Desert Biomes
of North America and Beyond

Optional reading: McAuliffe 1994,

Landscape Evolution, Soil Formation,
and Ecological Patterns and Processes
in Sonoran Desert Bajadas

(review figures)

DESERT ECOSYSTEMS

Deserts are the most widespread ecosystems on Earth

- 12% of the terrestrial surface (Fig 4.1)
- 18 million km^2 (56 million square miles)
- Mainly at ~30° N and S; subsiding branch of Hadley cells

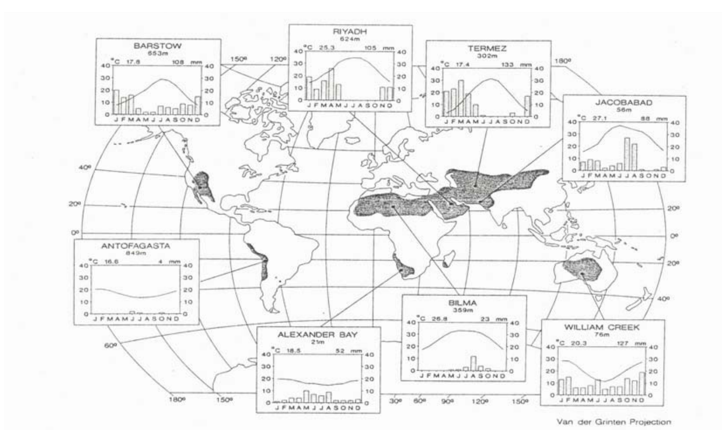


Figure 4.1 Distribution of arid regions and representative climatic conditions. Mean monthly temperatures are indicated by the line and mean precipitation for each month is shown by the bars. Station elevation, mean annual temperature and mean annual precipitation appear at the top of each climograph.

Physiographic Distribution of Deserts

- Coastal deserts (e.g., Atacama and Namib): Effect of cold ocean currents
- Rainshadow deserts (e.g., Mojave and Great Basin): Lee side of mountain ranges
- Continental Deserts (e.g., Sahara, Australia): High pressure zones in the subtropics and long distances from the ocean
- Polar Deserts: High pressure at poles

Desert Environments

- Water limited: huge variety of adaptations
- Annual precipitation is not a good predictor
- P/E ratio is less than about 0.7
  - Warm deserts P/E < 0.3
  - Cold deserts P/E about 0.3-0.7
- Low productivity: 10-250 g biomass m^{-2} $year^{-1}$
- Because of low P/E ratio, very little leaching
- Consequently, desert soils can be quite fertile if not saline; productive if water is provided

Desert Environments

- Disturbances such as fire are rare (why?)
- Regular, severe drought may be considered a type of disturbance to which desert plants are well adapted
- Variability (unreliability) of precipitation increases with decreasing amount of rainfall

Deserts in North America

Basin and Range physiographic province contains all N. American deserts

Figure 20-37 Four regions of desert scrub vegetation and one grassland-desert ecotone (sagebrush steppe) in North America. Modified from MacMahon and Wagner (1985) and West (1998).

Cold deserts: Great Basin, Sagebrush steppe
(Lectures on 10/7 & 10/9)
Distinguished by winter frosts and snow in colder regions

Warm deserts: Mojave, Sonoran, Chihuahuan
distinguished based on seasonality of precipitation

Table 20-8 Some climatic features of the four desert regions of North America.

	Great Basin	Mojave	Sonoran	Chihuahuan
Area (km^2)	409,000	140,000	275,000	453,000
Annual precipitation (mm)	100–300	100–200	50–300	150–300
Precipitation falling in summer (% of total)	30	35	45	65
Snowfall (cm; 10 cm snow = 1 cm rain)	15–30	25–75	trace	trace
Winter mean max/min temperatures (°C)	+8/−8	+15/0	+18/+4	+16/0
Hours of frost (% of total)	5–20	2–5	0–1	2–5
Summer mean max/min temperatures (°C)	34/10	39/20	40/26	34/19
Elevation (m)	>1000	variable	<600	600–1400

Warm deserts plotted in precipitation space

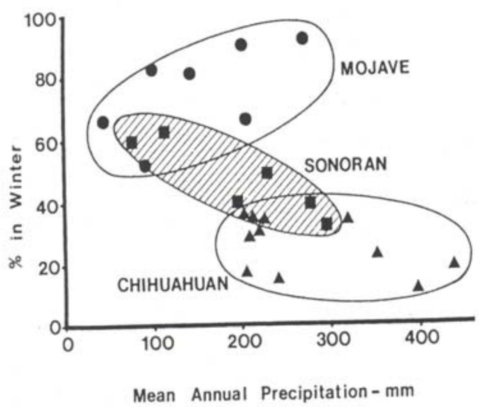
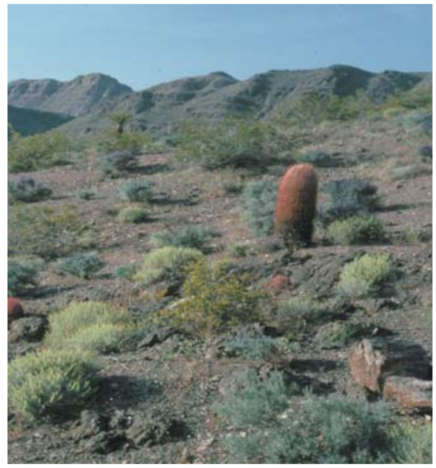


Figure 8.6. Percentage of winter rainfall plotted against mean annual precipitation for a variety of sites. Adapted from MacMahon and Wagner (1985).

Mojave desert

- Winter precipitation dominates
- Range of elevations: -70 to 1800 meters
- Canopy has 2 layers, 5-10% cover
  - Creosote (tall shrub) and variety of subshrubs
- Blackbrush (*Coleogyne ramosissima*) and shadscale (*Atriplex confertifolia*) communities occur at lower and upper creosote ecotones



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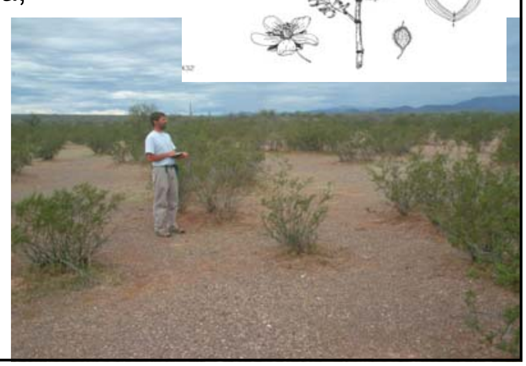
Mojave desert

- 70% of Mojave desert is co-dominated by creosote bush (*Larrea tridentata*) and white bursage (*Ambrosia dumosa*; Asteraceae)
- Creosote bush most widespread shrub in warm deserts; analogous to sagebrush in cold deserts



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Mojave desert

Joshua tree (*Yucca brevifolia*) is charismatic plant of Mojave, but found mainly at higher elevations, actually has low cover (<1 to 10%)

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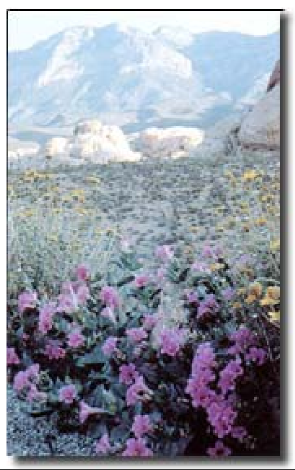
Mojave desert

- Winter annuals fill in spaces between shrubs during wet El Niño years



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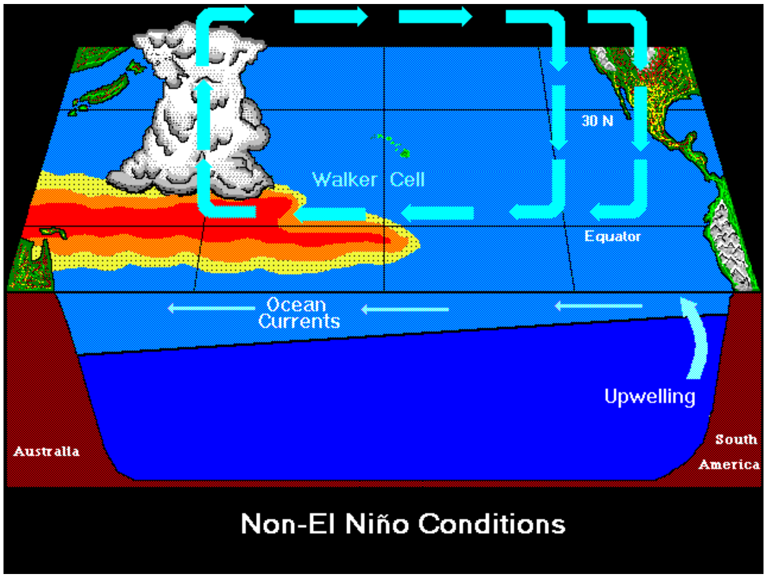

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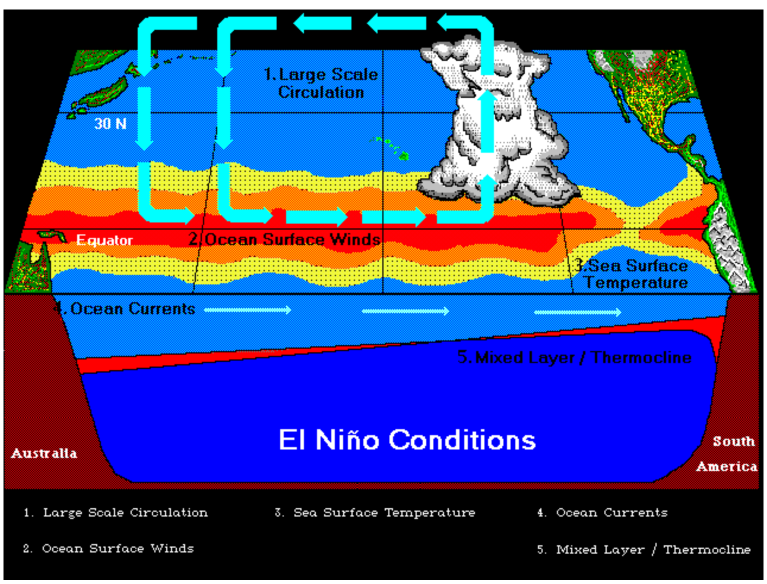

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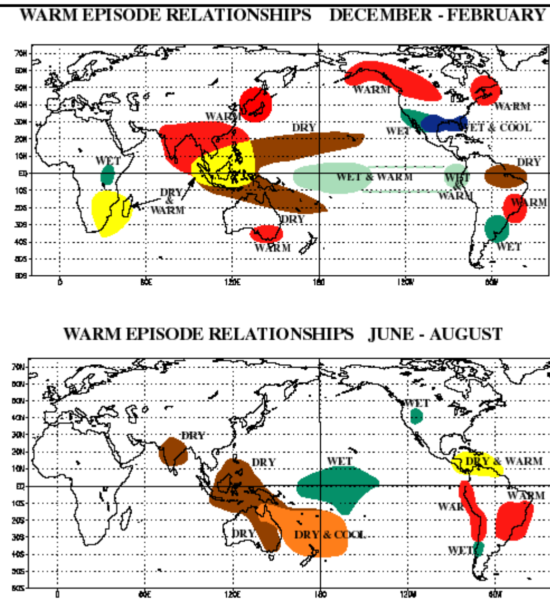
Warm episode refers to El Niño conditions



Climate Prediction Center
NCEP

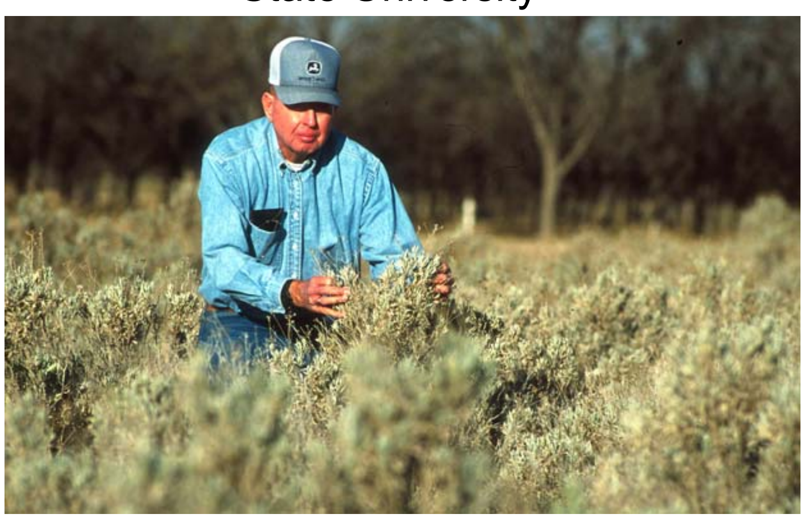
Chihuahuan Desert:

- Summer precipitation dominates
- Generally high elevation (400-2000m, average 1500 m)
- 2 layers or canopies, 20-25% cover
- Creosote bush dominant tall shrub; tarbush (*Fluorensia cernua*) common subshrub

Chihuahuan Desert:

- Guayule (*Parthenium argentatum*) low shrub, experimentally cultivated for latex
- Succulents are important: *Opuntia* and *Agave*
- Desert grassland component (C4!)
  - Tobosa (*Hilaria mutica*), bush muhly (*Muhlenbergia porteri*), black grama (*Bouteloua eriopoda*)
  - Mesquite (*Prosopis glandulosa*) invasion
- Summer annuals

Guayule, New Mexico State University



Sonoran desert

- Bimodal precipitation, more winter rain to west (more arid too), more summer rain to east (more humid)
- Generally low elevation (average 600 m)
- Highest biodiversity of all N. American deserts:
- 4 layers, 25-35% cover

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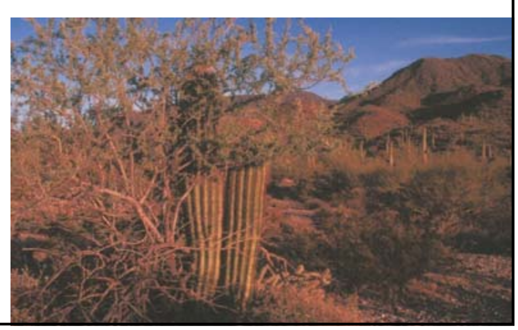
Sonoran desert

- Subtree layer (2-4 m tall)
- Creosote & cactus layer (1-2 m tall)
- Subshrub layer (1 m tall), bursage (*Ambrosia deltoidea*), brittle bush (*Encelia farinosa*), jojoba (*Simmondsia chinensis*) cultivated for oil
- Summer & winter annuals, perennial C4 grasses



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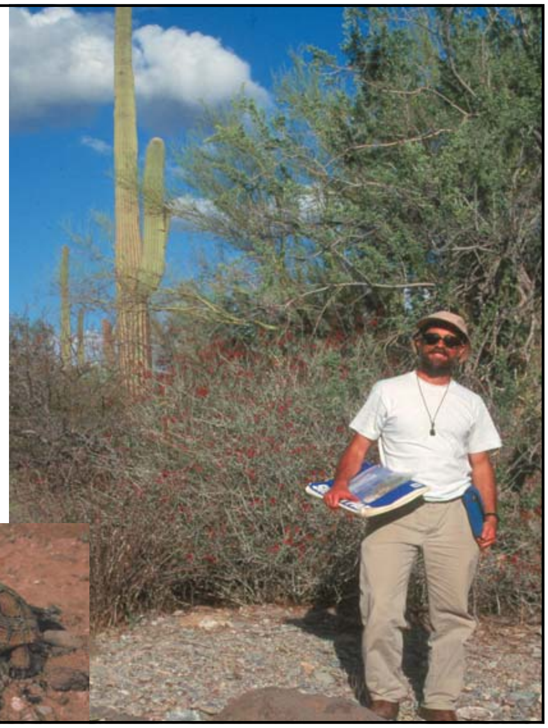
Sonoran desert

- Charismatic saguaro cactus (*Carnegia gigantea*) with leguminous subtrees paloverde (*Cercidium microphyllum*) and ironwood (*Olneya tesota*) (3-5 m tall)
- Charismatic endangered desert tortoise in all warm deserts



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Desert geomorphology characterized by alluvial fans and bajadas, dissected by arroyos or washes, grading down into playas

Dominant paradigm: Gradient of vegetation corresponds to gradual change in soil texture along bajada axis (coarse to fine)

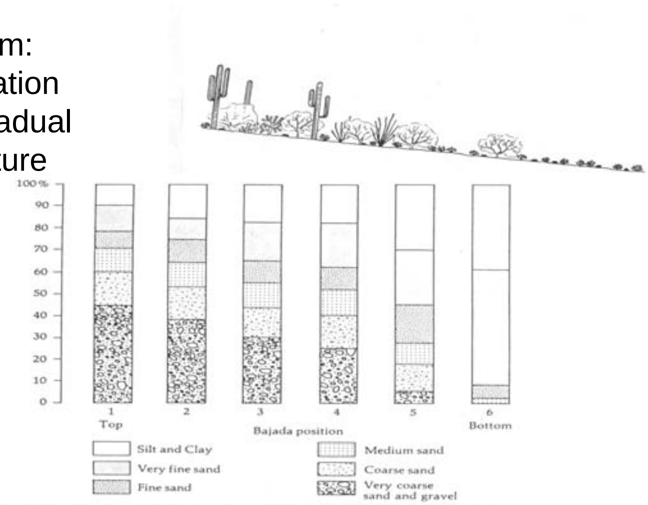

Figure 20-41 Soil particle size distribution for six sites along an Arizona bajada. Redrawn from MacMahon and Wagner (1985).

