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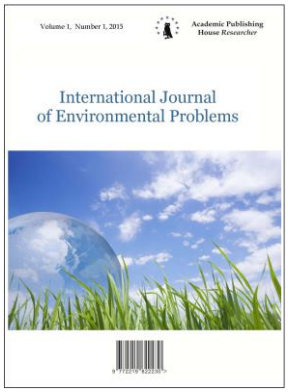

Global Warming Impact on Ecosystems

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Abstract

Climate is an important environmental influence on ecosystems. The impact of climate change on a particular species can ripple through a food web and affect a wide range of other organisms. Climate change and shifts in ecological conditions could support the spread of pathogens, parasites, and diseases, with potentially serious effects on human health, agriculture. Climate change, along with habitat destruction and pollution, is one of the important stressors that can contribute to species extinction. For many species, the climate where they live or spend part of the year influences key stages of their annual life cycle, such as migration, blooming, and reproduction. Boreal forests are invading tundra, reducing habitat for the many unique species that depend on the tundra ecosystem. It has been established that the most vulnerable system is the Black Sea coastline, which has a strategic importance for the rehabilitation of the country's economy and development of foreign trade.

Keywords: global warming, ecosystems, climate resources, population, habitat, food.

1. Introduction

Climate change affects the living world, including people, through changes in ecosystems, biodiversity, and ecosystem services. Ecosystems entail all the living things in a particular area as well as the non-living things with which they interact, such as air, soil, water, and sunlight. Biodiversity refers to the variety of life, including the number of species, life forms, genetic types, and habitats and biomes (which are characteristic groupings of plant and animal species found in a particular climate). Biodiversity and ecosystems produce a rich array of benefits that people depend on, including fisheries, drinking water, fertile soils for growing crops, climate regulation, inspiration, and aesthetic and cultural values. These benefits are called "ecosystem services" – some of which, like food, are more easily quantified than others, such as climate regulation or cultural values. Changes in many such services are often not obvious to those who depend on them.

2. Materials and methods

The study used materials from the meteorological database of the Institute of Hydrometeorology of the Georgian Technical University and published data (Berdzenishvili, 2012, 2018, 2020). Cartographic and statistical methods for processing observations were used.

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3. Discussion and results

Ecosystem services contribute to jobs, economic growth, health, and human well-being. Although we interact with ecosystems and ecosystem services every day, their linkage to climate change can be elusive because they are influenced by so many additional entangled factors. Ecosystem perturbations driven by climate change have direct human impacts, including reduced water supply and quality, the loss of iconic species and landscapes, distorted rhythms of nature, and the potential for extreme events to overwhelm the regulating services of ecosystems. Even with these well-documented ecosystem impacts, it is often difficult to quantify human vulnerability that results from shifts in ecosystem processes and services. For example, although it is more straightforward to predict how precipitation will change water flow, it is much harder to pinpoint which farms, cities, and habitats will be at risk of running out of water, and even more difficult to say how people will be affected by the loss of a favorite fishing spot or a wildflower that no longer blooms in the region. A better understanding of how a range of ecosystem responses affects people – from altered water flows to the loss of wildflowers – will help to inform the management of ecosystems in a way that promotes resilience to climate change.

The impact of climate change on a particular species can ripple through a food web and affect a wide range of other organisms. For example, the figure below shows the complex nature of the food web for polar bears. Not only is the decline of sea ice impairing polar bear populations by reducing the extent of their primary habitat, it is also negatively impacting them via food web effects. Declines in the duration and extent of sea ice in the Arctic leads to declines in the abundance of ice algae, which thrive in nutrient-rich pockets in the ice. These algae are eaten by zooplankton, which are in turn eaten by Arctic cod, an important food source for many marine mammals, including seals. Seals are eaten by polar bears. Hence, declines in ice algae can contribute to declines in polar bear populations (CCSP, 2008).

