

## The Importance of Forest Lands in Terms of Bioclimatic Comfort: Sample of Aras Basin

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**ABSTRACT** Humanity has been affected by some atmospheric phenomena such as temperature, precipitation, wind, pressure and humidity. The optimum level of atmospheric events (bioclimatic comfort) enables people to carry out various activities. Extreme climate characteristics have affected the daily life activities, work, production, recreation and leisure activities of people. Sustainable healthy and qualified life depends on suitable climate conditions. Bioclimatic comfort consists of temperatures between 21.0 °C to 27.5 °C, the relative humidity value between 30% and 65% and the wind speed up to 5.0 m/sec in an open space. The study area was a region of 22 7951 km<sup>2</sup>, which includes Aras Basin, one of the important hydrological basins of Turkey, and its environment. In this study, it was aimed to investigate interactions between the forest structure by determining the most suitable areas with regard to bioclimatic comfort according to climate data obtained from 13 meteorological stations in the Aras basin and its vicinity. Using the point data base, ArcGIS 9.3 software, climatic maps (average temperature, relative humidity and wind speed maps) were constituted by digitizing the national coordinate system. According to research results, the most suitable areas have been determined as totally 17 091 km<sup>2</sup> in terms of bioclimatic comfort in the Aras River Basin. This study has shown that forest lands have affected bioclimatic comfort data positively in parallel results determined on many studies proving a positive interaction between bioclimatic comfort and forest land. Most of the suitable areas with regard to bioclimatic comfort have rich forest potential.

### INTRODUCTION

Climate has been one of the most important factors affecting humanity from the past up to present. Social, cultural, historical and economic factors are all affected by climate. Climate is effective on residential areas. Natural conditions are a very important parameter for the planning of residential areas where people can live in comfort (Shakoor et al. 2008).

Climate conditions have been effective on rural residential areas in Turkey. Rural residential areas have been selected around water sources. Not only climate effects on the residential character in urban residential areas but also it has been thought of as a factor being controlled,

even though it has been ignored in urban planning (Kocman 2002).

Planned urbanization is one of the basic factors of development in terms of physical and socio-economics. Climate evaluation is the most important parameter to determine suitable regions with regard to human health in planned urbanization (Altunkasa and Gultekin 1991; Kocman 2002). Bioclimatic comfort is the climate conditions in which humans feel themselves to be healthier and more dynamic. In other words, conditions in which humans adapts to their environment by expending the least energy. Relationships between humans and bioclimatic comfort have been researched (Olgyay 1973; Evans 2003; Topay and Yilmaz 2004; Miguel et al. 2005; Frank 2005; Knes and Thorsson 2006; Andrade et al. 2008). Mahmoodi and Iravani (2012) determined optimum season as a bioclimatic comfort season is September in the Sirjan desert. Farajzadeh and Matzarakis (2012) studied bioclimatic comfort using “Ray Manile Climate Tourism/ Transfer Information Scheme (CTIS)” model in the Ourmieh Lake around Iran. They evaluated best suitable season is between June and September.

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Gomez et al. (2013) studied on positive effect of some settlement areas include water surface and forest cover in city of Valencia-Spain.

There have been many studies about determination of the upper and lower limits of climatic conditions provided bioclimatic comfort. Conversely, the Olgay's (1973) approach is important in this issue being developed to determine the bioclimatic conforming to the requirements of all people living in the outside of Equator and Polar regions. Olgay determined the climate conditions (Fig. 1) provided bioclimatic comfort. The bioclimatic comfort class of any area can be identified by "Bioclimatic Comfort Graphic" (Topay and Yilmaz 2004; Yannas 2013).

