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Desertification

Contributed by Jianguo Wu

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Dr. Jianguo Wu

Department of Life Sciences, Arizona State University West

P. O. Box 37100, Phoenix, AZ 85069-7100, USA

Phone: (602) 543-6131 Fax: (602) 543-6073

E-mail: jingle@asu.edu

<http://www.west.asu.edu/jing>

DESERTIFICATION

Human survival and prosperity are dependent ultimately on the productivity of the lands on which populations reside. However, in many parts of the world previously productive lands have become less fertile or completely sterile, failing to meet the basic needs of local populations. Desertification has widely been recognized as one of the several major global environmental problems since the 1970s. According to the United Nations Environmental Programme (UNEP, 1992), drylands that are susceptible to desertification account for more than one-third of the world land area (Table 1) and support more than 20 percent of the global human population. As the rapid growth of the human population continues, demands for resources from these fragile environments increase as well. Therefore, understanding the scope, causes and mechanisms of desertification and developing sound and effective management and mitigation plans are extremely important for maintaining the ecological, socioeconomic, and political stability of both the dryland areas and the entire world.

Definition of Desertification

The term *desertification* was first used by two French ecologists: L. Lavauden in 1927 and A. Aubreville in 1949, who then eye-witnessed the land degradation occurring in North and West Africa (Dregne, 1996). Since then, more than one hundred definitions have appeared in the English literature. Desertification sometimes has been used interchangeably with *desertization* which refers to desert encroachment into previously non-desert areas driven by human activities (Thomas, 1995, 1997; Zha and Gao, 1997). A widely used definition for desertification is land degradation in arid, semi-arid and dry sub-humid regions due to human activities and climate variations, which may lead to the permanent loss of land productivity. This definition was accepted at the United Nations Conference on Desertification in 1977, and later adopted by the Earth Summit, the United Nations Conference on Environment and Development (UNCED, Agenda 21) in 1992 and the Intergovernmental Convention to Combat Desertification in 1994.

Desertification may be viewed as the worst form of *land degradation* which refers to the general process of declining soil fertility, impairing ecosystem structure and function, decreasing biodiversity, and diminishing economic viability. After an ecosystem is severely *desertified*, its full recovery may not be achieved even during relatively moist conditions without intensive rehabilitation efforts. Natural deserts, without human disturbances, are healthy and relatively sta-

ble ecosystems that support a variety of, sometimes spectacular, life forms (e.g., the saguaro in the Sonoran desert). The simplistic view that desertification is a process that transforms non-desert lands into “desert-like” lands may thus be too superficial and misleading. Also, deserts do emerge independent of human activities, and the term *aridization* refers to this natural development of deserts through evolution of drier climates (West, 1995), which takes place much more slowly than desertification.

Table 1. The distribution of the world drylands (data from UNEP, 1992; Adapted from Le Houérou, 1996).

Bioclimatic zones	Extent (10 ³ km ²)	% World land area	P/PET ratio*
Dry-subhumid land	12947	9.9	0.45 – 0.65
Semiarid land	23053	17.7	0.20 – 0.45
Arid land	15692	12.1	0.05 – 0.20
Total drylands susceptible to desertification	51692	39.7	
Hyperarid land (Extremely harsh environment and thus not susceptible to de- sertification)	9781	7.5	< 0.05
Total dryland area of the world	61473	47.2	

* P is the mean annual precipitation, and PET is the mean annual potential evapotranspiration which is a combined term for water lost as vapor from soil surface (evaporation) and from the surface of plants mainly via stomata (transpiration). P/PET ratio is also called aridity index (I) and often used to classify bioclimatic zones. Smaller values of the ratio correspond to drier areas.

Causes and processes of Desertification

Human abuses of the land (e.g., overcultivation, overgrazing, urbanization) are the primary causes for desertification (Table 2), whereas adverse climate variations (e.g., droughts) may accelerate or trigger the process. By drastically reducing or destroying vegetation cover and soil fertility, human activities can result in desertification without drought, but not vice versa (Le Houérou, 1996). For example, overgrazing reduces both productivity and biodiversity of grasslands and can lead to a grassland-to-shrubland transition. Overcultivation completely destroys natural vegetation and can eventually exhaust soil resources. In both cases, human activities can transform drylands into unproductive “wastelands” through the processes of soil erosion (by wind and water), salinization, and alkalinization.

