



Human Impact on Forests

A cold wind was blowing from the north, and it
made the trees rustle like living things.

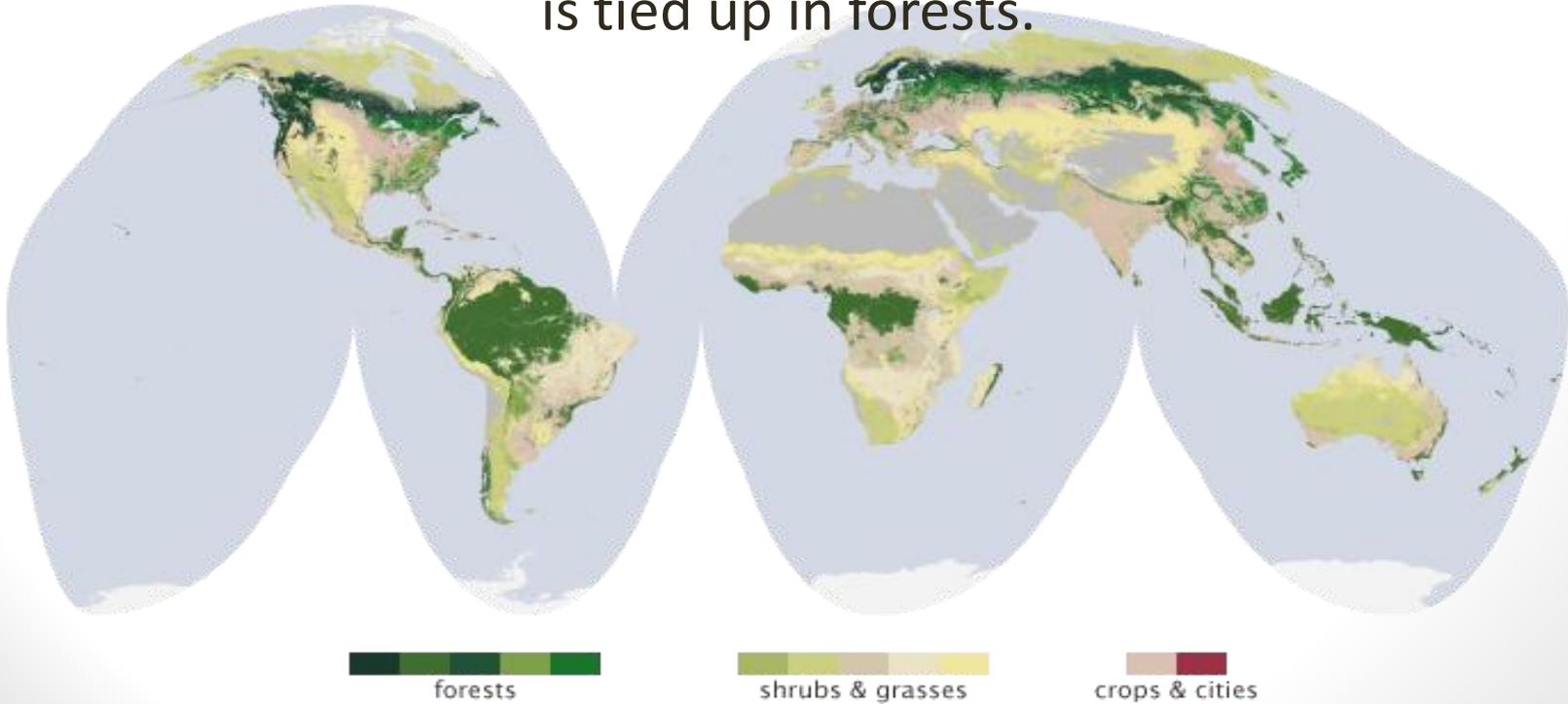
George R.R. Martin, *A Game of Thrones*



Forests

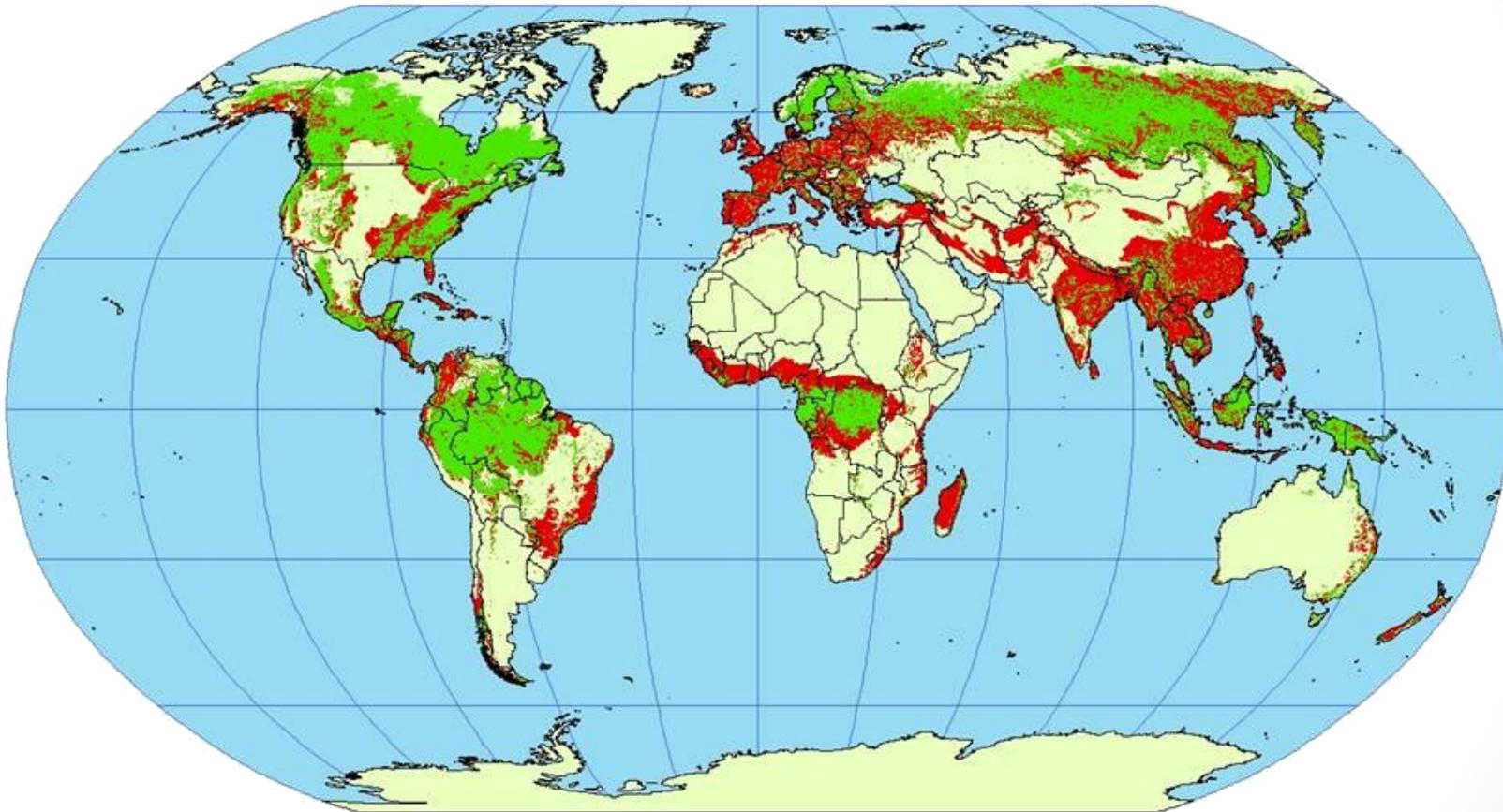
Forests are considered one of the world's largest banks for the carbon emitted into the atmosphere through natural processes and human activities. They cover about 30% of Earth's land surface, while accounting for 50% of plant productivity. As much as 45% of the carbon stored on land is tied up in forests.

Global Forest Cover





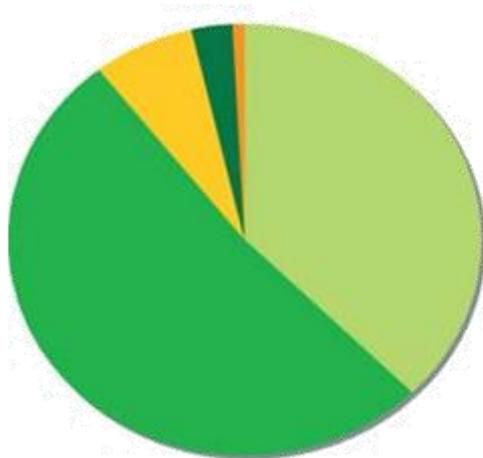
Forest Cover: Current and Past





Forest Cover: Current and Past

- 8,000 years ago about 50% of the earth was forest. Today about 30% of the planet is forested.
- That's a total loss of about 40%. **Primary** (virgin) **forests** are 65% gone.
- Many of today's forests are modified by humans (second- or third-growth).



Characteristics of the world's forests (%)

Primary forests	36.4
Modified natural forests	52.7
Semi-natural forests	7.1
Productive forest plantations	3.0
Protective forest plantations	0.8



Top 10 States with the Largest Forest Area

Rank	Country	Forested Area Sq Km	% of Land Covered
1	Russia	7,762,602	45%
2	Brazil	4,776,980	56%
3	Canada	3,101,340	31%
4	USA	3,030,890	30%
5	China	1,821,000	18%
6	Australia	1,470,832	19%
7	Republic of Congo	1,219,326	52%
8	Argentina	945,336	34%
9	Indonesia	884,950	46%
10	India	778,424	23%

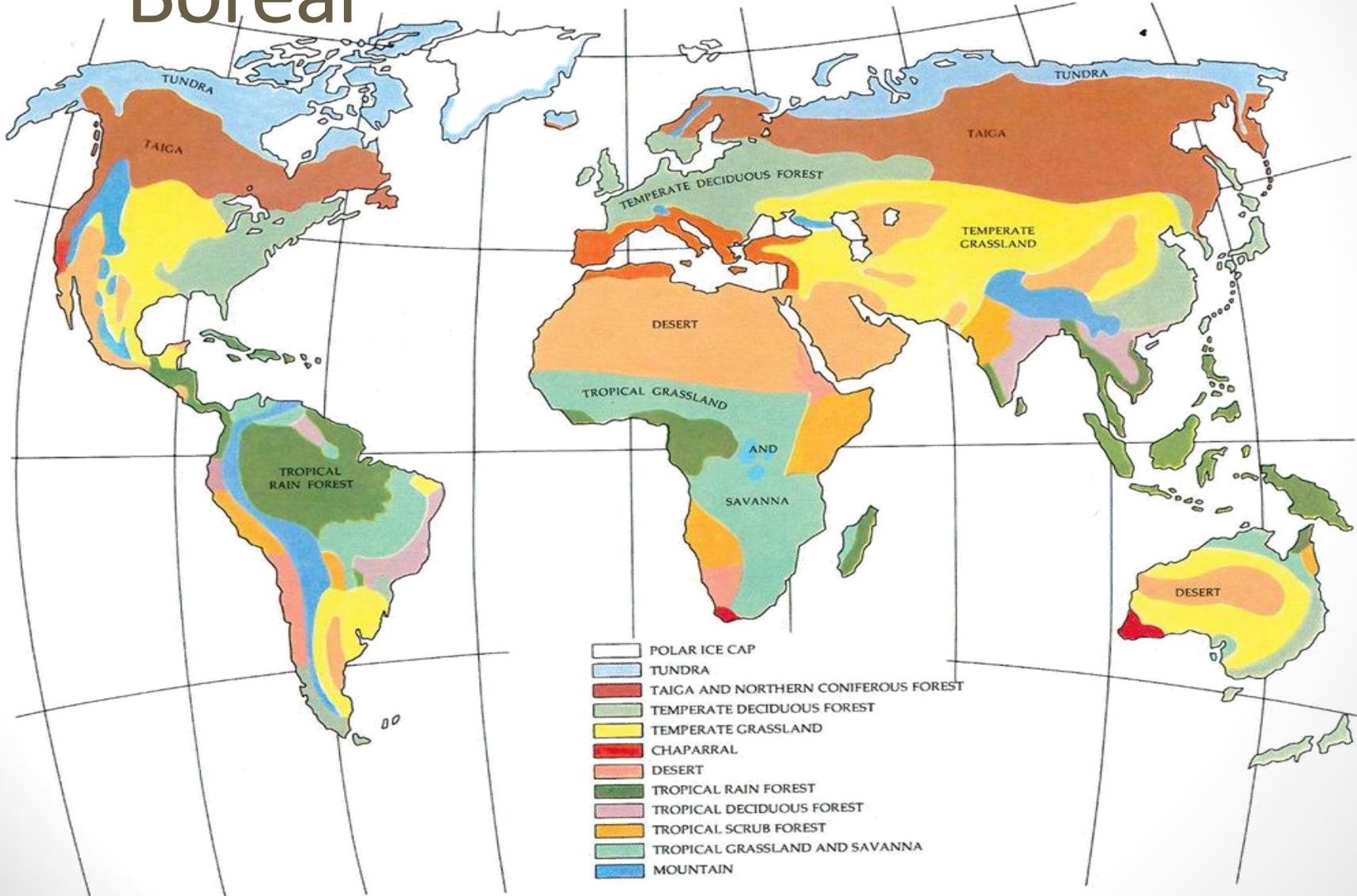


Forest Benefits

- food
- fuel
- construction materials
- biodiversity
- water and air filtration
- carbon sequestration
- soil stabilization
- tourism