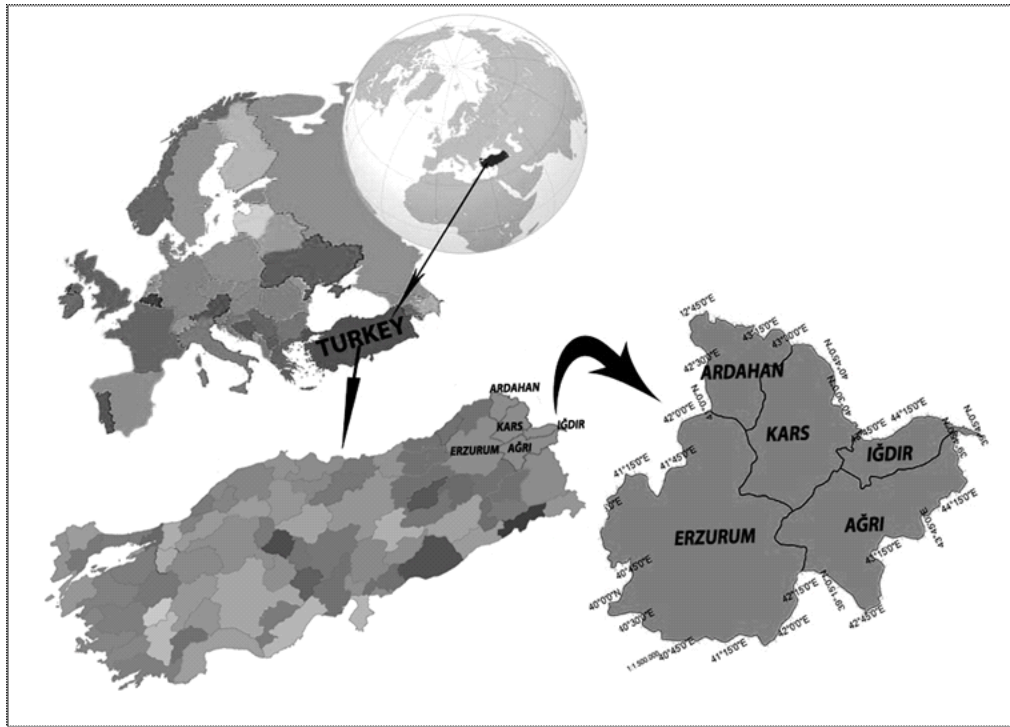
In many indexes, the bioclimatic comfort class has been identified depending on single or a combination of climate, humidity and wind factors. The most widely used criterion is "Sensed Climate" to determine comfort. Thermal comfort is effective in proportion as 80% on the constitution of bioclimatic comfort (Shakour et al. 2008). According to Hobbs (1995), the bioclimatic comfort level is a subjective value (Ta-

ble 1) which varies according to location, time and the individual. In assessment, the sensed temperature values of 15-27°C were calculated for a person who is 25 years old, has no-health problems, is inactive and is normally dressed in interior space. These values may be lower or higher by 5 degrees in outdoor conditions (Cetin et al. 2010).

**Table 1: The temperature values in determining the bioclimatic comfort**

Temperature (°C)	Comfort class
28>	Comfort is disrupted
27-28	Comfort is deteriorated
25-26.9	Transition value (hot)
17-24.9	Comfort
15-16.9	Transition value (Cold)
15<	Comfort deteriorates

In this study, it has been aimed to investigate interactions between the forest structure by determining the most suitable areas with regard to bioclimatic comfort according to climate data obtained from the meteorological station in



**Fig. 1. Research area "Vicinity of the Aras Basin"**

the Aras basin and its vicinity. Therefore, it bioclimatic comfort has been constituted in GIS and evaluations have been by being overlapped with digital "Forest Management Plans" showing the distribution of forest areas inside the area.

### MATERIAL AND METHODS

The Aras watershed is (Fig. 2) one of the major and important hydrological basins of Turkey. The Aras River Basin includes five provinces such as; Erzurum, Kars, Agri, Iğdir and Ardahan. The Aras and Kura rivers are the two major rivers within the watershed. The Aras River source is in the northeast of Bingol Mountains following the route of the Aras Valley, Iğdir, Aralık and it reaches Nakhichevan. The Kura River source is in the mountains of Allahuekber, passing out through Ardahan and it reaches to Georgia (EAP 2010). Research area is 54605 km<sup>2</sup> and it is between 40°022 02 2 and 39°452 02 2 north latitudes and 40°302 02 2 and 44°152 02 2 east longitudes.

In this study, it was aimed to investigate interactions between forest structure by determining the most suitable areas with regard to bioclimatic comfort according to climate data obtained from 13 meteorological station (Table 2) in the Aras basin and its vicinity. The study has three stages.

In the first stage of study, annual temperature, humidity and wind maps were constituted for the summer period (June-July-August) by GIS according to climate data. In the second stage, these climatic maps have been examined taking into account bioclimatic comfort data and

suitable areas have been determined in terms of bioclimatic comfort.

Bioclimatic comfort was obtained through the temperature value from 21°C to 27.5°C, the relative humidity value is 30% to 65% and the wind speed is 5.0 m/sec in an open space (Toy et al. 2005; Cetin et al. 2010).

In the third stage, some evaluations were made that will help planning studies depending on climate by being overlapped bioclimatic comfort maps with digital "Forest Management Plan" showing distribution of forest within the area.

The location of the 13 stations (Fig. 3) of which measurement values used (MDG 2005) and evaluated digital forest map (Fig. 4) in the Aras Basin.

Point-based climate data was evaluated in Geographic Information Systems (GIS) However, analysis of the areas without climate data is possible by the Inverse Distance Weighted interpolation (IDW) technique.

In this study, the maps, in which climatic data is essential, have been formed through the Spatial Analyst extension section (IDW) interpolation module located in ArcGIS 9.3 software produced by ESRI firm. Both evaluation of climate data with point based in GIS and joining to analysis using data of the station in vicinity for areas which have no station data are possible by point interpolation techniques. These techniques are called Inverse Distance Weighted (IDW), Splines and Kriging (Shepard 1968; Lo and Yeung 2002; Zengin et al. 2010)

IDW interpolation technique was used in constitution of maps. IDW formula related to the model is given below

**Table 2: General information of meteorological stations**

No.	Stations name	Coordinates (Latitude-longitude)	Observation years	Altitude (m)
1	Erzurum	39° 57' K - 41° 10' D	1975-2005	1757
2	Ispir	40° 29' K - 41° 00' D	1975-2005	1222
3	Hinis	39° 22' K - 41° 42' D	1975-2005	1715
4	Tortum	40° 18' K - 41° 33' D	1975-2005	1572
5	Horasan	40° 03' K - 42° 10' D	1975-2005	1540
6	Oltu	40° 33' K - 41° 59' D	1975-2005	1322
7	Sarikamis M	40° 20' K - 42° 34' D	1975-2005	2103
8	Agri	38° 03' K - 45° 05' D	1975-2005	1667
9	Kars	40° 26' K - 43° 05' D	1975-2005	1794
10	Arpaçay	40° 51' K - 43° 20' D	1975-2005	1688
11	Ardahan	41° 07' K - 42° 42' D	1975-2005	1829
12	Iğdir	39° 55' K - 44° 03' D	1975-2005	858
13	Dogubeyazit	39° 33' K - 44° 05' D	1975-2005	1725

