

Biomes and Climate Relationships

Plant Ecology in a Changing World

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<http://plantecology.net>



Part 1
Global patterns and ordination
with temperature and water



Biome and climate relationships

Our objective are to

- understand biome-climate relationships sufficiently to to make predictions on the expected biome (vegetation) within a climate zone under stable or equilibrium conditions
- to predict biome distributions in the future
- to reconstruct biome distributions in the past

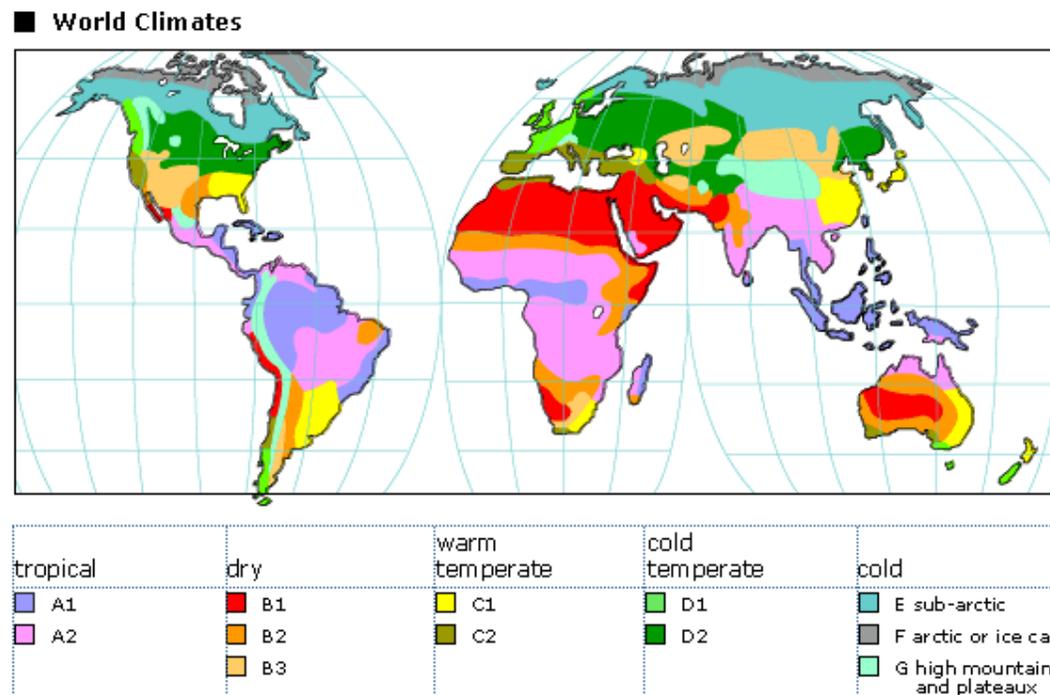
Our approaches are

- to classify plants on the basis of life form
- to explore life form similarities in similar climates
- to classify climate with a visual approach (climate diagrams)
- to explore homologous climates

The independent module for this lecture explores convergent evolution

Climate and vegetation relationships

- There are global latitudinal and continental climate patterns
- Similar climatic regions occur at equivalent latitudes north and south of equator on all continents
- These patterns in repeatable convergence vegetation structure
- Particular vegetation types are associated with specific climate zones

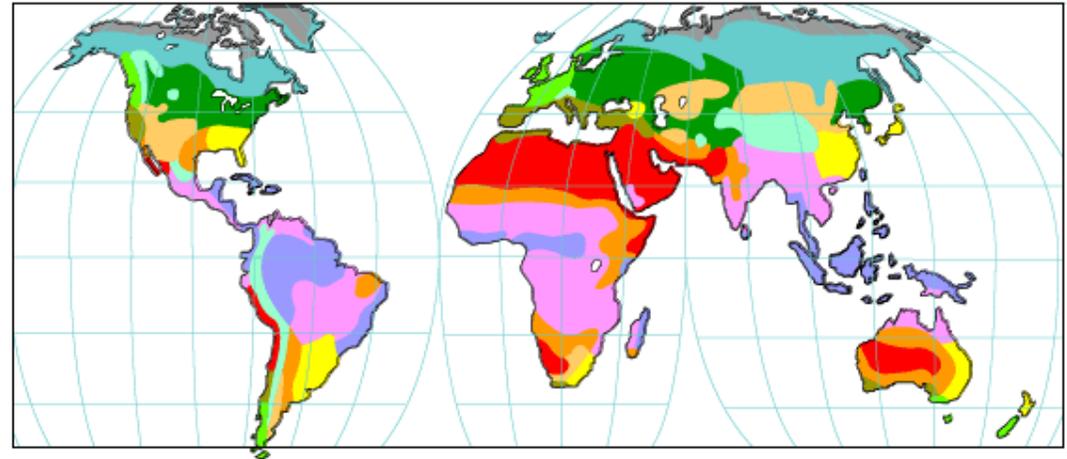


Koppen climate classification

terrestrial

oceanic

World Climates



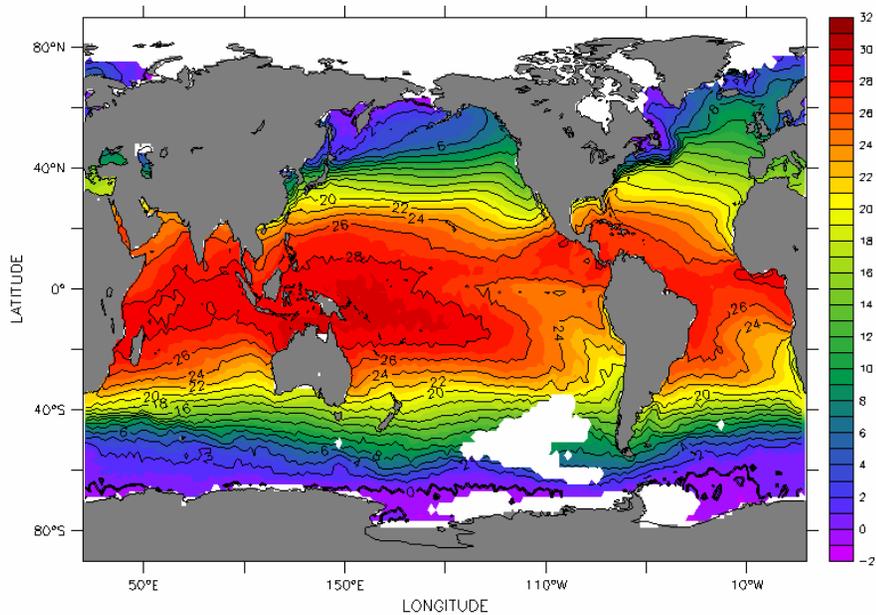
tropical	dry	warm temperate	cold temperate	cold
A1	B1	C1	D1	E sub-arctic
A2	B2	C2	D2	F arctic or ice cap
	B3			G high mountain and plateaux

NOAA/PMEL TMAP  FERRET Ver 4.0

TIME : JAN

DATA SET: coads-climatology

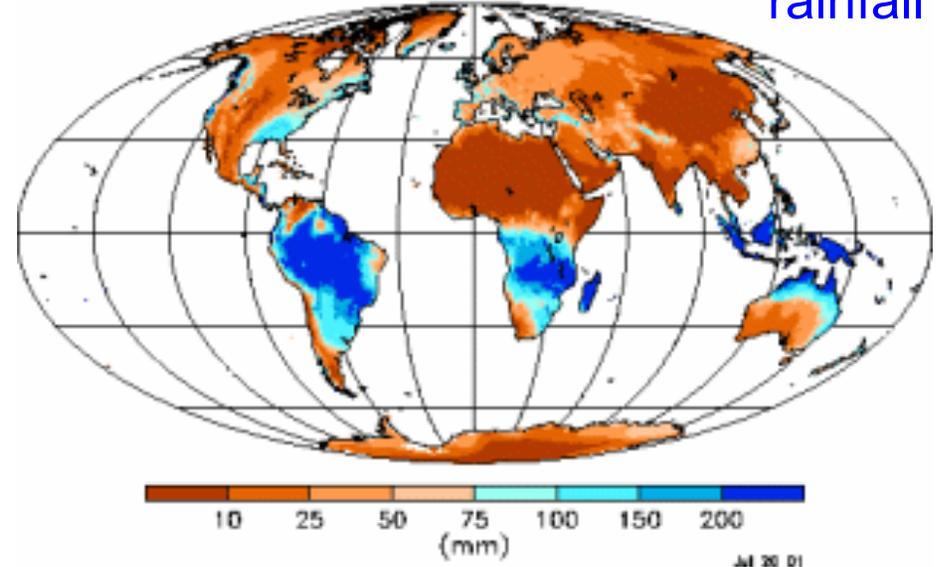
COADS Monthly Climatology (1946-1989)



SEA SURFACE TEMPERATURE (Deg C)

