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Incorporating zoning and socioeconomic costs in planning for bird conservation

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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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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:

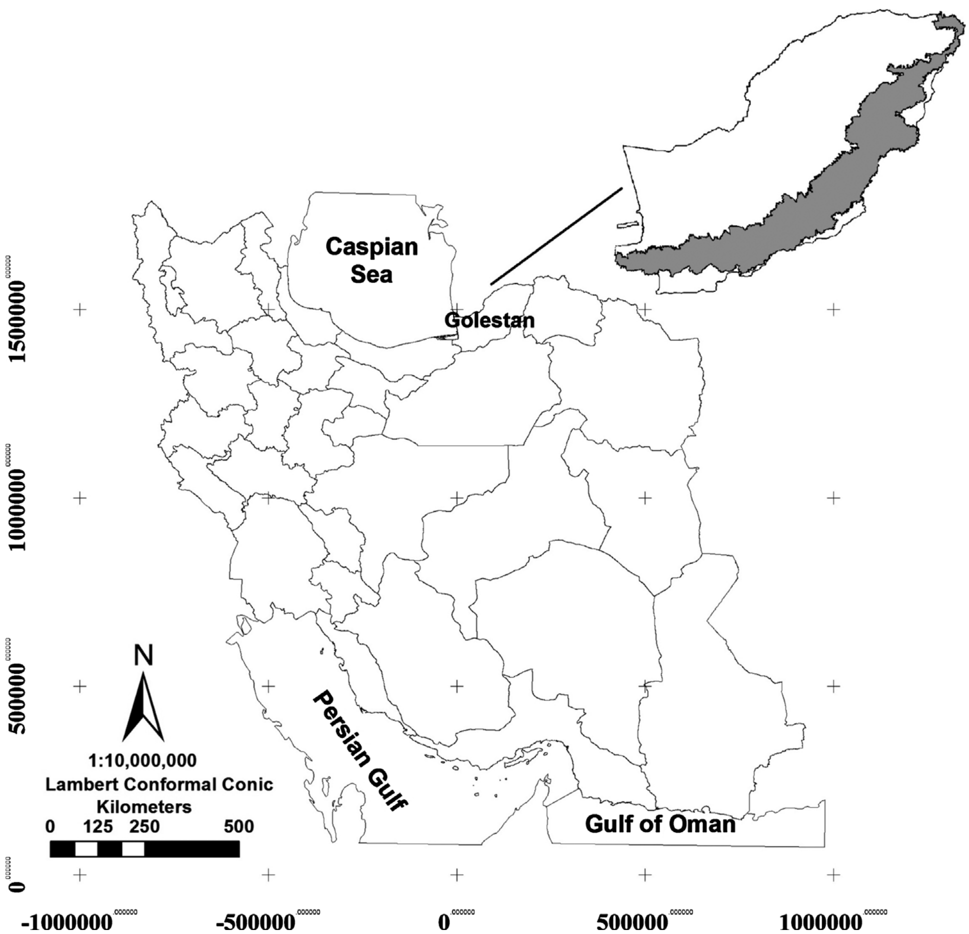

Fig. 1. Location of Caspian Hyrcanian mixed forests in Golestan Province of Iran.

Diversity = −sum (p*ln(p))

where sum is the sum over all land use classes in the entire image, P is proportion of each class in the kernel, and ln is natural logarithm. The values of resulting layer ranged from 0 to 2.08, with the average of 0.20.

The fragmentation index was defined as:

Fragmentation = (n-1)/(c-1)

where n is number of different land use classes present in the kernel, and c is number of cells considered (9 in this study). The fragmentation index varied from 0 to 0.33 with the average of 0.02.

Distance to water resources and streams was calculated as value of each pixel equaled to distance to the nearest water or stream pixel. The values of resulting layer ranged from 0 to 11883m, with the average of 1935m. The precipitation layer was obtained from the Golestan Province land use planning report (2013) that was derived from daily rainfall dataset from meteorological stations. The values of resulting layer ranged from 0 to 837 mm, with the average of 628 mm. The altitude layer was also obtained from the Golestan Province land use planning report (2013), that was derived from Degital Elevation Model (DEM) with a spatial resolution of 30 m. The altitude varied from −15 m to 3363m, with the average of 1015m.

