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Challenges in the successful implementation of ecological restoration projects: How can economics help?

Abstract

Restoration scientists and practitioners have recently begun to include economic and social aspects in the design and the investment decisions for restoration projects. With few exceptions, ecological restoration studies that include economics focus solely on evaluating costs of restoration projects. However, economic principles, tools and instruments can be applied to a range of other factors that affect project success. In this paper, we consider the relevance of applying economics to address four identified key challenges of ecological restoration: (1) assessing social and economic benefits, (2) estimating overall costs, (3) projects prioritisation and selection, and (4) long-term financing of restoration programs. We observed that it is not common to consider all types of benefits (such as non-market values) and costs (such as transaction costs) of restoration programs. However, efficient allocation of scarce public funding depends on rigorous assessment of the benefits and costs of the programs. We discuss how various economic principles, tools and instruments could be used to assist in overcoming them. We also highlighted the importance of often overlooked aspect of restoration that is securing continuous (or long-term) funding to achieve restoration goals. We reveal several strategies that agencies could employ to secure additional or long-term funding including establishing synergy with existing programs, public-private partnership and financing through council tax.

Key words: Conservation policy, Environmental economics, Non-market valuation, Project prioritization, Restoration programs

Introduction

While the importance of ecosystem restoration as a biodiversity conservation strategy is well established (Benayas et al. 2009), the design and implementation of restoration projects is complex and effectiveness highly variable. Jones and Schmitz (2009) reviewed 236 restoration case studies and found that only one-third demonstrated complete ecosystem recovery, whereas two-thirds reported partial or no recovery. Benayas et al. (2009) conducted a meta-analysis of 89 studies and found that, even though the results show an increased provision of biodiversity and ecosystem services by 44% and 25%, respectively, the values of biodiversity and ecosystem services of restored sites were below that of undisturbed reference sites. The variable effectiveness of restoration practices highlight the many challenges facing the successful implementation of ecological restoration projects (Maron et al. 2012). These challenges include ecological, technical, social and economic aspects of the restoration projects, behavioural aspects of those tasked with delivering the projects, and the values of communities who benefit from the restoration. The aim on this paper is to discuss ways that economics can contribute in tackling these challenges concerning ecosystem restoration.

The science and practice of ecosystem restoration has for many years been based primarily on ecological considerations (Aronson et al. 2006). Only recently have restoration scientists and practitioners begun to include economic aspects in the design of restoration projects (Blignaut et al. 2014). With few exceptions (e.g., Groot et al. 2013), ecological restoration studies that include economics focus heavily on the cost of restoration projects (Bullock et al. 2011; Wilson et al. 2012; Adame et al. 2015). While incorporating cost information is an important step in making sound economic decisions in conservation expenditure, there are many other facets (including principles, tools and instruments) of economics that can contribute to improving the effectiveness and efficiency of restoration programs (Yin et al. 2013). Economic principles are the rules for allocation and decision making (such as optimal resource allocation based on marginal cost and benefit) in economic theory. Economic tools and techniques (such

as non-market valuation techniques to measure social preferences of intangible benefits) are the application of economic principles and theories to collect information and make allocation decisions. Economic instruments (such as market-based instruments) are policy mechanisms (based on economic theories) applied to design and implement programs to achieve certain objectives.

Recently, the applications of economic tools to measure the benefits of ecological restoration have been explored. For example, Schultz et al. (2012) provide an in-depth discussion of the application of non-market valuation to estimate restoration benefits. Non-market valuation techniques are used to estimate people's willingness-to-pay when there is no established market. The authors considered different types of indicators used in the non-market valuation studies and observed that if the indicators do not capture the main characteristics of the ecological process, the estimated non-market values will not be reliable. Robbins and Daniels (2012) also discuss the use of economics of restoration benefits and costs, recommending the use of benefits and costs information during the early planning phase of restoration projects.

