Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.

Enduring understanding 4.B: Competition and cooperation are important aspects of biological systems.

Essential knowledge 4.B.4: Distribution of local and global ecosystems changes over time.

a. Human impact accelerates change at local and global levels. [See also 1.A.2]

To foster student understanding of this concept, instructors can choose an illustrative example such as:

Logging, slash and burn agriculture, urbanization, monocropping, infrastructure development (dams, transmission lines, roads), and global climate change threaten ecosystems and life on Earth.

Essential knowledge 4.B.4: Distribution of local and global ecosystems changes over time.

a. Human impact accelerates change at local and global levels. [See also 1.A.2]

To foster student understanding of this concept, instructors can choose an illustrative example such as:

An introduced species can exploit a new niche free of predators or competitors, thus exploiting new resources.

Introduction of new diseases can devastate native species.
Illustrative examples include:

Dutch elm disease, Potato blight, Small pox [historic example for Native Americans]

Human Impact on the Environment

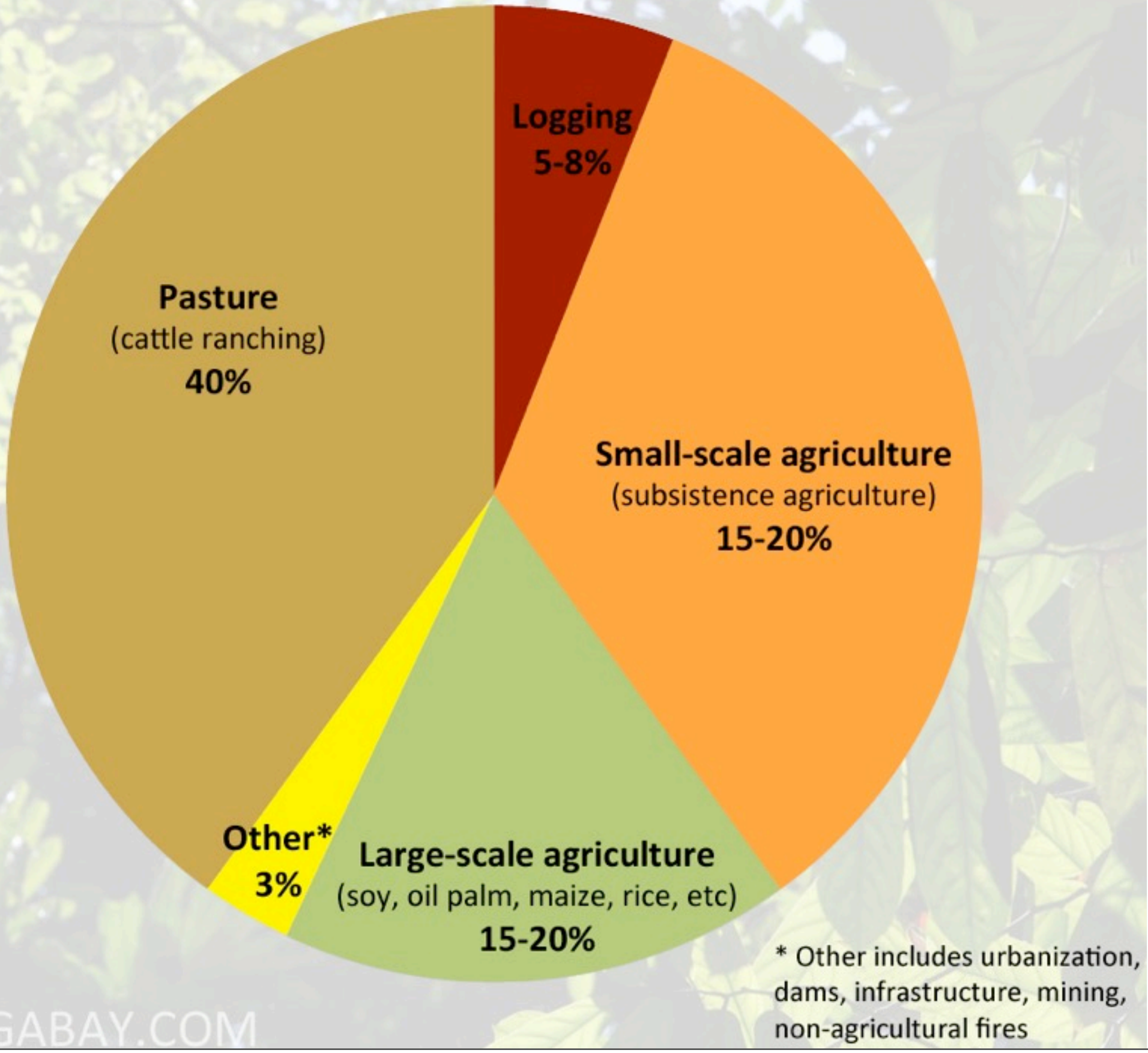
- Humans are the most significant agent of environmental change
  - our ever expanding population is..
    - **transforming** natural habitats,
    - **consuming** increasing amounts of finite resources, like soil, water and breathable air
    - **eradicating** thousands of species

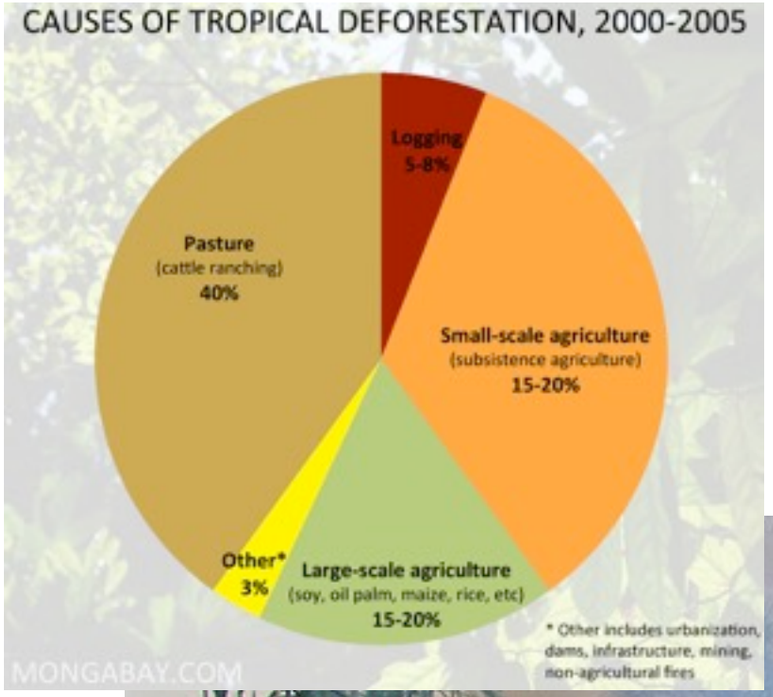
Deforestation

Deforestation is clearing Earth's forests on a massive scale, often resulting in damage to the quality of the land. Forests still cover about 30 percent of the world’s land area, but swaths half the size of England are lost each year.

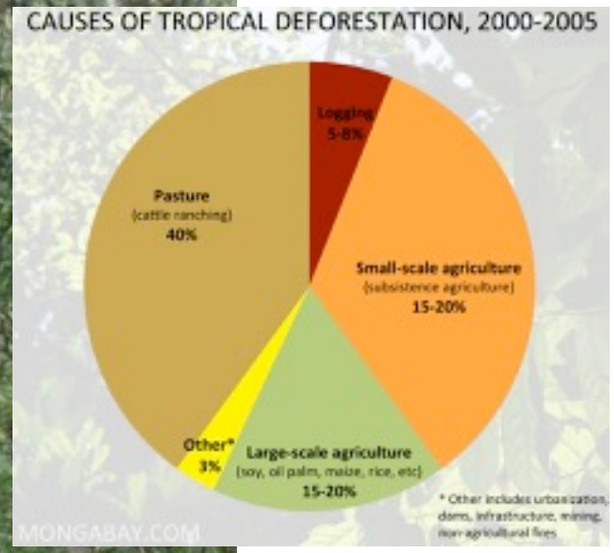
The world’s rain forests could completely vanish in a hundred years at the current rate of deforestation.

