

Global Climate Change and Biodiversity: Issues and Future Research

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Editorial

Biological diversity, commonly referred to as biodiversity, is a measure of variation of life forms within a given species, ecosystem, biome, or planet [1-3]. Biodiversity includes diversity within species (genetic diversity), between species (species diversity) and of ecosystems [4]. Biodiversity plays an important role in maintaining ecosystem productivity, stability, sustainability and other ecosystem services that are essential for human well-being [5-8]. Loss of biodiversity has become a serious issue in many places around the world. Many factors, such as habitat loss and degradation, excessive nutrient load, air and water pollution, over-exploitation and unsustainable use of natural resources, and invasive species, contribute to the loss of biodiversity [6,8]. However, global climate change is often considered as one of the major factors causing biodiversity loss [6,7,9].

Global climate change is occurring at an unprecedented rate today mainly due to an increased emission of greenhouse gases such as atmospheric CO₂ [10]. Global temperatures have increased by about 0.6-0.76°C since the mid-1800s and are predicted to further increase by 1.4°C to 5.8°C by 2100 [10]. Global mean sea level has risen by 12 to 22 cm during the last century. During the next century, precipitation is also anticipated to increase by about 0.5-1% per decade for most middle- and high-latitude land areas in the northern hemisphere, causing more frequent flooding and droughts [10-12]. Since climate is the fundamental factor that determines organism life-stages such as plant germination and flowering, it can severely alter habitats and food sources for animals, and ultimately, could have significant impacts on biodiversity of species and ecosystems around the world.

Global Climate Change affects our physical and biological environments, thus, it influences biodiversity both directly and indirectly through its interaction with other environmental factors [8,13]. Living organisms and ecosystems need to adapt to climate change through shifting habitats, changing life cycles, or developing new physical traits [7,8,11,14-16]. Documented effects of climate change on biodiversity and ecosystems mainly include: 1) species extinction and biodiversity loss. Climate change has led to a sharp increase in the rate of species extinction [6,11,13,17]. The Millennium Ecosystem Assessment (2005) highlighted a substantial loss of biodiversity on Earth, with some 10-30% of mammal, bird and amphibian species threatened with extinction [18]. 2) Phenology changes. Changes in phenology (i.e. time of natural events such as reproduction in certain species or the length of growing season) have been documented in many species including both plants and animals [11,13,16,19]. For example, higher temperatures have led to earlier flowering in certain plant species [20] and an increase in the number of eggs laid by the spruce budworm [21]. 3) Shifts in geographic range. Climate change forces organisms to respond by adapting or migrating, and results in geographic range changes for species [6,8]. As an example, the northern boundaries moved further north for some plants and animals as temperature increased [14]. 4) Ecosystem functioning and service changes. Ecosystem production and stability are closely linked to biodiversity. Loss of biodiversity due to climate and land use change may lead to increased greenhouse gas emissions, further exacerbating climate change [5,8]. In contrast,

increases in biodiversity could enhance ecosystem productivity and carbon sequestration, and may reduce the negative effects of climate change.

Substantial advances have been made in the past decades in our understanding of climate change effects on biodiversity. However, we still face many research challenges today [6-8]. More research is needed to improve our understanding of the effects of climate change on biodiversity and ecosystem functioning, particularly in the following three aspects: 1) To accurately describe the biodiversity change/trend and facilitate the comparison among different ecosystems and at different temporal scales, adequate biodiversity indicators and advanced analytic methods should be developed [22,23]. As changes in temperature and precipitation differ among different places, the effects of climate change on biodiversity may vary spatially and temporally. Since policy makers and resource managers are more interested in biodiversity at regional or national scales, these indicators should be able to scale up from a local to a regional and finally, a global scale [22]. A measure of the uncertainty in the estimates and ecological modeling should also be defined [23-25]. 2) To better understand climate change effects on biodiversity, observational networks ranging from local to international levels should continue to reinforce data collection on the range shifts of species and changes in ecosystem status [6,25-27]. Efforts should also be made to develop vulnerability assessments, identify flagship or keystone species, and evaluate the distribution and impacts of invasive species under climate change. Meta-data including climatic factors, land use change, fire etc should be recorded so both the direct and indirect effects of climate change on biodiversity could be investigated. 3) To predict the future impacts of climate change on biodiversity, integrating measured data with ecological models is an important and common approach [9,28-30]. At least two types of models have been widely used to simulate species distribution changes: bioclimatic envelope models and the more advanced dynamic or process-based models [31-33]. Since the dynamic models typically take factors such as life-history traits of species and processes such as dispersal and migration into account, they may provide better forecasts of species distribution changes under climate change. But most modeling studies on species distribution changes are only based on isothermal shifts and focused on a selected number of species [13]. Thus, improving data quality and reducing model uncertainty are also very important [6,23].

Overall, climate change has significantly changed biodiversity and will further increase species and ecosystem biodiversity loss. Due to the complexity of the problem at both spatial and temporal scales, it is a

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difficult task to accurately and reliably estimate and predict the impacts of climate change on biodiversity [6,8]. Further research on critical issues may improve our understanding of the effects of climate change and mitigate its influence on biodiversity [6-8,29,30].

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