In this study, we identify opportunities for the wider application of economic principles, tools and instruments in ecological restoration, from the planning of individual projects to the long-term financing of whole restoration programs. We summarise how economic tools and principles may address key project challenges, improve effectiveness and efficiency of ecological restoration projects. Our aim is not to provide a comprehensive review of the literature, but rather to draw on previous research to identify ways in which economics may specifically address the following four key restoration issues: 1) estimation of restoration benefits (Yin & Yin 2010; Bullock et al. 2011); 2) estimation of the costs of restoration (Menz et al. 2013; Armsworth 2014); 3) the selection and prioritization of projects (Miller & Hobbs 2007; Suding 2011), and; 4) securing long-term financial resources to support restoration (Holl & Howarth 2000; Bullock et al. 2011; Halme et al. 2013). We describe in detail each challenge (Table 1) and how each could impede success for ecological restoration, highlighting the present opportunities for using economic principles, tools and instruments that can be used to address them.

Challenge 1: Estimating the restoration benefits

The restoration of damaged or degraded ecosystems is often the primary objective of ecological restoration projects. In many cases, focusing restoration project outcomes purely on ecological benefits is well-justified, for example, in the case of a statutory requirement to conserve or restore an ecosystem or species. However, one concern is that in many cases, restoration practitioners are failing to demonstrate the links between ecological restoration, society and policy and are underselling the evidence of benefits of restoration as a worthwhile investment for society (Aronson et al. 2010; Wortley et al. 2013). A number of studies have found that private landholders are more likely to participate in restoration projects where there is a clear benefit, financial or non-financial (i.e., social goals), to their participation (Januchowski-Hartley et al. 2012). Therefore, consideration of broader social and economic benefits of restoration could help advocates and practitioners in restoration activities to tailor their programs to promote better engagement (Aronson & Alexander 2013).

Determining the social and economic benefits of restoration could be particularly useful for conservation agencies to seek cooperation from a private landholder on whose land the restoration is to occur. These agencies often operate in a budget constrained environment. The significant opportunity cost of restoration on agricultural land can present a barrier to restoration programs and increase the overall cost (House et al. 2008). Alternative restoration program designs that can reduce economic costs (e.g., reduction in agricultural production) may facilitate restoration in areas that have been traditionally difficult to access by conservation managers (Ansell et al. 2016). Although such an approach may necessitate some compromise in restoration design (i.e., in the size, or location of projects), they could lead to higher social acceptability and higher overall environmental gains compared to the alternative scenario (i.e., no restoration) (Petursdottir et al. 2013).

If there is a case for incorporating social benefits in planning and selection of restoration projects, then a key challenge is how these are assessed. Economics has a number of methods available for benefit assessment of ecosystem services and other societal values. The method applied depends on the type of value likely to be produced by the restoration project. Market based methods are generally not

applicable, as most of these values are not traded in formal markets (i.e. also known as non-market values). These non-market values are either a “use” value, like recreation, or a “non-use” value, like preserving a threatened species for future generations. Revealed preference approaches are applied to measure use values while stated preference approaches are applied to non-use values (Whitehead et al. 2008).

The revealed preference approaches, such as hedonic pricing and travel costs methods, use observed behaviour to estimate an individual’s willingness to pay for various goods or services (Whitehead et al. 2008). The hedonic pricing method uses heterogeneous or differentiated goods that are sold in a market, such as land, houses or cars, to determine the values of key underlying characteristics of these goods, including values of environmental assets (Taylor 2003). The travel cost method is used to estimate the benefits of outdoor recreation based on the assumption that costs of travel and time are the main cost to individuals engaged in outdoor recreation (Whitehead et al. 2008).

The stated preference approaches include contingent valuation and choice experiments and use hypothetical data, typically from community surveys, to estimate individuals’ willingness to pay for the gain or avoided loss in the value of a public good or service. In choice experiments, respondents are presented with a series of options where each option specifies the attributes or characteristics of the project and the amount of money individuals would pay to achieve options. The choices made by the respondent are used to estimate an individual’s willingness-to-pay, and aggregate value of the non-market good to society.