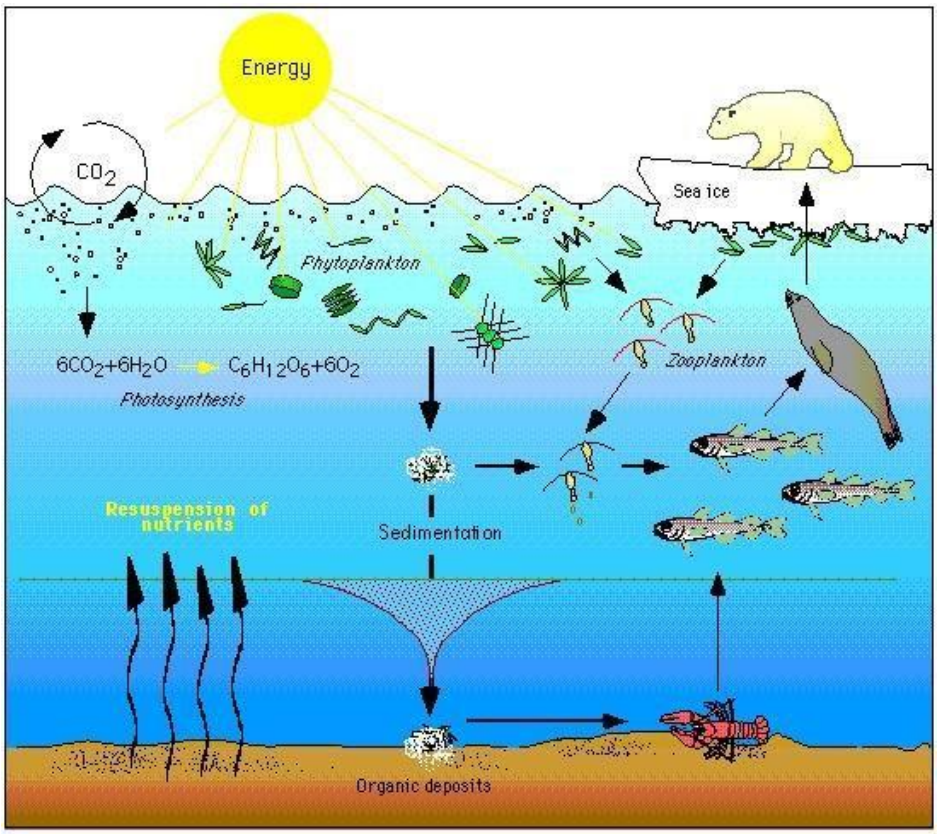

Fig. 1. The Arctic food web is complex. The loss of sea ice can ultimately affect the entire food web, from algae and plankton to fish to mammals. Source: NOAA (2011)

Climate change and shifts in ecological conditions could support the spread of pathogens, parasites, and diseases, with potentially serious effects on human health, agriculture, and fisheries.

For example, the oyster parasite, Perkinsus marinus, is capable of causing large oyster die-offs. This parasite has extended its range northward from Chesapeake Bay to Maine, a 310-mile expansion tied to above-average winter temperatures. For more information about climate change impacts on agriculture, visit the Health Impacts page.

Climate is an important environmental influence on ecosystems. Changing climate affects ecosystems in a variety of ways. For instance, warming may force species to migrate to higher latitudes or higher elevations where temperatures are more conducive to their survival. Similarly, as sea level rises, saltwater intrusion into a freshwater system may force some key species to relocate or die, thus removing predators or prey that are critical in the existing food chain.

Climate change not only affects ecosystems and species directly, it also interacts with other human stressors such as development. Although some stressors cause only minor impacts when acting alone, their cumulative impact may lead to dramatic ecological changes (Settele et al., 2014). For instance, climate change may exacerbate the stress that land development places on fragile coastal areas. Additionally, recently logged forested areas may become vulnerable to erosion if climate change leads to increases in heavy rain storms.

For many species, the climate where they live or spend part of the year influences key stages of their annual life cycle, such as migration, blooming, and reproduction. As winters have become shorter and milder, the timing of these events has changed in some parts of the country:

1. Earlier springs have led to earlier nesting for 28 migratory bird species on the East Coast of the United States (Settele et al., 2014);
2. Northeastern birds that winter in the southern United States are returning north in the spring 13 days earlier than they did in a century ago (CCSP, 2008);
3. In a California study, 16 out of 23 butterfly species shifted their migration timing and arrived earlier (CCSP, 2008);
4. Because species differ in their ability to adjust, asynchronies can develop, increasing species and ecosystem vulnerability. These asynchronies can include mismatches in the timing of migration, breeding, pest avoidance, and food availability. Growth and survival are reduced when migrants arrive at a location before or after food sources are present (CCSP, 2008; Horton et al., 2014).

