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Research article

Valuing conservation benefits of disease control in wildlife: A choice experiment approach to bovine tuberculosis management in New Zealand's native forests

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ABSTRACT

We assess the non-monetary environmental benefits that accrue incidentally in New Zealand (NZ) from pest management conducted primarily to control an animal disease, bovine tuberculosis (TB). TB is an infectious disease that is one of the world's most serious animal health problems and, in many parts of the developing world, still a major mortality risk for humans. The incidence of TB in New Zealand (NZ) farmed livestock has been reduced progressively over the last 20 years, largely due to extensive and sustained population control of the main wildlife reservoir of disease, the introduced brushtail possum. Possums are also major pests that threaten indigenous forest biodiversity, and so extensive possum control for TB mitigation also incidental benefits conservation, but the extent and public value of this benefit has yet to be quantified. We conducted a choice experiment survey of the NZ public in an effort to value the native forest biodiversity benefits of TB-related possum control. We find strong public support for conservation outcomes consequent to TB-possum control in public native forests. The public place substantial value on the most observable biodiversity benefits of TB possum control, such as improved forest canopies and presence of native birds. The benefits, costs and values of TB-possum control are discussed in relation to the future directives of NZ's TB control programme, which is headed toward first regional and then national level disease eradication.

1. Introduction

Valuing the non-monetary environmental benefits of pest management conducted for commercial or human or animal health reasons is difficult and has rarely been attempted, but here we document an attempt to do so in the context of bovine tuberculosis management in New Zealand. Bovine tuberculosis (TB) is a chronic zoonotic disease of livestock that still poses a significant threat to livestock production and human health in many developing countries (Ayele et al., 2004). In developed countries, however, TB has mostly been eliminated from livestock by identifying and removing infected or potentially infected animals from livestock herds (Cousins, 2002). In some places, however, eradication is far more difficult because the disease has widely established in wildlife — in NZ's case, the brushtail possum (*Trichosurus vulpecula;* a small forest-dwelling marsupial introduced from Australia) has, since the 1960s, become the main wildlife reservoir of TB (Nugent et al., 2015). Possums (and in a few places, ferrets (*Mustela furo*)) are the only wildlife hosts able to independently sustain TB infection, and can re-infect cattle, therefore control or eradication of TB from livestock necessarily requires controlling or eradicating it from possums. Government-led efforts to eliminate TB from livestock were therefore expanded (in 1970s) to include lethal control of infected possum populations. This eventually evolved into a public-private partnership between the government and the livestock industries under a formal National Pest Management Plan for Bovine Tuberculosis (NPMP) that is implemented by a statutory agency (OSPRI/TBfree, formerly the Animal Health Board; Livingstone et al., 2015). Since the inception of the NPMP in 1994, TB-related possum control has been implemented over about 8 million ha (approx. 30% of NZ), and TB levels in livestock have fallen by more than 95% (Livingstone et al., 2015b). The NPMP was reviewed in 2014–15, and, as part of that, the cost of possum

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control was evaluated in relation to the value of not only the direct TB-related benefits but also of other indirect benefits (NZIER, 2015).

As part of that evaluation, this paper focuses on valuing the benefits to conservation from TB-related possum control. These benefits arise because possums, as an invasive species, are also major pests that directly threaten native forest biodiversity (as well as causing other damage in other spheres such as plantation forestry (Jacometti et al., 2007)). In addition, TB-possum control (usually by poisoning) within native forests also typically reduces densities of other invasive conservation pests such as rats and stoats, further reducing the overall threat to biodiversity (Didham et al., 2009; Byrom et al., 2016). Possum are arboreal. They feed mainly on leaves, flowers, and fruits of preferred trees and other plants nestlings (Nugent et al., 2000) and their browsing can cause or exacerbate forest canopy dieback (Nugent et al., 2000; Gormley et al., 2012) and reduce the abundance of preferred sub-canopy plant species. In addition, as occasional omnivores, they also eat insects, bird's eggs and nestlings and even carrion (Nugent et al., 2000), adding to the devastating effect of other introduced small mammal pests on NZs native fauna (Brown et al., 2015). The NZ public is deeply aware of these adverse impacts and almost universally sees possums and other non-native mammalian predators as pests to be exterminated (Russell, 2014). Because of those threats, particularly to indigenous biodiversity, the Department of Conservation (DOC), regional councils, and private conservation groups impose intensive possum control on many areas of public and private land, and would do so vastly more widely if they could afford it. Thus, the large amount of possum control undertaken for TB-related purposes produces co-benefits to conservation; especially where agencies and groups focussed on conservation of native forest biodiversity would like to see control imposed but cannot afford it. However, those co-benefits have been only partially quantified in biological terms (Byrom et al., 2016), and not valued at all in economic terms. Despite the substantial uncertainty about the exact nature and size of those co-benefits, the need for an economic valuation of them arose from the likelihood that ongoing governmental funding (on behalf of the general public) of TB-related possum control would partly depend on the value of the ancillary benefits to conservation that it provides. Put simply, many New Zealanders are strongly aware of the damage that invasive alien pests (and weeds) cause in both productive and native ecosystems, and therefore desire action to be taken to reduce that damage (Russell, 2014), and here we focus on determining how much they are willing to pay to mitigate part of that damage.

