Photosynthesis

$6\ CO_2 + 12\ H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2 + 6H_2O$

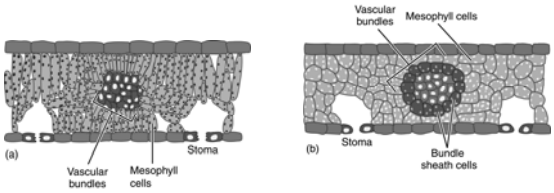
Light reactions

- Light energy absorbed by chlorophyll
- Raises energy level of chlorophyll molecule
- Energy transferred to acceptor molecule
  - Photosynthetic electron transport

Dark reactions

- CO_2 into carbohydrates – simple sugars

X-sections C_3 & C_4 Plants



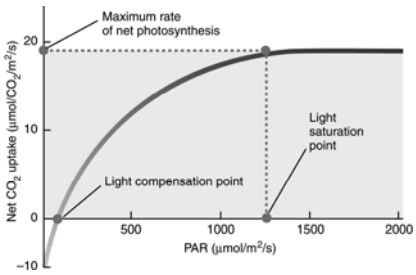
C_3 Plant

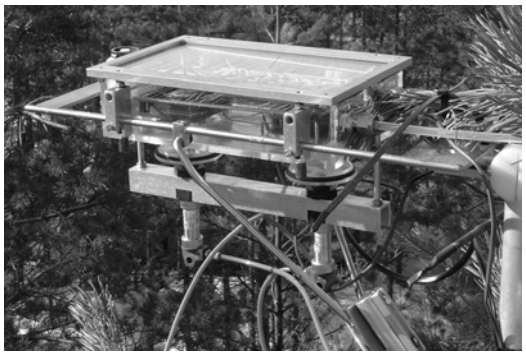
C_4 Plant
Note bundle sheath

Trait	C_3	C_4	CAM
Leaf	Palisade/ spongy	Sheath cells, Kranz anatomy	Succulent
Stomata	Open by day	Open by day	Open by night
Light Saturation	6,000 ftc	8-10,000 ftc	8-10,000 ftc
Maximum Photosynthesis	Intermediate	High	Low
Growth Rate	Intermediate	High	Low
Water Efficiency	Low	Intermediate	High
CO_2 Compensation Point	High	Low	Lowest
Habitat	No pattern	Open, warm, saline	Open, warm, saline

Response of Net Photosynthesis to PAR

Light response curve

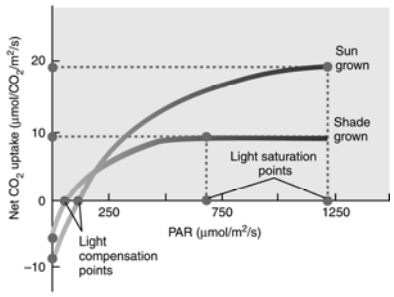




Measuring carbon dioxide uptake rates of trees (here by a branch cuvette in Hyytiälä / Finland).

Responses to Reduced PAR

Immediate response – lowered photosynthesis rate
Long-term response – evolutionary shifts in morphology & physiology

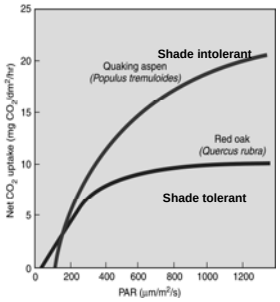


Leaves grown in sun vs. shade

Adaptations to PAR Variation

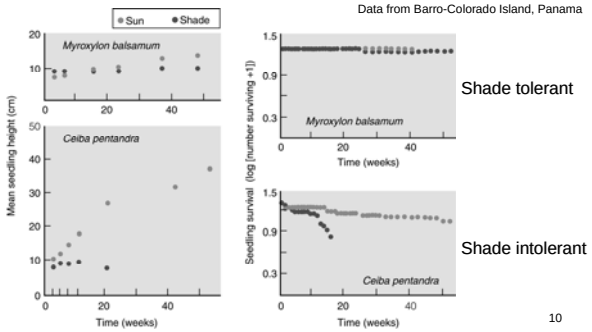
Shade intolerant/sun-adapted
- Higher respiration rate
- Higher growth rate
- Higher photosynthesis rate at high light

Shade tolerant/shade-adapted
- Lower respiration rate
- Lower growth rate
- Lower photosynthesis rate at high light