Average Monthly Total Precipitation Jan

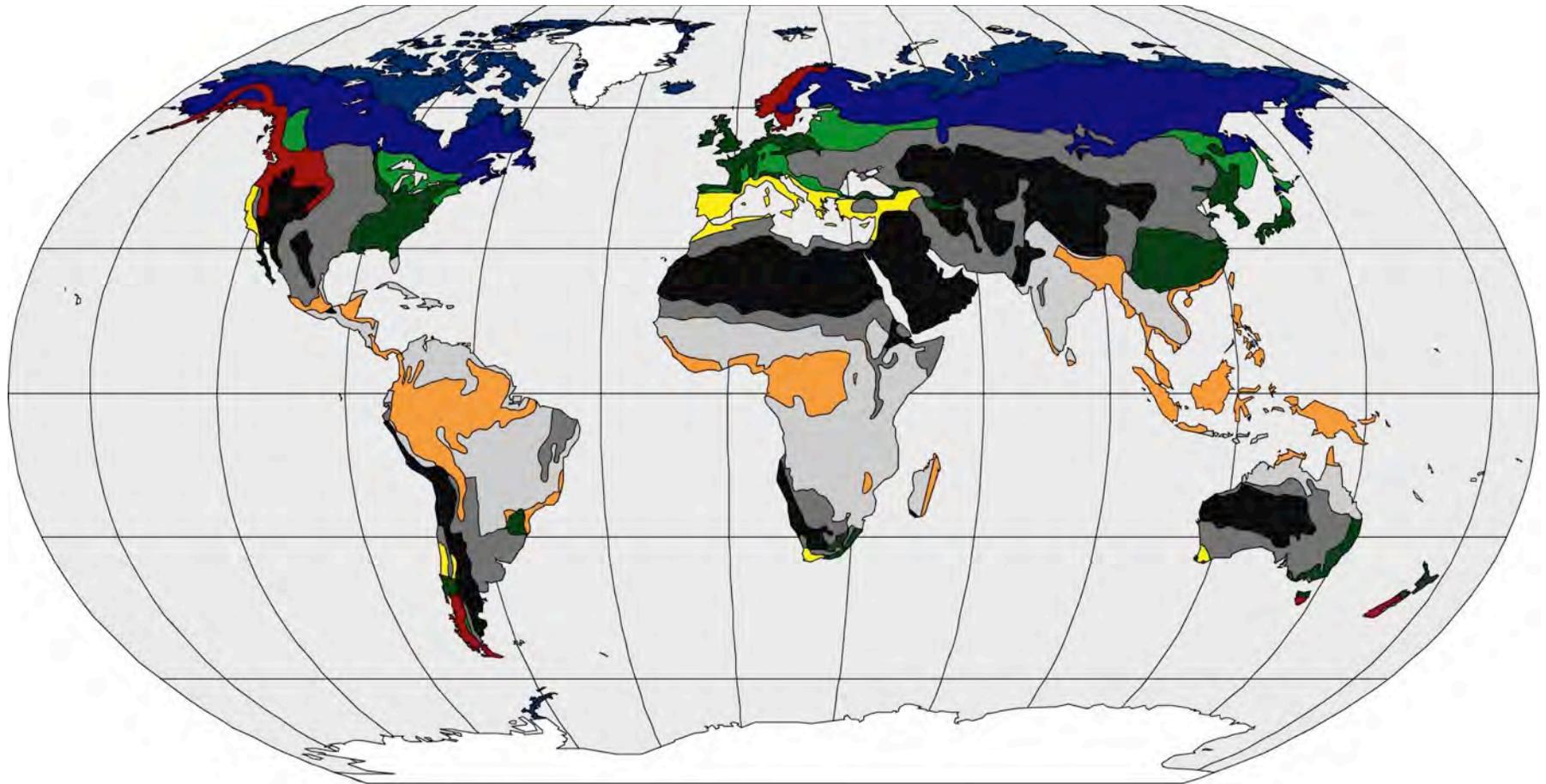
rainfall



<http://ferret.wrc.noaa.gov/ferret/bigpix2.gif>

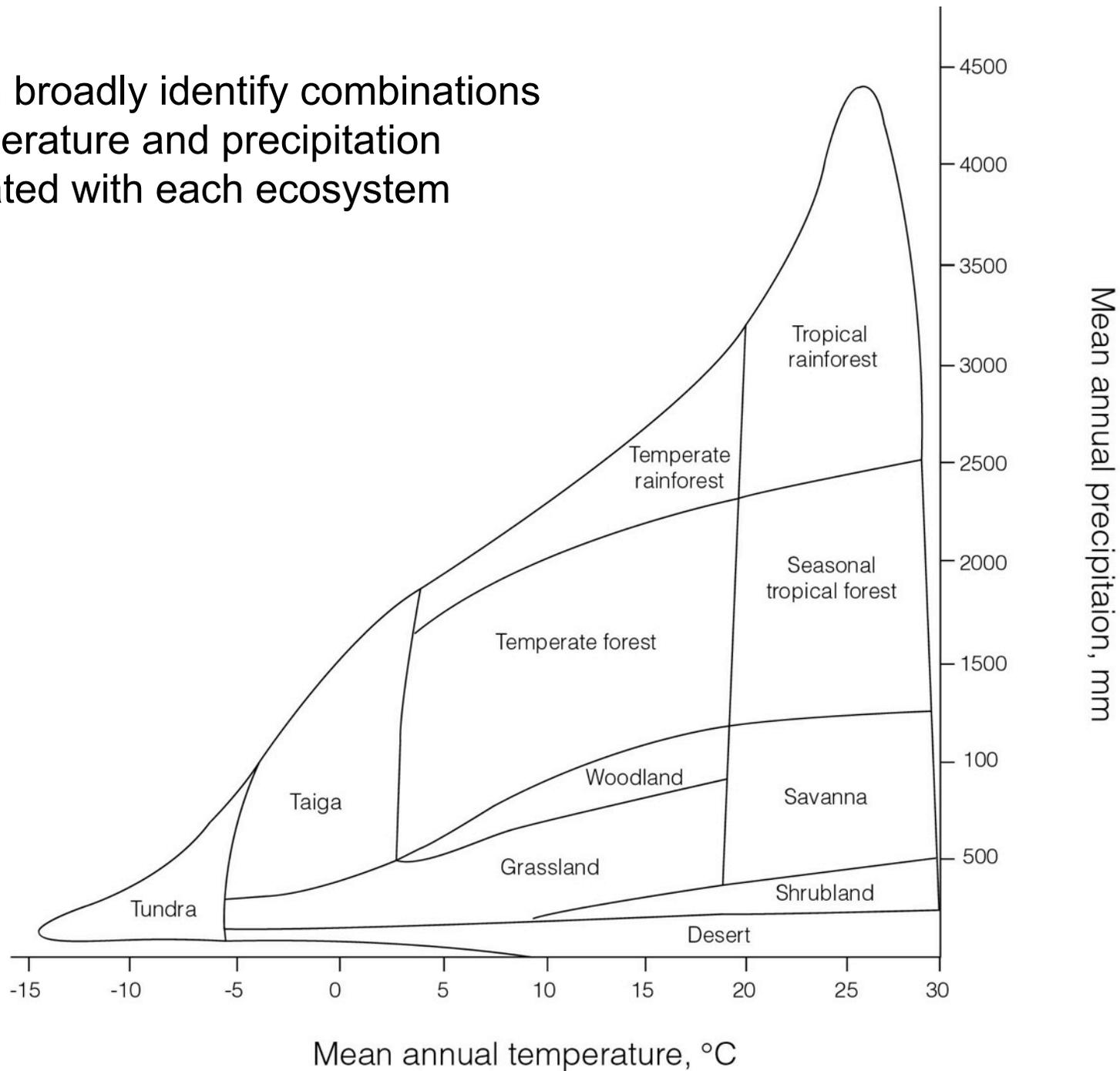
http://climate.geog.udel.edu/~climate/gif_files/title_map.gif

The global distribution of biomes

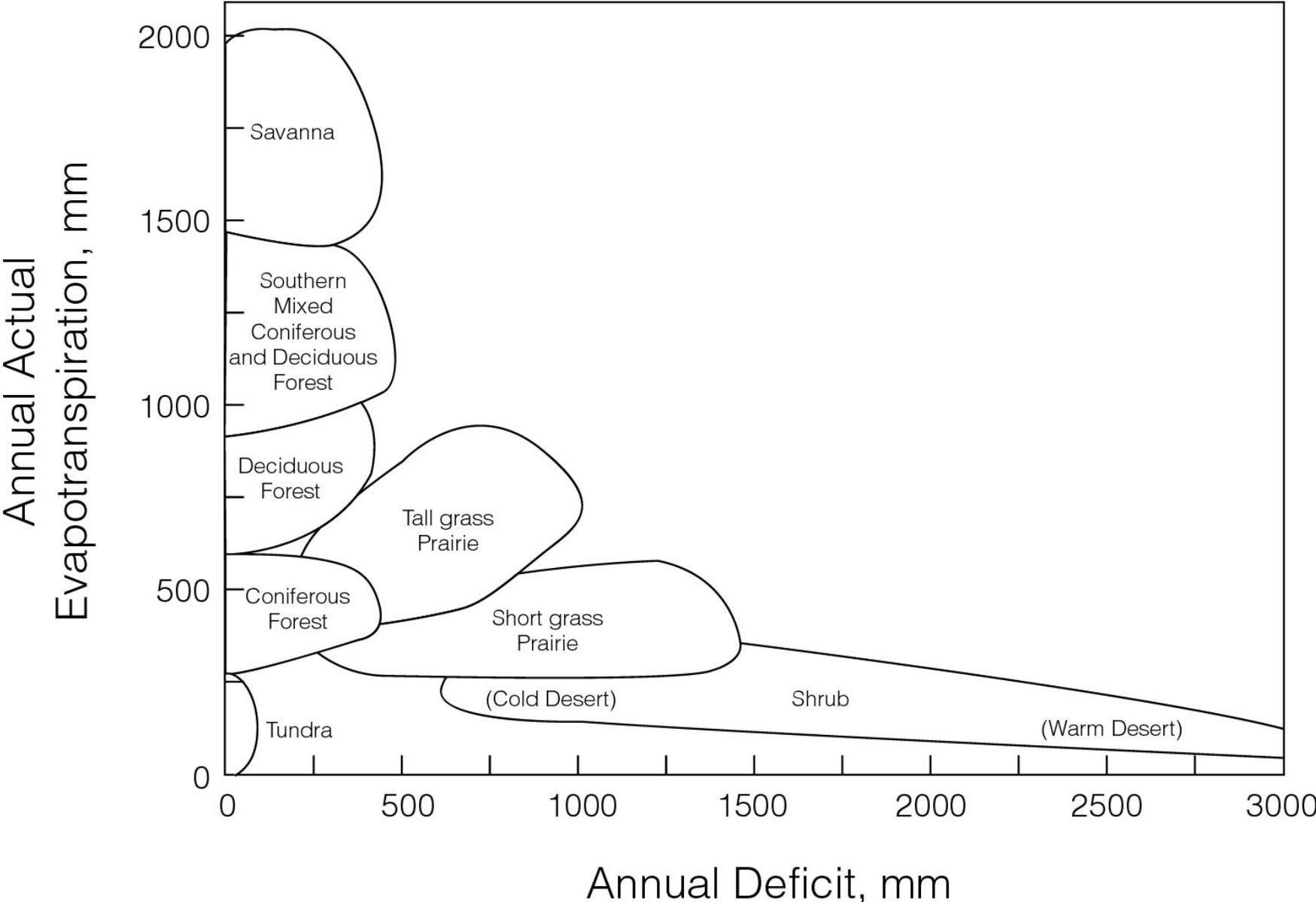


- | | | | |
|---|------------|---|-----------------------------|
|  | Rainforest |  | Boreal forest |
|  | Desert |  | Deciduous-coniferous forest |
|  | Savanna |  | Deciduous forest |
|  | Steppe |  | Coniferous Forest |
|  | Tundra |  | Mediterranean |

We can broadly identify combinations of temperature and precipitation associated with each ecosystem



Alternatively, we can also identify specific combinations of water balance and evapotranspiration associated with each ecosystem.



