

Monitoring the annual change of fauna in Ilgaz Mountain Wildlife Reserve by using biodiversity indices

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Abstract

Wildlife management, planning, and development, determining the current floristic and faunistic features in a given region are critical for future research. Biodiversity indices are tools that help to express concepts such as species richness and ecosystem richness of an area or areas numerically. Türkiye is one of the leading countries in Europe in terms of biodiversity, with many locations having a high level of diversity thanks to its fauna and flora. Kastamonu province is the unique region in the Black Sea region, consisting of four wildlife refuges, two national parks and a biodiversity hotspot. In the current study, the 4-year inventory carried out by the General Directorate of Nature Conservation and National Parks affiliated to the Ministry of Agriculture and Forestry for the determination of wildlife species in the Ilgaz Mountain Wildlife Reserve was examined, and the number of species in the area was calculated using biodiversity indices. Results of inventories were evaluated. In the study, it was observed that species diversity decreased over the years, but the populations of some species were dominant and increased.

Keywords: Biodiversity indices, Alpha diversity, Ilgaz Mountain Wildlife Reserve, Kastamonu

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1. Introduction

Biological diversity refers to the difference in species, functions, and structures among living organisms in a particular environment, biome, or across the globe. Genetic diversity, species diversity, and ecological diversity all fall under the umbrella of biological variety. (Hunter, 1996; Thompson et al., 2009; Aertsen et al., 2010; Gündoğdu et al., 2021).

Ecology research seeks to link the mentioned diversity values to environmental factors. Although these ideas of variety can be measured separately, they may not always be able to be evaluated as a whole and interpreted to fulfill a single purpose. It is more appropriate to evaluate and analyze all of the diversity values when determining biodiversity in a region (Gülsoy & Özkan, 2008).

Species diversity with environmental factors is critical for identifying areas with high conservation priority and potentially rich species diversity. Furthermore, the

changes and various effects that will occur in species diversity in these environments over time can be predicted. The impacts on species diversity in similar environments can be observable. These factors contribute to the ecological significance of species diversity.

Forest ecosystems constitute the most important sources of biological diversity as they contain 2/3 of the world's ecosystems. Species exist in a forest environment because they have adapted to the climatic, edaphic, or other conditions found there, and/or they rely on other species in the ecosystem. Forests are important ecosystems for biodiversity, as well as for the provision of a variety of ecosystem services that are vital to human well-being. (Brockerhoff et al., 2017).

One of the most important aspects determining biological variety in forest ecosystems is species diversity. Alpha diversity (α), beta diversity (β) and gamma (γ) diversity are the three types of species diversity. The measure of



diversity between areas is beta diversity, while alpha diversity is determined for a specific area. The entire diversity of the relevant ecosystem covering these areas is referred to as gamma diversity (Whittaker, 1972; Zhao et al., 2005; Gülsoy & Özkan, 2008; Launchbaugh, 2009; Özkan, 2016; Negiz & Kurt, 2019).

An ecosystem made up of a diverse range of species is durable and sustainable in the face of potential environmental threats. However, there are important and harmonious relationships between species diversity and habitat characteristics in forest ecosystems. Revealing such relationships helps to identify areas with high potential in terms of species diversity (Linder, 2001; Özkan, 2006; Negiz & Kurt, 2019).

In recent years, calculations on biodiversity have focused on soil organisms, microorganisms, insects, fungi, aquatic ecosystems, birds and mammalian wildlife (Banakar et al., 2012; Chandra & Gupta, 2012; Pereki et al., 2013; Prasad et al., 2014; López-Sánchez et al., 2016; Uğış et al., 2016; Gallo et al., 2017; Kucuk et al., 2017; Katani et al., 2019; Shutt & Lees, 2021; Singh et al., 2021; Schuette et al., 2022).

Turkiye is one of Europe's leading countries in terms of biodiversity, with several locations boasting high levels of variety thanks to fauna and flora (Evcin et al., 2019). Kastamonu province which is located in Blacksea region, is one of unique area, comprising four wildlife refuges, two national parks, and one biodiversity hotspot. Ilgaz Mountain is an area of high historical and biodiversity importance, located between the cities of Çankırı and Kastamonu. In this study, we analyzed for species richness, evenness and density by using alpha biodiversity indices at Ilgaz Mountain Wildlife Reserve.

