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21st Century Climate Change Threatens on the Brown Bear

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FOREST ECOLOGY

ABSTRACT

Background: Today, the biggest threat to mammalian predators with wide distribution areas is habitats fragmentation or changing climate conditions. We aimed to reveal the habitat suitability modeling and mapping of the Brown bear, which is an important large mammal in Turkey's borders, under change climate. The habitat suitability modelling was determined using the present (2010) and future (2040-2070-2100) chelsa climate scenarios (IPSL-CM6A-LR SSP126-SSP370-SSP585) Maxent method with the present data obtained by examining all studies on Brown bear. Then, the mapping result values for the different years and scenarios were classified as 0.5 unsuitable habitats, 0.51-0.8 suitable habitats and 0.81-1.0 most suitable habitats.

Results: We determined that the variables contributing to the habitat suitability model of Brown bear are annual precipitation amount, the average annual air temperature, the precipitation amount of the wettest month, the ruggedness and elevation. According to the mapping results for different years and scenarios; Brown bear have suitable habitat a minimum of 14.87% of the study area in today, 12.56% in 2040 year, 10.93% in 2070 year and 8.24% in 2100 year. According to the SSP585 climate scenario of 2100 year, the habitat suitability of the Brown bear decreases by approximately 45%. Also, the climate envelope model created with MaxEnt revealed, the change climate in the 2100 year endangered the Brown bear.

Conclusion: Therefore, these results will be a source of information for the sustainability of the extinction of the Brown bear, for the pre-protection of existing and potential habitats and for reducing the impact of change climate conditions.

Keywords: Brown bear; Chelsa climate scenarios; Maximum Entropy; Habitat suitability modelling and mapping; Sustainability.

HIGHLIGHTS

The predatory and endangered bear species, it is an indicator species for biodiversity.
The brown bear will be greatly affected by climate change.
According to the numerical and model-based mapping prepared for the sustainability of the target species, the preferred habitats of the species are significantly decreasing in the future.
Species distribution models are important in the protection and management plans to be made for the Brown bear.

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INTRODUCTION

The biodiversity refers to the variability, future and continuity in terms of species, function, structure among living organisms in different ecosystems (Jones and Tingley, 2022). Forest ecosystems which constitute approximately 1/3 of the existing ecosystems defined in the world (Forzieri et al., 2022), it has been known as important sources of biodiversity (Mori et al., 2017). When Turkey is evaluated in terms of its biodiversity resources, it is in a important position due to its geographical location being between Mediterranean, Euro-Siberia, and Irano-Turanian phytogeographical regions (Orhan and Karahan 2010). In the other words, Turkey holds an indispensable position in terms of biodiversity resources, characterized by its rich array of endemic plant species and diverse wildlife, which can be attributed to its diverse land structure, climate conditions, and vegetation composition.

However, humans are in constant interaction with these biodiversity resources in nature (Sponsel, 2013). It is known the humans who are in constant interaction used biodiversity resources unplanned and excessively to meet many needs. This situation which has increased over time, has led to the emergence of many environmental problems such as the shrinkage or fragmentation of the habitats of some wild animals and plant species (Mert and Yalçınkaya; 2016). Therefore, indicator or alternative species should be known in order to prevent fragmentation or slow down the shrinkage of the habitats of wild animals living and plant species in different ecosystems. Wild animals which are considered as flag or key species in terrestrial or aquatic ecosystems, have an effective role for the future of biodiversity (Corlett, 2020). For example, *Aegypius monachus* Linnaeus, 1766 known as the largest bird of prey whose number is approximately 50-100 couple in Turkey, it is characterized as an indicator of the existence of old and healthy *Pinus nigra* forests (Özçelik, 2009). In addition, Brown bear (*Ursus arctos* L. 1758) which needs natural and old forest areas away from human intervention especially in the Black Sea Region, is accepted as one of the flag species by conservation biologists in Turkey (Özçelik, 2009).

As considered to be the flag species in Turkey, the life stories of the Brown bear date back to ancient times. Turkish, as nomads throughout their history, having Bear motifs and figures on their works made in the places is the evidence for this. Some words used for Bear in Turkish tribes meaning father, ancestor, mother and brother shows that this animal has an extremely important place in Turkish culture (Sarpkaya, 2014). In addition, among the Siberian Turkish community, the Brown bear is respected as a symbol of right and justice, and also as the owner of the forests. It is also important not to say the name of the Brown bear directly, instead of this word, words such as "old timer with claws" are used.

It is obvious that humans have negative effects on many mammalians wild animal species such as Brown bears in line with various traditions, customs, economic gains or different beliefs. Among the Siberian Turkish community, even though harming the Brown bear is avoided, the Brown bears have been hunted due to the ceremony held under the name of "*Bear Ceremony*" known as the Bear Feast. In this ceremony, their meat has been cooked with different cooking techniques and eaten. Besides, in some beliefs, the tradition of eating the liver and heart of the bear raw, using its fat as an ointment, burying its bones and keeping its skin for 40 days still continues (Vural, 2019).

Human activities such as dancing bears and poaching have caused species populations to decline or face extinction (Wallach et al., 2018). Brown bear which has the highest population density and wide distribution in the Ursidae family, has limited habitats with the mountainous parts of the Artvin region, as well as the natural forest areas of Eastern Anatolia and the Black Sea Region in Turkey. Due to habitats are in a limited area, it caused an increase in population loss rates (Başkaya et al., 2008; Ambarlı, 2016). In addition, changing climatic conditions in the 21st century have negative effects on the endangered Brown bear in Turkey (Suel, 2019). For this reason, it is important to carry out detailed studies base on species for endangered wild animals (Pimm et al., 2014).

Especially in species-based studies, wild animal habitats can be quantified and explained statistically. In this context, the current habitats of the species are analyzed and an idea about their potential habitats is obtained. Different habitat suitability modelling methods are used to reveal the potential habitats of the species (Guisan et al., 2017). In habitat suitability modelling methods many methods such as generalized additive model, generalized linear model, random forest, logistic regression, classification and regression tree technique are used (Özkan et al., 2015). One of these analyses is Maximum Entropy (*MaxEnt*) method.