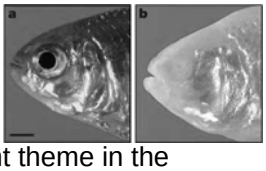


Adaptations Have Survival Consequences

Data from Barro-Colorado Island, Panama



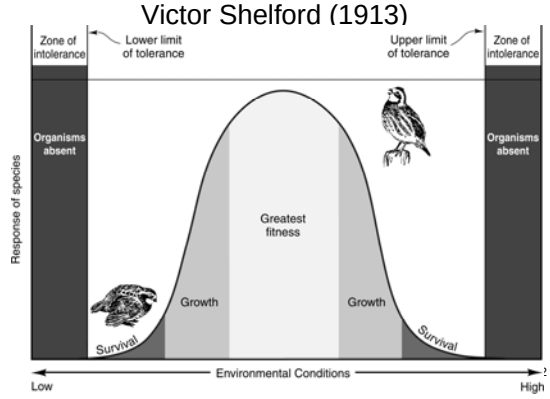
Adaptations



<u>Compromise</u> a consistent theme in the relationship of organisms to environment
- e.g., CAM – reduces water loss but also reduces access to O_2 or CO_2

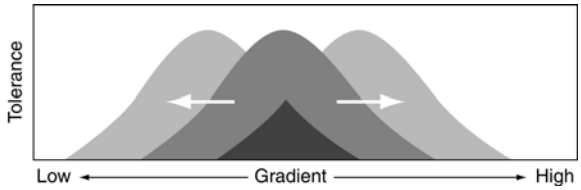
In absence of benefit, small costs apparent
- e.g., Eye is useless to cave-dwelling fish, reduced to rudimentary structure
- e.g., Carbohydrates devoted to spines or toxins, cannot be packaged into seeds

"The Law of Tolerance"
Victor Shelford (1913)



Tolerance Curves

Can be broad or narrow
- e.g., Fish – water temperature summer to winter



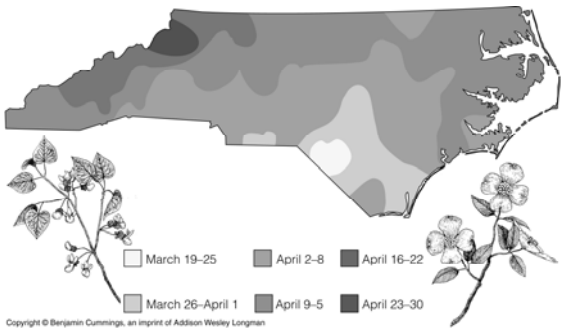
acclimatization – short term response of an individual to exposure to different or changing natural environments

Plant periodicity

Seasonality – seasonal fluctuations in plant growth and development corresponding to passage of seasons and influenced by interactions of light, temperature, and moisture.

Phenology – study of the causes and timing of these events, the biotic and abiotic forces affecting them, and the interrelations among phases of the same or different species.

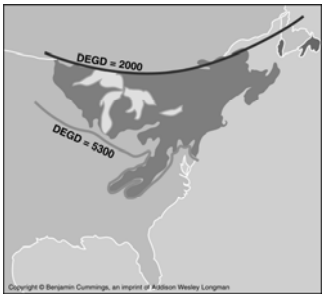
14



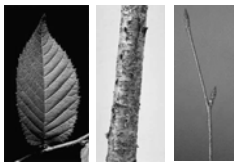
15

16

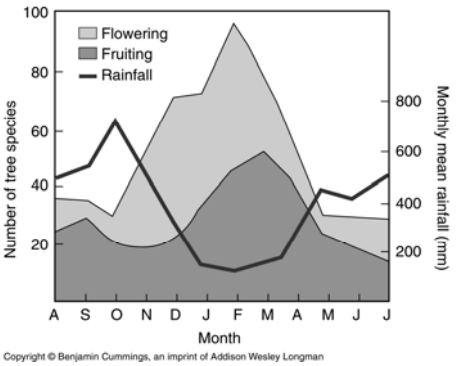
Environment Affects the Distributions of Organisms



Geographic range of yellow birch. Growing degree days values of 2000 & 5300 approximate the north & south boundaries of this species.

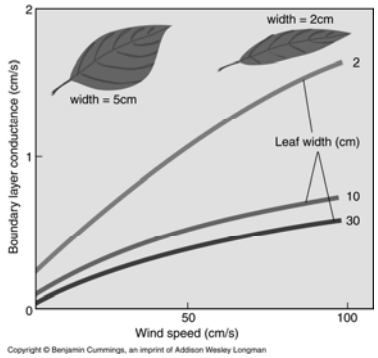


17



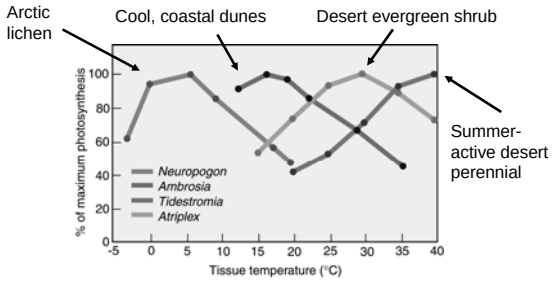
Costa Rica – flowering and fruiting associated with rainfall

18



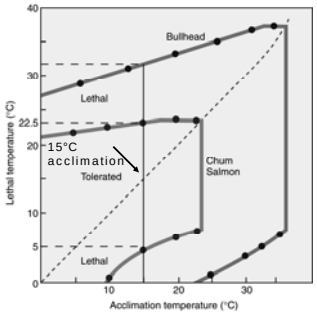
19

Thermal Habitats & Photosynthetic Rates



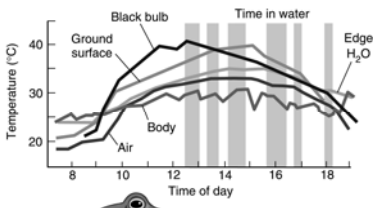
20

Thermal Tolerances:
Cold Water & Warm Water Fish

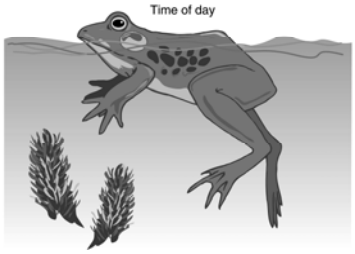


A fish kept at some temperature on the diagonal line until <u>fully acclimated</u> has the upper & lower lethal limits shown

21



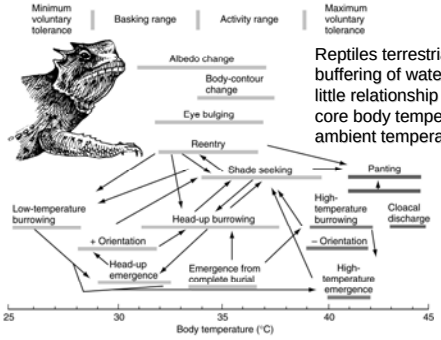
Bullfrog Body Temperature: Behavioral Control



Frog moves in & out of water to maintain near uniform body temperature, water buffers

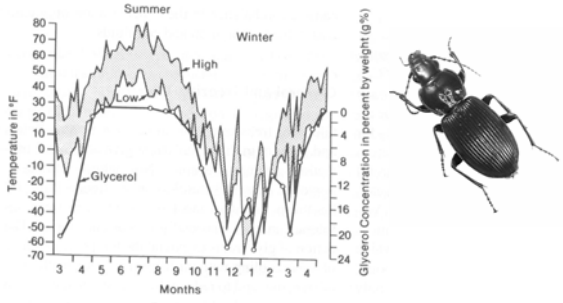
22

Horned Lizard:
Behavioral Temperature Regulation



Reptiles terrestrial, lack buffering of water. Exhibit little relationship between core body temperature & ambient temperature

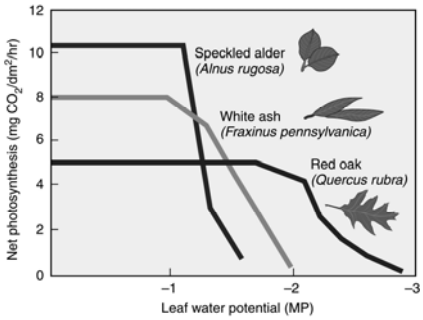
23



Seasonal variations in average glycerol concentration in hemolymph of Arctic carabid beetle and high/low ambient temperature near Fairbanks, AK.

24

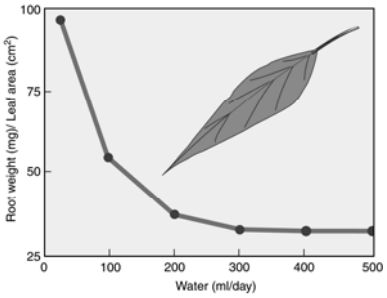
Responses to Water Availability



As soil water potentials become more negative, root & leaf potentials decline. Stomatal closure causes decline in net photosynthesis.

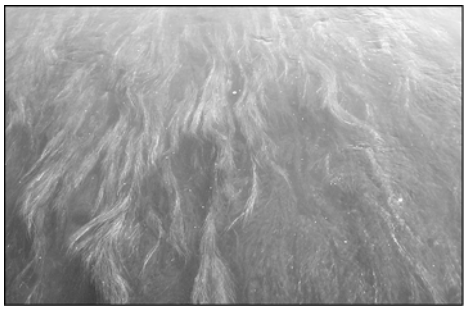
25

Water Potential & Growth Form



Eucalyptus seedlings grown under low water conditions allocate more to roots & less to leaves

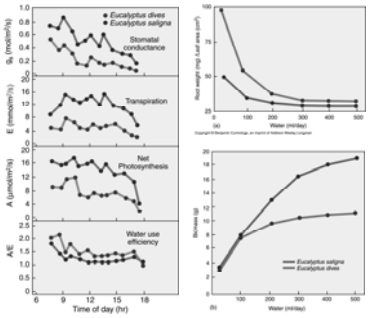
26



Macrophytes – lack lignin and vascular tissue

27

Long-term Variation in Water Availability



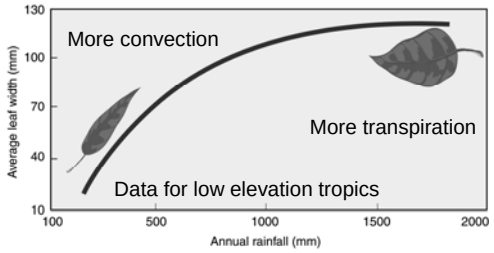
Mesic-adapted (*E.s.*) & xeric-adapted (*E.d.*) spp have different responses.

Higher photosynthetic rate has cost of high transpiration & hence lower water-use efficiency

28

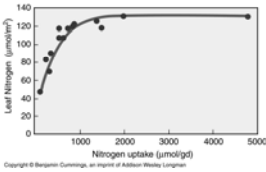
Water & Energy Balances

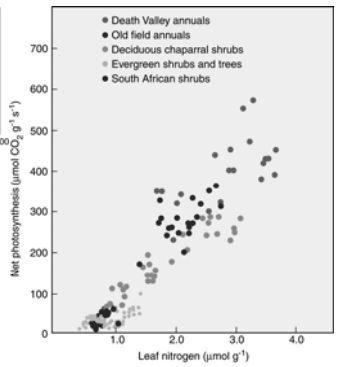
Heat lost via transpiration & convection – xeric-adapted plants constrained by water loss making convection more important – small leaves lose more heat per unit leaf area



29

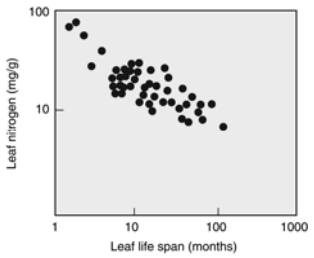
Nutrient Availability

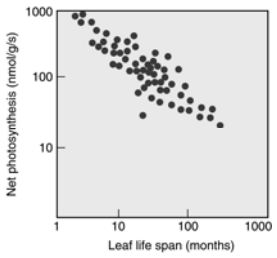




Nutrient concentrations directly affect growth, survival, & reproduction

Leaf Longevity Affects Leaf Function





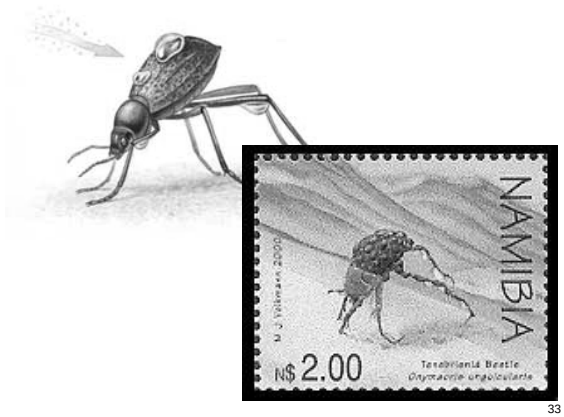
31

Leaf Longevity

Plants of low-nutrient habitats have adapted via longer-lived leaves

- Wasteful to throw leaves away, hence maintain evergreen leaves
- Leaves w/ lower N concentrations
- Defend w/ carbon-based defenses, not nutrient-based defenses
  - Lignins & cellulose, not alkaloids
- Cost is lower rates of photosynthesis