Both revealed and stated preferences approaches depend on primary data collection which can require significant resources, which are limited in many conservation agencies. Another approach is to use benefit transfer, where the results from the existing primary valuation studies are used to predict the values of benefits or services at a new policy site (Rolfe et al. 2015). The decision to use benefit transfer instead of a primary study depends on a number of factors, including: the availability of valuation data for the policy site; the availability of high quality studies at similar policy sites; and whether decision makers require exact valuation data for the policy site or can use approximations from benefit transfer

(Holland et al. 2010). If carefully conducted, benefit transfers have the potential to provide a reasonable approximation of the value of unstudied resources (see Johnston et al. 2015 for a comprehensive guide to benefit transfer). Many high profile environmental policies in the United States (Loomis 2015) and Europe (Brouwer & Navrud 2015), and some in Australia and New Zealand (Rolfe et al. 2015) utilise benefit transfer for estimating non-market values of intangible benefits.

Estimating non-market values of intangible benefits could be useful for planning a restoration project for a few reasons. First, it provides a broad understanding of the value for money of investment in restoration programs. For example, the restoration of grassland bird populations through the Conservation Reserve Program in the United States was estimated to generate USD\$33 million per year in non-use (or existence) value (Ahearn et al. 2006). Secondly, it helps in directly comparing expected benefits with expected costs (which are rarely expressed in non-monetary terms). Finally, it helps in demonstrating the distribution of benefits among different types of stakeholders, such as private landholders. For example, non-market valuation studies have shown that increasing the amount of natural vegetation can generate private amenity benefits reflected in increased property values (Polyakov et al. 2013), and Dumbrell et al. (2016) found people's attitudes towards climate change influenced their willingness-to-pay for increasing the area of native vegetation on farmland.

Like the application of any ecological or economic tools, application of non-market valuation techniques requires careful planning and judgement. They are often expensive to conduct and require specific skills. Each of the above mentioned methods have their own strengths and weaknesses (see Bateman et al. 2002; Kanninen 2007). Non-market valuation may not be suitable for all restoration projects, particularly those that are small-scale (see Rogers et al. 2015) or designed only to provide ecological benefits. However, in many instances it would be beneficial for the agencies to consider non-market values (which includes ecological benefits) of the restoration programs.

Challenge 2: Estimating the cost of ecological restoration

When public funding for biodiversity conservation is limited, information on cost is important for ecological restoration planning because it allows decisions to be made about whether to conserve or to restore, which restoration projects to select, and which restoration methods to use. Inappropriate accounting for costs during the planning phase of restoration projects could result in wastage of public funds, selection of wrong projects, and failure to achieve restoration targets. This is especially important when multiple methods with varying costs could be used to achieve the desired restoration outcome. However, restoration costs are rarely reported by ecological restoration studies and published cost data are often collected using different approaches, making them hard to compare (Bullock et al. 2011). There is also evidence that not all types of costs are considered during planning restoration projects (Pastorok et al. 1997; Groot et al. 2013). There are four main cost types in restoration: acquisition, establishment, maintenance and transaction costs. We describe each below.

Acquisition costs are the costs of acquiring the property right to the parcel/s of land to be restored. The acquired rights could be total (such as when a parcel is purchased outright) or partial. Partial costs might include purchasing some of the property rights, as conservation easements, covenants or restrictions (Kabii & Horwitz 2006), or purchasing rights for a specific period of time, such as conservation contracts (Stoneham et al. 2003). When a formal acquisition is not required, for example to restore public lands, the allocation of land to ecological restoration or protection still incurs an acquisition cost to society in the form of an opportunity cost. Opportunity cost is a measure of what could have been gained via the next-best use of land (Naidoo et al. 2006). Opportunity costs are often used to estimate landholders' compensation when conservation is conducted on private lands, particularly agricultural land (Mewes et al. 2015).

An important and often overlooked feature of acquisition costs and opportunity costs is their variability within and between properties (Armsworth 2014). This is caused by heterogeneity and/or fragmentation of land quality, land use and ownership. At a regional scale, as land is used up for restoration, the acquisition costs of the remaining land increases due to demand increasing the remaining lands' market

price (Jantke & Schneider 2011). At a local scale, ecological restoration on one property may create a spill-over effect by changing the ecological values of neighbouring properties (Butsic et al. 2013). At a property scale, when a fraction of a property is being acquired for restoration, acquisition cost of each additional unit of land may be higher than the cost of the previous unit due to the diminishing marginal benefit of land (Polyakov et al. 2015). Heterogeneity of acquisition costs could influence outcomes of a restoration program. For example, if heterogeneity between different properties is not considered, the financial incentive rate paid to private landholders could be set too low or too high. The former will result in lower participation and the latter will result in cost-ineffective outcomes (Iftekhar et al. 2012).

