ecosystems involve significant costs. Environment Department staff of the World Bank report that in Africa alone it has financed or managed for the Global Environmental Facility, 118 projects with biodiversity elements worth US $1.8 billion World Bank (1998). In New Zealand, 1997/98 expenditures on ecological management accounted for $72.5 million or 46.8% of the Department of Conservation budget Department of Conservation (1998a).

These expenditures are argued to be insufficient to stem the losses of biodiversity. Globally, extrapolation of loss rates to numbers of species currently at risk, suggests that biodiversity losses will climb to 200-1500 times the background level and wipe out all currently threatened species (Pimm et al 1995 quoted in Ministry for the Environment 1997). The New Zealand Department of Conservation (1998a) judge that ... "[w]hile there is a lack of detailed information ... current conservation efforts are insufficient to stem the decline in the health of indigenous biodiversity on the publicly conserved estate." Annual expenditures on possum and feral goat control are only sufficient to cover two thirds and half respectively of the areas necessary to provide sustainable control of those pests Department of Conservation (1998a). The Draft Biodiversity Strategy released on 20 January 1999 outlines proposals to halt the decline of indigenous New Zealand biodiversity. The NPV of the proposed expenditures over 20 years is $412 million MFE/DOC (1999). Halting biodiversity decline will be costly.

Because resources available for biodiversity protection are limited, economic efficiency questions are asked about biodiversity protection projects and programmes. A US ecologist Dr Jared Diamond, has offered high praise for some aspects of New Zealand's conservation management ... "The contributions of New Zealand's conservation biologists [have provided] the most imaginative and cost-effective conservation programme in the world" (Diamond 1990).

Surprisingly little research appears to exist documenting the performance or the cost effectiveness of conservation programmes. But the quotations above illustrate that despite problems of data availability, judgments are made on the contribution and merit of biodiversity protection activities. Given the issue faced both nationally and globally - declining health of indigenous biodiversity - and recognizing the facts of resource constraints, and costly protection programmes, evaluation of efforts at biodiversity protection activities is essential. This paper reviews the methodologies available to judge the success and merit of biodiversity protection actions, briefly reviews the empirical work completed to date, and provides recommendations on directions for further development.

1. Biodiversity and biodiversity loss

Biodiversity is defined in Article 2 of the Convention on Biological Diversity as ... 'the variability among living organisms from all sources, including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.' Species and ecosystems are the units which comprise biodiversity and are mutually interdependent. Species and ecosystems in many instances have use value, option value, and existence values to economies. Biodiversity is argued to be ecologically important because it underpins the ability to respond positively and creatively to environmental change Perrings et al (1995).

The world is widely agreed to be experiencing an extinction spasm (Perrings et al 1995) with species loss occurring at 100 to 1000 times the pre-human or background rate (Moran and Pearce 1998). The first New Zealand State of the Environment Report describes biodiversity loss as New Zealand's most pervasive environmental problem Ministry for the Environment (1997). Species and habitat loss has occurred on a major scale in New Zealand during 900 years of human occupation Ministry for the Environment (1997). In New Zealand over 1000 species are considered 'threatened' Ministry for the Environment (1997). Offsetting this loss of species is the rapid rate of development of new varieties of plants, animals and microbes by scientific effort Rose (1992).

Investments are made in many countries to retain biodiversity. Plant, animal and microbe breeding focuses on development of new varieties for use in agriculture, horticulture, forestry, floriculture, aquaculture etc. Varieties of domestic plant species are collected and held in seed banks for breeding programmes. Protection of wild varieties, species, and ecosystems are the focus of legislation and action in many countries. Conservation of those varieties, species and ecosystems provides public goods, whether local, national or global. In most high income countries these actions are predominantly taxpayer funded and government provided. Species protection, is the focus for most of these actions, but increased attention is being focussed on natural habitats and ecosystems MFE/DOC (1999).