2. Material and Methods

2.1. Study area

The Ilgaz Mountain Wildlife Reserve (17036 ha) is located in Turkiye's northwest, in the Ilgaz Mountains. The research area is located in Kastamonu. The study region is situated between 1400 and 2500 m elevation. The Ministry of Agriculture and Forestry employs the forests, which cover 91 percent of the land, for forestry activities and wildlife development. In all areas, 2 percent of the land is utilized for agricultural purposes, 7 percent for pastureland, and 6 percent is made up of national park land (Figure 1).

From a bioclimatic perspective, the Ilgaz Mountains are situated in a translational climate zone. The type of translational climate is characterized by semi-arid, less wet, and extremely cold Mediterranean and oceanic climates. The terrestrial ecosystem, which includes forest and bush habitats, is the most common form of vegetation found in the Ilgaz Mountain Wildlife Reserve. Kazdagi fir (*Abies nordmanniana* subsp. *equi-trojani* Coode et

Cullen), an important indigenous fir taxon, and Scots pine dominate the forests (*Pinus sylvestris* L.). *Juniperus communis* var. *saxatilis* Pall., *Daphne oleoides* Schreber, *Epilobium angustifolium* L., *Bromus tomentellus* L., *Verbascum abieticolum* Bornm., and *Genista vuralii* A. Duran & H. Dural are the prominent floristic features of this habitat (Kucuk et al., 2017; Evcin et al., 2019).

Within the boundaries of Ilgaz Mountain Wildlife Reserve, 41 insect, 6 amphibian, 7 reptile, 17 mammal, and 77 bird species have been identified (Anonymous, 2015). International conventions protect 42 of the known vertebrate species. Roe deer (*Capreolus capreolus*) is the target species of Ilgaz Wildlife Reserve. Also the reserve have wild ungulate community including wild boar (*Sus scrofa*) and red deer (*Cervus elaphus*). Additionally, carnivore species such as brown bear (*Ursus arctos*), gray wolf (*Canis lupus*), golden jackal (*Canis aureus*), red fox (*Vulpes vulpes*), Marten (*Martes* sp.) exist in the area (Anonymous, 2015).

2.2. Obtaining data

The General Directorate of Nature Conservation and National Parks makes medium and large mammals inventories every year, calculate the densities of these species in the wildlife refuges and protected areas and making management plans to determine the protection strategies. Inventories are mostly carried out by line counting, line transects, drive counting, direct observations and with using camera traps. In this study, 5-year annual wildlife inventory in the Ilgaz Mountain Wildlife Reserve was evaluated made by the 10th Regional Directorate of Nature Conservation and National Parks Kastamonu Directorate by using biodiversity indices and calculations in order to express biodiversity in the area mathematically.

2.3. Calculation of biodiversity

The number of species found in a given region or community is referred to as species richness (Brown et al., 2007). Currently, the Shannon index, Simpson index, and Berger-Parker index are the most often utilized alpha diversity indicators. Biologists have presented a wide variety of diversity indexes, demonstrating their exceptional creativity. It is critical to comprehend the right use of these metrics or indices by investigating their assumptions, various properties, and how they react when applied to a certain society (Gross et al., 2019). It is also essential to analyze and determine some alpha diversity indices efficiency since an efficient index provides more reliable, precise, and informative results. This means that one can determine which diversity index is appropriate for a particular species or community structure (Tinio & Sebuala, 2021). Calculation of biodiversity indices and visualization of calculations were done by using Alyoung Biodiversity Calculator (URL-1,2022) double-checked with PAST software (ver. 4.10) (Hammer et al., 2001).