CAUSES OF TROPICAL DEFORESTATION, 2000-2005





The biggest driver of deforestation is agriculture. Farmers cut forests to provide more room for planting crops or grazing livestock. Often, small farmers will clear a few acres by cutting down trees and burning them in a process known as slash and burn agriculture.



Logging operations, which provide the world's wood and paper products, also cut countless trees each year. Loggers, some of them acting illegally, also build roads to access more and more remote forests—which leads to further deforestation. Forests are also cut as a result of growing urban sprawl as land is developed for dwellings.

Effects of Deforestation

Deforestation can have a negative impact on the environment. The most dramatic impact is a loss of habitat for millions of species. Eighty percent of Earth's land animals and plants live in forests, and many cannot survive the deforestation that destroys their homes.

Effects of Deforestation

Deforestation also drives climate change. Forest soils are moist, but without protection from sun-blocking tree cover, they quickly dry out. Trees also help perpetuate the water cycle by returning water vapor to the atmosphere. Without trees to fill these roles, many former forest lands can quickly become barren deserts.

Removing trees deprives the forest of portions of its canopy, which blocks the sun's rays during the day, and holds in heat at night. This disruption leads to more extreme temperature swings that can be harmful to plants and animals.

Trees also play a critical role in absorbing the greenhouse gases that fuel global warming. Fewer forests means larger amounts of greenhouse gases entering the atmosphere—and increased speed and severity of global warming.

Monoculture

Monocultures, the agricultural practice of producing or growing genetically similar, or essentially identical plants, over a large areas (stands), year after year, is widely used in modern industrial agriculture. It is often argued that monoculture produces greater yields by utilizing plants' abilities to maximize growth under less pressure from other species and more uniform plant structure.

Of the myriad species of plants and animals available for human consumption, modern agriculture uses only a few. According to the UN's Food and Agriculture Organization, only 12 plant species provide 75% of our total food supply, and only 15 mammal and bird species make up over 90% of livestock production.

The Issues and problems...

However, these plants are selected because of their ability to grow well under the specific conditions of a particular place, and therefore are at greater risk when these conditions change, for instance in extreme weather, than are genetically diverse stands. Genetically diverse crops can better survive in environments in which conditions fluctuate, because some are vulnerable to certain changes and other are not. Thus genetic diversity is likely to reduce the odds of massive crop failure and to contribute to greater stability of production.

The vulnerability of monocultures to disease and insects also illustrates this point. Pathogens spread more readily, and epidemics tend to be more severe, when the host plants (or animals) are more genetically uniform and crowded. The pathogens encounter less resistance to spreading than they do in mixed stands. Outbreaks of disease, invasions of insects, and climatic anomalies have caused many wholesale crop and animal failures in the past.

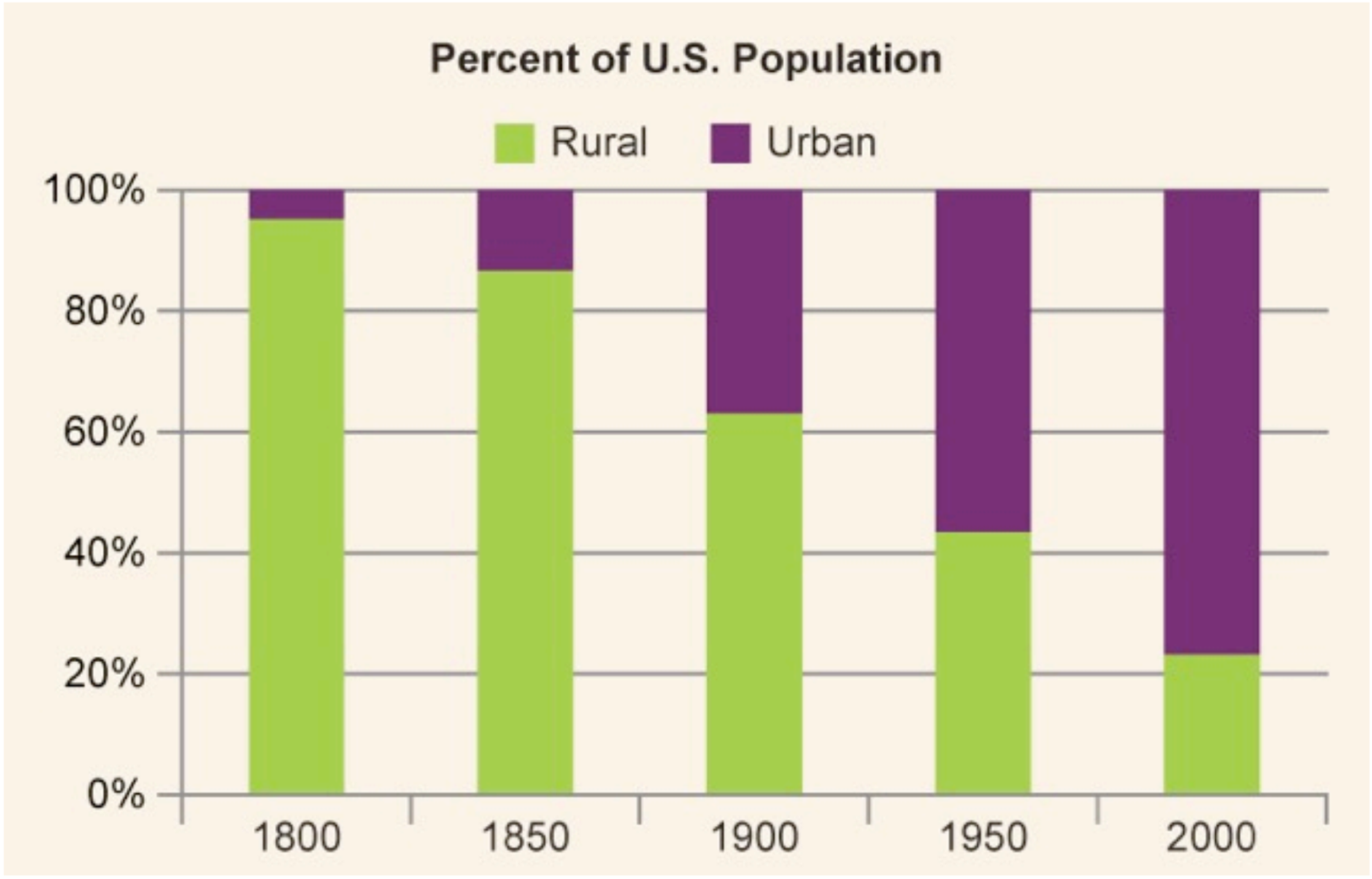
What is also not appreciated is that modern crops and livestock vitally depend on hundreds of thousands of other species, including insects and birds that pollinate crops and feed on pests, and numerous microbial species that live on and in plants and animals, and that are especially critical to survival.

Urbanization

Urbanization is a population shift from rural to urban areas, "the gradual increase in the proportion of people living in urban areas", and the ways in which each society adapts to the change. It is predominantly the process by which towns and cities are formed and become larger as more people begin living and working in central areas.

Trends

Nearly all urban areas are growing, having added 58,000 square kilometers in built-up land since 1970, an area equivalent to the size of Lake Michigan. While we find some global trends of rapid development near coastal and ecologically sensitive areas, urban areas also vary widely in their spatial patterns, rates, and types of growth.



