some very major dust storms indeed. In 1901 a dust storm carried approximately 165 million tons (150 million metric tons) of dust from the Sahara in Africa to western Europe and the Ural Mountains. In 1928 a dust storm removed an estimated 16.5 million tons (15 million metric tons) of soil from Ukraine and deposited it in Romania and Poland. The dust storms that occurred in the midwestern United States during the 1930s are legendary. Over 2.5 million acres (1 million hectares) of agricultural land were severaly damaged by the resulting loss of topsoil.

Floods

A *flood*, quite simply, is a high flow of water that overruns its normal confinements area and covers land that is usually dry. Natural floods are a normal part of the physical environment, but because they often seem ''unusual'' from a human perspective—occurring irregularly over periods of decades, centuries, or millennia —they may take us by surprise. Cumulatively, floods are among the most destructive of all natural hazards. In China flooding along the Yangtze and Yellow Rivers has taken the lives of millions of people over the last century and a half (many were drowned or died of flood-associated diseases or flood-caused starvation when crops were destroyed); in India floods have caused billions of rupees worth of damage and killed hundreds of people. The human losses due to floods are greatly exacerbated by the fact that riverfront properties are often considered prime real estate, many towns and farms are located in natural floodplains, and large cities are often situated along rivers.

Other than storm surges, where the sea level rises locally relative to a low coastal area (such as during a hurricane), two basic types of floods can be distinguished : riverine floods and flash floods. Riverine floods occur along major streams or rivers when particularly heavy rainfalls or the rapid melting of snow causes a large amount of water to flow through the drainage basin. Reverine floods may also occur when dams, either natural or human-made, break due to the strain imposed by high water levels and flood conditions or to other causes. Flash floods generally occur in drainage basins containing small, shallow, or ephemeral (periodically dry) streams when heavy rainfall overloads the system with water.

In the natural environment, rivers and streams are generally short-term phenomena. Rivers continually change their course and flood their banks; the flooding serves to transport and redistribute sediments and nutrients carried by the water. The annual floods of the Nile, bringing fresh nutrients to restore the fertility of the land, were the lifeblood of the ancient Egyptian civilization. Flooding can thus be viewed as a small part of the larger hydrologic and rock cycles.

When humans develop a drainage basin, however, they tend to build permanent structures as if the rivers and streams are permanent, sedentary features of the landscape. All too often humans do not properly consider the natural periodic occurrence of floods. Consequently, when the occasional major flood does occur (perhaps only when every hundred or thousand years), the toll in human life and property loss can be immense. To make matters worse, many human activities inadvertently promote flooding. Farming, overgrazing, deforestration, paving large expanses, and other aspects of development limit the ability of water to seep into the ground (infiltration). As a result, there will be more runoff —more water will travel overland when it rains—which can promote flooding. Mining, construction and other human activities can cause stream channels to become filled with sediment, hindering their ability to carry water quickly, and this too promotes flooding.

Even human activities that are specifically directed at controlling or avoiding flood conditions can actually promote flooding. Dams built to control flood surges may burst and cause even more flooding. Furthermore, even a properly maintained dam will eventually collect silt, ending its usefulness. Water reservoirs behind dams may flood large tracts of forest or agricultural land, and as these artificial pools sit stagnant, they may become a

breeding ground for disease vectors and pests. Dams also disrupt stream flow, causing areas downstream to undergo abnormal erosion due to sediment starvation (the sediments once carried by the stream are trapped behind the dam). Of course, some forms of aquatic wildlife can be severely disrupted by artificial dams.

Channelization, the artificial straightening of a stream or river to increase its capacity to carry large amounts of water quickly downstream, has been used in some areas as a flood control measure. Such channelization often damages the natural aquatic life in the stream, and it can further exacerbate flooding conditions downstream by carrying even more water at a faster rate. Likewise, for thousands of years, humans have built dikes, levees, and flood walls to keep a stream in its channel and avoid flooding. But if, or when, the levees or dikes are breached, the resulting flood can be devastating. All the evidence points to the conclusion that artificial containment structures can only be a temporary measure at best; ultimately, they are bound to fail.