32



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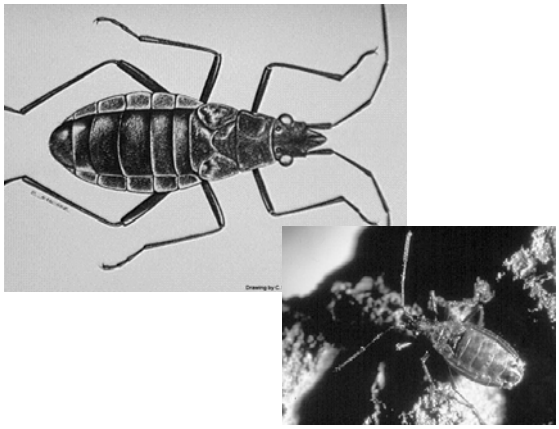
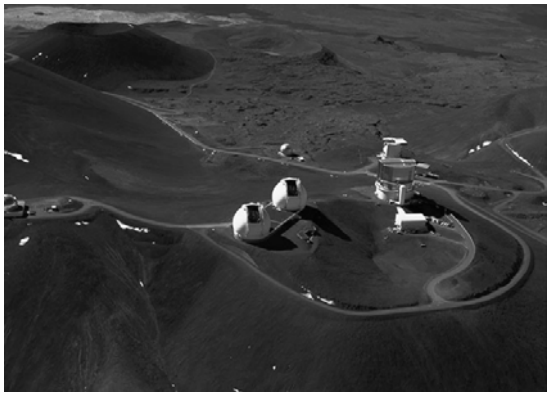


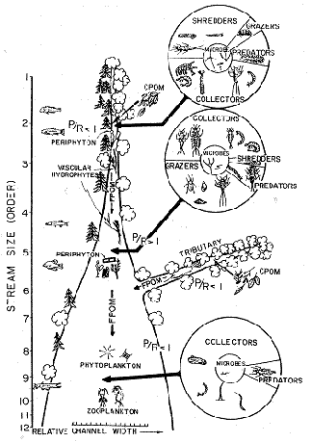


35

Silo (Europe)

Caddisflies

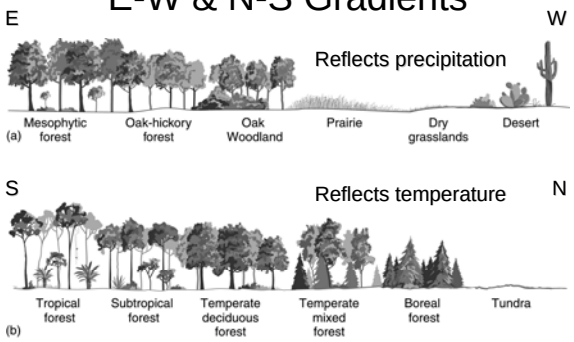
36

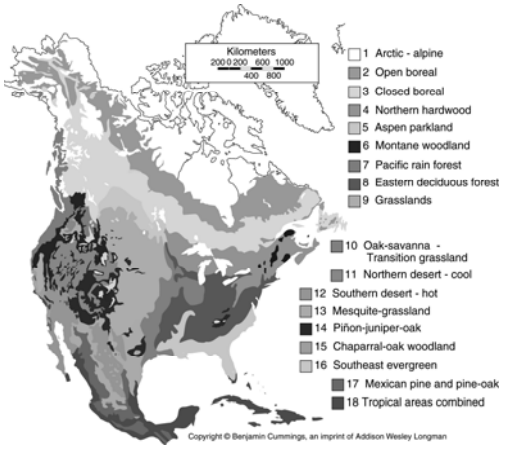


38

39

U.S.A.
E-W & N-S Gradients





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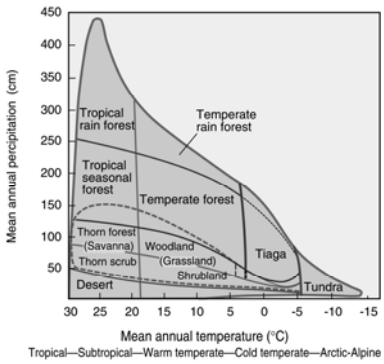
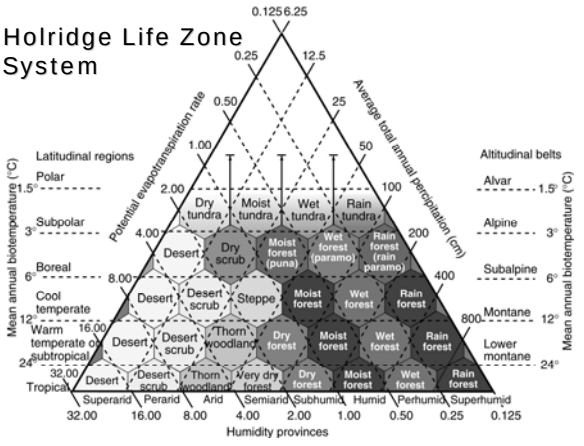