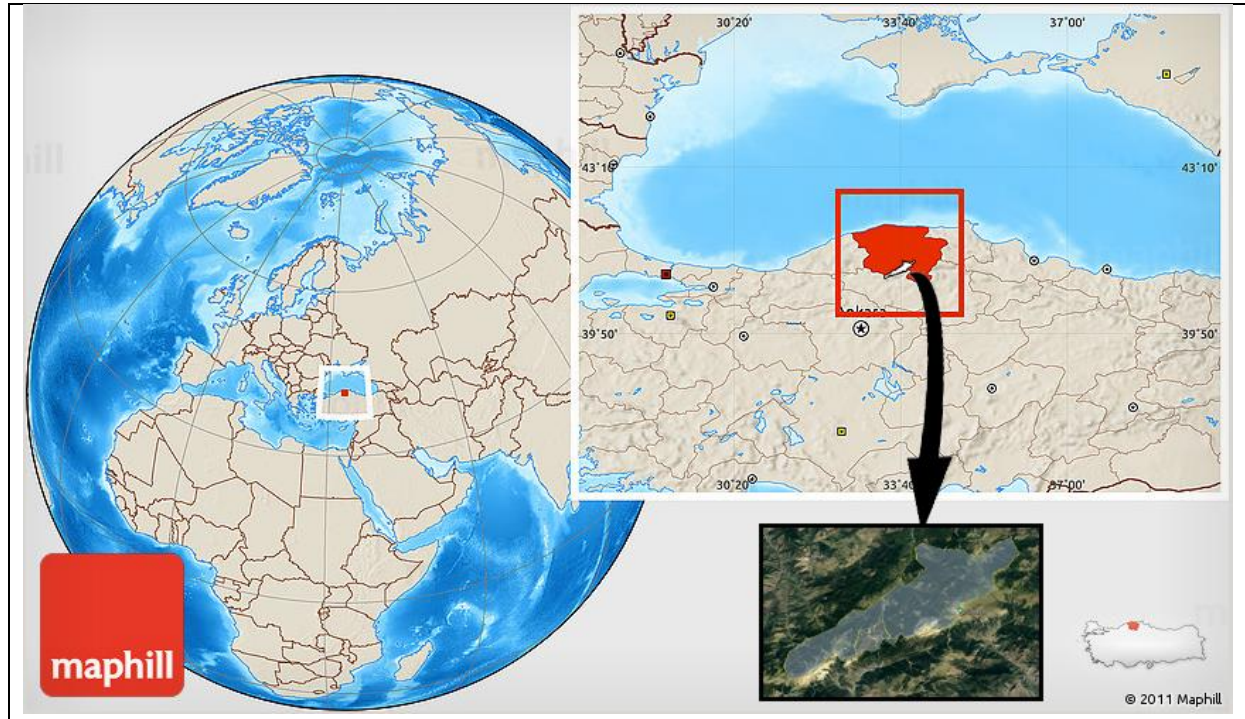


Figure 1. Location of Ilgaz Mountain Wildlife Reserve (Produced with www.maphill.com)

2.4. Biodiversity indices

The Shannon diversity index is a combined measurement of two things in the ecological literature: the number of species in a community (richness) and their relative frequency (the equitability) (Shannon & Wiener, 1963). It can be measured by the given formula:

$$H = \sum_{i=1}^s (p_i * \ln(p_i)) \quad (1)$$

H : Shannon diversity index,

p_i : the proportion of individuals found in the i th species,
 s : the number of species in the community.

The Simpson Index (D) determines the likelihood that two individuals chosen at random from a sample belong to the same species. Simpson calculates the likelihood of any two individuals from a large community belonging to distinct species (Simpson, 1949; Keylock, 2005).

$$D = \Sigma(n_i * (n_i - 1)) / (N * (N - 1)) \quad (2)$$

D : Simpson diversity index,

n_i : the total number of organisms of a particular species,
 N : the total number of organisms of all species.

Berger and Parker proposed the simplest of these indices, which has an analytical link with the geometric series of the species abundance model (May 1975; Caruso et al. 2007) and reflects simply the proportional abundance of the population's most abundant species (Berger & Parker 1970; Morris et al., 2005).

$$d = N_{max} / N \quad (3)$$

d : Berger-Parker diversity index,

N_{max} : the number of individuals in the most abundant species,

N : the total number of individuals in the sample.

Margalef's index is a species diversity indicator created in the 1950s by Ramon Margalef Lo'pez, a Spanish ecologist. Margalef's diversity index measures the diversity of species. Many species richness estimates have the drawback of being overly reliant on sampling effort. The more the sampling effort, the higher the index value might be. As a result, comparing measurements from samples gathered using different methods. (Margalef, 1958; Tu et al., 2020).

$$D_m = (S - 1) / \ln(N) \quad (4)$$

D_m : Margalef richness index,

N : the total number of individuals in the sample,
 S : the number of species recorded.