In this study we therefore aimed to quantify the economic value of the benefits to conservation of indigenous biodiversity in native forest ecosystems that flow from TB-possum control not previously available by employing a choice experiment survey of the NZ public's willingness to pay (WTP). This study adds to the limited empirical evidence base and also contributes to developing interdisciplinary approaches to evaluate pest management programmes by combining economic and biological measures of value (Laurila-Pant et al., 2015) to form an assessment of biodiversity outcomes that integrates natural and social science methods. To create a direct linkage between public preferences for biodiversity outcomes with assessment of possum control effectiveness and scale, our analysis relies on an approach that engages ecological expertise to characterise some key biodiversity attributes as readily understandable continuous measures of TB-possum control outcomes.

2. Methods and materials

2.1. Background to the use of a choice experiment approach

In face of ongoing invasive incursions, declining acceptability of some existing response methods, and intensifying land use, budgets for pest management are typically inadequate (Goldson et al., 2015). This drives the need for robust prioritisation systems, and Cost Benefit Analysis (CBA) has become a standard decision tool (Goldson et al., 2015). However, non-market benefits, such as improved environmental outcomes are difficult to monetise and so are usually ignored (Shwiff et al., 2013). Whilst perhaps secondary to commercial imperatives (Slaney et al., 2010), omission of these benefits may lead to significant undervaluation of response programmes (Holmes et al., 2009; Rosenberger et al., 2012). To overcome this, numerous studies have used non-market valuation (NMV) to estimate (for example) recreation values associated with forest resources (Riera et al., 2012), but there are few estimates of the non-market benefits from management of invasive species (Meldrum et al., 2013) or of public willingness to pay for protection and/or enhancement of forest biodiversity (Czajkowski et al., 2014; Giergiczny et al., 2015).

NZ's export markets value biodiversity as part of the 'clean and green' brand (Tait et al., 2016), and international tourists value the 'natural' experience which native biodiversity provides (Sun et al., 2015). The recreational opportunities and aesthetic benefits provided by native ecosystems combined with the uniqueness of NZ's indigenous biodiversity (because it evolved in the absence of any terrestrial mammals; Brown et al., 2015) has played a major role in forming cultural identity (Roberts et al., 2015). However, these benefits have rarely been quantified. Kerr and Cullen (1995) used a contingent valuation approach to show that protection of vulnerable rare species was, in that context, the most important benefit of possum control, and they estimated an annual mean WTP for possum control of $300 per adult. In another CV application, Yao and Kaval, (2010) found households were WTP $42 and $82 annually to support public native tree planting programs on private and public land respectively. However, the validity and reliability of the contingent valuation approach has long been questioned, particularly for valuing abstract or complex phenomena (Diamond and Hausman, 1994).

However, choice experiments have relatively recently emerged as a more sophisticated non-market methodological approach that is considered capable of accounting for the complexity and abstractness of biodiversity concepts in valuation (Meyerhoff et al., 2009; Bartkowski et al., 2015; Haefele et al., 2016). In NZ, choice experiments have been applied to estimate values for native biodiversity outcomes within a planted forestry context (Yao et al., 2014). Globally, there have also been some TB-related uses of choice experiments (Bennett and Willis, 2008; Bennett and Balcombe, 2012) but these are not directly relevant to TB management in NZ.

Choice experiments are based in Random Utility Theory in which a respondent's utility is decomposed into an observable deterministic part and an unobserved random component; and Lancaster's characteristics theory of value in which a good can be decomposed into its component attributes (Lancaster, 1966). This framework allows for preferences for the native forest good to be represented by the biodiversity attributes it contains, whilst econometrically accounting for unobserved influences on respondents utility not captured by the biodiversity attributes. This survey based method simulates a market in situations where no market exists. A good comprised of a bundle of attributes is offered at a given price, with respondents selecting their preferred combination of attributes and price (see Hensher et al. (2015) for substantive detail of the methodology). Responses are typically analysed within a probabilistic econometric framework to derive population estimates of changes in welfare for a substantive coverage. We also followed the guidance to best-practice in NMV of forest goods and services provided by Riera et al. (2012).