ARTICLE IN PRESS

Journal of Arid Environments xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Journal of Arid Environments

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

Factors affecting biodiversity in agrosylvopastoral ecosystems with in the Mediterranean Basin: A systematic review

Sofia Plexida[a,*], Alexandra Solomou[a], Kostas Poirazidis[b], Athanasios Sfougaris[a]

[a] Laboratory of Ecosystem and Biodiversity Management, Department of Agriculture, Crop Production and Rural Environment, University of Thessaly, Volos 384 46, Greece
[b] Laboratory of Environmental Management and Ecology, Department of Environmental Technology, Technological Educational Institute of Ionian Islands, Panagoula, 29100 Zakynthos, Greece

ARTICLE INFO

Keywords:
Natural ecosystems
Species richness
Plants
Birds
Agriculture

ABSTRACT

The biodiversity of Mediterranean agrosylvopastoral ecosystems has been extensively studied, because the Mediterranean Basin is a crossroad of biogeographical influences between cold temperate biota and subtropical species. Here, we systematically reviewed biodiversity studies published on natural and managed agrosylvopastoral ecosystems between 2000 and 2013 to obtain information on animal and plant species richness and diversity and the factors that affect biodiversity. Overall, 774 studies of potential relevance were identified, of which 230 provided information on biological monitoring and 154 met the requirements for the systematic review. Most articles were published in 2004, 2007, and 2011, and most were conducted in Spain. There was sufficient data on species richness to perform a meta-analysis comparing the species richness of 18 different terrestrial ecosystems containing seven taxonomic groups: plants, birds, invertebrates, reptiles, fungi, mammals, and amphibians. Ecosystem type, experimental design, number of study sites, habitat characteristics, and landscape structure were the most frequently mentioned factors affecting biodiversity. Plants were primarily analyzed (42.9% of reviewed studies), with patches and plots being the most common experimental design (64.8%). In comparison, amphibians were the least studied group (1.7%), with transects being the least used experimental design (11.1%). Plants had the highest average species richness (128.25) in managed woodlands, while birds had the lowest (18), with invertebrates generally representing good indicators of biodiversity. Overall, our review indicates that habitat heterogeneity is of importance for safeguarding species adapted to the variety of microhabitats, with it being important to implement traditional cultivation and grazing practices when managing these areas (such as the maintenance of the agro-forestry systems).

1. Introduction

Extensive growth of the human population, combined with the increase in the consumption of material goods per capita and high rates of urbanization over the last century, has led to irreversible changes in land cover globally (Foley et al., 2005). In this context, two opposite processes are being currently observed, both of which are having a significant impact on ecosystem composition and performance: (1) the intensification of ecosystem use through the introduction of modern management techniques and (2) the abandonment of areas under traditional land-use practices (Bassa et al., 2012; Schippers et al., 2015). Global land-use change has caused declines in biodiversity through the direct loss of habitats, degradation of soil and water, overexploitation of native species, and the introduction of exotic species (Sala et al., 2000; Sanderson et al., 2002), leading to the degradation and unsustainable use of 60% of the ecosystem services examined during the Millennium Ecosystem Assessment (15 out of 24 services; MEA, 2005). While there is clear experimental evidence of the linkage between biodiversity loss and the deterioration of ecosystem functions, the structure (shape and strength) of this relationship remains contentious (Schwartz et al., 2000; Balvanera et al., 2006).

The Mediterranean Basin is characterized by a long history of human intervention; consequently, the components and dynamics of today's biodiversity in this region cannot be understood without taking the human factor into account (Geri et al., 2010). Various types of anthropogenically shaped ecosystems, representing the unique cultural heritage of the Basin, and many species of flora and fauna, which are highly adapted to human-induced disturbances, depend on traditional management (Blondel et al., 2010; Otero et al., 2013) and policies aimed to conserve such cultural landscapes (Council of Europe, 2000). The exceptional resilience of Mediterranean ecosystems to disturbance, which has been evolving for millennia, is, in part, due to the relatively

* Corresponding author. Fytokou str., N. Ionia, 384 46 Volos, Greece.
E-mail addresses: sofiaplexida@uth.gr (S. Plexida), alexansolomou@gmail.com (A. Solomou), ecopoira@yahoo.gr (K. Poirazidis), asfoug@agr.uth.gr (A. Sfougaris).

https://doi.org/10.1016/j.jaridenv.2017.11.017
Received 11 August 2017; Received in revised form 23 November 2017; Accepted 24 November 2017
0140-1963/

Please cite this article as: Plexida, S., Journal of Arid Environments (2017), https://doi.org/10.1016/j.jaridenv.2017.11.017

low rates of the current biodiversity in the region (Blondel et al., 2010). Unfortunately, the progressive loss of traditional management in rural areas over the last century has led to a decline in biodiversity and the provision of ecosystem services (Matlack, 2005; Bugalho et al., 2011).