The aspect layer was extracted from DEM. North and west were the dominant aspects and covered 27% and 20% of the region, respectively. Also, the plain covered 23% of the region. The slope layer was extracted from DEM. The slope varied from 0% to 200%, with the average of 31%. The wind layer was obtained from the Golestan Province land use planning report (2013) that was derived from daily wind dataset from meteorological stations. The values of resulting layer ranged from 0 to 4.5m/s, with the average of 3.5m/s. Distance to farmlands was calculated as value of each pixel equaled to distance to the nearest farmland pixel. The values of resulting layer ranged from 0 to 13805m, with the average of 2391m. Normalized Difference Vegetation Index (NDVI) was obtained from the Golestan Province land use planning report (2013), that was derived from MODIS images. The NDVI varied from 1570 to 9975, with the average of 7776. Spatial resolution for all layers was converted to 30 × 30 m.

We used MaxEnt for modeling habitat suitability of each bird species by considering 25% of presence records as a random test percentage and bootstrap replicated run type (6 replications). Then, the produced continuous habitat suitability layers were converted to binary (with a value of one for suitable and zero for unsuitable regions) using ten percentile training presence logistic threshold. The conservation target was to preserve a minimum of 30% of the habitat of each bird species.

2.3. Conservation cost

To minimize socioeconomic impacts on silvicultural sector, we used forest economic value as conservation cost. The forest cover types map was obtained from the Forest, Rangeland, and Watershed Management Organization of Iran. We used two forest cover type maps at 1:50,000 and 1: 250,000 scales to prepare a final map for our region. This map included 109 forest types. Spatial data on the forest economic value was prepared via assigning an expert-based economic value to each forest type. We asked our experts, who are faculty members of the Department of Forestry, Gorgan University of Agricultural Sciences and Natural Resources, Iran, to assign a value of 0–100 for each forest type based on their knowledge about the species and forest types in the region and the commercial values of these species. To investigate the efficiency of considering conservation cost to minimize conflict between conservation and silvicultural sector, forest economic value was classified into three classes, including low, average and high economic values. We used Natural Breaks methods to classify data, through the Jenks Natural Breaks algorithm. Then, the percent of each class that was located in conservation zones was calculated.

2.4. Recreational activities

We used spatial data on tourism regions in order to minimize the impacts of conservation planning on recreational activities. The data was obtained from Iran's Cultural Heritage, Handicrafts and Tourism Organization and included 191 tourism regions such as; historical and archaeological sites, religious monuments, caves, waterfalls. These data were on the 1:25,000 scale. These regions have cultural or environmental characteristics that make them suitable for extensive or intensive recreational uses. Our purpose was to at least set aside 90% of these tourism regions outside of the high protection zone; therefore safeguard them in the partial protection zone for extensive recreation or in open zone for extensive and intensive recreation. In order to investigate the efficiency of the results in terms of minimizing conflict between conservation and recreational activities, the areal percentage of tourism regions that was located in high conservation zones was calculated.

2.5. Systematic conservation planning

The goal was to prioritize and identify representative areas for bird conservation, while minimizing the economic cost for silvicultural sector and resolving conflict with recreational activities. We used systematic conservation software Marxan with Zones to select candidate areas for conservation. Marxan with Zones is an extension of Marxan software that can allocate conservation areas to multiple zones, with different levels of protection and multiple costs for zones (Watts et al., 2008, 2009). Marxan offers different selection algorithms and run modes. We used simulated annealing with an iterative improvement algorithm because it is well documented that this run mode gives the best possible results (Watts et al., 2008; Mehri et al., 2014). We ran Marxan with zones to investigate the effects of including forest economic value and recreational activities on meeting goals and minimizing socioeconomic costs. Furthermore, the impacts of zoning conservation areas were examined. We defined two types of conservation networks, one with high and partial protection zones and the other with only high protection zone. In the high protection zone all human activities are prohibited, and in the partial protection zone, only extensive recreational activities are allowed. Also, another one is an open zone where all uses are allowed. According to these goals, four different scenarios were defined, as explained in the next section. All scenarios were run with 100 repeat runs and 10,000.000 iterations.

