Journal for Nature Conservation 40 (2017) 77–84

Contents lists available at ScienceDirect

Journal for Nature Conservation

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

Incorporating zoning and socioeconomic costs in planning for bird conservation

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ARTICLE INFO

Keywords:
Systematic conservation planning
Marxan with zones
Socioeconomic costs
Zoning
MaxEnt
Hyrcanian mixed forests

ABSTRACT

New systematic conservation approaches have high potential in evaluation of different conservation scenarios and can be used as decision support tools for managers and planners with multiple goals. The present study focused on two major issues in conservation planning including socioeconomic costs and zoning procedure. The goal was to prioritize and identify representative areas for bird conservation, while minimizing the economic cost for the silvicultural sector and resolve conflicts with recreational activities. The study was conducted in forest areas of Golestan Province as part of Hyrcanian mixed forests, located along the southern coasts of the Caspian Sea and northern slopes of the Alborz Mountains, northern Iran. We used systematic conservation software Marxan with Zones to select candidate areas for conservation. Two types of conservation networks were defined, one with high and partial protection zones and the other with high protection zones only. We focused on four conservation scenarios varying in targets, costs, and multiple zones. The results showed that incorporation of socioeconomic costs significantly decreases the potential impacts on the silvicultural and recreational sectors without significant change in the area of protection zones. Furthermore, we found that design of multiple zone conservation areas facilitates evaluation of a wider range of conservation scenarios that can reduce potential socioeconomic impacts on other interests.

1. Introduction

Despite the essential services of biodiversity for humanity, the rate of biodiversity loss due to human activities, overexploitation, and pressure from invasive species is increasing, and many species have been threatened all around the world (Naoe et al., 2015; Lu, Wei-hua, Zhi-yun, & Chun-quan, 2014). Protected areas have been accepted as the most effective conservation measures to prevent biodiversity loss (Lewis, 1996). In this regard, systematic conservation planning is an effective approach that facilitates locating and designing protected areas and other conservation networks based on quantitative conservation goals and using explicit methods (Margules and Pressey, 2000; Smith, Goodman, & Matthews, 2006; Cameron, Williams, & Mitchell, 2008). The ultimate purpose in these circumstances is to identify representative and complementary areas for conservation of biodiversity (Lin et al., 2014).

Two important issues to be considered in the conservation planning process are socioeconomic costs and zoning of conservation areas. Most of the studies published on systematic conservation planning have focused on the benefits of the conservation plans. However, despite the advantages of protected areas, overlooking other uses in conservation planning process have often had conssiderable cost for the local people; who are economically dependent on these areas; and other affected stakeholders. Therefore, incorporating socioeconomic costs into the planning process is essential and can minimize conflict with other uses and human activities (Ruiz-Frau et al., 2015; Lewis, 1996; Naidoo et al., 2006).

A range of freely available systematic conservation software and tools such as Marxan (Ball and Possingham, 2000; Ball, Possingham, & Watts, 2009), Zonation (Moilanen et al., 2012), ResNet (Kelley, Garson, Aggarwal, & Sarkar, 2002), c-Plan (Pressey, Watts, Ridges, & Barrett, 2005) are increasingly used around the world. Many studies applied these software and tools to identify areas that efficiently meet conservation goals for a range of biodiversity features for minimal cost (Pearce et al., 2008; Klein et al., 2008; Giakoumi, Grantham, Kokkoris, & Possingham, 2010; Jenkins, Alves, & Pimm, 2010; Momeni Dehaghi, Salman Mahiny, Alizadeh Shabani, & Karami, 2013; Mehri, Salmanmahiny, Mirkarimi, & Rezaei, 2014; Mendoza-Fernandez et al., 2015). However, in most of these studies, all planning units in the selected areas are only dedicated to reserved or not reserved zone and the

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http://dx.doi.org/10.1016/j.jnc.2017.10.001
Received 28 November 2016; Received in revised form 3 October 2017; Accepted 5 October 2017

effects of zoning conservation areas with different levels of protection and for multiple uses are not considered (Watts et al., 2009).

Zoning is a spatial planning tool that facilitates selection of the representative areas as a conservation zone in a special region while allowing reasonable human uses in other zones. Considering multiple use zoning in the conservation planning process instead of assuming two zones, including reserved and not reserved, with the regulation of other uses helps in management and resolving conflicts in protected areas and minimizes the effects of human activities in these areas (Day, 2002). Marxan with Zones is the first land use zoning software with a particular focus on conservation; it is an extension of Marxan software that can allocate conservation areas to multiple zones with different levels of protection and considering multiple costs for zones (Watts, Klein, Stewart, Ball, & Possingham, 2008; Watts et al., 2009).

The goal of the current study was to identify representative areas for bird conservation in Caspian Hyrcanian mixed forest, while minimizing the economic cost for silvicultural sector and resolving conflict with recreational activities. Caspian Hyrcanian mixed forests, located along the southern coast of the Caspian Sea and northern slopes of the Alborz Mountains, northern Iran, have been subject to multiple human pressures such as overexploitation for fuel wood and industrial wood production, clear-cutting for agricultural development and fire. Despite the crucial importance of protecting these unique forests and habitats of species they harbor, no systematic conservation plans have been applied in this region that simultaneously meet conservation targets while minimizing conflict with other uses. The lack of consideration of other uses, such as forestry and recreational activities, can result in inequitable solutions that cause substantial socioeconomic costs for these sectors. Our study is the first attempt to represent an approach to preserve critical habitats in the Hyrcanian forests while considering silvicultural and recreational activities simultaneously.

