Biomes 3, 7, and 7a: Subtropical Desert, Temperate Desert, Steppe

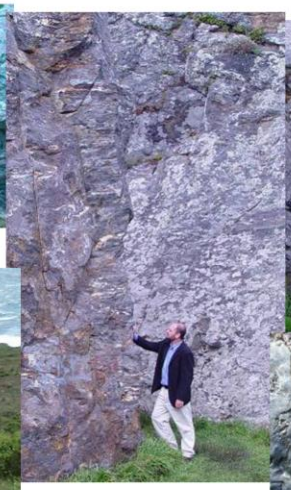
Lectures 7 & 8

Possible excursion Sunday to visit vernal pools 9AM-3PM. See www.yolobasin.org, sross@yolobasin.org

For a more ambitious road trip check out the wildflower display at the famous Bear Valley *www.totalescape.com/tripez/wildfl.html*

Or try the Stebbins Reserve just before the Berryessa Dam. http://nrs.ucdavis.edu/stebbins.html

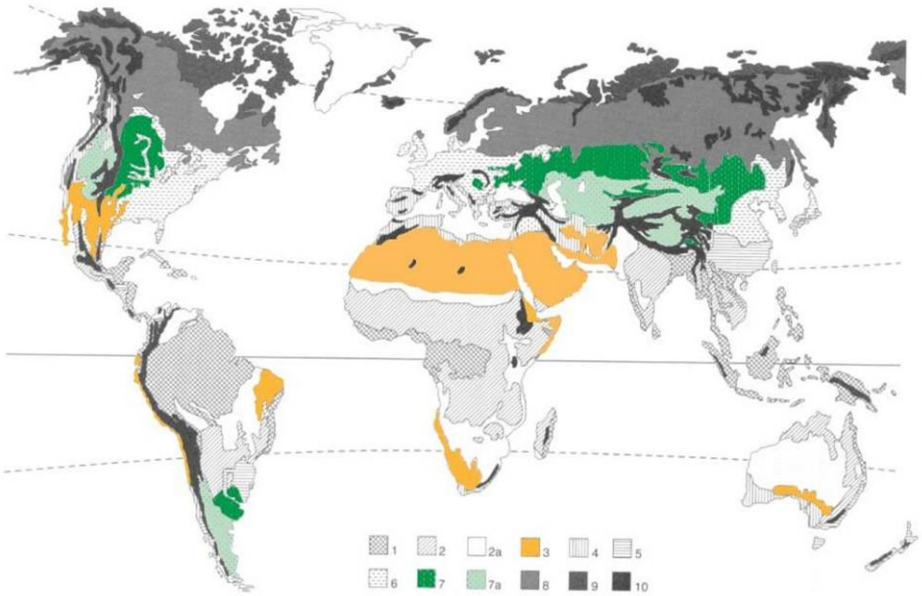
Natural History: Breck Parkman's megafaunal rubbing rocks at Goat Rock State Beach



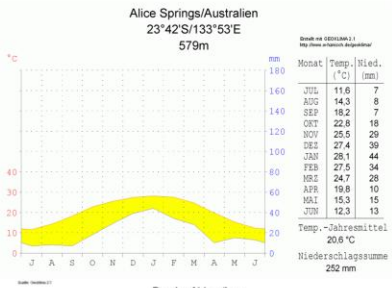
Visit on the self-guided field trip to coast

http://www.parks.ca.gov/?page_id=23566

The distribution of arid and semi-arid biomes



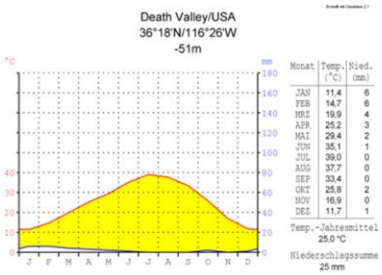
3 Subtropical Desert Biomes



Monat	Temp. (°C)	Nied. (mm)
JUL	11,6	7
AUG	14,3	8
SEP	18,2	7
OKT	22,8	18
NOV	25,5	29
DEZ	27,4	39
JAN	28,1	44
FEB	27,5	34
MRZ	24,7	28
APR	19,8	10
MAI	15,3	15
JUN	12,3	13

Temp.-Jahresmittel
20,6 °C

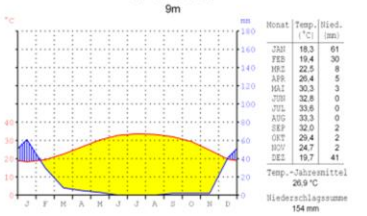
Niederschlagssumme
252 mm



Monat	Temp. (°C)	Nied. (mm)
JAN	11,4	6
FEB	14,7	6
MRZ	19,9	4
APR	25,2	3
MAI	29,4	2
JUN	35,1	1
JUL	39,0	0
AUG	37,7	0
SEP	33,4	0
OKT	25,8	2
NOV	16,9	0
DEZ	11,7	1

Temp.-Jahresmittel
25,0 °C

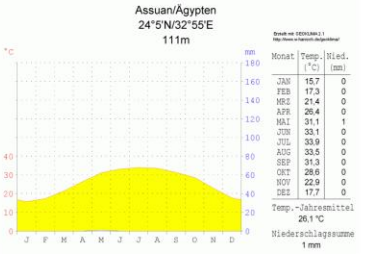
Niederschlagssumme
25 mm



Monat	Temp. (°C)	Nied. (mm)
JAN	18,3	61
FEB	19,4	30
MRZ	22,5	8
APR	26,4	5
MAI	30,3	3
JUN	32,8	0
JUL	33,6	0
AUG	33,3	0
SEP	32,0	2
OKT	29,4	2
NOV	24,7	2
DEZ	19,7	41

Temp.-Jahresmittel
26,9 °C

Niederschlagssumme
154 mm



Monat	Temp. (°C)	Nied. (mm)
JAN	15,7	0
FEB	17,3	0
MRZ	21,4	0
APR	26,4	0
MAI	31,1	1
JUN	33,1	0
JUL	33,9	0
AUG	33,5	0
SEP	31,3	0
OKT	28,6	0
NOV	22,9	0
DEZ	17,7	0

Temp.-Jahresmittel
26,1 °C

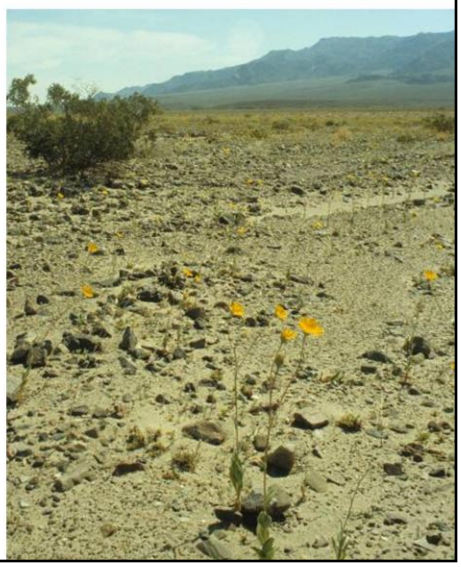
Niederschlagssumme
1 mm

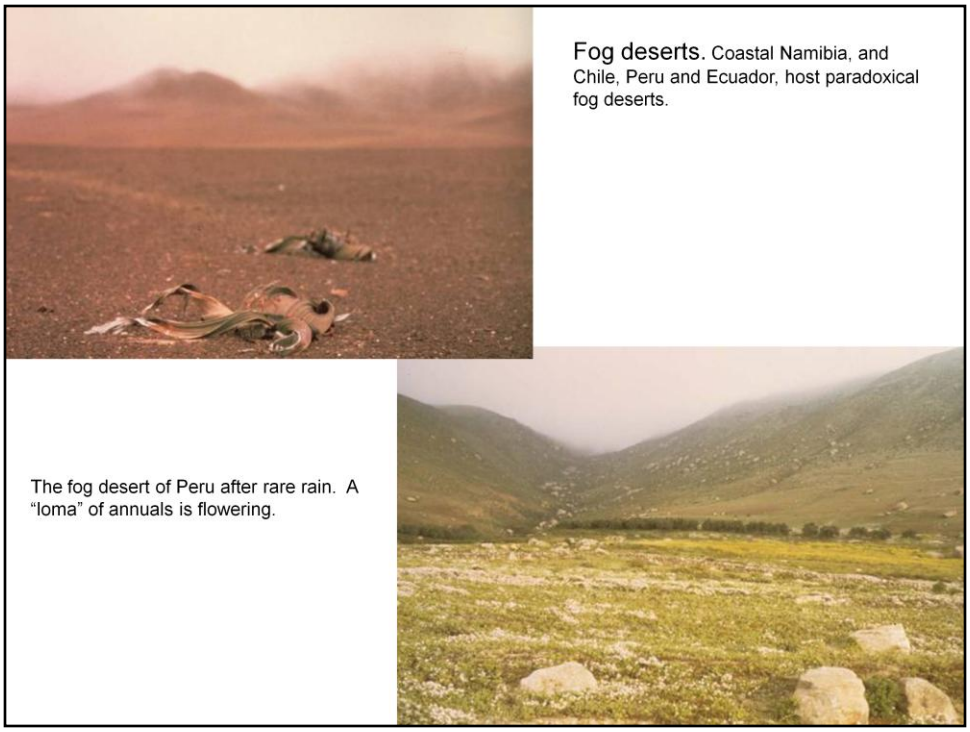
Relatively moist desert, Baja California

Drier Subtropical Desert: Death Valley

Creosote bush. This sort of open scraggly shrub is typical of subtropical desert plant dominants

Thin scatter of annuals after better-than normal winter rains



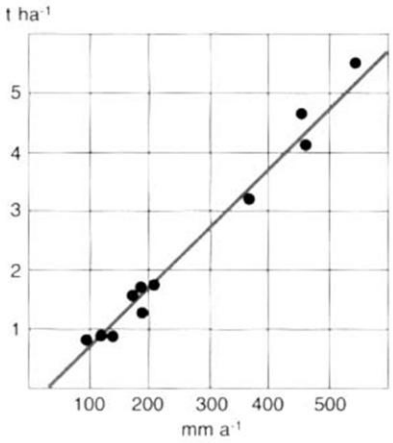


These are practically rainless but persistently cool and humid because of foggy air drifting off the cold offshore current. The California Coast in summer is something like a fog desert.

The Namib Desert is very old, so old that the iron inside its sand grains is oxidized to red rust. The Welwichia plant is a strange conifer with two giant flat leaves. You can find a couple in the desert section of the Plant Science teaching greenhouse, which we visit on an upcoming excursion.

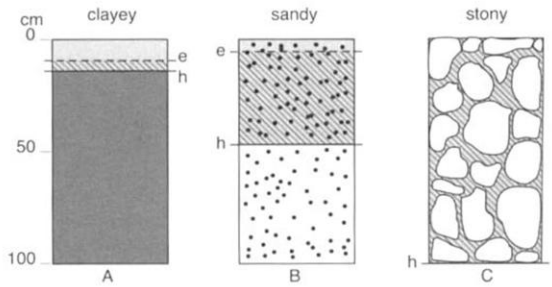
In arid and semiarid environments the relationship between rainfall and plant growth is very tight.

Fig. 129. Organic material production (above ground dry weight in t ha^{-1}) of grassland in south-west Africa, in relation to the annual precipitation in mm

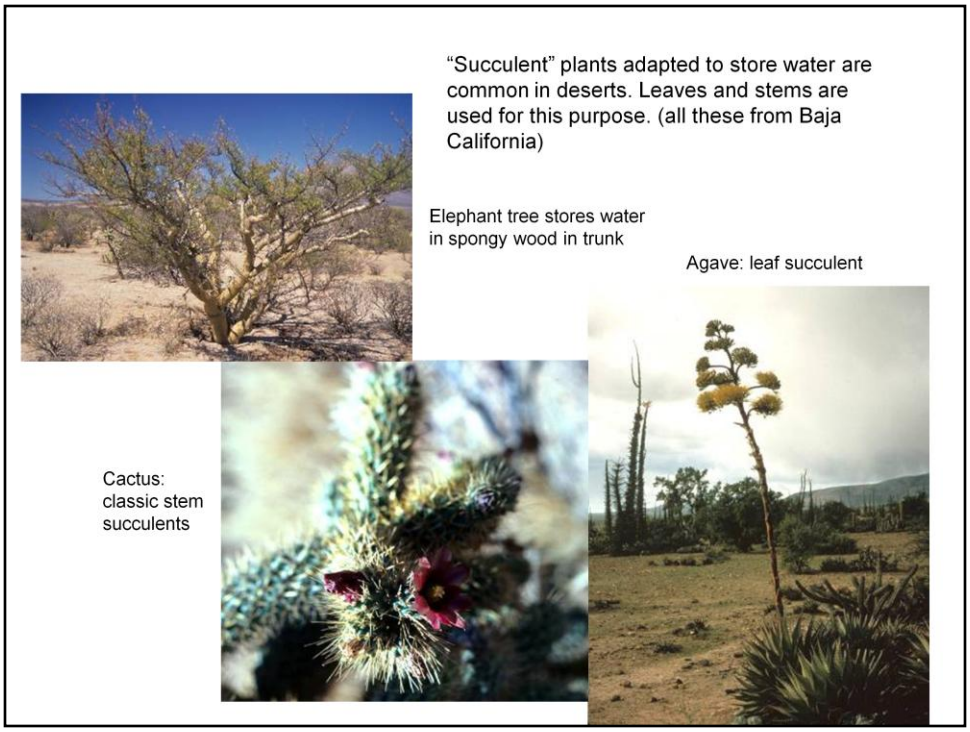


Desert soil science is a little different.

Fig. 127. Schematic representation of water retention in various kinds of soils after a rainfall of 50 mm in arid regions. *h–h* Lower limit of moistened soil; *e–e* lower level to which the soil dries out again. The clay soil retains 50% or less; the sandy soil, 90%; and the stony soil, 100% (*hatched*)



In more humid biomes, we think of clay soils as retaining much water and of sandy and rocky soils retaining little because they drain very fast. But when rainfall is scanty, we have to think differently. A small amount of rain may wet a clay soil to a depth of only a few centimeters. In a hot climate most of this water may be evaporated before plants can use it. In a sandy or stony soil, a small amount of rain penetrates much deeper and little or none is evaporated from the surface. Plants adapted to send an extensive root system deep onto sand or rock crevices find water to sustain photosynthesis.



Many plant families have converged on the succulent adaptation to store water in dry regions. For example in Africa plants in the Euphorb family have many members that look very much like cacti, which are restricted to the New World. Another mainly African group is the ice plant family of leaf succulents. These include the bizarre miniature "living stone" you sometimes find for sale in nurseries.

Cactus in cross section.

One of the African Euphorbs that has converged amazingly on the same pleated succulent adaptation as the cacti of the New World.

The tan ring is the woody support tissue of the plant. The main water storage is between the woody ring and the thick, nearly waterproof, exterior cuticle. The pleated exterior shape allows the water storage tissue to expand and contract easily with the cuticle expanding and contracting accordian fashion.

Desert annuals, Death Valley.

The soil contains a “seed bank.” Many annuals have hard seed coats of variable thickness. Over time, these degrade and when they are thin enough, water can enter the seed and it germinates. If enough rain falls, the plant will mature and re-stock the seed bank. In Death Valley, a wildflower display as good as this occurs perhaps one year in 10.

Soil depth, texture, and horizontal water movement are important in forming mosaics of communities in arid regions.

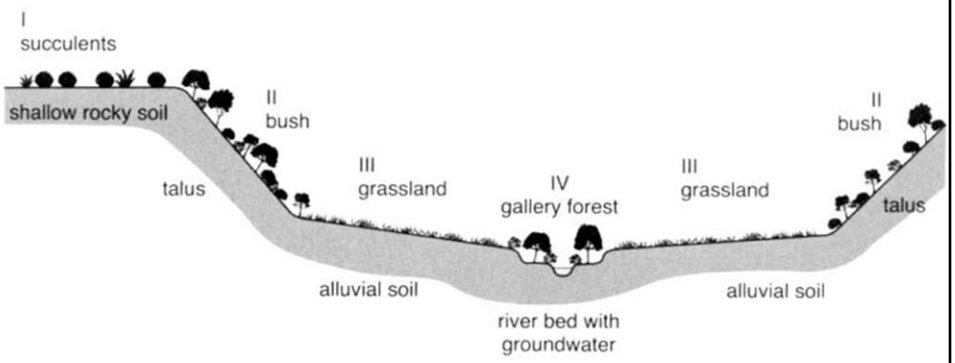
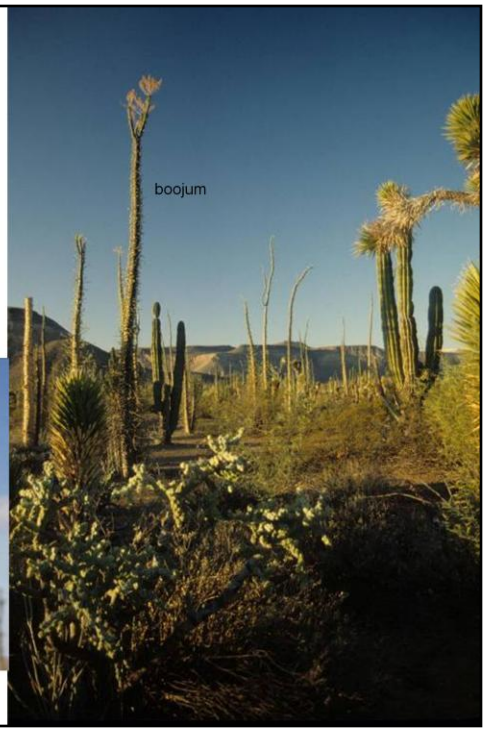


Fig. 135. Vegetation profile of a valley of the Upper Karroo near Fauresmith (South Africa). Distribution of the plant cover is determined by differences in soil. Bush with *Olea, Rhus* and *Euclea*

Plants that readily store water, like cacti and euphorbs, often dominate on shallow soils using shallow extensive roots to collect and store water when is rains. Deep but stony soils (“talus”) supports shrubs with long deep roots. Fine alluvial soils may support grasses with intensive roots that take up the shallow penetrating water from the rains. Valley bottoms, even if their beds are dry at the surface, frequently have ground water flowing underneath that supports a gallery forest of deep-rooted trees that tap the ground water. Water runs off of the rocky tops quickly and deeply penetrates the talus to form sources of groundwater.

The weird boojum tree (Baja California) has small ephemeral leaves.



The plant puts on a coat of thin tiny leaves when rains are sufficient and sheds them when the water is gone. Many on the plant left are turning brown and being shed.

Some other characteristic desert plant adaptations

Ephemerals, tiny plants that sprout, grow and set seed in a few weeks, needing only one or two good rains

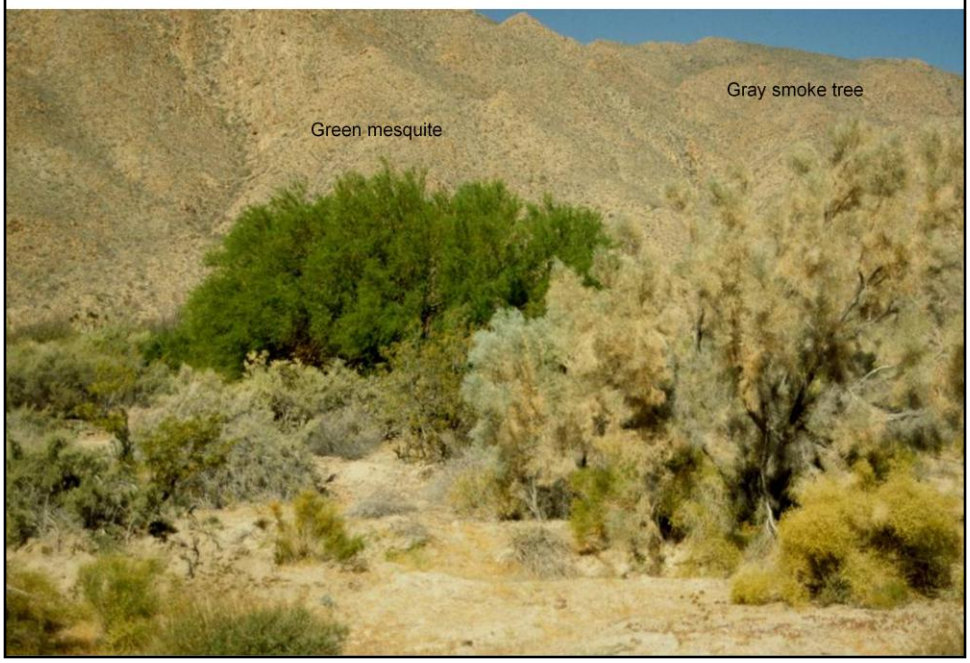
Desert nightshade with “malakophyll” leaves. These leaves can stay wilted without dying for prolonged periods. If the drought persists they are eventually shed.

Jojoba orients leaves vertically so that they are minimally stress by the midday sun. Some think that humans became upright so that we could be out in the African mid-day sun with minimal radiation load from the sun.

Baja cactus garden, but note importance of loose shrubs, often fairly large

Lightly weathered desert soils are often rocky or sandy. Shrubs, with extensive root systems that penetrate deeply for the water than collects deep in such soils, are very frequently the dominant plants even in very dry deserts like Death Valley or the Sahara.

Shrubs reaching the size of small trees are not uncommon.



Baja again. Why do you suppose than the gray smoke tree is so light in color compared to the mesquite?

Baja scene.

Just to underline that many desert communities are dominated by big rangy shrubs rather than succulents. Nitrogen fixing leguminous species are common. Desert soils are often rich in in P and K because of light weathering. But rocks generally contain no N, so N-fixers have a serious adaptive advantage.

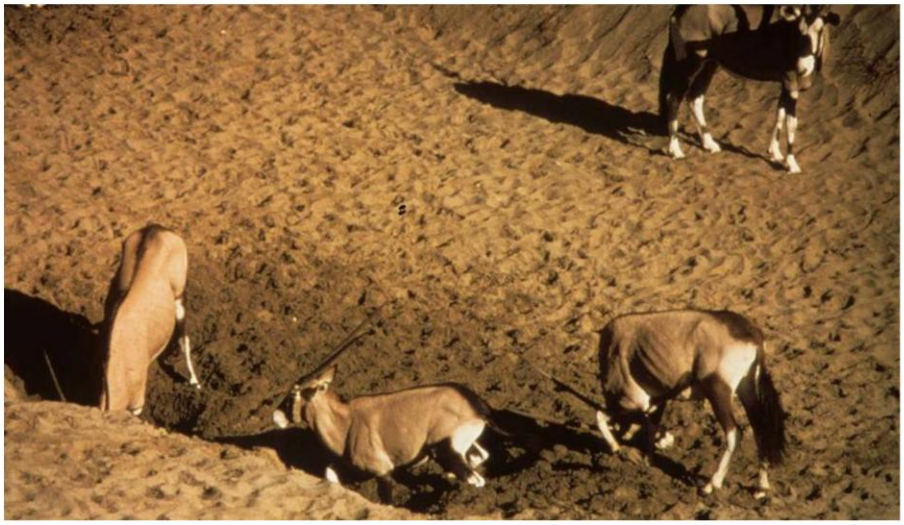
Animal adaptations.

Tip-toe beetle from Namibia. Long legs elevate body above hot sand.

Desert reptiles are sometimes quite herbivorous.

The importance of cold blooded animals is once again high in the desert for much the some reason as in rain forests. Plant productivity is low and unreliable, and slow growing plants tend to protect their tissues from grazing or browsing with spines and toxins. The more efficient slow metabolism of the cold blooded creatures gives them a competitive advantage relative to birds and mammals. Deserts will often strike you as having little animal life, particularly they very dry ones.

Somewhat as specialized mammalian herbivores, like primates find niches in tropical forests, occupy deserts.

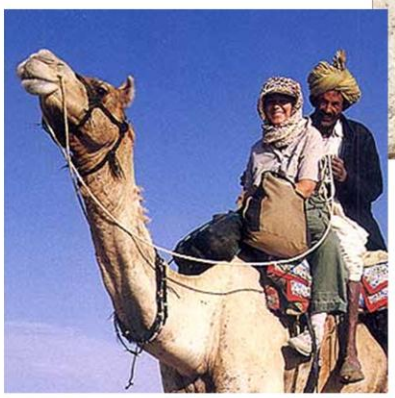


Rodents like kangaroo rats can subsist on metabolic water, the water produced in burning food for energy. They do not need to drink. Here Oryx, desert-specialist antelopes, dig their own water holes in a sandy riverbed (Namibia). The desert vegetation is low and exposed to grazing and browsing. Herbivores that are adapted to evade the chemical and physical defenses of desert plants can do OK. Donkeys and horses did so well in Death Valley that they have been exterminated as pests.

Human Uses of Subtropical Deserts: Hunter-gatherers.

Hunter-gatherers do all right in quite dry places. Prehistoric pictographs, Death Valley

Human uses of subtropical deserts: Pastoralism

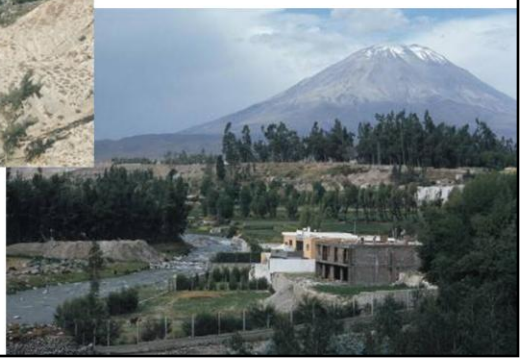


In the Old World, pastoralism based on highly drought adapted species like camels and donkeys is practiced in quite dry places. In wetter deserts cattle, goats, and sheep are often raised.

Human uses of subtropical desert:
Oasis agriculture.

The Spanish missionaries established date culture as part of their effort to build a string of missions up the Baja California peninsula. At right, the water supply at San Borja was too small to support much of a settlement. Below, the water supply at San Ignacio was much better. The present community is perhaps 3000 strong and maintains the impressive colonial church.

Where large rivers, like the Nile, flow across desert lands large linear oases develop.

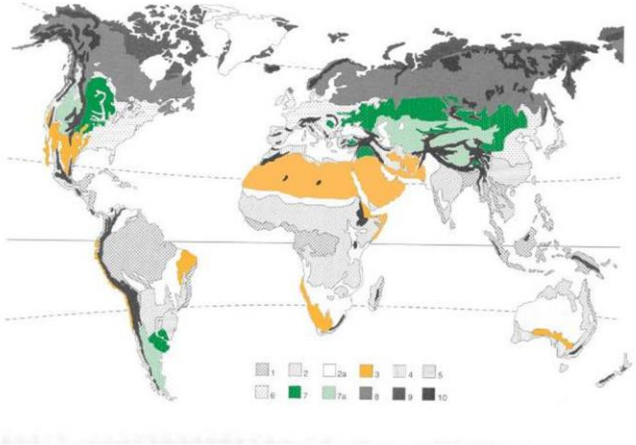


In coastal Peru, about 20 short rivers descend from the snowy Andes to the Pacific. Elaborate irrigation works have existed on these rivers for thousands of years. Here we see the Rio Chili, Arequipa Province.

Above. The stream here has incised a deep gully in volcanic ash. Probably irrigated far before the Spanish conquest. The ancient engineers had to tap the stream at points where harder bedrock forced it near the elevation of a downstream terrace. Then they dug long canals to irrigate the terraces. Across the canyon note two parallel canals running off to some high terrace in an adjacent drainage.

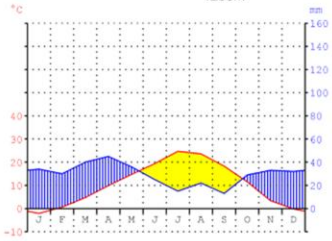
Below. The considerable city of Arequipa has pre-Columbian canals running all through the old town. In the 1970s at least, you irrigate your garden from a small feeder canal, not with a spigot and hose! Much agriculture was scattered on the edges of town

7 Steppe and 7a Temperate Desert



Temperate Desert Climate diagrams

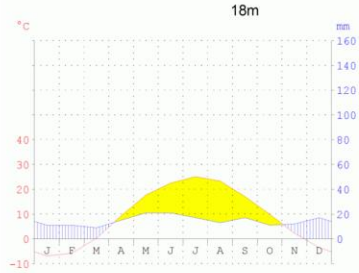
Salt Lake City/USA
40°46'N/111°58'W
1286m



Monat	Temp. (°C)	Nied. (mm)
JAN	-2,1	34
FEB	0,6	30
MRZ	4,7	40
APR	9,9	45
MAI	14,7	36
JUN	19,4	25
JUL	24,7	15
AUG	23,6	22
SEP	18,3	13
OKT	11,5	29
NOV	3,4	33
DEZ	-0,2	32

Temp.-Jahresmittel
10,7 °C
Niederschlagssumme
354 mm

Astrachan/Rußland
46°22'N/48°6'E
18m

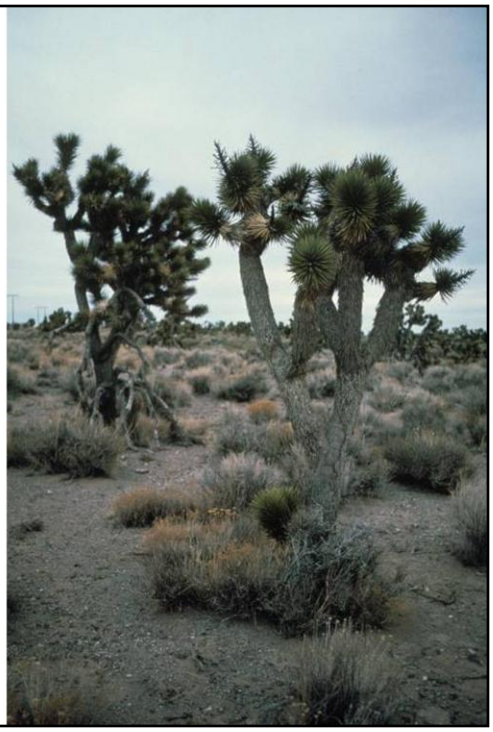


Monat	Temp. (°C)	Nied. (mm)
JAN	-6,9	11
FEB	-5,8	11
MRZ	0,2	9
APR	9,3	15
MAI	17,7	21
JUN	22,5	21
JUL	25,1	17
AUG	23,3	13
SEP	17,1	17
OKT	9,9	11
NOV	2,3	12
DEZ	-3,5	17

Temp.-Jahresmittel
9,3 °C
Niederschlagssumme
175 mm

Note cold winters and insufficient rain to support maximal plant production during the the summer growing season.

Ecotone between Subtropical and Temperate Desert.

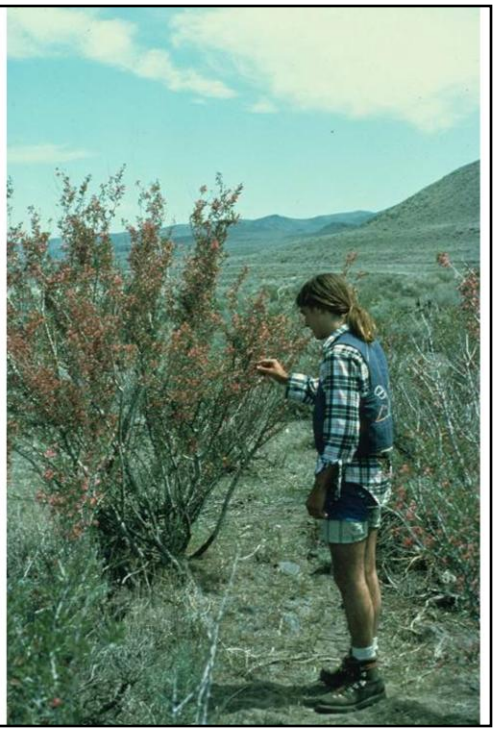


Southernmost California and Arizona and adjacent N Mexico are often called the Colorado desert. Almost frost-free, the flora is dominated by plants with tropical affinities. The sagebrush deserts of the Great Basin have plants of mainly temperate affinities. In between is the Mohave desert, with a mixture of species. The signature plant of the Mohave is the tree-like Joshua Tree, kind of yucca, a subtropical group. Notice that the Joshua Tree is vaguely reminiscent of the tall, open shrubs that are typical of the subtropical deserts. In the “understory” here, short compact shrubs are the rule. As we pass to the Great Basin Desert proper, low, compact shrubs become the usual dominant. .This difference is good for sight recognition of the biome. I don’t know of any good explanation for why subtropical desert shrubs tend to rangy and the temperate desert ones to compact.

Smoke Creek Desert, Nevada.

The monotony of sagebrush broken by groves of juniper and piñon pine, as here. At higher elevations, orographic precipitation supports Yellow Pine Forest

Desert Peach



An exception that illustrates the rule This shrub has the structure of a Subtropical Desert shrub tho it is from the Great Basin. It does have temperate not tropical affinities (it is in the big genus *Prunus* from which so many stone fruits come from—cherries, plums, and peaches Note the background dominated by sagebrush.

Atriplex, another exception

The greener shrub in the foreground is it the large *Atriplex* genus, which, though a compact shrub, is very common in Subtropical Deserts. Here an Atriplex is growing in a sagebrush dominated Temperate Desert community where its shape “belongs”

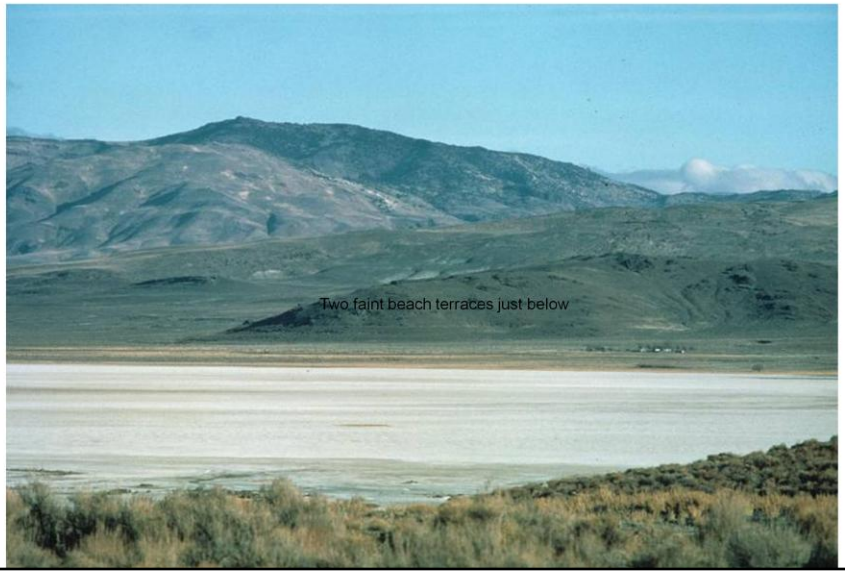
Typical Nevada scene.

Community heavily dominated by Big Sagebrush, *Artemesia tridentata*. The *Artemesia* genus is important in Old World Temperate Deserts too.

Smoke Creek Desert, Nevada. Dust blowing up from playa (dry lake bed).

Nevada. Some snow is usual in the Temperate Desert, quite unlike the Subtropical Desert.

Another playa. Nevada.



Dry lake beds are common in the Great Basin. A few more or less salty lakes remain, the largest being the Great Salt Lake. As late as 12,000 years ago, the Great Basin was a very different place. The valleys were drowned by a large series of lakes, the largest being the web-like Lake Lahontan in western Nevada. The slopes were covered with pine forest. The now dominant sagebrush was absent here but was an important part of the Mammoth Steppe just south of the glaciers. When you travel to Nevada, look for the old beach terraces from these lakes. They are often quite conspicuous as bathtub-ring like features tens or even hundreds of feet above the playa surface.

Smoke Creek Desert, Nevada.

Feral horses thrive in the Temperate Desert. Enough grass and palatable shrubs grow in the desert that horses can make a good living. Cattle need denser grass to support themselves in a feral conditions. Horse move quickly from one good patch to another. Slower cattle are forced to be less selective.

Cattle ranching in the Temperate Desert is a marginal business.

Ranchers move cattle when the lowland grass dries up in spring to moister mountain meadow pastures for the summer. In the meantime the grow hay wherever they can get sufficient water to irrigate. This they feed out in winter.

Historic Virginia City silver mining town (Nevada).

Mining is no more common in deserts than in other biomes, but it is typically a much large *proportion* of the economy than in in other biomes because other human uses are so limited. I often fly over the Great Basin at night on my way home. You can go for 45 minutes sometimes without seeing a light. During the day you often see huge open pit mining operations.

Shrub and grass competition for water is important in producing the ecotone between the Temperate Desert and the Steppe.

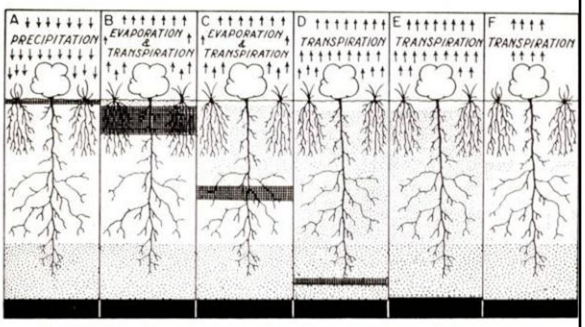


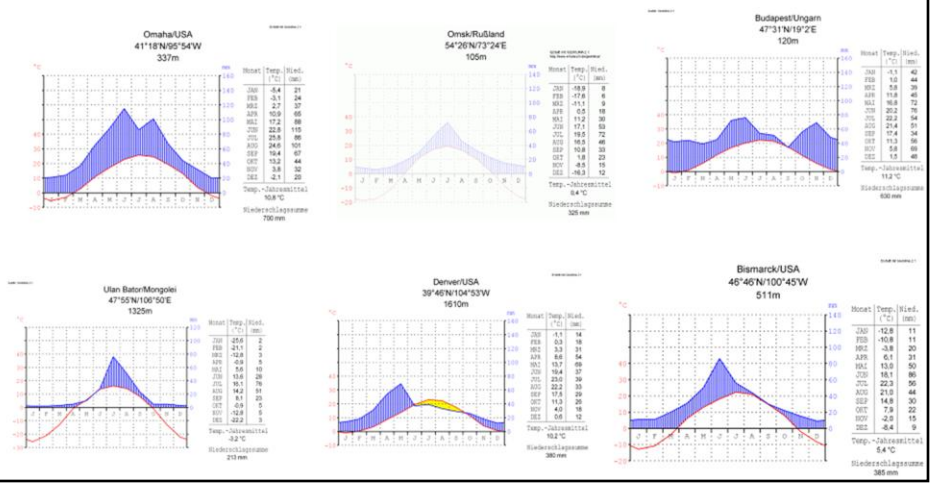
FIGURE 27. Diagram illustrating some effects of a short rainy season on a shrub and perennial grasses growing in an arid region. (*A*) When the rains begin the grasses are dormant because the soil is dry (unshaded) throughout the depth of their root systems, but the shrub is in active condition because its roots extend into the capillary fringe (heavy stippling) maintained by the ground water (black). (*B* and *C*) Free water (cross-hatched) percolates downward, leaving the soil moistened to the field capacity (light stippling). Water vaporizes from both plant and soil surfaces. (*D* and *E*) Free water approaches the water table, then becomes a part of ground water. Upper layer of soil which is subject to evaporation loss is desiccated to the extent that water loss is now chiefly transpirational. (*F*) Growth water above the capillary fringe is practically exhausted. Grasses again become dormant.

Soils in the desert tend to coarser, allow moisture to seep below the depths where grass roots can get them. On the well developed soils “mollisols” or “chernozems” of the Steppe, soils hold more water in surface horizons intensively rooted perennial grasses starve the shrubs for water.

In the Great Basin today, the weedy exotic cheatgrass has become common. It provides enough fuel to support wildfires which now regularly occur in the sagebrush country. Sagebrush is slow to recover from fires. One can imagine that cheatgrass could turn the shrub dominated Great Basin shrub desert into a cheatgrass steppe.

The more general point is that in all the arid and semiarid biomes, natural and human caused fires often play a very big role in semiarid biomes. Grass buds and seeds are at ground level where they are protected from fires. Trees and shrubs are liable to be killed by fires. In both Australia and South Africa, large areas might revert to forest or shrublands if fires we not used to keep the grasslands open. People there think fire is necessary and we think it a hazard. Perhaps all depends upon what sort of vegetation you prefer!

Steppe climographs.

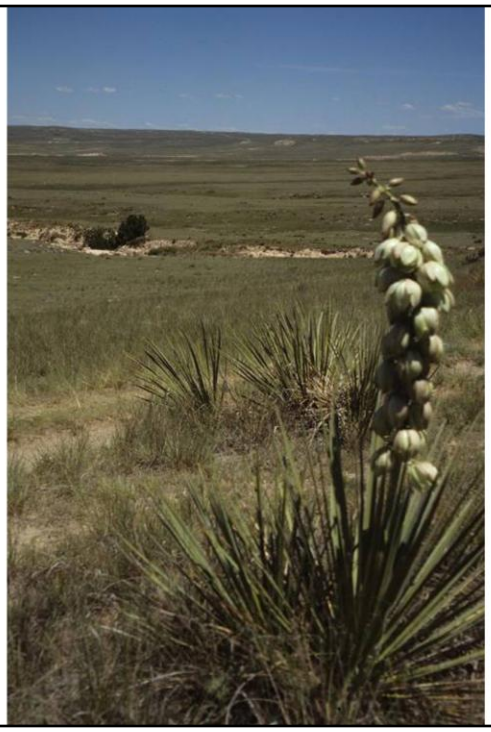


In the US we make a distinction between short-grass and tallgrass prairie. Omaha, Omsk, and Budapest have more rain relative to plant needs than Denver, Bismarck, and Ulan Bator and a taller grass sward. Rainfed agriculture thrives in the tallgrass regions which have become the world's great grain belts. The shortgrass regions can be farmed but the risk of drought-induced crop failure is high.

Pawnee National Grassland, Colorado.

Shortgrass prairie. In this shot, distant trees along a watercourse interrupt the otherwise uniform grassland.

Yucca (Spanish Bayonet) blooming in Pawnee National Grassland



Some subtropical desert species invade the short grass prairie. A cactus also enters this vegetation in Colorado.

Small cactus in overgrazed shortgrass prairie

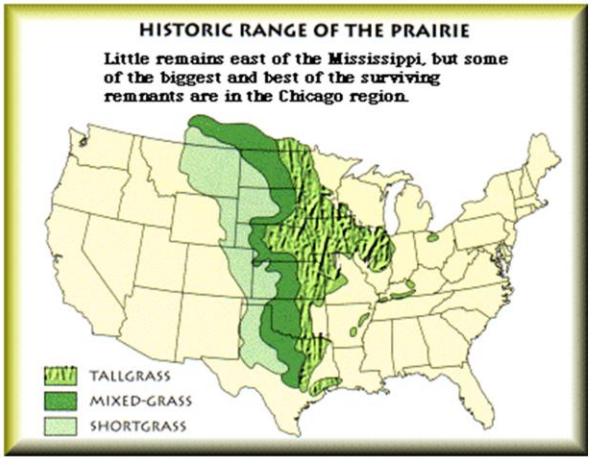
Bunchgrass

Turfgrass

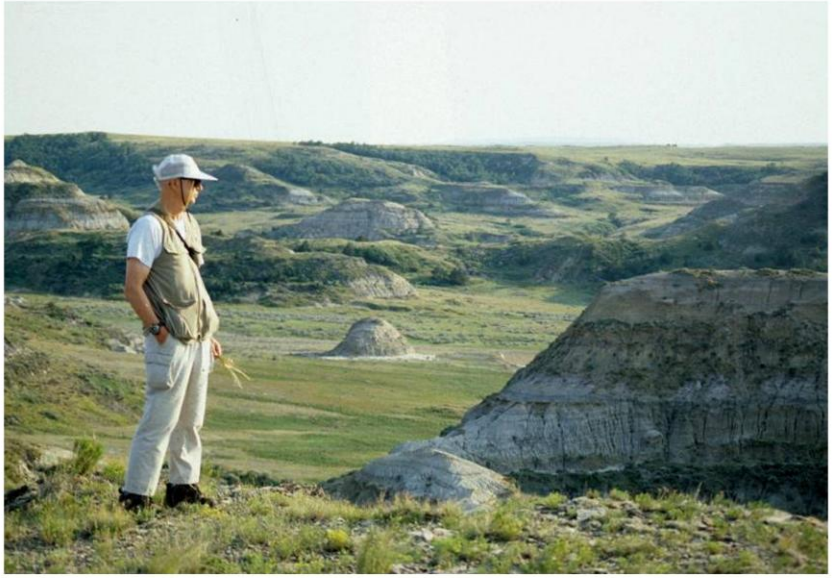
Herb mixed in with grass sward

Pawnee National Grassland. A few small lodgepole pines in the distance and a couple of pronghorn antelope in the foreground.

Tall-Grass prairie. Distribution and example from Eastern Kansas



Theodore Roosevelt National Park, eastern Montana. Shortgrass prairie. The badlands of the Little Missouri River were never developed for farming.



TRNP Bison bulls fighting.

The Steppe Biome in North America supported huge herds of these animals, a surviving remnant of the megafauna of the Pleistocene. Since farming and ranching are so marginal in the dry end of the Steppe Biome in North America, people have seriously proposed turning is back to the Bison. A bison dominated ecosystem might yield more meat and hides than the current system dominated by farming and ranching.

Human uses of the Steppe

Ghost farmhouse, Pawnee National Grassland.

Antique reaper

Iowa corn farm. Much more reliable rains on the former tallgrass prairie

The National Grassland system was established in the 1930s to buy out farmers beaten by drought on the shortgrass prairie and economic depression

Livestock raising is a dominant use of drier and colder variants of Steppes

Tibetan herders, yaks

Cattle, well, Colorado

The Mongol Empire.

Mongol heavy cavalry

Mongol Empire in 1280. Note that Biomes 7 and 7a are smack in the middle of the Empire

Batu's attacks on Hungary and Poland

Batu's Mongols fighting Christian knights in Eastern Europe

The Mongols were the last and greatest of many empires based on the military advantages of pastoral nomadism. Pastoralists live a hard life that includes much fighting over easily stolen livestock. They are practiced warriors as a matter of course. When mounted on horses they could move swiftly over long distances and concentrate masses of horse soldiers for raids and attacks. The Mongols under Genghis and his successors reduced this advantage to a science. On the other hand, tribal scale political units could operate a pastoral economy very effectively. Steppe empires typically dissolved into their tribal constituents after their charismatic founders died. The Moguls of India were the longest surviving part of the Mongol Empire, and were still around when the Europeans arrived in India in the late 18th Century.

From 1222-1242 Batu, Genghis Kahn's grandson, conquered the Russian kingdoms and then defeated Hungary and Poland. He abruptly returned with his army to Mongolia when his father died, ending the Mongol threat to conquer Europe.