MaxEnt is a method that determines the features needed by the species from the independent variables by using only the present data of the species and estimates the fitness level for the whole field according to the numerical values of the environmental variables in this field. MaxEnt method is frequently preferred in wildlife habitat suitability modelling studies because it gives more accurate and reliable results with the least available data on rare species. Due to the reasons mentioned above in this study, it is aimed to reveal the habitat suitability mapping present and future of the endangered Brown bear in Turkey by using the MaxEnt method (Elith et al., 2010). For this purpose, CHELSA V2.1 technical specification of present (2010) and future (2040-2070-2100) climate scenarios have been chosen and used.

MATERIAL AND METHODS

Species data collection

According to the inventory results of the International Union for Conservation of Nature and Natural Resources (IUCN), it is known that today there are belonging to the Ursidae family namely *Melursus*, *Ailuropoda*, *Tremarctos*, *Helarctos* and *Ursus* species. The place of Ursidae family in Turkey systematic is expressed as the *Ursus arctos* of the Ursus genus (Albayrak, 1997; Servheen et al., 1999). In this context, Can and Togan (2004) mapped out that the distribution of bears in Turkey is concentrated in the eastern black sea region from Artvin to Bolu (Figure 1A) In his study, Ambarlı et al., (2016) demonstrated and mapping that the species distribution of Brown bear in Turkey was taken under protection in 2003 and spread to the Mediterranean region (Figure 1B.)

When the literature studies that determine the potential distribution of the Brown bear distributed in Turkey are examined, it is clear that the mapping processes do not carry any numerical value and are not model-based. According to this information, the some present data of the target species were obtained from PhD theses, master's theses and various articles made in Turkey's border (Can and Togan 2004; Ambarlı, 2012; Çilingir et al., 2016; Suel, 2019; Başkaya et al., 2022) In this context, 299 present data (red points) of Brown bear are shown in red in the study area (Figure 2).

Environmental variables data

In this study, we aimed to carry out numerical and model-based mapping of the Brown bear on the scale of Turkey, which is a major deficiency in literature studies. In this context, the world scale digital elevation model (30 arc sec.) was obtained from the internet address www.worldclim.org The digital elevation model obtained in a

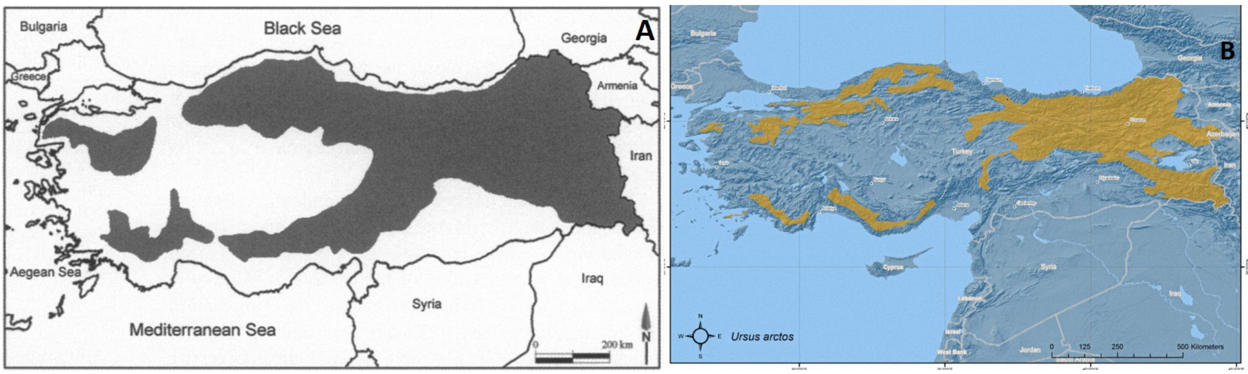

Figure 1: A) Approximate distribution of the Brown bear in 2004 by Can and Togan; B) The distribution map of Brown bear in 2016 by Ambarlı et al.

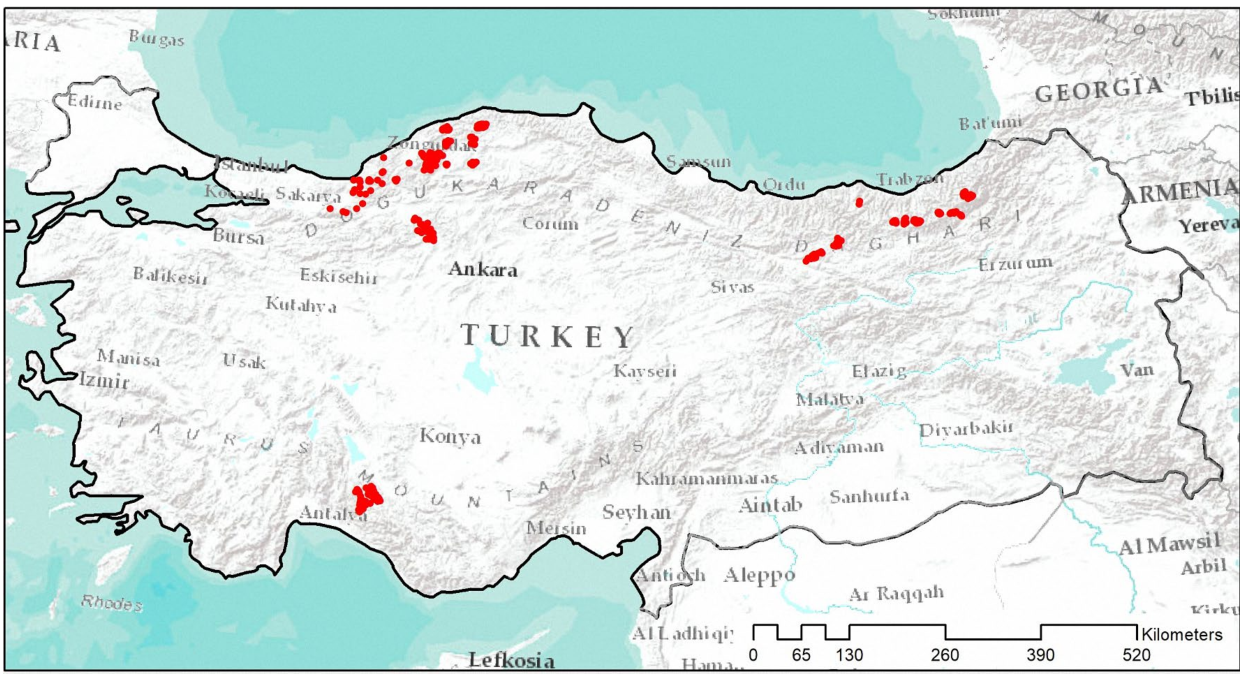

Figure 2: Distribution of 299 present data of Brown bear in the study area.