2.6. Conservation target

Conservation targets can be habitats, species, biophysical factors or anything that the user wants to preserve (Ruiz-Frau et al., 2015). The fundamental question in conservation planning that conservationist, scientist, and policymakers have struggled with for years is "How much is enough" to protect the biodiversity (Svancara et al., 2005; Tear et al., 2005; Soule and Sanjayan, 1998). It is obvious that every acre of habitat or every individual of a species cannot be preserved and we require to preserve at least some minimum amount. But, unfortunately, for the vast majority of species and ecosystems, this minimum is unknown (Tear et al., 2005). Many international commissions and nature conservation organizations consider 10 or 12% of total land in each nation or ecosystem (Soule and Sanjayan, 1998). In Global Biodiversity Outlook (Convention on Biological Diversity, 2014) Aichi Biodiversity Target 11 says that: by 2020, at least 17% of terrestrial areas, especially areas of particular importance for biodiversity and ecosystem services should be conserved. Recent reviews in the field of systematic conservation planning indicate that conservation targets range from 33% to 99% (Svancara et al., 2005; Wiersma and Nudds, 2006). In this study, the conservation target was to preserve a minimum of 30% of the habitat of each bird species. A 30% target was used because it is internationally preferred (Ruiz-Frau et al., 2015; IUCN, 2003; Klein et al., 2009). For instance, Leslie, Ruckelshaus, Ball, Andelman, & Possingham, 2003 examined the marine reserve networks generated using 10, 20, and 30% conservation targets and found that 30% scenario was more efficient in terms of habitat representation. Also, in a similar research by authors in another part of the Hyrcanian forests in Mazandaran Province of Iran (Mehri, 2012), different conservation targets, including 30, 40, 50, 60%, were examined. The result showed that targets of 40, 50, and 60% increase the area of conservation networks much more than can be reasonably managed in the region. Hence, in the discussion section, we will consider whether our results are in agreement with Convention on Biological Diversity targets; that is, conservation of at least 17% of terrestrial areas.

2.7. Conservation scenarios

In this study, four different conservation scenarios were considered (Table 1). The target of the first scenario was to preserve a minimum of 30% of habitat of each bird species in the high protection zone. In this scenario, no conservation cost was considered. The target of the second scenario was to preserve a minimum of 30% of the habitat of each bird species in high protection zone while minimizing socioeconomic impacts on silvicultural sector. The comparison of the first and second scenarios illustrates the impacts of considering socioeconomic costs on protection zone and silviculture. The target of the third scenario, in addition to meet the target of the second scenario, is to safeguard a minimum of 90% of tourism regions in the open zone. This target minimizes impacts on the recreational sector. The comparison of second and third scenarios illustrates the process for resolving conflict between conservation and recreational activities. In the fourth scenario, effect of zoning of conservation areas was examined. The target was to preserve a minimum of 30% of the habitat of each bird species in such a way that at least 15% was located in high protection zone and the rest in the partial protection zone. Furthermore, a minimum of 60% of tourism regions had to be located in the partial protection zone, and a minimum of 30% had to be safeguarded in the open zone.

3. Results

3.1. Habitat suitability modeling

Habitat suitability modeling results for fifteen bird species showed

Table 1
Summary of conservation scenarios to run Marxan with zones, showing the data used in each scenario and conservation targets and cost in each zone.

scenario	Conservation features	% conservation target in each zone			Conservation cost
		High protection	Partial protection	Open	
1	Birds habitat	≥30	–	–	–
	Tourism regions	–	–	–	
2	Birds habitat	≥30	–	–	forest economic value
	Tourism regions	–	–	–	
3	Birds habitat	≥30	–	–	forest economic value
	Tourism regions	–	–	≥90	
4	Birds habitat	≥15	≥15	–	forest economic value
	Tourism regions	–	≥60	≥30	

Table 2
Results of habitat suitability modeling for fifteen bird species using maximum entropy (MaxEnt) method.

Species	Mean AUC	Area of suitable habitats in Hyrcanian Forest (ha)	% suitable habitats
Coracias garrulus	0.929	49690	8.07
Accipiter nisus	0.891	108166	17.58
Accipiter badius	0.884	146608	23.83
Falco naumanni	0.955	27946	4.54
Falco tinnunculus	0.915	125663	20.43
Certhia familiaris	0.961	104546	16.99
Emberiza bruniceps	0.910	96471	15.68
Sylvia communis	0.954	83701	13.61
Sitta europaea	0.979	118438	19.25
Sturnus vulgaris	0.889	41573	6.75
Lanius collurio	0.972	82912	13.48
Phoenicurus ochruros	0.989	64448	10.47
Phoenicurus phoenicurus	0.976	92080	14.97
Erithacus rubecula	0.976	113455	18.44
Apus apus	0.926	93199	15.15