Establishment costs are upfront capital investments in restoration and, depending on the nature of the project, could include engineering works (for example in mine site or wetlands restoration), site preparation, planting or seeding, and fencing. Such costs are often highly variable but have not received sufficient attention. In the conservation literature, they are usually considered part of management costs (Naidoo et al. 2006), but they should be treated separately in the evaluation of ecological restoration because they could constitute a substantial proportion of total costs and because the selection of the ecological restoration method determines both costs and outcomes of the projects. The costs depend on the type of ecosystem being restored, level of degradation/modification of the site, selected methods, and weather condition (Kimball et al. 2015). Even aspects of the design of individual restoration sites, such as shape, can have a substantial influence on cost and cost-effectiveness of a project (Ansell et al. 2016).

Maintenance costs include ongoing management, administration, and monitoring. Ongoing management, such as the upkeep of fencing to control of invasive and feral species, is crucial for the project to succeed and is often neglected when estimating costs of ecological restoration projects. Monitoring the outcomes of restoration provides the basis for assessing the performance of restoration interventions as well as informs project funders and the broader society of the results. Ironically, however, this element of the project cycle is often poorly resourced and/or conducted (Brooks et al. 2006; Nichols & Williams 2006). As a result, there is growing attention paid not only to improving the

rigour of monitoring of restoration projects, but also their cost-effectiveness (e.g., Lindenmayer et al. 2012).

Transaction costs may include searching for suitable sites, organising programs and negotiating and signing contracts (Elmendorf 2004). Transaction costs are especially important for ecological restoration as they represent a large upfront investment and may provide a barrier for otherwise feasible restoration projects. However, these costs are often omitted in the evaluation of environmental programs (McCann et al. 2005). This is a critical omission as studies on general agri-environmental policies indicate that transaction costs could range from 20% to 50% of total policy costs (Coggan et al. 2010).

Various economic tools could be employed to estimate different types of costs. Establishment and maintenance costs are often most easy to estimate as market prices are available for most items under these costs categories. Acquisition costs and opportunity costs are estimated using capitalised gross revenue or gross margin of the productive use of land, or using methods based on property or land sales prices, such as hedonic pricing. When entire properties are acquired for ecological restoration, methods based on property values are more appropriate, because they capture all the values associated with the property beyond its productive (e.g. agricultural) value, such as amenity values. On the other hand, where partial property rights are acquired, methods based on estimation of the value of foregone benefits are appropriate because the owner retains some of the rights to the property. Transaction costs could be estimated by conducting surveys among the participating landholders or agencies. For example, Falconer and Saunders (2002) estimated agreement level transaction costs of around 50 agri-environmental programs using an organizational survey and document reviews.

Challenge 3: Prioritizing restoration projects

Project funding in many countries worldwide follows a democratic process, where a project analyst provides information on each project option so that the actual decision-maker is sufficiently informed to make their own well-founded judgements about a projects' social desirability (Nyborg 2012). Benefit cost analysis, provides information on the efficiency and social welfare of a project. It informs decision

makers in the political process about the projects or investments that will lead to the greatest net benefits to the community as a whole.

The next step in efficient project prioritisation relies on the accurate identification and estimation of benefits and costs. The potential loss from not considering all the benefits and costs could be demonstrated through the following hypothetical example (Table 2). First we assume that a public agency has a fixed budget (\$200,000) and can only select a sub-set of restoration projects from a set of projects. Each project has an estimate of expected environmental benefits and costs. The agency uses a cost-benefit ratio criterion to select projects, i.e., the project with the lowest cost-benefit ratio is selected first followed by the project with second lowest cost-benefit ratio and so on. However, let's assume that the agency does not have full information about the cost and uses the partial cost information to calculate cost-benefit ratio. If the partial cost-benefit ratio is used then the first four projects would be selected within a given budget of \$200,000. However, if the true cost is used to calculate the cost-benefit ratio then only the top three (1-3) projects could be selected.