As temperatures increase, the habitat ranges of many North American species are moving north and to higher elevations. In recent decades, in both land and aquatic environments, plants and animals have moved to higher elevations at a median rate of 36 feet (0.011 kilometers) per decade, and to higher latitudes at a median rate of 10.5 miles (16.9 kilometers) per decade. While this means a range expansion for some species, for others it means movement into less hospitable habitat, increased competition, or range reduction, with some species having nowhere to go because they are already at the top of a mountain or at the northern limit of land suitable for their habitat (Groffman et al., 2014; USGCRP, 2009).These factors lead to local extinctions of both plants and animals in some areas. As a result, the ranges of vegetative biomes are projected to change across 5-20 % of the land in the United States by 2100 (Groffman et al., 2014).

For example, boreal forests are invading tundra, reducing habitat for the many unique species that depend on the tundra ecosystem, such as caribou, arctic foxes, and snowy owls. Other observed changes in the United States include a shift in the temperate broadleaf/conifer forest boundary in the Green Mountains of Vermont; a shift in the shrubland/conifer forest boundary in New Mexico; and an upward elevation shift of the temperate mixed/conifer forest boundary in Southern California.

As rivers and streams warm, warm water fish are expanding into areas previously inhabited by cold water species (USGCRP, 2009). As waters warm, coldwater fish, including many highly-valued trout and salmon species, are losing their habitat, with projections of 47 % habitat loss by 2080 (Groffman et al., 2014). In certain regions in the western United States, losses of western trout populations may exceed 60 percent, while in other regions, losses of bull trout may reach about 90 percent (USGCRP, 2009). Range shifts disturb the current state of the ecosystem and can limit opportunities for fishing and hunting. See the Agriculture and Food Supply Impacts page for information about how habitats of marine species have shifted northward as waters have warmed.

Climate change, along with habitat destruction and pollution, is one of the important stressors that can contribute to species extinction. The IPCC estimates that 20-30 % of the plant and animal species evaluated so far in climate change studies are at risk of extinction if

temperatures reach the levels projected to occur by the end of this century (Settele et al., 2014). Global rates of species extinctions are likely to approach or exceed the upper limit of observed natural rates of extinction in the fossil record (Settele et al., 2014). Examples of species that are particularly climate sensitive and could be at risk of significant losses include animals that are adapted to mountain environments, such as the pika; animals that are dependent on sea ice habitats, such as ringed seals and polar bears; and coldwater fish, such as salmon in the Pacific Northwest (Groffman et al., 2014; USGCRP, 2009).

As a result of activities, conducted within the first National Communication, the systems most vulnerable to climate change in Georgia have been identified. It has been established that the most vulnerable system is the Black Sea coastline, which has a strategic importance for the rehabilitation of the country's economy and development of foreign trade. The second important vulnerable system in Georgia is agriculture, where special attention is paid to wheat in Eastern Georgia. Also, in spite of a sufficient supply of water resources, appropriate attention is being paid increase the efficiency of water utilization.

Georgia occupies the southeastern part of Europe, to the South of the watershed of Great Caucasian Range, in Transcaucasia, lying between the Black and Caspian Seas. Total area of the country is 69,700 km 2, 46 % of which is located at the altitude of 0-1000 m a.s.l. The Likhi Range, crossing the country almost meridionally in the middle of territory, divides the country into 2 different regions that is reflected mainly in the climate.

Western Georgia is rich in rivers, the biggest of which are Rioni and Enguri. The biggest river in Eastern Georgia is Mtkvari with its several confluents flowing down from the Great Caucasus. There are tens of lakes in Georgia. The biggest of them is Paravani with the area of its water plane of 37.5 km 2. Over 20 regulating water reservoirs are constructed on a number of rivers. Swamps occupy approximately 600 km 2 of the country's territory, and glaciers occupy the area of 511 km 2.

3. Conclusion

Almost all types of climate are presented over Georgian territory except savanna and tropical forests. The Black Sea coastal zone has humid subtropical climate. Mean annual temperature here is 14-15 0C and annual precipitation sums range from 1500 to 2500 mm. On the Plains of Eastern Georgia the climate is dry-subtropical with average annual temperatures in the range of 11-13 0 C and annual precipitation sums between 400-600 mm. In mountainous areas this value reaches 800-1200 mm.

In the cold period of the year stable snow cover does not form in both regions of Georgia up to the altitude of 400 m a.s.l. Duration of bright sunshine over the most part of the country's territory ranges from 1900 to 2200 hours. Warming period with 10 0C threshold value on the plains comprises 120-160 days, while in a mountainous zone it reaches 220-320 days.

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