that all calculated AUCs (Table 2) are more than 0.75, a threshold that is well-accepted by researchers (Elith 2002; Phillips and Dudík 2008). Among all of the studied species, *Falco naumanni*, and *Sturnus vulgaris* are the least and, *Accipiter badius* and *Falco tinnunculus* are the most dispersed in the Hyrcanian forest of the Golestan Province. According to the results, the environmental factors with the highest contribution to the modeling process are wind speed, altitude, and land use/cover, respectively. Also, relative contributions of the environmental variables to the Maxent model were presented in Table 3.

3.2. Scenario development

The highest representative areas for bird conservation that meet all targets were identified considering four different conservation scenarios (Fig. 2). All scenarios meet the conservation targets, however, in the first scenario, 22% of the region was selected as a high protection zone that included 35% of the area with high economic value for silviculture (Table 4 and Fig. 3). Considering forest economic value as conservation cost in the second scenario, decreased the impacts on the silvicultural sector. The highest percentage of high protection zone was located in an area with low economic value for silviculture while the impacts on the area with high economic value decreased by 21% in comparison with the first scenario that excluded conservation cost. There were no significant changes in the area of high protection zone (Table 4 and Fig. 3).

In the first two scenarios, the impacts on recreational sector were high. About 30% of tourism regions was included in the high protection zone. When the recreational activities, in addition to forest cost, were involved in the planning process (scenario 3), the percentage of tourism regions located in the high protection zone decreased to 8% while there were no significant changes in the impacts on silvicultural sector. Also, the area of high protection zone decreased to 18% of the region (Table 4 and Fig. 3).

In the fourth scenario, the impacts of zoning conservation area were evaluated. The total area of protection zone only increased 1%, in which high and partial protection zones included 10% and 9% of the region, respectively. The results showed that zoning conservation area decreased impacts on silvicultural and recreational sectors when compared to the scenario that included single zone. The percentage of area with high economic value for silviculture located in high and partial protection zones and the percentage of tourism regions included in high protection zone decreased to 11% and 2%, respectively (Table 4 and Fig. 3). We did not consider the tourism regions included in the partial protection zone as an element with impact on the recreational sector because they can still plan for extensive recreation.

Table 3
Relative contributions of the environmental variables to the MaxEnt model.

Variable	Percent contribution														
	Coracias garrulus	Accipiter nisus	Accipiter badius	Falco naumanni	Falco tinnunculus	Certhia familiaris	Emberiza bruniceps	Sylvia communis	Sitta europaea	Sturnus vulgaris	Lanius collurio	Phoenicurus ochruros	Phoenicurus phoenicurus	Erithacus rubecula	Apus apus
Wind speed	**24.7**	3.6	2.4	**49**	**27.5**	0.8	**36.7**	5.5	7.1	**43.7**	13.8	8.1	16.6	5.5	**35.4**
NDVI	20.9	2.9	6.6	2.9	2.5	8.1	11	4.7	5.1	1.2	4.3	8.7	2.1	4.1	0.8
Altitude	9.6	0.3	2.5	3.1	3.5	8.2	6.6	**43.5**	15.8	8.5	**34.3**	**38.6**	31.1	9.7	0.9
Distance to open water	8.2	4.3	4.8	3.6	10	3.3	3.9	1.7	2.9	6.8	5.2	1.5	8	7.2	0.3
Distance to streams	7.9	2.3	**48.5**	6.4	10.8	0.9	5.6	2.4	1.1	2.5	7.5	3.9	10	1.9	4.2
Distance to farmland	6.9	14.6	3.5	8.6	13.1	0	6.5	8.5	3.6	2.7	13.7	5.2	3.8	6.6	21.5
Slope	6	0.3	0.5	3.4	7.1	0.1	6.2	0.1	4.2	2.2	8.9	2.5	3	1.4	0
Precipitation	5.9	9.4	3	7.5	5.4	2.6	2.4	7.3	10.4	7.7	2.6	0.5	4.3	**29.3**	5.4
Land use/cover	5.8	**37.9**	17.6	10	13.1	**65.9**	14.4	20	38.3	13.7	6.2	13.9	10.8	28	10.8
Aspect	2.7	24.2	9.8	2.4	2.2	5.5	2.9	3.2	10.2	9.7	1.7	16.5	9.6	6	15.1
Land use/cover diversity	1	0.2	0.3	2.1	3.3	3.9	2.7	2.8	1.1	1.3	0.8	0.1	0.5	0	4.9
Fragmentation index	0.5	0	0.4	1	1.5	0.6	1	0.2	0	0	1	0.5	0.2	0.2	0.7

The bold values indicate the environmental factors with the highest contribution to the Maxent model.

