Land Use Policy 54 (2016) 313–320

Contents lists available at ScienceDirect

Land Use Policy

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

Anthropogenic and topographic correlates of natural vegetation cover within agricultural landscape mosaics in Turkey

Burak K. Pekin

Zoological Society of San Diego, Institute for Conservation Research, 15600 San Pasqual Valley Road, Escondido, CA 92027, United States

ARTICLE INFO

Article history:
Received 7 May 2015
Received in revised form 28 January 2016
Accepted 24 February 2016

Keywords:
High nature value farmland
Cultural landscapes
Semi-natural vegetation
Multi-function landscapes
Agricultural industrialization
Spatial land use patterns

ABSTRACT

Natural vegetation enhances the value of agricultural landscapes for people and wildlife. However, the role of anthropogenic versus topographic factors in driving the extent of natural vegetation cover within agricultural lands at large spatial scales remains unexplored. I assessed the influence of anthropogenic and topographic variables on the extent of agricultural mosaics with high natural vegetation cover in the country of Turkey where a large extent of natural and semi-natural vegetation is maintained by traditional agriculture. GIS layers depicting human land use, elevation, slope, roads and population data were obtained and summarized at two spatial scales, within provinces and for 100 km^2 grid cells covering the country's entire agricultural land area. Average farm size was also obtained at province level. Hierarchical Partitioning was conducted to determine the independent effect of anthropogenic and topographic variables on the variation in agriculture with high natural vegetation. Slope had the largest independent effect on the variation in the proportion of agricultural mosaic with high natural vegetation cover. The extent of agricultural and settlement area also explained much of the variation in natural vegetation across both grid cells and provinces. The proportion of natural vegetation increased as human population and road density decreased across grid cells and as average farm size decreased across provinces. These results suggest that while topography is the primary driver of natural vegetation cover within agricultural mosaics in Turkey, the pressures associated with urban development and agricultural industrialization may also influence the cultural and wildlife value of agricultural landscapes.

1. Introduction

Nearly half of the earth's terrestrial surface is utilized by humans for crop and livestock production (Ellis and Ramankutty, 2008). However, there is great variation in the type and intensity of agricultural land use (Ellis et al., 2010). Agriculture ranges from vast monocultures used to produce a single crop to highly heterogeneous landscape mosaics that support multiple ecosystem functions (Altieri, 1995). In recent years, interest has grown in assessing the value of different agricultural landscapes beyond food production (Swinton et al., 2007; Tagliafierro et al., 2013), such as for conservation of biodiversity (Martin et al., 2014; Pekin and Pijanowski, 2012; Tscharntke et al., 2005) and cultural heritage (Beilin et al., 2014; García-Llorente et al., 2012; Plieninger et al., 2014). Consequently, a variety of subsidies and investment schemes have been enacted to conserve traditional agriculture and to increase the conservation value of farmlands often with positive outcomes (Hiron et al., 2013; Vickery et al., 2004). However, assessments of the factors driving the spatial distribution and extent of natural vegetation cover in agricultural lands at regional scales are lacking.

Natural features of agricultural landscapes have been particularly neglected in rapidly industrializing countries such as Turkey, where they are at the most risk of being lost. There is evidence that Turkey's traditional low input agriculture, and associated natural landscape features (Redman and Hemmami, 2008), have an important role in supporting rare and threatened species (Pekin, 2013). Owing to its highly variable climate and unique geography, Turkey encompasses three of the planet's major biodiversity hotspots (the Mediterranean, Caucasian, and Irano-Anatolian) and harbors exceptionally high biodiversity for a temperate country of its size (Şekercioğlu et al., 2011). However, much of this biodiversity is currently threatened from poorly designed land use policies (Şekercioğlu et al., 2011) that generally favor agricultural industrialization over traditional farming (Aydin, 2010; Keyder and Yenal, 2011). There is thus an urgent need to understand how policy related changes in human activities and land use may impact the natural features of Turkey's agricultural landscapes.

E-mail address: burakpekin@hotmail.com

http://dx.doi.org/10.1016/j.landusepol.2016.02.029

My objective in this study was to assess the role of anthropogenic stressors in shaping the natural features of agricultural landscapes in Turkey as indicated by the presence of natural or semi-natural vegetation cover within the agricultural mosaic. While anthropogenic factors such as industrialization may reduce the natural vegetation found in agricultural landscapes, topographic factors that limit the suitability of the land for industrial farming are likely to determine the spatial extent and location of these changes. It is thus important to account for variation in topography when assessing anthropogenic impacts on agricultural land cover dynamics. To this end, I calculated elevation and slope along with human land use and population across all 81 Turkish provinces and 100 km^2 grid cells covering the country's entire agricultural land area. I then related the proportion of the agricultural mosaic with high natural vegetation cover to anthropogenic and topographic variables at these two spatial scales to assess the relative impact of anthropogenic stressors on the natural and cultural value of Turkey's agricultural landscapes.