Part 2
Classifying vegetation on the
basis of form and structure

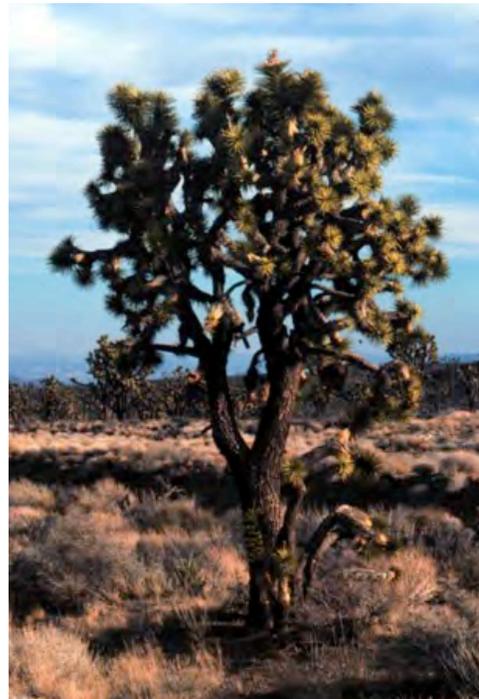


We will classify vegetation on the basis of structural characteristics

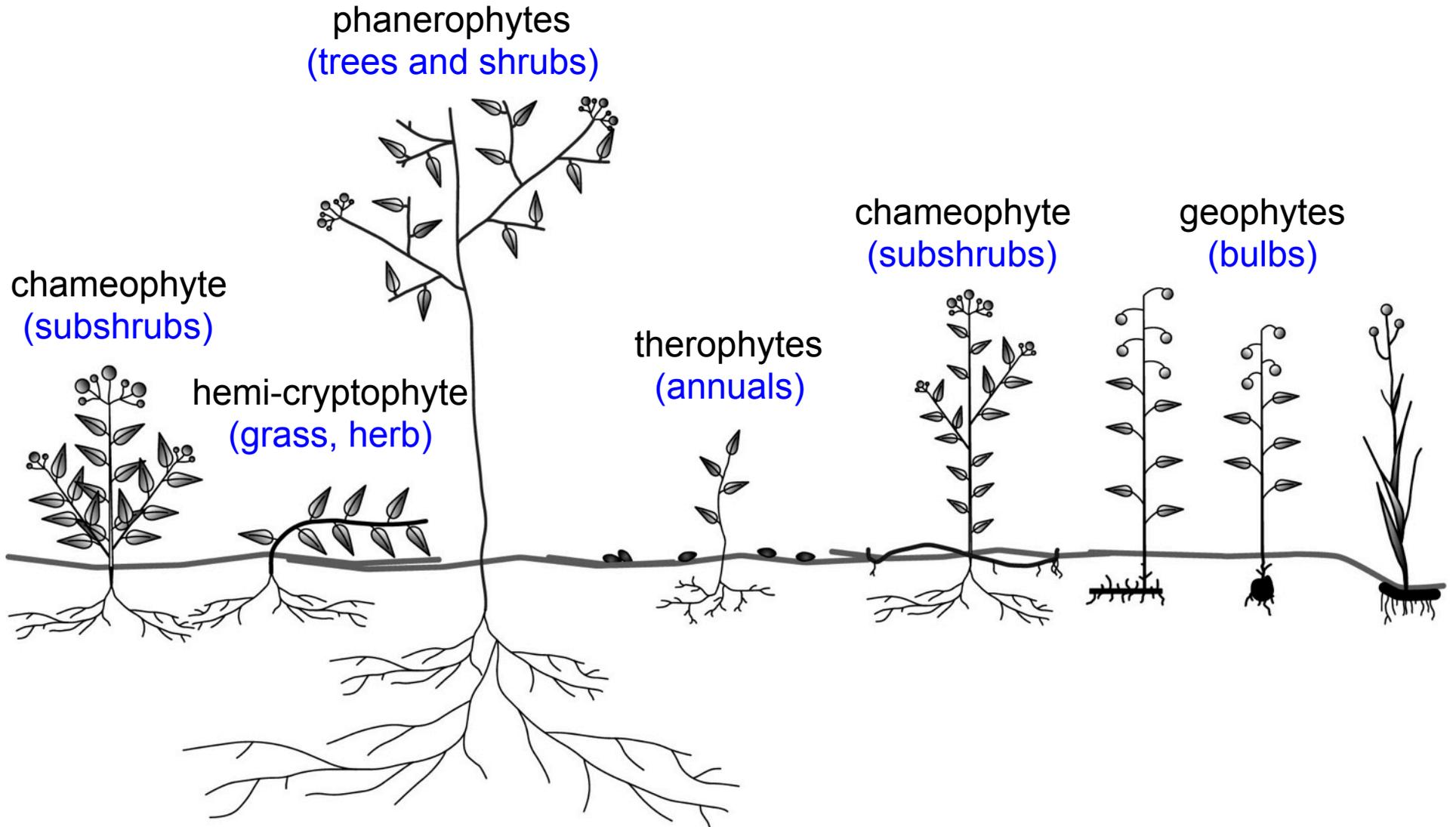
- location of the perennating bud (Raunkiaer classification)

Other classification approaches might include

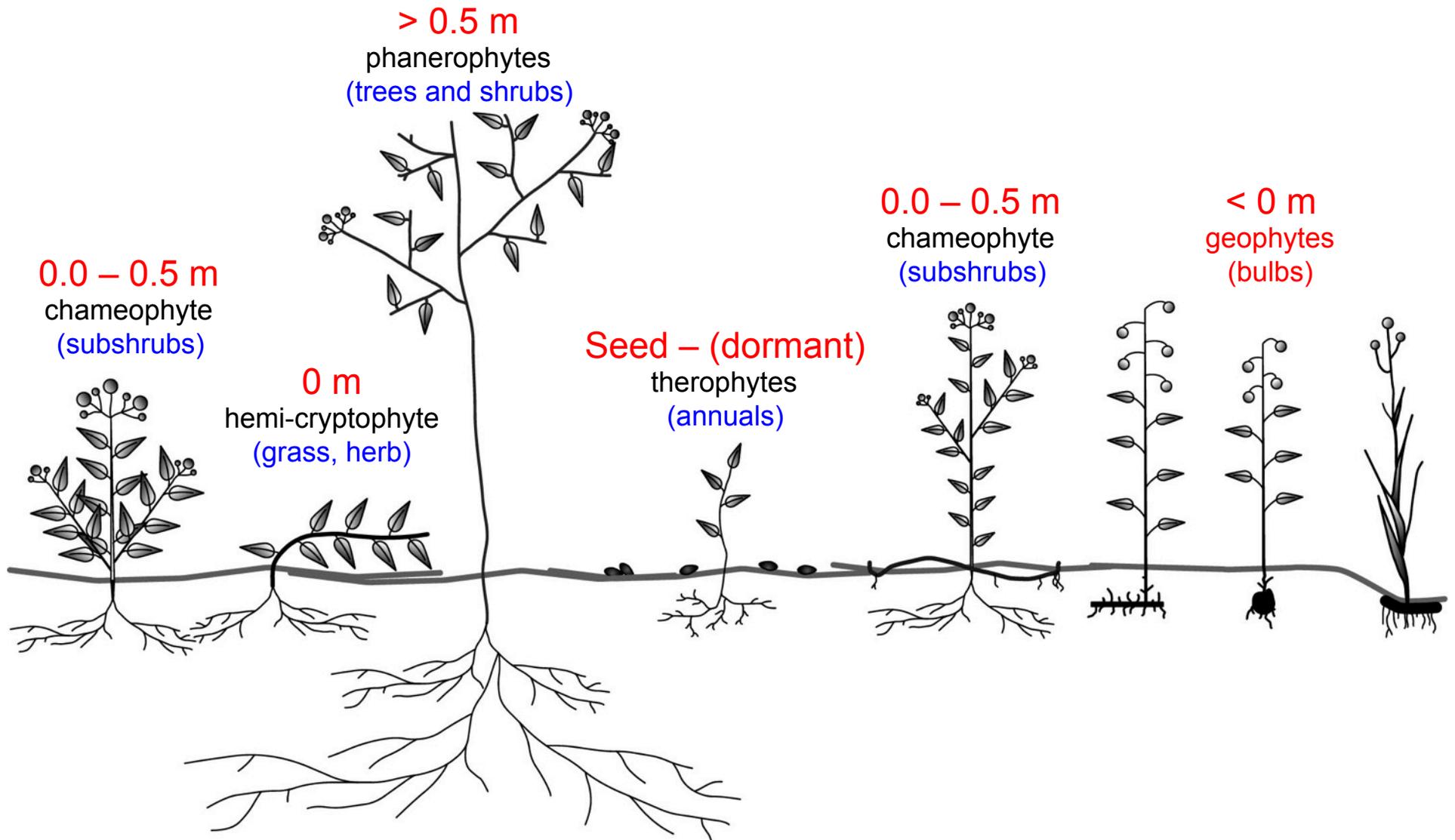
- leaf size
- leaf shape
- leaf phenology
- life history



Raunkiaer life forms



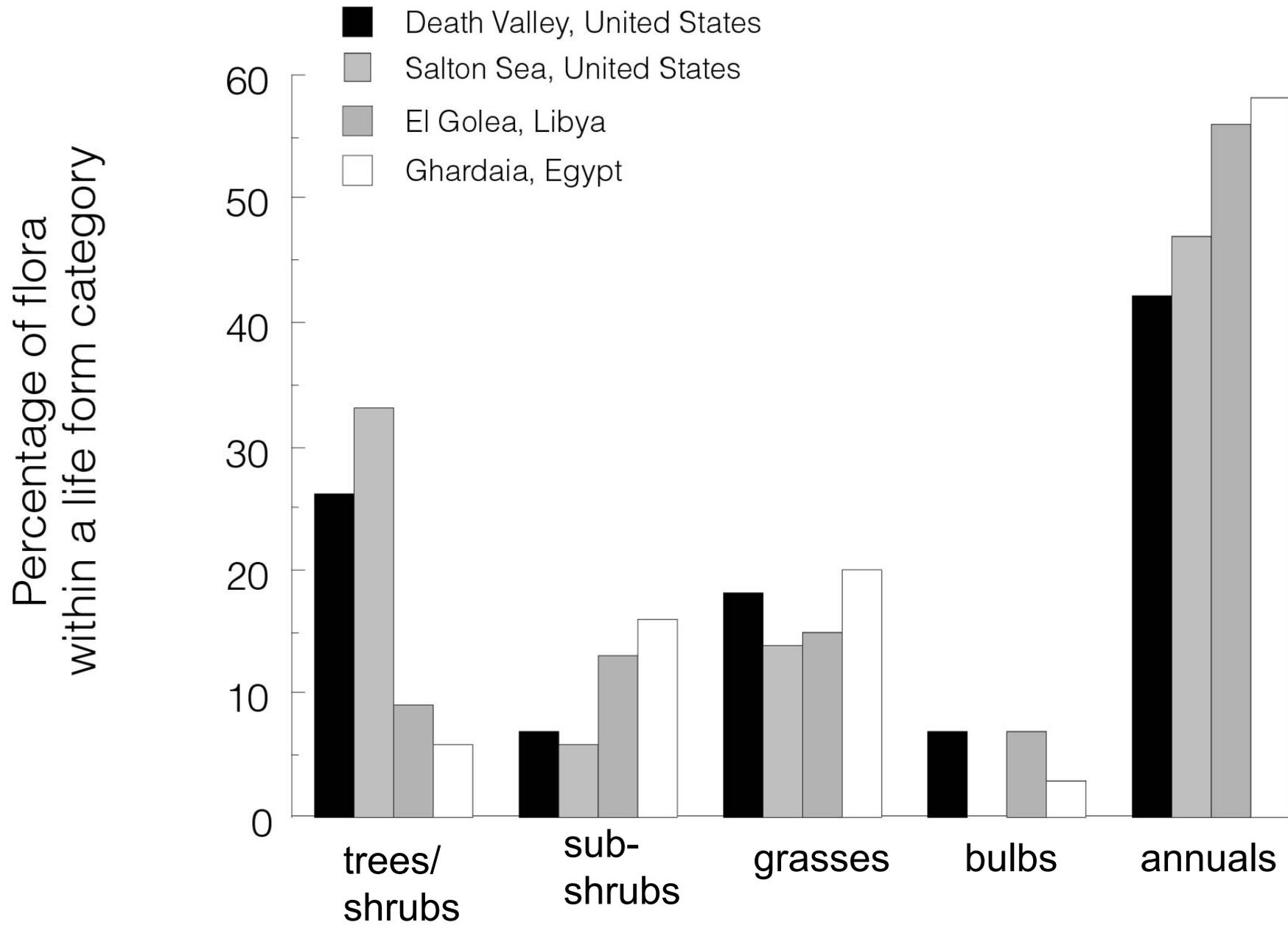
Raunkaier life forms are based on the location of the perennating bud