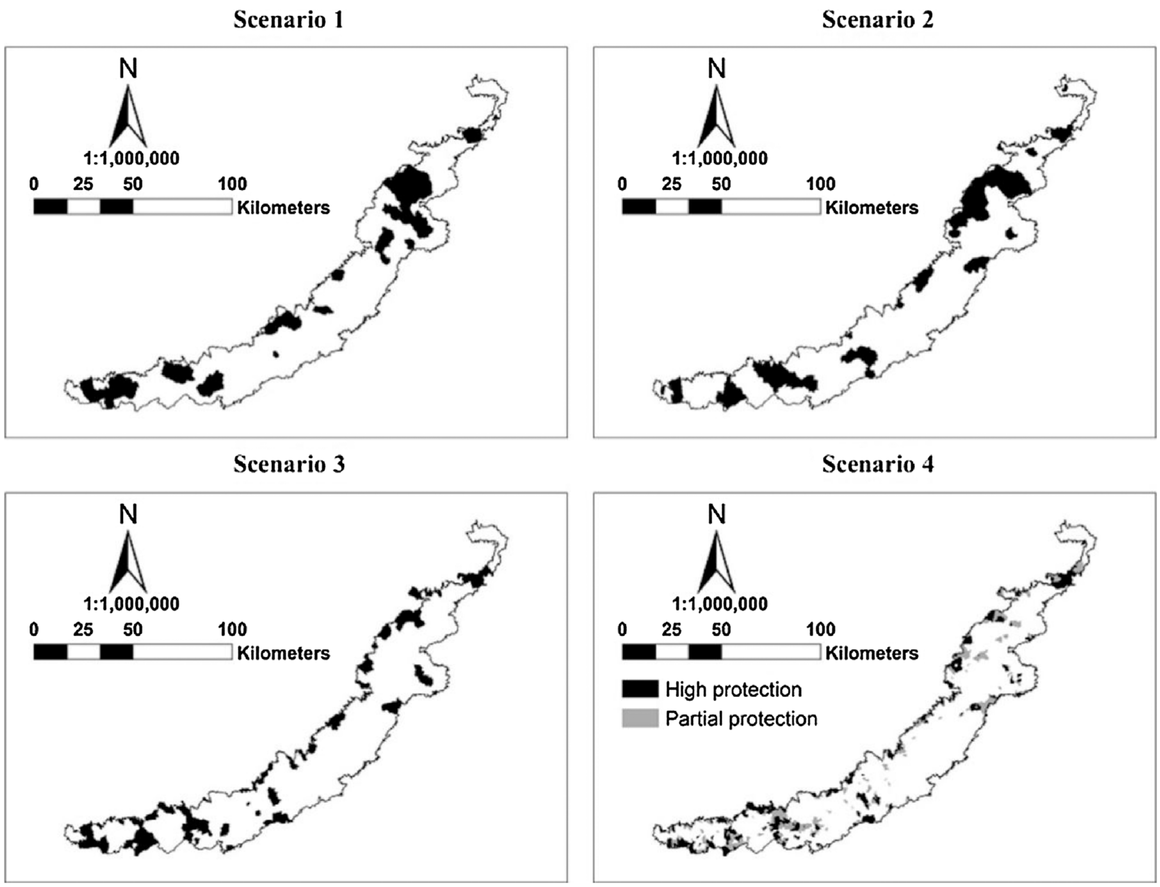

Fig. 2. The best representative areas for bird conservation considering four different conservation scenarios using Marxan with Zones.

4. Discussion

Incorporating socioeconomic costs into systematic conservation planning is essential and overlooking other uses and human activities in planning process could result in inequitable conservation solutions and often has conssiderable cost for the local people and other stakeholders. Systematic conservation planning traditionally allocates all planning units only to reserved or not reserved zones. However, the new systematic conservation planning tool Marxan with Zones has facilitated the possibility of conservation planning, considering multiple zones rather than single-zone and allows managers and decision makers to evaluate different management options under multiple conservation scenarios (Makino, Klein, Beger, Jupiter, & Possingham, 2013; Klein, Steinback, Watts, Scholz, & Possingham, 2010).

