FOREST ECOLOGY

WHAT IS IT???

ECOLOGY

- **'OIKOS'** (Gr.) household, home, place to live
- **'LOGIA'** knowledge
- **ECOLOGY** – the study of organisms and their environment – and the interrelationships between the two.

TYPES OF ECOLOGICAL STUDY

- Plant ecology
- Animal Ecology
- Population Ecology
- Behavioral Ecology
- Ecophysiology
- Evolutionary Ecology
  - These and other approaches are fragmentary and too compartmentalized.

ECOSYSTEM ECOLOGY

- **a holistic and integrated ecological concept that combines living organisms and their physical environment into a system called an ecosystem. (A.G.Tansley, 1935)**

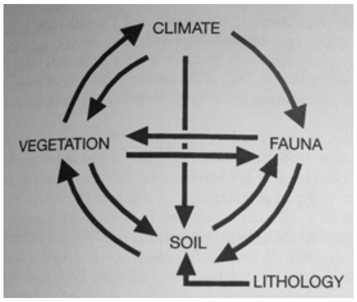
DIVISION OF STUDY

- **HOLISTIC - ecosystem study viewing the entire system as greater than the sum of its parts**
- **REDUCTIONIST - study the ecosystem parts (communities and processes) separately assuming the whole is the sum of its parts.**

DIVISION OF STUDY

- **VERTICAL – Study a small area from ground through atmosphere**
- **HORIZONTAL – Study a broad landscape with its spatial variation**

ECOSYSTEM ECOLOGY



TYPES OF ECOSYSTEMS

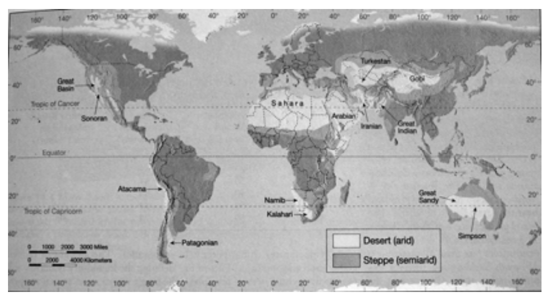
- GRASSLAND/ STEPPES

- TUNDRA

TYPES OF ECOSYSTEMS

- DESERTS

Global Grasslands and Deserts



TYPES OF ECOSYSTEMS

- SHRUBLANDS
  - Chaparral = shrubby evergreen oaks

  - Northern desert shrub = sagebrush

TYPES OF ECOSYSTEMS

- SAVANNAS –
  Occur on plains with low nutrient soil. Cannot support a forest. Well developed grasses with scattered patches of trees

AQUATIC ECOSYSTEMS

- **FRESHWATER ECOSYSTEMS**
- **SALT WATER ECOSYSTEMS**
- **WETLANDS**

FOREST ECOSYSTEMS

* Forests cover ~ 30% of earth's surface

What is a forest?

- **"Forests only exist in human minds. Groups of animals and plants that we call forests come together for a short time; then each species goes its separate way when conditions change."**

T. M. Bonnicksen "America's Ancient Forests: From the Ice Age to the Age of Discovery." 2000

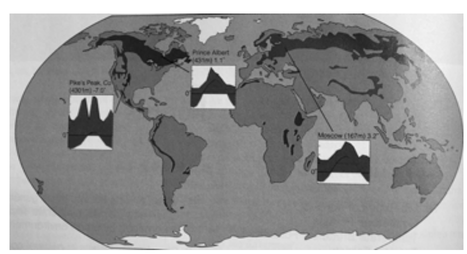
WHAT IS A FOREST?

- **'FOREST' denotes a collection of stands administered as an integrated unit, usually under one ownership.**
- **'STAND' is a <u>contiguous</u> group of trees sufficiently uniform in <u>species composition, age structure, site quality, and condition</u> to be a <u>distinguishable</u> <u>unit.</u>**
- **'PATCH' fundamental units of vegetation**

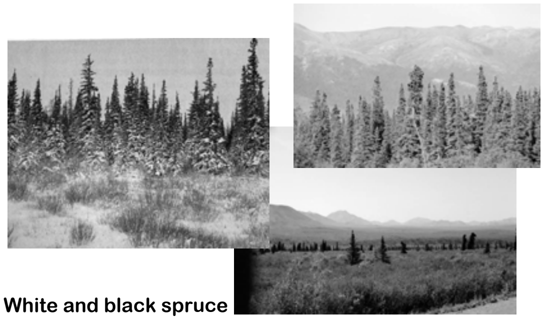
FOREST ECOSYSTEMS
Major types

- **<u>Coniferous (Cold/freeze resistant)</u> –range of environments; boreal, montane**
- **<u>Temperate</u> – in regions of moderate precipitation and mild temperatures. Hardwood and rain forest**
- **<u>Tropical</u> –in equatorial regions with a steady temperature (~23° C) and a wide variation in rainfall. (rain, montane and dry)**

CONIFEROUS FOREST
Boreal (Northern) forest

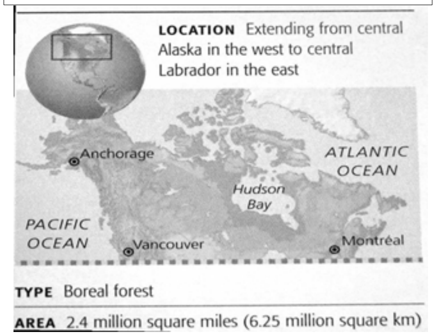


TAIGA (“LAND OF LITTLE STICKS” Ru.)

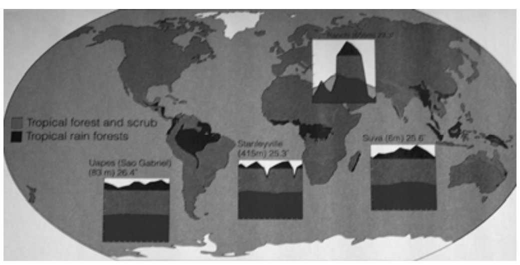


White and black spruce

North American Boreal Forests



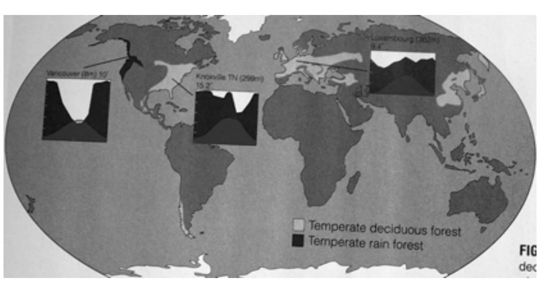
TROPICAL FORESTS



TROPICAL FORESTS

- **Tropical rain forests –** temperatures constantly high (~26°C annual mean)
  Heavy rainfall throughout the year
  (~400 cm/yr = ~157 “/year)
- **Tropical montane forests** – cooler on mountain slopes
- **Tropical dry** - ~42% of tropical forests. Experience a dry period varying with latitude

TEMPERATE FORESTS



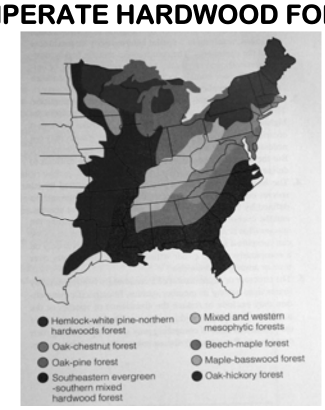
TEMPERATE RAIN FOREST

TEMPERATE HARDWOOD FORESTS

CENTRAL HARDWOOD FOREST

CENTRAL HARDWOOD FOREST

TEMPERATE HARDWOOD FORESTS



UNITED STATES FORESTS

(From USDA FS web site)