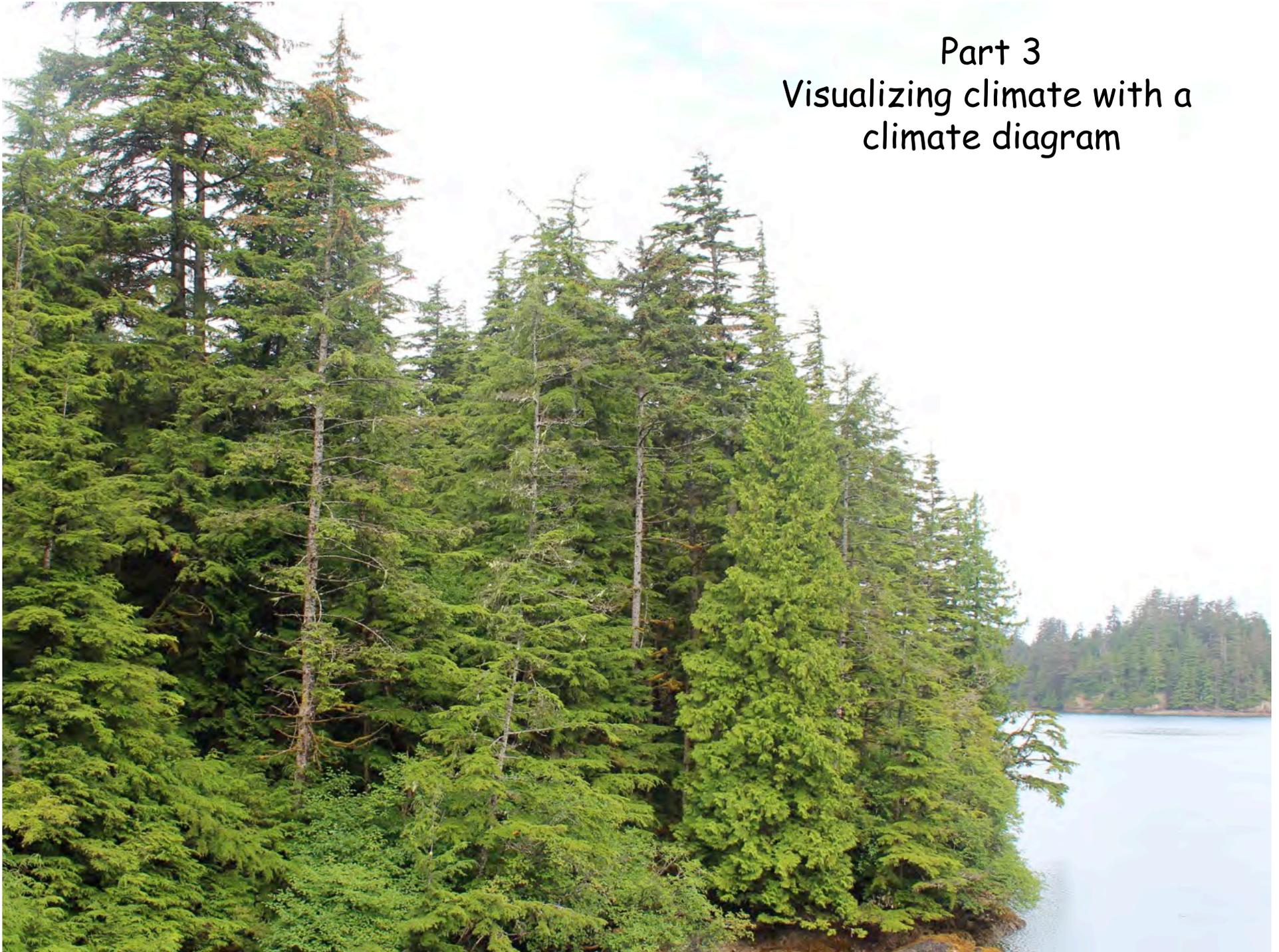
Raunkaier biome comparisons

	wet tropical	hot desert	cold tundra
phanerophyte	61	26	1
chamaephyte	6	7	23
hemicryptophyte	12	18	61
geophyte	5	7	15
therophyte	16	42	1

Raunkiaer life form distributions in deserts

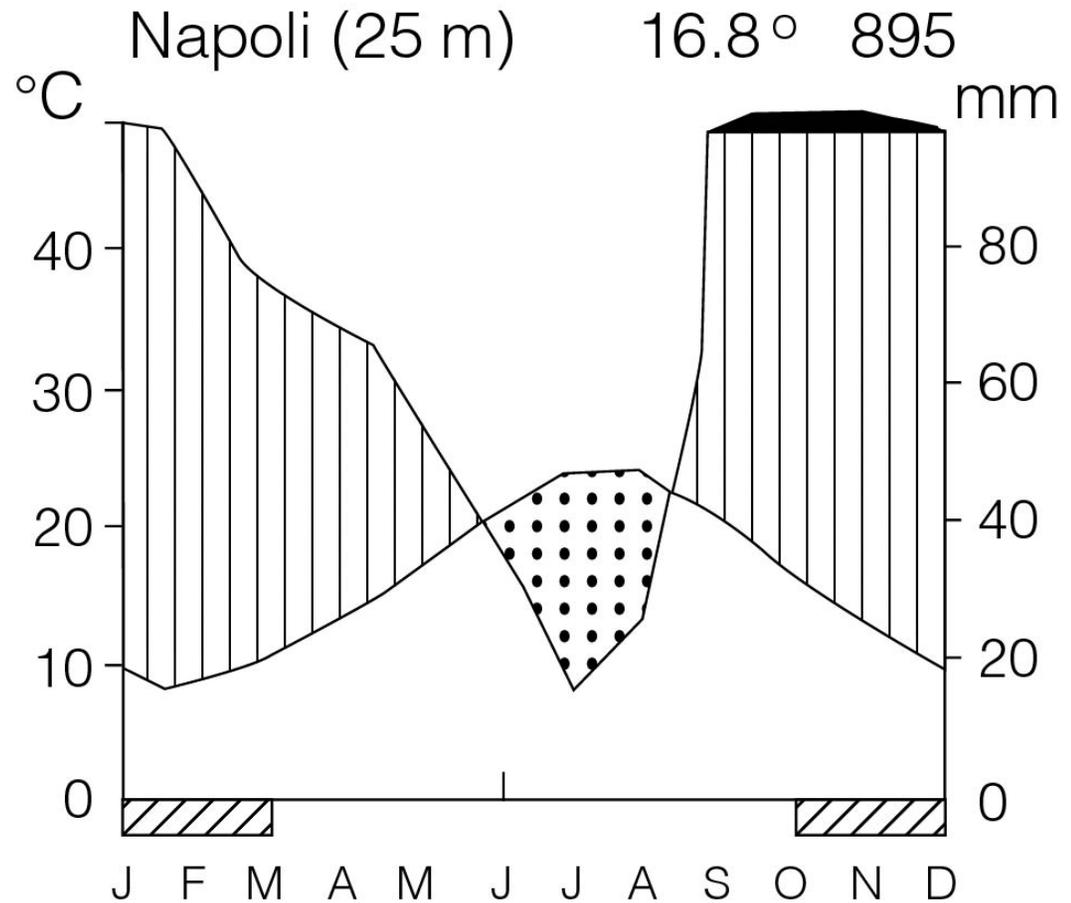


Part 3
Visualizing climate with a
climate diagram



Climate can be visualized using precipitation and temperature

Climate diagram

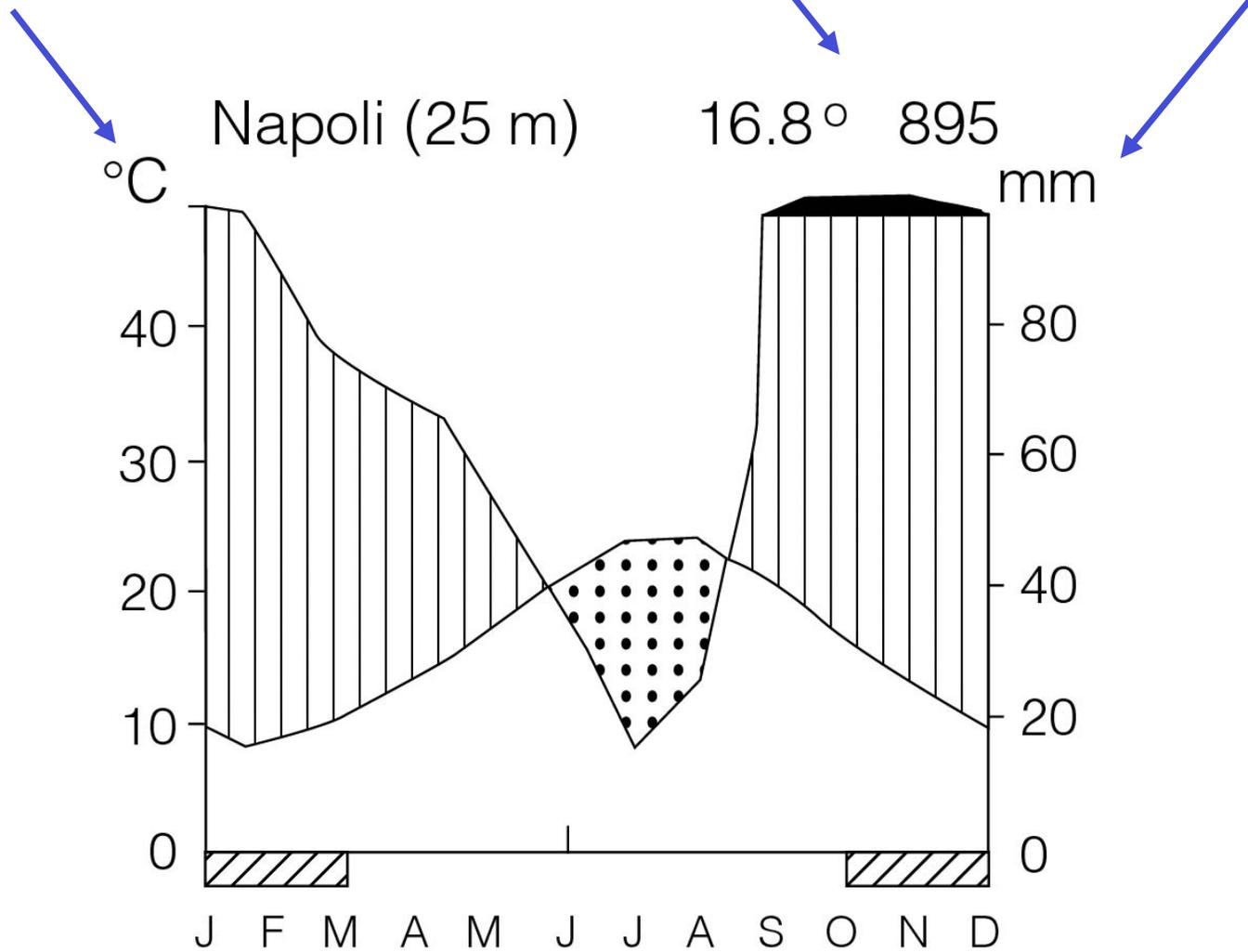


Napoli (Naples) is in a Mediterranean climate

temperature
(monthly ave.)