Today, rather than emphasizing engineering works such as the construction of dams and levees to control flooding, many authorities are advocating stricter zoning laws and better floodplain management policies. Ultimately, development may need to be strictly limited in flood-prone areas.

Droughts

Droughts—periods of abnormally low rainfall over an extended period of time in a particular area—can have devastating effects. Due to drought, agricultural productivity may drop dramatically, and even drinkable water for humans may be in short supply. Droughts, and likewise periods of abnormally high rainfall that may cause flooding, are a typical aspect of the climate in the long run. But in the short run, humans may settle in an area based on abnormally good (perhaps moister than usual) weather conditions, which may last for decades, and then be hard hit when direr weather conditions set in again. Changing human land-use patterns, especially the destruction of tropical forests and human-induced desertification, may affect circulation patterns globally, increasing local droughts. Additionally, it is possible that global warming due to the human-induced greenhouse effect may shift precipitation patterns, causing once well-watered areas to become drier.

Major droughts have been experienced in recent years in a number of places around the world, in particular, Ethiopia, Sudan, and especially the Sahel region (Chad, Niger, Mali, Burkina Faso, Mauritania Senegal, and Gambia) south of the Saharai (Africa in Figure). This area is instructive, for prolonged dry conditions have been exacerbated (made worse) by human practices. The declining rainfall in the area has led to reduced plant growth, which reduces the amount of evapotranspiration (water given off from the soil by evaporation and water given off from plants by transpiration) which decreases the local moisture content of the atmosphere, which futher decreases the amount of rainfall locally. Over time the soil dries out and heats up. The lack of vegetation allows the wind to carry more dust into the lower atmosphere, which can add to the heating of the air higher up in the troposphere, contributing to atmospheric instability and reducing the amount of dew that forms at night. All of these factors enhance and accelerate drought conditions in the Sahel region. Furthermore, human overpopulation has exacerbated the situation, Shrubs and trees are cut down and burned as fuel or fed to animals. Virtually all of the arable cultivation, often utilizing inappropriate Western plowing, which leads to progressive destruction of the soil structure and erosion of the topsoil. A hard crust remains on the surface of the land, preventing water from infiltrating the soil on the rare occasions when rain occurs. Together these factors are causing severe desertification.

Fires

Fires are a natural part of many ecosystems : particularly severe natural fires may be the result of drought conditions and lightning. Since prehistoric times, humans have set fires—some of

which invariably get out of control. Forest fires, grassland fires, and bushfires are particularly feared in the United States and Australia, but they pose a threat to forests around the world. Major fires in the past include the 1871 forest fires that destroyed 4.2 million acres (1.7 million hectares) of forest in Wisconsin and Michigan and killed 2200 people and the 12 million acres (4.8 million hectares) of forest that burned during 1980 in Canada. The Ash Wednesday fires of 16 February 1983 in South Australia and Victoria (southern Australia) destroyed over 1.2 million acres (over half a million hectares) of land, including urban areas (nearly two dozen towns were destroyed), forest, and pasture; killed over 300,000 sheep, 18,000 cattle, and 76 people; and injured another 3,500 people. By far the greatest known fire incident was the Great Siberian fire of 1915, which burned 390,000 square miles (1 million km^3) of land in Siberia following a severe drought. Huge amounts of smoke were injected into the atmosphere blocking incoming solar radiation and suppressing ground temperatures.

For the past century, a basic principle of wilderness management has been to fight fires, whether they are set by humans or occur naturally. Timber interests saw fighting fires as preserving a resource; people interested in recreation or preserving saw the prevention of fires as a way to protect the wilderness.

But by the 1940s, some foresters had begun to question the wisdom of suppressing all natural forest fires. Slowly, they came to realize that fires play a critical role in nature. Fires promote the decomposition of some forest litter (dead leaves, branches, and so on) and are an essential component of the biogeochemical nutrient cycle. Periodic fires increase the biotic diversity (the range of different organisms) of an area because they maintain more open habitats.