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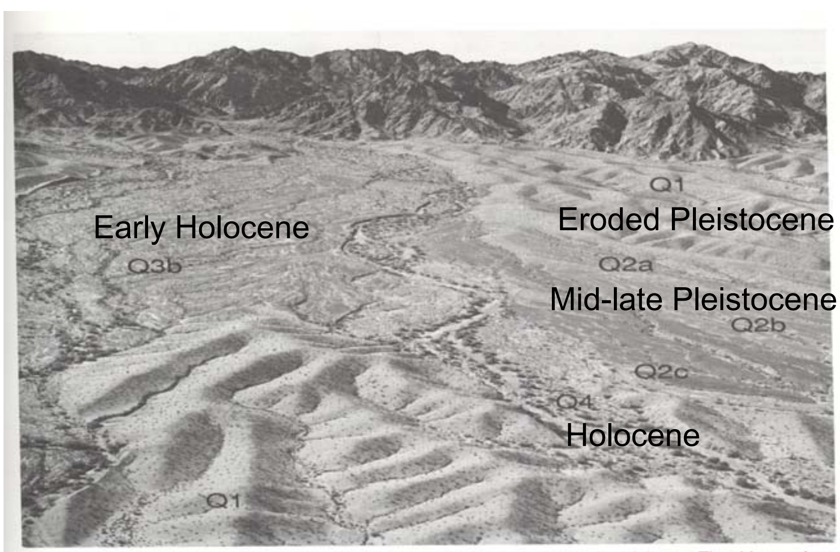
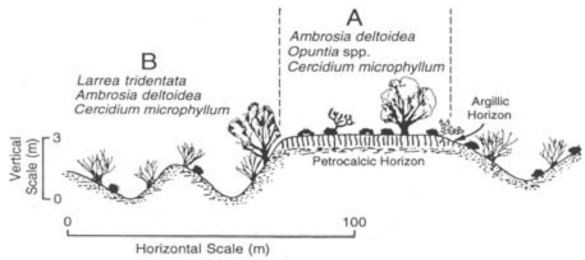
Joe McAuliffe (1994) used polar ordination (Bray-Curtis) to demonstrate the influence of soils & geomorphology on vegetation in Sonoran desert (see optional reading)

- Vegetation gradient “far too simplistic”
- Abrupt boundaries corresponding to soils and surface ages responsible for vegetation distribution, not the classic gradient paradigm



Example of two geomorphic surfaces



A: Mid-late Pleistocene surface age, clay-rich soils: Bursage, palo verde, cacti; shallow rooted

B: Early Pleistocene surface eroded to gravelly sideslopes: greatest diversity, many short-lived shrubs, paloverde; creosote and bursage co-dominant

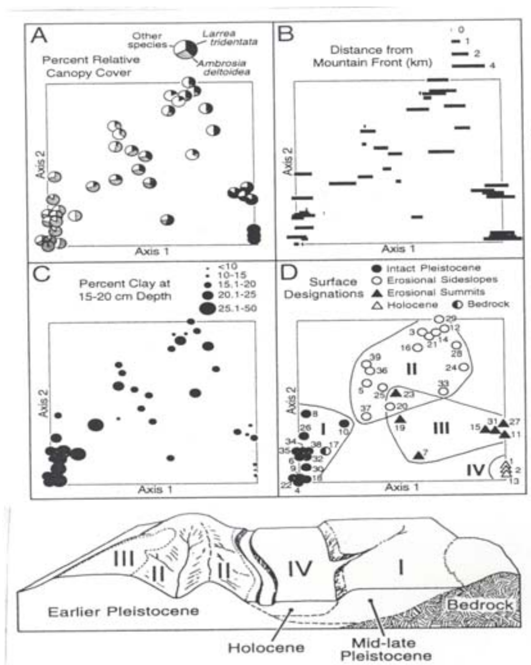


FIG. 12. Landscape designations of sites in the Tucson Mountains study area based on geomorphic and soils attributes. (I) Stable mid–late Pleistocene fan remnants mantled

Polar Ordination:

- Indirect approach
- Environment factors overlaid on plots
- Ambrosia dominant on clayey, mid-late Pleistocene surfaces (I)
- Larrea dominant on sandy, Holocene surfaces (IV)
- Greatest diversity on eroded Pleistocene sideslopes (II)