Rarefaction is a method for adjusting for changes in library sizes across samples in order to make alpha diversity comparisons easier. Rarefaction, which is based on the development of so-called rarefaction curves, permits the estimation of species richness for a given number of individual samples. Sanders (1968) proposed rarefaction, which entails picking a number of samples equal to or fewer than the number of samples in the smallest sample, then eliminating reads from bigger samples at random until the number of samples remaining is equal to this threshold. Diversity measures can be derived based on these equal-sized subsamples to compare ecosystems "fairly", regardless of sample size disparities (Weiss et al., 2017; Willis, 2019).

3. Results

The 4-year inventory, made by the General Directorate of Nature Conservation and National Parks affiliated to the Ministry of Agriculture and Forestry for the determination of wildlife species in the Ilgaz Mountain wildlife reserve, was analyzed and calculated using biodiversity indices. A total of 4620 species were included in the analysis with the proportions by years respectively, %16.7, %19.7, %29, %34.6. The year with the highest number of species was 2015, while the year with the lowest number of species was 2012 (Table 1).

Table 1. Results of the calculations for determining the biodiversity

	2012	2013	2014	2015
Total Number of Organisms	772	912	1344	1592
Shannon Index	2.515	2.632	2.635	2.471
Simpson Index	0.2128	0.1938	0.1865	0.2289
Berger-Parker Dominance Index	0.3523	0.3202	0.2679	0.3869
Margalef Richness Index	1.0530	1.0270	0.9718	0.9494

The number of species and the mean of the annual results of the inventories made in the field are given in the table below (Figure 2). We can see that roe deer (*Capreolus capreolus*) dominate the area, followed by wild boar (*Sus scrofa*) and red deer (*Cervus elaphus*). The least observed species were marten (*Martes sp.*) and red fox (*Vulpes vulpes*). Rarefaction curves were created by using the results of the analysis are given on the graphs (Figure 3).

As a result, the general population continues to grow throughout time. The population of the area, which had 772 species in 2012, reached 1592 species in 2015. A decrease is observed in the Shannon index despite the increase in populations. It has been observed that, this situation has occurred as a result of the dominant observation of the roe deer populations. Contrary to general belief, population growth does not increase species diversity. For this reason, Shannon index may be lower in areas dominated by a single species compared to other areas. This fact can be confirmed by looking at to the Berger-Parker Index. Thus, the Margalef richness index was higher in the first years and lower in the following years. This situation shows that not many species were encountered in the inventory studies carried out by the General Directorate of Nature Conservation and National Parks, but many individuals of the same species were recorded.