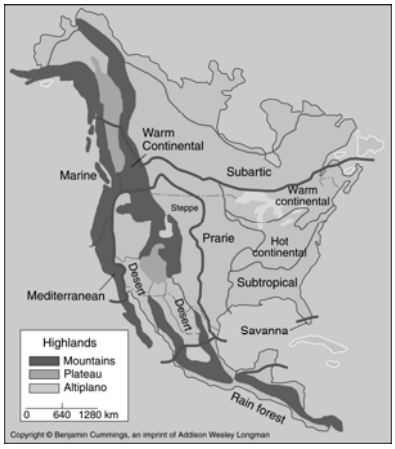
Biomes

Major regional ecological communities of plants & animals

42

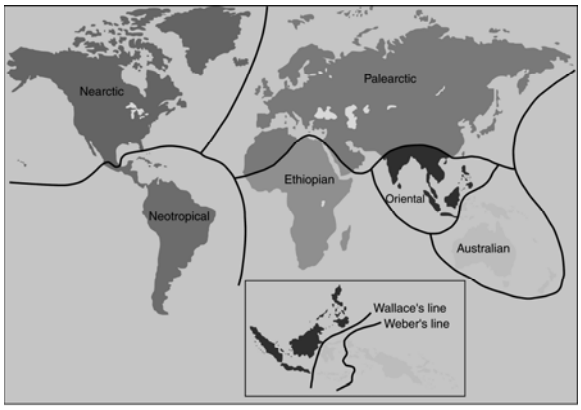
Holridge Life Zone System





Ecoregions of North America

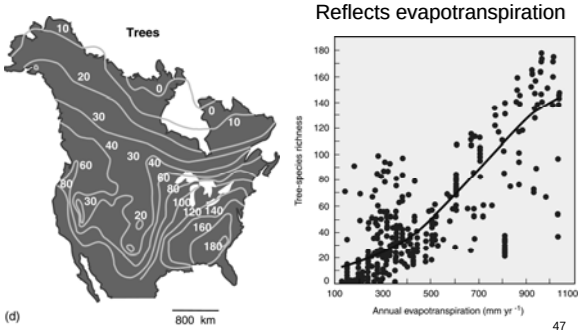
44



46

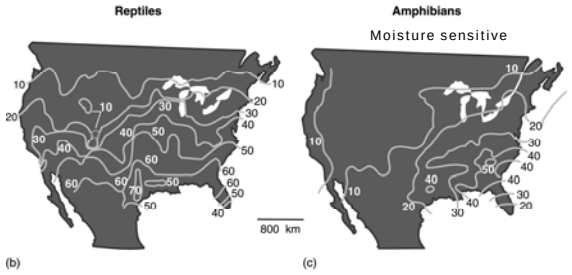
Tree Species Richness

Reflects evapotranspiration



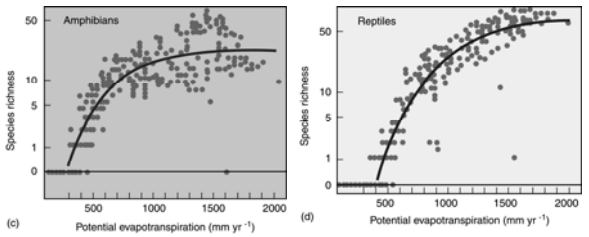
47

Species Richness



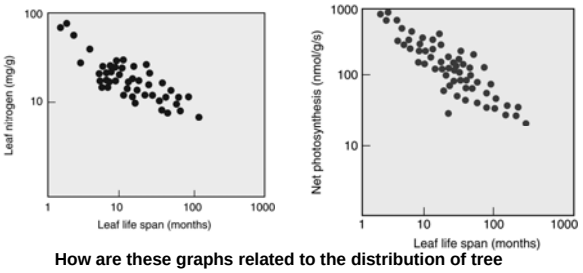
48

Species Richness



49

Leaf Longevity Affects Leaf Function



How are these graphs related to the distribution of tree species in North America?
Draw a graph comparing soil nutrient levels with leaf longevity.

50