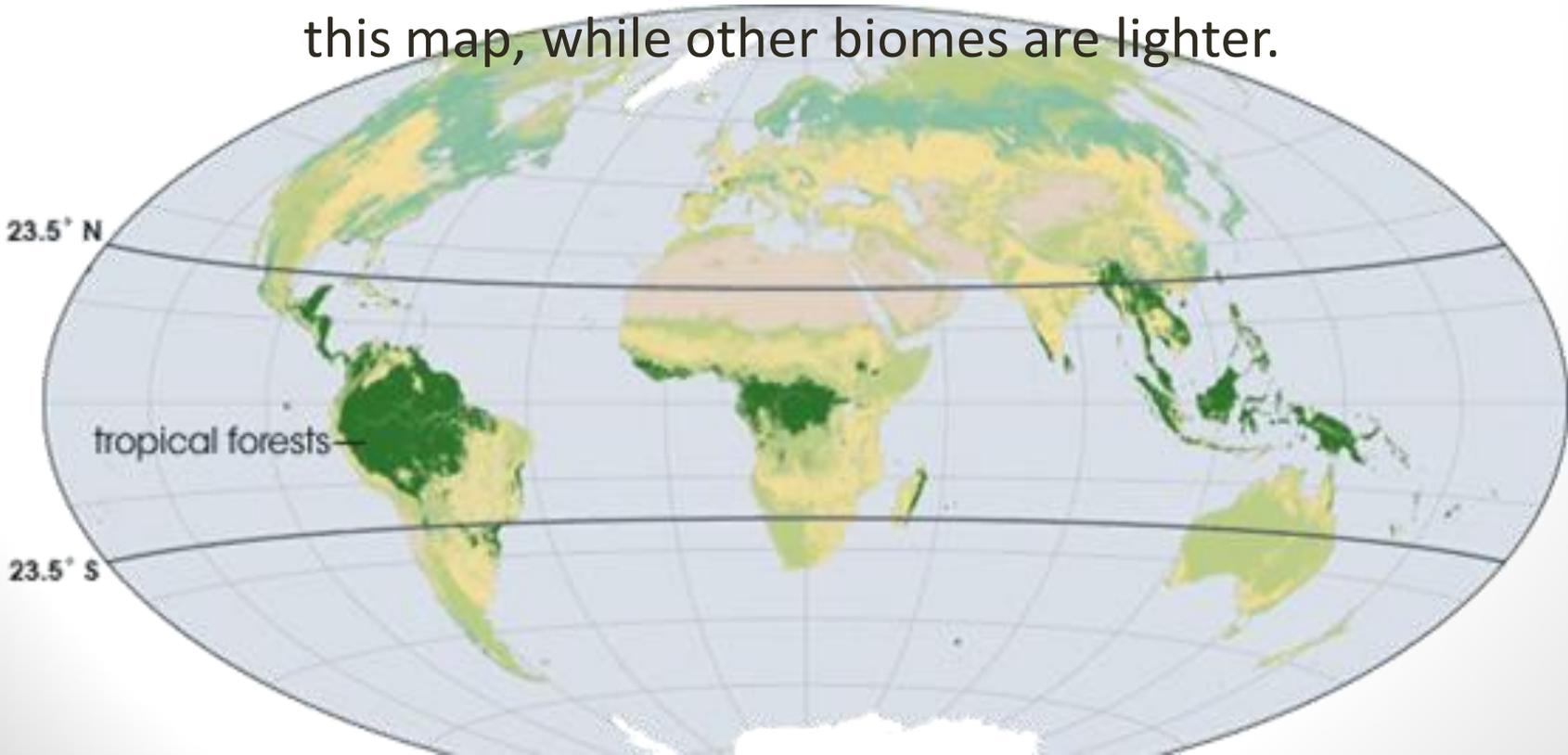
Forests: Tropical, Temperate, Boreal





Tropical Forests

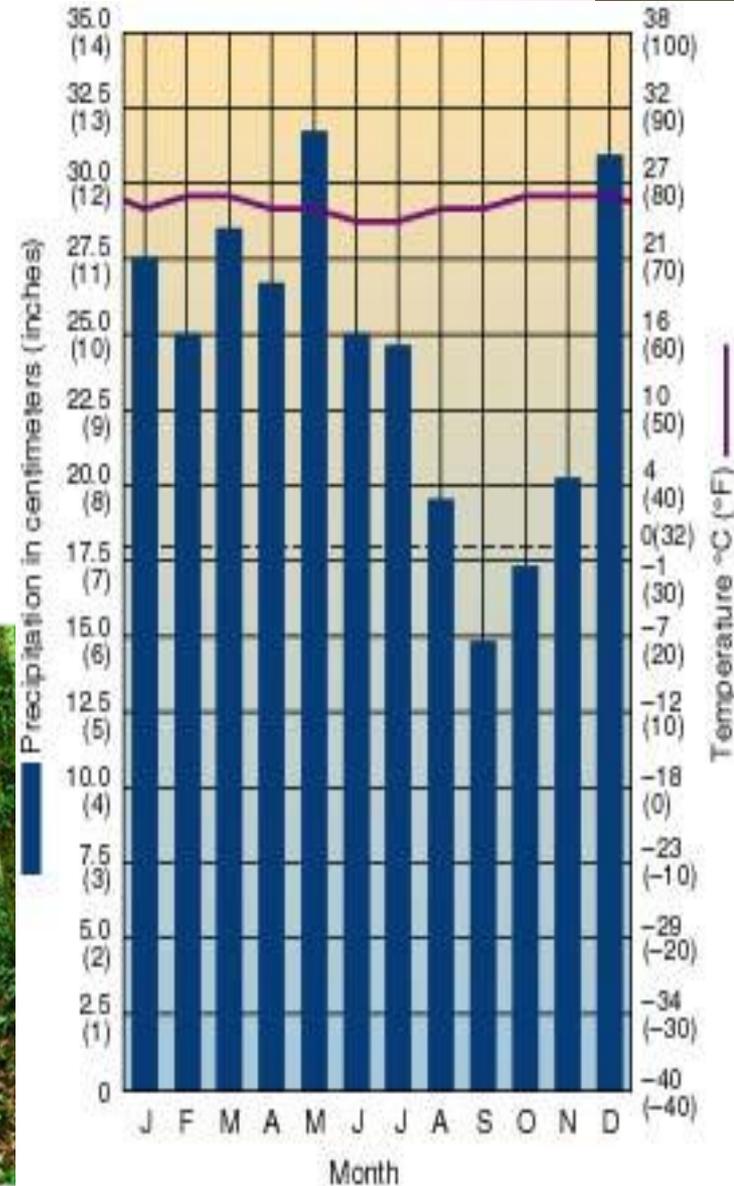
Tropical forests span both sides of the Equator, thriving in the warm and usually wet climate under the Sun's most direct rays. Evergreen forests between the Tropic of Cancer (north) and Tropic of Capricorn (south) are dark green on this map, while other biomes are lighter.





Tropical Forests: Climate

- 36% of Earth's total surface (roughly 20 °N to 20 °S)
- **consistently warm** (all months > 18°C/64.4 °F), daily temp range exceeds annual temp range
- **high rainfall** all year



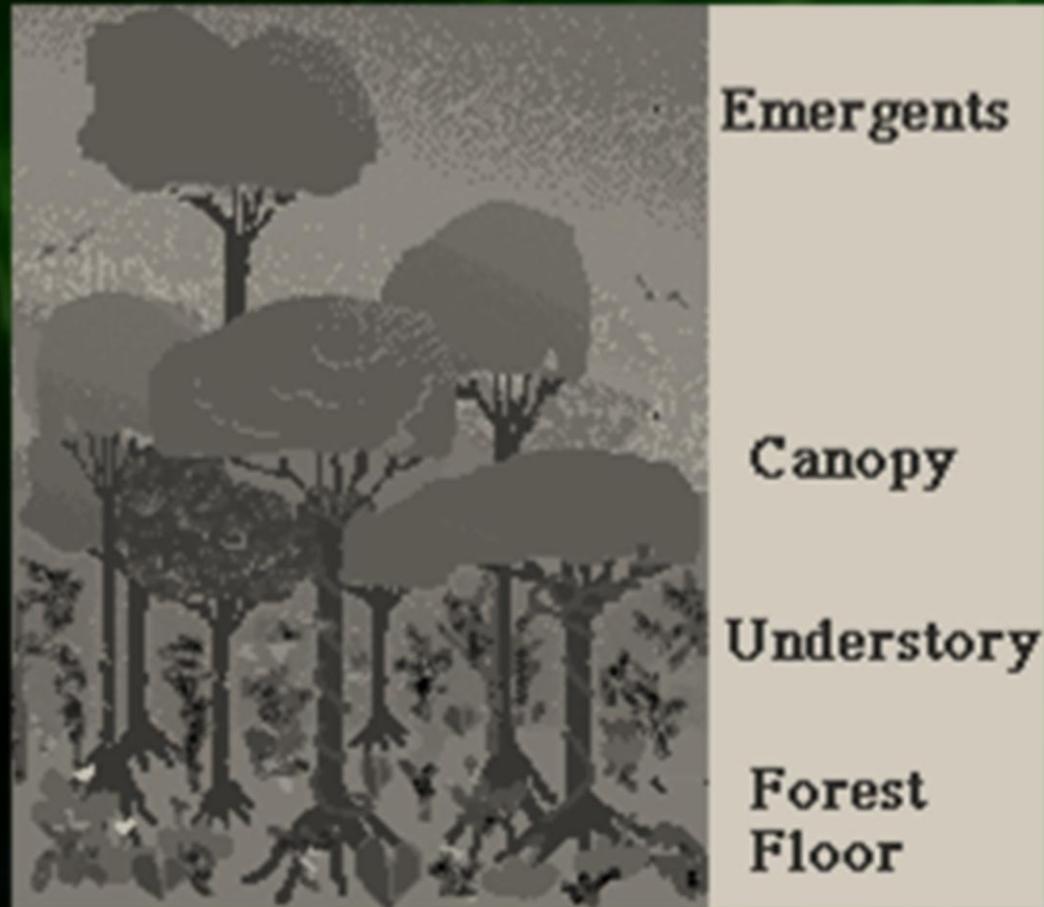


Tropical Forest: Flora and Fauna

- **Region/Distribution:** within 10-20 degrees of equator
- **Vegetation:** three-tiered, thousands of species, highest density of species, tall trees, many canopy layers, evergreen, broadleaf trees, epiphytes, lianas (vines), climbers, stranglers, ferns
- **Fauna:** more species than all other biomes combined, colorful insects, amphibians, reptiles, birds, few large animals, high density of biomass and incredible species diversity
- **Other:** among most threatened biomes



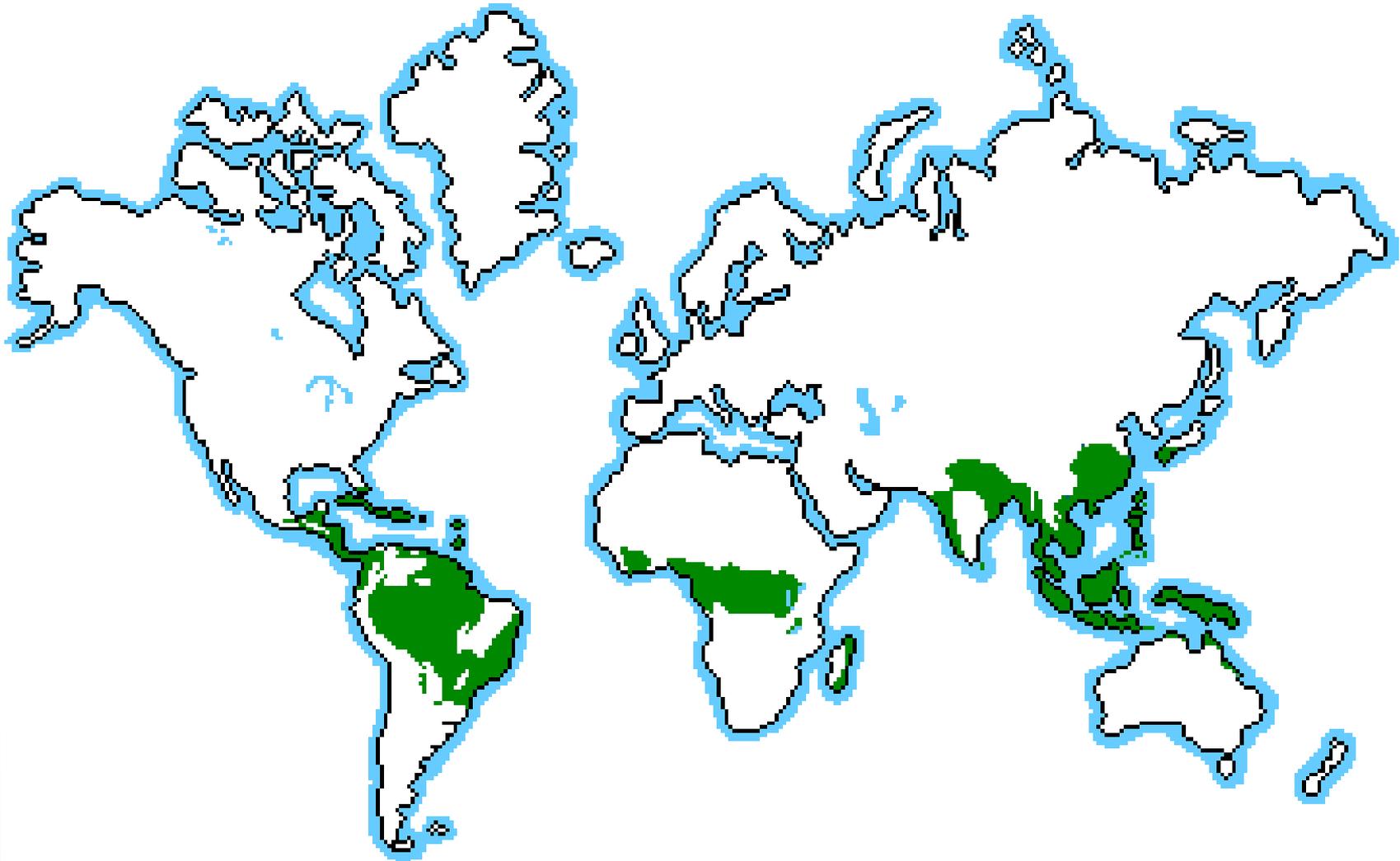
Tropical Forests: Strata





Tropical Forests:

7 % of Land Area, 50% of Species





Terry Erwin's Experiment (1982)

- In 1982 Terry Erwin published a provocative report in which he estimated the number of species of insects to be not several million but several tens of millions.
- Erwin reasoned that because the tropical forests appeared to contain vast unexplored areas of biodiversity he would sample there.
- Erwin, an expert on beetles, fogged the canopy of several trees of the species *Luebea seemannii*. The fogged insects then fell to the ground, allowing Erwin to sample them.
- From the canopy of a single species of tree (*L. seemannii*) Erwin found more than 1,100 species of beetles.
- Beetles are 40% of insect species so, based on Erwin's estimates, there should be 30 million species of insects in tropical rain forests.





