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Establishing the links between economic development and the restoration of natural capital

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We reviewed 1575 peer-reviewed papers on restoration published from January 2000 to September 2008 in 13 scientific journals to assess whether they considered the economic and policy implications of their research, and referred to the concept of, or emerging markets for, payments for ecosystem goods and services. Only 8% (125 papers) of the 1575 papers reviewed referred to the establishment of markets and/or payment for ecosystem services or surrogates. The findings suggest that the linkages between natural capital and ecosystem services are not being made and thus the benefits of restoration are not being integrated into development planning. Better communication of the socio-economic and political benefits of restoration will be required if restoration is to be advanced.

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Introduction

Renewable and cultivated natural capital provide the flow of ecosystem goods and services essential to human life [1]; intact or restored natural capital is, therefore, indispensable for economic development. Current approaches to development are unsustainable because people are depleting many of the finite stocks of natural capital at rates faster than they can regenerate [2]. For instance, according to some indicators and at the global scale, appropriation of fresh water and plant or animal biomass by humans far exceeds the rate at which these resources are replenished [3,4].

Long-term sustainability requires society to invest in restoring natural capital to increase the supply of ecosystem goods and services [5] and to maintain biodiversity that is vital to ecosystem functionality. Rey Benayas *et al.* [6], Bullock *et al.* [7••], and others have shown that restoration projects can enhance biodiversity and ecosystem goods and services simultaneously. But linkages between ecological restoration and economic development have only recently begun to be explored [8,9••]. Although some studies have made this link [2,6,10–12], most of the scientific literature on ecological restoration rarely considers conceptual or methodological approaches for measuring its impacts on economic development. Clearly, the majority of restoration ecologists and socio-economic scholars are still working in their own silos [13]. It is, therefore, no surprise that the drivers and symptoms of environmental degradation are seldom managed, or even perceived, in an integrated way when restoration projects and programmes are undertaken.

We screened papers published in 13 peer-reviewed academic journals for the period 2000–2008 to investigate whether restoration of natural capital is linked to the development of markets for ecosystem goods and services. We confined ourselves to the peer-reviewed scientific literature because it is available to search and review unlike the 'grey' (non peer-reviewed) literature. Academic research is not separate from, but rather an important step in, the successful development of evidence-based policy [14]. Some of the data used in this study were previously used to compare trends in ecological restoration research among journals [15••] and to establish links between the academic disciplines of restoration and invasion [16••]. While we previously [15••] focused on restoration science and its practitioners, this paper reviews the dataset from a socio-economic and policy perspective, broadening the focus. We therefore seek to answer the overarching question: 'Do the publications, that is, researchers and academic publishers, concerned with ecological restoration consider the economic and policy implications of their research, especially as represented by the market mechanism of payments for ecosystem goods and services (PES)?' We did not restrict the study to any particular PES definition (see Wunder [17] and Muradian *et al.* [18]), but rather accepted each set of authors' decisions as to whether their project

constituted a PES project or not according to their own criteria and definitions.

Method

We followed a two-step process to narrow the focus of the study to key journals as described in Aronson *et al.* [15••]. First, we searched a selection of papers for the words 'restoration' or 'rehabilitation' in the title, abstract or keywords. From this we narrowed the focus to 13 academic journals as listed in Annexure 1. The journal selection was also informed by the scope of papers published, their mission statements and target readership, as well as presumed relevance to the subject of this study. We considered these parameters to explicitly seek journals that would publish peer-reviewed papers on restoration, multi-disciplinary research related to restoration and/or PES. This sampling of journals is not exhaustive, but rather representative, in our view, of the relevant peer-reviewed literature of the stated period. The journals selected not only include a significant sampling of relevant ecological journals, but also two influential journals from the field of ecological and environmental economics.

Second, we screened all the papers (19 547 in total) published in these 13 academic journals from 1 January 2000 to 1 October 2008, for the words 'restoration' and/or 'rehabilitation' in the title, abstract, or keywords. (Detailed methods are described in Aronson *et al.* [15••].) All reference 'hits' were subsequently subjected

Table 1

List of variables and categories used for analysing the restoration papers to identify ('hits'). Many of the categories can have multiple answers for a given paper.

Category	Keywords and definitions
Paper descriptors	Author, year of publication, title of the article, journal, location of the keyword identification (title, abstract, and/or key words)
Ecosystem types in which the study was conducted	Grasslands, forests, woodlands, shrublands, savannas, arid (and semi-arid) regions, aquatic (rivers, other wetlands, marine, and coastal), urban, human modified and transformed, other, or unclassified
Restoration approach	Active = implies that something was added or removed (e.g., re-seeding, fertilizer, irrigation, plants) Passive = area was left to recover by itself Not specified
Restoration method used	Re-seeding, planting, succession, others, or not specified
Purpose of restoration; type of ecosystem services affected (as per MA [16] categories)	Supporting = a service such as pollination or seed dispersal that makes it possible to produce crops Regulating = a service that moderates environmental extremes or stabilises ecosystem components, dynamics and functions — for example, control of floods, erosion, dust storms Provisioning = direct values of goods that can be harvested, for example, firewood, craft materials, meat Cultural = benefits that people get from visiting wild places — scenery, traditional rituals, relaxation, scientific information
Constituents of well-being addressed or affected	Material = food, wood, fish, and other things, goods or products that people harvest from ecosystems Health = health benefits of natural environments, for example, water purification, removal of toxins from the air Security = ways in which natural vegetation or functioning ecosystems protect our atmosphere or prevent or minimise disasters such as floods or mudslides Social relations = ways in which natural environments contribute to our cultural and social lives; care for the innate value of biodiversity included here
Well-being impact description	Description of how the restoration improves quality of life for people
Link to agricultural systems or practices	Does the restoration link with agricultural systems or practices? Yes/No. If Yes, in what way? For example, crop production, forestry, ranching
Monitoring tools used	Yes/No. If Yes, description of how restoration was monitored. Instrumental = measuring, for example, vegetation cover, species abundance, or soil parameters. Interviews = asking people by phone or questionnaire about restoration project
Scale of influence and interventions	Level of ecological organisation, and specific kinds of interactions: Landscape (spatial interactions) = covering many habitats or communities Ecosystem (trophic interactions) = that the restoration influences plants, herbivores, and predators Community (inter-specific interactions) = restoration affects many organisms Population (re-introductions) = restoration focused on a single species
Policy outcome or (research) recommendation	This refers to the effect of the study of the restoration or the restoration itself on policy: none, locally (one town or settlement), regionally, nationally (whole country), or global
Policy intensity (scale of impact)	The number of people directly or indirectly affected by the policy or the importance of the policy for the way in which towns, nations, or the world is run: None, minor, major
Host country	Country where restoration took place
PES (payment for ecosystem services)	Yes/No. This describes the ways in which restoring an environmental to provide better services can be rewarded, for example, by tax credits or reductions. If Yes, does the market actually exist or is it only perceived? Formed = the reward method is functioning and that farmers, miners, NGO, and so on are actually receiving some payment or other benefits for doing the restoration Perceived = a possible method of reward has been described