Ecosystem Services xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Ecosystem Services

journal homepage: www.elsevier.com/locate/ecoser

# A bird's eye view over ecosystem services in Natura 2000 sites across Europe

Guy Ziv [a,*], Christopher Hassall [b], Bartosz Bartkowski [c], Anna F. Cord [d], Andrea Kaim [d], Michelle Kalamandeen [a], Patricia Landaverde-González [d,e], Joana L.B. Melo [a], Ralf Seppelt [d,f], Caitriona Shannon [b], Tomáš Václavík [d,g], Brenda Maria Zoderer [a,h], Michael Beckmann [d]

[a] School of Geography, Faculty of Environment, University of Leeds, Leeds LS2 9JT, UK
[b] School of Biology, Faculty of Biological Sciences, University of Leeds, Leeds LS2 9JT, UK
[c] UFZ – Helmholtz Centre for Environmental Research, Department of Economics, Permoserstr. 15, 04318 Leipzig, Germany
[d] UFZ – Helmholtz Centre for Environmental Research, Department of Computational Landscape Ecology, Permoserstr. 15, 04318 Leipzig, Germany
[e] General Zoology, Institute for Biology, Martin-Luther University Halle-Wittenberg, Hoher Weg 8, 06120 Halle (Saale), Germany
[f] Institute of Geoscience and Geography, Martin-Luther University Halle-Wittenberg, 06099 Halle (Saale), Germany
[g] Department of Ecology & Environmental Sciences, Faculty of Science, Palacký University Olomouc, Šlechtitelů 27, 78371 Olomouc, Czech Republic
[h] Institute of Ecology, University of Innsbruck, Sternwartestr. 15, 6020 Innsbruck, Austria

A R T I C L E I N F O

*Article history:*
Received 3 April 2017
Received in revised form 4 August 2017
Accepted 28 August 2017
Available online xxxx

*Keywords:*
Species conservation
Ecosystem services
Synergies
Trade-offs
Natura 2000
Special Protected Areas

A B S T R A C T

Recent 'New Conservation' approaches called for more ecosystem services (ES) emphasis in conservation. We analysed data from 3757 Natura 2000 special protection areas (SPAs) and translated positive and negative impacts listed by conservation managers into indicators of the use of nine provisioning, regulating and cultural ES. Overall, the use of ES is considered by SPA managers to affect conservation goals more negatively than positively. ES associated with livestock keeping and fodder production are recorded as having the highest fraction of positive impacts on SPAs, ranging from 88% and 78% in the Boreal biogeographic region to 20% and 6% in the Mediterranean. The use of ES varied according to dominant habitat class, highlighting the dependence of specific ES on associated ecosystem functions. For instance, fibre production was the predominant ES throughout forest habitats while crop, fodder and livestock exhibit similar patterns of dominance across agricultural landscapes. In contrast, the use of wild food and recreation activities are seen as causing mainly negative effects across all habitats. Our analysis suggests that most uses of ES result in negative effects on conservation goals. These outcomes should be considered when implementing future conservation strategies.



## 1. Introduction

In recent years, advocates of the 'New Conservation' approach (Kareiva and Marvier, 2012; Holmes et al., 2017; Xu et al., 2017) have called for placing more emphasis on the provision of ecosystem services (ES) and their role in benefiting human well-being. As this concept gains momentum in science and policy agendas (but also criticism e.g. Ridder, 2008; Silvertown, 2015), it has redefined current biodiversity policies such as the 2020 Aichi Targets and EU Biodiversity Strategy to 2020 to conserve nature beyond its intrinsic value. A plethora of studies focused on how biodiversity loss affects the functioning of ecosystems, the supply of ES (Diaz et al., 2006; Worm et al., 2006; Balvanera et al., 2014; Harrison et al., 2014) and human well-being (Raudsepp-Hearne et al., 2010; Cardinale et al., 2012; Sandifer et al., 2015). For instance, Costanza et al (2007) estimated that a 1% change in biodiversity may result in a 0.5% change in the value of ES worldwide. The majority of these studies generally indicate that biodiversity supports the provision of ES through many strong connections (Duraiappah et al., 2005, Science for Environment Policy, 2015). For example, Maes et al. (2012) demonstrated a positive correlation between current levels of biodiversity and ES supply across Europe and Harrison et al. (2014) analysed literature that links various attributes of biodiversity, including species/functional richness and abundance or community areas and structure, to different ES.

* Corresponding author.
*E-mail address:* g.ziv@leeds.ac.uk (G. Ziv).

http://dx.doi.org/10.1016/j.ecoser.2017.08.011
2212-0416/© 2017 Published by Elsevier B.V.

The abovementioned studies refer to community level attributes of biodiversity (e.g. taxonomic richness). Conservation practice, however, typically focuses on managing the populations of specific (e.g. listed) rare or endangered species, often within reserves or protected areas. So far, only a few studies have considered the synergetic effects between the protection of endangered habitats or species and the supply of ecosystem services (but see Eigenbrod et al., 2009; Eastwood et al., 2016; Márquez et al., 2017; Xu et al., 2017). For example, Eastwood et al. (2016) investigated the effect of conservation on ES provision by comparing the provision of a broad range of ES in nine UK protected areas with nearby non-protected areas representing the same site-characteristics and habitat type, finding higher levels of ES provision (mainly cultural and regulating) in protected areas. Eigenbrod et al. (2009) found that English protected areas provide higher carbon storage and biodiversity, but not recreation potential. Conversely, in central Colombia, Márquez et al. (2017) found <60% overlap between protected areas and hotspots of ES provision, with water provision hotspots being the least protected.