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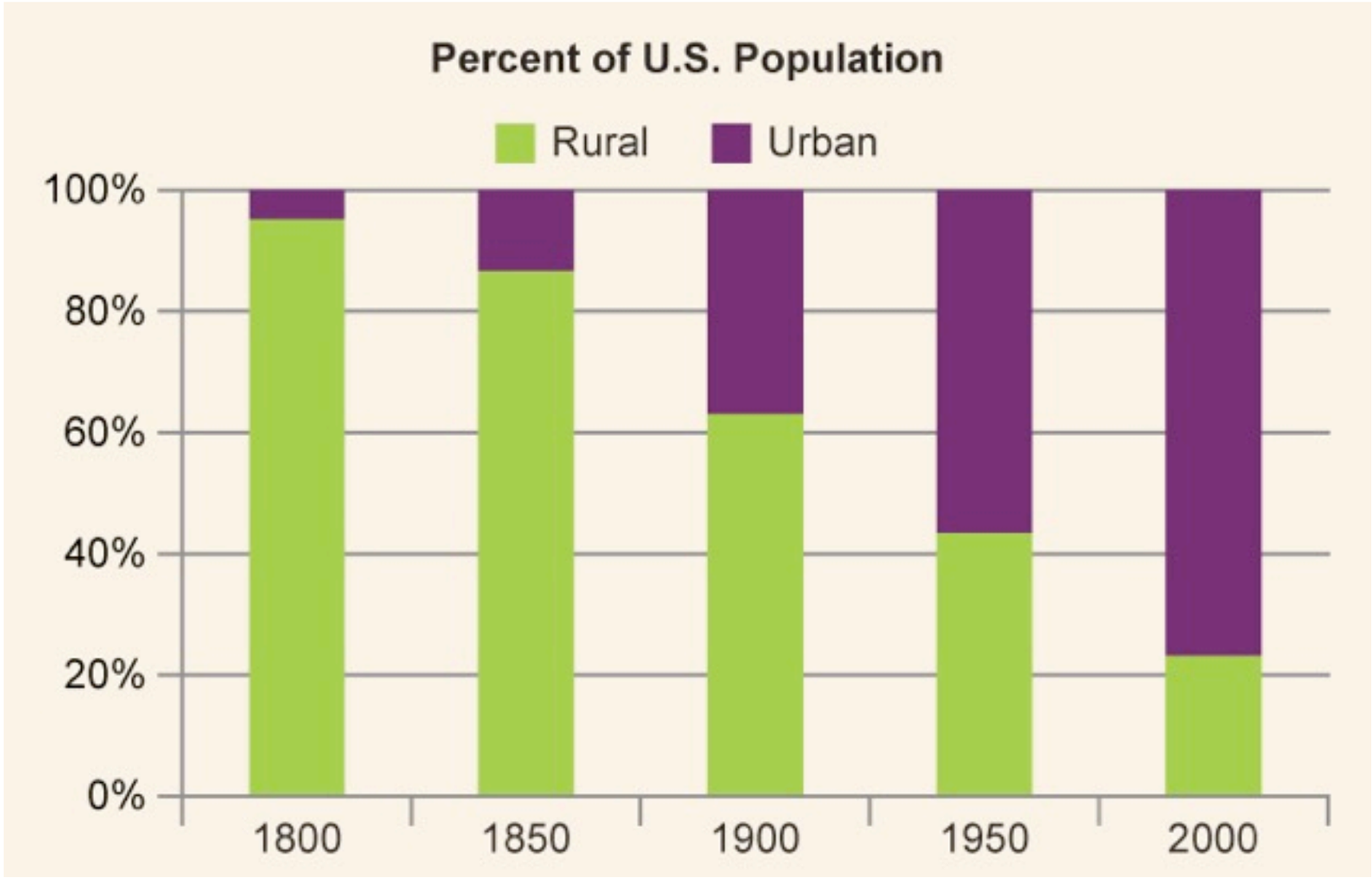


Urbanization

1900 | 2 out of every 10 people lived in an urban area

1990 | 4 out of every 10 people lived in an urban area

2010 | 5 out of every 10 people lived in an urban area

2030 | 6 out of every 10 people will live in an urban area

2050 | 7 out of every 10 people will live in an urban area

Defined by UN HABITAT as a city with a population of more than 10 million

Forecast...

In 2008, the global urban population exceeded the rural population for the first time, and it is estimated that by 2050, 70% of the world population will live in urban areas (UN DESA, 2012). Furthermore, mid-range forecasts show an increase of around 1.5 million square kilometers of new urban land area by 2030, an area nearly equal to the land area of Mongolia, and nearly tripling the global urban land area in 2000 (Seto et al. 2011; Seto et al. 2012) These forecasts suggest an important—and limited—window of opportunity to shape future urbanization.

Environmental Impacts

The conversion of Earth's land surface to urban uses is one of the most irreversible human impacts on the global biosphere.

It hastens the loss of...

-highly productive farmland,
-affects energy demand,
-alters the climate,
-modifies hydrologic and biogeochemical cycles,
-fragments habitats,
-and reduces biodiversity (Seto et al., 2011)

We see these effects on multiple levels. Future urbanization will, for example, pose direct threats to high-value ecosystems: the highest rates of land conversion over the next few decades will likely take place in biodiversity hotspots that were relatively undisturbed by urban development in 2000 (Seto et al., 2012).

Environmental Impacts

The environmental impacts of urban expansion reach far beyond urban areas themselves.

In rapidly urbanizing areas, agriculture intensifies on remaining undeveloped land and is likely to expand to new areas, **putting pressure on land resources** (Jiang et al., 2013).

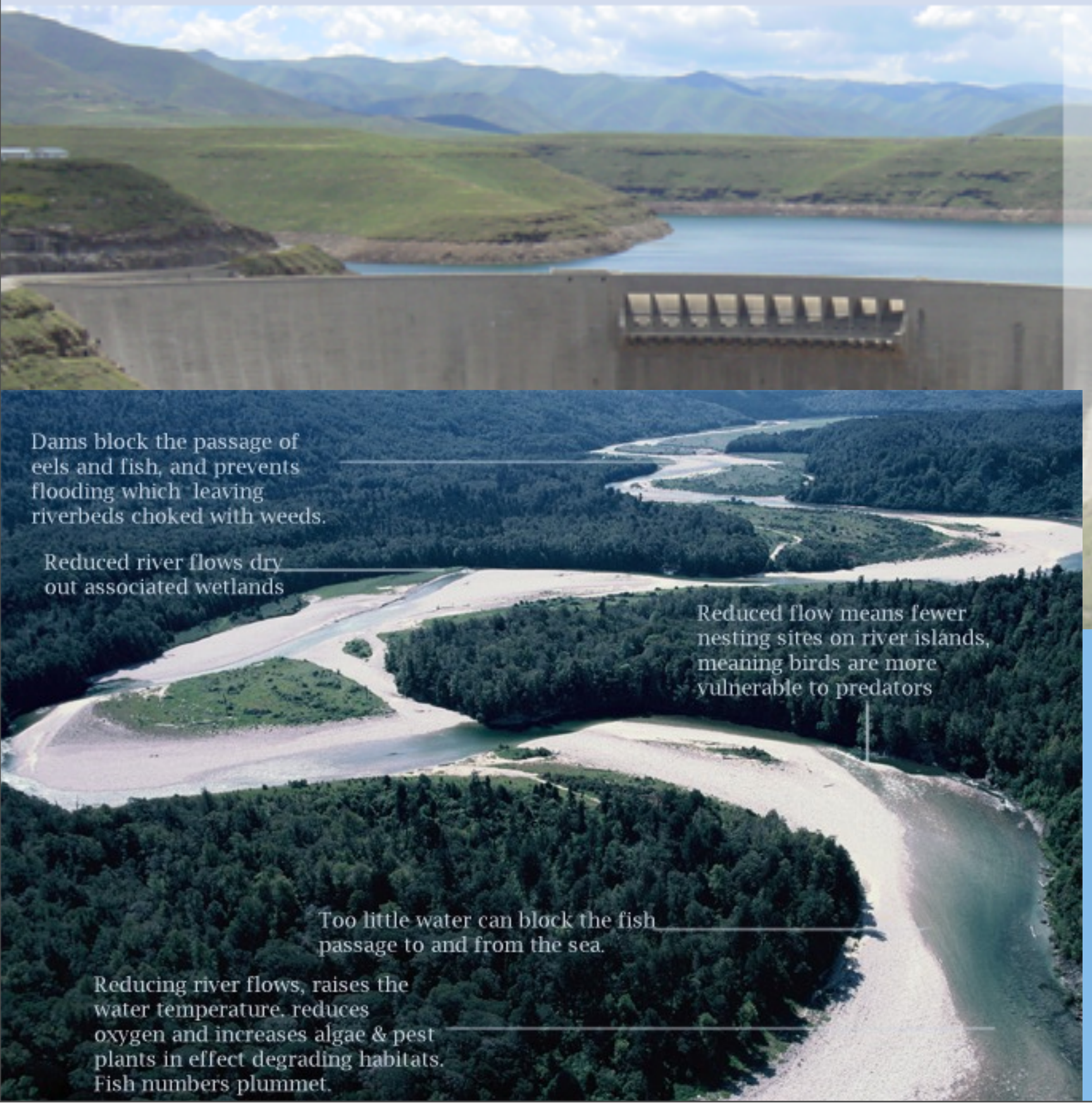
Furthermore, urban areas **change precipitation patterns** at scales of hundreds of square kilometers (Kaufman et al., 2007) .