Why are there so many species in the tropics?

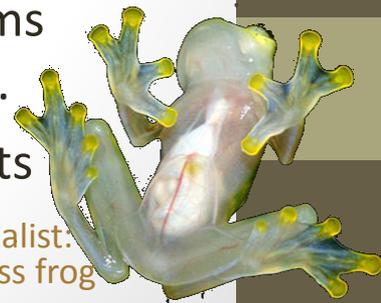
- **Age of the tropical forest biome:** Since tropical forests are thought to be the oldest biome on Earth, it is not surprising that they contain the most species.
- **Large area:** The tropics are enormous. Increasing size provides ample opportunity for geographic separation for groups within a species, leading to variation.
- **Stability:** The tropics have, overall, fairly constant temperature and humidity.
- **Geographical isolation due to changes in sea level, glaciation and other factors:** Some of the speciation which occurred in Amazonia and other tropical regions may have been due to warmer periods during which the sea level rose sufficiently to isolate fragments of these regions.
- **Mountains as diversity refuges:** Mountains provide stable habitats for species, older species being maintained and new ones forming.



Why are there so many species in the tropics?

- **Benign character of physical environment:** Greater species richness is related to the relatively uniform climatic and physical conditions over great areas in the tropics (which is not the case for most temperate areas), including temperature, rainfall and soil type. The less stressful environment – warm, humid and predictable – is beneficial for the existence of organisms.
- **Heterogeneity of biological environment:** Biodiversity is enhanced by the enormous heterogeneity of the rainforest environment. The highly varied kinds of habitats available in tropical areas (differing according to altitude, rainfall, seasonality, soil type, swampiness, etc) have led to the evolution of a myriad of plants and animals specialized for each of them. Often habitats to which organisms have adapted are very localized, some as small as 5 to 10 km².
- **The prevalence of specialized habitats:** Habitat specialist plants survive only in areas of unusual habitats.

habitat specialist:
Ecuadoran glass frog





Why are there so many species in the tropics?

- **Energy/productivity levels:** There is much more energy and productivity in low latitudes and therefore more individuals and species can exist in these regions. The richness of tropical forests is perhaps due to high levels of solar energy.
- **Presence of pathogens:** The great diversity of tree species in tropical forests is at least in part the result of the activity of pathogens. Trees of any one species will not be able to survive in close proximity and will become widely dispersed throughout a forest. Under these circumstances, trees of many different species will be present within a small area.
- **Natural disturbances:** Natural disturbances can maintain species diversity. Storms and high winds are common in tropical areas and frequently lead to considerable damage and the formation of fairly large gaps in forests, allowing pioneer species to enter gaps and flourish.



Tropical Rainforest: Biodiversity





Temperate Forests

Temperate forests can be found in North America, Europe, Eastern China, Japan, Southeast Australia and New Zealand. Only scattered remnants of original temperate forests remain.





Temperate Forests

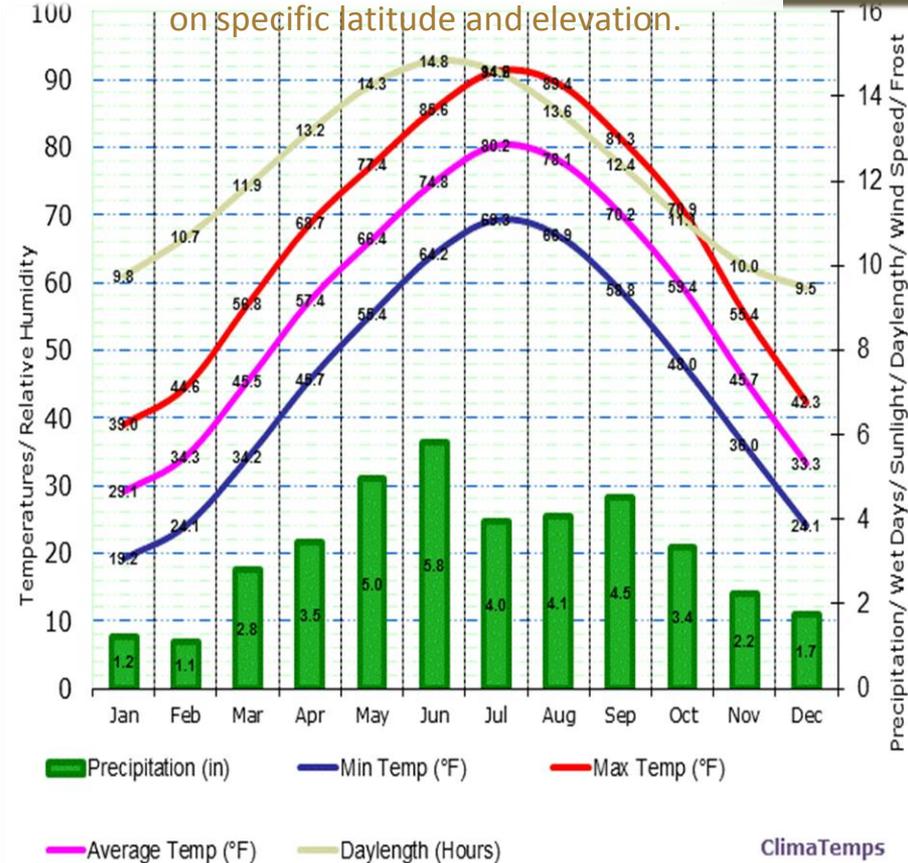
- Temperate forests include the forests found between the tropical and subtropical regions and the barren, treeless lands of the far north and extreme south.
- Main characteristics include **wide leaves**, **large and tall trees** and **non seasonal vegetation**.
- Temperate forests can be divided into
 - temperate **coniferous** forests
 - temperate **broadleaf and mixed** forests
 - temperate **deciduous** forests
 - temperate **rainforests**
- Temperate forests are **simpler in structure** than tropical forests and support a smaller number of tree species.



Temperate Forests: Climates

- well-defined **seasons** with a distinct winter
- **moderate** climate and a growing season of 140-200 days during 4-6 frost-free months
- **abundant precipitation**, usually between 20-60 inches of precipitation annually in the form of rain and/or snow
- Soil is **fertile**, enriched with decaying litter.
- Canopy is moderately dense and **allows light to penetrate**, resulting in well-developed and richly diversified understory.

Climograph can vary considerably depending on specific latitude and elevation.





Temperate Forests: Flora and Fauna

- Due to abundant rainfall and thick soil humus, temperate forests are able to support a wide variety of plant and animal life.
- Vegetation exists in several **layers** ranging from lichens and mosses on the ground layer to large tree species like oak and hickory that stretch high above the forest floor. Other examples include:
 - **Forest Canopy Tier:** Maple trees, Walnut trees, Birch trees
 - **Small Tree Tier:** Dogwoods, Redbuds, Shadbush
 - **Shrub Tier:** Azaleas, Mountain Laurel, Huckleberries
 - **Herb Tier:** Blue Bead Lily, Indian Cucumber, Wild Sarsaparilla
 - **Floor Tier:** Lichens and Mosses
- Temperate forests support a variety of **animals** that have different ways to deal with the cold and lack of food in winter. Some hibernate until spring when food is more plentiful. Others store food and burrow underground . Many migrate to warmer regions.



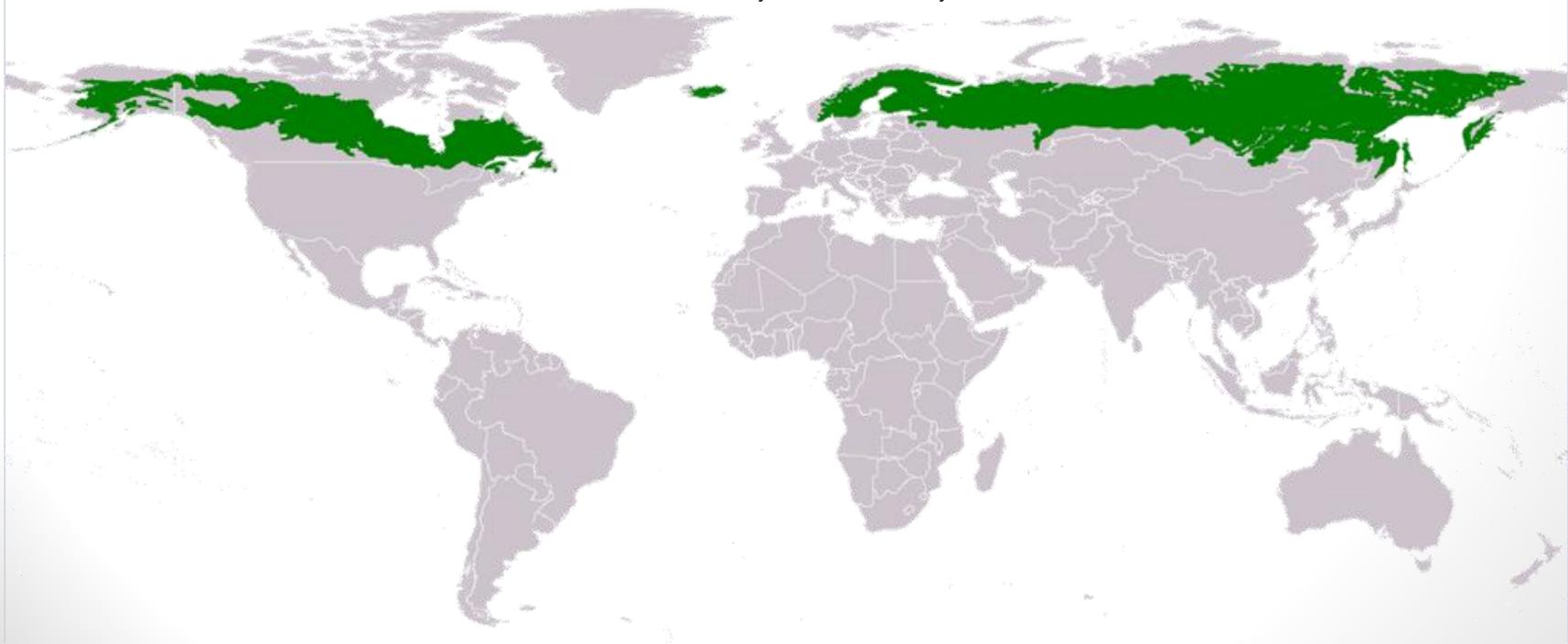
Temperate Forests: Fertile





Boreal Forests

Boreal forests, or taiga, represent the largest terrestrial biome. Occurring between 50 and 60 degrees north latitudes, boreal forests can be found in the broad belt of Eurasia and North America: two-thirds in Siberia with the rest in Scandinavia, Alaska, and Canada.