In the present study the goal was to prioritize and identify representative areas for bird conservation, while attempting to minimize the economic cost for the silvicultural sector and resolving conflict with recreational activities. We were able to show the applicability of using Marxan with Zones software to reach our goal. We focused on four conservation scenarios that considered different targets, costs, and multiple zones. The selection of protected area network without considering forest economic value caused the loss of important areas of economic activity for the silvicultural sector. When the forest economic value was considered as conservation cost, the impacts on the silvicultural sector decreased about 21%. Also, incorporating recreational activities as a target decreased conflict of conservation zone with this sector to about 23%. The result of considering multiple zones versus single-zone indicated that the potential impacts on both silvicultural and recreational sectors decreased in the multiple zones scenario.

One concern was that, the conservation network resulting from multiple zones scenario (scenario 4) was more dispersed than other scenarios. We examined this issue in more detail and found that the conservation network resulting from the fourth scenario was composed of 92 patches, with a minimum area of 26 and a maximum of 18003 ha. There were 19 patches with small area (an area of less than 100 ha), that covered only 0.8% of conservation networks. Further investigation illustrated that, after removing these patches from the conservation network, still, our conservation goals can be achieved. Also, 80% of the conservation networks were covered with patches with an area of more than 1000 ha. Therefore, it seems that the result of the fourth scenario

Table 4
Characteristics of the conservation networks generated by each conservation scenario, running in Marxan with Zones.

scenario	Coverage of study area (%)		percent of forest area located in conservation zones			Percentage of Tourism regions located in conservation zones
	High protection	Partial protection	Low economic value	Average economic value	High economic value	
1	22	–	20	22	35	30
2	23	–	30	14	13	31
3	18	–	23	11	12	8
4	9	10	26	10	11	2

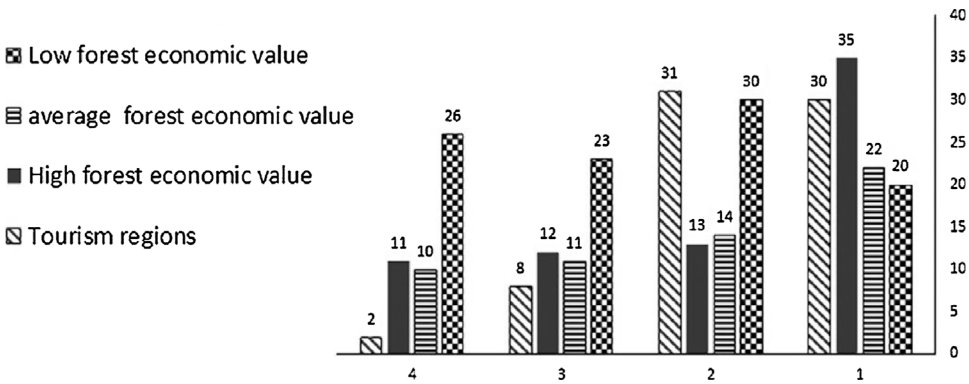

Fig. 3. Percentage of each activity which are in conflict with conservation networks generated by each conservation scenario.

has enough efficiency to reach our conservation goals.

Caspian Hyrcanian mixed forest is one of the most important and invaluable industrial and commercial forests in Iran and has many tourism values at national and regional levels. In recent decades, rapid industrial development and threats such as extensive grazing, over-exploitation of wood, construction, unsustainable tourism development and agricultural activities have had negative impacts on this valuable ecosystem. Therefore, providing an approach to preserve this ecosystem while considering other activities is necessary. Incorporating other interests and stakeholders in the conservation planning process can increase the probability of achieving conservation objectives.