<Table 2 here>

Therefore, by using the partial cost information, the agency is assuming the possibility that the total expenditure will be higher than the allocated budget. There could be two possible outcomes: either the agency will have to find additional money to implement the selected projects or some projects will need to be ceased prior to completion to reduce expenditure. The former will make a restoration program expensive, and socially inefficient, and the latter will run the risk of not achieving environmental outcomes, which is also cost-ineffective.

It could be further observed that projects with low cost will be selected even if partial cost information is used and high cost projects have little chance of getting selected. It is only the medium cost projects which are more sensitive to the cost estimates. Empirically, Carwardine et al. (2010) show that impact of cost data uncertainty on the prioritization of sites for conservation largely depends on the importance of the projects in achieving conservation goals. The sites which were essential or unimportant for meeting conservation goals maintained high or low priorities, respectively, regardless of cost estimates.

Sites with intermediate conservation priority were sensitive to cost data uncertainty: these represented the best option for efficiency gains.

In situations when the benefits and, to a lesser extent, the costs, are uncertain, delaying restoration to reduce uncertainty could allow achieving a more cost-effective allocation of funding across competing projects (Nelson et al. 2013). The benefit of delaying investment in the face of uncertainty could be assessed using Real Option Analysis (Freeman 1984; Majd and Pindyck 1987; Regan et al. 2015), which has been applied to prioritize and rank conservation Kassar & Lasserre 2004; Leroux et al. 2009; (Ben Abdallah & Lasserre 2012) as well as ecological restoration projects (Leroux & Whitten 2014).

Once the costs and benefits have been appropriately measured, the choice between projects requires a metric, which is a formula or a model to translate the various parameters of a project (such as cost, effectiveness and area) into a single score. Pannell and Gibson (2016) provide an empirical example of the importance of using a theoretically correct metric design in the selection of conservation projects. They found environmental losses from poor metric design could be up to 80% compared to the situation when a theoretically correct metric is used. The most costly metric errors are omitting information about environmental values, omitting project costs, omitting the effectiveness of management actions, and using a weighted-additive decision metric for variables that should be multiplied.

The use of a rigorously designed metric is even more important when combining multiple benefits. While restoration may generate ecological, economic and social benefits, the relationship between these benefits may be complex, and possibly conflicting (Bullock et al. 2011). Restoration strategies that target these multiple benefits may therefore necessitate trade-offs in one or more of those values. Concessions may be required in the location, design and complexity of restoration projects in order to achieve broader benefits. For example, the strategies that maximise biodiversity benefits of grassland restoration in agricultural production landscapes may exceed that required for increases in pollination services to the farmer, as well as impact on agricultural production (Korpela et al. 2013). The acceptability of such a trade-off is likely to vary between restoration projects and depend on factors

such as the project outcomes specified by regulatory or funding bodies, the threat status of the biodiversity asset and the value of the biodiversity asset to the community.

Challenge 4: Long-term financing of restoration projects

Even where restoration benefits and costs have been correctly assessed and appropriate prioritization procedures employed, without adequate financial support failure is a possibility. This is particularly acute in ecological restoration projects that require long timespans, often decades, to achieve objectives and to be considered successful (Jones & Schmitz 2009). While there are examples of long-running environmental programs (the Conservation Reserve Program in the United States was established more than 30 years ago), in most cases environmental programs have short funding timeframes. For example, the environmental and restoration projects funded under market-based initiative programs (such as BushTender, EcoTender in Australia) lasted 3 – 5 years (Iftekhar et al. 2009). Therefore, it might be useful for agencies to consider innovative solutions to securing long-term funding, an issue considered by some as one of the greatest hurdles currently facing restoration (Aronson & Alexander 2013). Long-term funding could be implemented through various economic instruments and financial arrangements. Below, we discuss a number of such potential solutions.