Boreal Forests

- Characterized by **coniferous** forests consisting mostly of pines, spruces and larches.
- The boreal represents **29% of the world's forest cover**.
- The **taiga** (a Russian word that recognizes the swampy nature of much of this forest in the summer) has no comparable zone in the southern hemisphere, probably because there is little land area there with the proper climate, temperatures in the southern hemisphere being moderated by close proximity to the sea.
- The largest area of **wetlands** in any ecosystem of the world is found in the Canadian boreal region, containing more lakes and rivers than any similarly sized landmass on earth.
- The **soils** of the boreal forest are often acidic, due to falling pine needles, and low on nutrients since the cold temperatures do not allow much foliage to rot and turn into dirt.

boreal wetlands





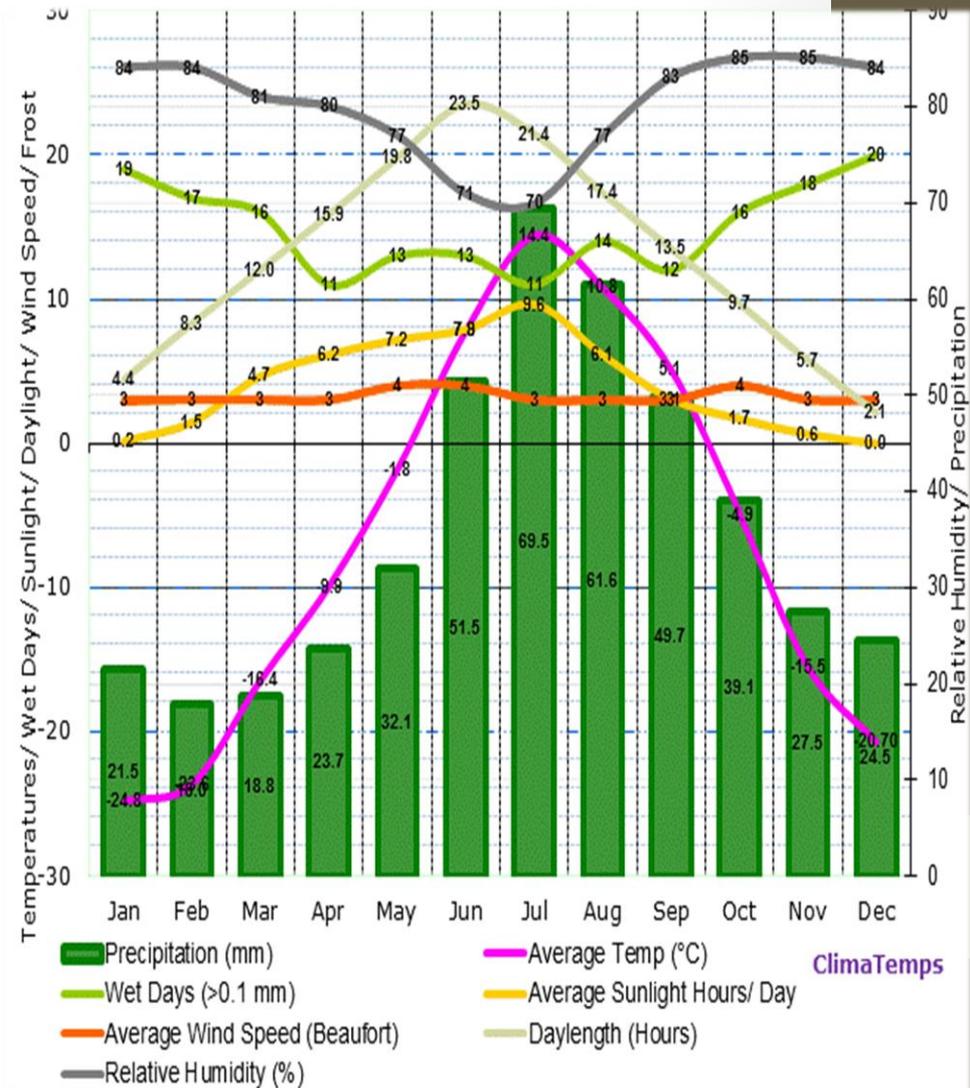
Boreal Forests

- Canopy permits **low light penetration**, and as a result, understory is limited.
- The zone of latitude occupied by the boreal forest has seen dramatic **temperature increases**, especially in winter and especially during the last quarter of the 20th century. The warming trend threatens to transform the boreal forest area into grassland, parkland or temperate forest, introducing a significant shift in species of plants and animals.
- The boreal forest stores enormous quantities of **carbon**, possibly more than the temperate and tropical forests combined, much of it in peat land.
- Current extensive **logging** in boreal forests may soon cause their disappearance. It has already endangered several boreal animal species.



Boreal Forests: Climate

- Seasons are divided into short, moist and moderately warm summers and **long, cold and dry winters**.
- Temperatures are **very low**.
- Precipitation is primarily in the form of **snow** (40-100 cm annually) and **fog**. There is little rainfall.





Boreal Forests: Flora and Fauna

- The big story in the taiga is **adaptation to winter cold and snow**.
- With snowmelt and low temperatures, there is little evaporation in the summer, so the ground is usually very moist during the growing season. Add to that the extremely long days at the northerly latitudes and you have a situation for explosive plant growth in the summer. The length of the growing season in boreal forests is 130 days.
- **Coniferous trees** - such as pine, fir and spruce - are the dominant plant form. These trees shed snow easily, and they retain their needles through the winter. They tend to have shallow roots due to the thin soils.
- **Mosses and lichens** are also important in the taiga and may be an important part of the diet for many animals.

Boreal Oak Moss





Boreal Forests: Flora and Fauna

- While typically **low on biodiversity**, the boreal around the globe supports a range of animals.
- Among the main **carnivores** of the boreal forest are a number of cats and canines ... tigers, lynx, bobcats, fox, wolves, etc. **Herbivores** include elk, moose, mule deer, reindeer, caribou, musk ox, etc.
- **Fauna** also include woodpeckers, hawks, bear, weasel, hares, chipmunks, shrews, owls, beavers and bats. Most bird species call the boreal home only in the summer and migrate elsewhere during the winter.



Boreal Forests: Cold





Forest Cover and Loss

Primary forests account for 36% of forest area - but 6 million hectares are lost or modified each year.

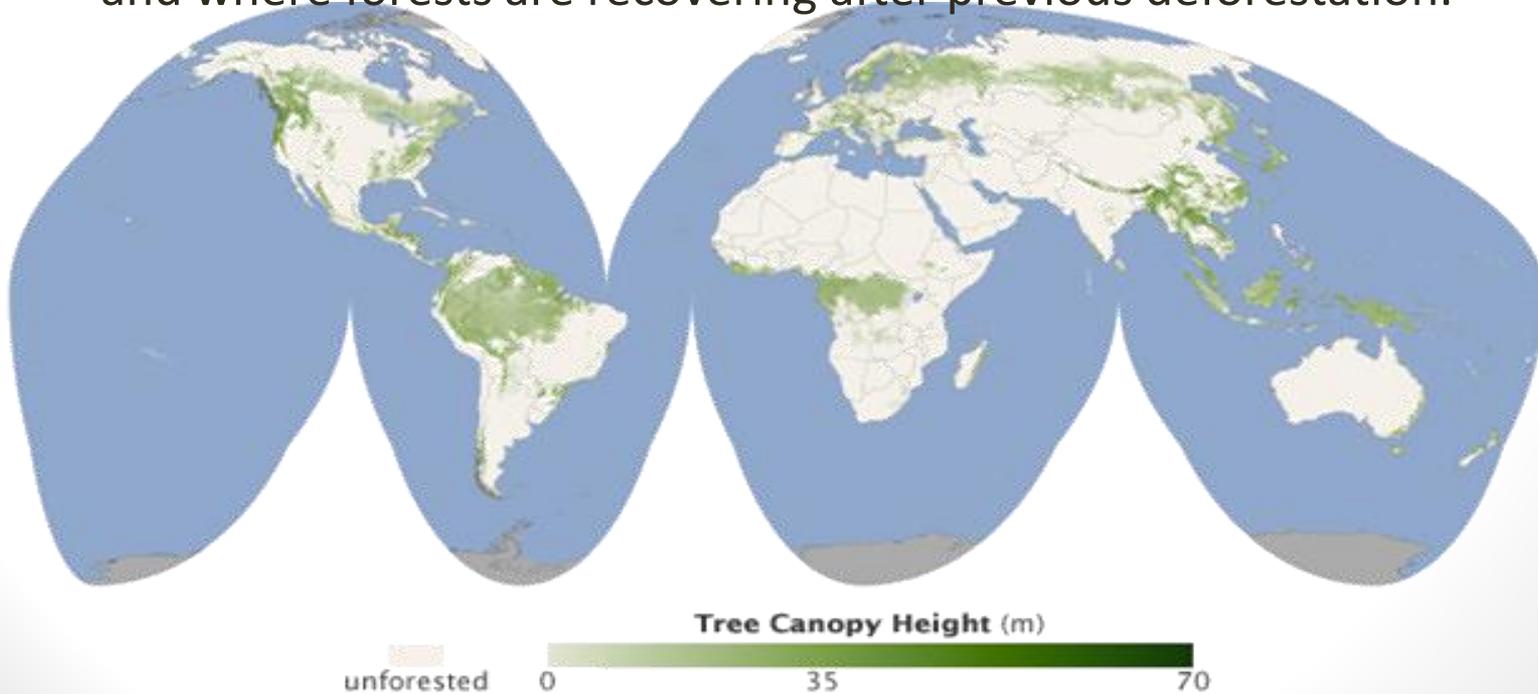
There is wide variation in the number of native tree species: from 3 species in Iceland to 7,780 in Brazil.





Tree Canopy Height

Forest canopy height, the height of the highest vegetation components above ground level, is essential for studying the contributions of forests and the effects of forest removal. Due to deforestation, there is a great deal of **variation in canopy height**. Until recently we could show where forests were located but not the height of those forests. New technology allows us to measure tree canopy height, telling us where deforestation has occurred, and where forests are recovering after previous deforestation.





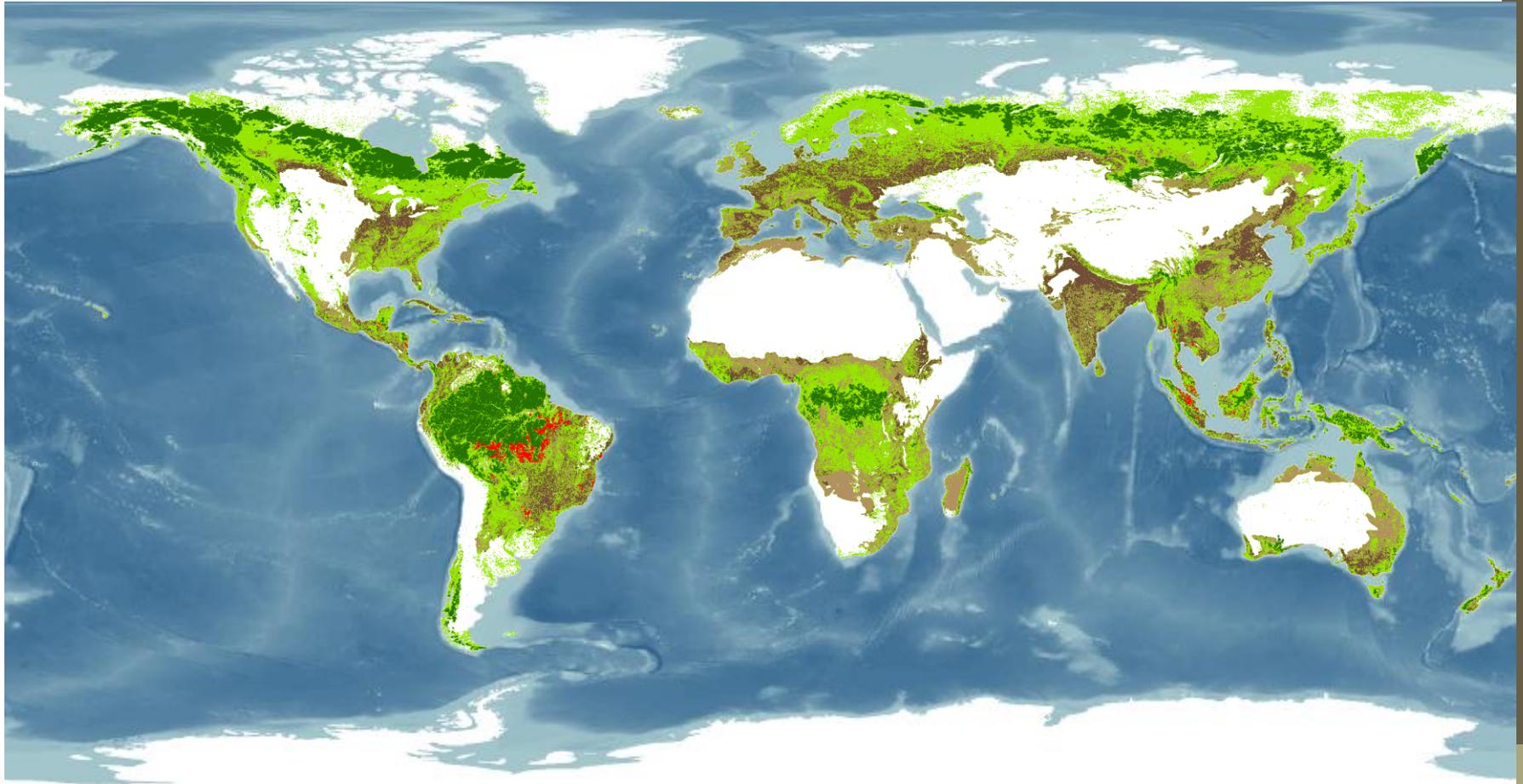
Forest Cover and Loss

For the map on the next slide...

- The extent of **historical deforestation** is the difference between original and current forest cover. This former forest landscape is mainly used either as **cropland** or as **pasture land**.
- The extent of recent **tropical deforestation** is shown based on an analysis of satellite images.
- An **intact forest landscape** is a part of today's forest that remains a large, unbroken expanse of natural ecosystems without signs of significant human activity (at least 50,000 hectares in size).
- [It's Time for a Global Landscape Restoration Revolution](#)



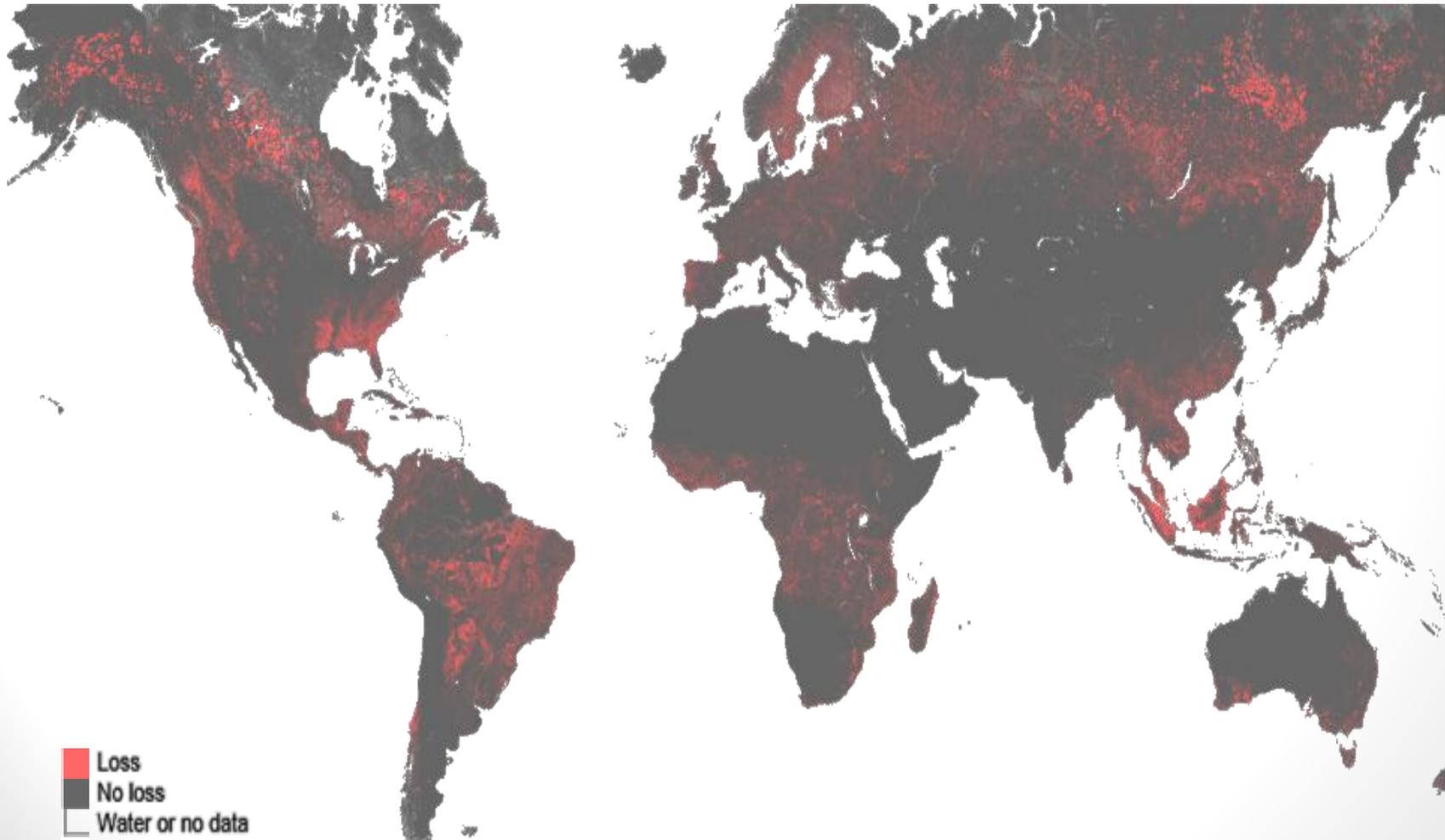
Forest Cover and Loss



- | | | | |
|---|---------------------------|---|----------------------------------|
|  | intact forest landscapes |  | formerly forest, now croplands |
|  | working forest landscapes |  | formerly forest, now pasture |
| | |  | tropical deforestation 2000-2005 |



Forest Cover Loss, 2000-2014





Causes of Deforestation

- The single biggest direct cause of tropical deforestation is **conversion to cropland and pasture**, mostly for subsistence (crops or livestock to meet daily needs).
- **population growth and pressure**
- **Large-scale commercial activities** play an increasingly significant role: industrial-scale cattle ranching, soybean production for world markets, commercial palm tree plantations to produce bio-fuels for export.
- **state policies to encourage economic development:** road and railway expansion projects, agricultural subsidies and tax breaks, timber concessions, low domestic costs of land, labor and fuel
- **global economic factors:** a state's foreign debt, expanding global markets for rainforest timber and pulpwood



Causes of Deforestation

- **Access to technology** may either enhance or diminish deforestation: The availability of technologies that allow industrial-scale agriculture can spur rapid forest clearing, while inefficient technology in the logging industry increases collateral damage in surrounding forests, making subsequent deforestation more likely.
- **urbanization**
- **wildfires**
- **overgrazing**: prevents the growth of young trees
- **fuel**: burn wood charcoal for domestic energy production
- **logging** for paper, furniture and homes
- **desertification**
- **mining**



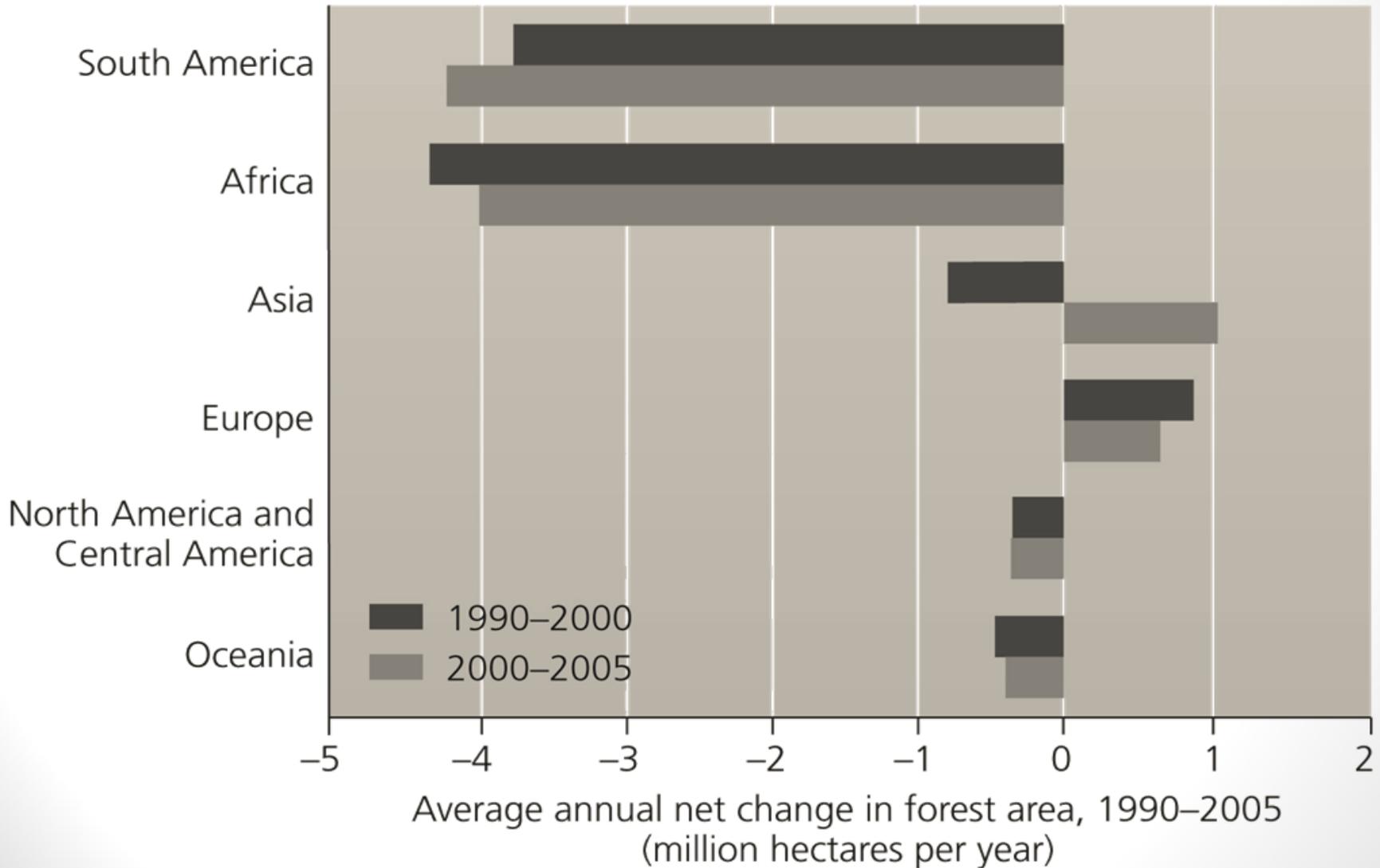


Agents of Deforestation

Agents	Links to Deforestation
slash-and-burn farmers	clear forest to grow subsistence and cash crops
commercial farmers	clear forest to plant commercial cash crops, sometimes displace slash-and-burn farmers who then move to forest
cattle ranchers	clear forest to plant pasture, sometimes displace slash-and-burn farmers who then move to forest
livestock herders	intensification of herding activities can lead to deforestation
loggers	remove commercial timber, logging roads provide access to other land users
commercial tree planters	clear mostly forest fallow or previously logged forests to establish plantations to supply fibre to the pulp and paper industry
firewood collectors	intensification of firewood collection can lead to deforestation
mining and petroleum industrialists	roads and seismic lines provide access to other land users, localized deforestation related to their operations
land settlement planners	relocation of people into forested areas as well as settlement projects displacing local people who then move to forest
infrastructure developers	new access for other land users from road and highway construction through forested areas, flooding by hydroelectric dams



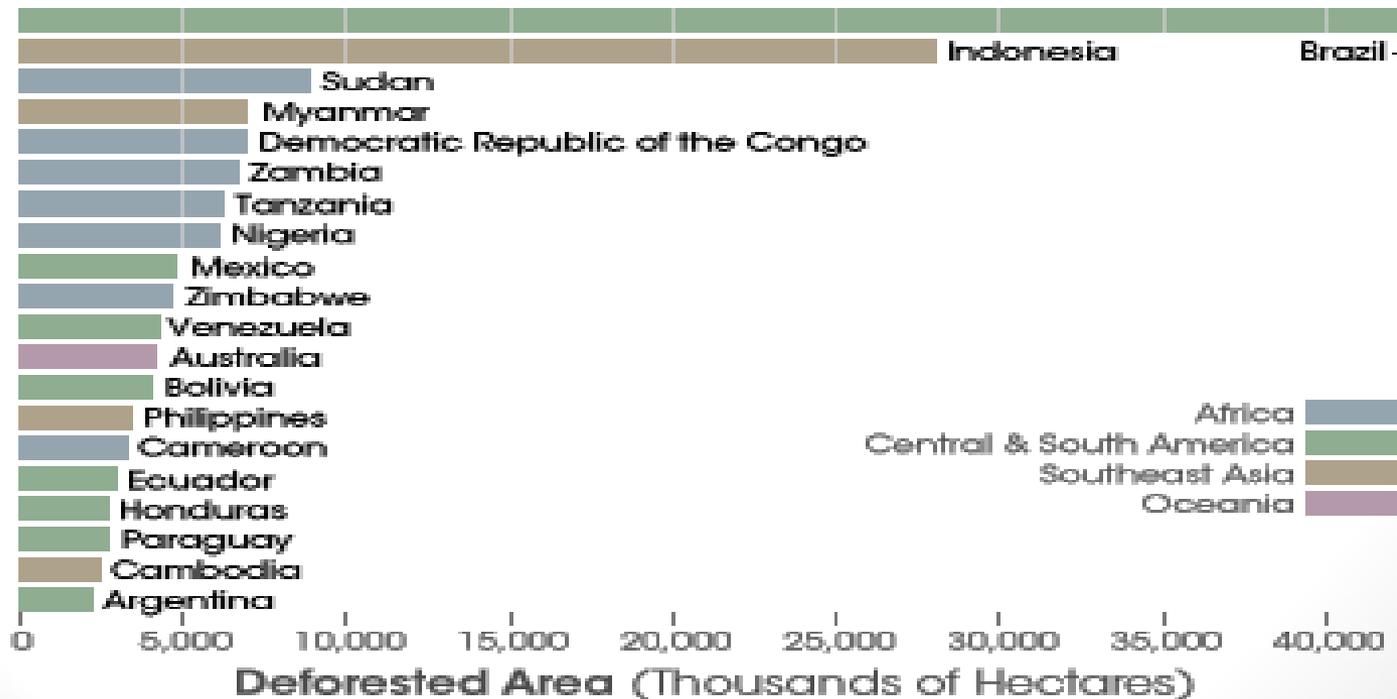
Forest Change by Region





States Clearing the Most Forest

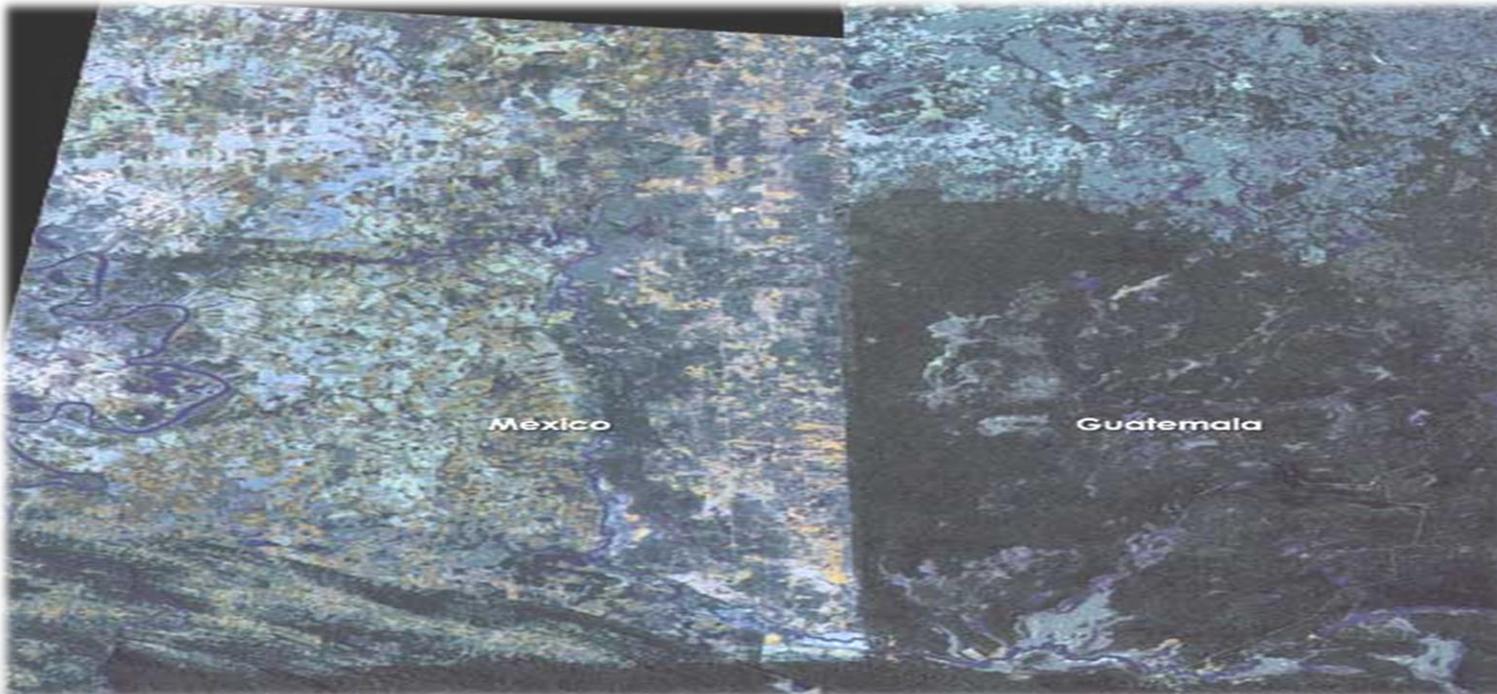
All tropical forest sub-regions (coded by color) are represented in a list of the top 20 states that cleared the most forest between 1990 and 2005. Brazil, the leader, cleared over 42 million hectares, an area the size of California.





Population Pressure

The razor-sharp border between Mexico and Guatemala, as seen in this 1988 LANDSAT image, shows the impact of high rural population on the rainforest. Guatemala's sparsely populated Petén district stands in stark contrast to the stripped and tilled landscape of Mexico.





Population Pressure

The state of Rondônia in western Brazil — once home to about 51.4 million acres of forest, an area slightly smaller than the state of Kansas — has become one of the most deforested parts of the Amazon.





Logging

...accelerating with population growth and economic development





Iguazu Falls, Argentina / Paraguay

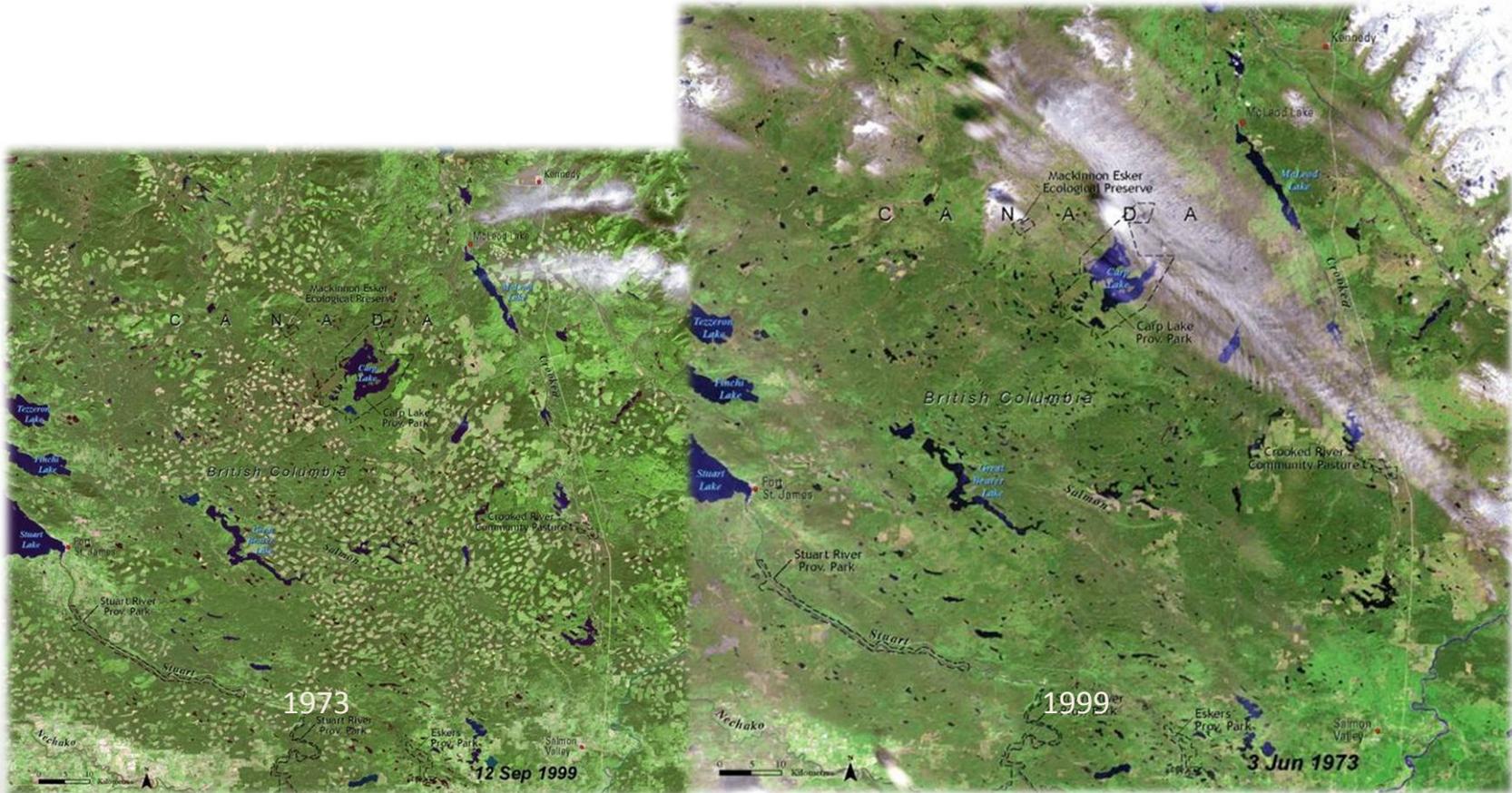
...due to **agricultural growth** and **construction** of roads and cities





British Columbia Conifer Forest, Canada

...due mostly to **logging**, some due to **forest fires**

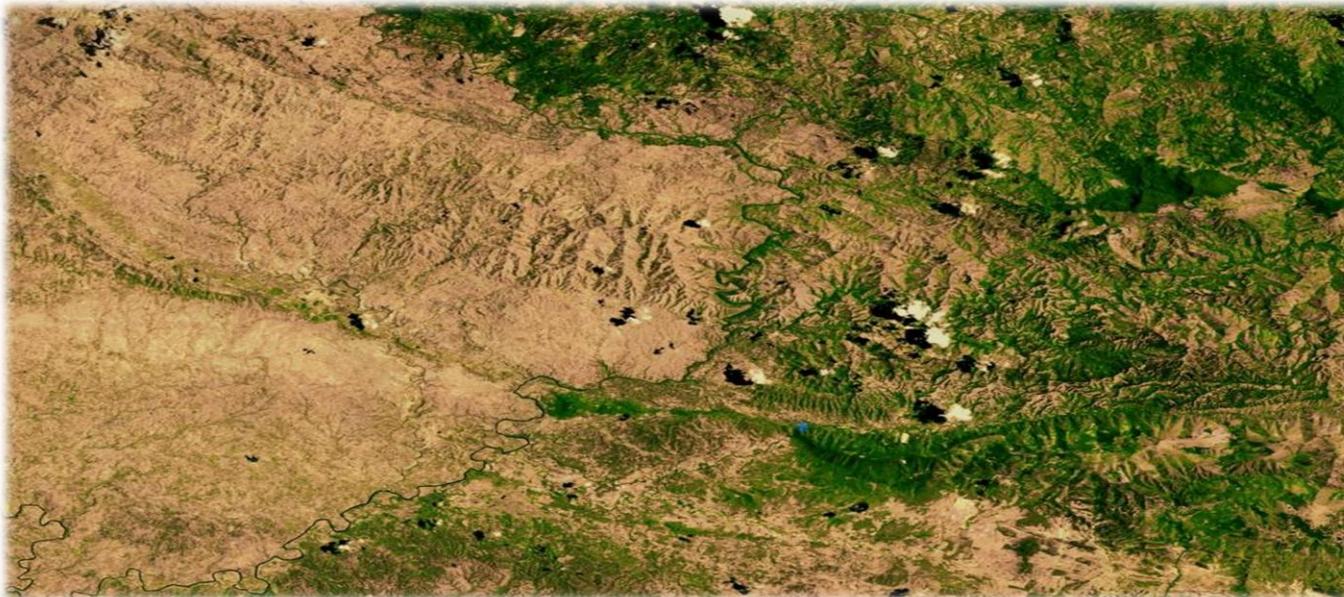




Haiti and the Dominican Republic

The border between Haiti and the Dominican Republic: Haiti is to the left and the Dominican Republic is the greener area to the right

In Haiti, the colonial system of **plantation monoculture** exhausted soil nutrients and led to rapid erosion. After independence, **export timber** and **subsistence** led to further deforestation. **Hurricanes** and **logging** exacerbated the situation. Currently, Haitians burn wood charcoal for 60% of their **domestic energy production**.

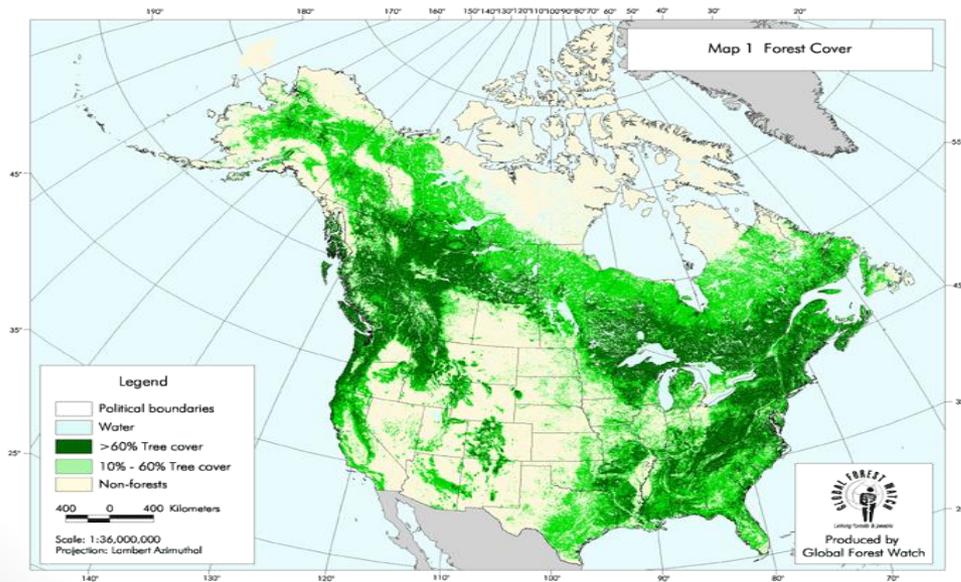
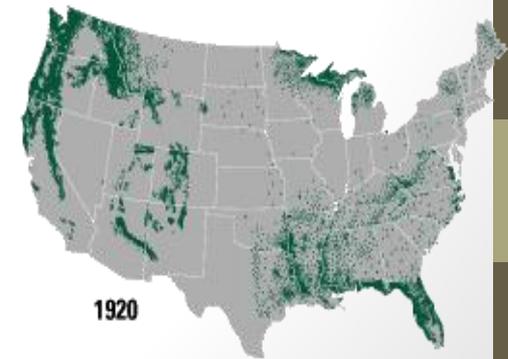
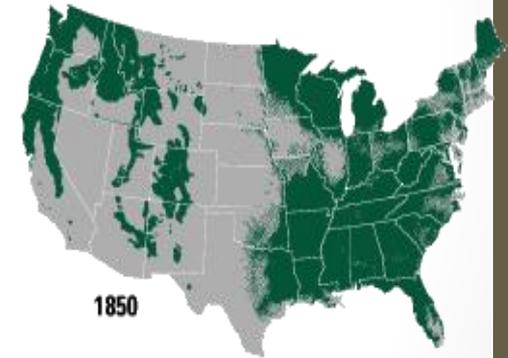




Deforestation in the United States

...was massive in scale, but is now essentially complete. In fact, today's maps show that some areas are recovering. Massachusetts now is 75% forested. At the time of Henry D. Thoreau's writings it was 25% forested.

Current deforestation is due to **agriculture**, **population pressures** and **logging** (a big industry in the US). Illegal logging is fairly widespread.