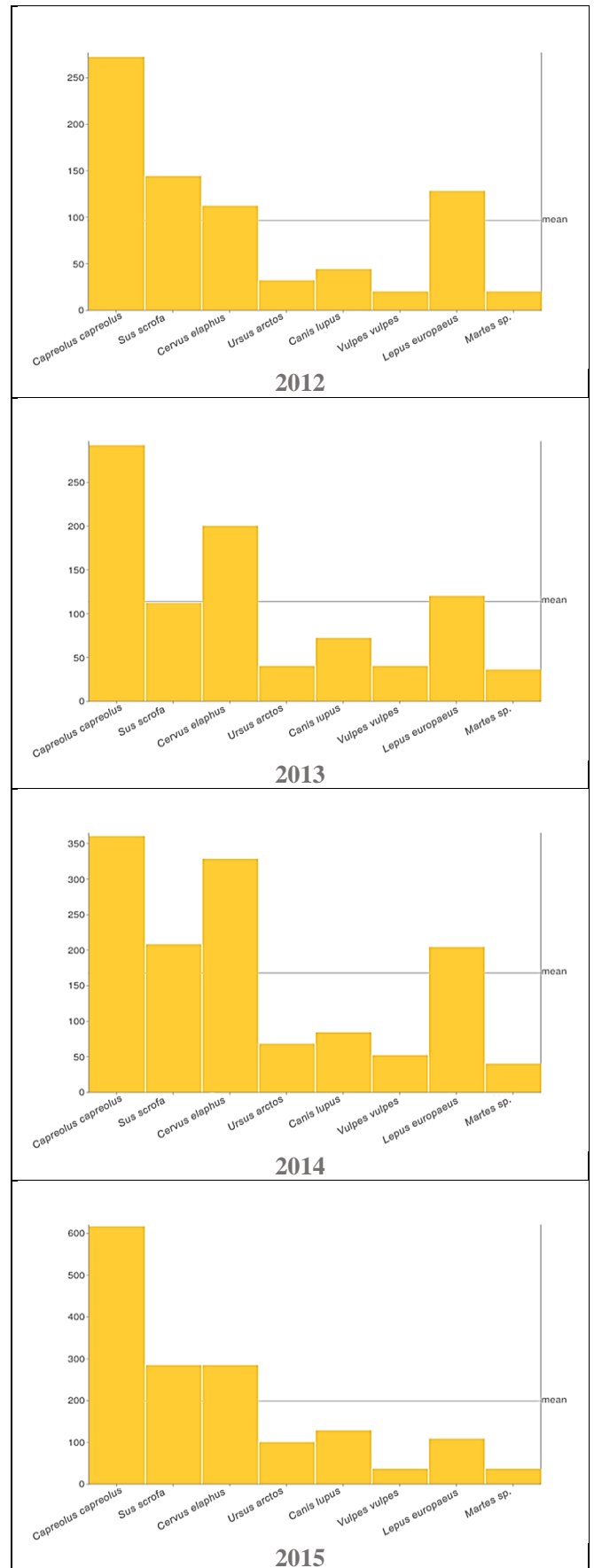


Figure 2. The number of species and the means of the annual results of the inventories