Urban expansion **will affect global climate** as well.

Direct **loss in vegetation biomass** from areas with high probability of urban expansion is predicted to contribute about 5% of total emissions from tropical deforestation and land-use change (Seto et al., 2012).

Infrastructure: Dams

Impacts of Dams



Downstream Impacts

reduced biodiversity; poor water quality; lower crop production; decreased fish populations

Dam

blocked fish migration; distrupted flow of sediments and water; hazards from ageing dams

Reservoir

contributes to global warming; displaces communities; increases water-borne illnesses; triggers earthquakes

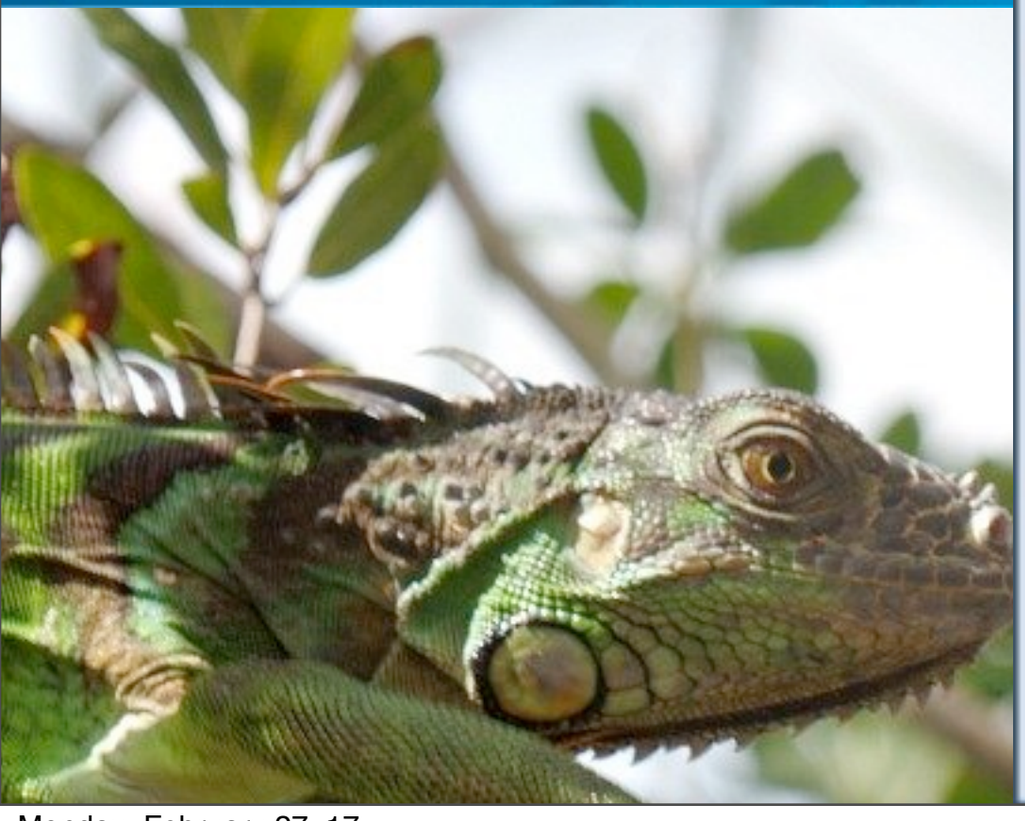
Invasive Species

An **invasive species** is a plant, fungus, or animal species that is not native to a specific location (an introduced **species**), and which has a tendency to spread to a degree believed to cause damage to the environment, human economy or human health.

What are some negative effects of invasive species?

- Invasive species do not provide food
- They out-compete our native species for limited resources such as food and habitat
- They explode in population because they do not have a natural **predator**
- They are a threat to our ecosystems, economy or society

Florida Invasives



In a nutshell:

- Invasive species and infectious diseases are becoming more prevalent and widespread with increased connectedness and globalization
- Alien species are the second leading cause of extinction in the US and cost approximately $120 billion annually
- Disease vectors and pathogens are spreading across continents due to human transport, land-use change, and climate change
- To adequately understand and predict the spread of invasive species and disease, we must coordinate the many existing networks at local, regional, continental, and global scales
- Both observational and experimental approaches are required to fully understand the effects and impacts of invasive species and diseases and, more importantly, to understand the biotic and abiotic factors that enhance or diminish their effects

Emerging Disease

Dutch elm disease (**DED**) is caused by a member of the sac fungi (Ascomycota) affecting elm trees, and is spread by the elm bark beetle. Although believed to be originally native to Asia, the disease has been accidentally introduced into America and Europe, where it has devastated native populations of elms that did not have resistance to the disease. It has also reached New Zealand.

The disease was first reported in the United States in 1928, with the beetles believed to have arrived in a shipment of logs from The Netherlands destined for use as veneer in the Ohio furniture industry.

Quarantine and sanitation procedures held most cases within 150 miles of metropolitan New York City until 1941 when war demands began to curtail them.[24]

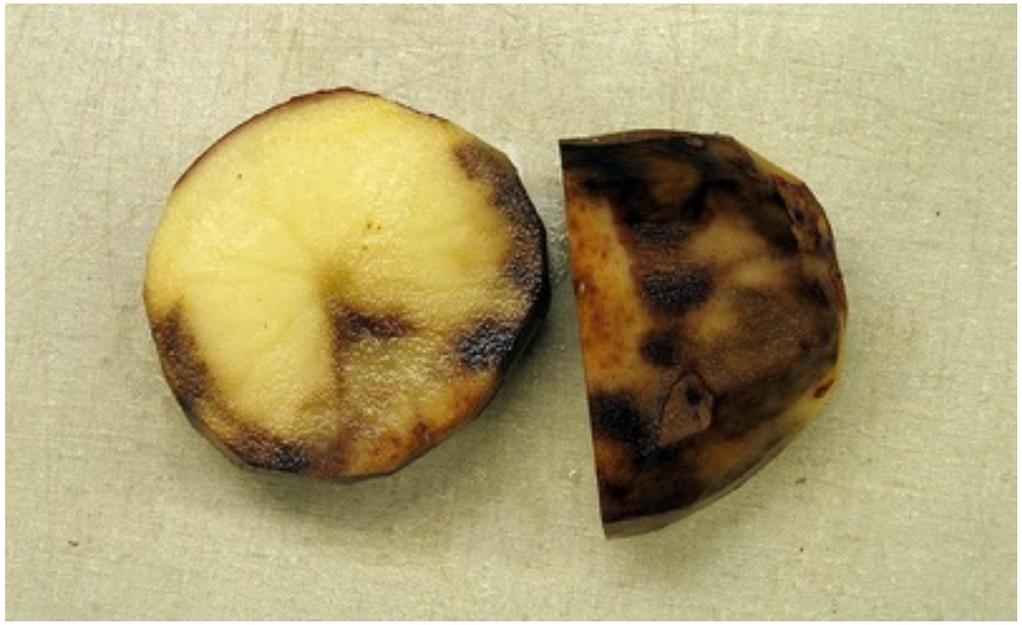
The disease spread from New England westward and southward, almost completely destroying the famous elms in the "Elm City" of New Haven, Connecticut, reaching the Detroit area in 1950,[25] the Chicago area by 1960, and Minneapolis by 1970. Of the estimated 77 million elms in North America in 1930, over 75% had been lost by 1989.

Emerging Disease

A potato blight

Phytophthora infestans is an oomycete (fungus) that causes the serious **potato** disease known as late **blight** or **potato blight**.

The Great Famine or the Great Hunger was a period of mass starvation, disease, and emigration in Ireland between 1845 and 1852.[1] It is sometimes referred to, mostly outside Ireland, as the Irish Potato Famine, because about two-fifths of the population was solely reliant on this cheap crop for a number of historical reasons.[2][3] During the famine, approximately one million people died and a million more emigrated from Ireland,[4] causing the island's population to fall by between 20% and 25%.[5]



The proximate cause of famine was potato blight,[6] which ravaged potato crops throughout Europe during the 1840s.