comprehensive manner was resized based on the study area boundaries. Lambert Conformal Conic coordinate system is defined for the digital elevation model obtained according to the study area boundary. This digital elevation model is divided into 1x1km square pixels, which are generally preferred in future climate change studies on wild animal habitat suitable modelling, potential distribution in plant and land use classes (Wright et al. 2020). Finally, based on the digital elevation model of the study area, 45 different environmental variable base maps were produced.

Chelsa climate data V2.1

High-resolution information on climate change is important for wildlife ecology and management. As they provide high resolution, Worldclim and CHELSA climate data are preferred in habitat suitability mapping and modelling. While more accurate results are achieved with worldclim climate variables in small scale areas, chelsa climate variables adapt better in large scale areas. CHELSA (Climatologies at high resolution for the earth's land surface areas) data includes bioclimatic variables derived for the current reference period 2040-2070-2100 for monthly mean temperature in °C and precipitation in mm/month. The variables that can be deducted are derived from monthly precipitation and temperature values (Karger and Zimmermann, 2019).

Chelsa climate data V2.1 (current and future) are available at www.chelsa-climate.org. (Karger et al., 2017). The current and future Chelsa climate data (30 arc sec.) in version 2.1 were downloaded in ESRI Grid format. From chelsa climate data current is being used IPSL-CM6A-LR (SSP126-SSP370-SSP585) scenario from Version 2. All variables of IPSL-CM6A-LR scenarios are based on daily, monthly and annual times. Variables of these times have their own characteristics and are calculated separately. The short names, long names, explanations, unit and offset of the 19 chelsa climate variables obtained are given below (Table 1).

Habitat Suitability Mapping of Brown bear

Target species presence data was randomly divided as 10% test data and 10 replications using MaxEnt. As a result, habitat suitability modelling, which is the average of all the data belonging to the target species, was revealed (Kaky et al., 2020). In order to control the accuracy of the model, ROC (Reciever Operating Characteristic) values of the recurrences, Average ommission graph and Jacknife graph should be evaluated. Two different methods are followed in the evaluation of the ROC values of the obtained model. The first of these is to choose the the highest ROC training value among the replications of the model. The other is to choose the model which has the the lowest difference between the ROC training and test values b is. It is paid attention that the test data value is not higher than the training data value (Markus, 2022). In addition, if the ROC value of the curve formed because of the modelling is less than 0.7, it is classified as "informative", between 0.7-0.9 values "good", and if it is greater than 0.9 it is classified in the "very good" category (Zannou et al., 2021).

After examining Jacknife graph, the variable with the lowest contribution to the model should be removed from the analysis and the remodeling process should be continued. This should continue until a total of two different variables remain. The most appropriate model should be selected with decision-making techniques according to the average training-test ROC values of the repetitions of the models obtained.

The modelling process were carried out until at least two variables that could be effective on the brown bear remained. After choosing the necessary model the current habitat suitability modelling of the Brown bear has been determined. The future model (2040-2070-2100 climate scenarios IPSL-CM6A-LR SSP126-SSP370-SSP585) of the Brown bear has been formed by determining the variables that contribute to current habitat suitability modelling and projecting the current model to future chelsa climate scenarios. The resulting mapping process has been classified as unsuitable habitat<0.5, 0.51-0.8 suitable habitat and 0.81-1 most suitable habitat.

RESULT

Variables selection

For the habitat suitability modelling of the Brown bear, 19 climatic and 45 environmental variables that may be effective on the target species were produced in 1x1km^2 pixel size. It has been stated in the literature studies that there is a high correlation between the 19 chelsa climate variables which can end up with errors and unreliable results. Therefore, Pearson Correlation Analysis was applied among 19 chelsa climate variables. As a result of this, a high correlation was determined between 19 chelsea climate variables (30 arc seconds = ~ 1km^2).

Factor analysis was applied to determine the best representative variable among the highly correlated climate variables. 4 variables among 19 chelsa climatic variables explained the model best with 93.711% of cumulative and 10,386% of variance value (Table 2). It was determined in the component matrix results (R^2<0.8) that those who contributed the most to the model were bio12 (-0,952), bio13 (0,935), bio10 (0,903) and bio2 (-0,893), respectively (Table 3).

As a result of the statistical analysis of 64 different base maps created for the study area, the habitat suitability modelling was started with 49 environmental and climatic variables that could be effective on the Brown bear. For habitat suitability modelling 49 base maps were converted to Ascii format for processing in the maxent package program. The habitat suitable modelling phase was started with 299 present data belonging to the brown bear with 49 different variables converted to Ascii format.

Table 1: Chelsa climate variables.

