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Ecosystem service tradeoff between grazing intensity and other services - A case study in Karei-Deshe experimental cattle range in northern Israel

Itai Divinsky[a,*], Nir Becker[b], Pua Bar (Kutiel)[a]

[a] Department of Geography and Environmental Development, Ben-Gurion University of the Negev, Be'er-Sheva 84105, Israel
[b] Department of Economics and Management, Tel-Hai College, Upper Galilee 12210, Israel

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ABSTRACT

Grasslands cover around 25% of the earth's land surface and provide many essential Ecosystem Services (ES) to human well-being. Changes in grazing intensity have led to changes in biodiversity and ecosystem functioning, resulting in loss of some of these ES. This emphasizes the need for grassland management schemes that aim to maximize economic returns from grasslands while maintaining ecosystem functioning, but tools to assess the tradeoffs between economic benefits and Ecosystem Services are, for the most part, lacking.

This study is aimed at economically valuing multiple ecosystem services, and the tradeoffs between them and species richness, across different management alternatives (control, light, moderate and heavy grazing) in the Karei-Deshe experimental farm and Long Term Ecosystem Research (LTER) site. Ecological data from previous research in Karei-Deshe was valuated using the Replacement Cost Method and a Contingent Valuation survey, which valued the farm's landscape.

Grazing intensity was inversely related to the delivery of ES studied and positively related to species richness, except for heavy grazing, which resulted in lower species richness. Only heavy grazing was found to be an inefficient management alternative. This research demonstrates a fairly simple path for providing land managers an ecological-data-based tool for comparing management alternatives.

1. Introduction

Pastures are the single most extensive form of land use on earth, covering around 25% of the earth's land surface (Asner et al., 2004). In addition, around one billion people live around and on pasture-land and are found in every region of the world (White et al., 2000). Pastures are defined as any lands used for grazing, which, since based on land use rather than habitat, can include different biomes (e.g. grasslands, savanna etc.). We focus in this study on pastural use of grasslands alone. Grasslands provide many Ecosystem Services (ES) necessary to sustain their inhabitants as well as others populations not living on pasture-land (Egoh et al., 2011; Fleischner, 1994; Havstad et al., 2007; Sala and Paruelo, 1997; White et al., 2000; Yu et al., 2005) and can therefore create win-win situations for conservation and economic goals if managed well (Bullock et al., 2011). The South African Grasslands Program, a governmental biome-wide conservation program for the grasslands of South Africa, has recognized the importance of securing biodiversity and ES of grasslands and has named their protection as its primary goal (http://www.sanbi.org/biodiversity-science/science-policyaction/mainstreaming-biodiversity/grasslands-program, last accessed 04/01/2017).

Studies that shed light on the services provided by grasslands and their value are important, because changes in grazing intensity may lead to changes in biodiversity and in ecosystem functions, and therefore may result in loss of certain ES, such as cultural or pollination services (Ford et al., 2012; Sala and Paruelo, 1997). Despite the wide recognition of their significance, relatively few studies have examined the economic valuation of ES provided by grasslands (e.g. Fleischer and Sternberg, 2006; Yu et al., 2005).

Ecosystem services valuation (ESV) is not exclusively used to obtain economic values, sometimes it is used to test the efficiency of different management scenarios. In conservation, an efficient management scenario is one that generates the maximum diversity for a given economic measure (and vice versa). The efficiency frontier illustrates what can be achieved in terms of biological and economic objectives by choosing one management policy over another (Polasky et al., 2008). In addition, the opportunity cost of conservation can be calculated using an efficiency frontier, thus avoiding attempts to valuate nature itself (Naidoo et al., 2006).

The ESV approach has been adopted and widely implemented in

* Corresponding author.
E-mail address: itaidivi@gmail.com (I. Divinsky).

