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Review

A review of methods, data, and models to assess changes in the value of ecosystem services from land degradation and restoration

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A B S T R A C T

This review assesses existing data, models, and other knowledge-based methods for valuing the effects of sustainable land management including the cost of land degradation on a global scale. The overall development goal of sustainable human well-being should be to obtain social, ecologic, and economic viability, not merely growth of the market economy. Therefore new and more integrated methods to value sustainable development are needed. There is a huge amount of data and methods currently available to model and analyze land management practices. However, it is scattered and requires consolidation and reformatting to be useful. In this review we collected and evaluated databases and computer models that could be useful for analyzing and valuing land management options for sustaining natural capital and maximizing ecosystem services. The current methods and models are not well equipped to handle large scale transdisciplinary analyses and a major conclusion of this synthesis paper is that there is a need for further development of the integrated approaches, which considers all four types of capital (human, built, natural, and social), and their interaction at spatially explicit, multiple scales. This should be facilitated by adapting existing models and make them and their outcomes more accessible to stakeholders. Other shortcomings and caveats of models should be addressed by adding the 'human factor', for instance, in participatory decision-making and scenario testing. For integration of the models themselves, a more participatory approach to model development is also recommended, along with the possibility of adding advanced gaming interfaces to the models to allow them to be "played" by a large number of interested parties and their trade-off decisions to be accumulated and compared.

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Contents

1. Introduction

It is becoming increasingly evident that allowing land to degrade is expensive, both to local owners and to society in general, in the short term, and especially, long-term (Costanza et al., 1997, 2014; Bateman et al., 2013; Trucost, 2013; Von Braun et al., 2013). At RIO + 20 the United Nations Conference on Combatting Desertification (UNCCD) set a target of zero net land degradation (ELD-Initiative, 2013). This need to prevent further land degradation, whether that is natural or human-dominated systems, and to restore degraded lands is especially important now because the demand for accessible productive land is increasing as human population and consumption increase. The geography of these changes are projected to affect mainly tropical regions that are already vulnerable to other stresses, including the increasing unpredictability of rainfall patterns and extreme events as a result of climate change (IPCC, 2007; Foley et al., 2011).

Land degradation is a decline in the processes and productivity of these ecosystems over an extended period of time (Lal, 1997; MEA, 2005; DeFries et al., 2012) and as defined in the Economics of Land Degradation (ELD) Interim Report (ELD-Initiative, 2013) results in “the reduction in the economic value of ecosystem services and goods derived from land as a result of anthropogenic activities or natural biophysical evolution”. In short it is a consequence of poor management of natural capital (soils, water, vegetation, etc.). We need better frameworks to quantify the scale of the problem globally, to calculate the cost of business as usual (ELD-Initiative, 2013), and explicitly and essentially to assess the benefits of ecological restoration. The current methods are often underestimating the cost of change, as they assume restoration will lead to full recovery of ecological functions, which is not necessarily the case. Visionary farmers and business leaders are becoming aware that degradation of ecosystems may become material issues affecting their bottom line and future prosperity (ACCA et al., 2012). However, they lack decision tools to develop robust and effective solutions to the problem (ACCA et al., 2012; ELD-Initiative, 2013). The identification of sustainable management strategies on both farm and landscape levels could be facilitated by the development of integrated decision tools. This could be, for instance, sound cost–benefit frameworks (ELD-Initiative, 2013) accompanied by modeling and simulation techniques that enable the creation and evaluation of scenarios of alternative futures and other decision tools to address this gap (Farley and Costanza, 2002; Costanza et al., 2006, 2013; Jarchow et al., 2012).

The managed land covers more than 60% of the Earth’s land surface and approximately 60% of this is under agriculture (Ellis et al., 2010; Foley et al., 2011). Ecosystems contribute to human well-being in a number of complex ways at multiple scales of space and time (Costanza and Daly, 1992; MEA, 2005; Dasgupta, 2008; Lal, 2012; UNEP, 2012; Costanza et al., 2013). Ecosystem services, including agricultural products, clean air, fresh water, disturbance regulation, climate regulation, recreational opportunities, and fertile soils are jeopardized by the effects of land degradation, and it is a global phenomenon (Walker et al., 2002; Foley et al., 2005; MEA, 2005; UNEP, 2012; Von Braun et al., 2013).

There is a need to integrate agricultural production and other land uses with ecosystem preservation to avoid land degradation in the future and to begin to restore degraded lands (Acevedo, 2011). This involves a standardized framework with methods to quantify and compare the extent of land degradation across political, cultural, biophysical, and managerial boundaries.

The overall development goal of sustainable human well-being cannot be measured in the mere growth of the market economy (Costanza et al., 2013). To obtain sustainable well-being through improved land management depends on the interaction of four basic types of capital assets: built, human, social, and natural. For example, the value of ecosystem services is the relative contribution of natural capital in combination with the other three types of assets to produce sustainable well-being. Although it focuses on natural capital and ecosystem services, it recognizes that the understanding, modeling, and valuing of ecosystem services requires an integrated, transdisciplinary approach which includes all four types of capital and their complex interactions.

The aim of this paper is to identify and discuss the data and methods used to determine global land degradation and to assess the sustainability of alternative management strategies.