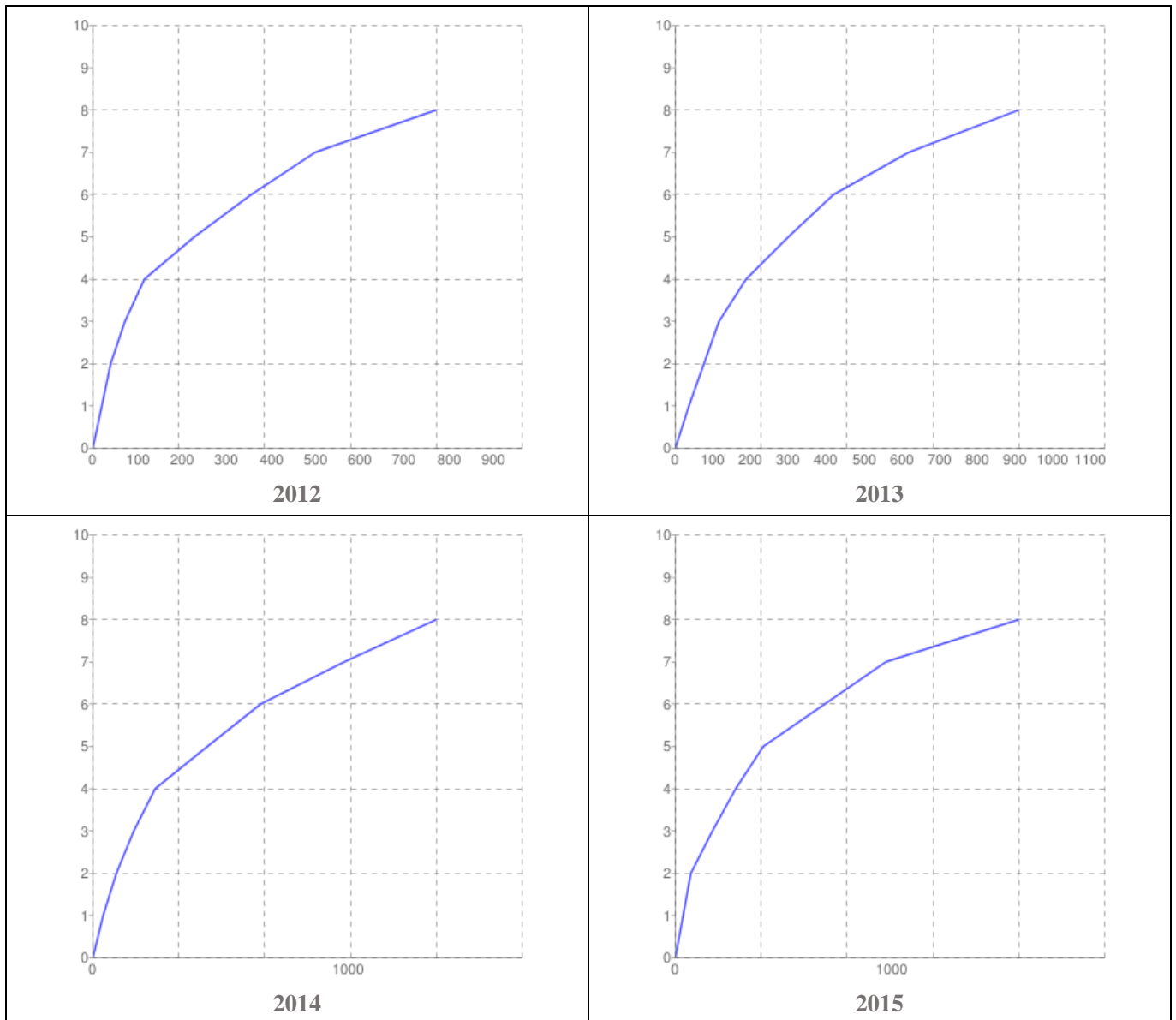


Figure 3. Results of Rarefaction Analysis

4. Discussion and Conclusion

When the results of the study are examined, it is observed that the number of species has increased every year during the 4-year period. Looking at the inventory studies, it was observed that the number of individuals increased. Factors such as the development of technology and experience with various inventory methods, and the appropriateness of observation at the time of inventory can be used to explain this situation.

However, when we look at the species Shannon index, we observe that this value decreased even though the number of species increased. When we consider the increase and decrease of Simpson and Shannon indexes, we can say that despite the increase in the total number of individuals, this situation has occurred in the last year, especially as the roe deer outperformed other species alone. Likewise, it is seen that the roe deer population is much higher than the other

species populations in the last year.

Berger and Parker is an index that reflects the proportional abundance of the most abundant species of the population, and when the results of the study are examined, it is seen that it is directly proportional to the decrease in the populations. However, it is seen that the variation of species numbers among themselves does not change these values much. The sample-based rarefaction curve has exact equivalents for the observed components of α -, β - and γ - diversity, and the randomization test employing randomized placement of individuals is an approximate parallel to the individual-based rarefaction curve. Diversity components identify the spatial or temporal components of sampling that contribute the most to, and thus where additional sampling effort would yield the greatest increase in species numbers, additive partitions of diversity may inform survey efforts aimed at estimating biodiversity. (Crist, 2006). In a three-year moth study of

an old-growth deciduous forest, Summerville and Crist (2005) found that increasing sampling effort between seasons resulted in a bigger accumulation of new species than adding more years.

Roe deer are a target species in Ilgaz Mountain Wildlife Reserve, and since they are one of the important species of hunting tourism, special importance has been given to conservation studies in recent years. It is known that the increasing conservation activities with biodiversity awareness will also cause an increase in the number of species (Kucuk et al., 2017). Despite this, a large number of individuals are still killing due to poaching.

The variations in species populations from year to year can be explained by a variety of causes, including issues with inventory methodologies, inventories that were not done sensitively, anthropogenic pressures on species, and the reaction of species to climate change. The fact that just a few species are encountered in inventory studies conducted in an area as significant in terms of biodiversity as Ilgaz Mountain Wildlife Reserve, and that only these species are inventoried, demonstrates how insufficient the inventory studies are. The General Directorate of Nature Conservation and National Parks, on the other hand, has recognized the importance of inventory studies in recent years and has begun to apply modern and up-to-date inventory methodologies. Continuing and increasing wildlife research in Turkey, as well as growing the number of scientists working on wildlife and conducting scientific studies in the field, are critical for the conservation and sustainability of biodiversity, which is one of Türkiye's most important values.

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Conflict of interest

The author declares that there is no conflict of interest.

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