Work with an existing funding arrangement: Funding through existing government mechanisms could be a cost-effective way to fund long-term restoration projects. A prominent example is the Environmental Stewardship Program in Australia where AU\$152.3 million was invested in long-term contracts (up to 15 years) with private landholders to provide ongoing agri-environmental services (Zammit et al. 2010; Lindenmayer et al. 2012; Zammit 2013). The commitment of long-term contracts presents a substantial departure from previous funding models for conservation programs in Australia, which have been historically characterised by the disbursement of public funds for conservation through regional and local government and non-government bodies (Hajkowicz 2009). While programs are funded through existing government budgets, a key aspect of the Environmental Stewardship Program was that funds were secured beyond the forward estimates of the Government. Securing funds through

establishment of specific “beyond-government” accounts is challenging, but critically, allowed for enduring action on long-term environment programs.

Developing synergy with existing programs: Undertaking restoration programs in isolation could be costly. Agencies could consider restoration activities in combination with other activities (such as habitat protection, eradication of invasive species, carbon credits, etc.). For example, Kappes and Jones (2014) discuss the potential for combining programs for eradication of invasive mammals and restoration of seabird populations, two programs that are commonly undertaken separately for different objectives. The authors showed that by combining these programs it is possible to improve the effectiveness of the program. Moreover, it is possible to access greater funding opportunities. In another example, Matzek et al. (2015) discuss the potential to fund a riparian restoration project in California. They observed that carbon credits alone can cover the establishment and maintenance costs provided that sufficient effort is committed in the first few years of the restoration program. However, it may not be enough to cover the opportunity costs of private landholders and requires funding from other sources, further illustrating the importance of accounting of the full range of restoration costs as outlined above.

Financing through property tax: It has been shown that environmental restoration can improve the wellbeing of communities (Pressey et al. 2002). Such improvement in well-being is often reflected in increased house prices (Polyakov et al. 2016). Local governments typically collect property taxes based on property values. Implementation of restoration projects may result in the rise of local government revenues due to increase of house prices. Local governments could use this additional money to fund restoration programs. If the restoration program is large-scale, local governments could borrow money against the expected increase in tax to finance restoration (Paull & Lewis 2008). The limitations of this approach are that for the restoration to have impact on property prices it should be within close proximity to residential areas.

Public-private partnership: Private investors can be substantial contributors to restoration programs. For example, around 23% of the funding provided for the River Network, a US-based association of 2000 organizations, was sourced from corporate funders (BenDor et al. 2015). Among the reasons

private investors or commercial enterprises invest in restoration programs are: to meet regulatory requirements, to meet corporate social responsibility, as an investment mechanism to earn profit, for cost saving purposes and / or to improve their brand profile (BenDor et al. 2015; Videras & Alberini 2000). Being largely immune to the short-term political cycles and public pressures on competing policy priorities, corporate sponsors may provide a more secure and flexible source to augment restoration funding.

Payment for ecosystem services (PES) is a concept often used to solicit private investment in restoration. One of the early examples is the US\$1.5 billion investment by New York City in watershed conservation to avoid large infrastructure projects (McPhearson et al. 2014). Another example is the payment for ecosystem services program by Clean Water Services, a wastewater utility in Oregon, where landholders were paid to plant trees in riparian areas to reduce warming effect from solar radiation (Bennett et al. 2014). Under the United Nations Reducing Emissions from Deforestation and Forest Degradation (REDD+) program, companies often form partnerships with NGOs, government agencies and local communities to protect forests. PES programs are not without risks when applied to restoration, including the threats to enduring benefits as schemes reach completion and land use is reverted, with long-term sustainability being a primary concern (see Bullock et al. 2011).

Volunteerism: Private landholders often undertake conservation programs on their land for personal reasons such as from a sense of stewardship (Greiner 2015). In many studies landholders' intrinsic motivations have been identified as one of the primary reason for their participation in environmental programs (Clayton 2011; Greiner & Gregg 2011; Blackmore & Doole 2013). People also contribute money and labour to many environmental programs such as revegetation (Langenfeld 2009). Crowdfunding, where individuals could donate money to specific projects, has been recently trialled to generate funding for many projects (Hörisch 2015). It might be possible for agencies to generate funding and manpower for restoration programs by appealing to the philanthropic nature of individuals.