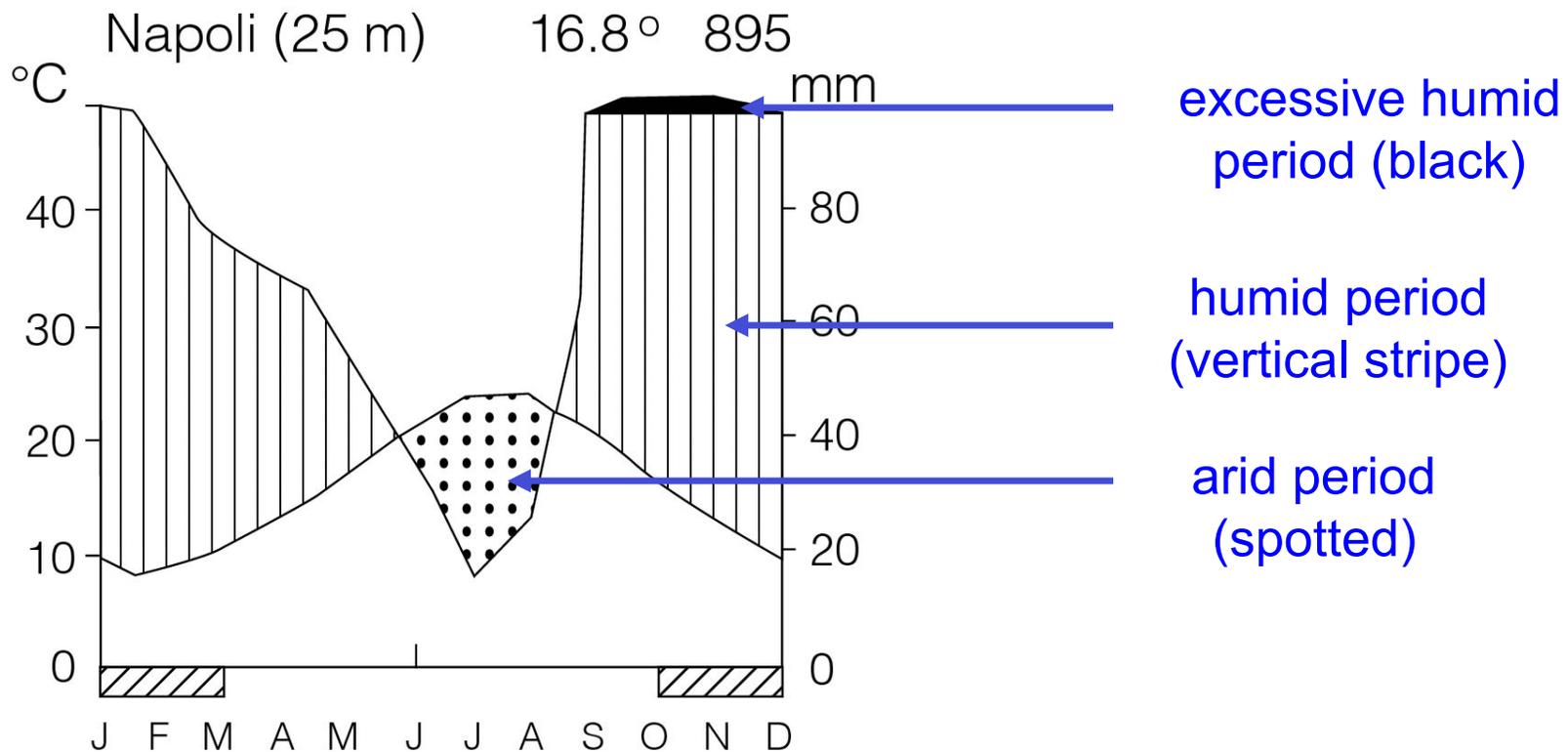
annual
ave.

precipitation
(monthly ave.)

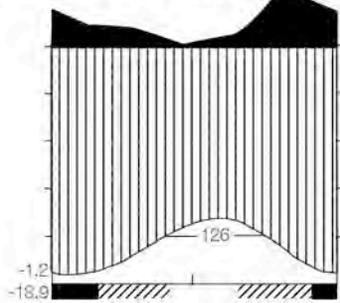


Climate diagram scaling is $10\text{ }^{\circ}\text{C} = 20\text{ mm}$, which approximates expected evapotranspiration at that temperature

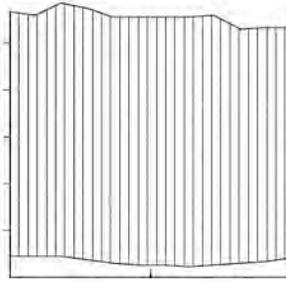
With climate diagram we can visualize monthly site water balance



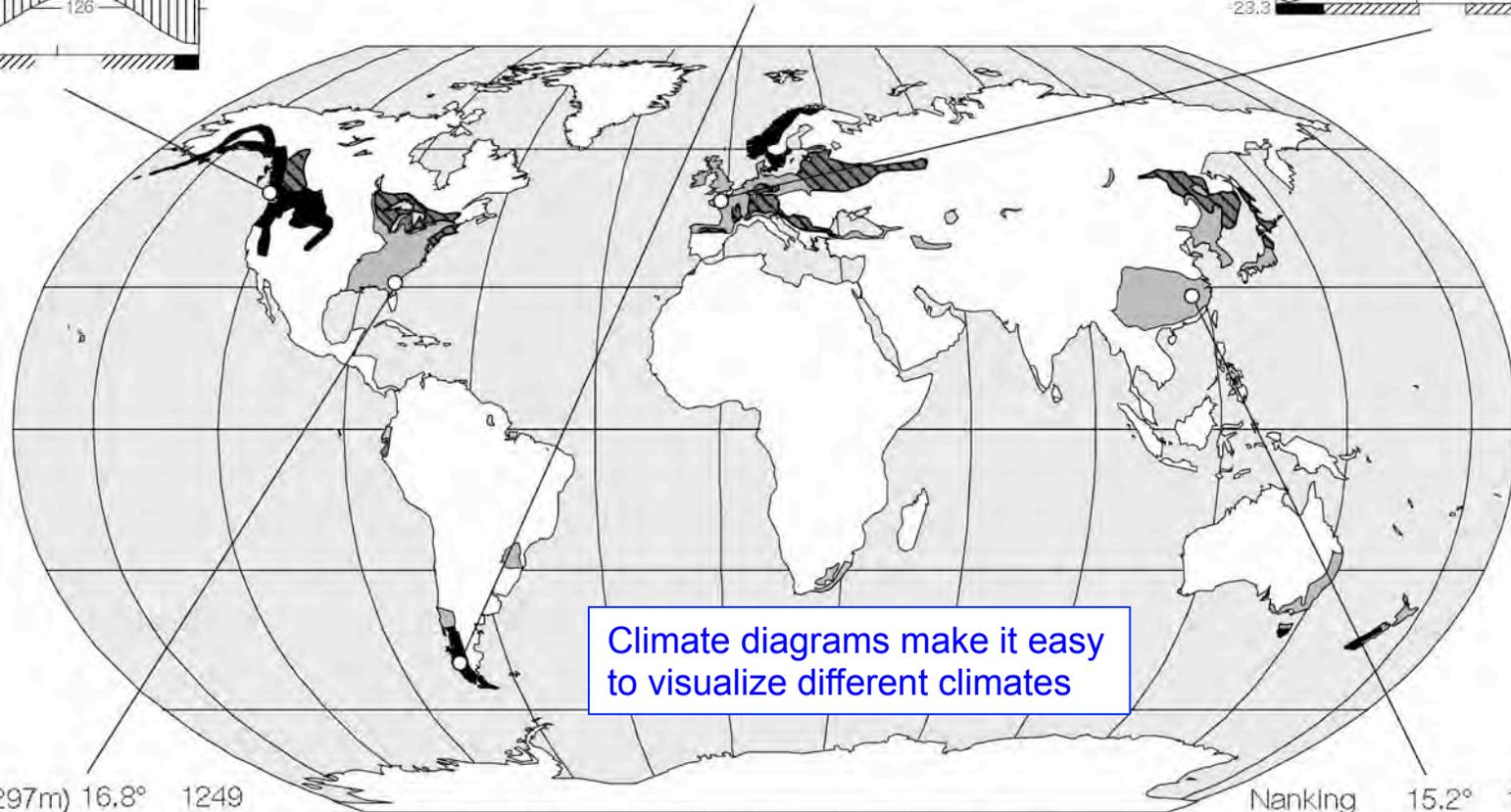
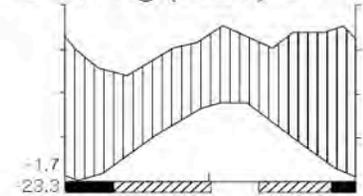
Prince Rupert (518m) 7.7° 2360



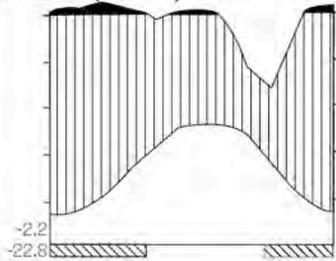
Los Evangelistas 6.4° 2570



Luxembourg (362m) 9.4° 739

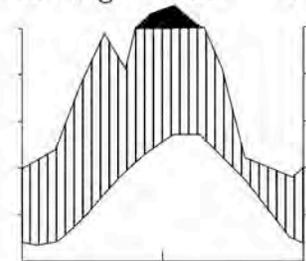


Atlanta (297m) 16.8° 1249



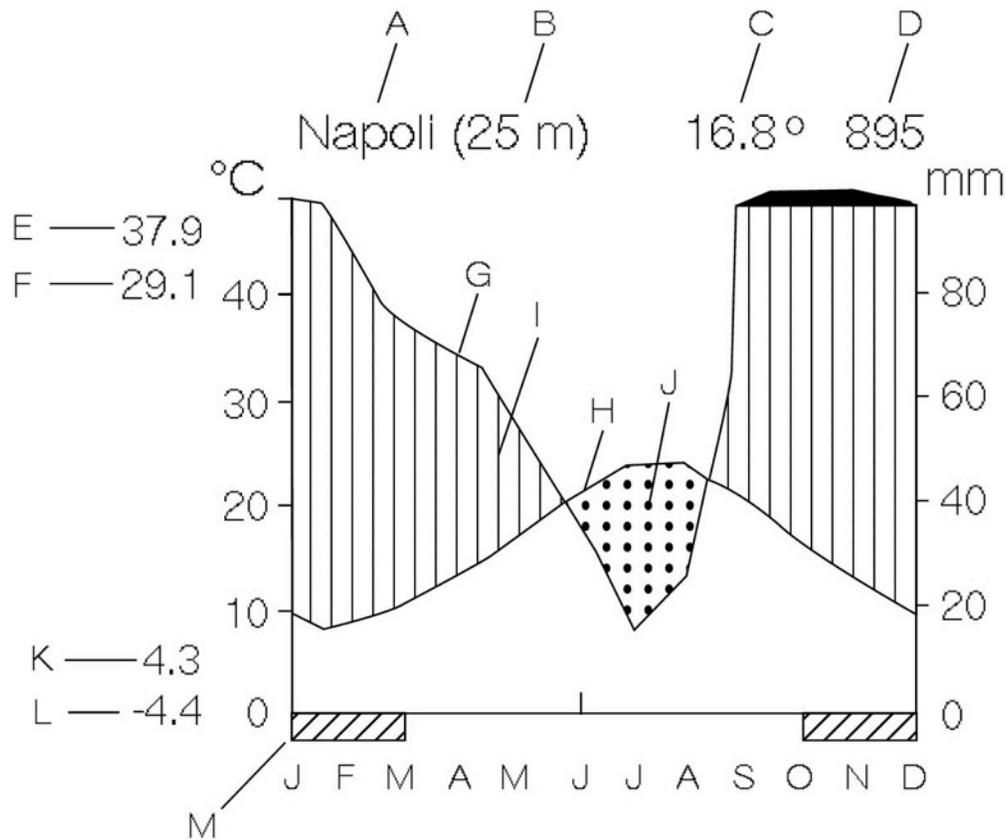
-  Mixed deciduous-coniferous forest
-  Deciduous forest
-  Coniferous Forest

Nanking 15.2° 1017



A detailed description of a complete climate diagram according to Walter

Climate Diagram



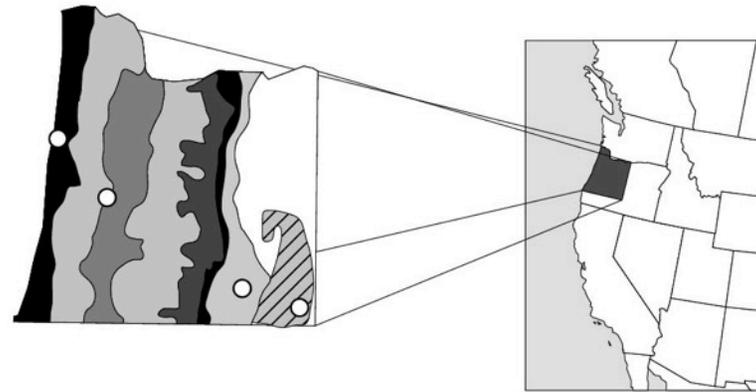
- A - Station name
- B - Altitude (meters)
- C - Mean annual temperature (°C)
- D - Mean annual precipitation (mm)
- E - Absolute maximum temperature (°C)
- F - Mean daily maximum of the hottest month (°C)
- G - Monthly mean precipitation (mm)
- H - Monthly mean temperature (°C)
- I - Humid period (vertical lines)
- J - Dry period (dots)
- K - Mean daily minimum temperature of the coldest month (°C)
- L - Absolute minimum temperature (°C)
- M - Months with an absolute minimum below 0°C

