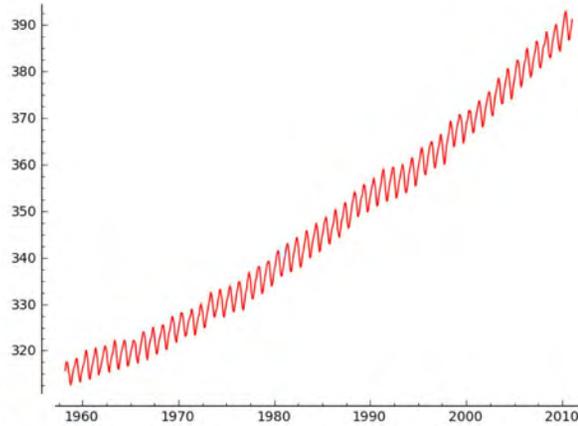


CO₂

H₂O



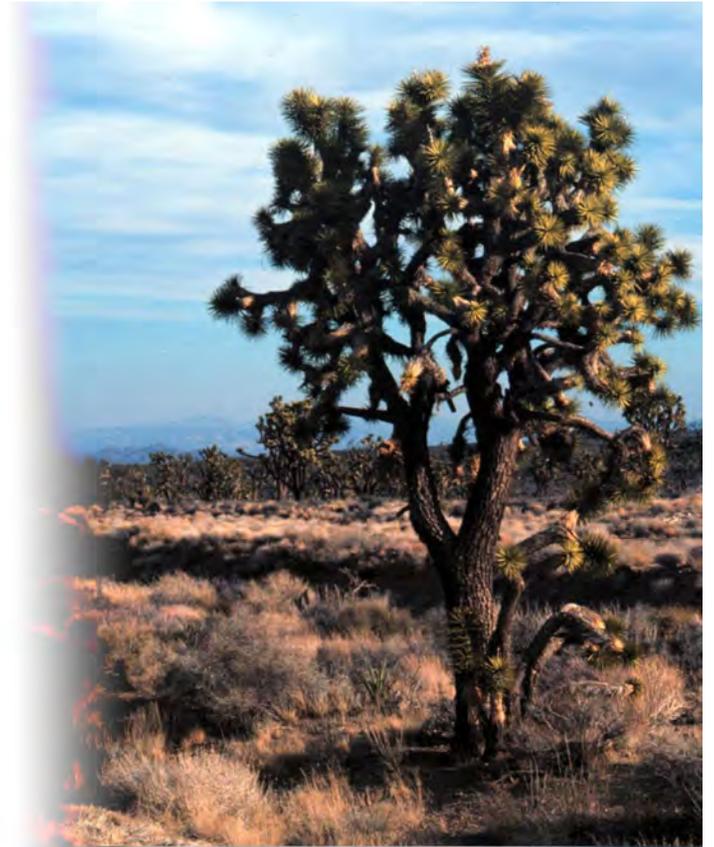
Desert and Steppe Biomes

Part 1

Distribution and climate

Plant Ecology in a Changing World

Jim Ehleringer, University of Utah
<http://plantecology.net>



What do most people think of when you first say “desert”?





Near monospecific stands of jumping cholla, *Opuntia bigelovii*, a largely asexually reproducing perennial, Oatman, Arizona



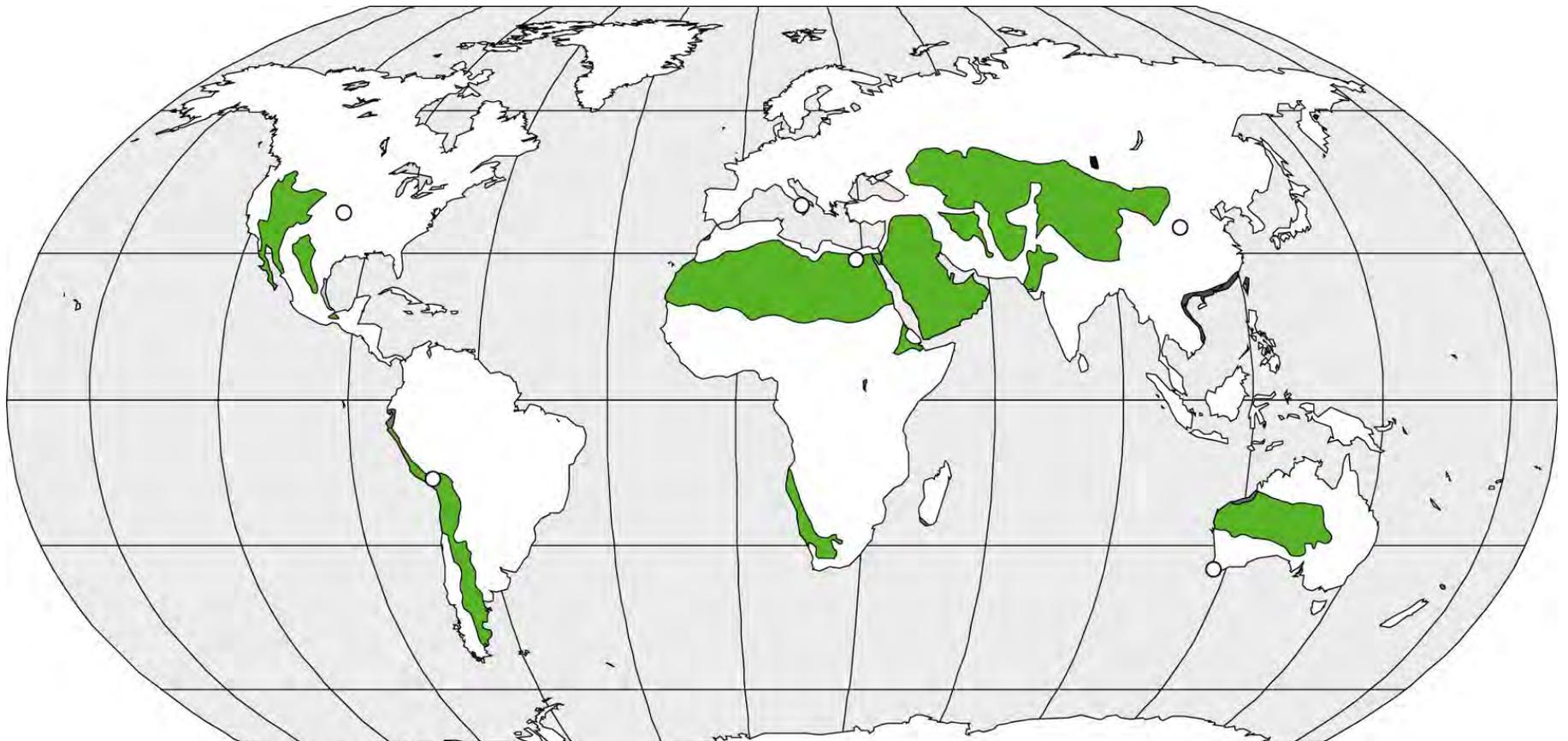
Disarticulating and marescent stems are features of jumping cholla, *Opuntia bigelovii*, Oatman, Arizona



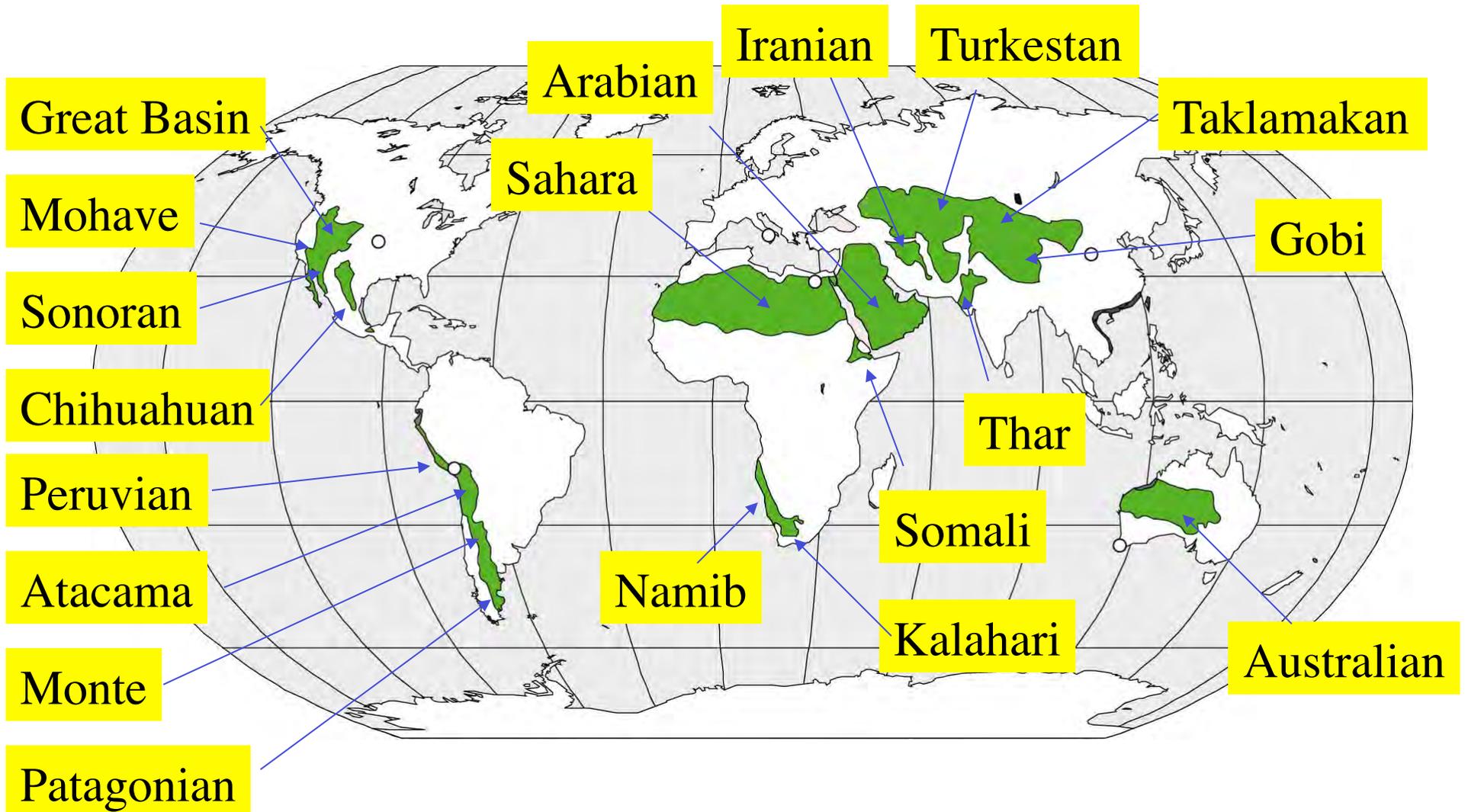
And at the same time, the extensive spines increase reflectance of jumping cholla, *Opuntia bigelovii*, Oatman, Arizona