2. Key questions

It is useful to consider species, populations and ecosystems as assets which countries have inherited, and which very often require management Swanson (1994). The collection of biological assets make up a country's biodiversity portfolio. Countries have to determine how best to allocate the scarce resources available for management of the biodiversity portfolio. If biodiversity loss is steadily occurring despite protection efforts, they have to decide what they intend to retain in the biodiversity portfolio, and confront the costs of maintaining a biodiversity inventory. The release of a Draft Biodiversity Strategy reveals the nation is focussing on these issues. A thoughtful citizen considering the idea that nations have a portfolio of biodiversity assets, aware that a Draft Biodiversity Strategy has been produced, could also be expected to ask some blunt questions about the portfolio and its management.

(a) Inventory
A fundamental question is what biodiversity assets does the nation currently contain? Biodiversity can be defined at the genetic information level, species level, and ecological association level. Techniques exist to distinguish genetic information. Classification systems have been developed to enable us to distinguish species, and ecological associations. Genetic information and numbers of species are extremely large - perhaps 50 million in the latter case (Moran and Pearce 1998). Terrestrial vascular plants and vertebrates are reasonably well catalogued in some countries, but invertebrates, marine taxon, fungi etc are very poorly catalogued. More than one million species have been identified and described (McNeely et al 1990; Pimm 1995), and a rough working estimate is 1.4 million Ministry for the Environment (1997). In New Zealand approximately 30 000 species of the estimated total of 80 000 have been identified, described and classified by taxonomists (Ministry for the Environment 1997). Australia is similar to many countries in that low percentages of invertebrates, algae, microorganisms have been identified and inventoried State of the Environment Advisory Council (1996). The spatial distribution of New Zealand species is also poorly understood. In contrast ecological associations are much fewer in number, and it has been argued New Zealand is much closer to completing an inventory of these, and of their condition Stephens (1998). Judgements about the current status of biodiversity portfolios may most readily be accomplished at the ecological association level by employing data from land cover surveys to provide surrogate measures of biodiversity.

The first questions focuses on 'what is', but the concerned citizen will look ahead and ask questions about individual asset and biodiversity portfolio management.

(b) Goals
A key question is what goals are being pursued for the biodiversity portfolio? In many countries the focus of attention is on preservation of species. Countries with conservation legislation and departments may be directed to pursue goals of portfolio conservation and enhancement. They may also have risk management goals. Are they the right goals, and are they in fact being pursued?

(c) Trajectory
The citizen can ask about the trajectory for the biodiversity portfolio - is the portfolio increasing in value, static or decreasing? Many authors judge that

globally and nationally, indigenous biodiversity is declining as populations and species are lost (Department of Conservation 1998; Ministry for the Environment 1997; Moran and Pearce 1998). Judgments based on numbers of populations and species are likely to make heroic leaps. If perhaps only 2% of the portfolio is catalogued, and the unknown species are as likely to become extinct as the known species, it is not easy to determine whether a portfolio is growing in value, static or decreasing. A focus on ecological associations, where classification is much closer to completion, may allow more balanced judgements to be completed on the trajectory being followed by biodiversity.

(d) Productive efficiency
Countries use resources to manage their biodiversity assets. The citizen can ask what returns are being achieved from use of those resources? Are the number of species 'at risk' increasing or decreasing? How much is the threat to endangered species reduced by pest control programmes and how long does that payoff last? Output measurements are required to calculate responses to these questions.

(e) Allocative efficiency
The citizen can compare the returns achieved by individual biodiversity protection projects and can ask if greater total returns could be achieved by reallocating the resources amongst the biodiversity management activities. Projections of the likely outputs from alternative biodiversity management activities are required to respond to the citizen. Tougher questioning will ask if the benefits from biodiversity protection exceed the costs of those actions, prompting debate about the possibility of valuing benefits Brown and Shogren (1998).

Citizens can legitimately ask for answers to these five questions. Providing high quality answers to those questions will be challenging tasks for most nations. Question one it has been argued might best be answered by cataloguing size, and numbers of ecological associations, and indexing their status or health. If numbers of ecological associations are relatively small compared to numbers of species, their status could feasibly be individually monitored and recorded. Stephens (1998) argues that New Zealand is close to being able to complete that task for terrestrial ecological associations. If the current health of the biodiversity portfolio can be indexed, then time series data might be established, and trends extrapolated to allow a nation to report the trajectory its biodiversity portfolio is tracking.

