DESERT ECOSYSTEMS AND GLOBAL CLIMATE CHANGE

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Summary

Deserts occupy one third of the world’s land surface and occur in every continent including Antarctica. World’s large deserts are concentrated in a zone about 15 ^{o}N and S latitude to about 30 ^{o}N and S along the western coasts of continents, and expanding much further into the heart of the continents. This chapter provides an overview of ecosystems in desert environments and their potential response to global climate changes. Drought and extremely hot summer temperature of desert areas represent the ultimate natural challenges for life in desert ecosystems. Many desert plants have remarkable ways to survive drought. Their ways of adaptation include variations in anatomical forms and changes in life style. Many cacti and other stem-succulent plants of hot deserts grow columnar, with leafless, vertically-erect, green trunks that maximize light interception during the early and late hours of the day, but minimize the midday sunlight. The ephemeral life-cycle is one of the most effective drought-survival adaptations for many species in desert ecosystems. Animals are able to adapt to the arid climate in desert ecosystems through three forms of adaptations, i.e. behavioral, morphological and anatomical, and physiological adaptations. Behavioral adaptation refers to the changing of activity to evade difficult times. As the desert ecosystem is a product of dry climate, it is extremely sensitive to global climate changes. Geological and sedimentological evidences show that the climate experienced clear fluctuations in many deserts even during the Quaternary, the latest period in Earth’s history. There were large wetlands in many deserts such as Sahara of northern Africa and Badain Jaran of western Inner Mongolia in China during the middle Holocene. The twenty-first century global warming would make the survival and development of desert flora and fauna as well as pastoral and agricultural activities more difficult.

1. Introduction

Desert ecosystems are characterized by a severe shortage of moisture, lack of perennial and integrated system of drainage, covering about one third of the world’s land surface and occurring in every continent including Antarctica and in various landforms. Consequently, the desert biomes are distributed in a very wide range of temperatures, from the very hot areas such as Sahara to the very cold regions like Antarctica. The shortage of moisture arises predominantly from small amount of precipitation and partly from high temperatures. Desert ecosystems can be divided into integrated subsystems according to aridity index (AI) that is the ratio of potential annual evapotranspiration to its average annual precipitation.

$AI = P/PET$, where P is annual precipitation and PET is potential annual evapotranspiration. Based on this formula, desert ecosystems can be classified into subsystems, like

Hyper-arid, where $AI \le 0.05$
Arid, where $0.05 \le AI \le 0.20$
Semi-arid, where $0.2 \le AI \le 0.5$
Dry-sub-humid, where $0.5 \le AI \le 0.65$

For statistics, it is often put hyper-arid to the subsystem of arid zones. Table 1 shows the distribution of arid (including hyper-arid) and semi-arid areas in the main continents.

continent	arid area	semi-arid area	sum
Asia	8.96	7.516	16.476
Europe	0.171	0.844	1.015
Africa	11.862	6.081	17.943
Australia	3.864	2.517	6.381
North America	1.31	2.657	3.967
South America	1.388	1.626	3.014
sum	**27.555**	**21.241**	**48.796**

Table 1. Arid (including hyper-arid) and semi-arid area of the world ($km^2 \times 10^6$)

World's large deserts are concentrated in a zone about 15 ^oN and S latitude to about 30 ^oN and S along the western coasts of continents, and expanding much farther into the heart of the continents. The main reason for the formation of desert ecosystems in the low latitudes is air subsidence in the subtropical high pressure systems. Cold currents off coasts cause coast deserts, reinforcing the effect of the subtropical anticyclones in reducing rainfall along the west coasts in the subtropical zone. The deserts in the heart of landmasses are linked to the remoteness from the oceanic moisture supply or/and the blockage of moisture pathway by high mountains and plateaus. Located in the interior of the largest continent, Eurasia, the dry lands in China and Mongolia are distributed in a wide range of geomorphological and tectonic settings, from 155 m below sea level to altitudes of more than 5000 m above sea level. One associates deserts often with sand seas, but the land surface in arid regions is covered to a larger degree by bare exposures of regoliths, alluviums and bedrocks. For example, active sand seas cover between 15 and 30 percent of the arid areas in the Sahara, Arabian Peninsula, Australia and Southern Africa. Active and stable dunes occupy as much as 45% of deserts in China.

By contrast, aeolian sand covers only less than one percent of the arid zone in the Americas.

Various studies have demonstrated that semiarid desert fringes were the basis of some of the world's oldest civilizations. For instance, the fertile crescent between Rivers Tigris and Euphrates, is the original area of domestication of wheat and barley. Early agricultural development also took place extensively in the fertile oases in the Taklamakan Desert of western China and in the Loess Plateau of Central China.

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Biographical Sketches

Xiaoping YANG studied geography in the 1980s in Xian, Nanjing and Lanzhou of China and received his doctoral degree in physical geography, environmental geology and bio-climatology from Goettingen University, Germany, in 1992. He is now a full professor at the Institute of Geology and Geophysics, Chinese Academy of Sciences (CAS). His main research interests: dryland environments, specifically arid geomorphology and paleoclimatology during the Late Quaternary; global change and contemporary environmental issues such as desertification, particularly in Inner Mongolia and Xinjiang of China. He has published about 80 papers in international and Chinese journals and in abstract volumes of scientific conferences, and has been guest editor for dryland special issues of international journals as well as co-author for a Chinese university textbook 'Physical Geography'. He was awarded the Prize for Young Scientists in 2002 by Chinese Quaternary Association, and COMLAND AWARD in 2007 by the International Geographical Union's Commission on Land Degradation and Desertification (COMLAND). He is also in the editorial teams for several internationally recognized journals such as *Quaternary Science Reviews, Quaternary Research, Catena, Geographical Research, Progress in Physical Geography, Quaternary International, Geo-Oeko, Quaternary Sciences* (in Chinese).

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