Name	Longname	Unit
Bio1	Mean diurnal air temperature range	^0C
Bio2	Mean annual air temperature	^0C
Bio3	İsothermality	^0C
Bio4	Temperature seasonality	^0C
Bio5	Mean daily maximum air temperature of the warmest month	^0C
Bio6	Mean daily minimum air temperature of the coldest month	^0C
Bio7	Annual range of air temperature	^0C
Bio8	Mean daily mean air temperatures of the wettest quarter	^0C
Bio9	Mean daily mean air temperatures of the driest quarter	^0C
Bio10	Mean daily mean air temperatures of the warmest quarter	^0C
Bio11	Mean daily mean air temperatures of the coldest quarter	^0C
Bio12	Annual precipitation amount	Kg m^{-2} $year^{-1}$
Bio13	Precipitation amount of the wettest month	Kg m^{-2} $month^{-1}$
Bio14	Precipitation amount of the driest month	Kg m^{-2} $month^{-1}$
Bio15	Precipitation seasonality	Kg m^{-2}
Bio16	Mean monthly precipitation amount of the wettest quarter	Kg m^{-2} $month^{-1}$
Bio17	Mean monthly precipitation amount of the driest quarter	Kg m^{-2} $month^{-1}$
Bio18	Mean monthly precipitation amount of the warmest quarter	Kg m^{-2} $month^{-1}$
Bio19	Mean monthly precipitation amount of the coldest quarter	Kg m^{-2} $month^{-1}$

Table 2: Factor Analysis results applied to Chelsea Bioclimate variables.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	9.152	48.168	48.168	9.152	48.168	48.168
2	4.056	21.346	69.514	4.056	21.346	69.514
3	3.574	18.812	88.326	3.574	18.812	88.326
4	1.023	5.386	93.711	1.023	10.386	93.711
5	0.581	3.060	96.772			
6	0.388	2.042	98.814			
7	0.169	0.892	99.706			
8	0.022	0.115	99.821			
9	0.012	0.064	99.884			
10	0.009	0.047	99.932			
11	0.005	0.028	99.960			
12	0.004	0.019	99.978			
13	0.002	0.008	99.986			
14	0.001	0.006	99.993			
15	0.001	0.003	99.996			
16	0.001	0.003	99.999			
17	0.000	0.001	100.000			
18	0.000	0.000	100.000			
19	0.000	0.000	100.000			

Table 3: Component Matrix results (R^2) applied to Chelsea Bioclimate variables.

variable	Component			
	1	2	3	4
bio1	0.866	0.373	0.286	-0.063
bio10	**0.903**	0.200	0.282	-0.096
bio11	0.801	0.500	0.316	-0.031
bio12	**-0.952**	0.138	0.541	0.095
bio13	-0.455	-0.301	**0.935**	-0.106
bio14	-0.841	0.488	0.070	0.122
bio15	0.472	-0.663	0.491	-0.246
bio16	-0.468	-0.241	0.840	-0.091
bio17	-0.851	0.465	0.071	0.136
bio18	-0.846	0.476	-0.003	0.142
bio19	-0.245	-0.225	0.819	0.039
bio2	0.694	**-0.893**	-0.053	0.486
bio3	0.721	0.217	0.129	0.568
bio4	-0.213	-0.878	-0.236	-0.127
bio5	0.811	-0.010	0.229	-0.005
bio6	0.755	0.533	0.359	-0.090
bio7	0.257	-0.472	-0.230	0.141
bio8	0.525	0.401	-0.358	-0.482
bio9	0.751	0.047	0.286	0.173

Climatic habitat suitability modelling results for Brown bear

Current modelling and mapping (Chelsa V2.1: 1981-2010)

A total of 47 different models were created with the present data obtained to reveal the current habitat suitability mapping of Brown bear. Among the models obtained, 44 model was determined as the best model with the AUC 936 (Figure 3A). In addition, there is no tolerancing in the omission graph of 44 models (Figure 3B). It was determined that 9 replications in training data (AUC:945) and test data (AUC:936) of 44 models were the best separation (Figure 3C).

The variables contributing to 9 recurrences that constitute the current potential distribution of endangered and protected bear species in Turkey are Annual precipitation amount (bio12), Mean annual air temperature (bio2), Precipitation amount of the wettest month (bio13), Ruggedness (rugg_3) and Elevation (ykslti) respectively. The marginal respondent graphics of the variables contributing to the current habitat suitability modelling of Brown bear and the resulting mapping by values are as follows. When the marginal respondent graphs are examined; it has been determined that the probability of existence of the species is high in areas where the annual precipitation amount is up to 11.4 ^{0}C (Figure 4A), the average annual air temperature is up to 5 ^{0}C (Figure 4B), the precipitation amount of the wettest month is 2500 Kg m^{-2} month^{-1} (Figure 4C), the ruggedness increase (Figure 4D) and elevation is up to 2900 meters (Figure 4E).

According to the results of the marginal responsive graph value revealed, current habitat suitability mapping reveal of the Brown bear (Figure 5). When the habitat suitability map was examined, it was determined that suitable habitats for the species were concentrated in the north, south and east direction, which has ruggedness areas. Compare to the mapping by Can and Togan (2004), Ambarlı et al., (2016), it has been revealed that the predictive values are clearer and more reliable as it is numerical and model-based.

Future modelling and mapping

2040-2070-2100 climate scenarios IPSL-CM6A-LR SSP126-SSP370-SSP585 were combined with variables affecting the current habitat suitability modelling (Figure 6, Figure 7, Figure 8) The combined mapping areas with high habitat suitability are shown in red, and areas where the Brown bear habitat suitability is low are shown in blue.

The results were classified based on values of 0.5 (Unsuitable habitat), 0.51-0.8 (Suitable habitat), and 0.81-1.00 (The most suitable habitats). By evaluating to the classification results, unsuitable habitats, suitable habitats and most suitable habitat areas of the species were determined in % (Table 4).