2. Methods

2.1. Study area

The study was conducted in forest areas of Golestan Province, northern Iran (Fig. 1). The region covers approximately 616670 h and is part of the Caspian Hyrcanian mixed forests, located along the southern coast of the Caspian Sea and northern slopes of the Alborz Mountains, northern Iran. Dense and semi-dense forest areas and rangelands cover approximately 59% and 24% of the region, respectively. About 16% of the region is covered with clear cut areas for agriculture and human-constructed surfaces. The altitude varies from −15 m in the northwestern parts to about 3363 m in the southwestern parts. The climate of this region is humid, with average annual rainfall of 628 mm and mean annual temperature of 12° C. The natural forest vegetation is a temperate deciduous broad-leaved forest. This forest includes valuable species such as, *Quercus castaneifolia*, *Fagus orientalis*, *Alnus subcordata*, *Acer velutinum*, *Sorbus torminalis*, *Ulmus glabra*, *Tilia begonifolia*, *Acer cappadocicum*, *Fraxinus excelsior*, *Juglans regia*, etc. The species *Quercus castaneifolia* is dominant in the eastern areas of the Province and *Fagus orientalis* in the western areas. Valuable and rare species such as *Taxus baccata*, *Thuja orientalis*, *Cupressus sempervirens*, *Buxus sempervirensa*, and *Zelkova carpinifolia*, are considered as genetic resources. The region has unique biodiversity and provides habitat for a wide range of plant and animal species. This region is an important resting area for birds migrating between Russia and Africa and is thus a key habitat for many bird species. Furthermore, it is one of the most important and invaluable industrial and commercial forests of Iran and has many tourism values at national and regional levels. This region has been subject to multiple human pressures such as overexploitation for fuelwood and industrial wood production, clear-cutting for agricultural development, road construction, intensive tourism, and wild fires. These problems have led to habitat fragmentation and a decline in biodiversity of the region.

The unique biodiversity of the region makes it an important area for conservation. The present study used systematic conservation software Marxan with Zones to select candidate areas for conservation of birds' habitat. In doing so, the entire region was divided into a set of watersheds with a minimum area of 50 h, which delineated 11094 planning units. Marxan selects the best combination of these planning units to create a conservation network that meets all conservation targets.

2.2. Conservation features

The goal of our study was to identify representative areas for bird conservation. Fifteen bird species were selected for conservation based on the IUCN Red List, CITES species database and data availability. These species are European roller (*Coracias garrulus*), Eurasian Sparrowhawk (*Accipiter nisus*), Shikra (*Accipiter badius*), Lesser Kestrel (*Falco naumanni*), Common Kestrel (*Falco tinnunculus*), Eurasian tree-creeper (*Certhia familiaris*), Red-headed Bunting (*Emberiza bruniceps*), Common Whitethroat (*Sylvia communis*), Eurasian Nuthatch (*Sitta europaea*), Common Starling (*Sturnus vulgaris*), Red-backed Shrike (*Lanius collurio*), Black Redstart (*Phoenicurus ochruros*), Common Redstart (*Phoenicurus phoenicurus*), European robin (*Erithacus rubecula*), and Common Swift (*Apus apus*). Bird occurrence data was obtained from Golestan's department of environment, that was collected by Rezaei et al. (2010). Presence data were collected as part of a project of developing a bird atlas for northern Iran in 2012 and 2013. To collect data, the region was divided into square cells with a width of 20 km referring to researches such as that of Scott, Moravej Hamadani, and Adhami Mirhosseyni (1975). This was practical due to accessibility through main and secondary roads on which the survey grouped travelled, stopped and conducted visual inspections using binoculars and also recording evidence of bird voices. The bird's data was monitored in forest habitats, and also open habitats, that include forest clear-cuts and other areas free of tree cover. Rangelands, agriculture and human-constructed patches are in the region as a result of forest clear cutting, and considered as open habitats for monitoring birds. Point and linear sampling transects were used to monitor bird's presence in forested habitats and open habitats, respectively. Transects were surveyed visually by multiple field teams at various times of the day. A GPS (Global Positioning System) was used to record data. (Rezaei et al., 2010). These data consist of 495 presence records across the study area. We used maximum entropy (MaxEnt) method (Phillips, Dudík, & Schapire, 2004; Phillips, Anderson, & Schapire, 2006; Phillips and Dudík 2008) for habitat suitability modeling of the selected species. This method is popular and well accepted in researches so much so that the MaxEnt original paper (Phillips et al., 2006) has been cited more than 3600 times with 1600 citations between 2012 and 2015. Even with few numbers of occurrence data, MaxEnt provides reasonable results (Pearson, Raxworthy, Nakamura, & Townsend Peterson, 2007; Wisz et al., 2008) and this method is less sensitive to spatial error of occurrence data (Baldwin, 2009). Evidently, these two aspects are imperative in developing countries such as Iran with poor data about wildlife species (Momeni Dehaghi et al., 2013). Comparisons between various habitat suitability models indicate that MaxEnt outperforms most of other presence-only methods (Elith et al., 2006; Miguel, Ortega, & Townsend Peterson, 2008).

Environmental parameters used in the modeling process are land-use/cover, land use/cover diversity, fragmentation index, distance to water resources and streams, precipitation, altitude, aspect, slope, wind speed, distance to farmlands, NDVI. The land use layer was obtained from the Golestan Province land use planning report (2013), that was derived from Landsat images with a spatial resolution of 30 m. Dense and semi-dense forest areas and rangelands covered approximately 59% and 24% of the region, respectively. About 16% of region was covered with clear cut areas for agriculture and human-constructed surfaces.

The land use/cover diversity index was calculated as: