9,000 years ago; they also primarily subsisted on hunting but apparently had a stronger connection to the aquatic resources, including fish and shellfish, and the migratory birds provided by the Chesapeake Bay. Woodland Indians moved into the Chesapeake Bay region some 3,000 years ago, remaining until after European settlers arrived; evidence of many villages and stronger relation to bay resources survives.

The Chesapeake Bay has been negatively affected and will continue to be so, both by direct and indirect human impact According to U.S. Fish and Wildlife reports, there is a long list of threatened and endangered species of flora and fauna in the bay area. Climate change is predicted to lower salinity due to increased flows from major rivers such as the Susquehanna, which could potentially affect important bay species that are intolerant of low salinity conditions, such as oysters and crabs. Moreover, sea-level rise from melting glaciers, due to global warming trends, will submerge some salt marshes. Models predict greater future increases in mean temperatures, and lower dissolved oxygen levels, which may affect numerous organisms.

The bay's productivity is limited by degradation of water quality caused by excessive chemical, nutrient, and sediment input. Sediment accretion rates in the bay have increased one and a half to seven times over the pre-European settlement rate. Europeans started settling the region in the early 17th and 18th centuries. Between 1830 and 1890, 80 percent of the land was cleared of timber, and much of it was plowed and put into agriculture. Clearing of the land led to increased flow of freshwater into the bay, resulting in greater sediment deposition. With the advent of commercial fertilizers since the mid-1800s—most notably those containing nitrogen and phosphate compounds—fertilizer discharge has increased, as have sewage discharge and industrial waste. The 1940s brought about common agricultural practices implementing a variety of pesticides. Starting in the 1960s, efforts have been made to reduce the effects of contaminated runoff. Water quality continues to fluctuate, as do population numbers of various species in the region.

The Chesapeake Bay in 2009 was declared a national treasure, and President Barack Obama issued an executive order to promote and restore its health, heritage, and natural resources. The U.S. Environmental Protection Agency has mandated goals in the form of Total Maximum Daily Load for the amount of pollutants that can enter the bay. These goals and related solutions to reduce sediment, nitrogen, and phosphorous runoff are implemented for each state in the watershed. In addition to federal and state agencies, numerous local and regional watershed groups, such as the Chesapeake Bay Foundation, are working to improve water quality in the bay.

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Chihuahuan Desert

Category: Desert Biomes.
Geographic Location: North America.
Summary: The vast Chihuahuan Desert, covering a large portion of southwestern United States and

northern Mexico, hosts wildlife adapted to this isolated, harsh, and extreme ecoregion in diverse and unique ways.

The Chihuahuan Desert is the largest desert in North America, stretching across more than 170,000 square miles (440,000 square kilometers). This is an area larger than the state of California. The northernmost extent of the desert is in central New Mexico, while its southern extreme is in the southeastern corner of the Mexican state of Zacatecas. The desert was formed approximately 8,000 years ago as a result of its location in the midlatitudes, combined with the rain-shadow effect of two major mountain ranges: the Sierra Madre Occidental to the west and the Sierra Madre Oriental to the east. Elevations in the Chihuahuan Desert range from 2,000 feet (600 meters) to 8,750 feet (2,700 meters), the majority of this occurring between 3,600 feet (1,100 meters) and 4,900 feet (1,500 meters).

Much of the Chihuahuan Desert is characterized by having basin-and-range geomorphology including a central highland that accounts for the relatively low mean annual temperature of 65 degrees F (18.6 degrees C). Abrupt changes in elevation often reveal unique habitats known as Sky Islands that are home to endemic species (native only to a particular biome), and also support one of the most critical migratory flyways in North America.

Precipitation in the Chihuahuan Desert varies greatly, depending on elevation and geographic location, but on average, the desert has annual precipitation of less than nine inches (24 centimeters), most of which falls during the months of July and August. The desert is composed mainly of marine sedimentary rock, resulting from the region being underwater as part of the Cretaceous Seaway, which filled the entire region approximately 90 million years ago. The rich gypsum deposits that are widespread throughout this desert have resulted in the subterranean formation of expansive cave systems such as Carlsbad Caverns and Lechuguilla Cave in southern New Mexico. The largest body of water in the Chihuahuan Desert is the Rio Grande (called Rio Bravo in Mexico), which dissects the desert into northern and southern halves. Other important sources of water are seeps and groundwater springs: groundwater is the source of most surface water in this desert. Seeps and springs support complex ecosystems with a large number of endemic plants and animals. Of special interest is the valley at Cuatro Cienegas in Coahuila, Mexico, which supports more than 500 freshwater pools and an enormous and varied amount of wildlife.

The ecosystems of the Chihuahuan Desert are very diverse and range from xeric habitat to riparian zones along major rivers. Other types include vast grasslands, savannas, and alpine habitat. The vast majority of the Chihuahuan Desert is xeric habitat categorized as desert scrub. Desert-scrub habitat tends to occur at lower elevations and tends to have the least precipitation in the desert. Grasslands and savannas occur at low to midrange elevations and tend to have slightly more precipitation than desert scrub but, still remain quite arid. Grasslands have been extremely modified over the past 200 years as overgrazing and water diversion have led to desertification and drastic changes in the flora and fauna of the region. The basin-and-range topography along with changes in climate over the past 10,000 years has resulted in isolated areas that support, collectively, up to 1,000 endemic species.

Flora and Fauna

The organisms of the Chihuahuan Desert are often unique, including the indicator species *Agave lechuguilla,* a small agave species found only in the calcareous soils of this desert. The region is home to an estimated 3,500 plant species, of which 25 to 30 percent are endemic. Among the most common are creosote bush (*Larrea tridentata*), various species of mesquite (*Prosopis* spp.), tarbush, acacia, an abundance of grasses, and hundreds of species of cacti in the *Coryphantha* and *Opuntia* genera. As many as one-fifth of the world's cacti species can be found in this desert.

Many of these plant species have evolved mechanisms to tolerate long periods of drought and intense heat. Deep root systems allow species

of mesquite to tap into groundwater reservoirs, while extensive networks of shallow roots allow species like creosote bush to maximize water capture during the short, intense rainfall periods. Some species have even evolved ways to improve their photosynthetic efficiency in response to the extreme environmental conditions of the desert.

Animal species diversity is higher in the Chihuahuan Desert than in any other North American desert. Vertebrates include approximately 120 species of mammals, 300 species of birds, more than 100 species of fish, and more than 150 species of amphibians and reptiles. The diversity of habitat types in the desert provides homes for several endemic species of vertebrates and countless species of insects. The species diversity of bees, which are important pollinators here, is higher than in any other North American desert.

Many of the species have adapted to the extreme desert environment by modifying their behavior (such as nocturnal activity) and evolving physiological adaptations that maximize water retention and allow organisms to function for long periods without food or water. Large mammals that can still be found in the Chihuahuan Desert, though in small populations, include: brown bear, pronghorn antelope, American bison, wolves, peccaries, and even jaguars and mountain lions. Common birds of this desert include several species each of hummingbirds, owls including the great horned owl (*Bubo virginianus*), hawks, vireo, migrating sparrows, and quail. Also commonly found here are roadrunners and other ground-birds.

Human Impact

Native Americans have occupied the Chihuahuan Desert throughout its entire history. The Mogollon people occupied much of the desert for more than 1,000 years and eventually were displaced by Pueblo and Apache cultures. The Tarahumara people of the highlands of Chihuahua, Mexico, still occupy much of the harshest mountainous terrain of the Chihuahuan Desert and have adapted to the area with unique hunting and agricultural practices. Urban, agrarian, and industrial development over the past 200 years, especially along the United States-Mexico border, has led to major threats to the ecological balance in the desert: over-grazing (and the related invasion of non-native species); depletion of water sources due to irrigation and pumping of groundwater; mining; and off-road vehicle use in some fragile areas.