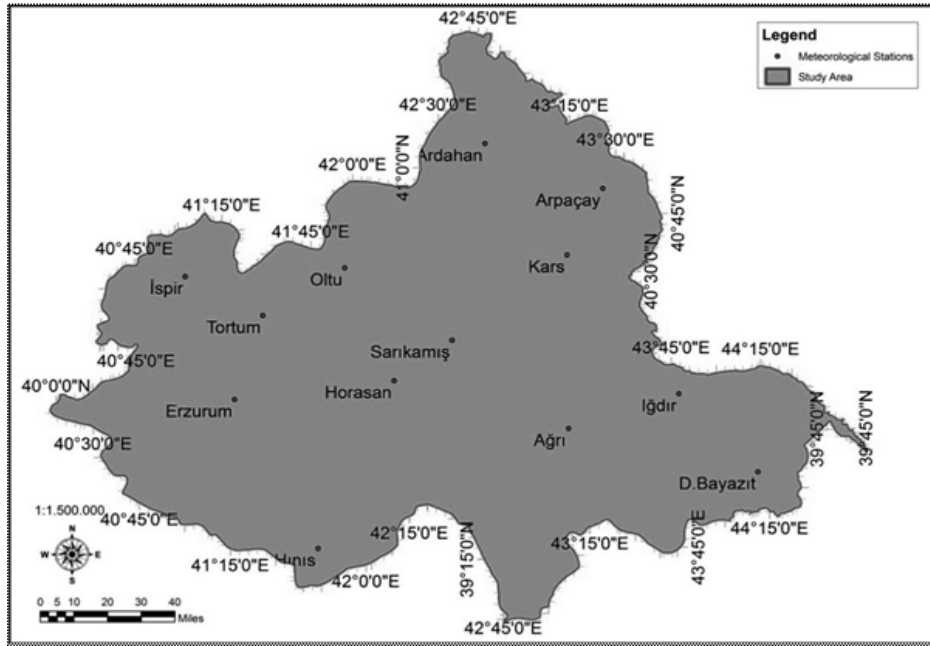


Fig. 2. Meteorological stations

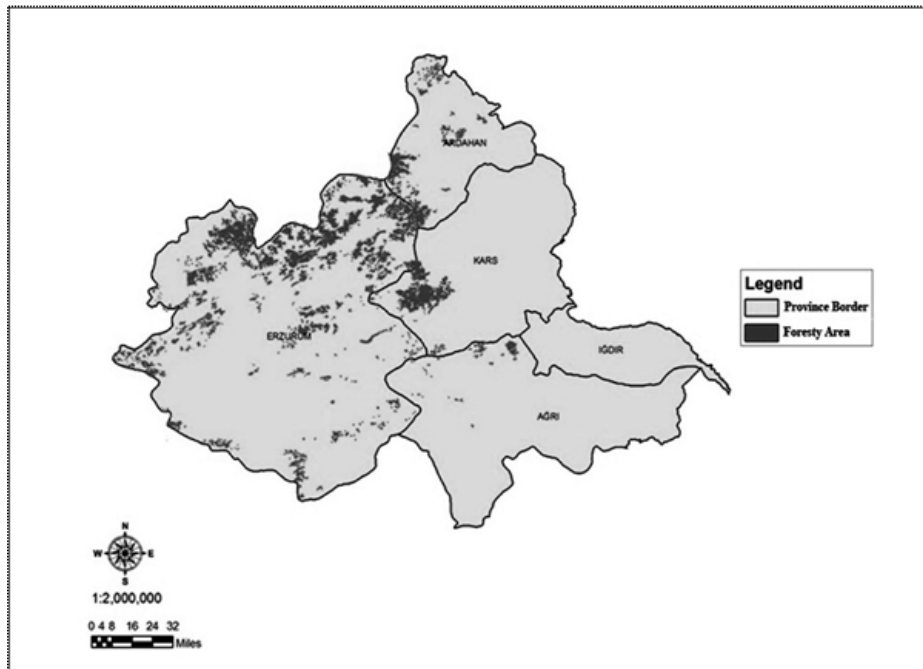


Fig. 3. Digital forest lands of research area

Interpolated value  $u$  at a given point  $x$  based on samples;  $u_i = u(x_i)$  for  $i = 0, 1, \dots, N$  using IDW is an interpolating function:

$$U(x) = \frac{\sum_{i=0}^N \frac{w_i(x) u_i}{d_i^p}}{\sum_{j=0}^N w_j(x)}$$

$$w_i(x) = \frac{1}{d_i^p}$$

IDW is defined as;

$X$ : interpolated (arbitrary) point,  $x_i$  is an interpolating (known) point,

$d$ : distance from the known point

$x_i$ : unknown point

$x$ :  $N$  is the total number of known points used in interpolation

$p$ : a positive real number called as the power parameter.

**RESULTS AND DISCUSSION**

In the first stage, independent maps have been constituted by averages of temperature, humidity values and wind speed. According to climate data obtained from meteorological stations inside of the research area, the annual average temperature map (Fig. 4), average humidity map (Fig. 5) and average wind speed map

(Fig. 6) for the summer period (June, July, August) was evaluated.

The annual average temperature varied between 20.9°C to 30.5°C during the summer season. The highest distribution of annual temperature values (between 28.7°C and 30.5°C) were around of the province of Iğdir which is in the southeast of the research area. The lowest temperature variations were (between 20.9°C and 22.2°C) in Arpacay Kars and Sarikamis route.

Annual average relative humidity values of the research field varied between 30.6% and 47%. The highest average relative humidity values were found in Sarikamis, Ardahan and Kars region as 45.1% and 47%.

Annual average wind speed values varied between 1.6 m/s and 4.3 m/s. The highest average wind speed values were found in Erzurum, Kars and Dogubeyazit regions as 3.9 m/s and 4.3 m/s. The lowest average wind speed values were found in Tortum, Iğdir and the Hınıs regions as 1.6 m/s and 2.1 m/s.