The history of systematic conservation planning in Iran is limited to the few past years meaning that nearly all of the current protected areas have been selected using general IUCN-based guidelines or non-systematic approaches. Iran's protected areas are selected based on IUCN's global standards in four categories, namely, National Park, National Natural Monuments, Wildlife Refuges, and Protected Areas. Recording and management of these areas is within the jurisdiction of Department of Environment. Unfortunately, economics and policies have an important role in the selection of such areas which in some cases contradict with their ecological values. This is also true with the case of Golestan Province, which includes the Caspian Hyrcanian mixed forest. In this region, no systematic conservation plans have been applied to select current protected areas. A part of these protected areas are located in our study area. We compared these areas with the conservation networks resulting from Marxan scenarios 3 and 4. The results showed that only 13.45% and 11.62% of the results of scenario 3 and 4 respectively, overlapped with the current protected areas. We hope that the approach we presented in this study can increase the efficiency of conservation plans in Caspian Hyrcanian mixed forests. Our results can be used to introduce new sites for protection of bird species or to modify the boundaries of the existing protected areas.

Nevertheless, we should note that consideration of the following issues in future studies can improve our approach. As mentioned before, "how much is enough" is a serious question that is not easy to answer. In this study, we considered the suitable forest habitats for bird conservation as conservation targets and aimed to preserve a minimum of 30% of the habitat of each bird species. The conservation networks resulting from four different conservation scenarios covered 18–23% of the study area. These are in agreement with the Convention on Biological Diversity targets; that is, conservation of at least 17% of terrestrial areas (Convention on Biological Diversity, 2014). However, to improve the process of setting measurable targets, we can consider different targets and compare the results, as Leslie et al. (2003) did for 10, 20, and 30% conservation targets. Also, Tear et al. (2005) proposed a set of principles and standards that can help set measurable objectives to achieve more conservation success. The criteria such as population viability can help establish more practical quantitative targets for species. For our study area, we found no previous studies on minimum viable population of target species. A new research is required to provide information on the population of bird species. Then, the results can be used to enhance our application.

Assigning an economic value to each forest type as a surrogate to represent the opportunity cost of implementing a protection zone could improve our results regarding reducing impacts on the silvicultural sector. However, our methods can be enhanced by using a more realistic cost. For instance, fine scale resolution data on the spatial distribution of gross revenues for silviculture can be used as Ruiz-Frau et al. (2015) used it for commercial and recreational fisheries. Also, other uses such as aquaculture can be considered as opportunity cost in planning process, but it should be noted that the complexity of the conservation planning problem will increase when the number of costs increase. Incorporating multiple uses and effort to reduce potential impacts of conservation planning on them, can result in increasing the area of final conservation network or reducing the compactness of it and increasing the number of patches. We ran each scenario several times to calibrate the best run parameters for our model.

The results of the present study illustrated that zoning conservation area have the ability to meet conservation targets while resolving or minimizing conflicts between conservation and other activities. We define two protection zones with different conservation targets. In future studies, the impact of setting multiple targets for each zone on the conservation priorities can be explored. We demonstrated a simple approach for incorporating multiple interests and stakeholders in the conservation planning process. Our approach has the ability to consider multiple conservation goals and minimize conflict between different sectors. It is applicable to other regions, especially where existing protected areas suffer from contradictory management decisions. Any decisions taken at any level have to consider conflicting needs of the groups who are affected by the decisions. How well the conflict is resolved depends on the proficiency and capability of decision makers; our approach helps them to cope with this kind of problem.

5. Conclusion

The process of establishing protected areas in the past in Iran has not been all inclusive of multiple uses and interests. This have often had a lot of substantial socioeconomic costs for the local people and other affected stakeholders. New systematic conservation approaches have high potential in the 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 conservation areas. Zoning conservation areas balances conservation and socioeconomic goals across different parts of the region and among diverse stakeholders.

We used systematic conservation software Marxan with Zones to run our conservation scenarios. The results showed that incorporation of socioeconomic costs significantly decreased the potential impacts on the silvicultural and recreational sectors without significant changes in the area of protection zones. Furthermore, the results illustrated that design of multiple zones conservation area facilitated evaluation of a wider range of conservation scenarios that can reduce potential socio-economic impacts on other interests. The results of this study can be used to introduce new sites for protection of bird species in forest areas. However, it should be noted that considering other activities such as aquaculture can help reach more comprehensive solutions.

The approach presented here is a support tool that helps managers and decision makers in a conservation planning process to obtain more equitable outcomes. To further investigate the approach, it can be applied to other similar regions throughout Iran. However, it is essential to note that our approach is not the most completed to select protected areas networks, as it can be promoted by taking into account a wide range of other ecological, political and socioeconomic considerations. It may be useful to compare the performance of Marxan with Zones in providing optimal solutions with other conservation planning software and tools, such as Zonation.

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