2. Methods

2.1. Study region

Turkey is located in the eastern end of the Mediterranean Basin (Fig. 1a) and spans in latitude from the 36th parallel in its southern, to the 42nd parallel in its northern extent. Being located between two major seas, the Mediterranean and Black sea, the country has a considerable amount of coastline with relatively mild and wet climate. However, the climate varies greatly from the coastal to interior areas, and from north to south due to the presence of several large mountain chains. Some inland areas receive as little as 250 mm of mean annual precipitation which can reach over 2000 mm in the eastern Black Sea region. Mean annual temperatures vary from approximately 19 °C in Antalya, a major city on the Mediterranean coast in the south of the country, to 5 °C in towns and cities of the eastern highlands. Sharp transitions in climate are common throughout the country due to highly variable topography.

2.2. Natural vegetation cover within the agricultural mosaic

GIS data of agricultural land use for Turkey as well as Europe was obtained from CORINE land cover (CLC) 2006 as 100 m resolution pixel raster (European Environment Agency, 2011). In the CLC, agricultural land uses are categorized into arable land, permanent crops (e.g., orchards, vineyards), pastures, and heterogeneous agricultural areas. The latter category is composed of four subcategories, one of which is "Land principally occupied by agriculture, with significant areas of natural vegetation". This category is defined by an agricultural use of less than 75% of the land with the remaining land being occupied by natural or semi-natural vegetation. This agricultural landscape mosaic, referred to as 'agriculture with high natural vegetation' (AHNV) from here on, is likely to be an important land use type for wildlife in the Mediterranean Basin as it exemplifies the human modified semi-natural landscapes that are characteristic of the high biodiversity of the region (Zamora et al., 2007). In Turkey, semi-natural vegetation patches in agricultural mosaics often consist of native trees such as oaks that are used for shade and fuel wood. Tree and shrub patches are commonly found at field margins, and large trees can sometimes be seen in the middle of fields. The understory of these trees and tree patches is often grazed and provide an important shaded area for livestock to take refuge during the hottest months. Riparian vegetation along stream and creek beds is also often left intact, and planting and harvesting of poplars is common. It is important to note that other agricultural lands, such as pastures or permanent crops such as olive groves, may also comprise important habitat for wildlife. However, my focus in this study is on agriculture with natural vegetation as one of the main agricultural land use types with high nature value in the region.

2.3. Land use and topographic data

Several other land use and topographic data were obtained (see Table 1). Total agricultural land area which included all arable land, permanent crop, pasture, and heterogeneous agricultural area classes, along with human settlement area were also obtained from the CLC. Human settlements included all CLC land uses classified as artificial surfaces such as urban, industrial, commercial, and transportation units, as well as green urban space and sports facilities.

Elevation and slope were calculated from a Digital Elevation Model (DEM) covering the entire country of Turkey at 3″ resolution (De Ferranti, 2014) using the *Terrain Analysis* tool in QGIS (QGIS Development Team, 2014). GIS shapefiles showing location of all roads and settlements in Turkey were obtained from OpenStreetMap (Haklay and Weber, 2008). Gridded population estimates at 1 km resolution were obtained from Global Rural-Urban Mapping Project, GRUMP (CIESIN, 2011).

The total area and number of farms within all 81 Turkish provinces was obtained from the Turkish Statistical Institute (2014). Total farm area was divided by the number of farms to obtain average farm size within each province.

3. Data analyses

Patterns and correlates of AHNV were explored at two spatial scales. First, the proportion of AHNV, agricultural area and settlement area, as well as average elevation and slope, population density, and average farm size (see Table 1) were summarized across all 81 provinces (Fig. 1b). Second, proportion of AHNV, agricultural area and settlement area, as well as slope, elevation, population density, and road density (see Table 1) were summarized across 7382 10 km × 10 km (100 km^2) grid cells (Fig. 1c). Road density was calculated as the total length of all roads within grid cells in QGIS. Road density was included among explanatory variables to provide a proxy for how utilized the landscape is by humans in grid cells that may have few or no settlements. Average farm size was not used at grid scale because the data were not available at that scale. All 81 provinces were included in the analyses. Grid cells that fell entirely or mostly on water bodies such as lakes and those with no agricultural land area were excluded from further analysis. There are no country scale summaries available for the CLC classes. Hence, I also calculated total agricultural area, and area of AHNV at the country scale, for all countries included in the CLC database. This was done to provide context for the extent and relative importance of this land use class within the region. Comparisons between countries (e.g., Turkey, Spain, France, etc.) were conducted to provide context for the study.

Independent effects of anthropogenic and topographic variables on AHNV at province and grid scales were tested using hierarchical partitioning (Chevan and Sutherland, 1991; Mac Nally, 2000) with the *hier.part* package (Walsh and Mac Nally, 2012) in R (R Core Team, 2009) at both grid and province scales. Hierarchical partitioning is a semi-parametric regression based method where the significance of the contribution of each variable is based on goodness of fit measures conducted on multiple randomized versions of the original data matrix (Mac Nally, 2002). The approach is based on a Multi-Model Inference framework which is more appropriate for analyzing multidimensional data than classical regression approaches that require hypothesis testing. Hierarchical partitioning is especially useful for overcoming multicollinearity which is