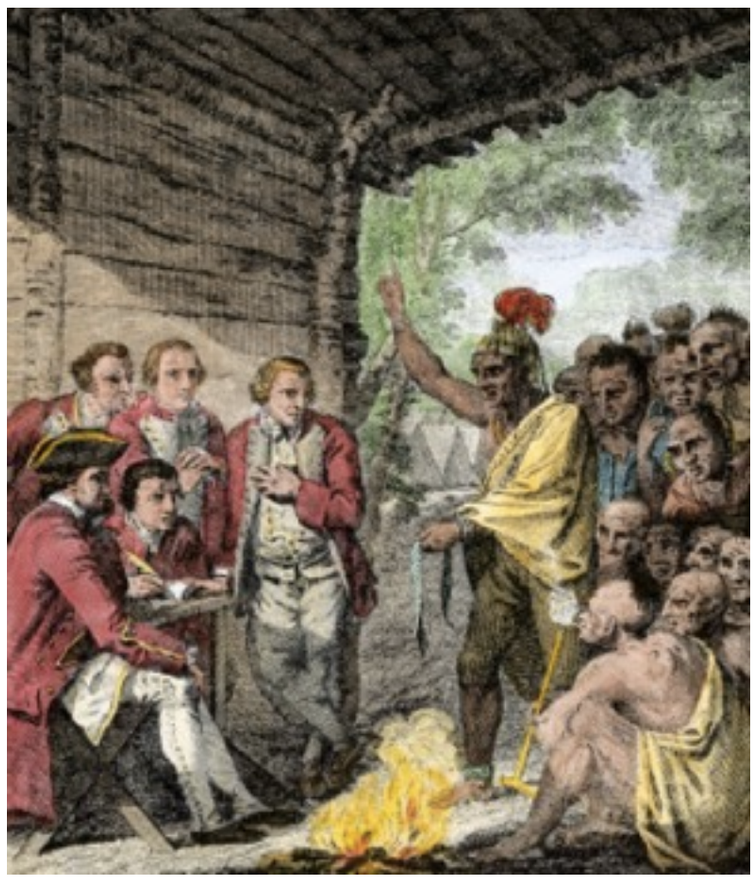
How and when the blight Phytophthora infestans arrived in Europe is still uncertain; however, it almost certainly was not present prior to 1842, and probably arrived in 1844.[32] The origin of the pathogen has been traced to Toluca Valley of Mexico,[33] whence it spread first within North America and then to Europe.[32]

Emerging Disease

Smallpox is a viral infection which usually enters the body through the nose or throat. From here the virus travels to the lungs, where it multiplies and spreads to the lymphatic system. Within a few days, large pustules begin to appear all over the victim's skin.

Within just a few generations, the continents of the Americas were virtually emptied of their native inhabitants – some academics estimate that approximately 20 million people may have died in the years following the European invasion – up to 95% of the population of the Americas.

No medieval force, no matter how bloodthirsty, could have achieved such enormous levels of genocide. Instead, Europeans were aided by a deadly secret weapon they weren't even aware they were carrying: **Smallpox**.

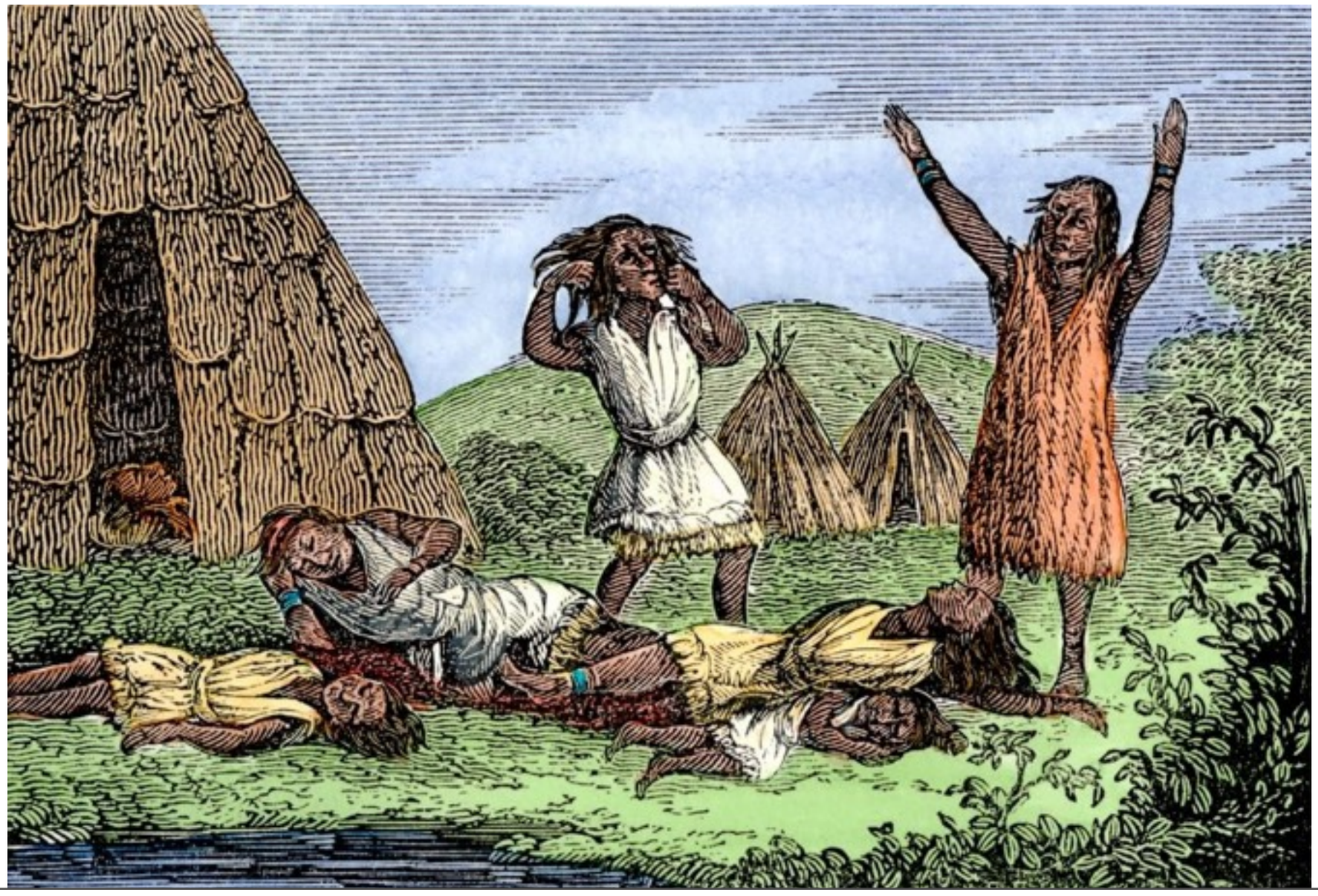


When the Europeans arrived, carrying germs which thrived in dense, semi-urban populations, the indigenous people of the Americas were effectively doomed. They had never experienced smallpox, measles or flu before, and the viruses tore through the continent, killing an estimated 90% of Native Americans.

Smallpox is believed to have arrived in the Americas in 1520 on a Spanish ship sailing from Cuba, carried by an infected African slave. As soon as the party landed in Mexico, the infection began its deadly voyage through the continent. Even before the arrival of Pizarro, smallpox had already devastated the Inca Empire, killing the Emperor Huayna Capac and unleashing a bitter civil war that distracted and weakened his successor, Atahuallpa.

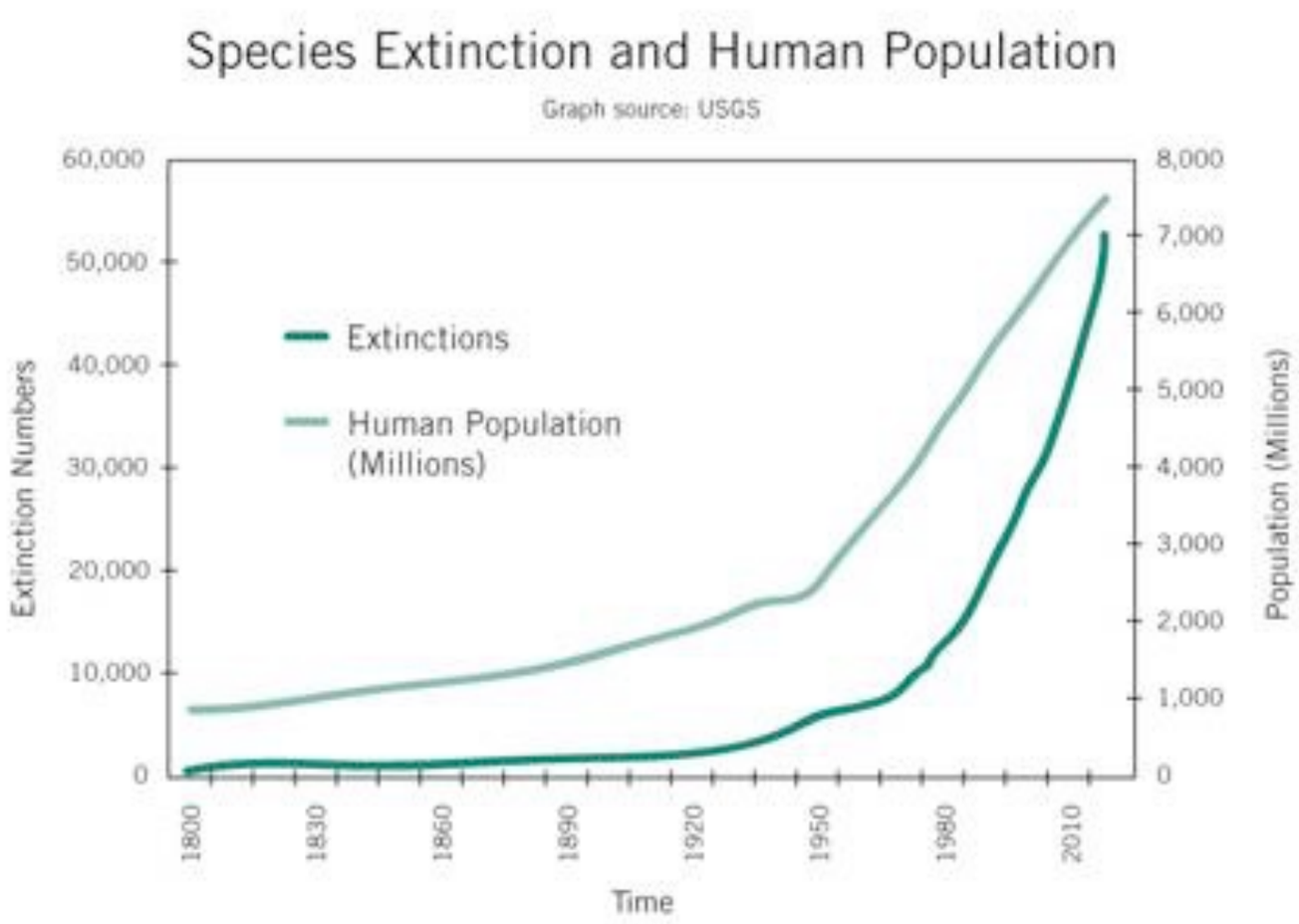
In the era of global conquest which followed, European colonizers were assisted around the world by the germs which they carried. A 1713 smallpox epidemic in the Cape of Good Hope decimated the South African Khoi San people, rendering them incapable of resisting the process of colonization. European germs also wreaked devastation on the aboriginal communities of Australia and New Zealand.

More victims of colonization were killed by Eurasian germs, than by either the gun or the sword, making germs the deadliest agent of conquest.

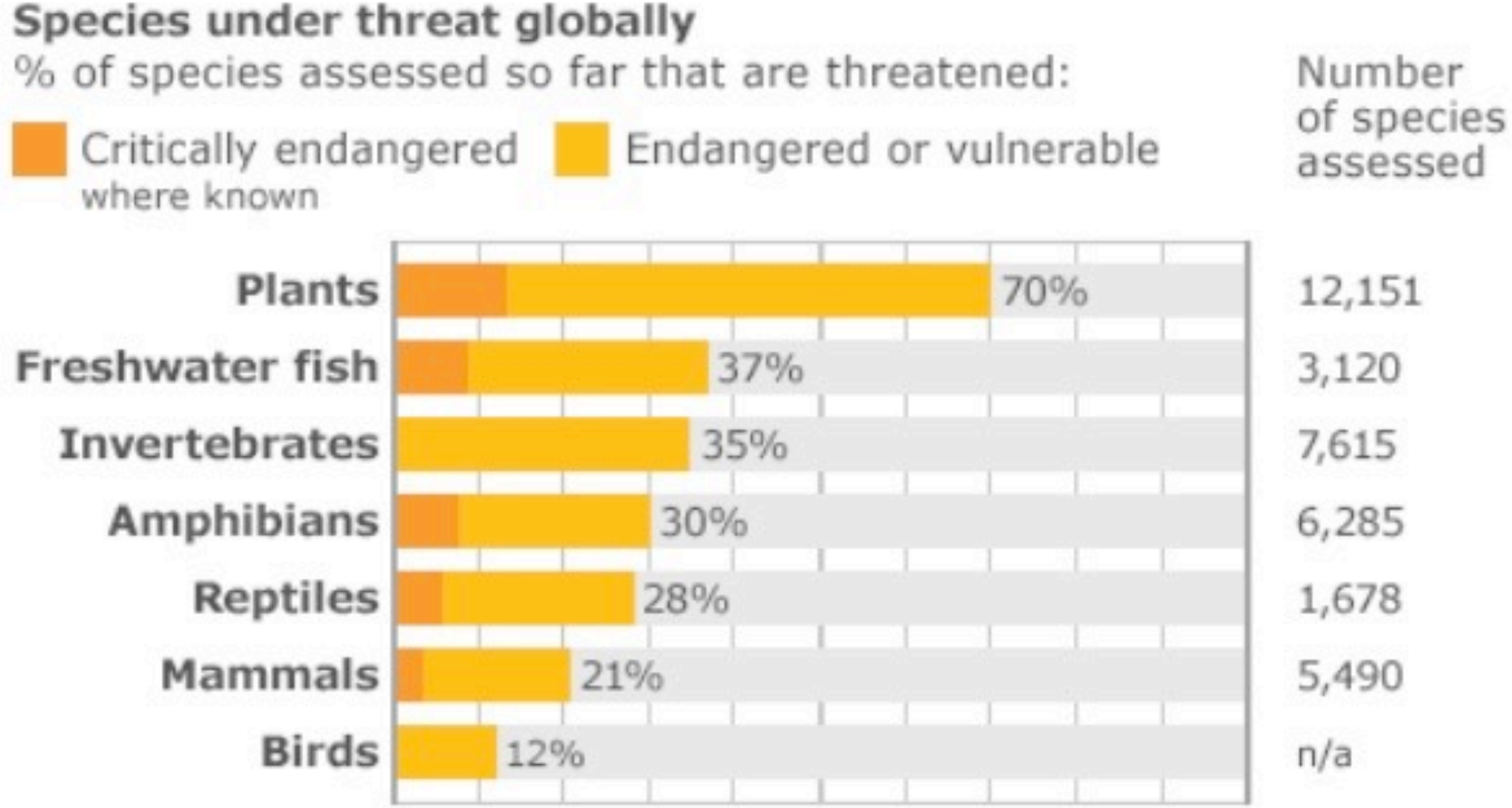


Biodiversity

Species extinction and the degradation of ecosystems are proceeding rapidly and the pace is accelerating. The world is losing species at a rate that is 100 to 1000 times faster than the natural extinction rate.



The biodiversity crisis



The number of wild animals living on Earth is set to fall by two-thirds by 2020, according to a new report, part of a mass extinction that is destroying the natural world upon which humanity depends.

The analysis, the most comprehensive to date, indicates that animal populations plummeted by 58% between 1970 and 2012, with losses on track to reach 67% by 2020.

Researchers from WWF and the Zoological Society of London compiled the report from scientific data and found that the **destruction of wild habitats**, **hunting** and **pollution** were to blame.

The biggest cause of tumbling animal numbers is the **destruction of wild areas for farming and logging**: the majority of the Earth's land area has now been impacted by humans, with just 15% protected for nature.