The biodiversity present within communities can be studied at different levels. However, species richness is the simplest example, in which three levels of species diversity may be assessed; for instance, (1) Alpha: within an ecosystem; (2) Beta: among ecosystems; and (3) Gamma: as the overall diversity for the different ecosystems within a given region (Noss, 1990). Many ecological studies (Naeem et al., 2002) have been undertaken using species richness as a measure to understand different aspects of biodiversity and the relationship between ecological function and species richness. Ecological factors determining species richness and diversity vary across spatial scales, in addition to affecting particular organism groups differently (Bengtsson et al., 2005; Paillet et al., 2010; Felton et al., 2010). Yet, it is not possible to account for all of the effects of various parameters in a single experimental study. However, meta-analyses have proven effective for identifying overarching factors affecting species richness, providing a complete picture across multiple spatial scales and taxa (Field et al., 2008). Consequently, the meta-analysis approach was proposed as a more objective way of surveying the literature on key ecological subjects (Berman and Parker, 2002). Meta-analyses are especially useful for examining general patterns in the responses of biodiversity before different pressures were introduced in ecology (Bengtsson et al., 2005; Jactel and Brockerhoff, 2007). Meta-analyses also reduce the bias caused by significant studies that have low sample sizes and high sample variance (Gaertner et al., 2009). There are many examples of how meta-analysis has been used to investigate questions on biodiversity (Bengtsson et al., 2005; Eglington et al., 2012). The meta-analysis technique applied in ecology consists of searching and combining results from several studies performed at different spatial scales and with a focus on different targets, providing a wide view of the ecological mosaic to identify potential patterns among the results of multiple studies. In this way, the synthesis of multiple studies provides a tool to increase our ability to understand, conserve, and restore ecosystems.

Considerable research has focused on testing how various management activities influence biodiversity within the Mediterranean Basin, where just 4.7% of the primary vegetation remains unaltered (Falcucci et al., 2007; Serra et al., 2008). A number of studies have focused on comparing traditional vs. modern management systems and their impact on biodiversity indicators (José-María et al., 2011; Ponce et al., 2011). In comparison, other studies have evaluated unmanaged vs. managed ecosystems have been (Aragon et al., 2010). Gaertner et al. (2009) conducted a meta-analysis of 11 studies to understand how invasive plants affect the species richness of invaded communities across a range of spatial extents in Mediterranean ecosystems. The authors found a positive relationship between the loss of species and spatial scale, with more species being lost at smaller spatial scales. However, our understanding on how different human-based actions affect biodiversity are linked to ecosystem goods and services provided in the Mediterranean region remains challenging, and requires thorough exploration.

Thus, here, we performed a quantitative assessment of the relationship between biodiversity measurements and landscape characteristics through a meta-analysis of experimental research carried out over the last decade. Specifically, this study examined the biodiversity studies of countries within the Mediterranean Basin between 2000 and 2013 to: (i) identify key abiotic factors, (ii) list the recorded taxonomic groups and those actually used as biodiversity indicators, and (iii) determine the diversity measures used to assess species richness. Our results are expected to provide new insights into the patterns and trends of biodiversity indicators in Mediterranean terrestrial ecosystems.

Table 1
Classification scheme for the factors extracted from the biodiversity studies.

Factor	Description
Ecosystem type	managed croplands, abandoned arable land, managed woodlands and forestry plantations, abandoned forestry plantations, managed shrub plantations, natural woodlands/forests, shrublands, crubs
Type of experimental design	category 1 = fields/patches/plots, category 2 = traps/bottle, category 3 = transects
Number of studied sites	category 1 = 0–5, category 2 = 5–10, category 3 > 10
Habitat characteristics	category 1 = topography, category 2 = vegetation description
Landscape structure	landscape configuration, landscape composition
Type of taxon	plants, birds, invertebrates, herpetofauna, mammals, fungi, amphibians
Type of diversity measure	species richness, abundance, diversity indices, evenness

2. Material and methods

2.1. Literature search

Seven-hundred and seventy-four (774) publications were included in our database, representing biodiversity measurements of terrestrial Mediterranean agrosylvopastoral ecosystems within the Mediterranean Basin from January 2000 to June 2013. We searched multiple electronic databases and the internet using different combinations of search-terms. The databases used included Google (http://google.com), Google Scholar (http://scholar.google.com), Web of Science (http://www.isiwebofknowledge.com), Scirus (http://www.scirus.com/), and Scopus (http://www.scopus.com). Scoping was performed to find optimal key words and to obtain a preliminary overview of the availability of suitable studies. We used the following search terms in various combinations: (agricultural ecosystem* OR natural ecosystem* OR abandoned ecosystem* OR managed ecosystem* OR forest OR shrub OR pasture) AND (landscape* OR topography* OR biotic* OR abiotic* OR field*) AND (biodiversity OR diversity OR species richness OR abundance OR bird* OR mammal* OR reptile* OR amphibian* OR fungi* OR invertebrate* OR insect* OR herpetofauna* OR arthropod* OR plant* OR flora OR fauna). Search terms were run in separate or limited combinations, depending on the requirements, or limitations, of the database used. In addition, we identified scientific articles, books, and reports by consulting published studies, including major review articles (Bugalho et al., 2011; García-Ruiz and Lana-Renault, 2011). This search produced 774 peer-reviewed papers.

2.2. Inclusion and exclusion criteria of studies

The selection of studies relevant to this systematic review followed three-stages (Plieninger et al., 2013). First, the relevance of a publication for inclusion in the current study was initially assessed based on its title. Second, further selection was performed based on the abstract of the publication. To assess the consistency in the use of inclusion criteria, a kappa test was performed. Two reviewers applied the inclusion criteria to a random set of 87 articles at the abstract filtering stage. The kappa statistic was calculated to measure the level of agreement between reviewers. A score of 0.75 was achieved, which indicates substantial strength of agreement (Edwards et al., 2002). In the third stage, the content of full papers was assessed. In cases of doubt, studies were generally included to the next phase of the selection process. Repeatability of study inclusion was checked through a random subset of at least 10% of references, the titles and abstracts of which were assessed by another reviewer, independently. This led to the rejection of 620 papers. These papers were rejected because they did not address a biodiversity issue or did not take place in the terrestrial ecosystem of