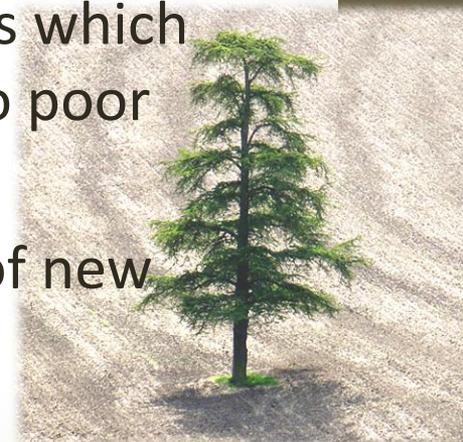
Effects of Deforestation

- **drives climate change**: forest soils are moist but without tree cover they quickly dry out, trees perpetuate the water cycle and without them former forest lands quickly become barren deserts and water tables are negatively affected
- **can change local weather patterns**, as well as hemispheric patterns
- more **extreme temperatures swings** due to loss of forest canopy
- larger amounts of **greenhouse gases** entering the atmosphere without forests to absorb them leading to increased speed and severity of global warming



Effects of Deforestation

- **destruction of renewable resources** leading to loss of potential renewable revenues
- releases **carbon dioxide** into the air (When trees die, they release stored carbon.)
- soil **erosion** (Soils never regain their full potential.)
- **flooding**
- **desertification**
- **silting** of lakes, streams and other water sources which decreases local water quality and contributes to poor health
- emergence of tropical **diseases** and outbreaks of new diseases





Effects of Deforestation

- destruction of **indigenous homelands**
- disruption of **livelihoods**
- **environmental refugees**: people who are displaced due to environmental degradation, including deforestation
- **habitat fragmentation**
- **loss of habitat**: millions of species, 70% of land animals and plants live in forests and many cannot survive deforestation
- **human-wildlife conflict**
- **Monga Bay**



Carbon Dioxide Release

Wildfires and **slash-and-burn agriculture** release carbon dioxide into the atmosphere (would otherwise be stored in the forest biomass). Forest regrowth and crops recapture some carbon, but overall, deforestation is a source of atmospheric carbon dioxide and therefore a contributor to global warming.





Local Weather Change

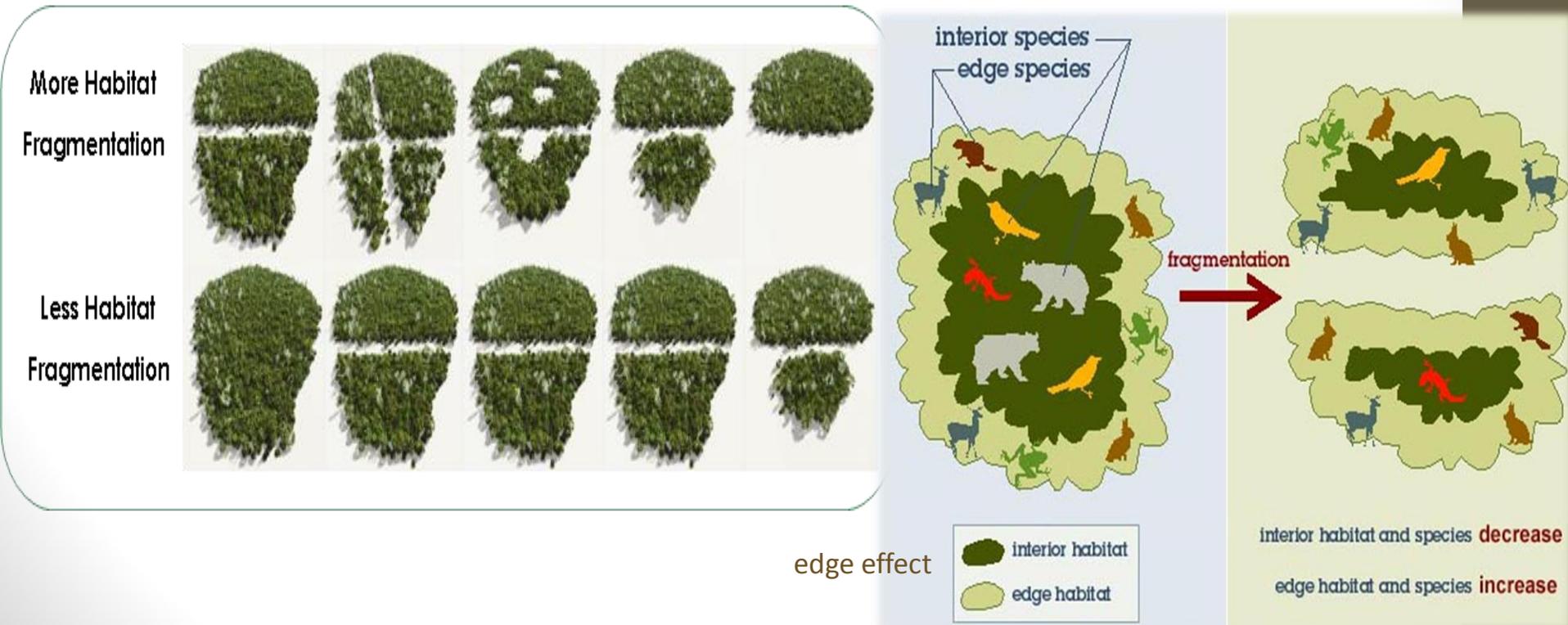
Alta Floresta, Brazil: Deforestation changes local weather. Cloudiness and rainfall can be greater over cleared land (right) than over intact forest (left).





Habitat Fragmentation

...the process by which habitat loss results in the division of large, continuous habitats into smaller, more isolated remnants causing population fragmentation and ecosystem decay.





Habitat Fragmentation and Human-Wildlife Conflict

Most species are affected to varying degrees by habitat fragmentation from encroaching civilization.





Habitat Fragmentation

Core Habitat, Habitat Edge and Connectivity



Maximum habitat interior (core habitat) and minimum edge



Maximum habitat edge and no interior habitat



Connect core habitat 'nodes' to prevent habitat fragmentation

Images courtesy of Benjamin Penington, 1000 Friends of Florida

Maintain large circular nodes (core areas) of habitat to maximize interior habitat and minimize edge. Habitat edges occur at the border of incompatible land and are generally detrimental to priority wildlife species because edges are more accessible to predators and parasites that reduce the survival of their young. For this reason, wider wildlife travel corridors are better. Wildlife also need to be able to travel through uninterrupted, contiguous habitat.



The World's Forests, Remaining and Lost

- Forests once covered almost twice the area they do today. Large expanses have been **converted or degraded** to produce food, timber and energy. More than three quarters of the world's forests have been cleared, fragmented or degraded. The loss is continuing at a rapid rate. Just one fifth of the world's original forest cover remains in large tracts of relatively undisturbed forest.
- Yesterday's loss, however, can be tomorrow's gain. Forests can **recover**. Some of the lost forests can be restored. And as forest landscapes recover, climate and other benefits will grow with the trees.
- Not all converted or degraded forests are suitable for restoration. Some of the world's most productive agricultural lands are former forests. But vast areas of **marginally productive lands and pastures** could grow trees once more and be part of multifunctional forest landscapes.



Why should we care?

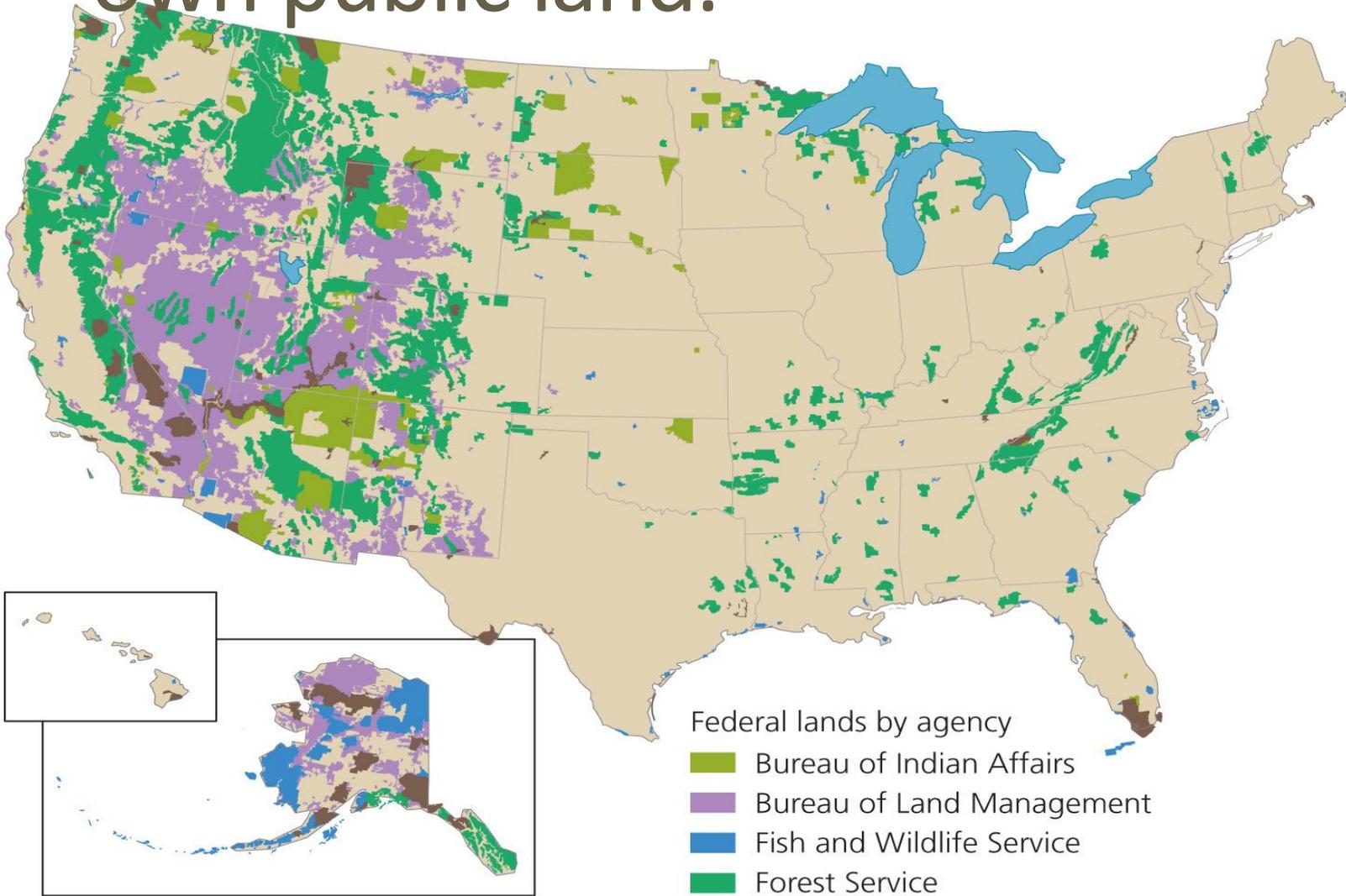
Where did your breakfast originate?

- 200 food crops derived from 250,000 species of flowering plants; 80% of food supply is from only 20 plants.
- Many crops (wheat, cotton, tobacco, sugar cane, bananas, potatoes, safflower, corn) are hybrids from wild and domesticated plant species.
- Many of these crops originate in the tropics, along with oranges (SE Asian tropics), coffee (Ethiopian highlands), chocolate (S. American tropics).





US Forest Policy: Federal agencies own public land.



- Federal lands by agency
-  Bureau of Indian Affairs
 -  Bureau of Land Management
 -  Fish and Wildlife Service
 -  Forest Service
 -  National Park Service

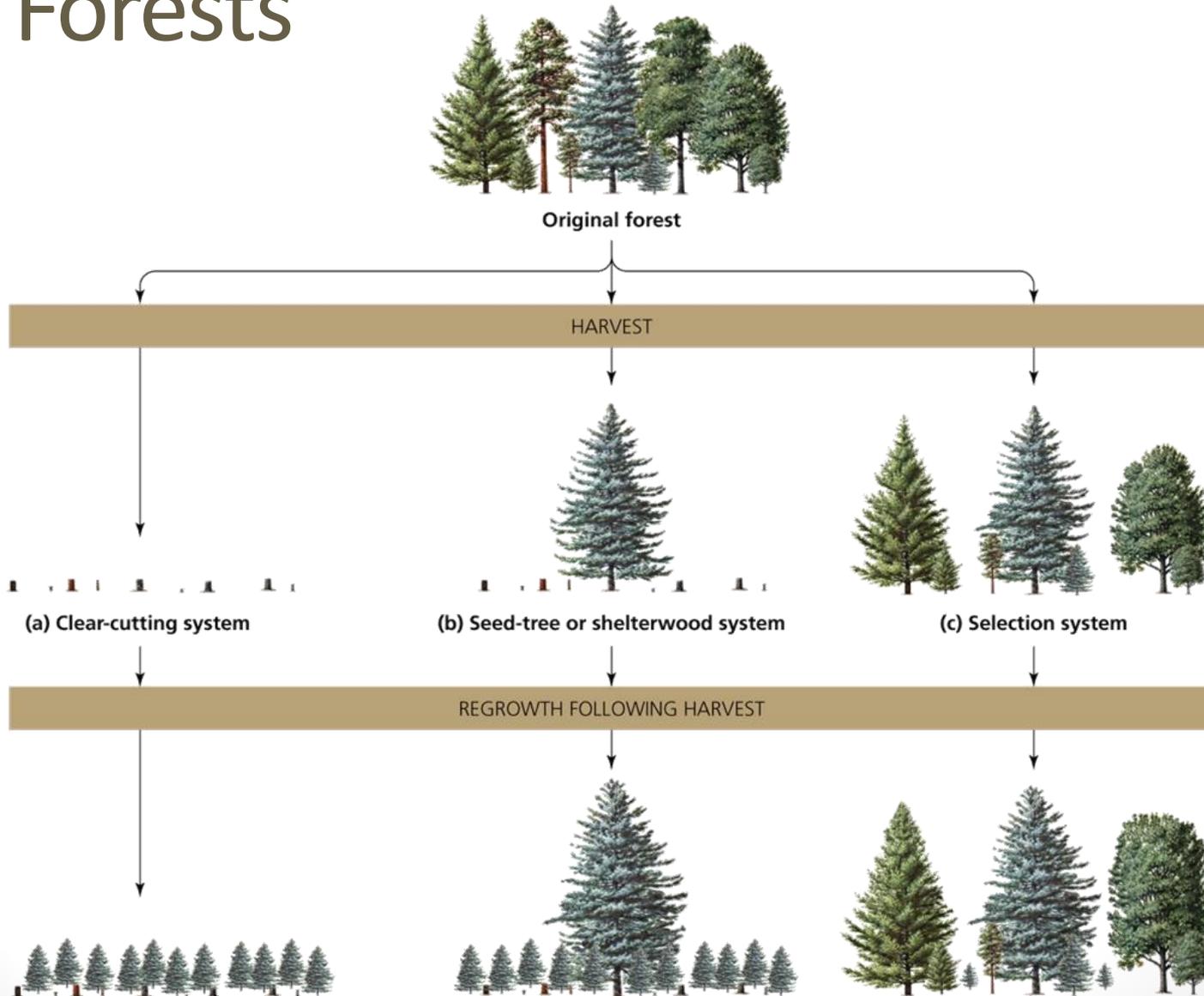


US Forest Policy: The National Forest Management Act (1976)

