Lecture 4:
Mechanisms of Influence: Basic ecology

Climate Change Ecology
Geography 404
Jeff Hicke

Moisture

Soil moisture controls on woody plants in desert Southwest

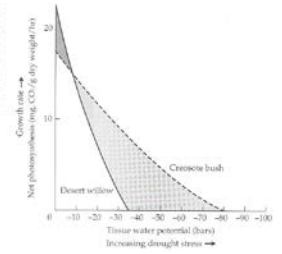


FIGURE 4.23 Trade-offs between growth rate and drought tolerance in two species of desert shrubs: creosote bush (*Larrea tridentata*), which grows in some of the driest North American deserts; and desert willow (*Chilopsis linearis*), which has an overlapping geographic range, but is more mesophytic, occurring in microhabitats along watercourses where the soil is permanently moist. Note that under relatively high drought stress (light gray region) creosote bush has the higher net photosynthetic rate and is able to grow faster, shade, and competitively exclude desert willow. (After Odening et al. 1974.)

Lomolino et al. 2006

Moisture

Moisture stress on plants: mortality

Croplands

http://soilcrop.tamu.edu/photogallery/sorsorghum+images/drought%20stress%203.jpg

Pinyon pine in SW

Photo by Craig Allen - USGS

Moisture

Soil moisture controls on tree species distribution in PNW

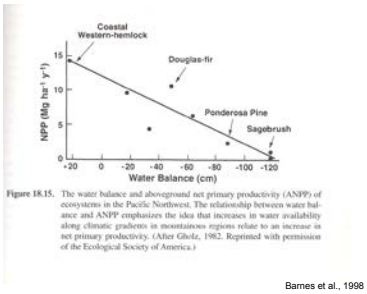


Figure 18.15. The water balance and aboveground net primary productivity (ANPP) of ecosystems in the Pacific Northwest. The relationship between water balance and ANPP emphasizes the idea that increases in water availability along climatic gradients in mountainous regions relate to an increase in net primary productivity. (After Gholz, 1982. Reprinted with permission of the Ecological Society of America.)

Barnes et al., 1998

Moisture

Rooting depth in arid landscape controls species distribution

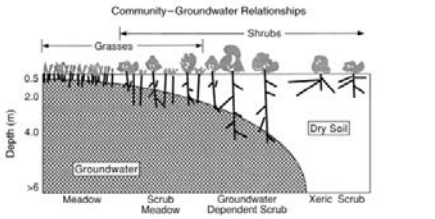
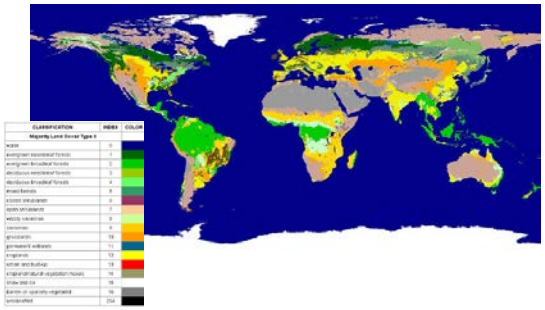


FIG. 2. Phreatophytic plant communities in Owens Valley are distributed on the landscape according to patterns of groundwater availability. Meadow communities require shallow water tables, a mixture of shrubs and grasses occur at intermediate water table depths, and shrubs dominate the deepest levels. Xeric shrub communities, as defined here, require no groundwater resources. Exotic annuals can compete with varying success at any point on this gradient.

Elmore et al., 2003

Moisture

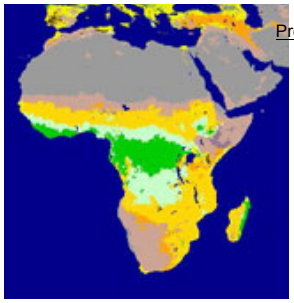
Controls of soil moisture at larger scale



Friedl et al.