Conclusions

There have been several attempts in recent years to highlight the benefits of incorporating economics into ecological restoration. To date, this literature has largely focussed on the use of cost information in the spatial planning of restoration projects (Schultz et al. 2012). While this is an important step in improving the effectiveness of scarce conservation funding (Perring et al. 2015), in this paper, we have identified three additional areas where principles, tools and instruments from economics could be useful: assessment of benefits, project prioritization, and long-term funding. We observed that the appropriate selection of a project depends on a rigorous assessment of the benefits and costs of the programs. While ecological benefit assessment tools are commonly used, proper assessment of economic and social benefits could also be important. Non-market valuation techniques might be useful in determining appropriate social values. It has also been observed that even though some costs are generally included in decision making, others are not (such as transaction costs). The use of a rigorous prioritization tool capable to consider all relevant benefits and costs are thus very important. By failing to capture the full suite of benefits and costs, we risk undervaluing restoration and making poor investment decisions.

An additional challenge for conservation agencies is to secure continuous (or long-term) funding to achieve restoration goals. Current environmental programs are often short-lived and may not be adequate to support restoration programs. We reveal several strategies that agencies could employ to secure additional or long-term funding, such as synergy with existing programs, public-private partnership, financing through council tax, etc. The suitability of different funding arrangements would depend on the context in which the restoration program is being planned and would need to be examined before application. In essence, the sound application of economic principles, tools and instruments discussed in this paper can help in planning and successful implementation of restoration programs globally.

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Table 1: A summary of the common challenges facing ecological restoration and the economic principals, tools and instruments available to address them.

Challenges	Potential causes of not meeting the challenge	Consequence of not meeting the challenges	Key economic principles, tools and instrument to tackle the challenge
Assessing benefits	<ul style="list-style-type: none"> Narrow focus in program scope, meaning some benefits or preferences are excluded Lack of familiarity and skills with non-market valuation techniques within conservation agencies Limited funding available 	<ul style="list-style-type: none"> Suboptimal project selection Lack of political and/or community support, resistance during and after implementation 	<ul style="list-style-type: none"> Non-market valuation techniques Benefit transfer technique when adequate resources to conduct primary non-market valuation studies are not available
Assessing costs	<ul style="list-style-type: none"> Lack of understanding of different types of costs and their importance Difficulty to estimate different types of costs Limited funding available 	<ul style="list-style-type: none"> Suboptimal project selection Failure to complete project due to insufficient financing. Discontinuation of funding as the project becomes financially unviable 	<ul style="list-style-type: none"> Capitalised gross revenue or gross margin of the productive use of land Methods based on property or land sales prices, such as hedonic pricing method Estimation of transaction costs based on organizational surveys Collecting and publishing establishment costs
Prioritization and targeting	<ul style="list-style-type: none"> Inadequate information on benefits and costs Using wrong metrics Failure to capture all the elements of the decision making process during prioritisation 	<ul style="list-style-type: none"> Wasting of valuable public resources Failure to meet environmental targets Negative (or unintended) environmental consequences 	<ul style="list-style-type: none"> Selection and use of appropriate metric Use of comprehensive prioritisation protocol Real option analysis
Long-term financing	<ul style="list-style-type: none"> Inadequate information on net benefits Wrong project selection 	<ul style="list-style-type: none"> The project becomes financially unviable due to lack of funding 	<ul style="list-style-type: none"> Working with existing funding arrangement Developing synergy with existing programs Financing through council tax Public-private partnership Offsetting Volunteerism

Table 2: A hypothetical example of the impact of using partial cost information in the calculation of cost-benefit ratio.

Project ID	Benefit*	Cost*	Partial Cost*	Partial Cost-Benefit Ratio	Cost-Benefit Ratio
1	40	75	60	1.50	1.88
2	10	25	20	2.00	2.50
3	35	90	72	2.06	2.57
4	20	60	48	2.40	3.00
5	30	150	120	4.00	5.00
6	15	80	64	4.27	5.33

*Benefits and costs are in \$10,000. The shaded cells indicate the projects selected under partial and full cost-benefit ratios