- ...mandated that plans for **renewable resource management** had to be drawn up for every national forest
- Guidelines include:
 - consideration of both economic and environmental factors
 - provision for species diversity
 - ensuring research and monitoring
 - permitting only sustainable harvests
 - protection of soils and wetlands
 - assessing all impacts before logging to protect resources



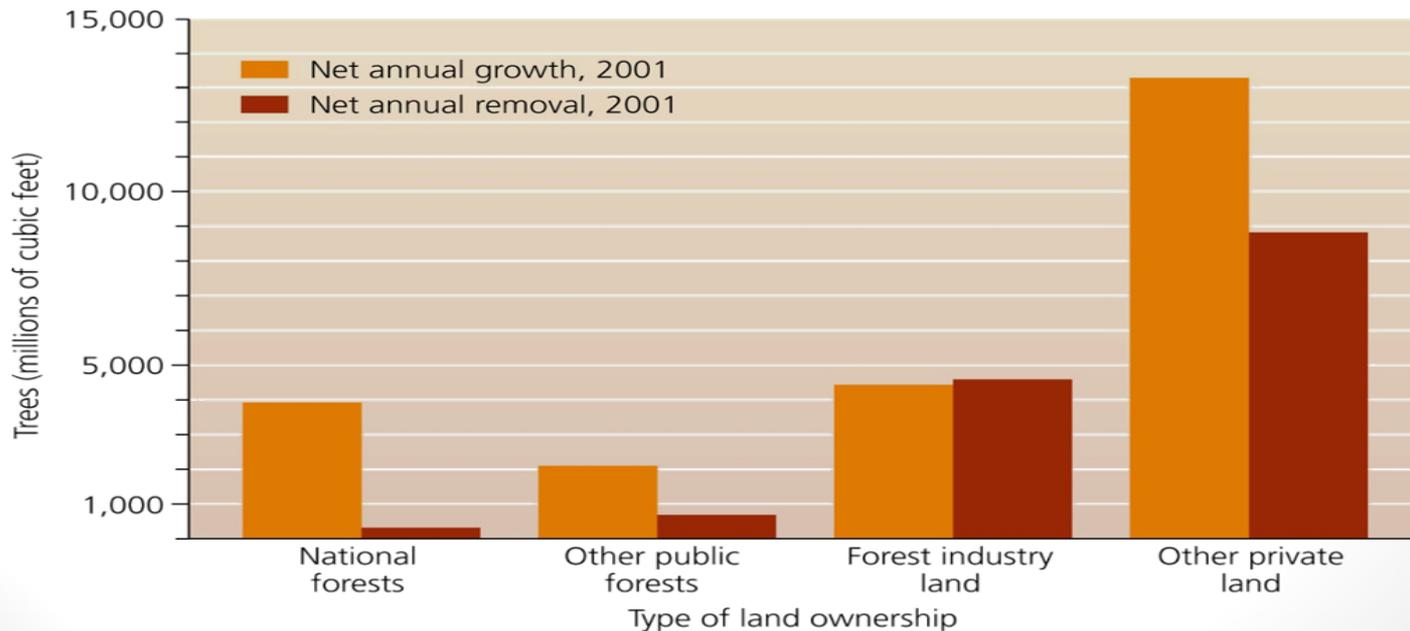
US Forest Policy: Harvesting Forests





US Forest Policy: Timber is extracted from public and private land.

- Timber is extracted by private companies, even on public land.
 - Forest Service employees plan and manage timber sales and build roads.
 - Companies log and sell the timber for profit.





US Forest Policy: Fire Policy

- For over 100 years, the Forest Service suppressed all fires.
 - Many **ecosystems** depend on fires.
 - Fire suppression allows **woody accumulation**, which produces kindling for future fires ... which are much worse.
- Housing developments near forests and climate change will increase fire risk.





US Forest Policy: Fire Policy

- **Prescribed (controlled) burns:** burning areas of forests under carefully controlled conditions
 - effective
 - could get out of control
 - impeded by public misunderstanding and political interference
- **Healthy Forests Restoration Act (2003):** promotes removal of small trees, underbrush and dead trees
 - passed in response to forest fires



US Forest Policy: Salvage Logging

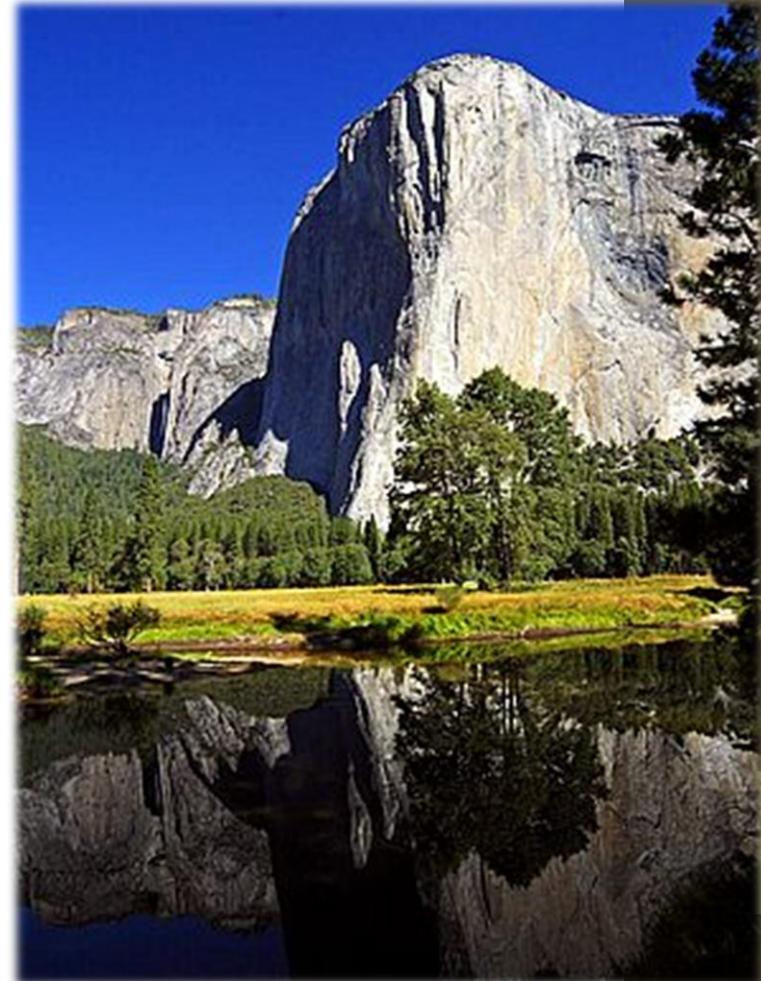
- ...removal of dead trees following a natural disturbance such as a forest fire
- seems logical, but is destructive
 - **Snags** (standing dead trees) provide nesting cavities for countless animals.
 - Removing timber from recently burned areas **increases erosion and soil damage.**
 - Promotes **future fires.**
 - Increases **commercial logging** in national forests.
 - Decreases **oversight** and public participation.





US Conservation Policy: Federal parks and reserves began in the US.

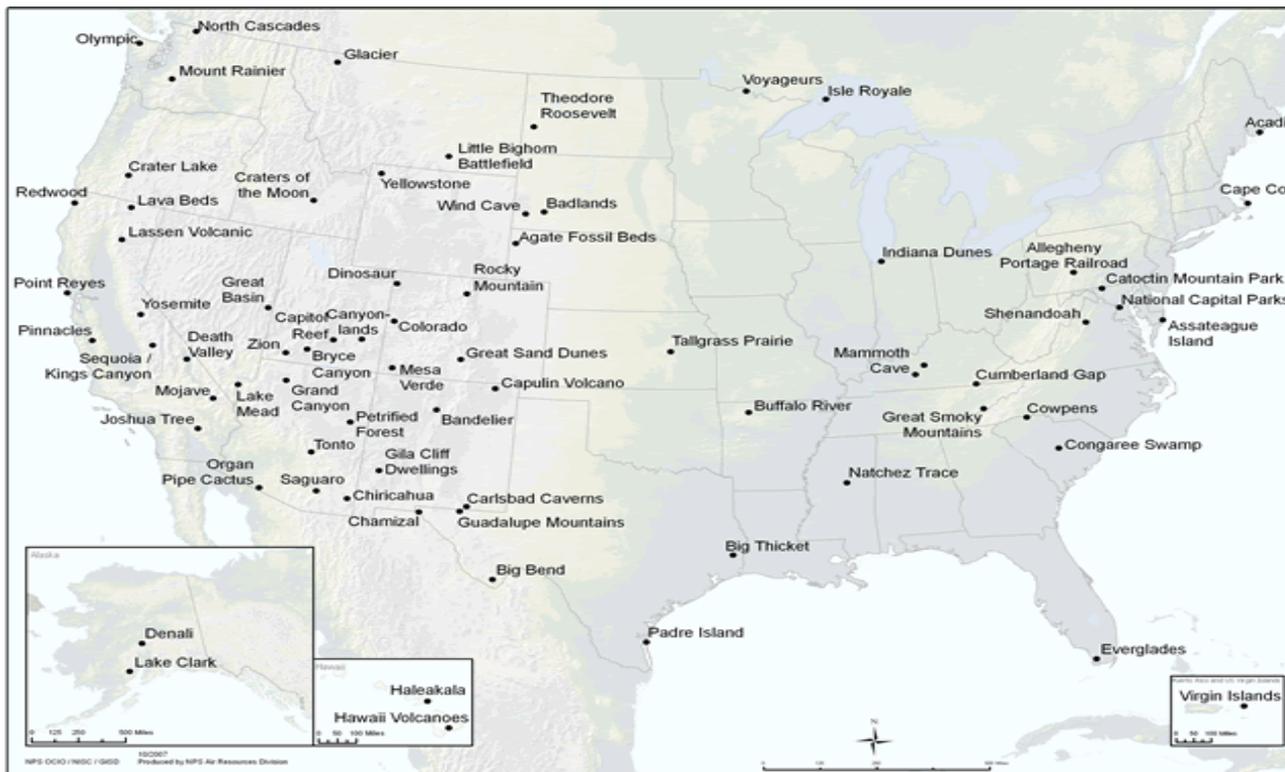
- **National Parks:** public lands protected from resource extraction and development
 - open to nature appreciation and recreation
 - Yellowstone National Park was established in 1872.
- The Antiquities Act of 1906
 - The president can declare selected public lands as national monuments.





US Conservation Policy: The National Park Service (NPS)

- ...created in 1916 to administer parks and monuments
 - 388 sites totaling 72 million acres
 - includes national historic sites, national recreation areas, national wild and scenic rivers





US Conservation Policy: National Wildlife Refuges

- ...began in 1903 by President Theodore Roosevelt
- 91 million acres in 541 sites
- US Fish and Wildlife Service administers refuges.
 - management ranges from preservation to manipulation
 - wildlife havens
 - allows hunting, fishing, wildlife observation, photography, education





US Conservation Policy: Wilderness Areas

- **Wilderness Areas:** off-limits to development of any kind
 - open to the public for hiking, nature study, etc
 - must have minimal impact on the land
 - necessary to ensure that humans don't occupy and modify all natural areas
- Established within federal lands
 - overseen by the agencies that administer those areas
- 1964 Wilderness Act: <http://www.wilderness.net>





US Conservation Policy: Conservation Reserve Program

- ...pays a yearly rental payment in exchange for farmers removing environmentally sensitive land from agricultural production and planting species that will improve environmental quality
- **set-aside**: set aside a certain percentage of total acreage for conservation uses
- have specific reserve programs for forests, wetlands, grasslands, source water and emergency situations



US Conservation Policy: Some don't support land set-asides.

- Restriction of activities in wilderness areas generated opposition to US land protection policies.
 - Some western states want resource extraction and development.
- The **wise-use movement**: a coalition of individuals and industries that oppose environmental protection
 - farmers, ranchers, loggers, mineral and fossil fuel industries (All have a great deal of political clout.)
 - protect private property, transfer federal lands to state or private hands, promote motorized recreation on public lands

Blue areas show land set-aside in Montana.





US Conservation Policy: The SLOSS Debate

- Which is better to protect species?
 - A **Single Large Or Several Small** reserves?
 - depends on the species: tigers vs. insects
- **corridors**: protected land that allows animals to travel between islands of protected habitat
 - Enables gene flow between populations.
 - Animals have more resources.



The End