Location	% cover range	Total forest acres (x1000)	Timberland acres (x1000)
Eastern ME,NH,VT,WV,MA,NY,CT,PA,RI,NJ,MD,DE,OH	59% 90%-30%	93,103	85,857
Pacific West WA,OR,HI,CA,AK	43.16% 51.4 -34.9	219,287	72,214
Inland West ID,CO,UT,AZ,MT,NM,WY	25.33% 41.8-13.8	91.45	NA

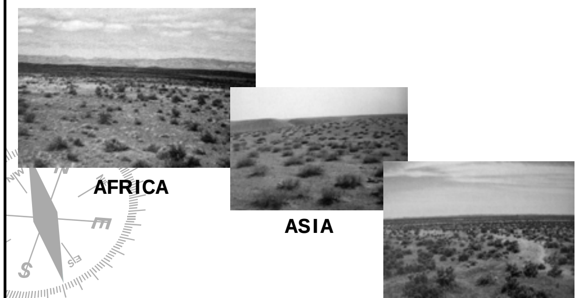
SUMMARY

- **<u>Ecology</u> – the study of organisms and their environment**
- **<u>Ecosystem</u> – the combination of living organisms and their environment**
- **Climate common denominator of each ecosystem**

SUMMARY

- Types of ecosystems:
  - Grasslands, deserts, forests, wetlands, etc
- <u>Forest</u> and <u>stand</u> definitions
- <u>Forest ecosystems</u>:
  - Coniferous (freeze resistant)
  - Temperate –hardwood and rain
  - Tropical – dry, montane and rain

BIOGEOGRAPHY



AUSTRALIA

BIOGEOGRAPHY

- Similarity in vegetation led to correlation of vegetation to climate, 19th century
- Earth divided into blocks of similar vegetation (deserts, grasslands, Etc,)
- Divisions called FORMATIONS

BIOGEOGRAPHY OF ECOSYSTEMS

- **The study of distributions of organisms, both past and present.**
- **Goal: to describe and understand the many patterns of distribution of species**

VEGETATION ZONATION

Climate-induced patterns of vegetation influenced by:

- Latitude
- Location of regions within a landmass (continents) affecting moisture
- Altitude [1000' (300m) = 100 miles (160 km) of latitude]

VEGETATION ZONATION North America

- Northern: broad west to east belts of vegetation are temperature dependent
- South of these belts vegetation zones lie north/south influenced by physiography of land
- Physiography = physical geography; study of earth's physical features

Vegetation zones – North America

ECOREGIONS

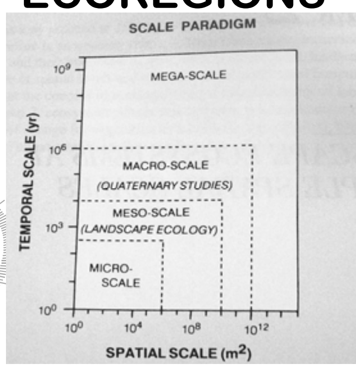
(R.G. Bailey – USDA-FS)

- **Ecosphere: entire globe**
- **Megascale: continental**
- **Macroscale: climate oriented, latitude, elevation, subcontinental**
- **Mesoscale: land form units (landscape) scale of 10-100's of square miles**
- **Microscale: Local site factors**

LANDSCAPE ECOLOGY

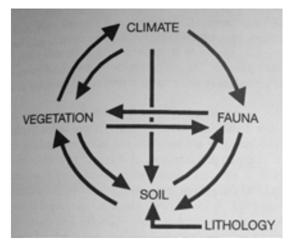
The study of ecosystems and their relationship to one another, considering the spatial nature of ecosystems, focusing on their spatial patterns and functional relationships.

ECOREGIONS



SITE

- **Represents the sum total of all environmental factors that affect the functioning of a community in a given locale**



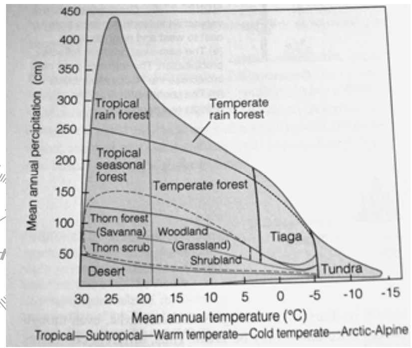
NICHE

- **Species adaptations occur at smaller scale than 'Microscale'.**
- **Allow species to adapt to a very specific niche**
- **Factors relating to role and adaptability:**
  - **Ecological requirements**
  - **Ecological tolerance**
  - **Ecological efficiency**

BIOMES

- **Considers broad plant formations and their associated animal life as a biotic unit.**
- **Introduced 1939 (Clements & Shelford)**
- **Biome characterized by a uniform life form of vegetation (desert, grassland, etc.)**
- **Boundaries indistinct as one type blends into another**

BIOMES



1970

LIFE ZONES*

(Merriman -1884)

► Emphasizes the importance of temperature:
- Law #1: the northward distribution of terrestrial plants and animals is governed by the sum of the positive temperatures as an influence for the entire growing season
- Law #2: The southward distribution is governed by the mean temperature of a brief period during the hottest part of the year.

***Used in temperature hardiness planting guides**

HOLDRIDGE LIFE ZONE SYSTEM

(1947- 1971)

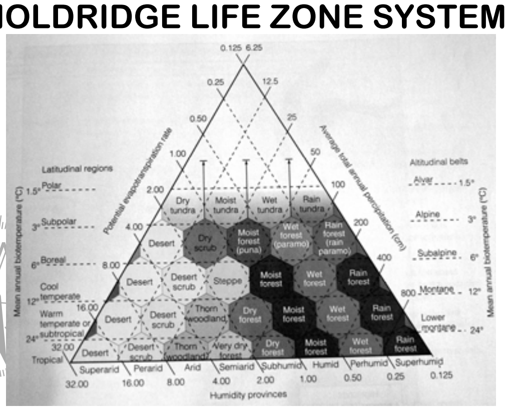
Three levels of classification:
- **Climatically defined life zones**
- **Associations, subdivisions based on local environment**
- **Further local subdivisions based on actual cover or land use**

HOLDRIDGE LIFE ZONE SYSTEM

Assumptions

1. **Interaction between temperature and rainfall determine vegetations patterns**
2. **Geographic boundaries correspond closely to boundaries between climate zones**
3. **Mature stable vegetational types represent discrete vegetation units recognizable throughout the world.**

HOLDRIDGE LIFE ZONE SYSTEM



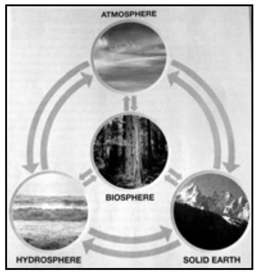
ECOREGIONS

(R.G. Bailey – USDA-FS, 1983-1996)

► ECOREGIONS: major ecosystems that result from predictable patterns of climate as influenced by latitude, global position and altitude (Bailey, *Ecosystem Geography,* 1996)

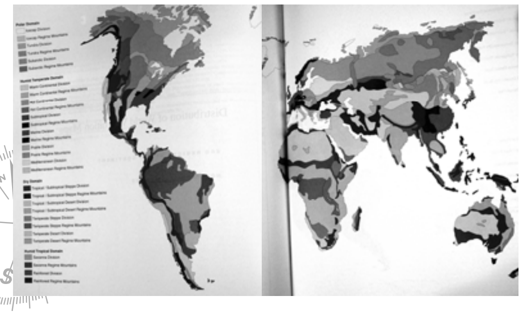
► Each ecoregion is a continuous geographical area across which the interactions of climate, soil and topography are sufficiently uniform to permit the development of similar types/ forms of vegetation
→ Hierarchical classification