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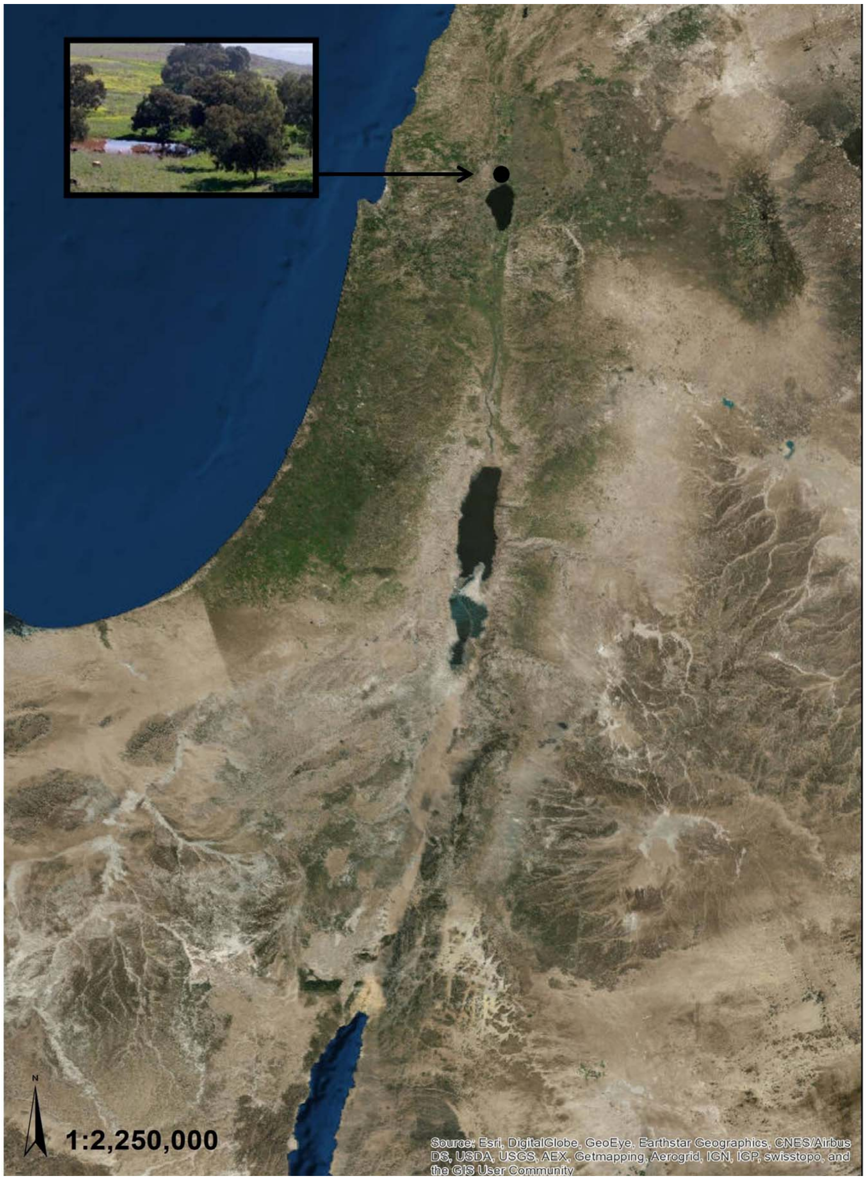

Fig. 1. Reseach area.

conservation management around the world (Bateman et al., 2013; Bullock et al., 2011; CONABIO, 2006a, 2006b; Daily et al., 2009; Ruckelshaus et al., 2015). Monetary valuation has proven useful because it provides decision makers with a common denominator for the gains and costs of available management alternatives (Bockstael et al., 2000; Pagiola et al., 2004). A good example of this is the South African Grasslands Program, which invested $8.3m in an effort to foster grasslands biodiversity by "mainstreaming biodiversity into the Grassland Biome by influencing policies and regulations, strengthening institutional capacity, and catalysing pilot projects that demonstrate biodiversity gains across sectors" (http://www.sanbi.org/biodiversity-science/science-policyaction/mainstreaming-biodiversity/grasslands-program, last accessed 04/01/2017).

In order to assess the impact that certain ecological changes will have on ES delivery, the link between the services and the ecosystem providing them must be understood (Bateman et al., 2011; Norberg, 1999; Palmer et al., 2004; US EPA, 2009). One way of understanding the link between ES delivery and ecosystem properties and processes is by studying the relationship between ecological indicators and ES (Balmford et al., 2003; Niemi and McDonald, 2004). Species richness is a widely used indicator (e.g. Costanza et al., 2007; Polasky et al., 2008) because it is generally more available at large scales than other proxy for biodiversity (Costanza et al., 2007). Harrison et al. (2014) in their review on "Linkages between biodiversity attributes and ecosystem services: A systematic review" indicated that species richness "displays a predominantly positive relationship across the services, most commonly discussed for atmospheric regulation, pest regulation and pollination". Additionally, Biswas and Mallik (2011) indicated that species richness and functional diversity (both components of biodiversity) are positively correlated and varies significantly with disturbance intensities.

The majority of ESV studies are conducted at small scales (a specific ecosystem) aimed at providing TEV (total economic value) (e.g. Ninan and Inoue, 2013). TEV may not be sufficiently useful for land managers facing decisions that involve tradeoffs between ES delivery and biodiversity conservation, since it does not inform them of comparable