Ecologists and economists are in agreement that the establishment of goals is a crucial first step toward coherent biodiversity protection strategy (Spellerberg and Sawyer 1996; Metrick and Weitzman 1998; Moran and Pearce 1998). Goals are essential to determine the targets, which the biodiversity protection expenditures are ultimately directed toward. Measurable goals are likely to be much more useful than ill-defined ones. Legislation provides some guidance on the tasks to be pursued. In the US the Endangered Species Act ... 'directs that priority be given without regard to taxonomic classification to those listed species that are most likely to benefit from recovery plans, particularly species which are in conflict with economic activity' Doerksen, Leff and Simon (1998). In New Zealand the Conservation Act 1987 directs the Department of Conservation to ... 'promote the conservation of natural and historic resources for the purposes of maintaining their intrinsic values, providing for their appreciation and recreational enjoyment by the public, and safeguarding the options of future generations.' Other relevant legislation includes the Wildlife Act 1953, the Reserves Act 1977, the Marine Reserves Act 1971, the Marine Mammals Protection Act 1978, the National Parks Act 1980, the Resource Management Act 1991, the Environment Act 1986, and the Fisheries Act 1996. Much of the current New Zealand conservation legislation fails to provide measurable targets and criteria. A National Policy Statement to assist New Zealand biodiversity management has been proposed MFE/DOC (1999), and this provides an opportunity to include measurable targets.

Biodiversity protection goals can be expressed using asset management terminology. Key ideas from asset management theory are to conserve assets, and to achieve a return subject to some chosen level of risk. Judgement of success or failure at those goals requires quantification of biodiversity assets, measurement of return on assets, and of risk. Some current examples of biodiversity goals are found in the New Zealand Department of Conservation Strategic Business Plan ... "*Conserve and restore the ecosystems in protected natural areas on land, through integrated management actions*", and "*Protect New Zealand's marine natural heritage*" (Department of Conservation 1998a). These are very high level statements, and are too vague to allow consensus to be reached on success or failure in meeting the goals,. The recently released Draft Biodiversity Strategy proposes three biodiversity goals which are more detailed and more clearly defined MFE/DOC (1999).

Questions four and five are the areas where output measurements are required to allow answers to be provided to citizens. Following the creation of goals for the biodiversity portfolio, objectives can be established to determine the way in which the goals will be pursued. Objectives can be focused on specific asset types in the portfolio, or on particular strategies for asset management. Current New Zealand examples include the following Department of Conservation (1998a):

> 1.1.1 Prevent, manage and control threats to maintain or improve the health of natural areas that are important for natural heritage conservation.
>
> 1.1.2 Enhance population numbers and distributional ranges of species and subspecies threatened with extinction, where recovery action will be effective.
>
> 1.1.4 Restore degraded protected natural areas and establish offshore and "mainland" islands where invasive threats have been minimized.

1.2.1 Establish a network of protected natural areas which represent the full range of New Zealand's marine natural heritage.

Moran and Pearce (1997) argue that a basic economic objective to strive for is maximization of biodiversity conserved with a given budget. This statement provides a useful starting point when commencing evaluation of biodiversity protection actions. Economic evaluation of biodiversity protection activities could focus on four issues:

1. are the marginal benefits from biodiversity protection greater than equal to or less than the marginal costs of protection?
2. are biodiversity protection objectives being met in least cost ways, subject to risk of biodiversity loss being maintained below some chosen level?
3. are resources being allocated to the biodiversity protection activities which provide the greatest marginal benefits subject to risk of biodiversity loss being maintained below some chosen level?
4. are the actions of biodiversity protection agencies in accord with society's objectives, or are they pursuing different objectives?

Some authors argue that we must judge biodiversity protection actions by reference to the major issues faced Spellerberg and Sawyer (1996). In New Zealand three classes of biodiversity protection action occur: population and species recovery programmes; island restoration programmes; pest control programmes (Ministry for the Environment 1997, OECD 1996). Given those three different programmes, biodiversity protection activities can take diverse forms including: fire and other physical threat prevention; weed and pest prevention, management, and control; individual species assistance (e.g. aiding beached whales); population maintenance and enhancement; range expansion; habitat protection, management, increase; establishment and regeneration of protected areas. The broad objective of these actions must be to halt the decline or maintain biodiversity, or to reduce the risks to biodiversity in designated areas, over designated time periods. Needed are measures to judge the contributions provided by these diverse conservation actions.