The Ecosphere



Global Ecoregions

(Based on the Holdridge life zone system)



ECOREGIONS

HIERARCHICAL SCHEME

► **Subdivisions of ecosystems based on the interaction of climate, soil, continental position and topography**

ECOREGIONS

HIERARCHICAL SCHEME

► **<u>DOMAIN</u>: largest division**
- **Subcontinental in scale**
- **Includes:**
  - **Polar**
  - **Dry**
  - **Humid temperate**
  - **Humid tropical**

ECOREGIONS

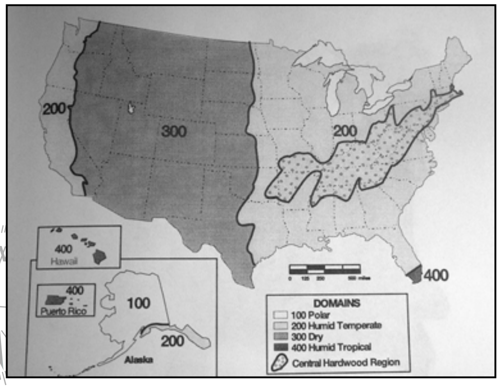
► **<u>DIVISIONS</u>: subcategory of domains (14 divisions) Based on the seasonality of precipitation or degree of coldness and dryness**

► **<u>PROVINCES</u>: vegetation regions having uniform regional climate**

ECOREGIONS

TABLE 27.1 A Hierarchy for Ecosystems

Name	*Character*
1. Domain	Subcontinental area of related climates
2. Division	Single regional climate at the level of Köppen's types (Trewartha 19
3. Province	Broad vegetation region with the same type or types of zonal soils
4. Section	Climatic climax at the level of Küchler's potential
5. District	Part of a section having uniform geomorphology at the level of Hamm regions (1964)
6. Landtype association	Group of neighboring landtypes with recurring pattern of landforms vegetation associations
7. Landtype	Group of neighboring phases with similar soil series or families wit at the level of Daubenmire's habitat types (1968)
8. Landtype phase	Group of neighboring sites belonging to the same soil series with cl
9. Site	Single soil type or phase and single habitat type or phase



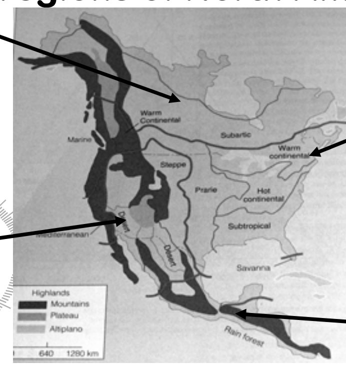
Ecoregions of North America

Polar Domain

Humid Temperate Domain

Dry Domain

Humid Tropical Domain



From: Bailey, R.W., 1978

ECOREGIONS

Domain	Division
► Polar	► Tundra ► Subarctic
► Humid Temperate	► Warm continental ► Hot Continental ► Subtropical ► Marine ► Prairie ► Mediterranean

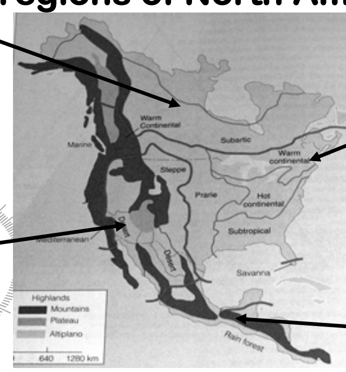
Ecoregions of North America

Polar Domain

Humid Temperate Domain

Dry Domain

Humid Tropical Domain



From: Bailey, R.W., 1978

ECOREGIONS

Domain	Division
► Dry	► Steppe ► Desert
► Humid Tropical	► Savanna ► Rain Forest

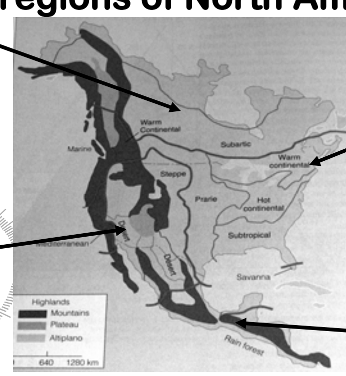
Ecoregions of North America

Polar Domain

Humid Temperate Domain

Dry Domain

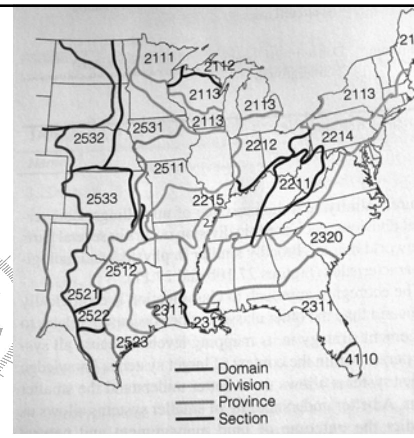
Humid Tropical Domain



From: Bailey, R.W., 1978

Humid Temperate Domain

Eastern United States



SUMMARY

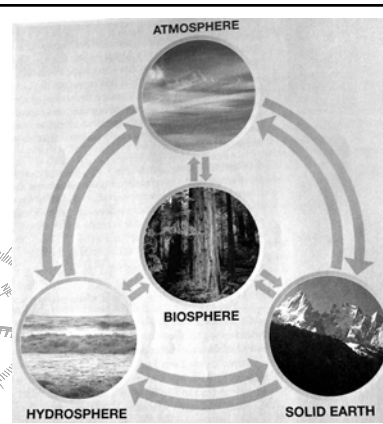
- **Climate has a pronounced influence on the latitudinal and altitudinal distribution of vegetation**
- **Latitudinal changes result in continental zonation as in N. America and Africa**
- **Altitudinal changes in patterns of vegetation mimic latitudinal changes**

SUMMARY

- **ECOLOGICAL CLASSIFICATION: an attempt to group sites with similar ecological characteristics**
- **BIOMES:** Blocks of similar vegetation (and animals) corresponding to similar blocks of climate – may have widely different species and indistinct boundaries. [Macroscale]
- **HOLDRIDGE LIFE ZONE SYSTEM:** refines into zones defined by mean annual temperature and rainfall

SUMMARY

- **Ecoregion scheme:** refines biomes into hierarchies- applies to both terrestrial and ocean ecosystems
  - Domain, Division, etc. classification of Ecoregions
- Scale of ecological study
  - Megascale -continental
  - Macroscale – region
  - Mesoscale – landscape; landforms
  - Microscale – local site

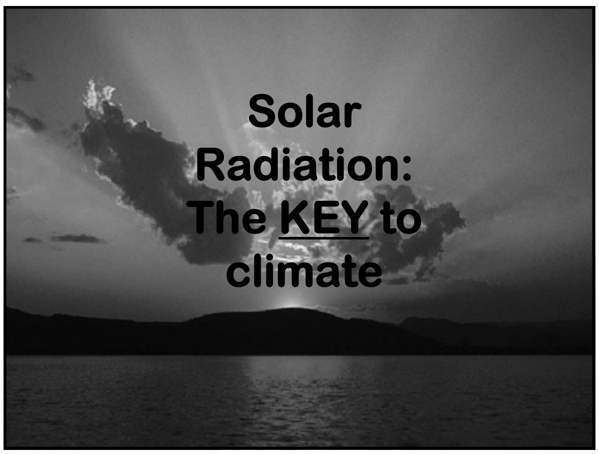


THE PHYSICAL ENVIRONMENT

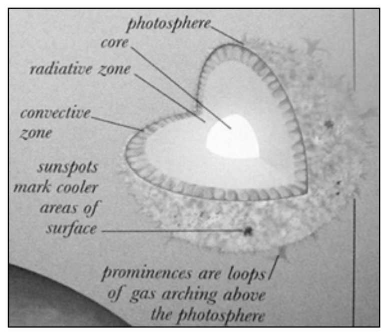
'Direct' factors necessary for autotrophs

('<u>autotrophs'</u> = plants that create their own food source

- HEAT
- LIGHT
- WATER
- OXYGEN
- CARBON DIOXIDE
- MINERAL NUTRIENTS



THE SUN



Surface temperature ~ 5,800° C

FATE OF SOLAR RADIATION

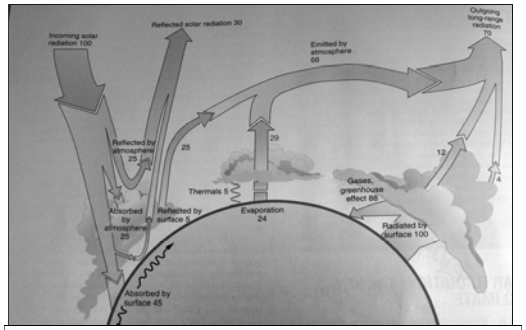
- Travels unimpeded to earth's atmosphere
- 100% strikes outer atmosphere
  - **<u>Solar constant:</u>** the amount of radiation reaching outer atmosphere = 2cal./cm2/min

    Fluctuations in solar constant due to variations in output of sun

FATE OF SOLAR RADIATION

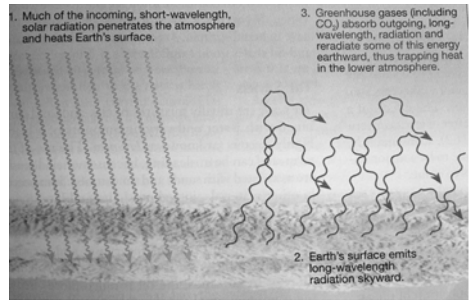
- 50% absorbed by or reflected by atmosphere
- 5% reflected by earth's surface
  - **<u>Albedo :</u>** solar radiation reflected back from earth's surface (amount depends on reflecting surface)
- 45% absorbed by surface as short wave radiation
- 29% radiated back as long wave radiation

FATE OF SOLAR RADIATION



Solar energy reaching earth's surface

FATE OF SOLAR RADIATION

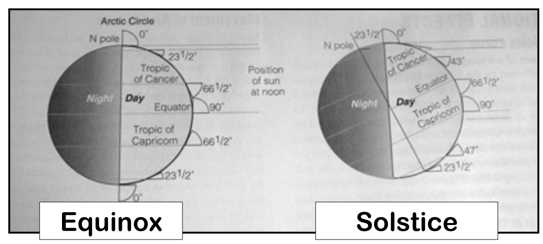


Greenhouse Effect

ALBEDO

- Low for water: ~ 2% when rays are perpendicular
- Very high for low angle rays
- Snow & ice ~ 45 – 90%
- Forests and grasslands 5-30%
- Albedo varies region to region and seasonally
- High in polar regions, low at equator

ROTATIONAL EFFECTS

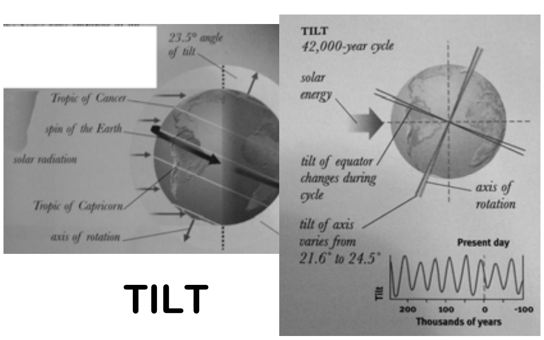


Equinox

Solstice

Declination of earth = 23 ½ °

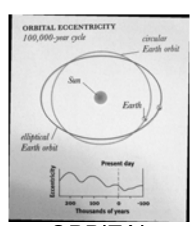
ROTATIONAL EFFECTS



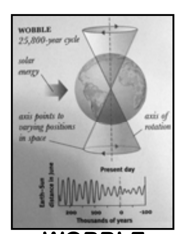
TILT

ROTATIONAL EFFECTS

Fluctuations in earth's orbit and rotation are reflected by cyclical climate changes

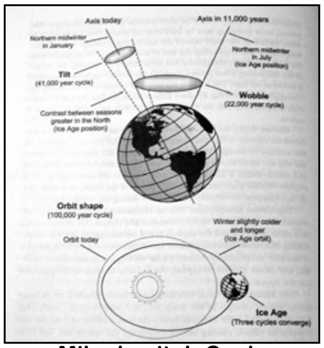


ORBITAL ECCENTRICITY



WOBBLE

ROTATIONAL EFFECTS



Milankovitch Cycle

ROTATIONAL EFFECTS

- **Average global temperature is rising**
  ~ 1.7° C/100years
- **Not evenly distributed –some places are colder**
- **Causes:**
  - **Enhanced greenhouse effect**
  - **Earth emerging from Little Ice Age (15th-mid-19th centuries)**
  - **Solar output varies**

Movement of Air Masses

- Air is constantly moving
- Air masses are huge bodies of air with gradual temperature and humidity changes
- Temperature and humidity based on surface over which they formed

Movement of Air Masses

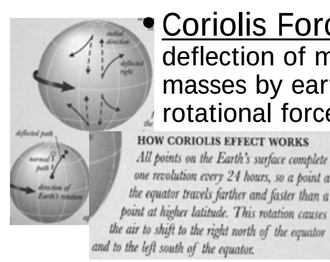
- **INTERTROPICAL CONVERGENCE ZONE:** Heated, low pressure equatorial air rises high (15-20 KM) into the atmosphere and moves poleward – **ITCZ** shifts with season
  - Equatorial low pressure area very rainy
- Air cools at high altitudes and due to frictional drag sinks toward the surface at ~30° latitude forming a subtropical high pressure area
  - Clear skies, sun and dry

Movement of Air Masses

- Zone of rising air around 60° forms another low pressure area
  - Great variability in weather
- This air flows toward poles and equator
- The air aloft descends in the polar region where it cools
  - polar air sinking and high pressure
- This dense mass of cold air flows toward the equator

ROTATIONAL EFFECTS ON AIR MOVEMENT

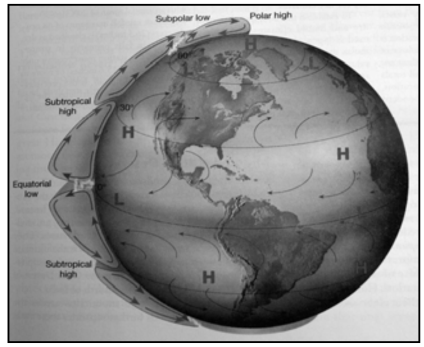
- Coriolis Force – deflection of moving air masses by earth's rotational force



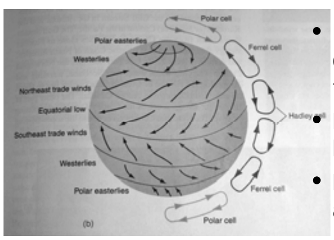
ROTATIONAL EFFECTS

Prevailing winds – North America
(named by direction from which they come)

Global Movement of Air Masses



Global Movement of Air Masses

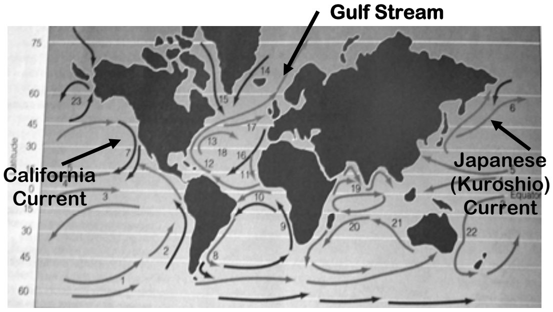


- Hadley cells: circulation cell near the equator
- Ferrel cell: mid-latitude cells
- Polar cell: air circuit at the poles

OCEAN CURRENTS

- Surface waters of the oceans in constant motion
- Transport enormous quantities of water
- A mechanism for transport of heat from equator to arctic areas
- Movements of currents influenced by prevailing winds and the Coriolis Effect

OCEAN CURRENTS



Reds arrow = warm **Blue arrow = cold**

OCEAN CURRENTS

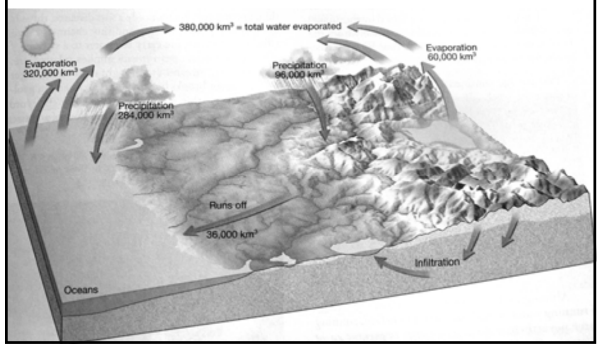
- **Climate determined by:**
  - **Sea surface temperatures**
  - **Ocean currents**
  - **atmosphere**

GLOBAL PRECIPITATION

WATER (HYDROLOGIC) CYCLE

All the rivers run into the sea;
Yet the sea is not full;
unto the place from whence the rivers come,
thither they return again.
(Ecclesiastes 1:7)
This unending circulation of earth's waters is the <u>hydrologic cycle</u>

WATER CYCLE



WATER CYCLE

- Solar energy evaporates:
  - 320,000 km3 from ocean
  - 60,000 km3 from land
- 88% falls back in oceans as rain
- 96,000 km3 falls on land
- 2/3 evaporates; 1/3 runs off to sea

WATER CYCLE

- **Precipitation on land moves back to the ocean by:**
  - **Infiltration**
  - **Runoff**
  - **Evapotranspiration**

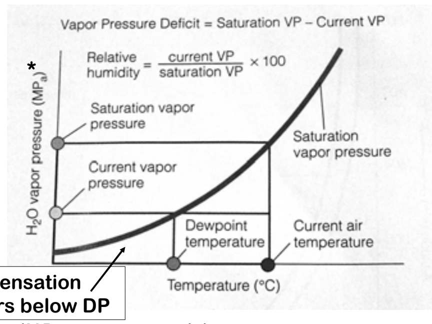
HUMIDITY & WATER VAPOR

- <u>Water vapor</u> (water in gaseous state) results from evaporation
- Water acts in air as an independent gas
- Pressure is proportional to <u>temperature x density</u>
- <u>Vapor pressure</u> : the amount of pressure exerted by water vapor independent of dry air
- Amount of water vapor in air is a function of temperature

HUMIDITY & WATER VAPOR

- <u>Saturation vapor pressure (SVP):</u>
  The pressure water exerts when the air is saturated
- <u>Relative humidity (RH)</u>: amount of water vapor as a % of SVP (At SVP RH = 100%)
- <u>Dew point:</u> The temperature at which SVP is achieved (Condensation occurs)

HUMIDITY & WATER VAPOR



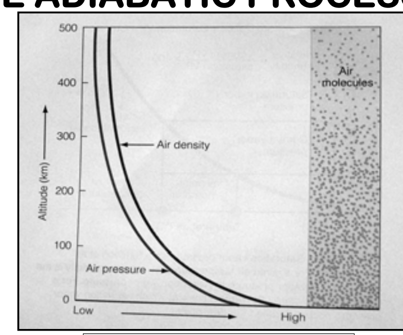
Condensation occurs below DP

(MP = megapascals)

THE ADIABATIC PROCESS

- **<u>Adiabatic Process</u>: a volume of air compresses and warms or expands and cools with no interchange of energy with surroundings**

THE ADIABATIC PROCESS

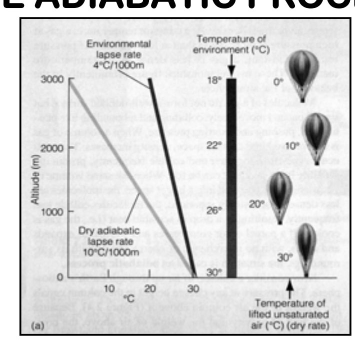


Altitude v. pressure

THE ADIABATIC PROCESS

- <u>Lapse rate</u>: rate at which air temperature changes with height in an air column
- <u>Environmental lapse rate</u>: decrease in surrounding temperature as air rises
- <u>Dry adiabatic lapse rate</u>: unsaturated air changes 10° C for every 1000 meters of altitude change
- RH increases as air rises – if saturation occurs as air cools – clouds form

THE ADIABATIC PROCESS

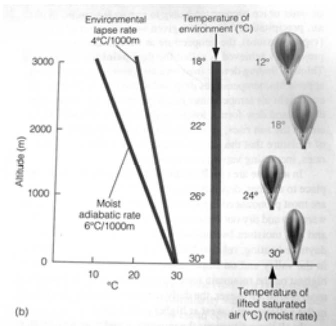


Dry adiabatic process

THE ADIABATIC PROCESS

- **<u>Moist adiabatic process</u>: Saturated air cools more slowly because conversion of vapor to liquid releases <u>latent heat</u> slowing the cooling process.**
- **Moist adiabatic rate = ~ 6° C /1000 m.**

THE ADIABATIC PROCESS



Moist adiabatic process

SUMMARY

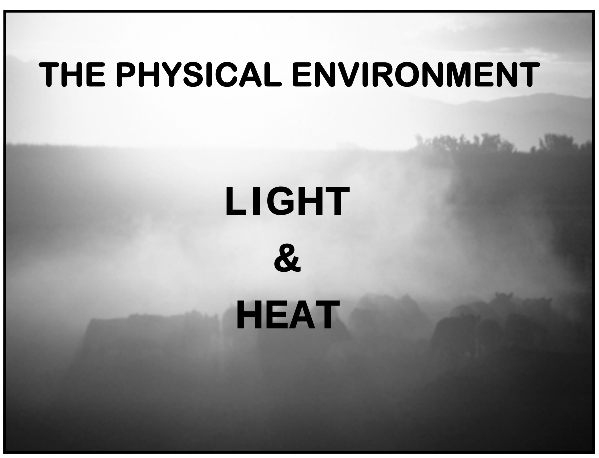
- **Direct factors for autotrophs:**
  - **Heat, light, water, CO2, oxygen, nutrients**
- **Fate of solar radiation: ~45% absorbed by earth's surface**
- **Greenhouse effect**
- **Albedo: sunlight reflected back by surface**
- **Solar constant: 2cal/cm2/min**

SUMMARY

- **Rotational effects:**
  Tilt, wobble, elliptical orbit
- **Seasonal changes**
- **Movement of air masses**
- **Coriolis Effect**
- **Ocean currents**

SUMMARY

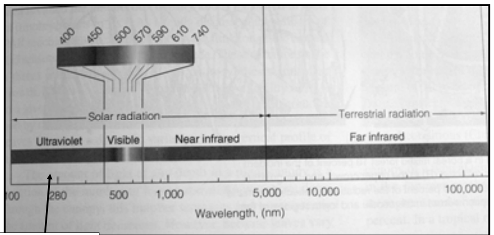
- **Water cycle**
- **Water vapor**
- **Relative Humidity**
- **Pressure proportional to temperature times density**
- **The adiabatic process**



PROPERTIES OF LIGHT

- **Wavelengths of visible light**
  - **400 – 740 nanometers (microns)**
- **Light > 740 nm is infrared (IR)**
- **Light < 400 nm is ultraviolet (UV)**
- **Illuminance = measure of radiation**

PROPERTIES OF LIGHT



UV absorbed by ozone layer

Photon *= unit of light*

FUNCTIONS OF LIGHT

- **<u>Energy for photosynthesis</u>**
  - **Green plant chloroplast reaction center contains two chlorophyll molecules**
  - **Photon excites molecules – low to high energy state**
  - **Split water molecule to oxygen**

FUNCTIONS OF LIGHT

- **<u>Photoregulation</u>**
  - **Provides signals enabling plants to respond and adapt to environmental changes**
  - **Photosensory systems process information about the properties of light**

PROPERTIES OF LIGHT

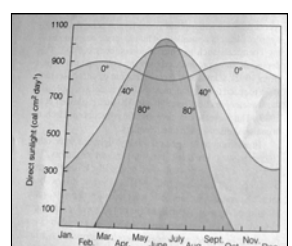
- **<u>Photosynthetically active radiation (PAR)</u>: wavelengths used in photosynthesis**
- **PAR: measure of total number of photons within the visible spectrum striking a surface**
- **Used to study effects of radiant energy on plants**

PROPERTIES OF LIGHT

- **Intensity:** **how much**
- **Duration:** **how long**
- **Directionality:** **what direction**

PROPERTIES OF LIGHT

- **<u>Intensity</u> – varies daily and seasonally; influenced by <u>angle of incidence</u>**



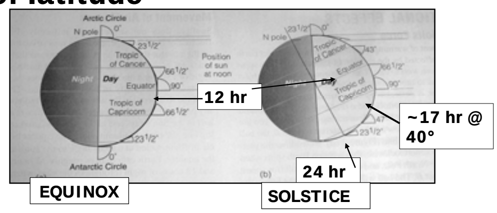
Amount of direct sunlight seasonally at 0°, 40° and 80° at outer edge of atmosphere

PROPERTIES OF LIGHT

- **<u>Angle of incidence</u>: the angle at which radiation strikes a surface**
- **The greater the angle the greater the area covered and the less the intensity at any given point**
- **Lanbert's cosine law: irradiation of a surface varies with the cosine of the angle of incidence**

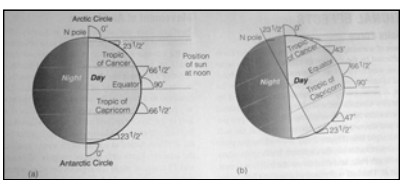
PROPERTIES OF LIGHT

- **<u>Duration</u> – seasonal ; function of latitude**



PROPERTIES OF LIGHT

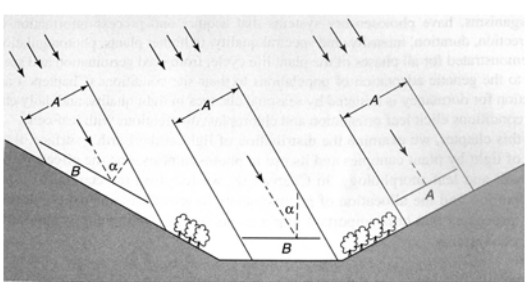
- **<u>Directionality</u> – Changes daily and seasonally**
  - **Nearly overhead in summer; nearer the horizon in winter.**



PROPERTIES OF LIGHT
Physiography

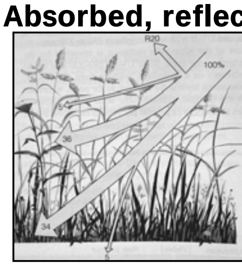
- **<u>North and south facing slopes</u>**
  - **South-facing slopes receive the most solar energy (N. hemisphere)**
  - **North-facing slopes receive the least**
- **Microclimate different based on aspect**

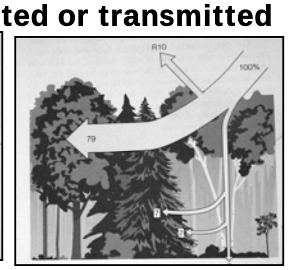
PROPERTIES OF LIGHT
Physiography



FATE OF LIGHT

- **Absorbed, reflected or transmitted**





FATE OF LIGHT
Plant foliage absorption

- **High absorptivity in visible and ultraviolet range – reflect 6-12 % visible light**
- **Very low absorption in far-infrared range -~70% reflected**
- **Leaves use red & blue photons – thus reflect and appear green**
- **~4-5 % of gross solar energy absorbed**
- **~1-2 % total solar energy used in photosynthesis**

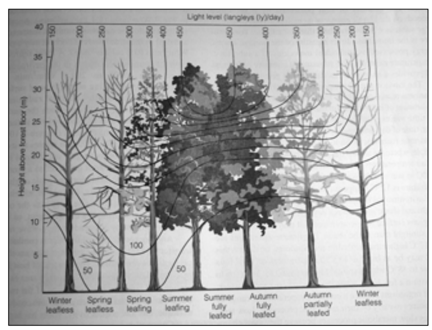
FATE OF LIGHT

- **Remaining light is transmitted through leaves depending on thickness and structure of foliage**
- **Amount of light at any depth in canopy is function of the number of leaves above that point**

FATE OF LIGHT

- **Relative illumination (RI) within forest**
  - **Leafless deciduous trees – 50-80 %**
  - **Even-aged pine - 10-15 %**
  - **Temperate hardwood - <1-5 %**
  - **Tropical rain forest - 0.1-2.0 %**

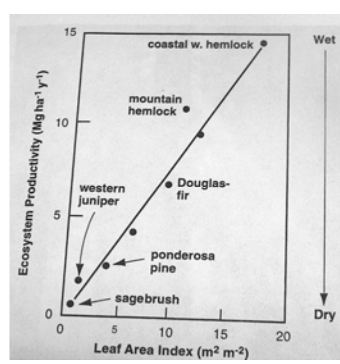
FATE OF LIGHT



LEAF AREA

- **Foliage density - leaf area best means to quantify differences in productivity among forest ecosystems**
- **Leaf area is a direct measure of the photosynthetically-active surface area converting light to energy**
- **<u>LEAF AREA INDEX (LAI)</u>**
  - **LAI = leaf area m^2 /ground area m^2**
    - **LAI of 3 means there are three square meters of leaves for every square meter of ground**
    - **(average 5; range 1-23)**

LEAF AREA INDEX

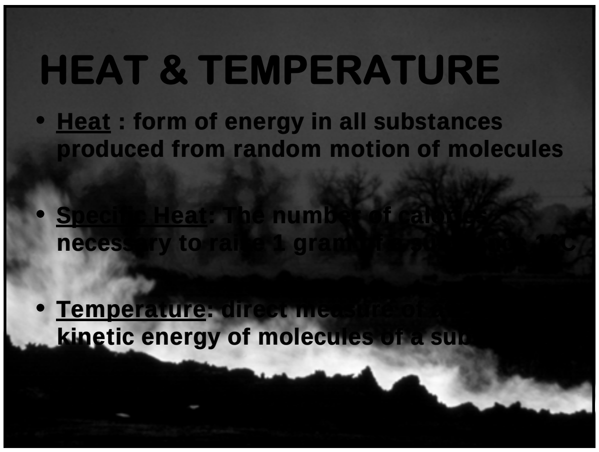


SUNFLECKS

- Direct sun light sweeps across the floor as the day progresses
- Radiation nearly half of full sunlight
- Duration brief – 5.7-7.1 minutes
- Can be used for effective photosynthesis if plants can respond rapidly

FOREST FLOOR LIGHT

- Canopy leaves transmit 10-25 % of visible radiation they receive.
- May be selective for wavelength; light is poor in red/blue light
- Understory light:
  - Sunflecks
  - Diffuse light filtered through canopy
  - Full light in canopy gaps



HEAT & TEMPERATURE

- <u>Heat</u> : form of energy in all substances produced from random motion of molecules
- <u>Specific Heat</u>: The number of calories necessary to raise 1 gram of a substance 1°C
- <u>Temperature</u>: direct measure of [illegible] kinetic energy of molecules of a sub[illegible]

HEAT & TEMPERATURE

- Solar radiation controls temperature near the surface of the earth
- Terrestrial radiation and air movements critical to the level and distribution of temperature
- Heating of daytime surface layers most intense where greatest IR radiation is received

HEAT & TEMPERATURE
Types of heat transfer

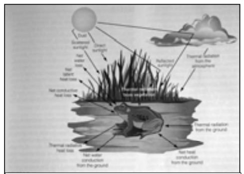
- <u>Radiation</u>: direct transfer of heat such as sunlight, fire, metabolism
- <u>Conduction</u>: direct transfer of heat from one substance to another
- <u>Convection</u>: transfer of heat by circulation of fluid or gas

HEAT & TEMPERATURE

- <u>Cardinal temperature:</u> the range within which physiologic functions can occur
  - Thermal limits for vascular plant = +60° to - 60° C (-30°F-120°F)
- <u>Optimum temperature</u>: that temperature at which physiologic functions are optimized

HEAT & TEMPERATURE

- Moist material dissipates heat *via* evaporation
- Water vapor decreases incoming solar energy
- Mineral and organic soil poor heat conductors

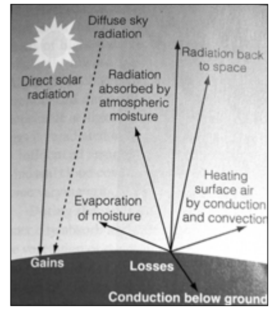


Thermal energy gained

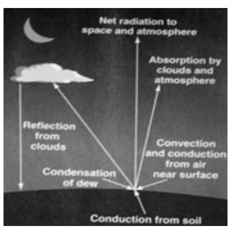
= thermal energy lost

HEAT & TEMPERATURE

- By day solar energy heats earth's surface and the air above it
- Heat gains exceed heat losses
- Evaporation results in cooling



HEAT & TEMPERATURE



- At night the surface air loses more radiant energy than it receives.
- Layer of cooler surface air deepens resulting in nighttime inversion
- Net cooling at night

<u>Thermoperiod</u>: difference between day and night temperatures

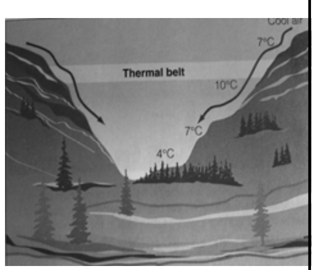
HEAT & TEMPERATURE

Surface temperature dependent upon

- Amount of vegetation and litter
- Color: black absorbs best
- Moisture: dissipates heat *via* evaporation
- Wind speed : most important in dissipation of heat

HEAT & TEMPERATURE

- Temperature at surface dependent upon:
  - Topography
  - Aspect
  - Altitude



TEMPERATURE EXTREMES

- HEAT INJURY
  - <u>Heat kill</u>: Temperatures to 45°C (140°F), disrupts cell metabolism
  - <u>Sun scald</u>: In thin barked trees when suddenly exposed to high temperatures, necrosis of the bark
  - <u>Water stress</u>: Dehydration due to water loss in response to heat

TEMPERATURE EXTREMES

- COLD INJURY
  - Freezing:
    - rapid freezing forms ice crystals within protoplasm of cells
    - Rapid thawing causes disruption of cell membranes
    - Slow freezing may also kill some plants
    - Intercellular water freezes causing dehydration
  - Winter drought:

TEMPERATURE EXTREMES

- COLD INJURY
  - Frost crack / frost rib

Asymmetrical contraction , upon freezing plant tissues contract

SUMMARY - LIGHT

- Light is essential to most life and is the only thing the forester can manipulate
  - Photosynthesis, Photoregulation
- Light can be <u>reflected</u>, <u>absorbed</u> or <u>transmitted</u>
- Properties of light
  - Intensity
  - Duration
  - Direction

SUMMARY - LIGHT

- Photosynthetically Active Radiation (PAR)
- Fate of light through forest canopy
- Leaf Area Index
- Understory Light
  - Sunflecks
  - Diffuse light

SUMMARY

- All organisms live in a thermal environment characterized by heat and temperature
- Heat is a form of energy
- Temperature is a measure of a material's tendency to give up heat
- Heat gains equal heat losses

SUMMARY

- Types of heat transfer
  - Radiation – given off directly
  - Convection – moved with air currents
  - Conduction – transfers through adjacent material

SUMMARY

- Factors controlling surface temperature
  - Color
  - Soil
  - Vegetation
  - Moisture
  - Air movement
  - Aspect

SUMMARY

- Extremes of temperature
  - Heat injury
  - Cold injury

CLIMATE & WEATHER

- CLIMATE: characteristic patterns, means, and extremes of weather evaluated over many years
- CLIMATE: is a product of weather, which is air in motion driven by uneven heating

CLIMATE & WEATHER

- Atmosphere and oceans combine to produce climate
- Water warms and cools more slowly than land thus moderating temperatures
- Ocean currents transport heat
- North Pole warmer than South Pole

CLIMATE CHANGE

- World's climates are constantly changing
  - Orbital variation
  - Emergence from Little Ice Age (15th – mid 19th centuries)
  - Natural oscillations - natural variations between pressure areas
  - Changes in solar output
  - Enhanced greenhouse effect

CLIMATE & WEATHER

- **MACROCLIMATE: Massive circulation patterns of atmosphere and ocean currents as well as major land forms determine climate pattern of large regions**
- **MESOCLIMATE: physiography influences regional climate**
- **MICROCLIMATE: The distinctive climate of a particular place. Microclimate influences the spatial patterning of local ecosystems and their species composition**

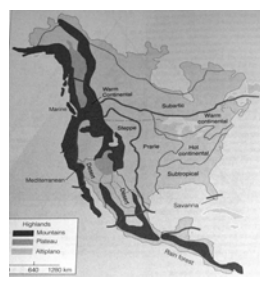
CLIMATE AND PHYSIOGRAPHY

Physiography with its relatively stable landforms controls climatic regimes at all levels

CLIMATE AND PHYSIOGRAPHY

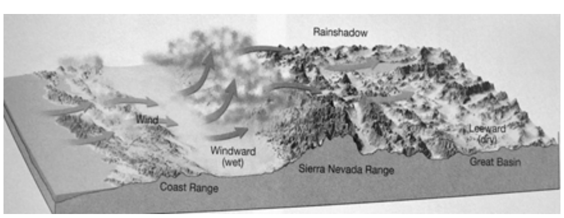
- **Maritime or oceanic climates – air masses arise over oceans**
- **Continental climates - air masses that formed over continents or lost their moisture over mountains**

CLIMATE AND PHYSIOGRAPHY



CLIMATE AND PHYSIOGRAPHY

Rain shadow or Orographic rain



CLIMATE AND PHYSIOGRAPHY

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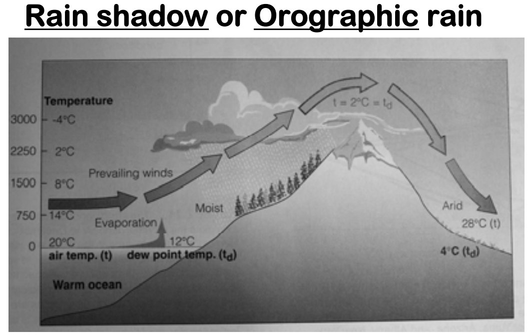


WEATHER

- WEATHER: constantly changing atmospheric conditions prevailing at a particular place and time
- WEATHER: a result of the physical interactions between sunlight, air and water and local physiography

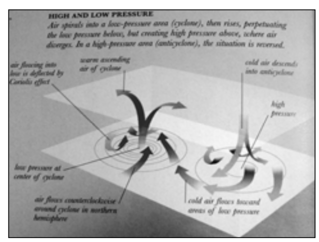
WEATHER

- Front: boundary between different air masses named for the air behind it
- Warm air masses (rising)– low-pressure systems (cyclone)
- Cool air masses (sinking) – high pressure systems (anticyclone)

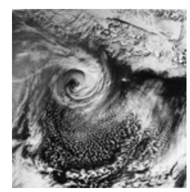
WEATHER

- Pressure gradient: difference between the pressure at the center of a system and the air outside the system
- Air flows along this gradient
- The steeper the gradient the stronger the winds

WEATHER



High and low pressure systems

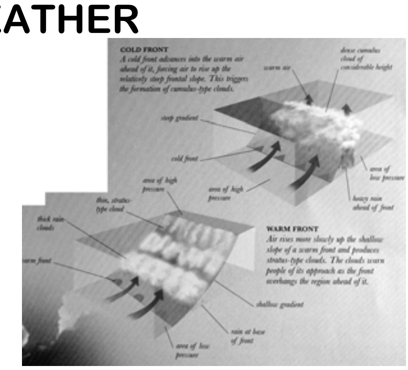


Low-pressure spiral

WEATHER

- Air masses meet:
  - Do not merge because they are at different temperatures and densities
  - Denser air moves beneath the less dense air
  - Winds in warm front / low pressure system stronger

WEATHER

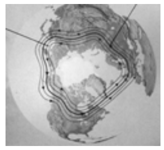


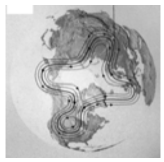
WEATHER

- **JET STREAM**

  Narrow ribbons of fast moving air that circle the earth west to east

  Produced by difference in temperature between air masses



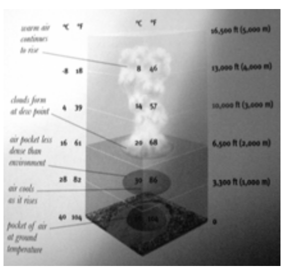


PRECIPITATION

Modes of precipitation

- **<u>Convection</u> – warm updrafts form clouds**
- **<u>Orographic</u> – air forced over topographic features**
- **<u>Cyclonic</u> – frontal storms, the most common in the temperate area**

PRECIPITATION



Cloud formation

- **Rising air warmer than surrounding air**
- **Clouds form at dew point**
- **Latent heat given off as water molecules merge**
- **Water droplets fall as rain when large enough**

PRECIPITATION

- **<u>Hail</u>: begins as a raindrop, rises and freezes, grows by collecting supercooled water that freezes onto it. Sizes dependent on number of circuits in the cloud**
- **Hail defoliates**

PRECIPITATION

- **<u>FOG</u> is a cloud at ground level**
  - **<u>Radiation fog</u> –night time when surface radiation cools the surface and air layer above it. Fog forms if air is moisture laden. (Valley fog)**
  - **<u>Advection fog</u> – warm air moves over cold water**
  - **Fog a valuable part of total water for vegetation**
- **<u>DEW</u> nighttime condensation as earth surface cools**

PRECIPITATION

- **SNOW: ice crystals adhere to one another, 6 - sided**
  - **Snow fall is distinct from rain.**
  - **Frozen water is unavailable to plants**
  - **Snow can be protective, can be damaging**
- **ICE and SLEET: rain or melted snow flakes that freeze between the cloud and ground, limb breakage**
- **FROST: dew-point below freezing, kills plants**

WEATHER

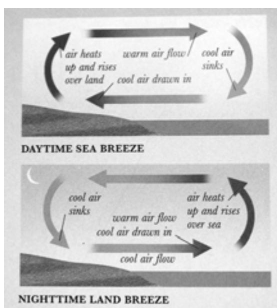
- **WIND: The movement of air away from areas of high pressure to areas of low pressure**
- **WIND SPEED: proportional to the pressure gradient**
- **Air spirals into a low pressure center**

WEATHER

- **Ocean Winds – always stronger than wind over land; less friction**
  - **Strongest winds in the Antarctic Ocean where they circle the earth unimpeded.**
- **Seasonal Winds**
  - **Sirocco – spring time from Africa to Europe**
  - **Bora – winter from Russia to Mediterranean**

WEATHER

- **Daily Winds**
  - **Most common are land – sea breezes**
- **Drainage wind – cool air settles**



WEATHER
Extreme Events

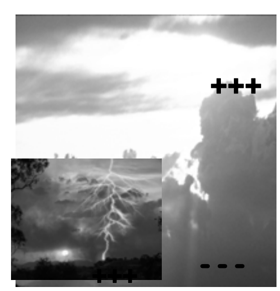
- **HURRICANE: Tropical cyclone - a low pressure system generated at sea when water temperature >80° F**
  - **Occurs in late summer**
  - **Coriolis Effect makes the winds spiral**
  - **Eye is a calm area of warm sinking air in the center**
  - **Cause tremendous wind and flood damage**

WEATHER
Extreme Events

- **TORNADOES: speeds up to 300 mph**
- **Can occur anywhere**
- **Funnel cloud until it touches down**

WEATHER
Extreme Events

- **Lightning**
  - **Thunder the audible result**
  - **Large amounts of water/ ice reach temps of -30° C**
  - **Cloud becomes bipolar – strikes when charge is high enough**
  - **Discharge can be extremely strong**



WEATHER
Extreme Events

- Direct Effects of Lightning
  - Death or serious injury to trees
  - Strips (Blows) bark away
  - Cambial damage may not be visible
  - Amount of damage related to strength of charge

WEATHER
Extreme Events

- Indirect Effects of Lightning
  - Fire – especially in dry climates
  - Nitrogen fixation 5lbs/ac/yr
  - Predisposes tree to insect damage

SUMMARY

- CLIMATE: Patterns of weather evaluated over time
- Atmosphere, oceans and topography combine to produce climate
- Causes of changing climate
  - Orbital variation, greenhouse effect, changes in solar output, natural oscillations,

SUMMARY

- Classification:
  - Macro- (continental),
  - meso (physiography),
  - micro- (local factors)
- Oceanic/ Maritime climates
- Continental climates

SUMMARY

- Weather – constantly changing atmospheric conditions prevailing at a particular place and time
- Front – boundary between air masses
- Warm fronts – low pressure
- Cold fronts – high pressure
- Air masses do not merge

SUMMARY

- Precipitation:
  - Convection – warm updrafts
  - Orographic – air forced over topographic features
  - Cyclonic – frontal storms, most common in this area

SUMMARY

- Forms of precipitation:
  - Rain
  - Hail
  - Fog/ Dew
  - Snow
  - Ice /Sleet
- Effects of each on vegetation

SUMMARY

- Wind: movement of air from areas of high pressure to areas of low pressure
  - Ocean winds
  - Seasonal winds
  - Daily winds (land-sea breezes)
  - Drainage wind

SUMMARY

- Extreme weather events
  - Hurricane
  - Tornado
  - Lightning
    - Direct effects of lightning
    - Indirect effects of lightning