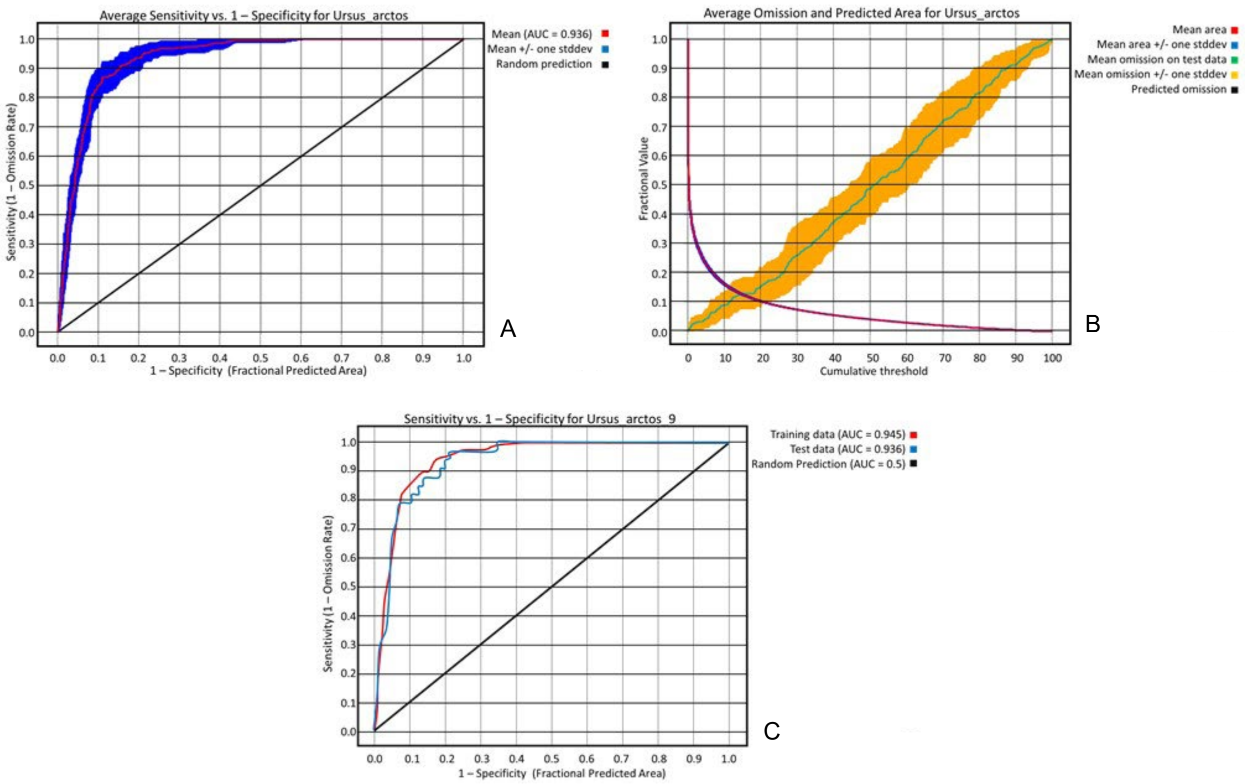

Figure 3: A) AUC values of Brown bear current habitat suitability model, B) Omission graph of the current model, C) The receiver operating characteristic (ROC) curves forcurrent model.

When the habitat suitability degree table is evaluated, the total of suitable and most suitable habitats for the Brown bear in current model is scenario 14.87%. According to the 2040 year climate scenarios, the least suitable habitat total for the species is 12,56%. In 2070 year, this value is 10.93%. Therefore, according to the 2100 SSP585 chelsa climate scenario, the total of suitable habitat and the most suitable habitat for the species is 8.24%. When the SSP585 climate scenario of 2100 is evaluated according to current model, it has been revealed that approximately 45% of the total suitable habitat for the Brown bear will decrease. As a result of the change climate conditions and scenarios, the target species is endangered in the 21st century.

DISCUSSION

To ensure the sustainability of ecosystems, it is necessary to examine the plant, fungus, insect and wild animal species as a whole. For this reason, determining the habitat preferences or demands of wild animal species, which provides information about the vitality, diversity and continuity of different ecosystems, constitutes an important base for biodiversity protection and management plans. Based on this, we aim to show how the brown bear which distribution in Turkey, will be affected by climate scenarios in the future. Therefore, the variables that influence the current potential distribution modelling of brown bear were determined and discussed.

It has been detected that the annual average precipitation (bio12) variable contributing to the model is the most effective variable on the Brown bear. By Su et al. (2018), it is stated that the habitats of the Brown bear and their potential distribution in the future will be affected depending on the annual average precipitation. It has been estimated that it continues to exist in regions where the amount of precipitation is up to 406 mm in the area, and this value will increase up to 459 mm in 2050. In the study stated that the effect of rainy weather conditions on the target species during the season is 51% (Seryodkin et al., 2013) and the daily activity will increase by 0.1 km/hour with an increase of 5 mm in annual precipitation values (Martin, 2009). However, heavy rainfall reduces the diet of the bear species and negatively affected the amount of fat accumulated in its body. As a result of, Brown bear distribution and population density change depending on the climate variable such as annual precipitation (Aryal et al., 2014).

The mean annual air temperature (bio2) variable in the model contributed to the habitat suitability modelling of the Brown bear. Due to the decreasing snowfall and increasing temperatures in the area, the Brown bear in the form of torpor (Sahdo et al., 2013) emerges earlier from the shelter areas to meet its nutritional needs (Delgado et al., 2018). The annual air temperature which is effective on leaving the shelter early, also caused the body temperature (thermoregulation) of the target species to increase (Evans et al., 2016; Evans and Rittenhouse, 2018). As the