3. Output measures

Biodiversity protection outputs must be distinguished from intermediate targets such as reduced pest numbers at a site following a pest control programme. Outputs in this paper are defined as changes in the status of biodiversity, which result from protection actions. Outcomes in contrast, focus on the impact or consequences for the community, of the outputs produced.

Scoring systems for biological assets are used in some countries to determine priorities for conservation action. New Zealand for example, employs two such systems. A system devised by Elliot and Ogle (1985) is used to calculate Primary Scores for indigenous vegetation at sites around the country to aid selection of areas for pest control. Sites are ranked from highest to lowest Primary Scores

and allocated pest control funds until the budget is exhausted. The method is as follows:
Primary Scores = Rarity x Vulnerability
where
Rarity and Vulnerability are ratings for each site from 1 low, to 7 high.

A second scoring system devised by Molloy and Davis (1992) focuses on species. It sums ratings on seventeen criteria to determine priority scores for each indigenous species. The seventeen criteria are selected to assess five different factors - Taxonomic Distinctiveness, Status of the Species, Threats facing the Species, Vulnerability of the Species, Human Values. Highest scoring species are first in line to receive conservation protection.

These prioritization systems do not provide measures of output from conservation action. They provide statements about the status of biodiversity prior to any protection activity occurring. Because they do not provide information about changes in status, they do not quantify biodiversity gains from conservation action. They are not helpful in providing answers to the citizen who enquires about the returns from conservation projects. Biodiversity protection actions have many dimensions - spatial, temporal, qualitative, riskiness etc. Useful output measures must capture information on several of those dimensions and provide a summary of project performance against the selected criteria.

What measures of biodiversity protection output exist? While many authors have written about biodiversity protection only a handful have grappled with the problem of how to measure conservation output. Some of the measures proposed include: impact on quantity of genetic information available Weitzman (1996); impact on probability of species' survival (Hyde 1989; Montgomery et al 1994); impact on biodiversity standards Spellerberg and Sawyer (1996); impact on a forest quality ladder Kerr and Cullen (1995); impact on species' status COPY, Cullen et al (1997); impact on indigenous ecosystems as measured by Project Merit Stephens (1998). This paper selects some of those measures for scrutiny. Availability of genetic information may be be closely linked to species numbers and their status and that type of indicator is considered below. Several papers use impact on species survival probabilities as their measure of output and this paper reviews the merit of that approach. Impact on a forest quality ladder provides less information than does COPY and so this paper focuses on the latter measure. Biodiversity standards can be encompassed within Project Merit and again I focus on the latter measure.

Table 1 below displays the four selected measures of output from biodiversity protection projects. Output measures can be used to compare 'with project' and 'without project' states. Conservation project evaluation requires some knowledge of starting points and trajectories, irrespective of whether they are species numbers, survival probabilities, COPY or Project Merit scores. Cell contents indicate that projects can make positive, negative, zero, or unknown contributions to biodiversity protection goals.

Table 1. Output measurement by selected measures

	impact on numbers, or status	impact on Probability of Survival	impact measured by COPY	impact measured by Project Merit
individual species (taxon)	+, -, 0, ?	+, -, 0, ?	+, -, 0, ?	+, -, 0, ?
ecological associations	+, -, 0, ?	+, -, 0, ?	+, -, 0, ?	+, -, 0, ?

4. Assessing biodiversity protection measures

Judging the merit of output measures requires some criteria and four are employed in this paper. Output data type - nominal ordinal, interval, ratio - will determine the comparability of measures between projects. The data requirements of each measure will influence their timeliness and costliness. The output measures available are likely to be pressed into use in economic appraisal of biodiversity projects, hence they must provide information which is useful in Benefit Cost Analyses, Cost Utility Analyses, and Cost Effectiveness Analyses as these are the standards tools used to provide answers to the citizen's questions four and five. Widespread practical usefulness is a summary statement for each measure. We briefly explain each output measure, then assess each against the four criteria below.

output type (nominal, ordinal, interval, ratio)
data requirements
aid to economic evaluation
practical usefulness