Assessments demonstrating and quantifying the impacts (both positive and negative) of multiple ES use on species conservation are also rare. Macfadyen et al. (2012) suggested that management of agricultural landscapes for the provision of ecosystem services and management for biodiversity conservation can have either synergistic or conflicting outcomes. To date, there is no comprehensive analysis of these impacts at the continental scale, accounting for site-specific characteristics and spatial differences in habitat distribution, and using a range of ES.

To close this gap we here make use of data collected in sites of the European Union's Natura 2000 network, which was established to ensure the long-term survival of Europe's most valued and threatened species and habitats. There have been many studies focusing on the biodiversity conservation within the Natura 2000 network (reviewed in Popescu et al., 2014, and, Orlikowska et al., 2016). Here, we specifically focus on "Special Protection Areas" (SPAs) which comprise a subset of the network that targets the protection of bird species listed under the "Birds Directive" (European Commission, 2009, Directive 2009/147/EC). Birds have been shown to provide a good, common and well researched indicator or umbrella taxon for environmental degradation all around the globe (e.g. Gregory et al., 2005; Roberge and Angelstam, 2006). The European Environment Agency collects data on all Natura 2000 sites, gathered through the responsible protected area managers and thus based on local expert knowledge. This dataset covers a large spatial scale and contains details on the conservation status of more than 1550 protected species and 27,312 protected areas, but appears to be relatively underused in research. Only a few studies have mapped the provision of ecosystem services to existing Natura 2000 sites or have used Natura 2000 data to analyse the potential provision of ecosystem services at the local scale (Bastian, 2013).

Here, we make use of this dataset in order to assess the trade-offs and synergies between the use of ecosystem services and conservation goals. We specifically consider i) the extent to which the use of ES is leading to benefits and pressures on species conservation in SPA sites, ii) how these patterns differ across biogeographical regions and dominant habitat classes, and iii) how the trends in bird species conservation are affected by the use of ES, while comparing to other sources of data regarding conservation status. To our knowledge, this is the first study that provides a detailed, continental-scale analysis of the effects ES use has on conservation goals using data from Natura 2000 sites.

## 2. Data and methods

### 2.1. Study area and data sources

To examine the relationship between the use of ES and conservation goals, we focused on 5572 SPAs in Europe (Fig. 1) designated under Article 4 of the EC Birds Directive (Annex I). The data of Natura 2000 sites were available from the Data Service of the European Environmental Agency (Natura 2000 data – the European network of protected sites, 2017). From the geospatial database (seventh update since 2011; database release version: "End of 2015"), we extracted geographical boundaries of all SPAs, i.e. sites classified either as SPA only or SPA fully overlapping with a 'Site of Community Importance' (SCI). The available site-specific data are based on standard data forms (SDF) which are used by conservation managers for communicating information that is necessary to coordinate and maintain the Natura 2000 network and to evaluate its effectiveness for conservation. We specifically used the information provided in SDF Section 4.3 on 'threats, pressures and activities'. Here, the responsible conservation managers report the most relevant activities occurring in each site, choosing from a list of 412 codes, ranging from agriculture and silviculture to human disturbances and biological resource use. In addition, the form includes information on (i) whether the activity has a negative or positive impact on conservation goals (i.e. the targeted species), (ii) whether the activity occurs inside or outside the SPA, and (iii) whether the importance or impact is low, medium or high, defined by the level of immediate influence and the area the activity is affecting. For the list of codes and other metadata, please see the Reference Portal for Natura 2000 (European Topic Centre on Biological Diversity, 2017). From the same database, we also collected information on the biogeographical region in which each SPA occurs, the percent of coverage of habitat classes and the conservation status of Annex I species.

This dataset covers all member states of the European Union. However, 1400 sites (many of which are found in Italy and the Baltic states) were excluded from further analyses because the standard data forms were unavailable or only partially completed for these sites (see Fig. A1). We further excluded 415 sites in which, according to the SDF definition, the threats, pressures and activities had 'low' importance, i.e. they had "low direct or immediate influence, indirect influence and/or acting over small part of the area/ locally". The remaining 3757 SPAs used further in statistical analyses cover 540,479 $km^2$ across 9 biogeographical regions (see Fig. A1, Table A1).

### 2.2. Indicators for the use of ecosystem services

To identify the positive and negative impacts of the use of ES on the conservation of bird species in SPAs, we translated the reported threats, pressures and activities inside SPAs with high or medium impact into indicators of ES use. Low impact codes refer to activities of low or indirect influence, and/or acting over small part of the SPA (European Commission 2011), and were excluded from this analysis. We developed a matrix where each code that represents a certain activity was linked to a specific ES class as defined by the European Common International Classification of Ecosystem Services (CICES, Haines-Young and Potschin, 2013). For instance, reported agricultural or forestry activities were used as an indicator for the "provision of crops" or "provision of fibre", respectively. We ignored codes that (i) referred to human activities and natural phenomena impacting on abiotic aspects of a site (e.g. mining, extreme events), or (ii) mentioned the absence of activity (e.g. lack of grazing or biomass removal). In cases when the code could not be meaningfully translated into the class level of CICES, we