Desert biomes

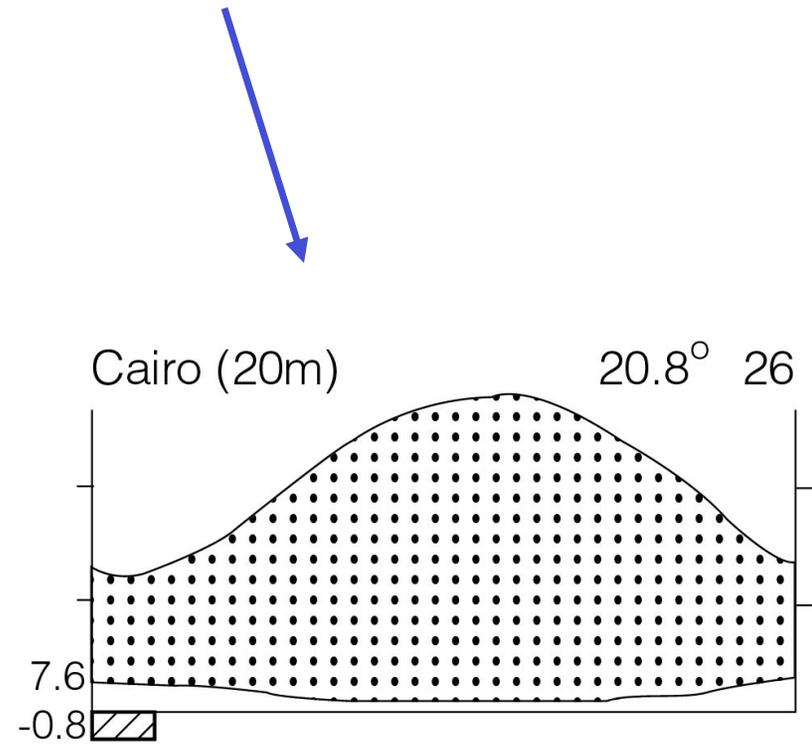
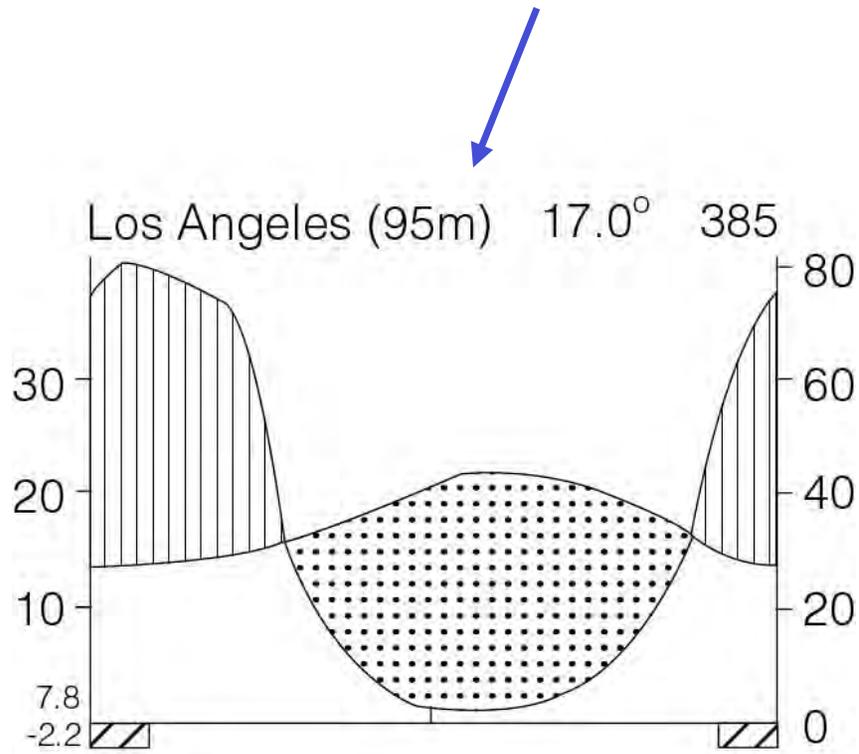
- globally distributed in regions of descending air
- P/E is < 1 , precipitation is generally < 250 mm annually
- Temperature amplitude reflects interior versus coastal distributions



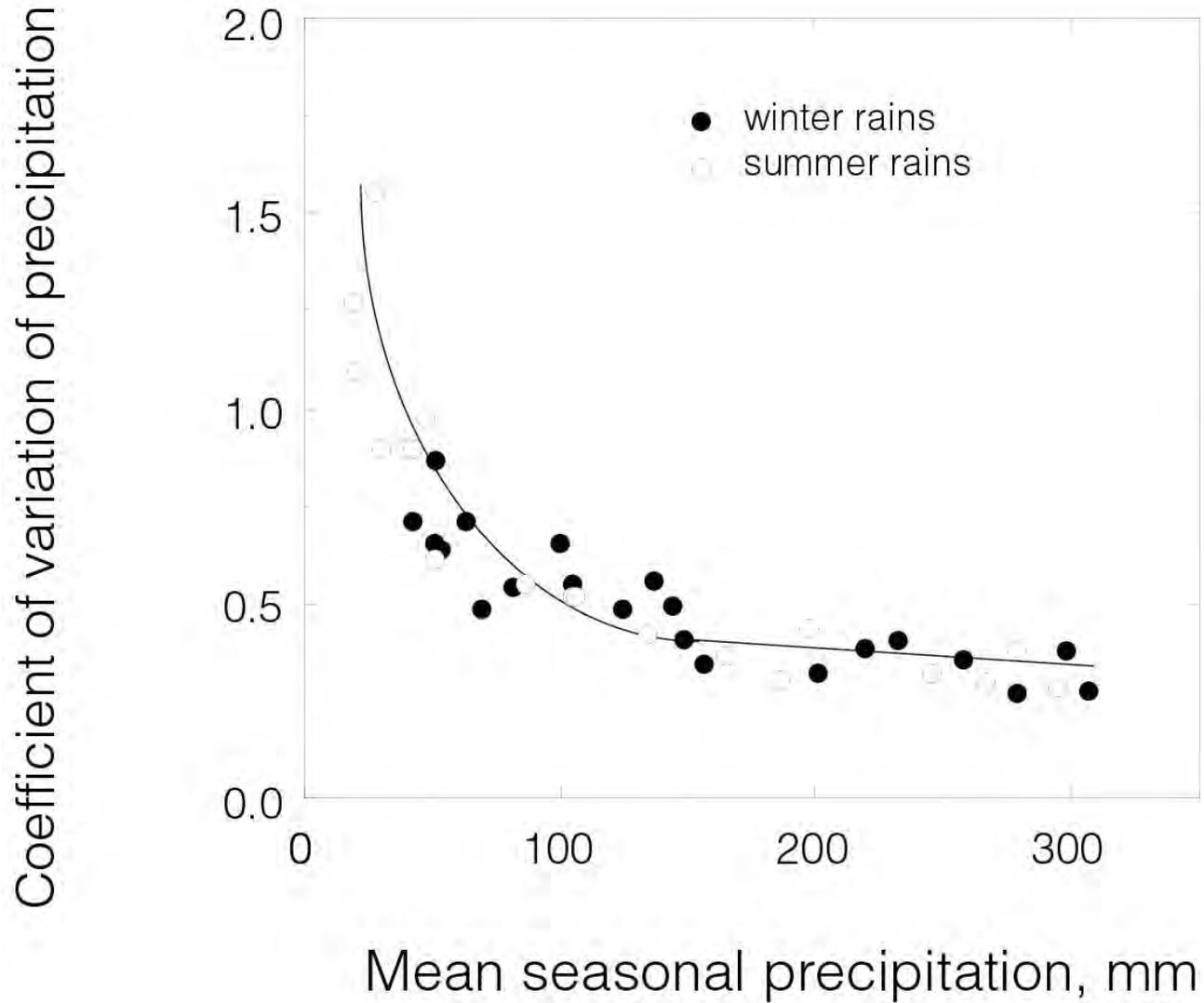
~ 20% of the land surface is classified as desert



Notice differences in the climate diagrams for Mediterranean and desert climates



Interannual predictability of precipitation is low in deserts



Coastal deserts

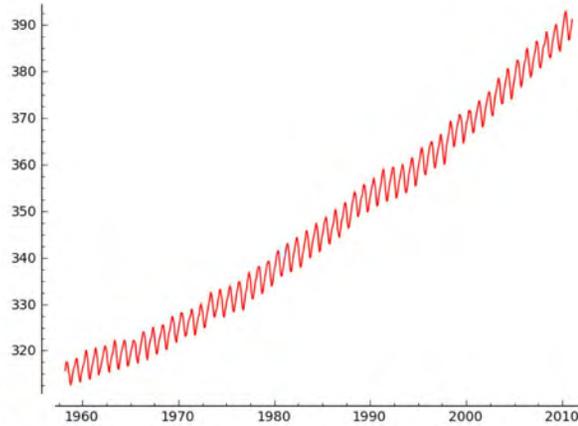
- western portions of continents in areas of cold-water upwellings
- low annual temperature amplitudes
- diurnal air temperatures are typically moderate
- typically very low precipitation; El Nino impacted
- often associated with fog zones

Interior deserts

- interior portions of continents, often in geographic rain shadows
- large annual temperature amplitudes
- diurnal air temperatures are often quite high
- may have winter, summer, or biseasonal precipitation patterns

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H₂O



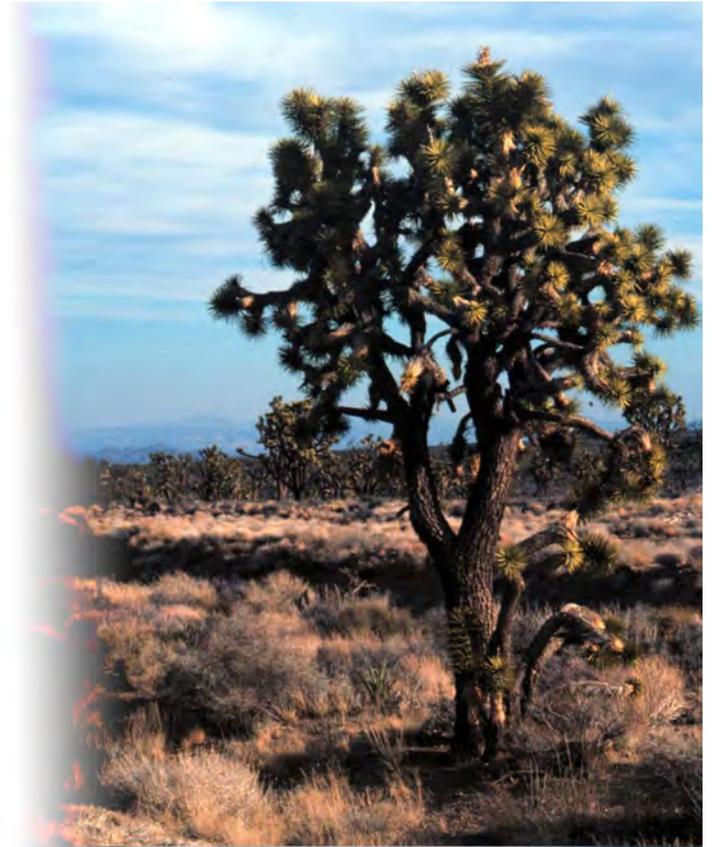
Desert and Steppe Biomes

Part 2

North American and Utah deserts

Plant Ecology in a Changing World

Jim Ehleringer, University of Utah
<http://plantecology.net>



Precipitation patterns distinguish among North American deserts

- Sonoran
- Mohave
- Chihuahuan
- Great Basin (steppe)



Precipitation in North American deserts is strongly dependent on rain shadow, moisture source, and elevational factors

	cold desert	warm desert
winter moisture	Great Basin	Mohave
summer moisture	---	Chihuahuan
bi-seasonal moisture	Colorado Plateau	Sonoran



Steppe is a term describing interior desert shrublands and grasslands, often applied to Eurasian sites and can be applied to the Intermountain West



Sagebrush steppe (*Artemisia tridentata*) near Shoshone, Idaho

Steppe is a term describing interior desert shrublands and grasslands, often applied to Eurasian sites and can be applied to the Intermountain West



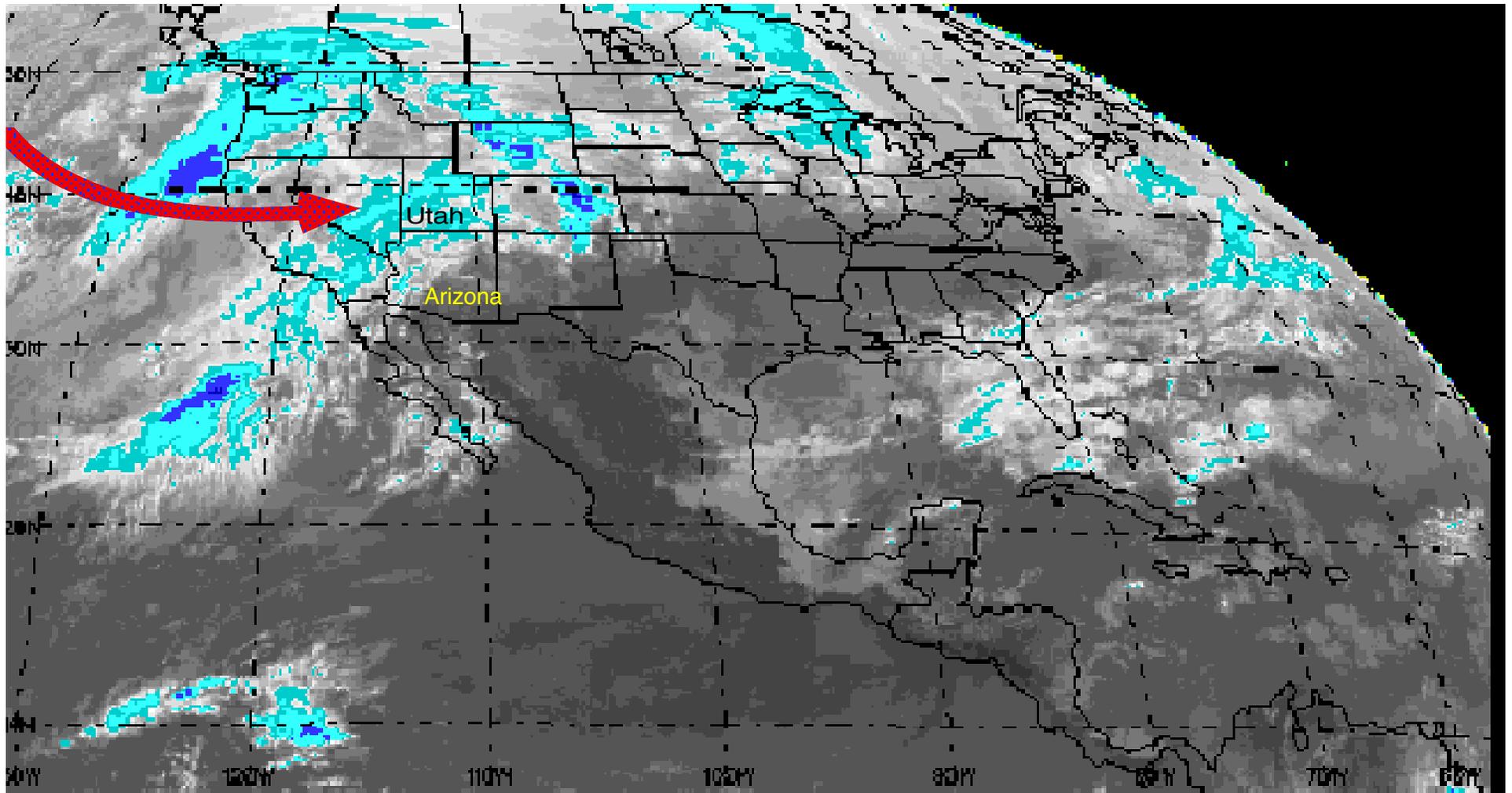
Bromus tectorum
(cheatgrass)

Sagebrush steppe (*Artemisia tridentata*) near Shoshone, Idaho
Note the sharp background transition from shrubs to grassland

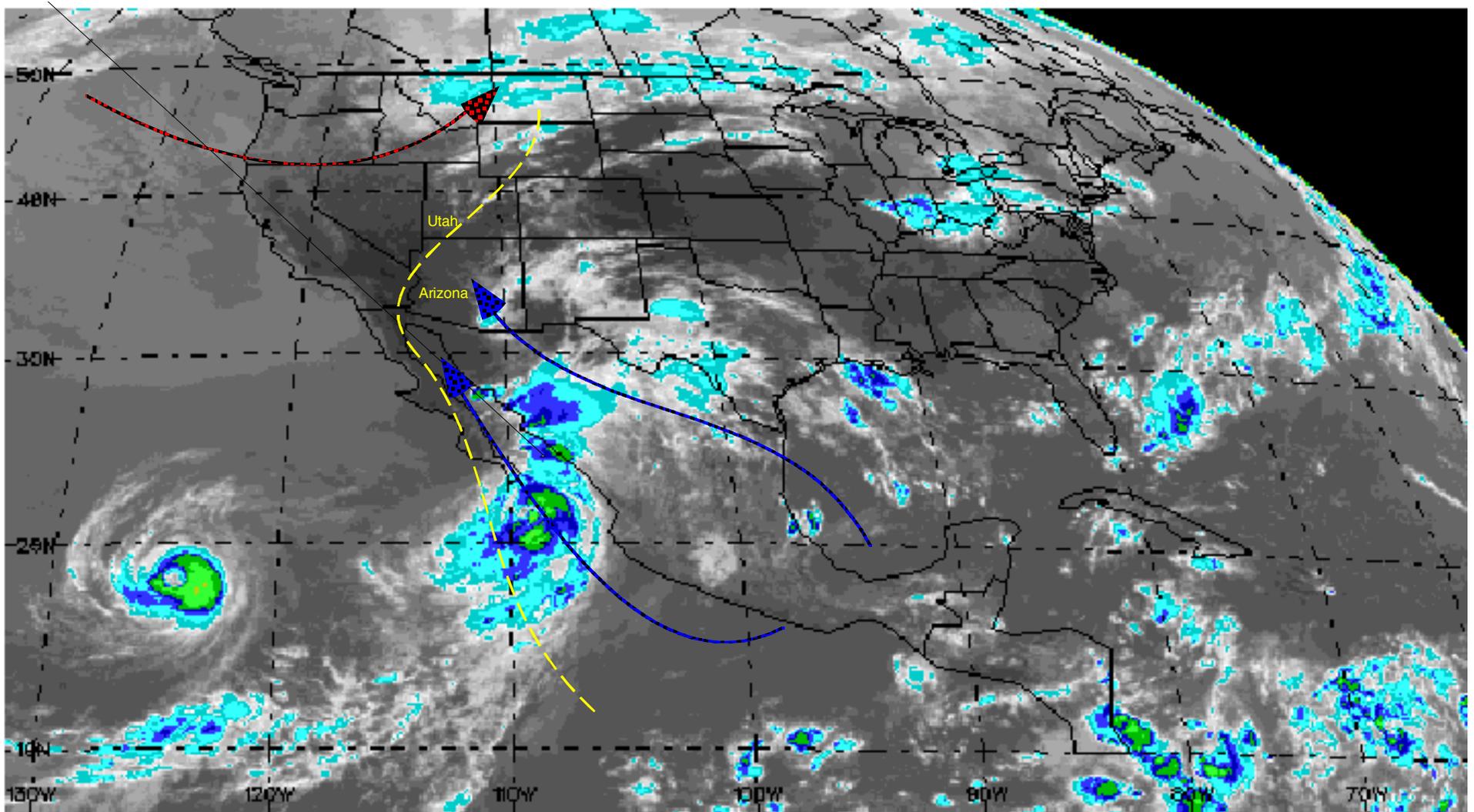
Steppe ecosystems often experience extensive fire conditions, especially here in the Intermountain West following invasion of cheatgrass (*Bromus tectorum*)

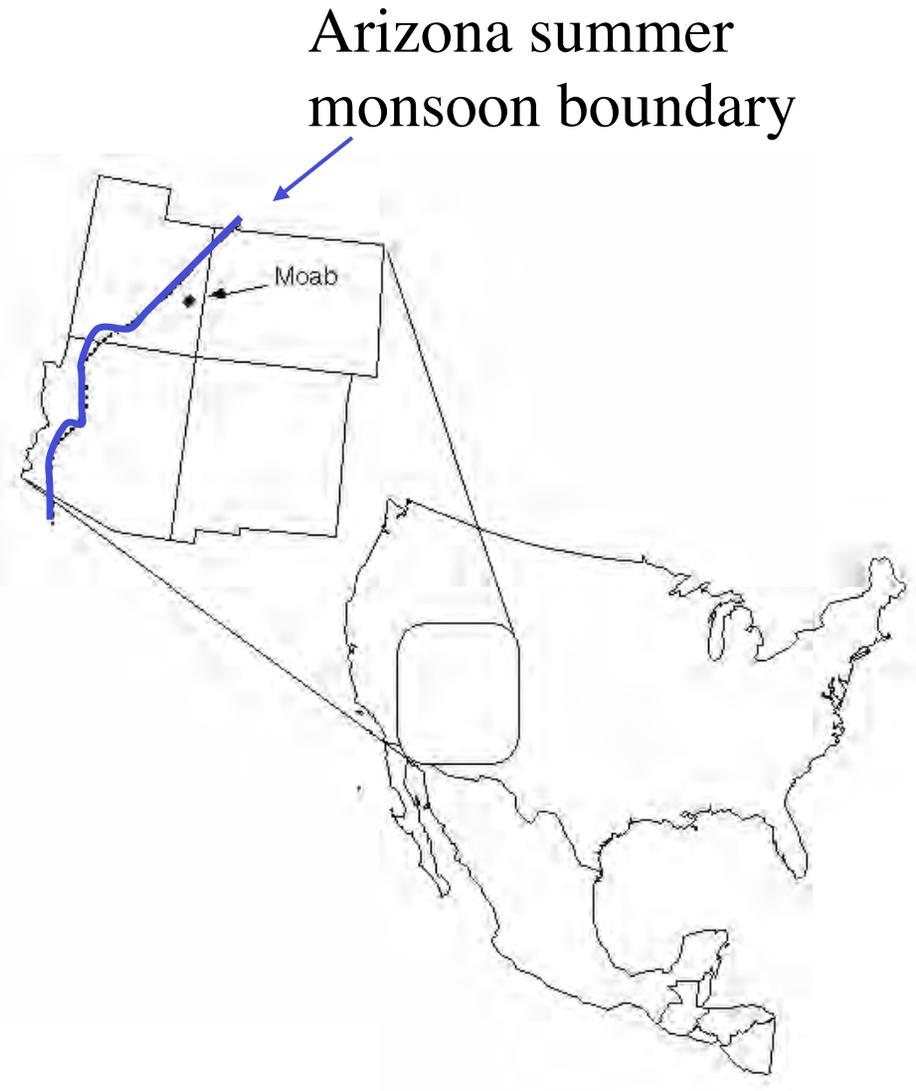
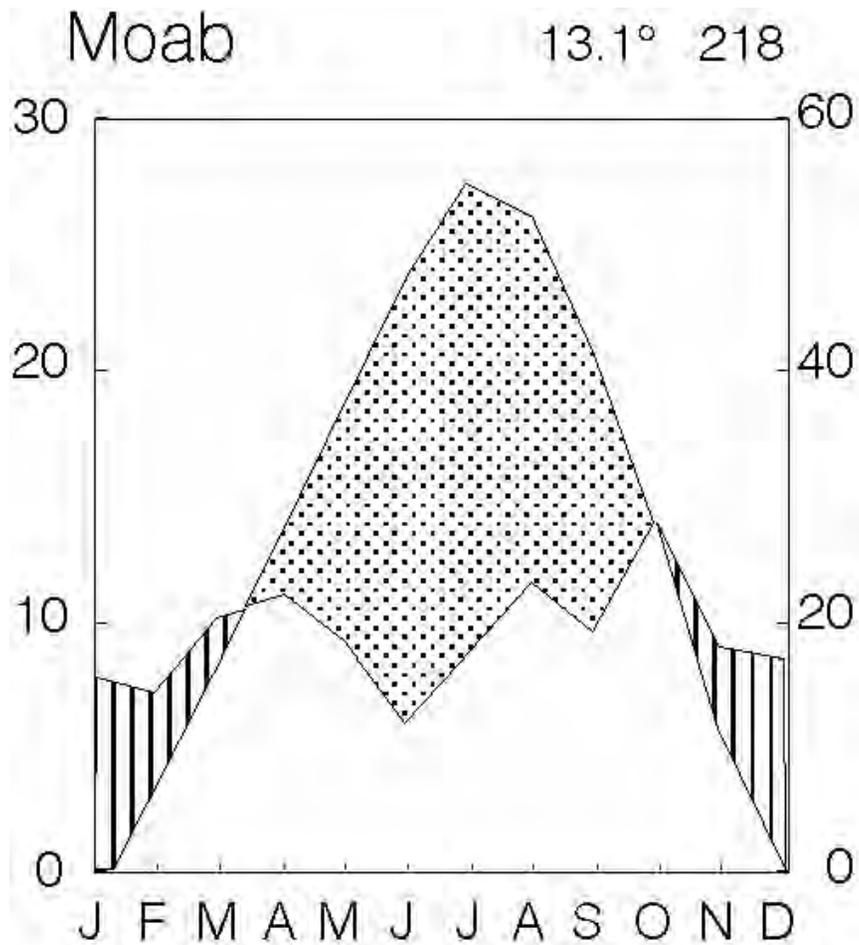


Winter rains are generated from moisture sources in the northern Pacific Ocean

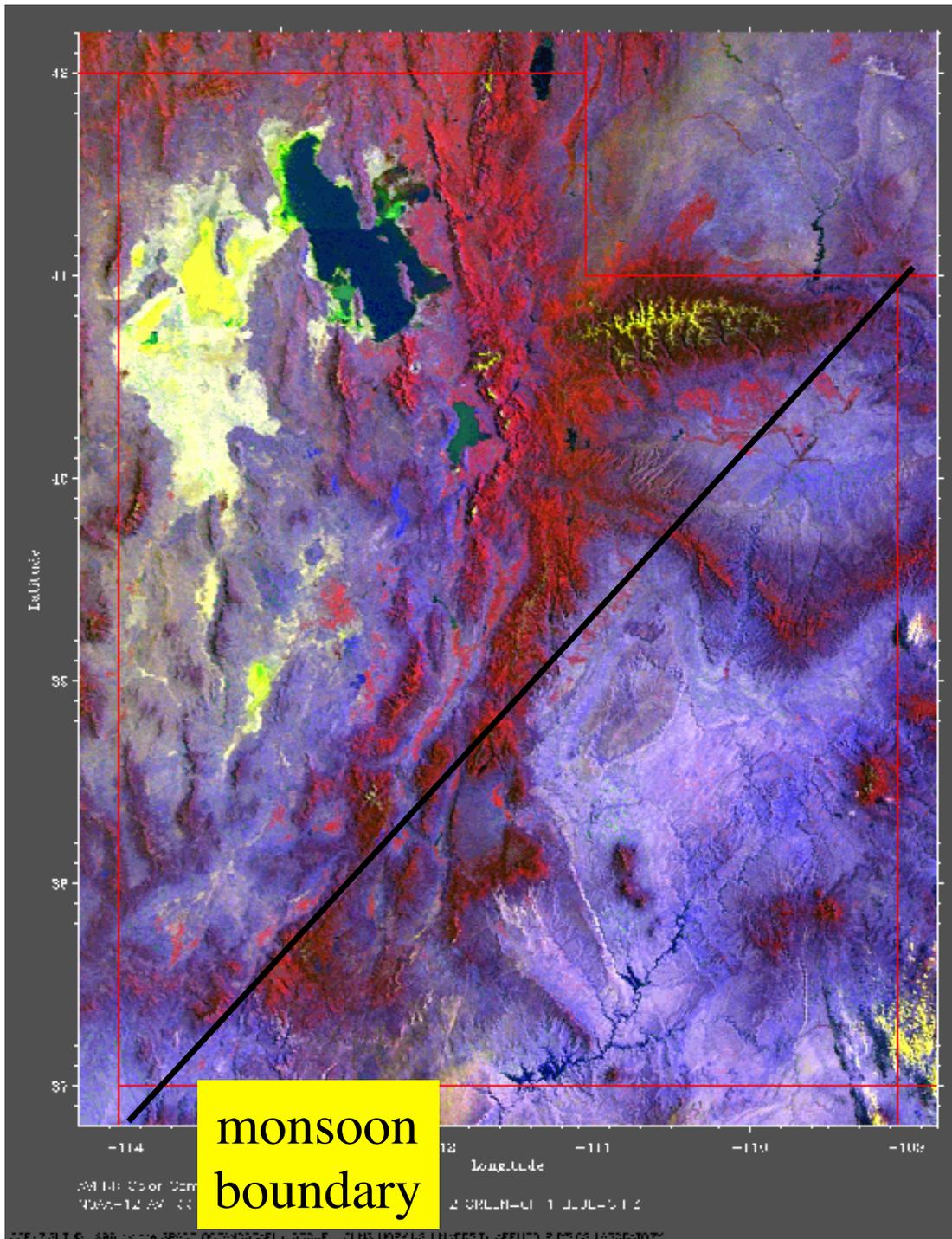


Summer rains are generated from moisture sources in the eastern Pacific Ocean





in Moab, there is an equal probability of precipitation every month



Precipitation in Utah deserts is also strongly dependent on rain shadow, moisture source, and elevation

winter rains -
primarily northwest, decreasing to south

summer rains -
primarily southeast, decreasing to north

west deserts -
primarily saline soils, closed basins

southeast deserts -
aka Colorado Plateau
primarily sandstone, red rock country



Colorado Plateau desert is dominated by perennial shrubs and grasses; sensitive to annual plant invasions

There are few trees, few annuals, and very few succulents

Blackbrush (*Coleogyne ramosissima*)

Utah Juniper (*Juniperus osteosperma*)
(aka cedar)



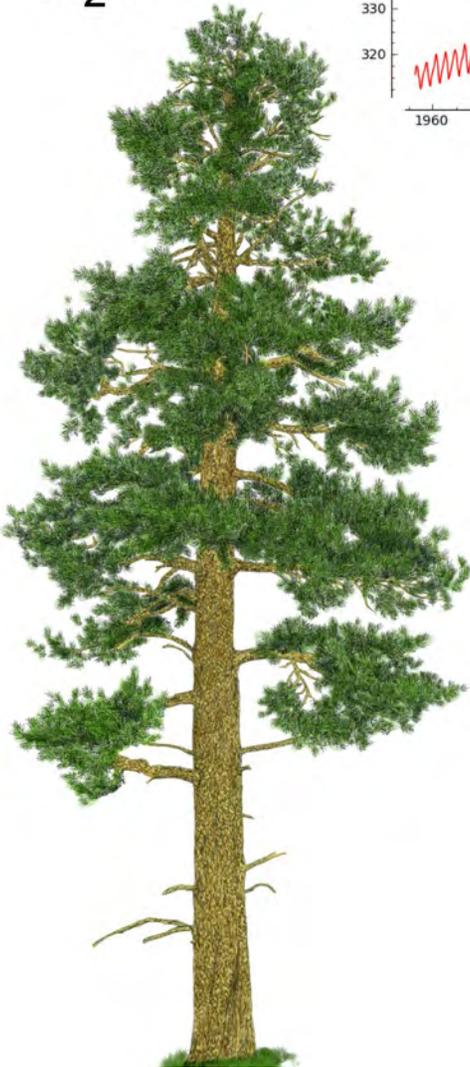
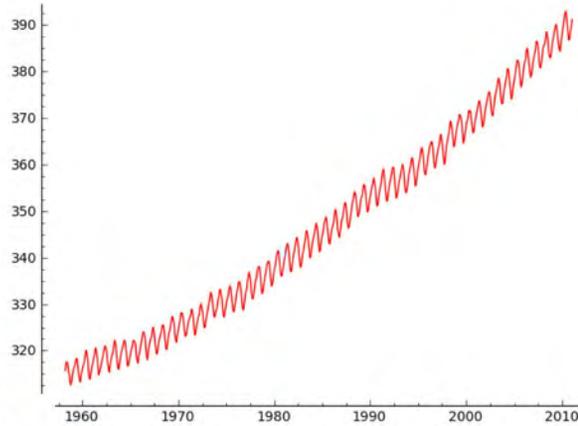


The Joshua Tree (*Yucca brevifolia*) is found at the transition between Mohave and Great Basin Deserts



CO₂

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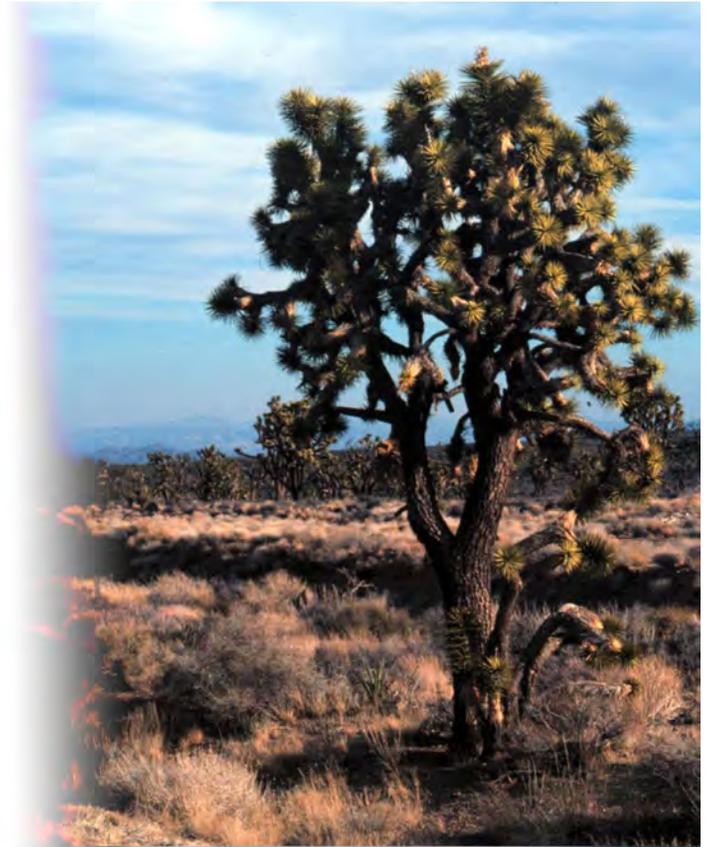
Desert and Steppe Biomes

Part 3

A wide range of
adaptive responses

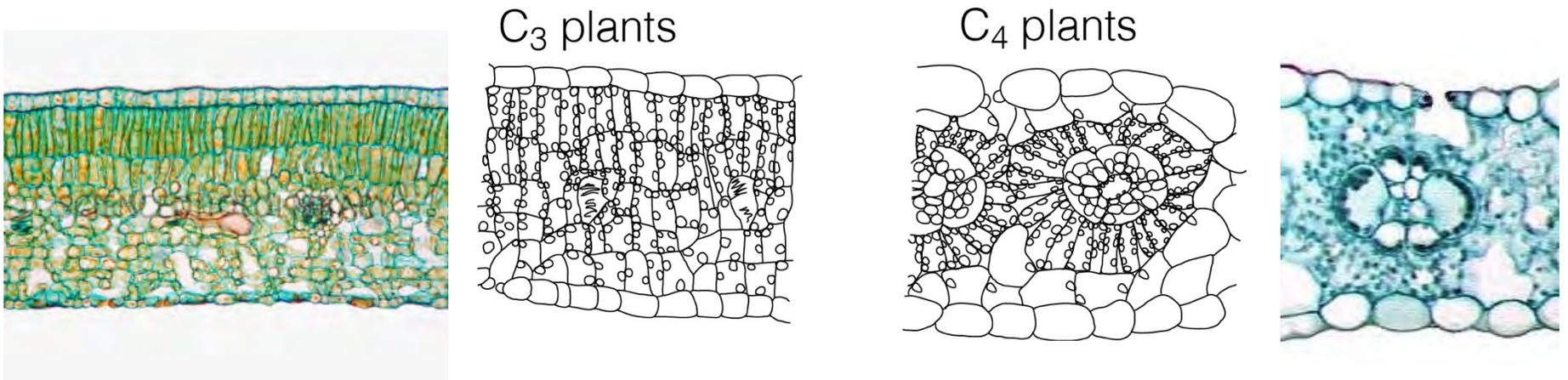
Plant Ecology in a Changing World

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General vegetation characteristics in desert ecosystems

- predominantly annuals and shrubs
- trees typically only in riparian zones
- tendency for a limited number of plant families to predominate (e.g., Asteraceae and Chenopodiaceae)
- variations in photosynthetic pathways (C_3 , C_4 and CAM)
- C_4 and CAM become more common in habitats with summer rains



General patterns of photosynthetic pathway distribution

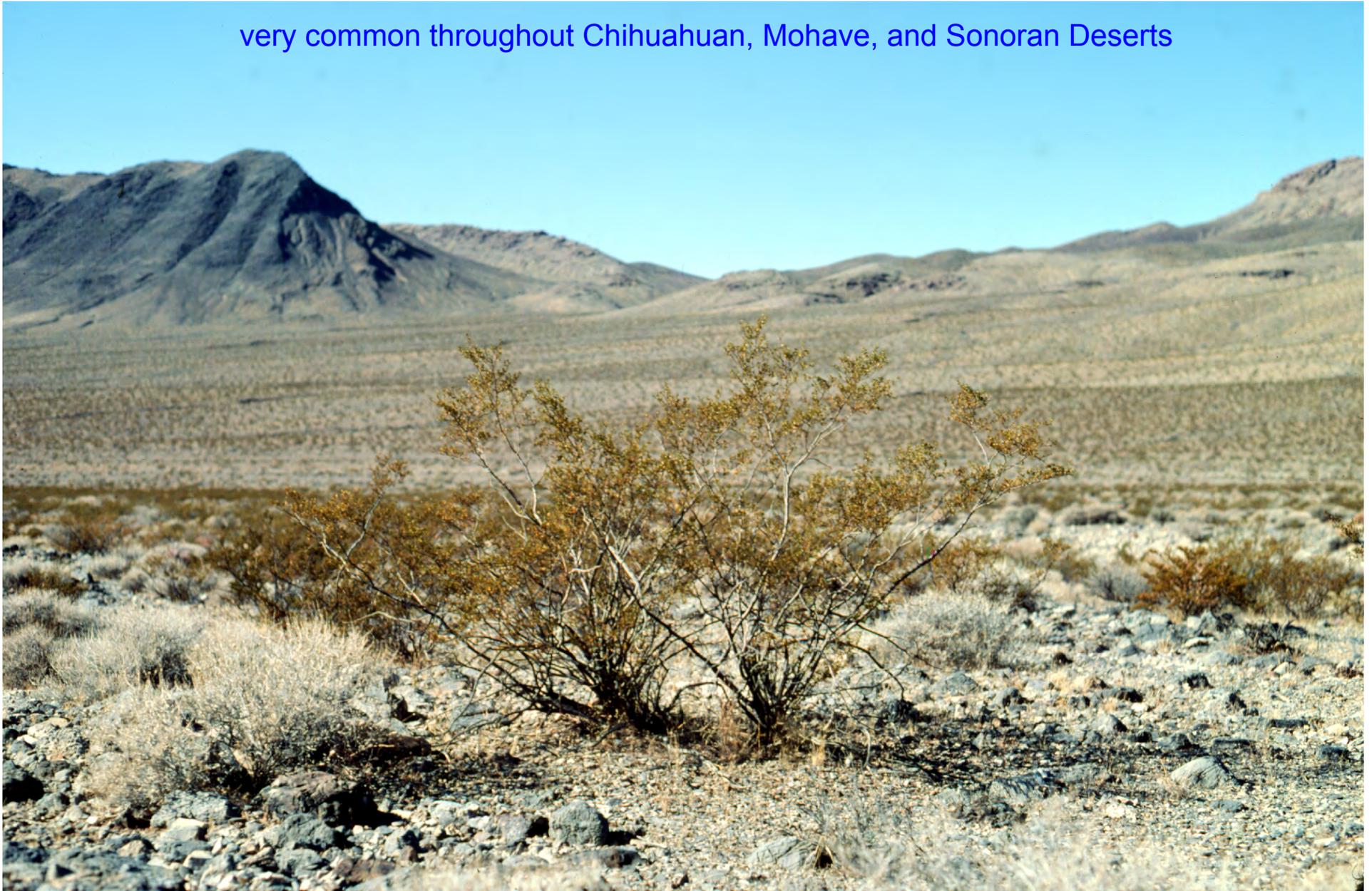
	C3	C4	CAM	C3 - CAM
winter annual	x			
summer annual		x		
winter grass	x			
summer grass		x		
leaf succulent				x
stem succulent			x	
evergreen shrub	x			
deciduous shrub	x			
tree	x			

Solar tracking leaf movements are common in short-lived annuals.

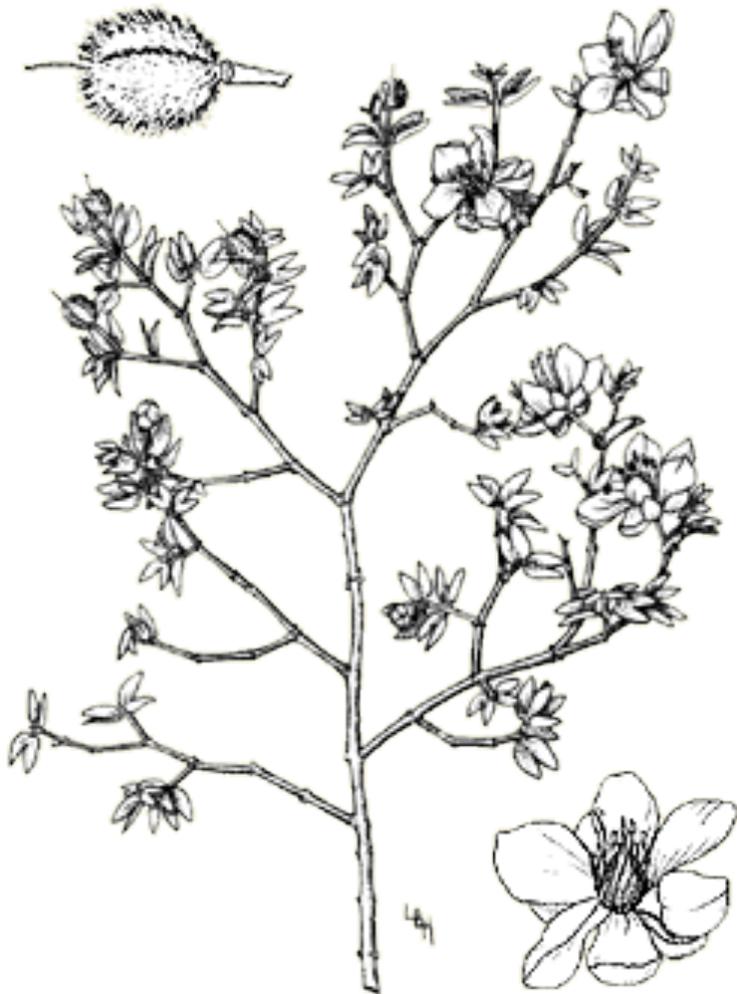


Evergreen leaves as an adaptive feature:
Larrea divaricata dominates many North American deserts

very common throughout Chihuahuan, Mohave, and Sonoran Deserts



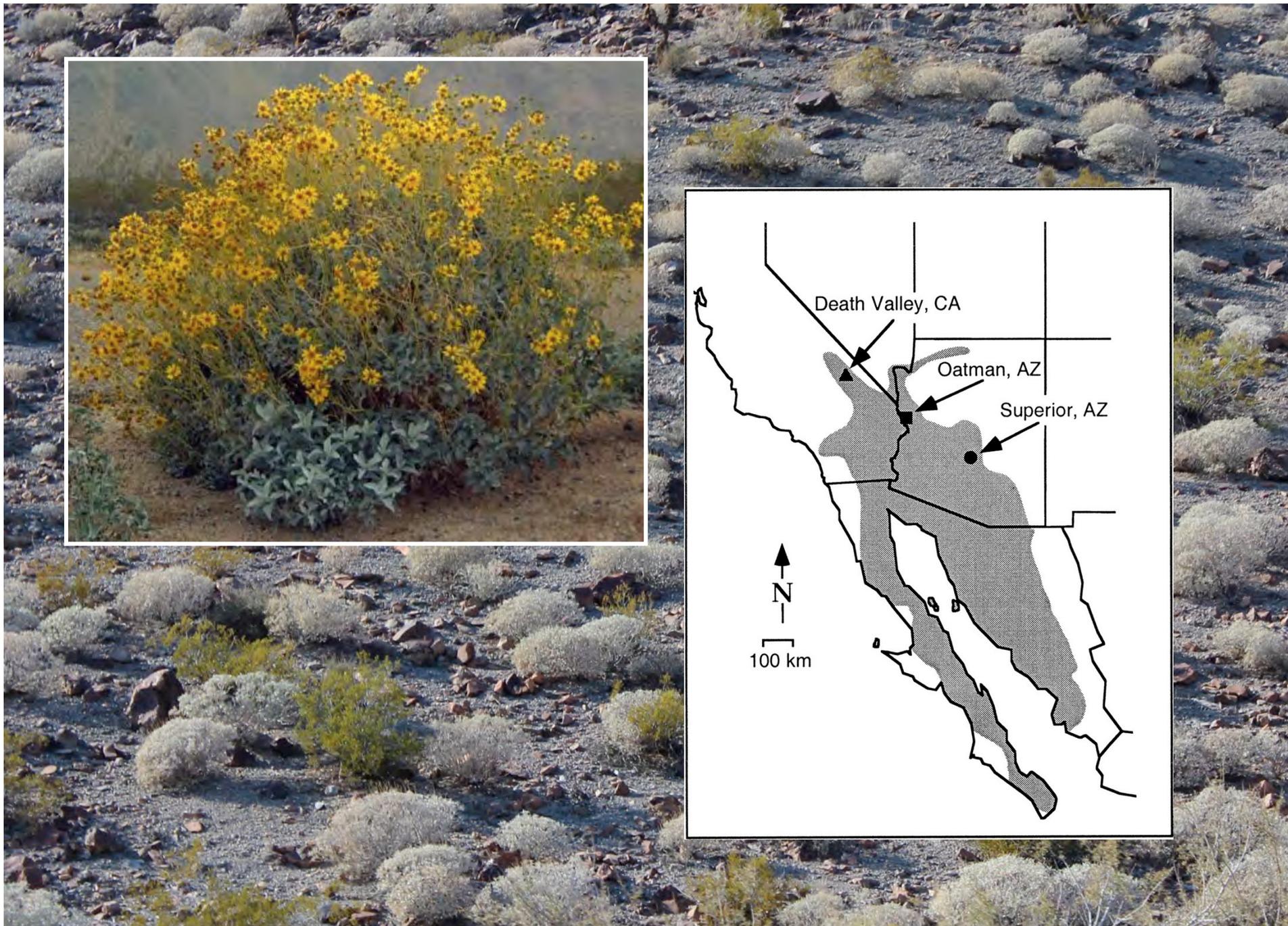
Larrea is often referred to as creosote bush. Its evergreen, sticky leaves emit a strong odor. *Larrea* is very drought tolerant (tolerates extreme water deficits potentials), with clones surviving for thousands of years.



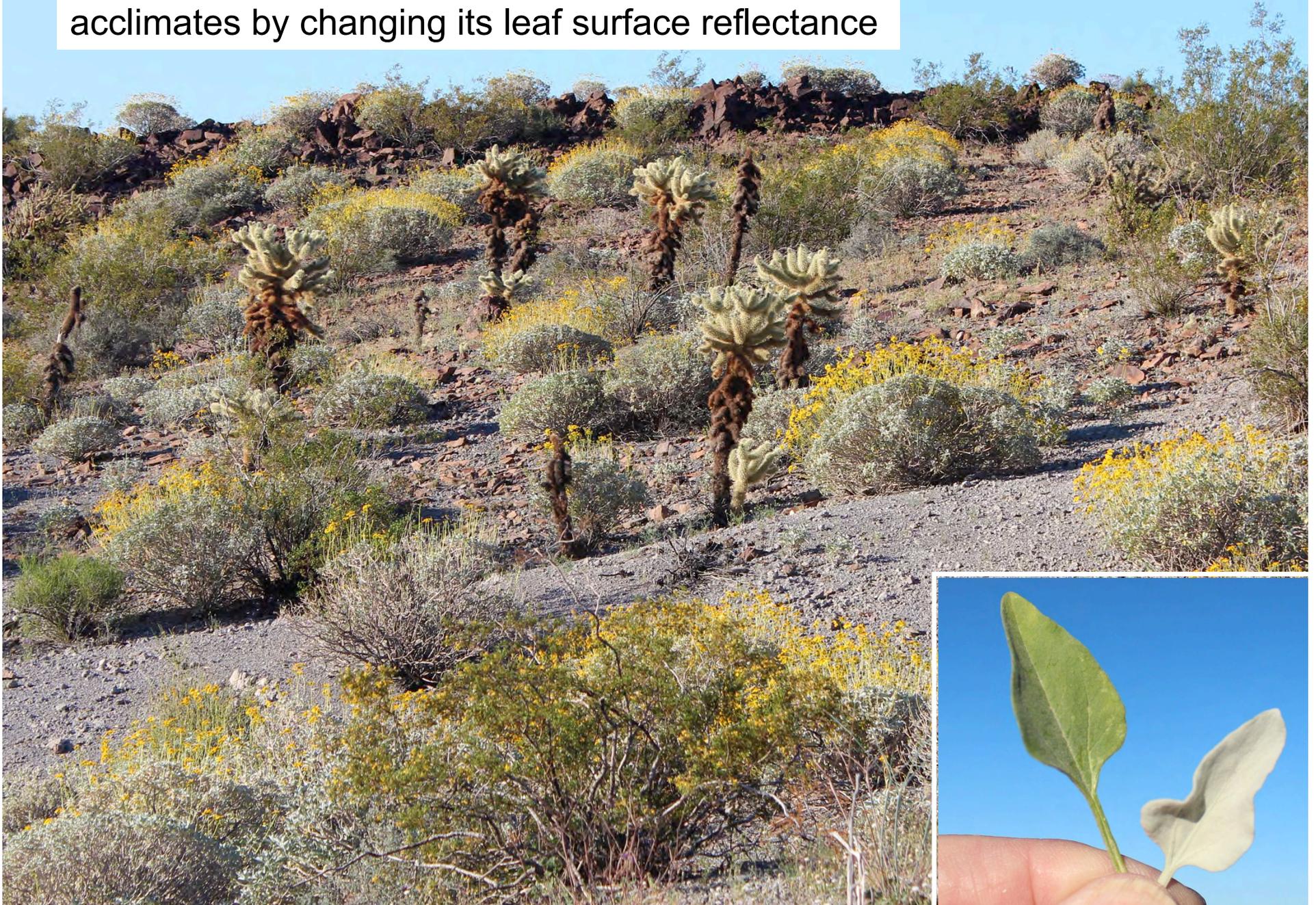
Drought-deciduous leaves as an adaptive feature: *Fouquieria*, a drought-deciduous “tree” of the Sonoran Desert intolerant of water deficits



Other shrubs are less drought tolerant, such as the drought deciduous *Encelia farinosa*



The drought deciduous shrub *Encelia farinosa* acclimates by changing its leaf surface reflectance

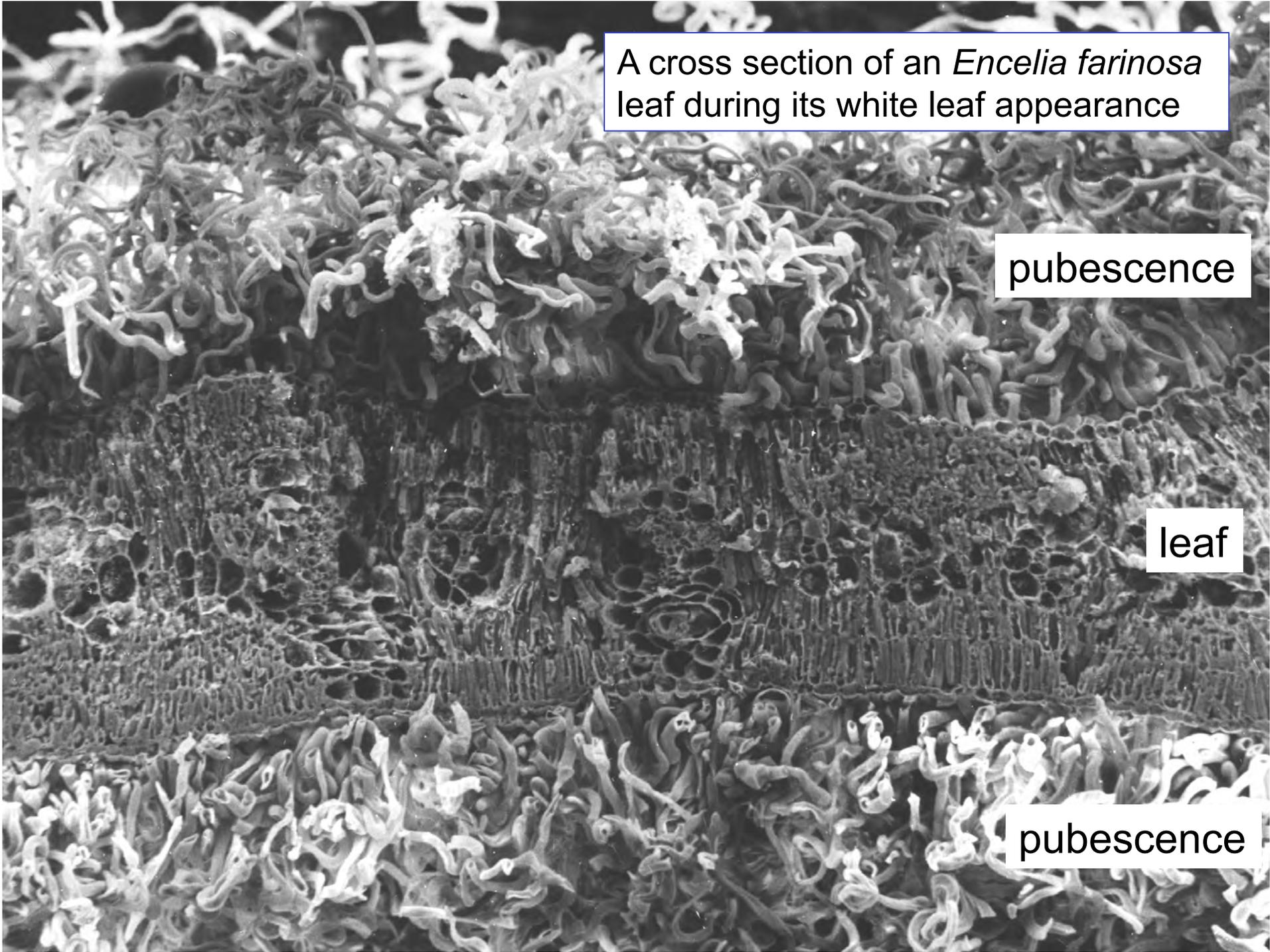


A cross section of an *Encelia farinosa* leaf during its white leaf appearance

pubescence

leaf

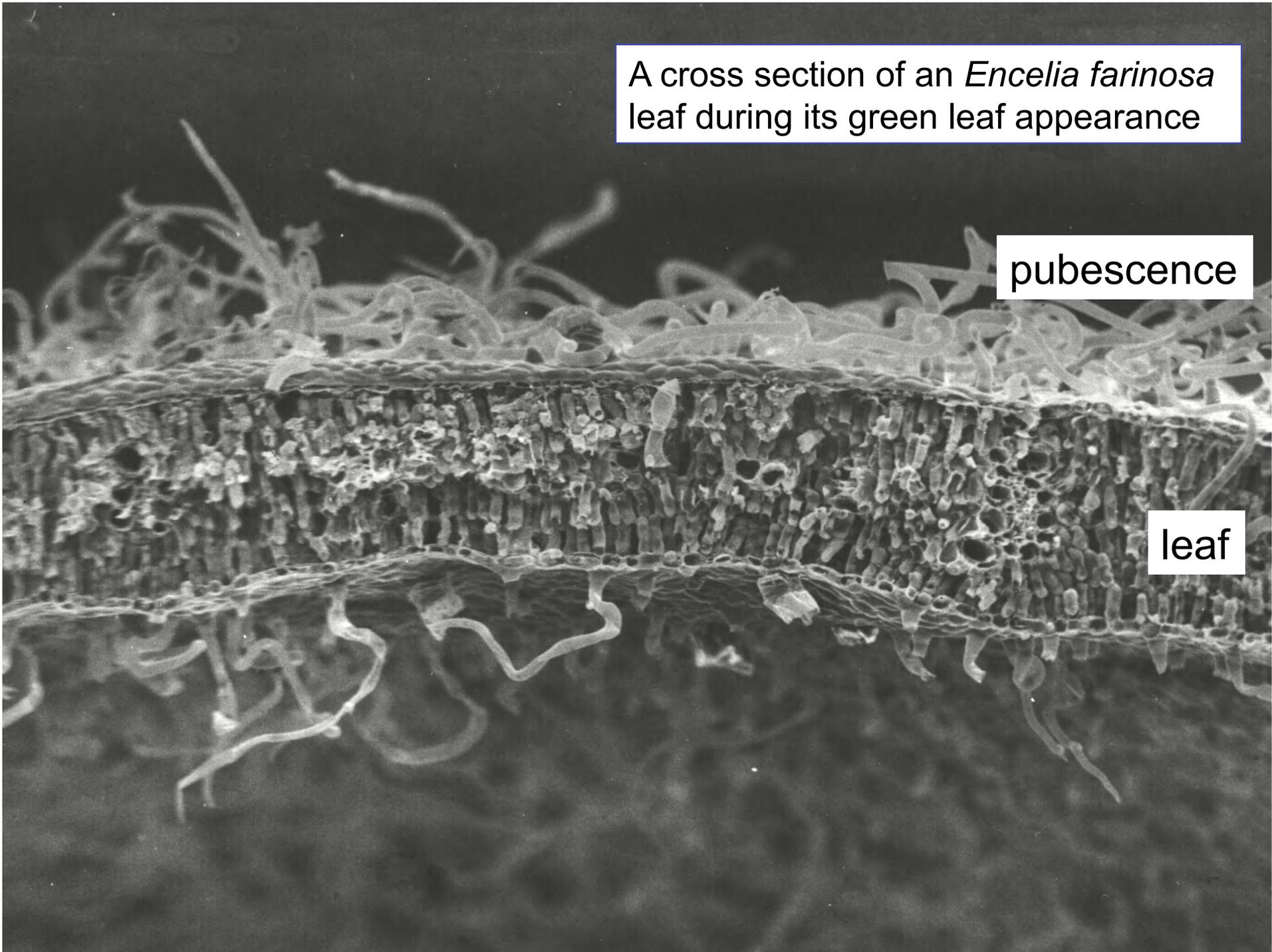
pubescence



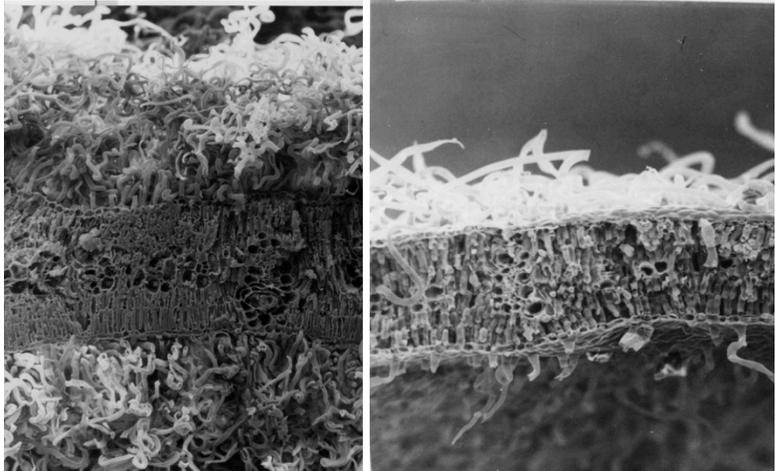
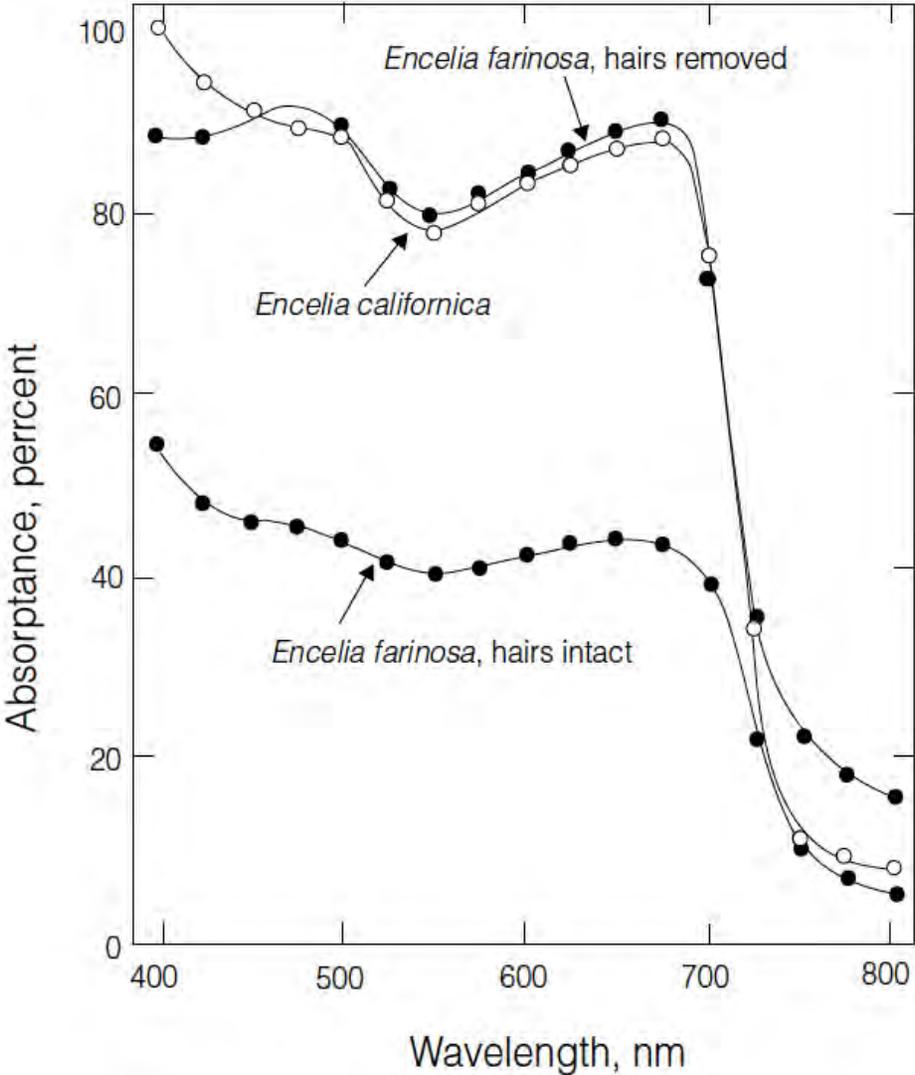
A cross section of an *Encelia farinosa* leaf during its green leaf appearance

pubescence

leaf



Leaf pubescence changes in *Encelia* result in a 50% absorptance reduction



Atriplex hymenelytra leaves (evergreen) also have a reflective surface; dried salt gland on the leaf reflect sunlight (common in Death Valley)



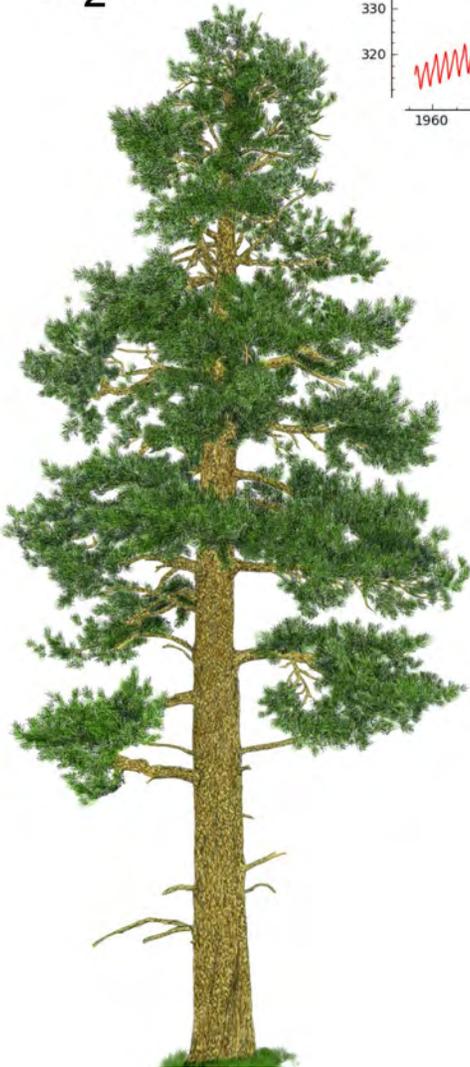
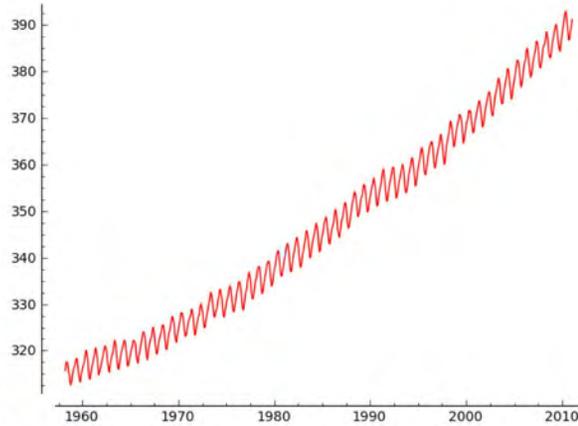


Some species, such as *Oldenbergia* in South Africa, have a reflective hair layer only when leaves are young.



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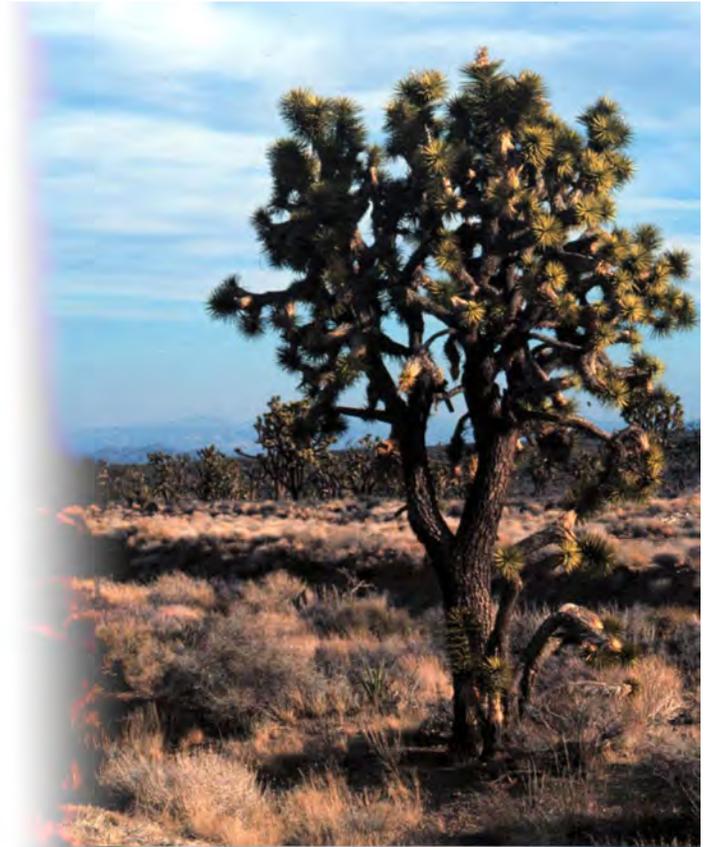
Desert and Steppe Biomes

Part 4

CAM as a water storage strategy and a means of efficient water use

Plant Ecology in a Changing World

Jim Ehleringer, University of Utah
<http://plantecology.net>





Succulence as a water conservation feature

Cacti are characterized by

- extensive shallow roots
- CAM
- often protective spines
- absence of leaves

Ferocactus (Beaver Dams)

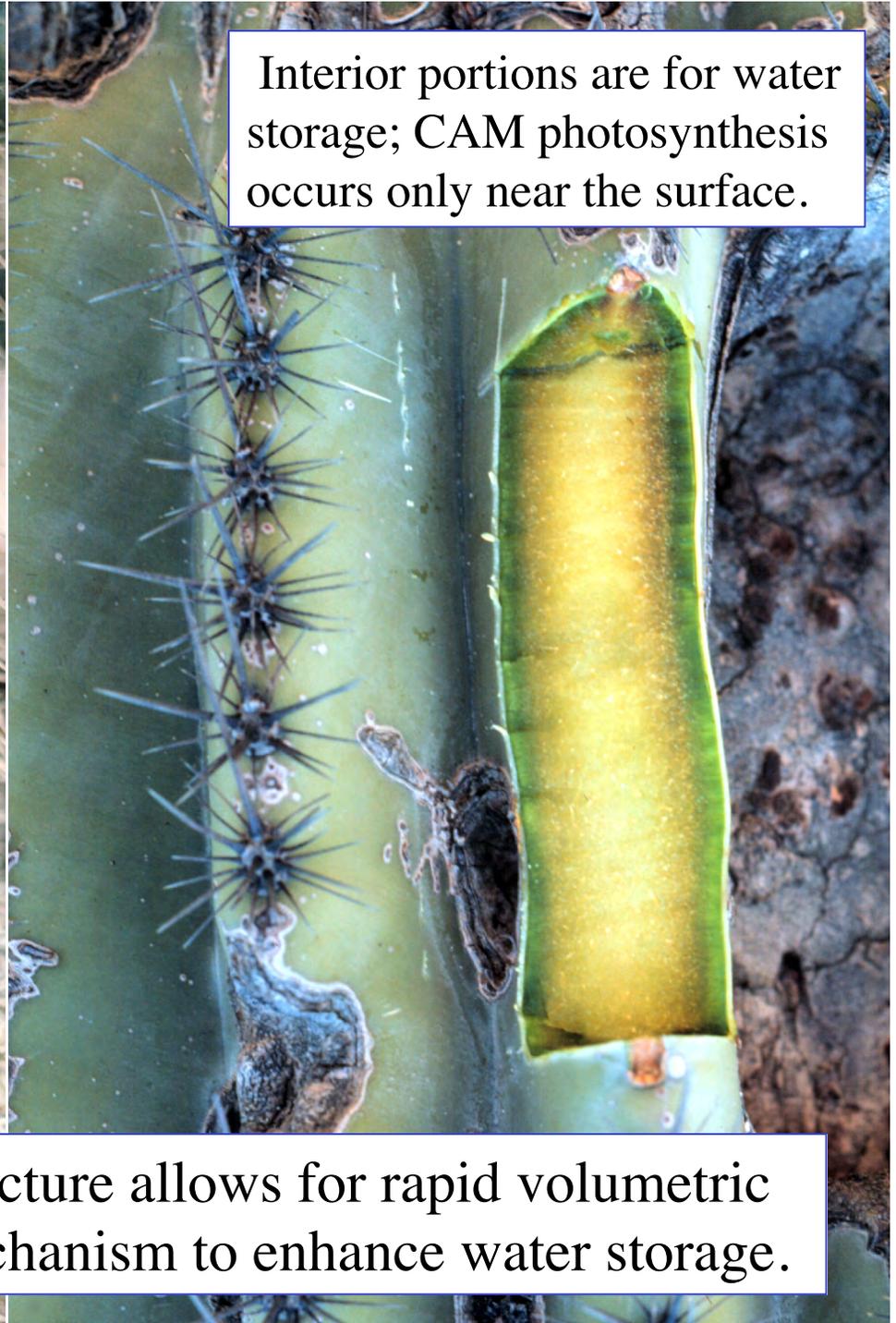
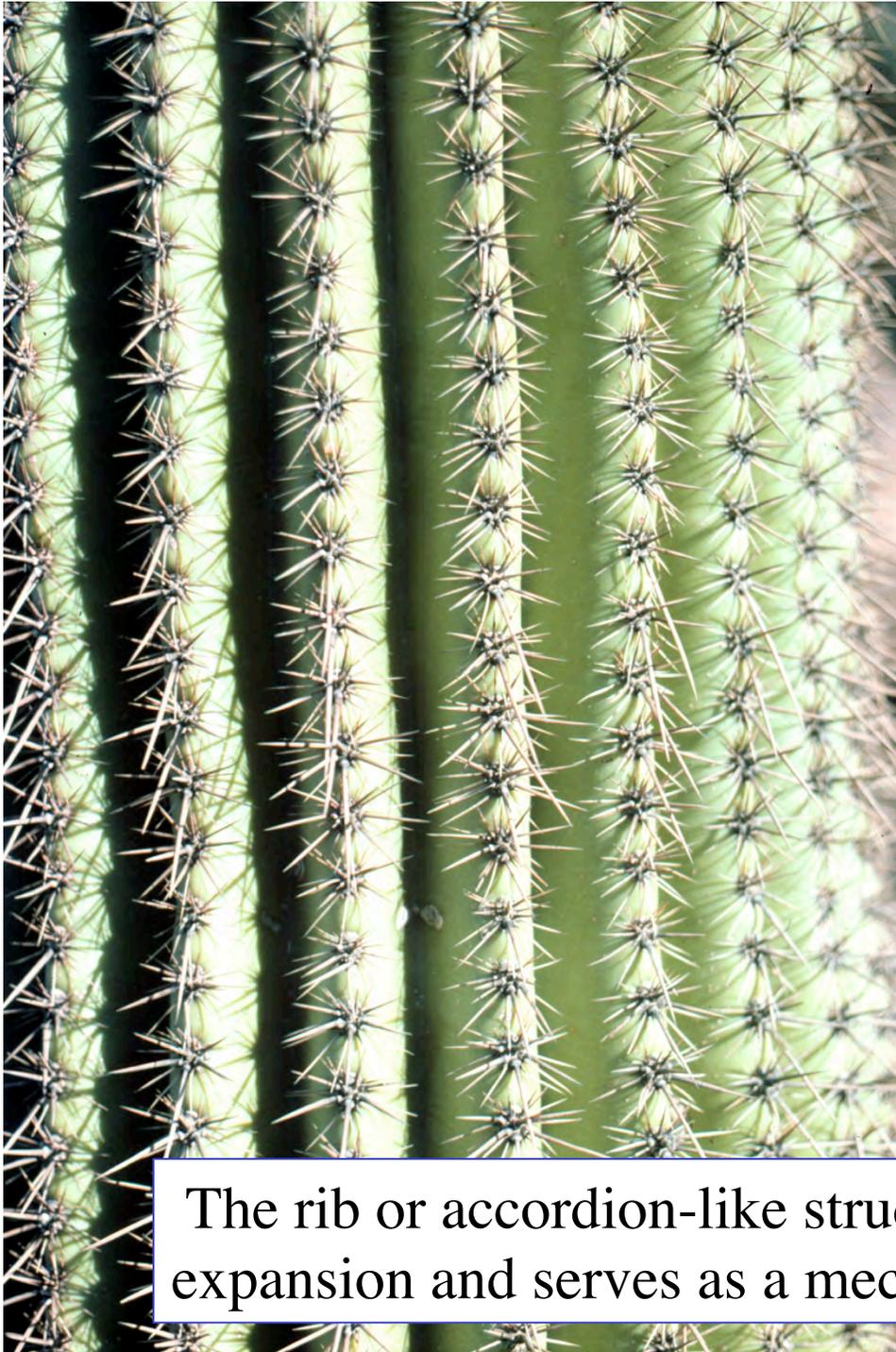
note orientation of stem



Cacti are diagnostic of locations with summer rain.

Giant stem succulents, such as this organ pipe cactus, occur only in regions with a high and reliable summer summer rains

- water storage in stems
- surface roots
- CAM



The rib or accordion-like structure allows for rapid volumetric expansion and serves as a mechanism to enhance water storage.

In regions with summer rains,
North American deserts show
high life-form diversity

Without a doubt, it must
be a boojum !

Idria columnaris, commonly known
as the boojum, occurs in central
Baja California where summer rains
are common. This is a stem succulent
tree with C_3 photosynthesis grows up
to 15 m tall. It is closely related to
Fouqueria (ocotillo).

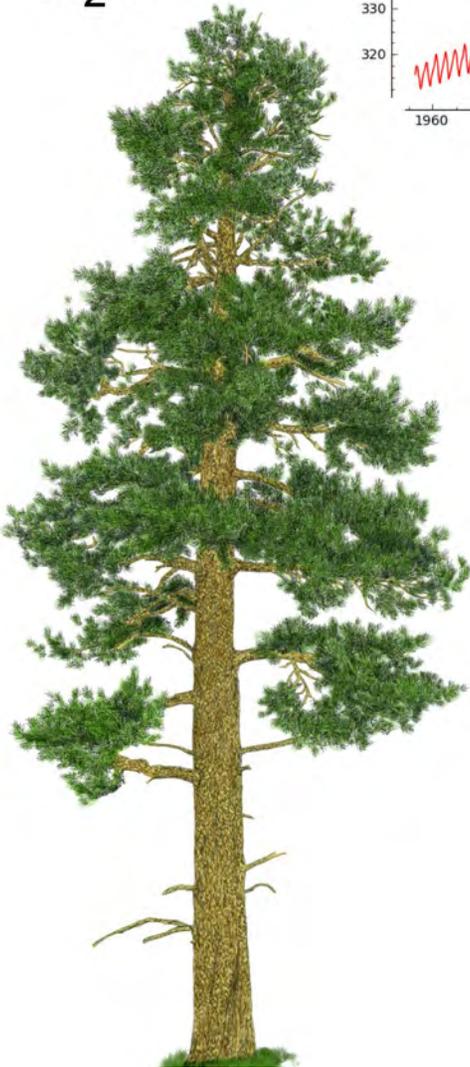
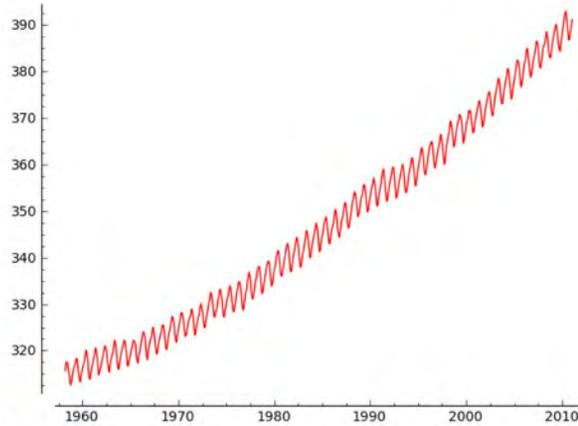


Another stem succulent tree is *Bursera*, the elephant tree of Baja California



CO₂

H₂O



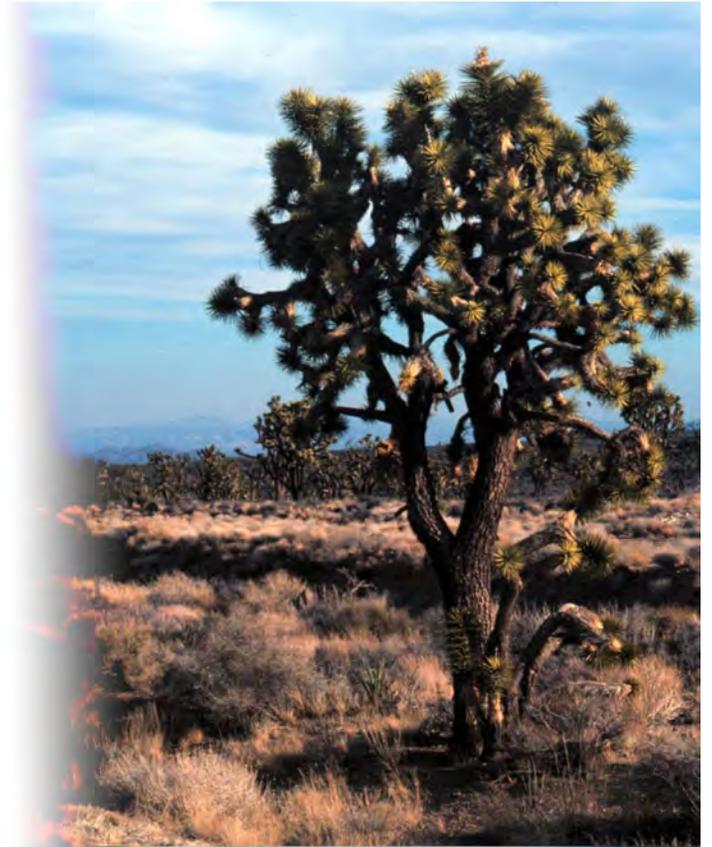
Desert and Steppe Biomes

Part 5

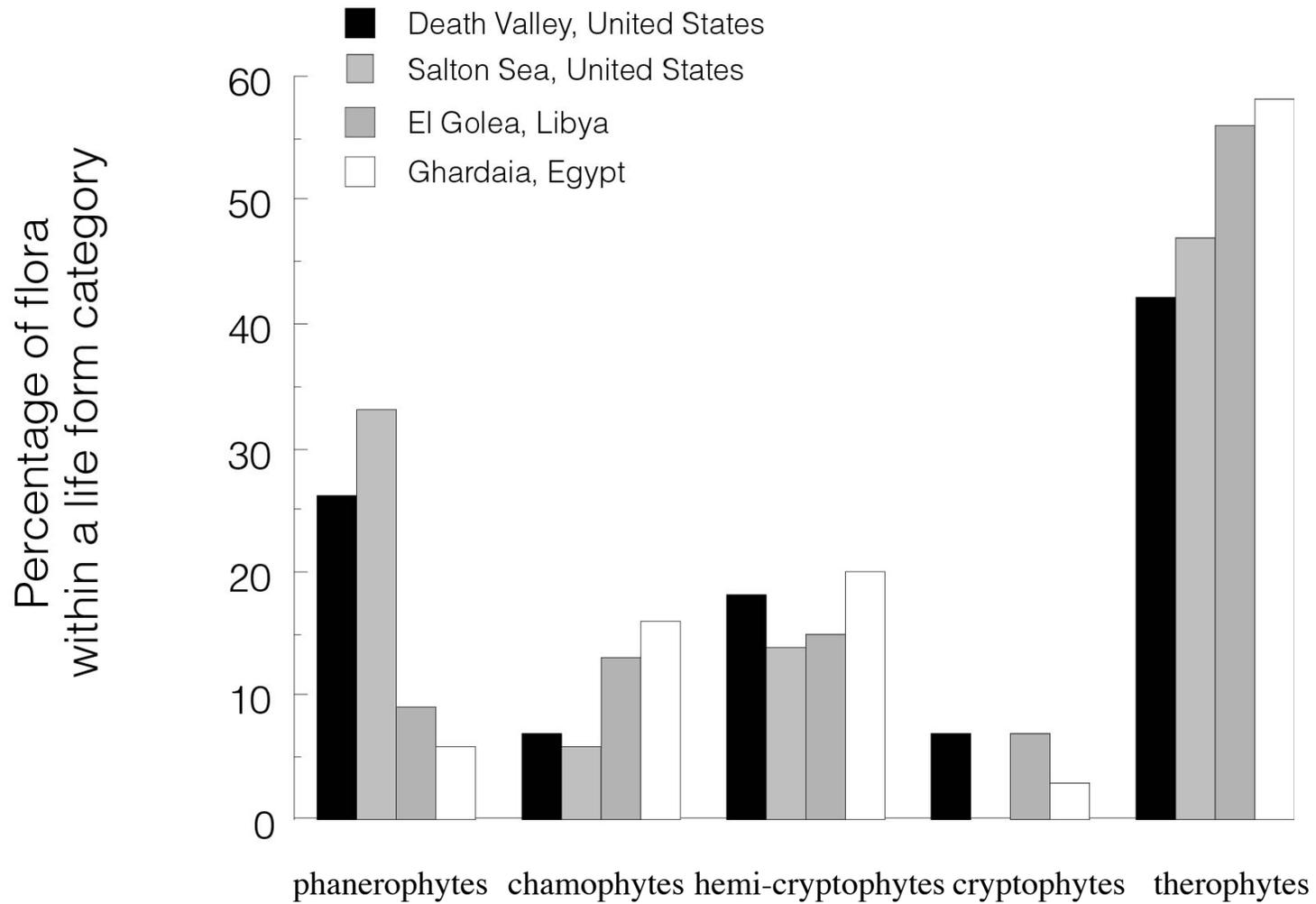
Variations in life history

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<http://plantecology.net>



Raunkiaer life form distributions in deserts



A field of the annual *Geraea canescens* in flower near Death Valley



But a few weeks later, the annuals have all died, leaving behind seeds in the soil to persist until the next major rains in 1-4 years

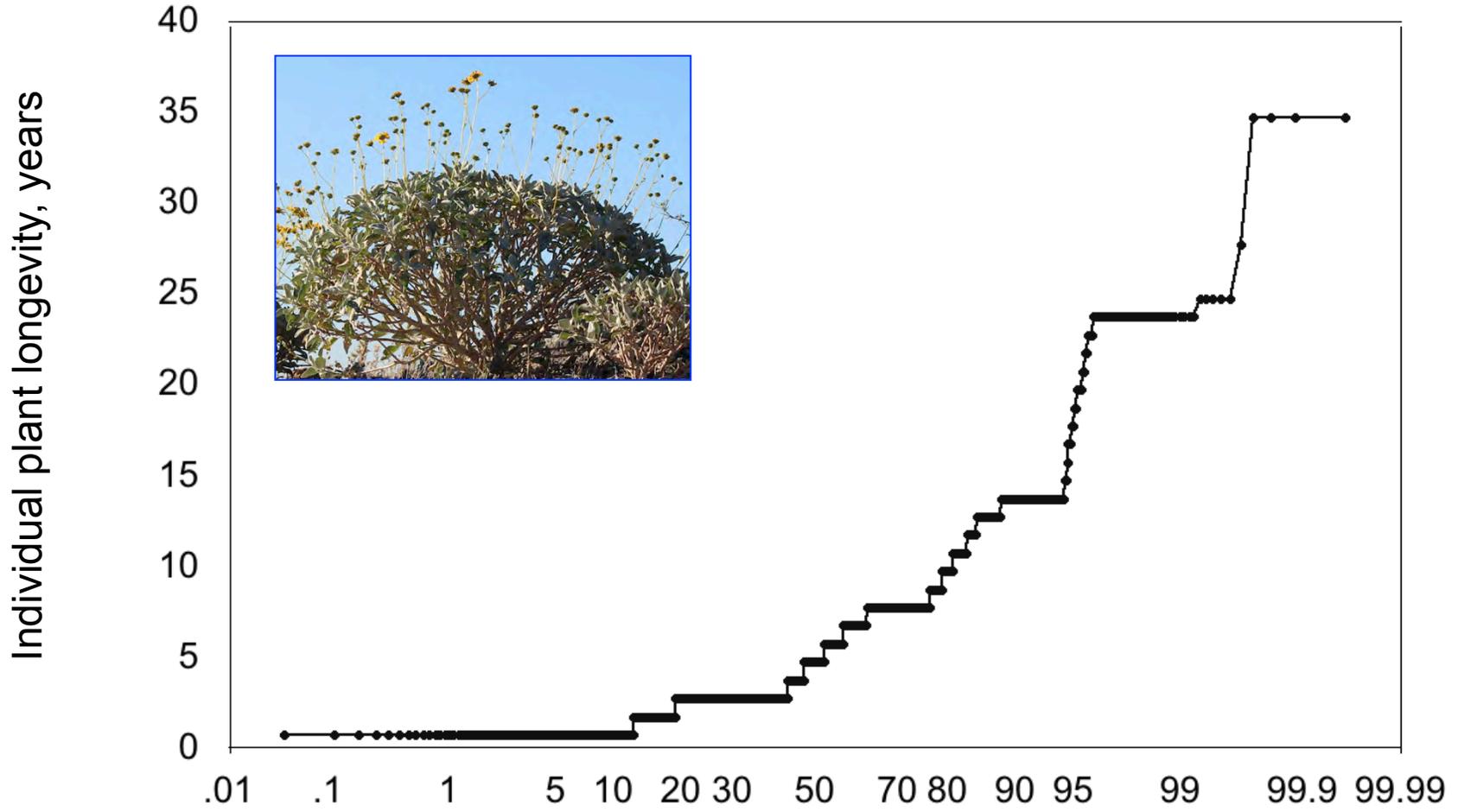


Sonoran Desert - *Encelia farinosa*, *Larrea divaricata*, *Carnegiea gigantea*



How long do these plants live?

Encelia farinosa (POPFAR1)



Cumulative percentage of the population over the last 35 years

Plants compete for water and this competition constrains plant size.
Neighbor mortality is an opportunity for plants to increase in size.

Neighbor-removal experiments confirm that neighbor-free plants rapidly increase in size and maintain leaves longer into drought period.



Larrea divaricata, a long-lived evergreen-leaf shrub that often clones with suffrutescent stems



Like many desert shrubs, *Larrea* is suffrutescent (multiple stems emerging from a common base). As the interior basal stems die, the plant radiates out to create a ring. “King Clone”, from the Mohave Desert, is thought to be thousands of years old.



Deserts are filled with plants having many fascinating adaptations. Take the time to go enjoy our deserts.