Change in numbers, or status, of (threatened) species

Head counts of species in a country and comparison between years is one means to assess the output from biodiversity protection projects. If species become extinct this will be noted in the annual head count, and the failure to retain the species will record a lack of output from the biodiversity project. More sophisticated versions are head counts of species on 'endangered species' or 'at risk species' lists. Output can be measured by way of the number of species which move off these lists following biodiversity project actions. Such lists are readily available, easily understood, and make low demands for data. Definitions of 'endangered' and 'threatened' obviously need to be clear and consistently applied Brown and Shogren (1998). The information head counts provide appears to be nominal - at risk, endangered etc. When combined with information on costs it can support simple comparisons between biodiversity protection projects, eg cost to move a species from endangered status back to threatened. Head counts appear to be the simplest of the four output measures considered and provide the least information for project evaluation.

Change in probability of 'species' survival
Hyde (1989), Montgomery et al (1995), Moran and Pearce (1998), DeKay and McClelland 1996), focus on probability of species survival to provide a measure of output from biodiversity protection actions. Montgomery et al argue that no species can be guaranteed survival, and every species has some current probability of survival. The ultimate objective of species protection actions is to maintain or increase the probability of survival for a population, species, or an ecosystem. The output from protection actions is their impacts on the probabilities of survival. Thus Montgomery et al attempt to gauge the impact of increases in area of forest reserved for Northern Spotted Owl habitat on the probability of survival of that species. This approach requires estimation of with and without project survival probabilities, a challenging task. Once the relationship between increase in habitat available and probability of survival of the species has been' established, Montgomery et al, Hyde, can calculate the opportunity cost of the habitat protection project.' Montgomery et al (1995) for example estimate that the marginal cost of increasing the survival probability for the shy Northern Spotted Owl by one percentage point above its current level of 90%, at US $1.4 billion, and increasing the chance of survival from 90 to 95% was estimated to cost an additional US $13 billion. Hyde (1989) completes similar calculations and shows the marginal cost of habitat reservation for the much more gregarious Red Cockaded Woodpecker to be considerably smaller.

This measure of output is useful for determining the economic tradeoffs for projects focused on individual species. Some biodiversity protection projects are directed at ecological associations rather than an individual species, or they have beneficial impacts on numerous species. In those circumstances calculation of survival probabilities seems of limited value. If the focus of a project is an ecological association, the target may be improvement in the health of the association. Direct measures of ecological association health seem more appropriate measures for those projects.

Biodiversity protection very often involves multi-year projects and hence output measurement requires recognition of dynamics. New Zealand examples include island regeneration, projects, which control pests such as goat, possums, stoat, and weasels. Suppression of these pests can require perpetual control actions and provide benefits over many years. If the pest control activity occurs infrequently and pest numbers rebound following control, the biodiversity benefits will decay over time. Survival probabilities are ill suited to measuring the outputs from this type of activity.

New Zealand has 1000 plus species 'at risk' Ministry for the Environment (1997). Calculation of survival probabilities with and without biodiversity protection actions for all 1000 plus species would be a major task. The magnitude of the scientific effort required to complete these calculations diminishes the likelihood of widespread use of survival probabilities as an output measure. If the requirement is for an output measure which enables comparison to be made between projects, survival probabilities appear to be little better than head counts. Ultimately they appear to provide ordinal data - a species is 'more' or 'less' at risk.

COPY

Biodiversity protection projects are typically multi-year, have varying success between projects, and provide varying levels of protection over time. Valid output measures need to be able to cope with those features. One measure designed with those requirements in mind is Conservation Output Protection Years - COPY (Cullen et al 1998; Fairburn 1998). COPY has several similarities to Quality Adjusted Life Years (QALY) which are widely used in Cost Utility Analyses of health care Drummond et al (1997).

COPY for a biodiversity protection project are calculated by scoring the health of a population, or an ecological assembly, prior to the commencement of a project and for each year during the project time horizon. Scoring of health is completed by reference to a Conservation Asset Security scale CAS. The scale has 7 levels as shown below.