Climate diagrams and plant distribution in Oregon

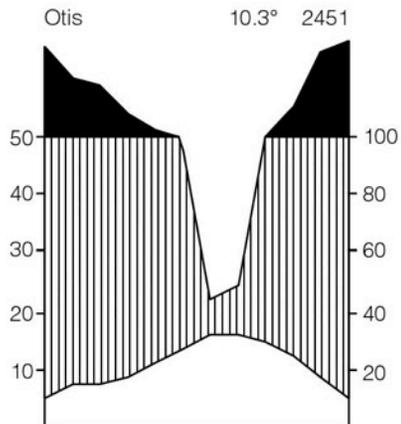
Annual precipitation (mm)



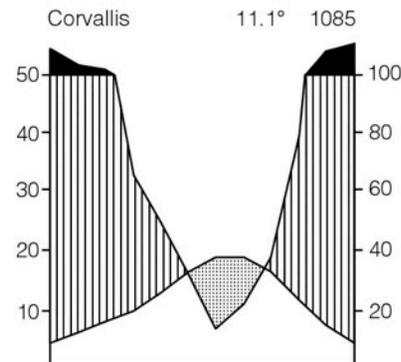
-  *Picea sitchensis*
-  *Pseudotsuga menziesii*
-  *Quercus*
-  *Tsuga heterophylla*
-  *Abies lasiocarpa*
-  *Pinus ponderosa*
-  *Juniperus occidentalis*
-  *Artemisia tridentata*



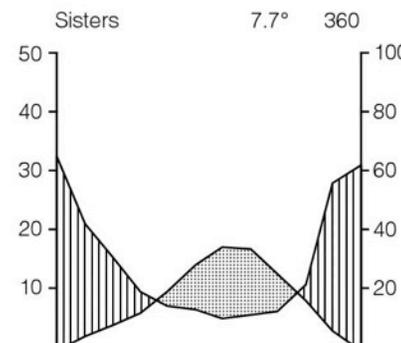
Cascade Head



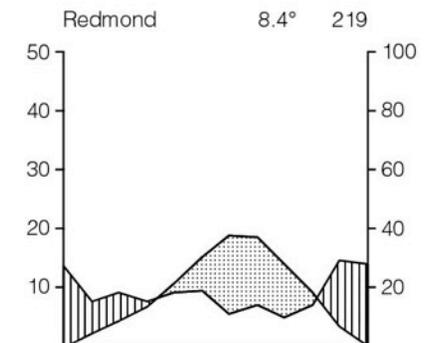
Corvallis



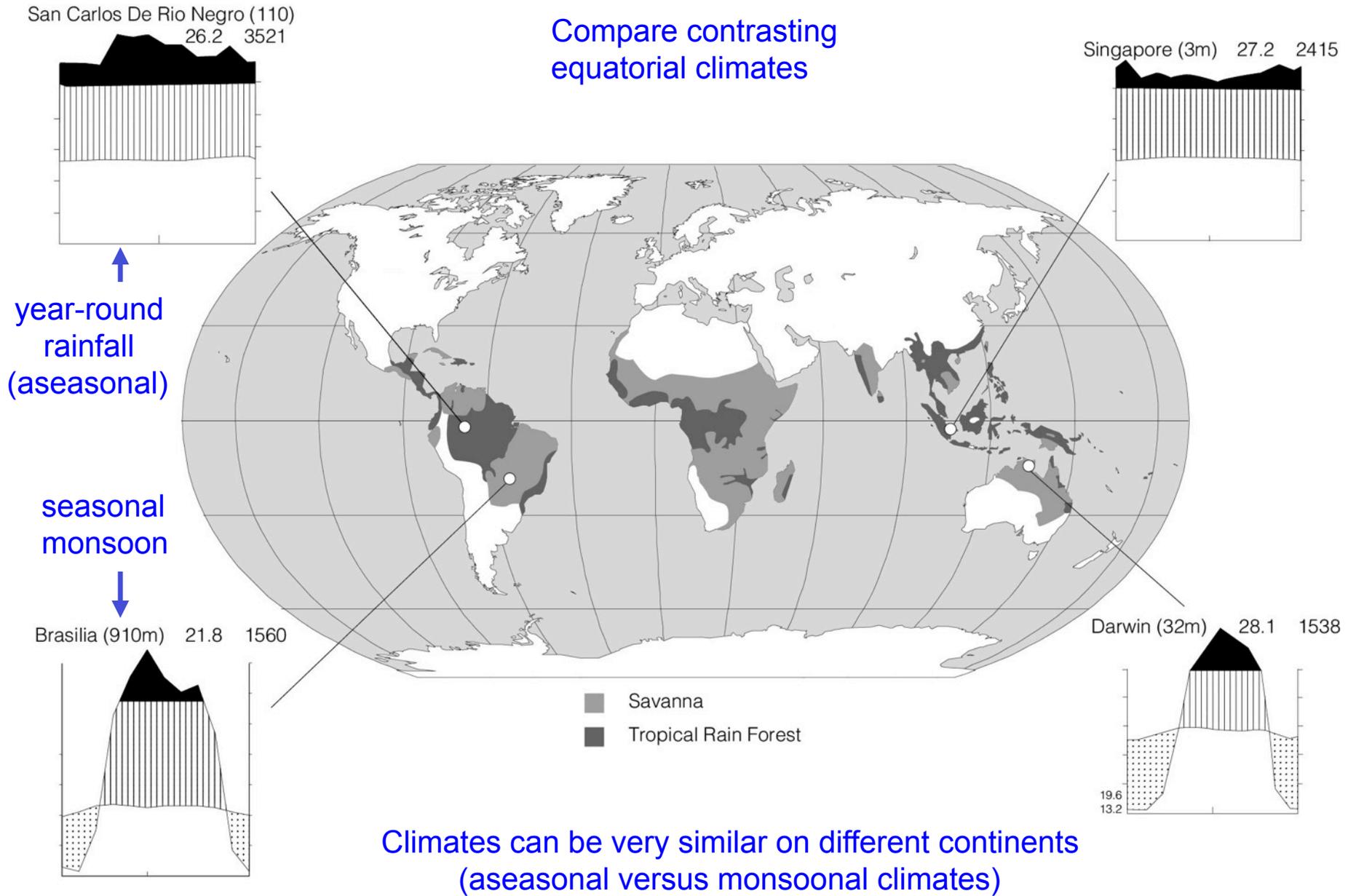
Sisters



Richmond



Compare contrasting equatorial climates



Part 4
Convergent evolution:
comparing vegetation in
Mediterranean climates

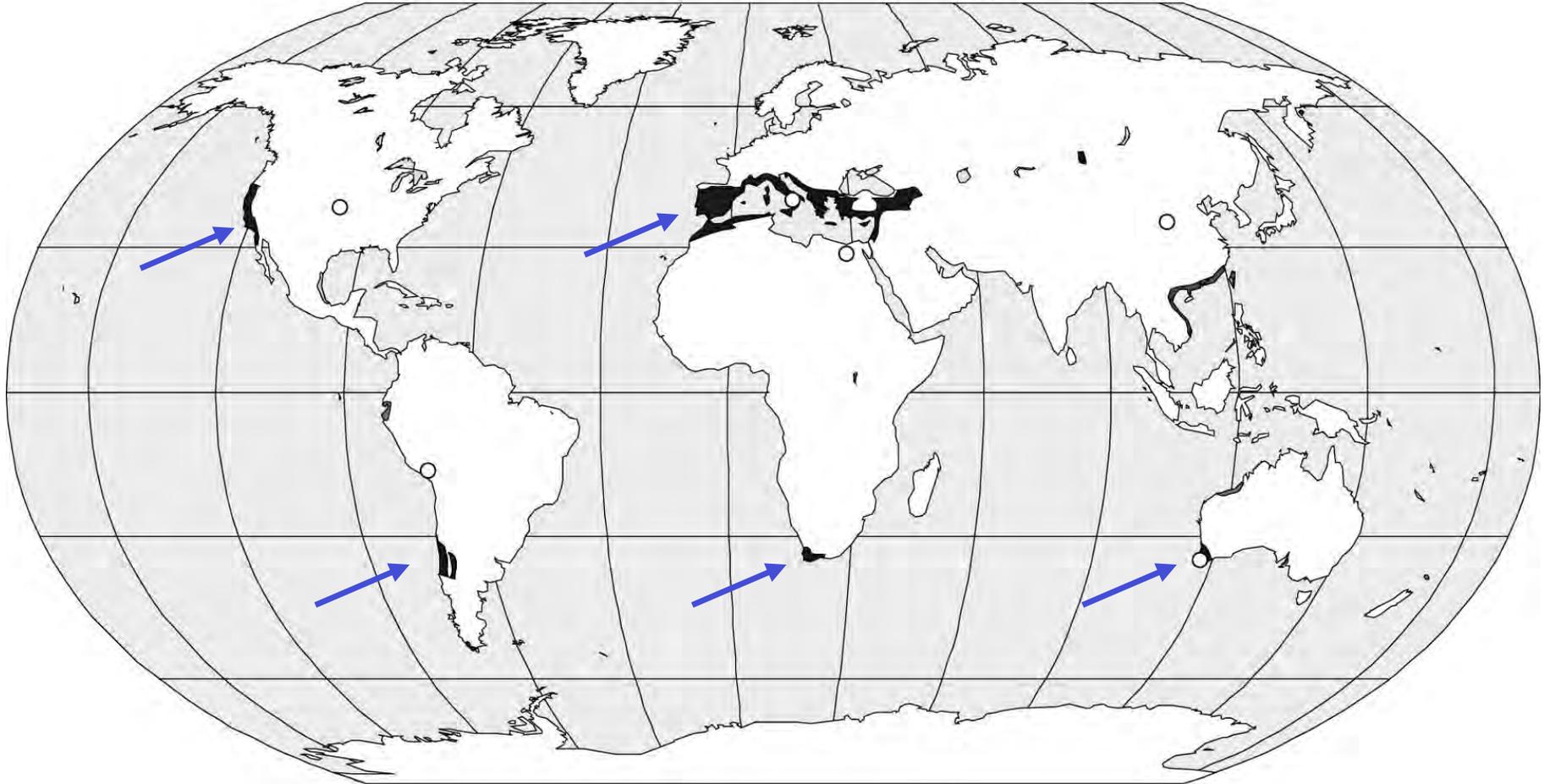


Convergent evolution is the concept that similar climates should select for similar life forms, irrespective of phylogenetic history

Consider coastal California and Chile, both are Mediterranean climates

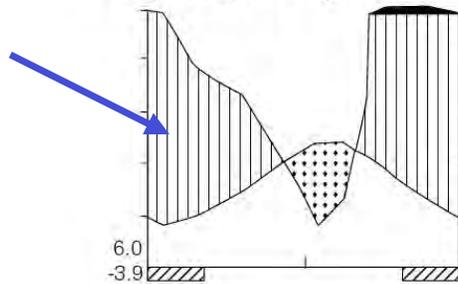
Let's explore examples that suggest natural selection favors evolution of analogous structures under similar environmental conditions

Mediterranean vegetation

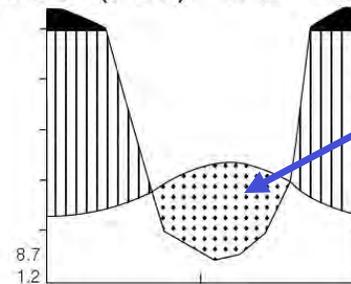


winter
wet

Naples (149m) 16.3° 675



Perth (65m) 17.9° 883



summer
dry

'chaparral' in
southern
California'

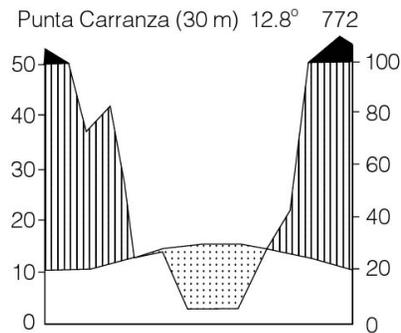
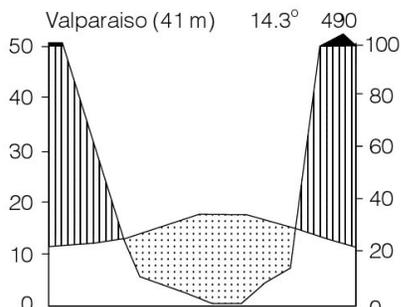
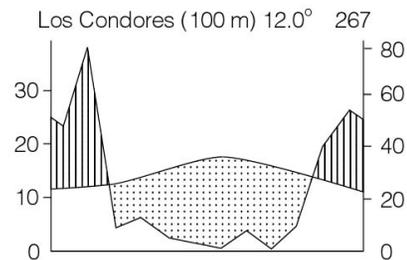
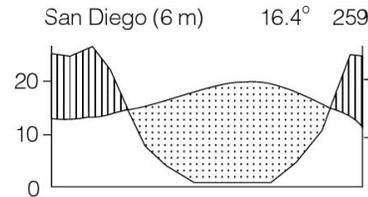
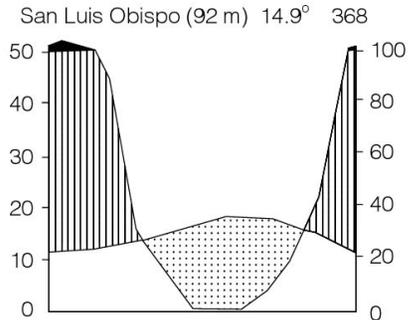
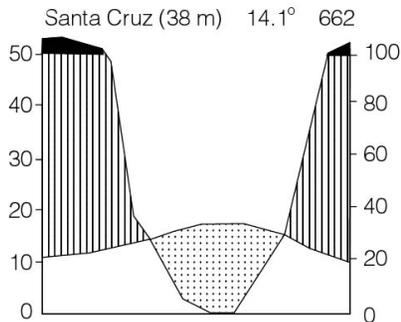


http://room42.wikispaces.com/file/view/555_PS-Chamise-RS-chaparral.jpg/34450629/585x416/555_PS-Chamise-RS-chaparral.jpg
http://www.calacademy.org/exhibits/california_hotspot/images/chaparral_mountains.jpg
<http://www.roebuckclasses.com/105/images/physical/biome/chaparral.jpg>

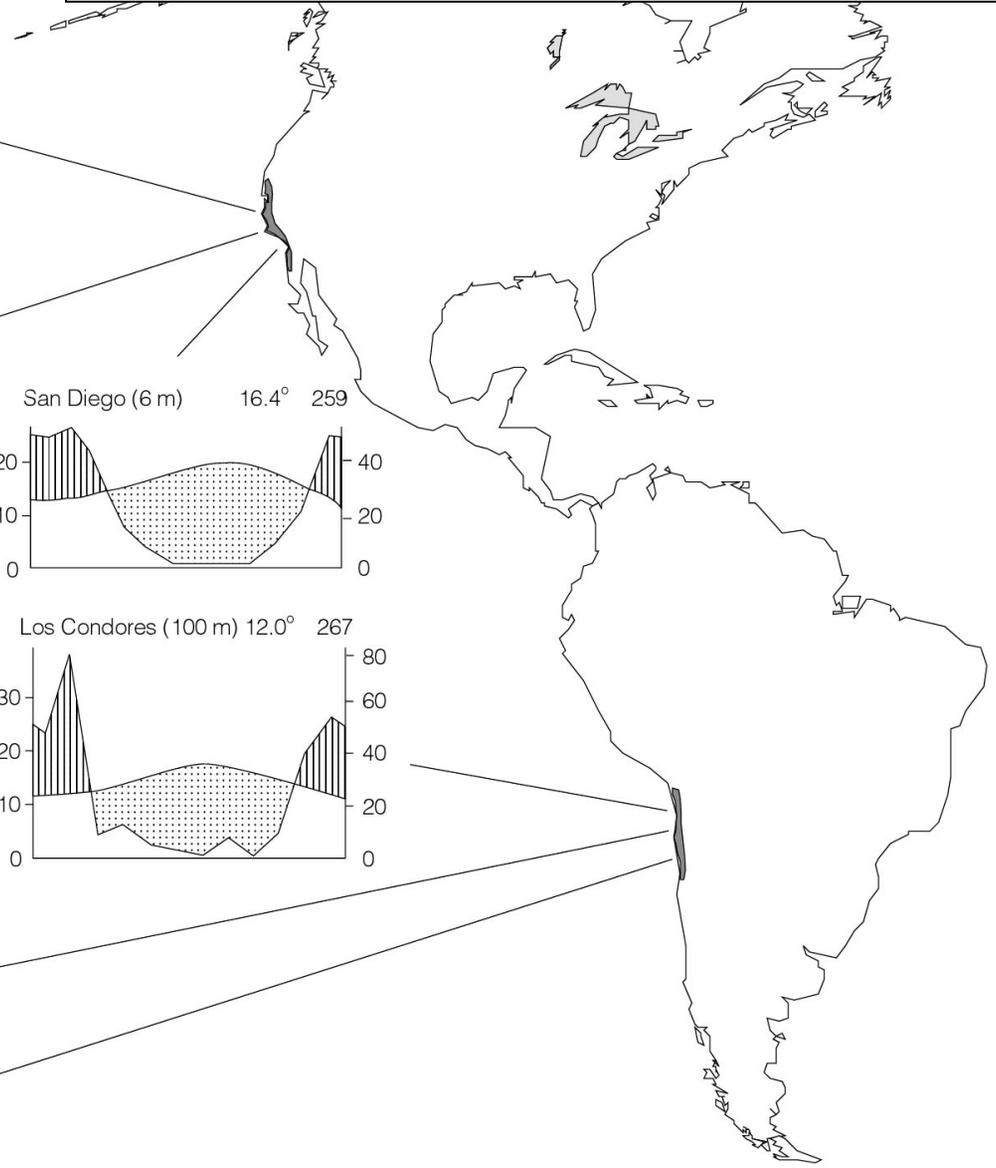
'chaparral' in Greece, where it is known as 'mattoral'



Mediterranean climates



Note similarity in climates
between Chile and California



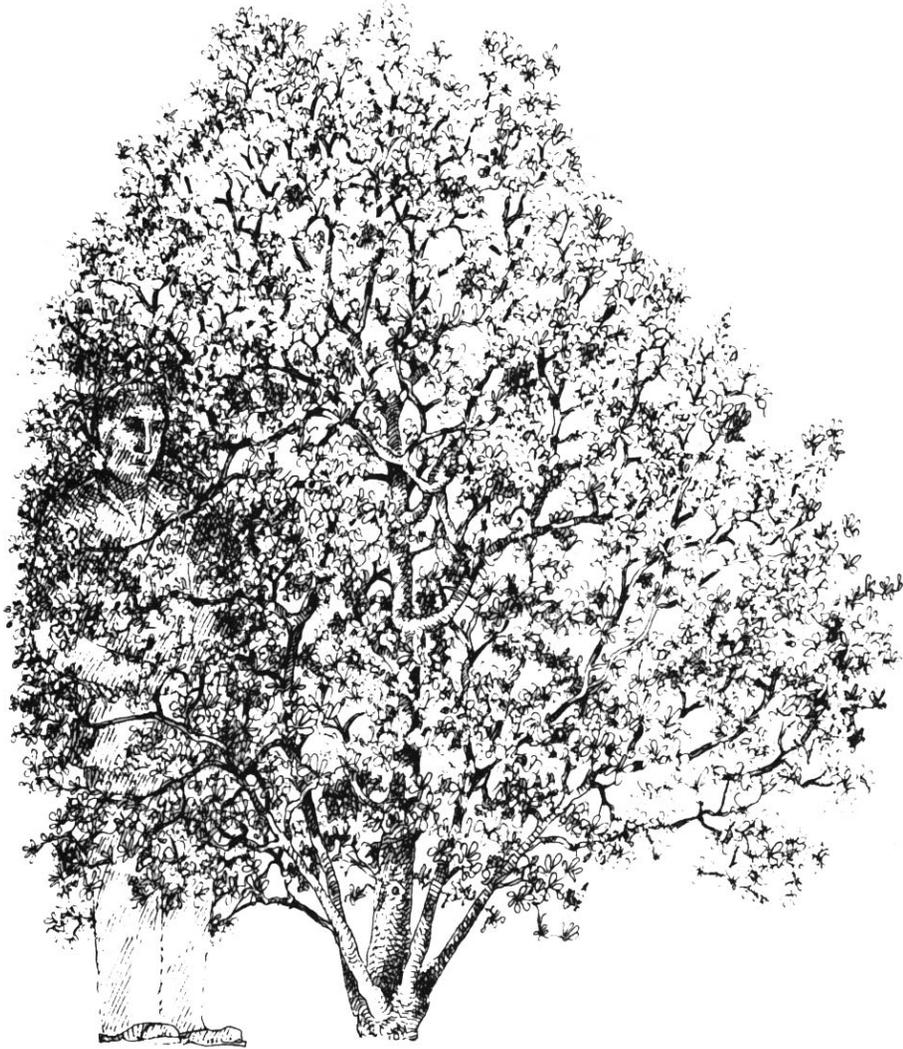
We also note convergence in vegetation, with unrelated plant species looking like each other in form and phenology



