CLIMATE CHANGE AND BIODIVERSITY RELATIONS IN THE EASTERN BLACK SEA REGION

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Abstract

Turkey contains a great variety of natural habitats, ranging from Mediterranean, Aegean, and Black Sea beaches to towering coastal and interior mountains, from deeply incised valleys to expensive steppes, from fertile alluvial plains to arid, rocky hillslopes. The richness in the diversity of habitats translates into richness in the biodiversity in Turkey. But, because of rapid human population growth (about 2.5% per year) and associated intensive or unwise utilization of natural resources and habitats the biodiversity of Turkey is deteriorating.

Eastern Black Sea Region of Turkey is rich in biodiversity compared to other regions. The east-west oriented, parallel ranges of the Northern Anatolian Mountains run in the southern part of the Eastern Black Sea. Climate change will significantly influence the biodiversity of the region according to future climate scenarios for the region. We used existing literature related to flora and future climate of the region and field observations done in the different times to assess biodiversity in the region. Future climate of the region has been predicted by the Dalfes et al. (2007) using RegCM3 regional climate model.

The region has total of around 2500 plant species and 386 of them are endemic. High mountain areas in Artvin, Rize and Trabzon are the places rich in endemism. Eight of the endemics are in the critically endangered list of IUCN while 55 are in endangered list in the region. The numbers of total species in each city are 1219 for Artvin, 747 for Rize, 894 for Trabzon, 457 for Giresun and 301 for Ordu. Numbers of endemic species in each city are 119 for Artvin, 74 for Rize, 70 for Trabzon, 54 for Giresun and 19 for Ordu.

According to future climate scenarios, the eastern part of the region will get 200-300 mm increases in precipitation, while the western part won't have any increase in precipitation in the next century. The temperatures will increase 2-4 °C in the region in the next century according to RegCM3 regional climate model. Both plant belts and tree line will change under the current climate scenarios for the region. The influence of these changes on diversity in the region will be important and will vary according to site conditions.

Introduction

Human activities have caused and will continue to cause a loss in biodiversity through land-use and land-cover changes; soil and water pollution and degradation (including desertification), and air pollution; diversion of water to intensively managed ecosystems and urban systems; habitat fragmentation; selective exploitation of species; the introduction of non-native species; and stratospheric ozone depletion. The current rate of biodiversity loss is greater than the natural background rate of extinction (Anon., 2002; Green et al., 2003).

Changes in climate exert additional pressure and have already begun to affect biodiversity. The atmospheric concentrations of greenhouse gases have increased since the pre-industrial era due to human activities, primarily the combustion of fossil fuels and land-use and land-cover change. These and natural forces have contributed to changes in the Earth's climate over the 20th century. For the wide range of Intergovernmental Panel on Climate Change (IPCC) emissions scenarios, the Earth's mean surface temperature is projected to warm 1.4 to 5.8°C by the end of the 21st century, with land areas warming more than the oceans, and the high latitudes warming more than the tropics. The associated sea-level rise is projected to be 0.09 to 0.88 m (Anon., 2002).

In general, precipitation is projected to increase in high-latitude and equatorial areas and decrease in the subtropics, with an increase in heavy precipitation events. Climate change is projected to affect individual organisms, populations, species distributions, and ecosystem composition and function both directly (e.g., through increases in temperature and changes in precipitation and in the case of marine and coastal ecosystems also changes in sea level and storm surges) and indirectly (e.g., through climate changing the intensity and frequency of disturbances such as wildfires) (Anon., 2002).

Turkey contains a great variety of natural habitats, ranging from Mediterranean, Aegean, and Black Sea beaches to towering coastal and interior mountains, from deeply incised valleys to expensive steppes, from fertile alluvial plains to arid, rocky hillslopes (Kaya and Raynal, 2001). The components of biodiversity are important to maintain for the welfare and sustainable development of Turkey. Turkey contains the wild relatives of many domesticated plants, which have economic importance for the world, thus forming one of the eight major gene centers on earth (Harlan, 1995). For example, wild progenitors of such cultivated plants as chickpea, wheat, peach, lentil, almond and pistachio are native to Turkey.

Civilizations have exploited the natural resources of Turkey over many millennia. Today, because of rapid human population growth (about 2.5% per year) and associated intensive or unwise utilization of natural resources and habitats the biodiversity of Turkey is deteriorating. Diverse ecological conditions (e.g. great variation in topography and land-forms) are responsible for the growth of more than 9.500 plant species and hundreds of plant communities in Turkey (Ekim et al., 2000).