Table 2. The Conservation Asset Security (CAS) rating system

6	The asset is secure, very high survival probability, no need for active management
5	The asset is in need of occasional monitoring in case potential threats become actual threats, some uncertainty
4	Positive prospects for asset security so long as potential threats continue to be managed, some security concerns/questions unanswered
3	Marginal/poor asset security, in need of additional management or input to remedy and mitigate threats to security
2	Very poor asset security, very large management effort required to secure the asset, in need of management and or research to determine how to improve asset security, very large concerns over future security
1	The asset cannot be protected, there is no possible management action available given present technology
0	The asset is extinct

If CAS are estimated for each year of a project, then number of COPY produced by the project can be calculated as below:

$$COPY = \sum_i [(CAS_i + CAS_{i-1})/2] - CAS_0 \qquad (1)$$

Where
CAS_i - Conservation Asset Security in year i
CAS_0 - Conservation Asset Security in year 0

A biodiversity protection activity for a population or an ecological assembly can be evaluated by dividing the number of COPYs it delivers, by the cost of the biodiversity protection action. This calculated cost per COPY can be compared to similarly calculated costs per COPY for other biodiversity protection actions. COPY has been tested in the field in New Zealand, appears to make low demands for data, and readily passes practicality tests Cullen et al (1998).

An obvious modification of this approach is to replace the CAS_0 scores by projected scores for each year in the 'without project' situation. This modification would then capture the contribution of a project which for example holds constant the CAS scores for a population, if the without project CAS scores are declining.

The CAS scale used to date is linear, which asserts that a movement from 1 to 2 on the scale is equal to a movement from 6 to 7 on the scale. The definitions for each point on the CAS scale are based upon management status of the species rather than strictly biological criteria. COPY measure but do not value output from a biodiversity protection project. They do not distinguish between output produced from protection of a unique species and output from protection of a population which has similar populations in say another region. However the COPY can be weighted for biological importance using an existing scoring system such as the Molloy and Davis scores currently used by the Department of Conservation to prioritize sites for conservation action Molloy and Davis (1992). COPY scores can be calculated after discounting the gains or losses in CAS to reflect the fact that distant conservation achievements are less valuable than current conservation achievements.

Project Merit
A multi-dimensional measure of conservation output has been proposed by Stephens (1998). He argues that the return from a conservation project can be defined in a number of steps, and in general is ... 'the alteration in natural character and spatial extent of natural areas in ways that enhance the sustainability of natural heritage.' His measure appears directed particularly at ex ante project evaluation. The steps required to calculate project return are as follows:

Project Return = Final Site Value x Project Efficacy (2)

where
Project Efficacy = $(Size_w \times NC_w) - (Size_{wo} \times NC_{wo}) - (R \times Size_{wo} \times NC_{wo})$ (3)
and
Size is the logarithm of site area
subscripts w and wo refer to with and without the conservation project
R is a recovery index to reflect society's concern about the duration of damage, and t is the projected time in years until satisfactory recovery occurs. it is represented by a function $R = exp^{-ln(1 + \beta t)}$. The index ranges in value between 0.0 and 1.0.

Site Value Stephens (1998) defines as being comprised of four substantially independent attributes and is defined as:

Site Value = Distinctiveness + Importance + Size + Natural Character (4)

Suggestions on methodology to index Distinctiveness, Importance and Natural Character are provided by Stephens (1998) Sections 4.1.1- 4.1.2.

Project Merit is Stephens' index of project worth and is defined as:

Project Merit = Project Return x Urgency x Feasibility (5)

Suggestions on methodology to index Urgency and Feasibility are provided by Stephens (1998) in Sections 4.2.1 and 4.2.2 and both will take values between 0.0 and 1.0.

Stephens (198) observes that the attributes Return, Urgency and Feasibility of a project's outcome can be characterized, and he has proposed an approach to measurement and combination of these attributes into an index of outcome worth, i.e. Project Merit.

Assessment of Stephens' proposed measure of conservation output could focus on some key points - internal logic, data requirements and feasibility. His proposed measure Project Merit, can be interpreted as providing an estimate by conservation experts of the projected discounted utility expected to arise from conservation projects. This is considerably more ambitious than any other conservation output measure proposed to date combining as it does biological, psychological, spatial, temporal, and risk elements to calculate scores. Stephens observes that ecological assemblies are well catalogued in New Zealand, and Project Merit can be applied at that scale. The data requirements of this proposed approach are large and assessment of each conservation project appears to require 37 items of data. The proposed measure may be very costly to employ.