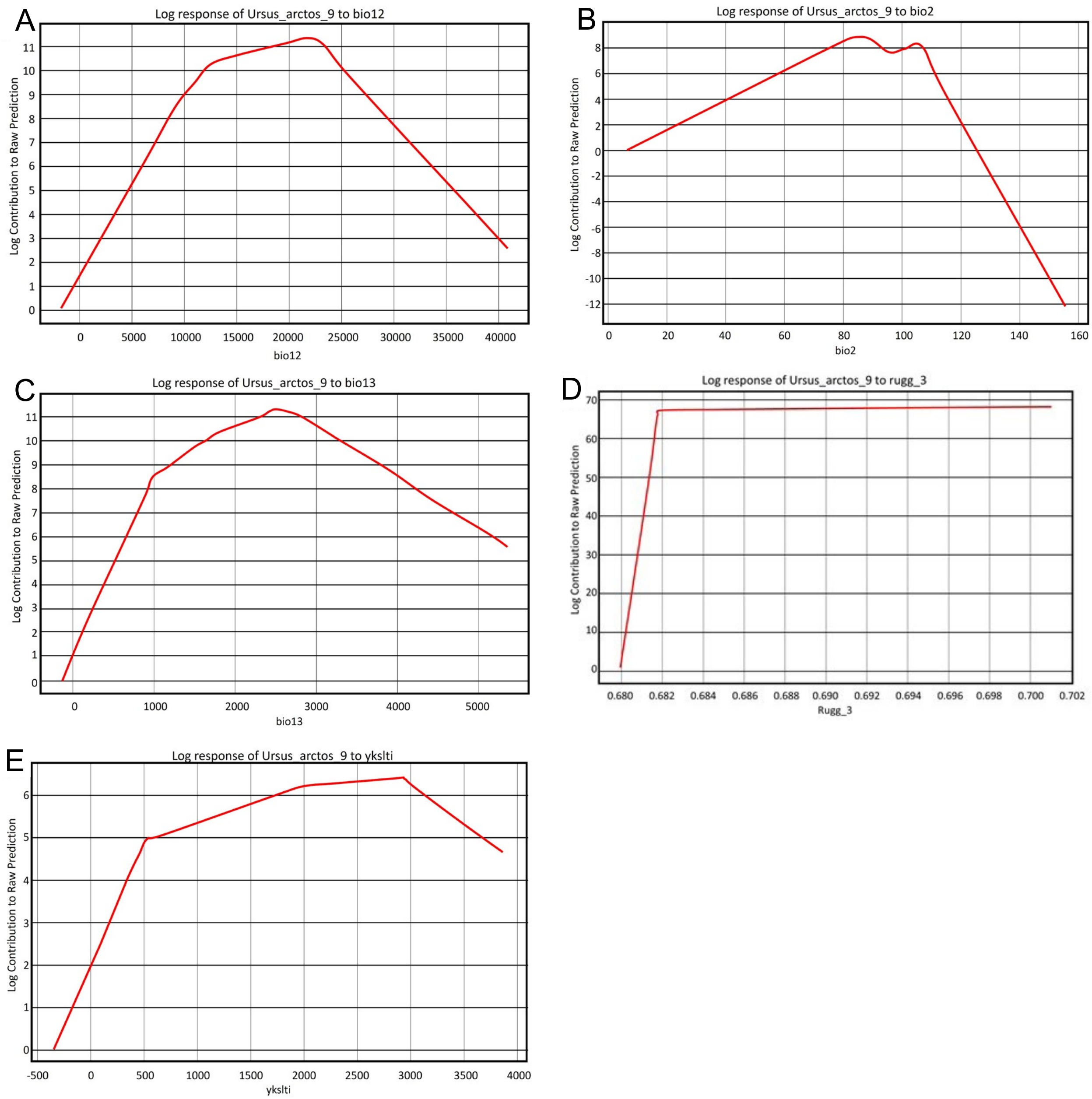

Figure 4: A) Annual precipitation amount graph; B) Mean annual air temperature graph; C) Precipitation amount of the wettest month graph; D) Ruggedness index; E) Elevation.

body temperature increases, the efficiency of high calorie foraging around the natural habitat of the target species decreases, and its interest in ungulates, which provides for its food needs, decreases (Niedzialkowska et al., 2019). In this context, it has been revealed that the daily, monthly, annual or seasonal temperatures of Brown bear have positive or negative effects on their habitats and food preferences due to changes in their body temperature. (Martin et al., 2013; Pigeon et al., 2016). Su et al. (2018) put emphasis on, for the Brown bear it was determined that with the increase in the annual average temperature variable values, the habitat suitability of the species narrowed or fragmented.

It has been determined that the rainfall variable of the Precipitation amount of the wettest month (bio13) in the model is effective on the species. In the studies, it was stated that 33% of the rainy weather is caused by the rains that occur in the autumn season (Seryodkin et al., 2013). Therefore, it has been revealed that the amount of precipitation in the autumn season is a important factor on the species. In addition, it is stated that the target species rested less than other seasons due to the heavy rainy weather in the autumn (Fernandez et al., 2020). In this context, Brown bear who daily activity varies with the onset of precipitation, rest less at noon of the day compared to other seasons (Stelmock and Dean, 1986). Small mammal species such as Pika (*Ochotona spp.*) and Marmot (*Marmota spp.*), whose distribution is affected depending on the precipitation variable, have an important place in the feeding preference (Su et al., 2018). As the precipitation amount of the wettest month changes, the feeding pattern and habitat preference of the Bear species are affected.

One variable that reveals the current habitat suitability modelling of the bear is ruggedness index (rugg_3). It was also determined that the habitat suitability level of the Brown bear increased as the roughness value increased in the area. In a study conducted in Croatia, the ruggedness index was revealed as the most important variable according to the model put forward to protect the Brown bear. It has been stated that as the ruggedness index value increases, the habitat preferences of the Brown bear also increase (Whiteman et al., 2017). In a study conducted, it was determined that 78% of the den of the Brown bear consists of karst caves. It stated that these cave formations are less likely to occur in low and flat areas and higher in rough areas (Huber and Roth, 1993). In addition, using data collected from 119 cave areas in Romania, they revealed that terrain roughness was the most important factor when estimating the den areas of the Brown bear. The contribution