Moisture

Controls of soil moisture at larger scale



Precip	Biomass	Veg type
dry	none	none shrublands savannas
wet	high	dense forest
dry	none	

Friedl et al.

Moisture

Plant strategies to deal with drought: 1. Escapees

- Perennials (dormancy)
- Annuals ("emphemerals")

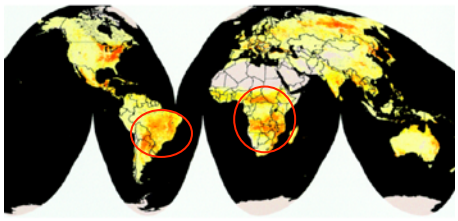
Still very dry and nothing is blooming yet, photo from Anza Borrego Desert State Park on Jan. 1, 2007

www.desertusa.com/wildflo/wildupdates.html

Moisture

Plant strategies to deal with drought: 2. Avoiders

another strategy: shed leaves (drought deciduous)
focus on subtropical forests with high % deciduous



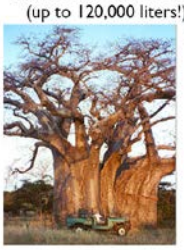
Slide courtesy C. Still

DeFries et al., 2000

Moisture

Plant strategies to deal with drought: 2. Avoiders

store water in the trunk (up to 120,000 liters!)



http://www.safari-tours.com/pgbs/images/lodges/baobab.jpg

have deep roots (*Larrea tridentata* roots measured to 53 m!)

Slide courtesy C. Still

Moisture

Adaptations to low water availability

Namib Desert beetle (*Onymacris unguicularis*)

morphology adaptations to capture fog:
- bumps on back
- channels to mouth
- head down behavior

can capture 40% of body weight in one morning

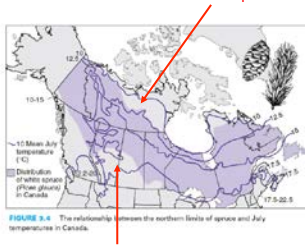
www.nacoma.org.na/Pictures/Photos/Beetle.jpg

http://www.biomechanics.bio.uci.edu/_html/nh_biomech/namib/beetle.htm

Multiple factors/interactions

What factors limit white spruce at its northern and southern extent?

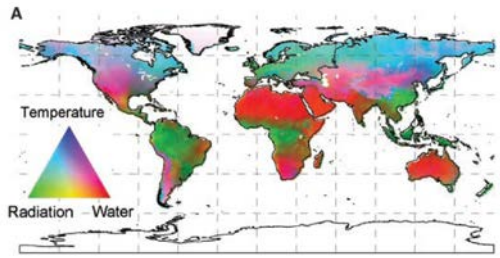
Summer temperatures



Moisture stress (high summer temps, low precip)

Multiple factors/interactions

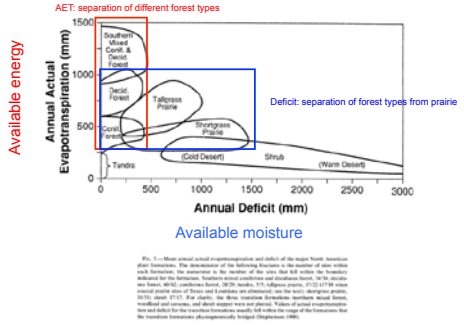
Controls on Net Primary Production



Nemani et al., 2003

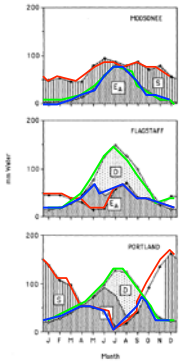
Multiple factors/interactions

Distribution of major N. America plant formations



Stephenson, 1990

Physical environment



Three reasons conifers dominate over deciduous trees

energy limited: low PET => low AET

water limited: low precip => low AET

S = surplus of water (hatched)
D = deficit of water (stippled)

asynchrony in energy, water supplies => low AET

Stephenson, 1990