Conservation and protective measures have been put in place in the United States in the regions that fall under National Park status, and in Mexico with the creation of the National Commission for the Knowledge and Use of Biodiversity (CANABIO).

Such agencies will have to contend with changes wrought by global warming, such as wider opportunities for invasive species as both droughts and floods become more severe. It is expected that salt cedar (*Tamarix ramosissima*) and Russian olive (*Elaeagnus angustifolia*), for example, will spread through riparian areas by crowding out native species and reducing diversity as groundwater supply declines.

A lengthening of the frost-free season and higher minimum temperatures will expand the desert to the north and east, while higher elevations are likely to be colonized by arid savanna vegetation; some sky island communities will be severely stressed and may disappear as the warming climate alters their fundamental temperature, humidity, and snowpack regimes.

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Chilean Matorral Forests

Category: Forest Biomes.
Geographic Location: South America.
Summary: The Chilean Matorral ecosystem is rich with wildlife, much of it endemic, but human activity and low protection status present a continuing challenge.

*A chilla (*Lycalopex griseus*) in the Parque Nacional La Campana in Chile in 2009. The chilla is one of the increasingly threatened small mammals unique to the Chilean Matorral biome. (Flickr/Andrea Ugarte)*

Outside of the Mediterranean Sea area itself, Mediterranean-type ecosystems worldwide are found in only a few areas, including the southwestern coast of Australia, the Cape of Good Hope area in South Africa, the coastal chaparral zone of California, and one part of South America: the Chilean Matorral. The term *matorral* refers to the Spanish word *mata,* for scrub vegetation. The Chilean Matorral covers an area of roughly 57,300 square miles (148,000 square kilometers), predominately a patchwork of small parks, agricultural areas, private lands, towns, and cities. Chile's capital, Santiago, is located here, as are other urban centers.

The Matorral is a narrow stretch of land in central Chile, extending south from one of the driest deserts in the world, the Atacama, to the mixed deciduous-evergreen temperate zone known as the Valdivian forests. The Matorral is about 350 miles (563 kilometers) long and 62 miles (100 kilometers) wide. Here, the summers are hot and dry and prone to drought conditions; winters are wet and mild. The mean annual temperature is 54 degrees F (12.2 degrees C). The native plant and animal communities in the Chilean Matorral biome are species-rich with a very high proportion of endemism (found only in this ecosystem), particularly among plants.

Flora and Fauna

As a plant community, Matorral refers to a zone of sclerophyll shrubs and trees (i.e., evergreen "hard-leaved" woody vegetation with small, waxy leaves that prevent water loss in the dry summer); cacti, bromeliads, and palms; and diverse understories of herbs, vines, and grasses. Most of the present scrubland was created by human activity and is a successional remnant of the native sclerophyllous forest. It now exists as a mosaic of shrubs and trees within a matrix of naturalized herbaceous plants.

This land hosts animals that are specially adapted to their unique habitat and cannot be found anywhere else on Earth—making them extremely rare and dependent upon protected areas for their survival. These include many small mammals such as the chilla, a fox-like animal; the yaca (mouse opossum); and the kodkod, the smallest wildcat in the Americas. Several lizard species are also endemic to the Chilean Matorral, as are 15 known species of birds. Among the latter are the Chilean mockingbird; three varieties of tapaculo; two species of parrots; the giant hummingbird; and some carnivorous species such as the aplomado falcon, cinereous harrier, and the short-eared owl.

Human Impact

The ecoregion's core, the Central Valley, constitutes Chile's most intensively inhabited area. It is very fertile and is the agricultural heartland with booming wine, vegetable, and fruit industries. In the more southerly parts fruit, crops, pasture, and fire-prone pine and eucalyptus plantations are widespread. Because of the high agricultural value, the Central Valley of Chile has been highly modified since the arrival of Europeans. Although