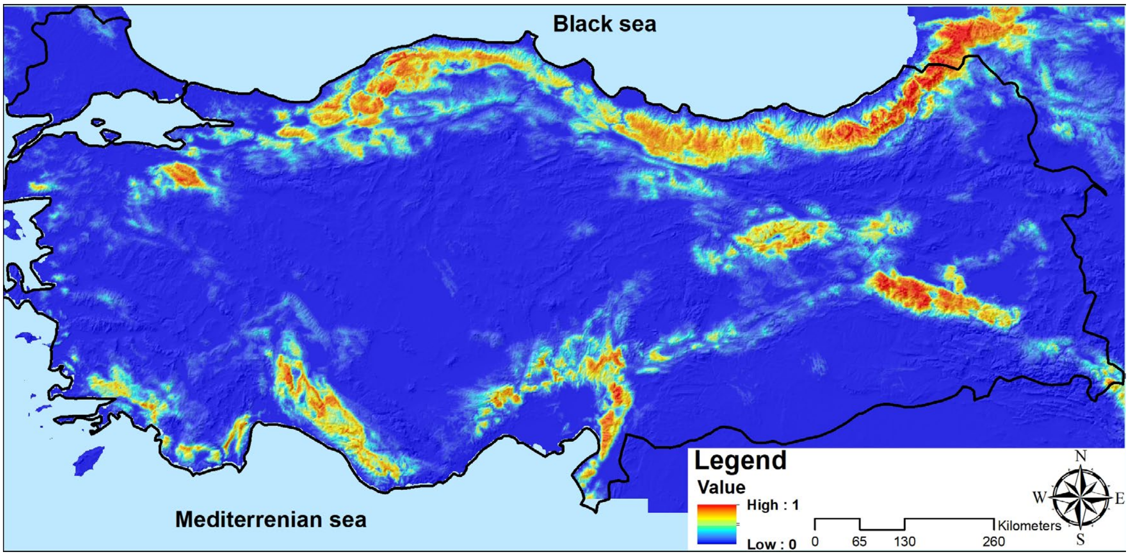

Figure 5: Current habitat suitability mapping of the Brown bear.

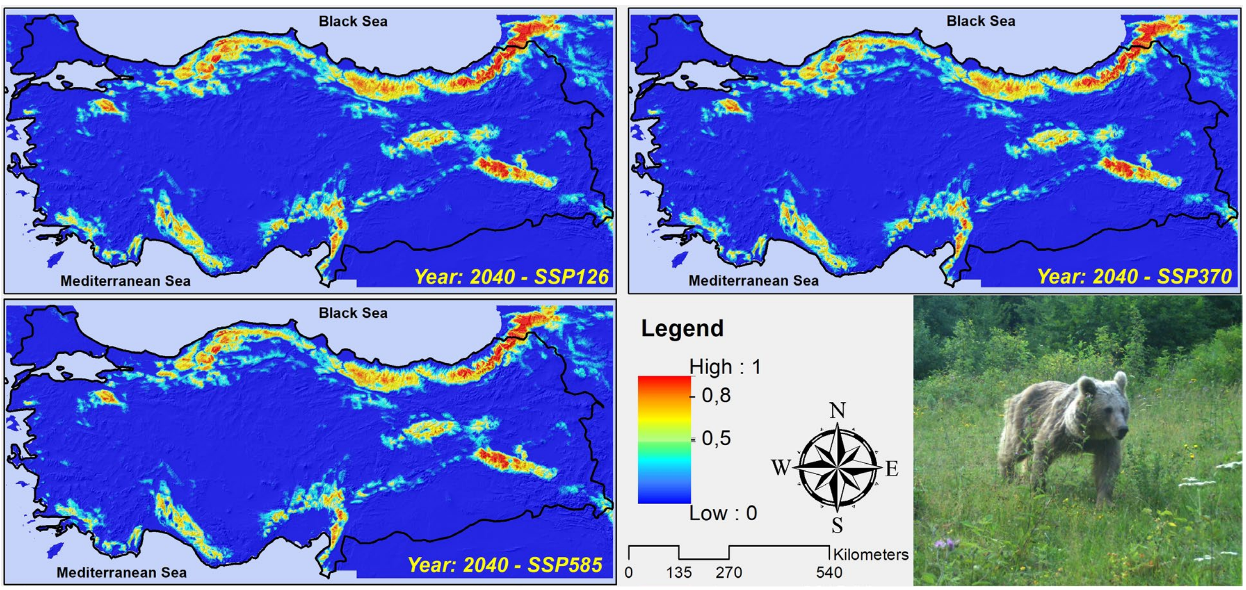

Figure 6: Habitat suitability mapping of Brown bear according to 2040 chelsa climate scenarios (Future model: SSP 126-SSP 370-SSP 585).

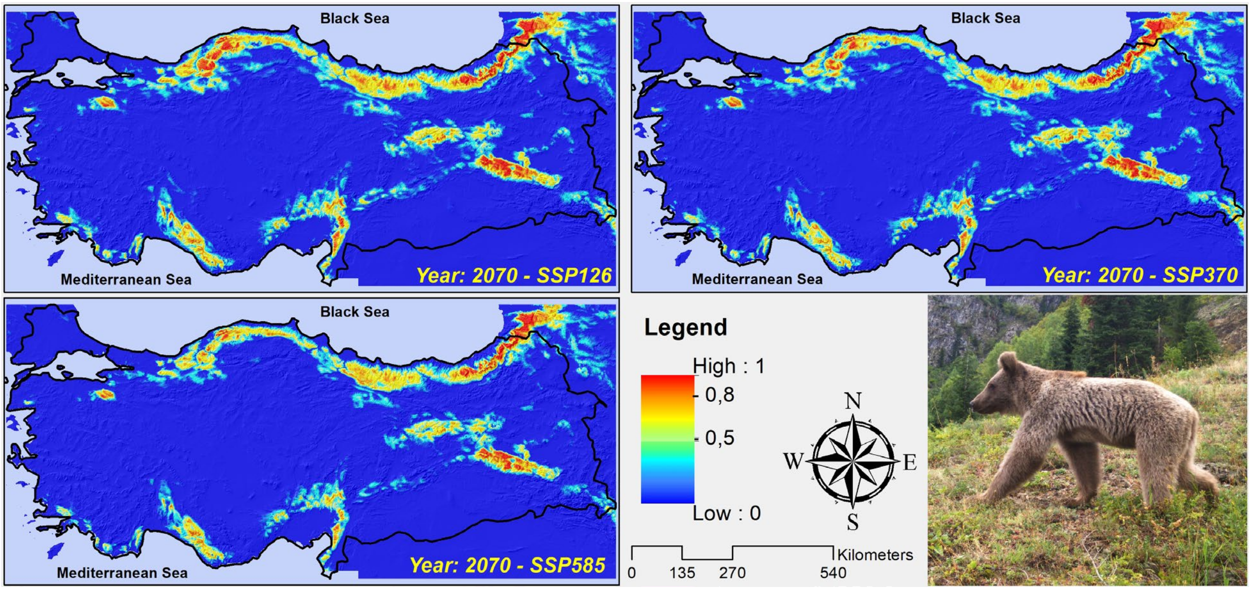

Figure 7: Habitat suitability mapping of Brown bear according to 2070 chelsa climate scenarios (Future model: SSP 126-SSP 370-SSP 585).

