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ANALYSIS

Exploring welfare implications of resource equivalency analysis in natural resource damage assessments

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ABSTRACT

Resource equivalency analysis (REA) has become the dominant method for calculating natural resource damages for biological injuries from pollution incidents. This methodology compares resources lost as a result of an incident to benefits that can be gained from a habitat or wildlife restoration project. Compensation is evaluated in terms of resource services instead of market currency. Recently, this approach has been questioned regarding its ability to provide adequate compensation based on economic welfare principles. The following paper examines these critiques and develops a model to quantify the welfare implications of using REA when some of its implicit assumptions are violated.

We focus on the situation where compensatory restoration projects provide services that are comparable to those lost as a result of an incident. We examine simulation scenarios where the public has heterogeneous preferences for resources and where resource values change over time. Using the Hicks–Kaldor criterion, we find that the traditional REA provides an acceptable approximation of aggregate compensation for a reasonably wide range of economic and biological parameter combinations.

1. Introduction

In 1997, the National Oceanic and Atmospheric Administration (NOAA) issued a guidance document for conducting natural resource damage assessments (NRDA) under the Oil Pollution Act of 1990 (NOAA, 1997). These assessments determine the compensation that parties responsible for oil spills owe to the public. NOAA recommended that the calculation of compensation for biological injuries be based upon restoration projects, where the sizes of those projects are "scaled" using habitat equivalency analysis (HEA) and the cost of the projects becomes the measure of damages. At the same time, natural resource agencies were suffering negative experiences using more traditional valuation methods, especially contingent valuation (Thompson, 2002). Since that time, HEA has evolved into the more generic resource equivalency analysis (REA) and has become the primary method for calculating damages from pollution events nationwide.[2]

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[2] While HEA only refers to habitat-based analyses, REA includes analyses that focus on any natural resource (e.g. birds, sea turtles, etc.).

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Flores and Thacher (2002) have accurately described this as a "paradigm shift". Indeed, nearly every pollution damages case in the past five years has employed REA as the primary method to quantify damages to wildlife and habitat. Furthermore, the method has recently been affirmed by two courts as an appropriate measure to determine the scale of compensatory restoration projects (United States v. Fisher, 1977; United States v. Great Lakes Dredge and Dock Co., 1999).

While REA has been widely applied and evaluated within numerous natural resource damage assessments, the methodology has not been explored in the academic literature to the same extent as other valuation approaches (e.g., contingent valuation). Most papers describing REA have focused on either the policy and legal contexts within which it is applied (Mazzotta et al., 1994; Jones and Pease, 1997) or specific applications (Unsworth and Bishop, 1994; Penn and Tomasi, 2002; Strange et al., 2002; Sperduto et al., 2003; French McCay et al., 2003a,b; French McCay and Rowe, 2003; Donlan et al., 2003). The two most prominent critiques evaluate the methodology from different perspectives. Flores and Thacher (2002) use welfare economic principles to ground their evaluation of restoration-based damages calculations. Prominent among their concerns is the effect of value changes over time and heterogeneity of preferences. The main limitation of their analysis is that they do not inform the practitioner of how much and when these factors substantively influence results. Dunford et al. (2004) provide a broader review of the REA methodology and include many practical considerations associated with its application in NRDA. Their critique is especially intriguing because it includes sensitivity analyses of REA results to several price change scenarios. However, since they do not motivate their value changes with an economic model, the reader is left to speculate on the assumptions made about individual preferences and the supply of natural resources.

This paper builds on the work of Flores and Thacher (2002) and Dunford et al. (2004). It explores the degrees to which violations of REA assumptions can result in either under-compensation or over-compensation of the public. We achieve this end by developing a "monetized" variation of the traditional REA model that incorporates monetary resource values explicitly. We treat the biological state of the world as given, and focus on the two main economic issues of Flores and Thacher (2002): price changes and heterogeneity of preferences. We conduct two sets of simulations using this model to examine how the traditional REA approach fares under a range of conditions relevant to typical applications. Finally, we discuss the implications of our results to economists performing NRDA. We conclude that REA provides a close approximation of compensating wealth under many but not all conditions where it is reasonable to assume substitutability between injured and restored resource services.

2. The new paradigm for natural resource damage assessment

2.1. *Resource equivalency analysis: an overview*

Trustee agencies are required to spend damage recoveries "restoring, rehabilitating, replacing or acquiring the equivalent" of the injured resources (15 CFR 990.30). REA is a tool that is intended to evaluate the amount of restoration needed to compensate from incident-related losses. It involves two steps. The first is to quantify the natural resource injury in terms of the loss of ecological services. This utilizes information on the degree of injury (e.g., the impact per unit area), the duration of injury (e.g., time for the resource to recover), and spatial extent of the injury (e.g., the number of acres, miles of stream, or number of birds affected). The second step is to identify an appropriate restoration project (usually offsite) and evaluate it in terms of the degree and duration of ecological benefits that it is likely to provide. The project is then "scaled" in size so that the total value of ecological service benefits from a compensatory restoration project offsets the value of ecological service losses that resulted from the injury (Jones and Pease, 1997).[3]

In its simplest single-period formulation, the above resource equivalency problem solves the following equation for the scale, or spatial extent, of the required compensatory restoration project (denoted A_R):

$$v_I A_I I(1+r)^{-t_I} = v_R A_R R(1+r)^{-t_R} \tag{1}$$

The parameters A_I, t_I, I, t_R, R, and A_R summarize the "biology" of resource injury and restoration. A_I is the spatial extent of the injury, t_I is the time of the injury, I is the severity of injury over space (over A_I at t_I), t_R is the time the compensatory restoration project provide benefits, and R is the magnitude of the restoration benefits/improvements (over A_R at t_R). Although topics of considerable debate during litigation and settlement (Dunford et al., 2004), these biological parameters (and their units of measurement) are predetermined by the incident and the restoration concept(s) being examined. The "economics" of the equivalency come from the parameters v_I, v_R, and r. These are the values (in market currency) attributed to each injured and restored resource unit, along with the discount rate. When the above equivalency is satisfied, the project cost of conducting restoration of size A_R is estimated, and this becomes the measure of damages.

In practice, Trustee agencies are directed to restore resources that are "of the same type and quality, and of comparable value" as the injured resource (NOAA, 1995). This reasoning is used to assume that $v_I = v_R$, which allows per-unit resource value to drop out the equation (Jones and Pease, 1997). This leaves the discount rate (r) as the only non-biological parameter in the REA solution. Multiple time periods are then added to produce a more thorough examination of the "biology" of the problem, resulting in some variant of the following (depending on whether calculations are made in discrete or continuous time):

$$A_I \sum_{t=1}^{T_I} (1+r)^{-t} I_t = A_R \sum_{t=1}^{T_R} (1+r)^{-t} R_t$$
(or)
$$A_I \int_0^{T_I} e^{-rt} I(t)dt = A_R \int_0^{T_R} e^{-rt} R(t)dt \tag{2}$$

[3] This compensatory restoration differs from "primary restoration". The latter targets the injured area in an attempt to improve the recovery and thus shorten the duration of the injury, while compensatory restoration may occur off-site.