These climatic maps, constituted at the second stage of research, have been interrogated with regard of bioclimatic comfort values and suitable areas have been determined in terms of bioclimatic comfort. Suitable areas in terms of

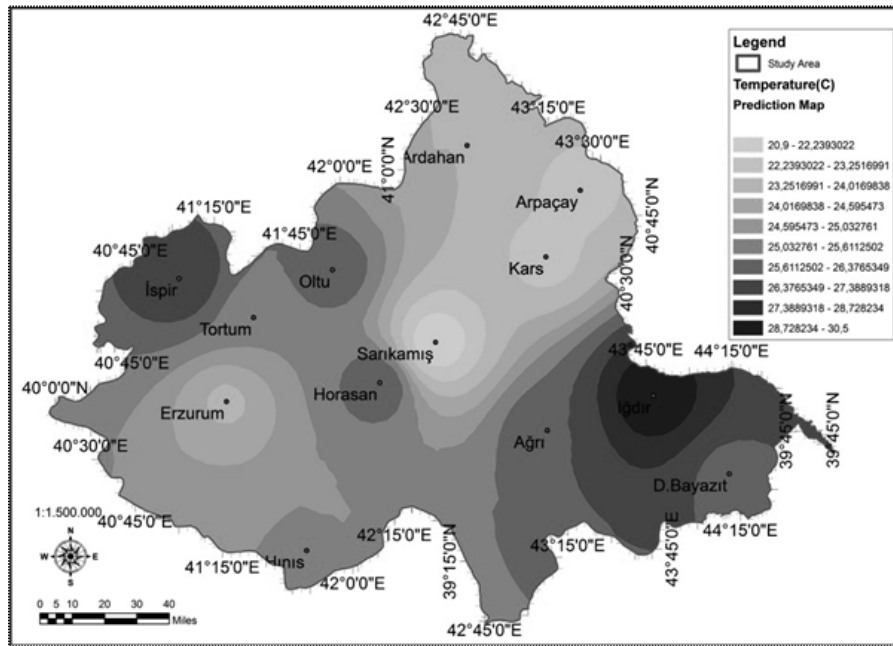


Fig. 4. Annual average temperature map of the Aras River Basin

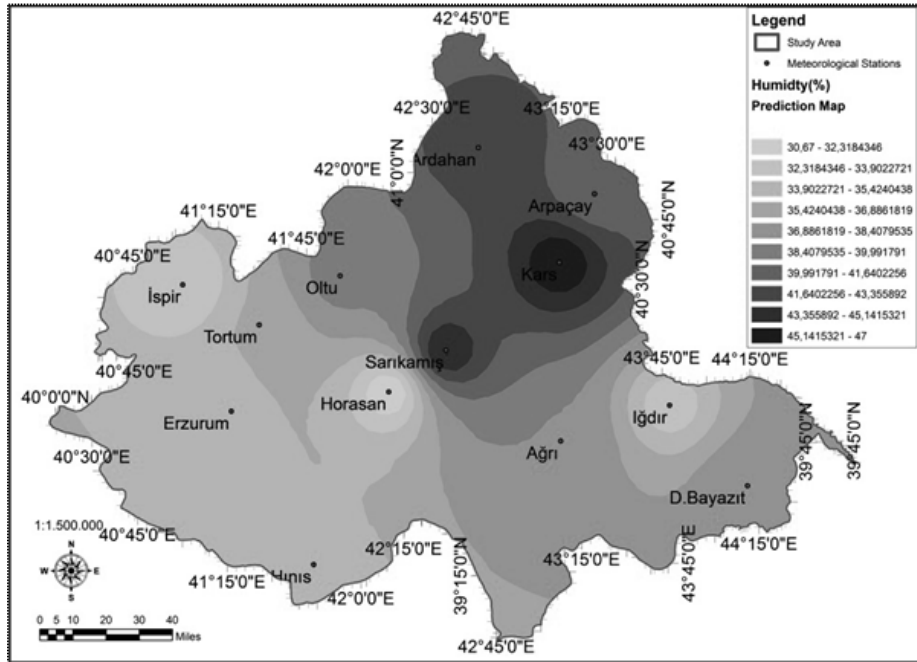


Fig. 5. Annual average relative humidity map of the Aras River Basin

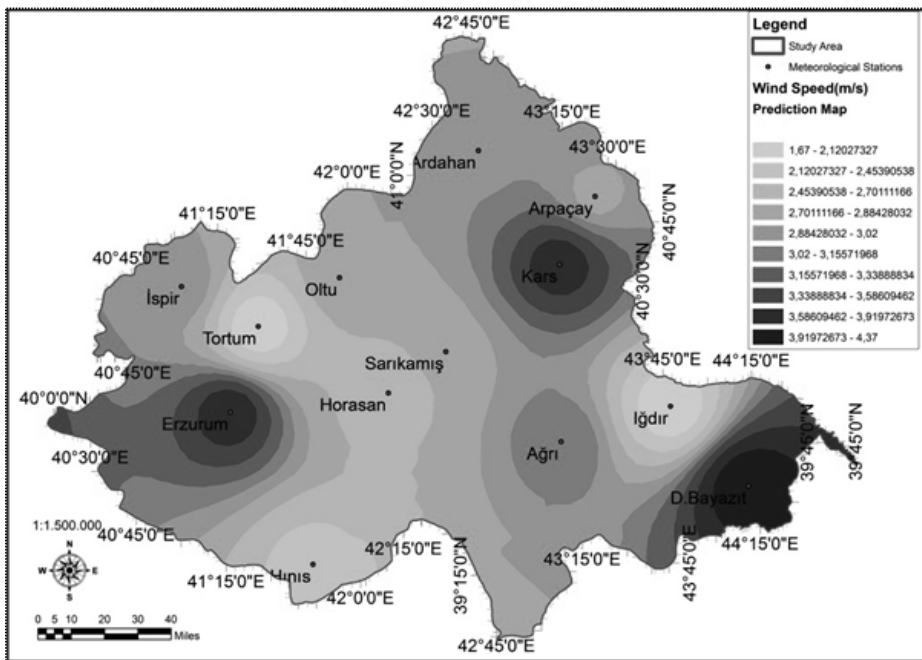


Fig. 6. Annual average wind speed map of the Aras River Basin

bioclimatic comfort had a large proportion as 90% in the study carried out in the summer.

The average temperature values were between 20.9°C–30.5°C, the mean relative humidity values were between 30.6% and 47%, average values of wind speed were between 1.6m/s and 4.3m/s) in the research area. Temperature was found to be the most important factor affecting the bioclimatic comfort when these climatic parameters were evaluated in the research area.

Human’s short travelling from regions with high temperature and humidity levels to regions with lower temperature and high altitude especially in the summer is the main reason for taking daily and summer period temperatures in this study.

It has been determined that a large part of the Aras River watershed and its vicinity were suitable in terms of bioclimatic comfort especially in the summer in which bioclimatic comfort is not suitable generally. In this context, although the climatic comfort is not feasible especially in the summer months, the Aras River watershed and its surroundings are appropriate in terms of climatic comfort.

Finally the optimum bioclimatic comfort map (Fig. 7) was created for the Aras River watershed.

According to research results, the most suitable areas in terms of bioclimatic comfort have been determined as totally 17 091 km<sup>2</sup> in the Aras River Basin.

In the third stage of research, bioclimatic comfort maps have been overlapped with digital “Forest Management Maps” (Fig. 8) used Model Builder module in the ArcGIS software program. According to the overlaid map, bioclimatic comfort has affected by altitude and forest cover area (Table 3) in the research watershed. Average altitude found approximately same for two uncomfortable region (Ispir and Iğdir). Forest cover effected positively bioclimatic comfort as balanced temperature, wind and humidity. Thus uncomfortable area found smaller in Ispir than Iğdir.