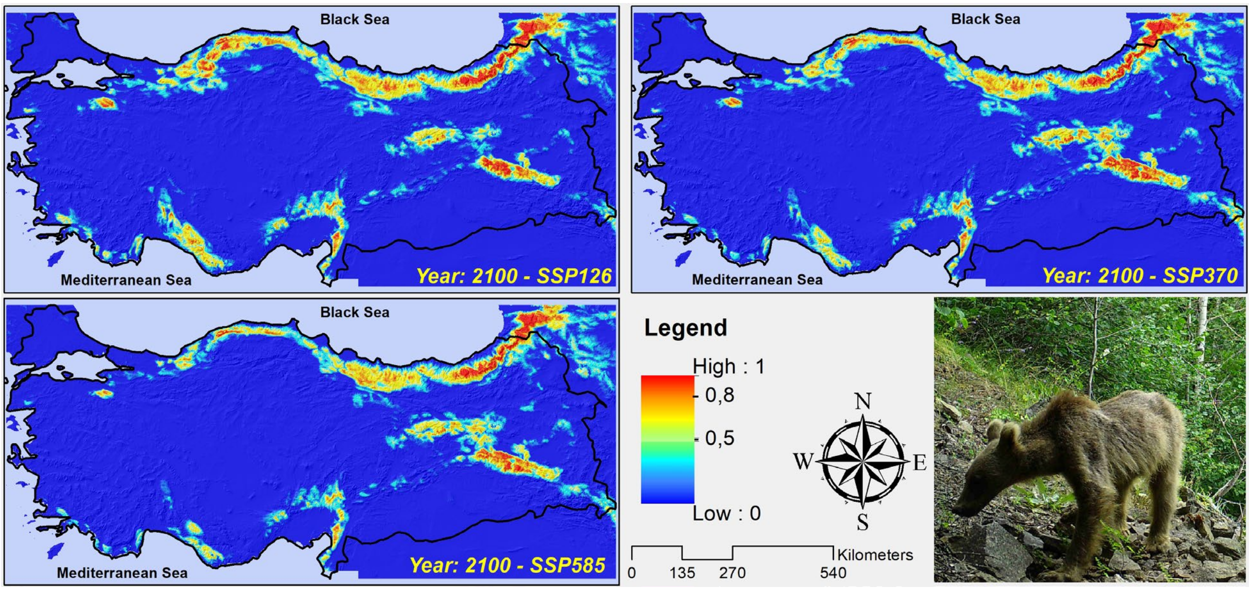

Figure 8: Habitat suitability mapping of Brown bear according to 2070 chelsa climate scenarios (Future model: SSP 126-SSP 370-SSP 585).

Table 4: Habitat suitability modelling rate.

Habitat suitability rate	Current	Future SSP (2040)			Future SSP (2070)			Future SSP (2100)		
		126	370	585	126	370	585	126	370	585
0.0-0.50	85.13%	86.76%	87.08%	87.44%	88.21%	88.67%	89.07%	90.62%	91.15%	91.76%
0.51-0.80	11.45%	9.98%	9.87%	9.75%	8.96%	8.71%	8.56%	7.53%	7.21%	6.87%
0.81-1.00	3.42%	3.26%	3.05%	2.81%	2.83%	2.62%	2.37%	1.85%	1.64%	1.37%
Total suitable habitat	14.87%	13.24%	12.92%	12.56%	11.79%	11.33%	10.93%	9.38%	8.85%	8.24%

of the roughness index value to the model was 92.7% in the habitat suitability map they have revealed using the Maxent method. According to the variable results, it was stated that the species prefers rough areas and the probability of existence of the species in rough terrain structures is high (Faure et al., 2020).

It is the elevation (yksIti) variable that makes the lowest contribution to the formation of the modelling. When the studies on the Brown bear in Turkey are examined; It is stated by Çanakçıoğlu and Mol (1996) that the bear species spreads up to an elevation of 2 800 meter. Başkaya et al. (2008), it was stated that the Bear target species is distributed in the high parts of the mountains up to 3 500-4 000 meters in the Alps in Turkey. Also in another study it was stated the range of target species in Russia is highest in the autumn seasons (Seryodkin et al., 2013). In Turkey, Suel (2019) recently conducted a study and pointed out the Brown bear is distributed in Antalya region and this distribution generally has a positive effect up to 2000-meter elevation. In a study conducted in Iran, it was also stated the species ranges between 1000 m-2100 m in the autumn season (Kiani, 2020).

Shortly, the annual average precipitation,the mean annual air temperature, precipitation amount of the wettest month, ruggedness index and elevation variable is effective on the target species, which has the widest distribution area, and the results are in consistency with the literature. Climate variables such as precipitation and temperature will affect the breeding, feeding and habitat suitability of the Brown bear and cause it to change over time. Due to the increasing rainfall on the Brown bear, which has a large size, the species will have difficulty in leaving their areas and will not meet its nutritional needs. Or this increasing temperatures according to future climate scenarios will cause the body temperature of the species to increase. Since the Brown bear, is sensitive to precipitation and temperature, these factors will limit the current distribution of the species and if this situation continues, the existence of the species will be endangered.

CONCLUSION

Areas that are important for the sustainability of the Brown bear have been identified. Within the scope of the habitat suitability mapping results we have made, the determined habitat or regions must be given priority to ensure the sustainability of the Brown bear. These habitat suitability maps will form a basis for the studies to be carried out for species protection and habitat protection within the scope of the protection of biological diversity. Also, it will be the main source of information regarding future ecosystem changes in Turkey. Finally, it is expected that the habitat suitability model results obtained within the scope of this study will have a widespread effect on researchers who will study the Brown bear species later on.

AUTHORSHIP CONTRIBUTION

Project Idea: AA, AM

Funding: AA, AM

Database: AA

Processing: AA, AM

Analysis: AA, AM

Writing: AA, AM

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