A summary of the respective characteristics of each output measure is provided in Table 3.

Table 3. Assessment of the biodiversity protection output measures

	Output type	Data requirements	Aid economic evaluation	Practicality
Head count of species	nominal	small	limited	good
Survival probabilities	ordinal	huge	moderate	limited
COPY	interval	moderate	high	good
Project Merit	interval	large	uncertain	limited

5. Empirical work

Moran and Pearce (1998) note ..." the total absence of any work on the issue of effectiveness'. Data problems, ill-defined objectives, and the complexity of the evaluation task all impose obstacles to evaluation. Noted in earlier sections are research reports by Montgomery et al (1994), Hyde (1989). These provide empirical research, but the focus of those articles is on potential biodiversity protection actions rather than ex post evaluation of actual projects. In practice there are very few examples of ex post evaluation of biodiversity protection output.

Biodiversity protection performance monitoring completed by conservation agencies typically reports numbers of projects completed, together with indicators of progress such as breeding success rates for bird species, increases in numbers of weta. In some instances there are reports of changer in status for a species from Endangered A to Endangered B Department of Conservation (1998a). These reports provide the raw material for evaluation. Needed is measurement of the duration and quality of status changes, analysis which consider the costs of gains accomplished, and comparison across biodiversity protection projects.

In New Zealand information exists on numbers of species conservation programmes, and species recovery programmes Ministry for the Environment (1997). New Zealand and Australian State of the environment reports both provide information on numbers of species on their 'endangered' lists. Time series of these data might be used to provide measures of status change, crude measurement of output, and allow comparison of the costs of achieving those outputs. Surprisingly, even data on trends in numbers of endangered species is lacking in the New Zealand State of the Environment report Ministry for the Environment (1997).

Cullen et al (1997) explicitly focus on output measurement and report on numbers of COPY produced by six New Zealand biodiversity protection projects. That research employs Cost Utility Analysis and illustrates the range of costs per COPY for the six projects. Table 4 below provides information from that research.

Table 4: Outputs and costs of six conservation projects

Project	COPY	Mean annual PV of costs, r = 7.5%	PV of costs per COPY, r = 7.5%
Whitakker's Skink	15	9 508	7 606
Kakabeak	4	8 267	18 601
Hector's Dolphin	17	54 865	32 260
N.I.Kokako	4	161 654	323 308
Black Stilt	0	130 304	-
Brown Teal	-3	13 029	-

Source: Fairburn (1998)

The calculations illustrate that for the four species, which produce positive conservation output, PV of costs per COPY, have a very large range from $7606 to $323 308. The cost per COPY for protection of Kokako at Mapara is 42.5 times greater than the cost per COPY for Whitakker's Skink.

Numerous non market valuation studies have been conducted which focus on biodiversity protection. Typically those studies ask respondents about their willingness to pay for a proposed or hypothetical change in biodiversity status (Kerr and Cullen 1995; Carson 1998; Morrison et al 1998). Eliciting useful responses to those questions requires that respondents be well informed about likely changes in biodiversity status. Ensuring that respondents are well informed and able to make valid judgements about the item to be valued appears to be a major challenge DeKay and McClelland (1996). The development and adoption of standard units for output measurement may aid that work.

6. Discussion

Significant expenditures are already directed toward biodiversity protection, and there are many proposals for further conservation action, each likely to result in further cost. Expenditures require justification, and in this area measurement of the outputs resulting from biodiversity protection seem essential to evaluate what is being produced and at what cost. Similar questions are asked of health care programmes and it is noticeable that methodologies have been developed to allow economic evaluations of health care to be completed. Search of the biodiversity literature reveals that there are a large number of articles on biodiversity protection, but far fewer which report empirical research.

A number of biodiversity protection output measures have been devised and used in economic research, but measurement of conservation output achieved is rare. Versatile, widely useful techniques for measuring output are required to determine what is being achieved, and to aid future decision making on biodiversity protection. Head counts and change of status measures are widely used at present but provide only nominal data. Needed is a measure which captures and summarises change in status over time. COPY has been designed to meet that need, and a first trial has demonstrated its practicality. But that measure requires further scrutiny to determine if it provides a valid, widely useful measure of output.

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