Desertification often is a result of the interactions between human and climate factors. Since human actions are tied to many social, economic, political, and environmental processes, the relative importance of major causes for desertification varies from one region to another. For example, the most dominant cause for desertification is overcultivation in China, but overgrazing in North Africa and Near East (Table 2). Besides droughts, global climate change may also affect desertification. Studies have suggested that global warming may reduce soil moisture over large areas of semiarid grasslands and thus increase the extent of desertified lands in North America and Asia (Schlesinger et al., 1990). However, the possible effects of climate change on desertification seem much smaller than the impact of land use activities by humans (Le Houerou, 1996).

Table 2. Causes of desertification in different regions of the world (from Le Houérou, 1996). The numbers are in percent of the total desertified area in the corresponding region.

Regions or Countries	Over-cultivation	Over-stocking	Fuelwood collection	Salinization	Urbanization	Other
NW China	45	16	18	2	3	14
N. Africa and Near East	50	26	21	2	1	-
Sahel and East Africa	25	65	10	-	-	-
Middle Asia	10	62	-	9	10	9
U. S. A.	22	73	-	5	No data	-
Australia	20	75	-	2	1	-

Extent and severity of Desertification

Dry-subhumid, semiarid, arid, and hyperarid areas together form the world *drylands*, covering as much as 47 percent of the total land area (Table 1). Dry forest, grassland, and shrubland ecosystems are found in drylands except the hyperarid land (the “true desert”), which experiences extreme dry conditions and usually seems lifeless (e.g., central Sahara and Namib desert of Africa, the Hizad on the Arabian Peninsula, the Takla Makan and Turfan depressions in Central Asia, Death Valley in U.S.A.). Desertification occurs primarily in all drylands except hyperarid lands because climatic and ecological conditions make them more susceptible to land degradation than more humid regions. It is hard for hyperarid lands to become more “desert-

like”, and thus they are usually excluded from the consideration of desertification (Dregne, 1992; Thomas, 1995).

Table 3. Extent and severity of desertification in different regions of the world (from Thomas, 1995).

Region	Total dryland area (10^3 km^2)	Desertified area (10^3 km^2)		
		Light and moderate	Strong and extreme	Total area of desertified land
Asia	16718	3267	437	3704
Africa	12860	2453	740	3193
Europe	2997	946	49	995
Australasia	6633	860	16	876
North America	7324	722	71	793
South America	5160	728	63	791
Total	51692	8976	1376	10352

Desertification has been occurring at an astonishing rate over six continents. Most of the desertified lands are found in Asia and Africa, while the problem also has become significant in Europe, Australasia, North America, and South America (Table 3). Approximately 25 percent of the irrigated land (3% of the drylands), 50 percent of the rainfed cropland (9% of the drylands), and 75 percent of the rangeland (88% of the drylands) have been desertified at different degrees (Dregne, 1992). Although the accuracy of estimating the exact extent and rate of desertification needs to be improved with the aid of advanced technologies such as satellite remote sensing and geographic information systems (computer systems for storing, retrieving, and manipulating spatial or geographic data), there is little doubt that extensive areas of the world drylands have increasingly experienced some form of chronic land degradation since the early 1900s (Binns, 1990; Dregne, 1996).

Desertification has affected more than one hundred countries and resulted in profound ecological, social, and economic consequences throughout the world (Dregne, 1992; Cardy, 1993). Combating desertification is an urgent and grand challenge facing humanity today. Global efforts and local solutions are both needed. Preventive and rehabilitation measures must be undertaken simultaneously based on scientific findings and socioeconomic considerations.

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Dr. Jianguo Wu

**Department of Life Sciences, Arizona State University West
P.O. Box 37100, Phoenix, AZ 85609, USA**