Eastern Black Sea Region of Turkey is rich in biodiversity compared to other regions. The east-west oriented, parallel ranges of the Northern Anatolian Mountains run in the southern part of the Eastern Black Sea. These coastal mountain ranges are the broadest and the highest in their eastern section, attaining elevations of over 3000 m (the highest peak Kaçkar Mountain is 3937 m). Northern Anatolian mountains form a barrier between the Black Sea and inland part of Central Anatolia. The north-facing slopes of these mountains receive abundant precipitation. For this reason, the broad-leaved deciduous forests and coniferous forests composed of *Fagus orientalis, Picea orientalis, Castanea sativa, Alnus glutinosa* and *Tilia rubra* species are found on the north-facing slopes of the northern Anatolian mountains. But tectonic depressions produce semi-arid climatic conditions due to lee of the mountains. These areas are covered by generally xerophytic plant communities composed of some Mediterranean plant elements.

Global climate change is one of the major challenges that Eastern Black Sea Region will face in this century, as in the other parts of the Turkey and the world. Global change will affect the region's climate, land-use, forest productivity and stability, biodiversity, risks of biotic and abiotic disruptions

Main objective of this paper was to discuss the effects of climate change on biodiversity in the region based on existing literature. We tried to evaluate status of biodiversity in the region under the climate change scenarios.

Current Status of Biodiversity in the Region

The region is very rich in biodiversity. There are around 2500 plant species in the region and 386 of them are endemic. High mountain areas in Artvin, Rize and Trabzon are the places rich in endemism. Eight of the endemics are in critically endangered list of IUCN while 55 are in endangered list in the region. Most of the critically endangered and endangered species were found in grasslands and forest openings. The distribution of total

Table 1 The distribution of total numbers of plant species and endemics according to major cities in the Eastern Black Sea Region.

	Artvin	Rize	Trabzon	Giresun	Ordu
Total number of species	1219	747	894	457	301
Number of endemics	119	74	70	54	19

numbers of plant species and endemics are shown in Table 1. The region is one of the 200 ecologically important areas in the world. Four of the important plant areas reside in the region. An important bird migrating route passes through the region. Distribution of threatened species according to cities are listed below (Ekim et al., 2000) (CR: critically endangered; EN: endangered; DD: data deficient):

1. **Artvin:** *Anthemis calcarea* var. *calcarea* (CR), *Centaurea leptophylla* (CR), *Hypericum fissurale* (CR), *Lathyrus woronowii* (CR), *Onosma circinnatum* (EN), *Symphytum savvalense* (EN), *Campanula choruhensis* (EN), *Campanula troegerae* (EN), *Silene scythicina* (EN), *Rhodothamnus sessilifolius* (EN), *Helichrysum artvinense* (EN), *Hieracium diaphanoidiceps* (EN), *Hieracum foliosissimum* (EN), *Hieracium radiatellum* (EN), *Clypeola raddeana* (EN), *Hypericum marginatum* (EN), *Crocus biflorus* subsp. *artvinensis* (EN), *Crocus biflorus* subsp. *fibroannulatus* (EN), *Stachys choruhensis* (EN), *Lilium carniolicum* subsp. *ponticum* var. *artvinense* (EN), *Ornithogalum byzantinum* var. *proliferum* (EN), *Orobanche armena* (EN), *Heracleum sphondylium* subsp. *artvinense* (EN), *Hieracum artvinense* (DD), *Hieracium cinereostriatum* (DD), *Hieracium debilescens* (DD), *Hieracium floccicomatum* (DD), *Hieracium subartvinense* (DD), *Hieracium subhastulatum* (DD), *Hieracium virosiforme* (DD), *Astragalus imbricatus* (DD), *Allium koenigianum* (DD), *Gagea tenuissima* (DD), *Verbascum artvinense* (DD), *Ferulago latiloba* (DD),

2. **Rize:** *Campanula latiloba* subsp. *rizeensis* (EN), *Silene scythicina* (EN), *Senecio ovatifolius* (EN), *Blysmus compressus* subsp. *subulifolia* (EN), *Onobrychis lasistanica* (EN), *Geranium davisianum* (EN), *Sorbus caucasica* var *yaltirikii* (EN), *Alchemilla ancerensis* (EN), *Alchemilla cimilensis* (EN), *Alchemilla ciminensis* (EN), *Alchemilla hemsinica* (EN), *Alchemilla ikizdereensis* (EN), *Alchemilla kackarensis* (EN), *Salix rizeensis* (EN), *Angelica sylvestris* var. *stenoptera* (EN), *Symphyandra lazica* (DD), *Hieracium amblylepis* (DD), *Festuca paphlagonica* subsp. *villosula* (DD), *Ranunculus dissectus* subsp. *rigidulus* (DD), *Ornithogalum balansae* (DD),

3. **Gümüşhane**: *Paracaryum erysimifolium* (EN), *Paracaryum leptophyllum* (EN), *Barbarea integrifolia* (EN), *Aethionema sintenisii* (EN), *Hesperis stellata* (EN), *Thlaspi sintenisii* (EN), *Vicia quadrijuga* (EN), *Elymus longearistatus* subsp. *sintenisii* (EN), *Erodium hendrikii* (EN), *Arenaria scariosa* (EN), *Onosma obtusifolium* (EN), *Galanthus koenianus* (EN), *Centaurea rhizocalathium* (DD), *Echinops sintenisii* (DD*), Hieracium mannagattae* (DD), *Hieracium subrosulatum* (DD), *Taraxacum bassarabicum* subsp. *gumusanicum* (DD),