Many other studies confirm the results of this study. In the studies carried out by Olemba and Rahm (1987) in Francfurt, Germany, it has been determined that the forest belt with a 50-100 meter width surrounding the city has de-

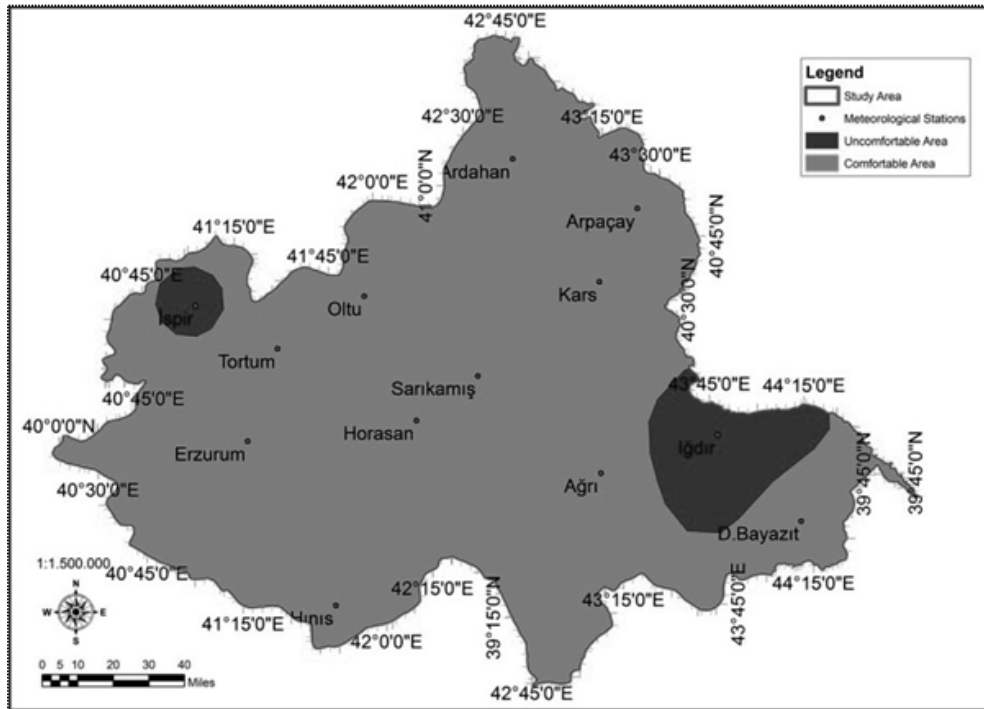
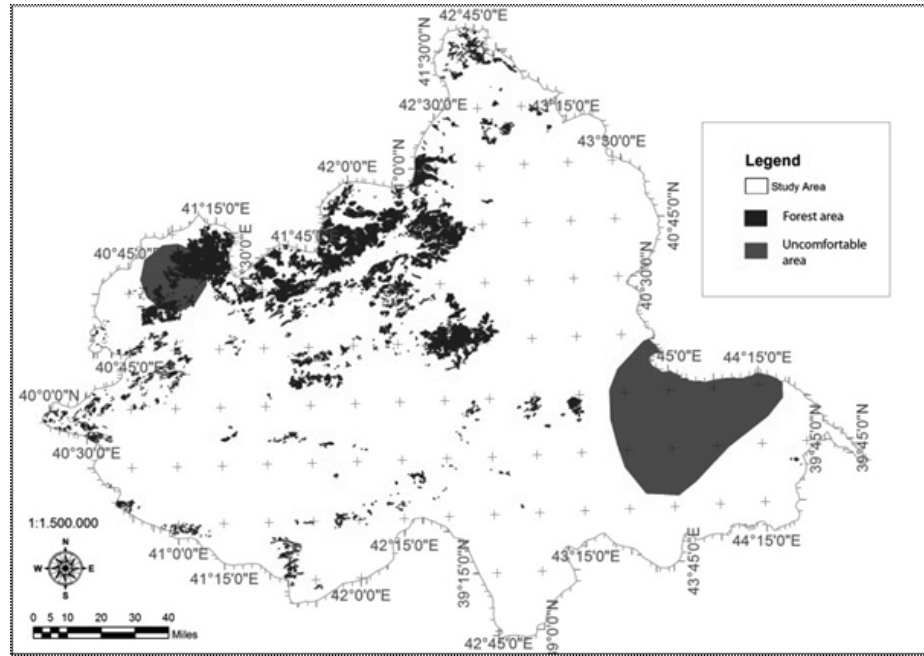