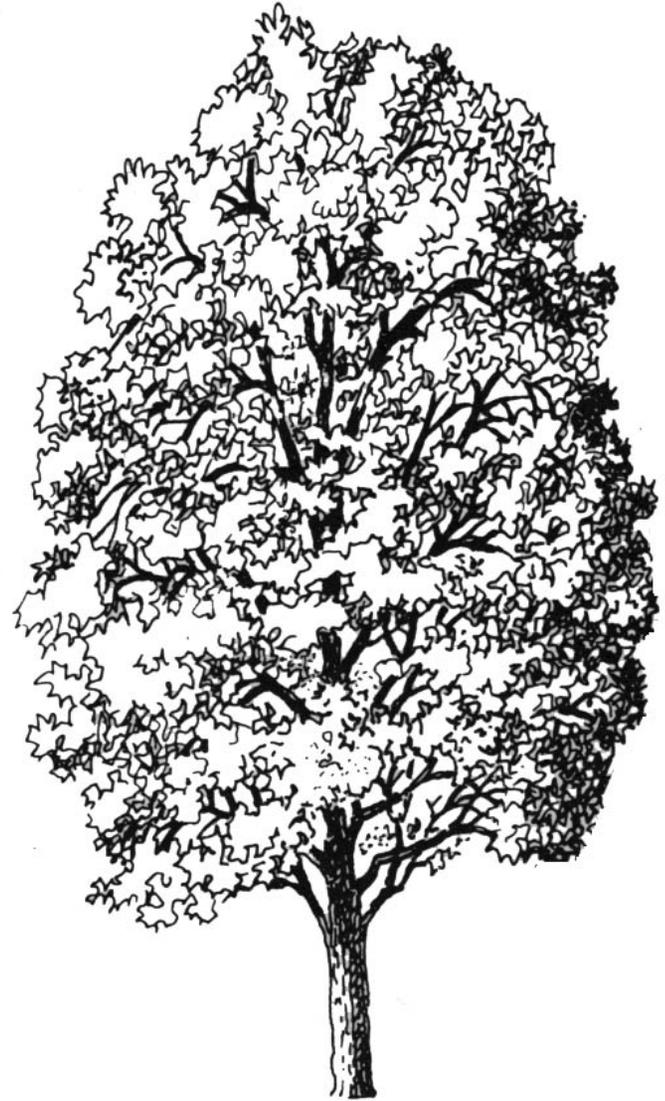
Quercus - California



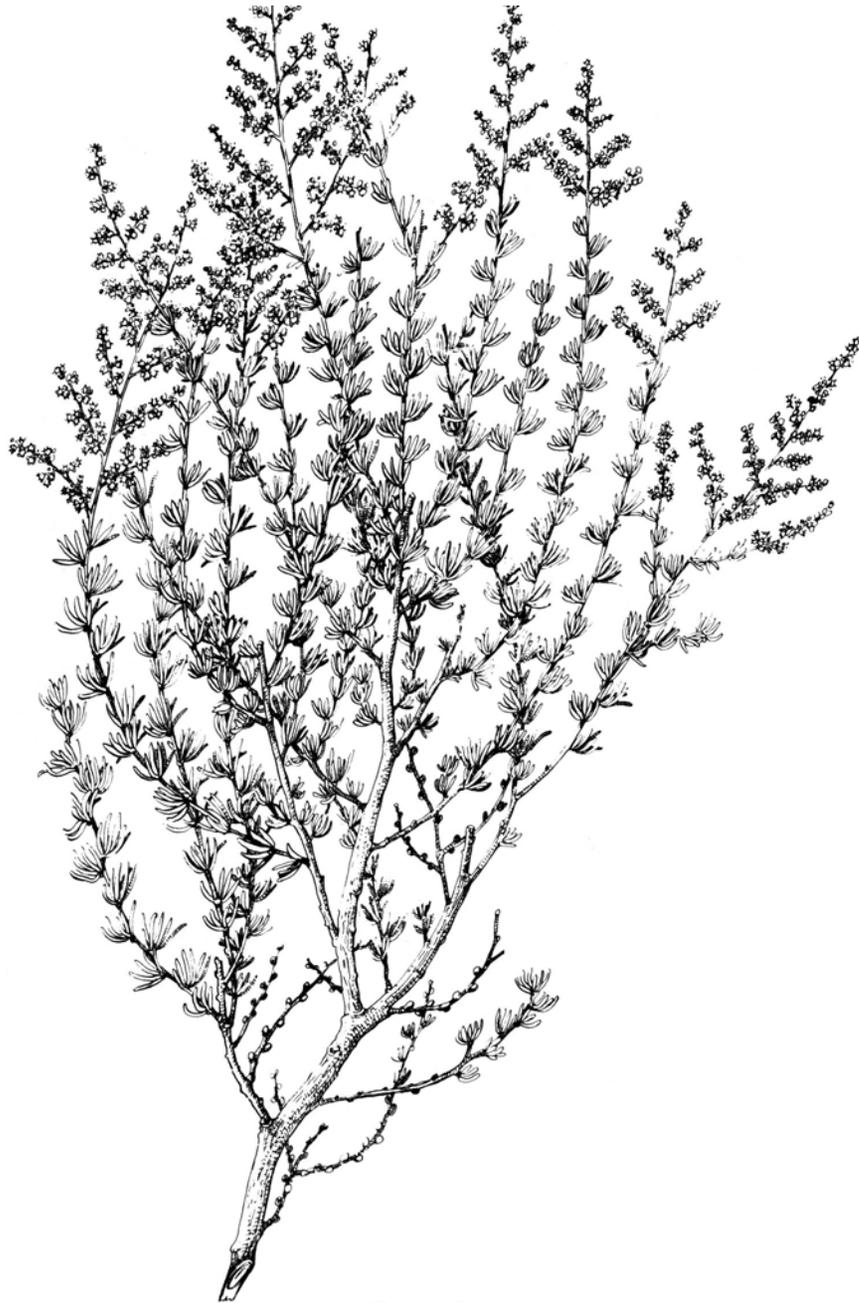
Quillaja - Chile



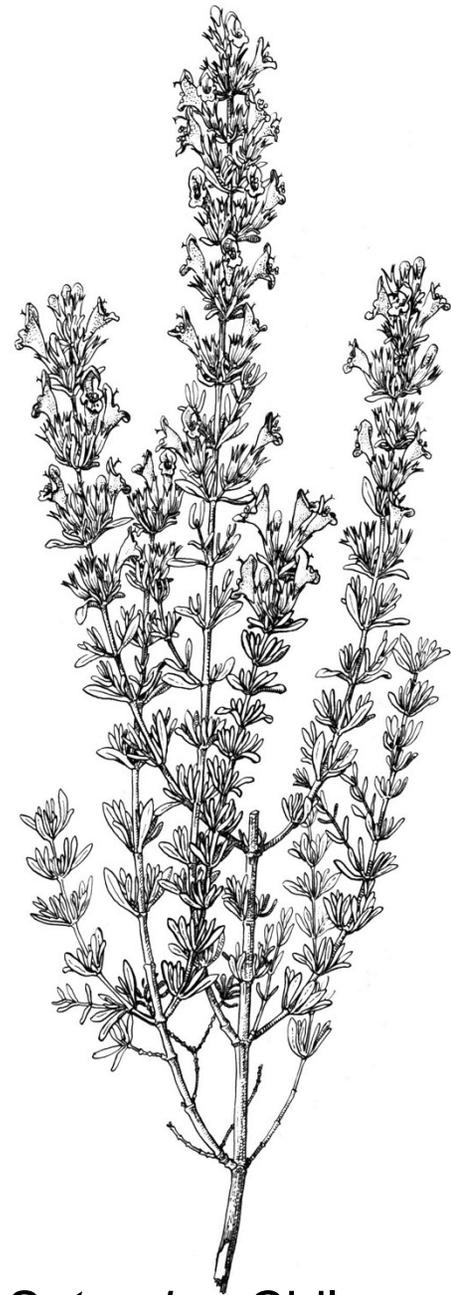
Quercus - California



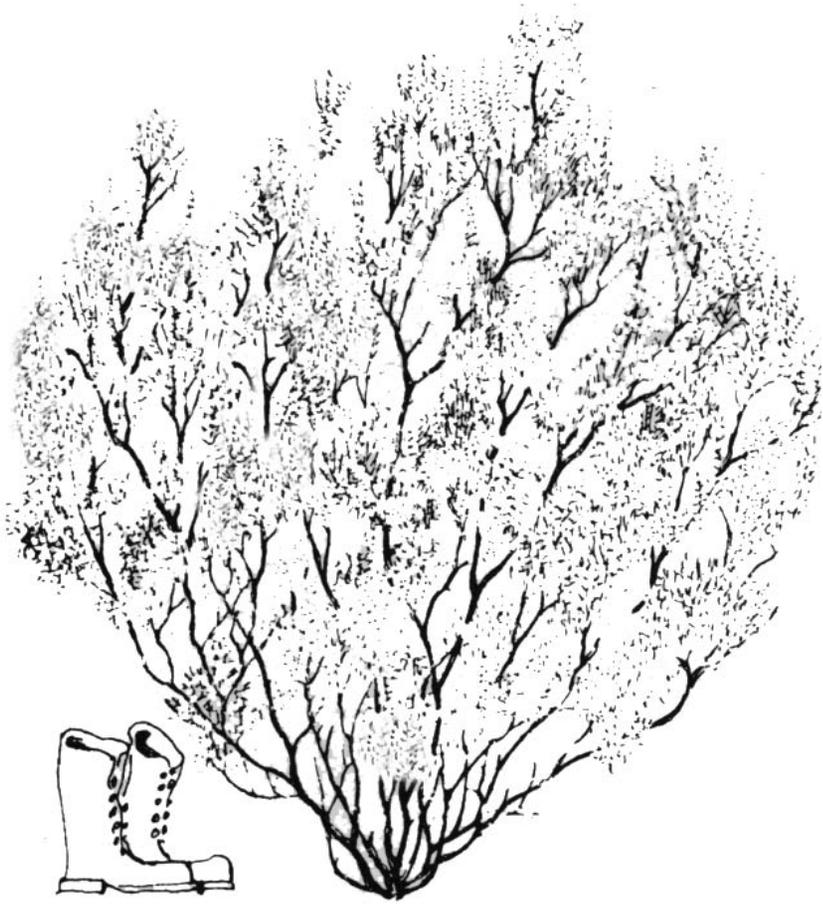
Quillaja - Chile



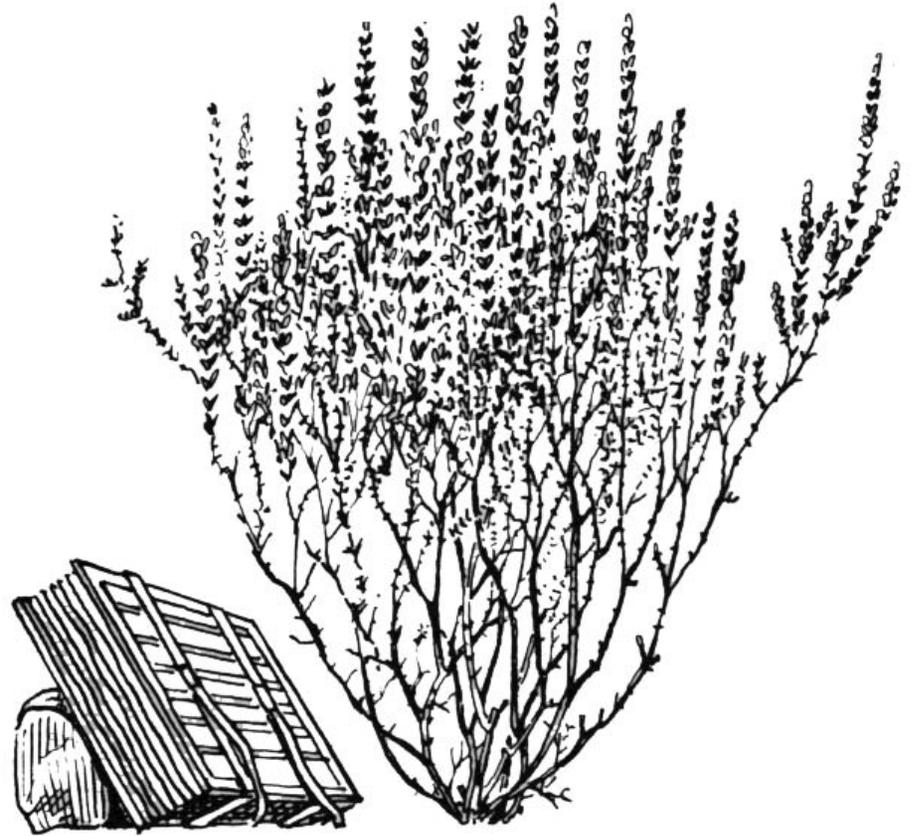
Adenostoma - California



Satureja - Chile



Adenostoma - California



Satureja - Chile

We also note convergence in plant structural patterns along environmental gradients in both California and Chile