4. **Trabzon**: *Symphytum sylvaticum* subsp. *sepulcrale* var. *hordorkopii* (EN), *Symphytum sylvaticum* subsp. *sylvaticum* (EN), *Sempervivum furseorum* (EN), *Erysimum deflexum* (EN), *Rhododdendron ponticum* subsp. *ponticum* var. *heterophyllum* (EN), *Erodium absinthoides* subsp. *latifolium* (EN), *Festuca pontica* (EN), *Astragalus arakliensis* (EN), *Alchemilla trabzonica* (EN), *Salix rizeensis* (EN), *Salix trabzonica* (EN), *Verbascum varians* var. *trapezunticum* (EN), *Zelkova carpinifolia* subsp. *yomraensis* (EN), *Angelica sylvestris* var. *stenoptera* (EN), *Elymus longearistatus* subsp. s*intenisii* (EN),

5. **Giresun:** *Micromeria fruticosa* subsp. *giresunica* (CR), *Doronicum tobeyi* (CR), *Hieracium tamderense* (EN), *Hieracium giresunense* (EN)

Climate change scenarios for the region

Analyzing the meteorological data belong to stations located in the Eastern Black Sea Region from 1951 to 2004, Dalfes et al. (2007) observed increases in winter and spring precipitations in Artvin, decrease in spring precipitation in Trabzon and decrease in mean annual temperature in Artvin. In the same report, future climate of the region has been predicted using RegCM3 regional climate model.
According to RegCM3 regional climate model, the temperatures will increase 2-4 °C in the region in the next century. Future climate scenarios predict 200-300 mm increases in precipitation in the eastern part of the region while the western part won't have any increase in precipitation in the next century.

Influence of climate change on biodiversity in the region

Climate change will influence distribution, structure, stability and diversity of plant ecosystems in the region. With the influence of predicted changes, it is possible to observe 400-800 m upward shifts in the plant belts in the western part of the region and upward movement of treeline in the eastern part. The upward shift in the treeline will threaten the biodiversity of the alpine grassland areas. An important portion of these areas will be covered by spruce or pine forests. Sub-alpine forest areas don't support plant species as many as alpine grasslands support. According to Tüfekçioğlu et al. (2004), alpine grasslands support 550 plant species, while spruce forests support around 100 plant species.
Temperature increases in the region will put more stress on spruce trees and will probably increase the bark beetle attacks. Around 100 000 spruce trees have been killed by the bark beetle attacks in Hatilla National Park, Artvin (Tüfekçioğlu et al., 2005, 2008). This will influence the diversity of these forests. Insect-attacks regulated secondary succession will be more common in spruce ecosystems.
Fire could become an important threat in the western and inner parts of the region with the predicted climate change. Currently, fire is not a problem in oriental spruce ecosystems. Spruce ecosystems in our country have a humid climate in summer season. Therefore, it is unusual to see fire in them. However, fire is an important factor in maintaining structure, diversity and health of boreal spruce ecosystems. Influence of fire on biodiversity of the region will possibly be positive up to a certain level. It will be possible to see fire-induced secondary succession taken place in the western part of the region.
Replacement of some spruce and beech forests with the pine forests will increase species diversity in the region. Because spruce and beech are shade tolerant species, while pine is a shade intolerant species. Stands of shade intolerant species have more plant species in understory compared to shade tolerant stands.

Conclusions

Climate change will significantly influence distribution, diversity, structure and stability of the ecosystems in the Eastern Black Sea Region. According to RegCM3 regional climate model, the temperatures will increase 2-4 °C in the region in the next century. Future climate scenarios predict 200-300 mm increases in precipitation in the eastern part of the region while the western part won't have any increase in precipitation in the next century. The following measures need to be taken to protect the biodiversity and human health in the region in the future:

- Flooding and land-sliding events will possibly increase in the region. Emergency management center need to be established to help and warn people
- Forest fires will increase in the western part of the region. Fire observation towers and fire fighters teams need to be established in these areas.
- Biodiversity in high mountain areas will decrease due to upward movement of treeline and effects of heavy grazing. Establishing small gaps in these newly forested areas will help to save biodiversity.
- Biodiversity in lowland areas will increase due to decrease in tea garden areas.
- Spruce forests in the western part will mainly be replaced by the beech forests.
- Habitats of mountain grouse and goat will decrease significantly; threatening survival of these threatened species.
- Spruce bark beetle attack will kill more spruce trees and will be a serious problem for the spruce ecosystems. Appropriate measures need to be taken to prevent bark beetle outbreaks in the region.

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