Fig. 7. The climatic comfort map for the of Aras River Basin



**Fig. 8. The climatic comfort map and forest area spatial distribution vicinity of Aras River Basin**

creased the temperature by 3.5°C and increased humidity by 5% depending on evapotranspiration. The summer temperature in the forest is lower than in open areas by approximately 5-8.5°C. The winter temperature in the forest is higher than opened area approximately 1.6-2.8°C. It has been determined over precipitation in proportion as 50% in the studies carried out in USA (Caglar 1992). The effect of bioclimatic comfort occurred by the effects of temperature, humidity and wind is more significant under the forest cover in comparison with open areas (Kuchelmeister and Braatz 1993). Irmak et al. (2013) found that that the canopy of Scotch pine trees can provide the most comfortable environment by increasing the human thermal condition by 5.1%, followed by Silver birch trees by 3.8% which increased human thermal condition when com-

pared to open spaces while mixed canopy did not give the respective results. As will be understood from spatial analysis maps prepared according to measurement values in GIS, forest lands affect bioclimatic comfort positively in parallel with results obtained from a lot of studies proving positive effect between bioclimatic comfort and forest lands. Most of the areas suitable for bioclimatic comfort have a rich potential with regard to comfort values in the research area. The research results, which were obtained from being overlapped spatial distribution of bioclimatic comfort with forest lands in the region, show that comfort values are high in the region with intensive forest lands, low in the region without forest lands. So, these results bring up how effective forest lands on comfort values are.

**Table 3: Relationship of the uncomfortable areas between forests and altitude**

Location	Uncomfortable area				
	Min. altitude (m)	Max. altitude (m)	Average altitude (m)	Uncomfortable area (km <sup>2</sup> )	Forest cover area (km <sup>2</sup> )
Ispir	1196	2150	1673	804	201
Igdir	840	2300	1570	3707	0



## CONCLUSION

The highest amount of people human activities in nature depends on climatic events and play a vital role for in life. Meteorological data plays an important role in the direction of landscape and urban planning. Maps, obtained by analysis of meteorological data, play an important role in planning and design studies.

At first, the annual average temperature, humidity, wind speed values and maps constituted in GIS have been investigated with regard to bioclimatic comfort values such as temperature (between 15°C and 27°C), relative humidity (between 30% and 70%) and wind speed (between 0m/s and 5m/s). Iğdir province and Ispir county centre were not suitable for climatic comfort during the summer period. The other areas except for these (Iğdir and Ispir) areas were found to be suitable for all climatic comfort parameters. According to the research results, the most suitable areas have been determined as totally 17 091 km<sup>2</sup> in terms of bioclimatic comfort in the Aras River Basin.

## RECOMMENDATIONS

The research areas which are suitable in terms of bioclimatic comfort, are all suitable for cultural, recreational and sportive activities of domestic and foreign tourists. Especially in the summer months in which the desert heat is experienced, accommodation and travel where the climatic comfort is at optimum levels are of great significance for the development of cultural tourism. In this context, the necessity for administration of the internal and external tourism by determining the suitable areas for the climatic comfort as seasonal has emerged.

Distribution of the plant community is mostly connected with climate. Conversely, the plant community affects climate. The effect of flora on a region is related with its area size and intensity.

According to the results, there is an important point in bioclimatic comfort values between Ispir and Iğdir which have the same altitudes. When areas with the same altitudes are compared with each other, unsuitable areas with regard to bioclimatic comfort are low in Ispir where forest lands are much as shown in Figure 3.

According to different publications, the relaxing effects of the forest have been explained thus;

- ♦ Shading effects of tree crowns protect harmful effects of sun light on the skin in the forest.
- ♦ Eyes perceive the environment easily because of the decreased light intensity; also green light has a positive effect on the retina.
- ♦ Mechanical drying effect of strong weather movements on the skin is low because of the reduced cut wind speed in the forest.
- ♦ Not only humidity given atmosphere by transpiration cools environment atmosphere, but also provides downfall of solid particles in the air. Therefore, breathing clean and humid air is easy.

As a result, the climatologically characteristics of residential areas such as, distribution of temperature, distribution of precipitation, distribution of wind speed and direction, changing of wind due to altitude, distribution of humidity, distribution of soil temperature, occurrence of low cloud and fog, snow thickness and the staying time of snow, insulation intensity must be evaluated very well for good planning. Forest lands in the vicinity of the city play an important role on development of healthy communities as physically and spiritually. Importance must be given to approaches about the increasing of forest lands in and the current forest lands in regional and local planning studies.

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