Poaching and exploitation for food is another major factor, due to **unsustainable fishing and hunting**: more than 300 mammal species are being eaten into extinction, according to recent research.

Pollution is also a significant problem with, for example, killer whales and dolphins in European seas being seriously harmed by long-lived industrial pollutants. Vultures in south-east Asia have been decimated over the last 20 years, dying after eating the carcasses of cattle dosed with an anti-inflammatory drug. Amphibians have suffered one of the greatest declines of all animals due to a fungal disease thought to be spread around the world by the trade in frogs and newts.

Rivers and lakes are the hardest hit habitats, with animals populations down by 81% since 1970, due to excessive water extraction, pollution and dams. All the pressures are magnified by global warming, which shifts the ranges in which animals are able to live.

Humanity is completely dependent on nature for clean air and water, food and materials, as well as inspiration and happiness.

Essential knowledge 4.B.4: Distribution of local and global ecosystems changes over time.

b. Geological and meteorological events impact ecosystem distribution.

Evidence of student learning is a demonstrated understanding of the following:

1. Biogeographical studies illustrate these changes.

To foster student understanding of this concept, instructors can choose an illustrative example such as:

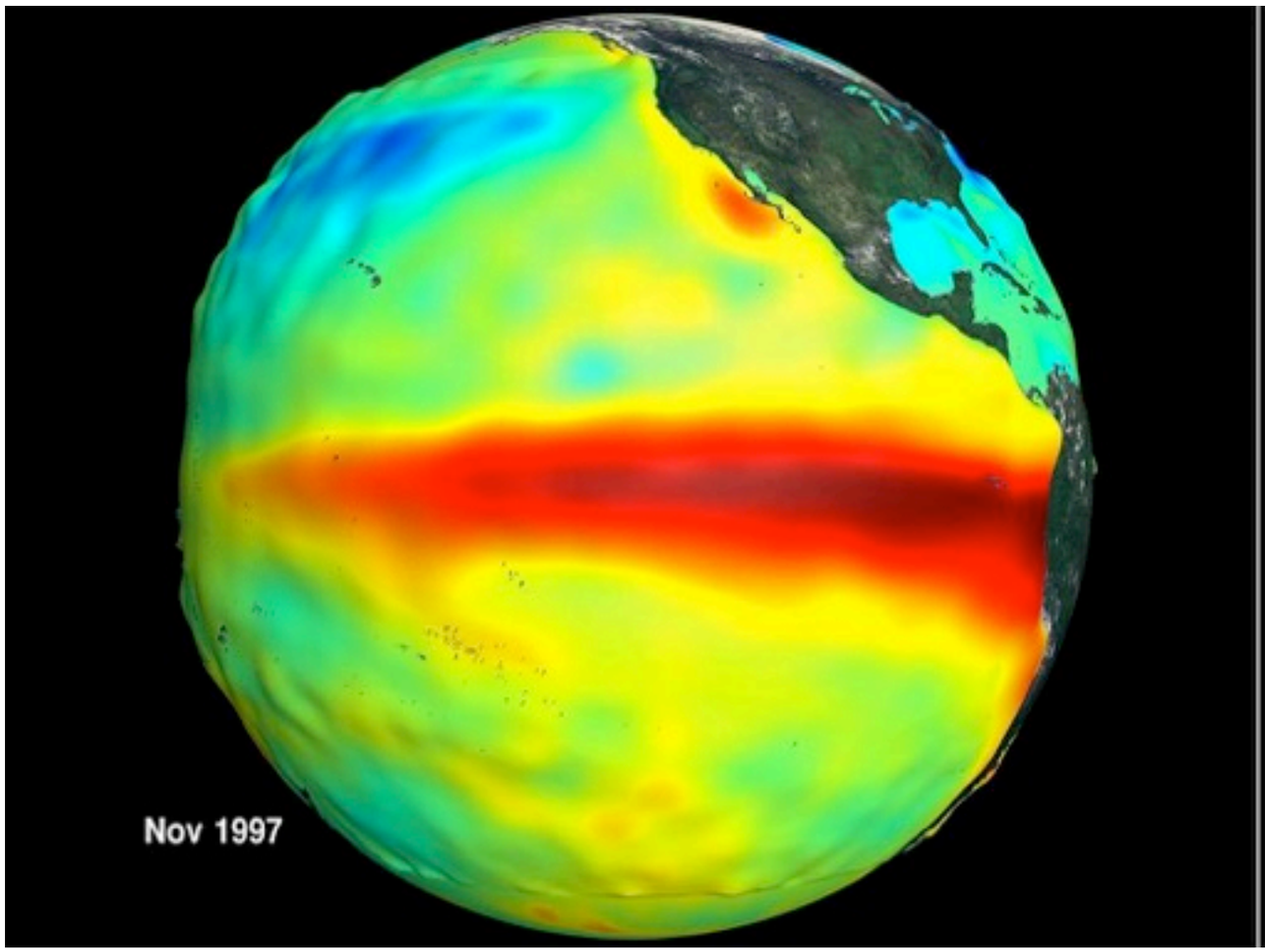
El Niño

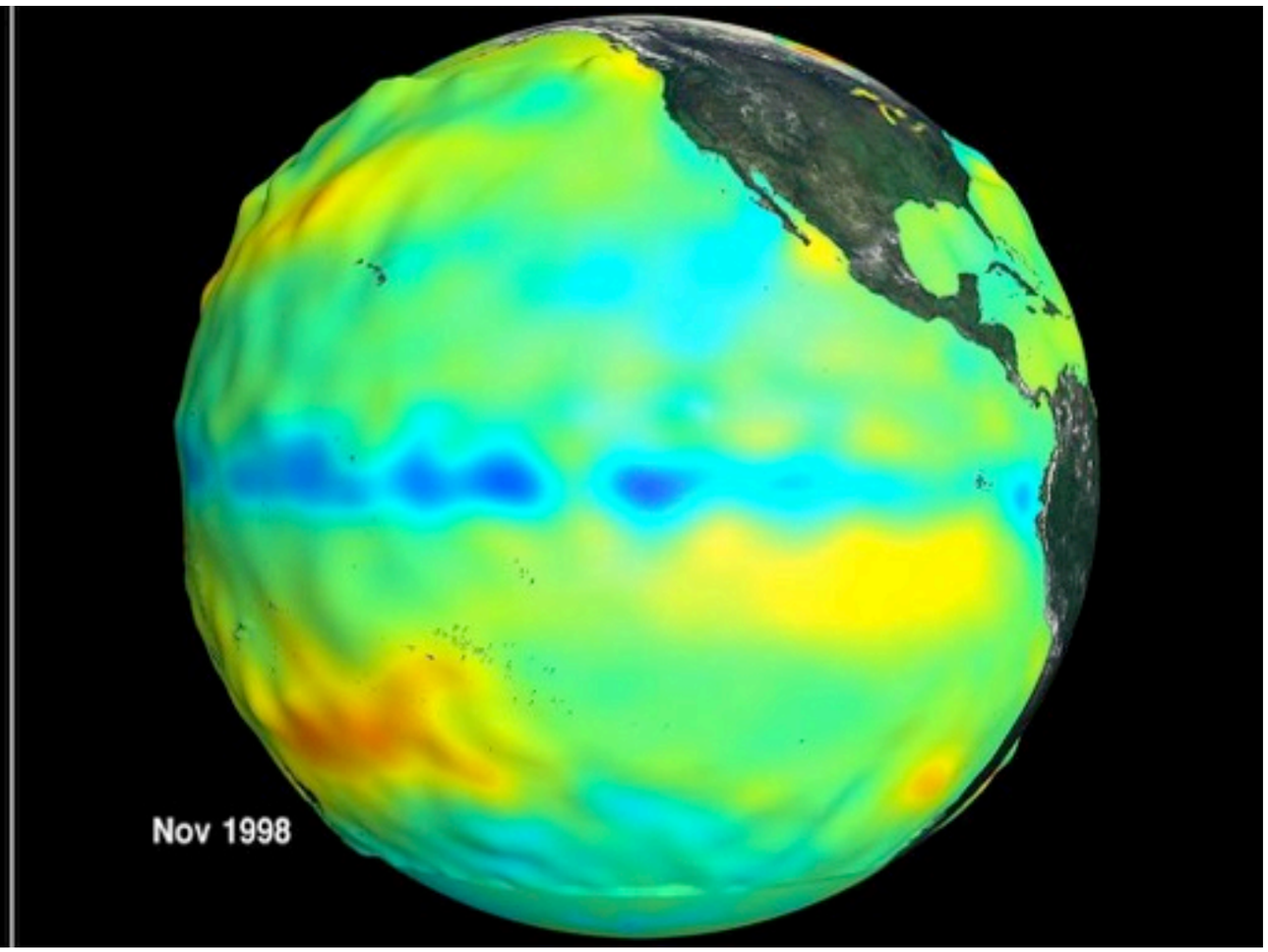
Meteor impact on dinosaurs

Continental drift

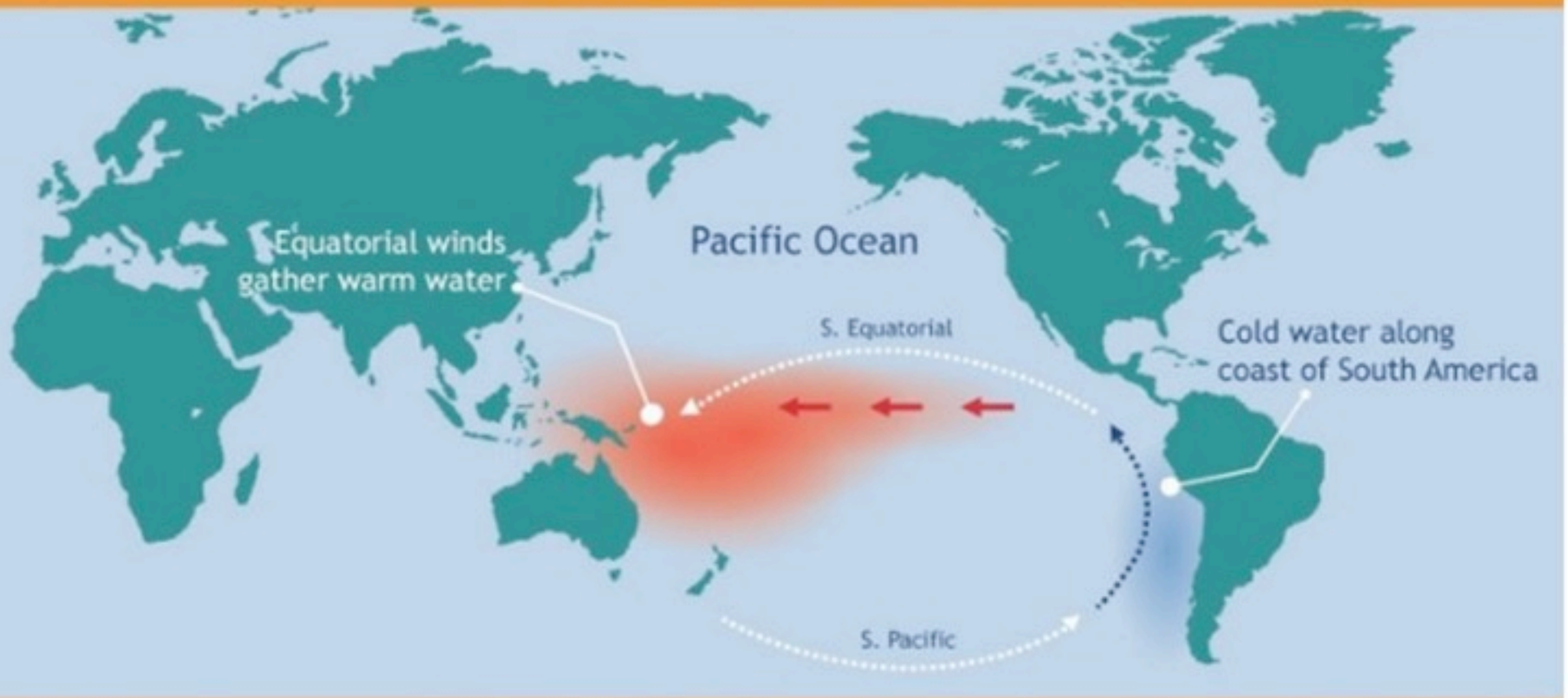
El Nino (short term)

El Niño and the Southern Oscillation, also known as ENSO is a periodic fluctuation in sea surface temperature (El Niño) and the air pressure of the overlying atmosphere (Southern Oscillation) across the equatorial Pacific Ocean.

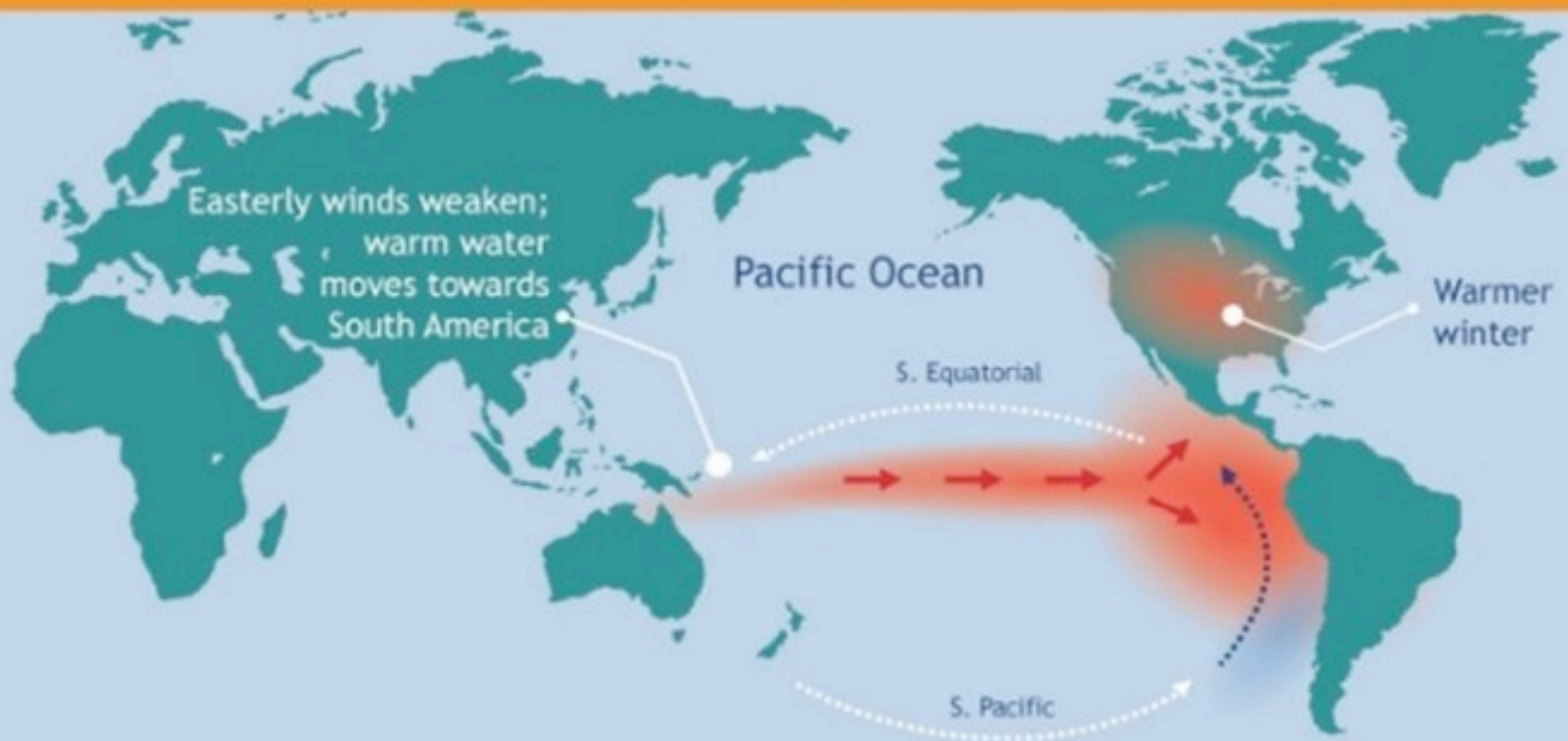




NORMAL YEAR

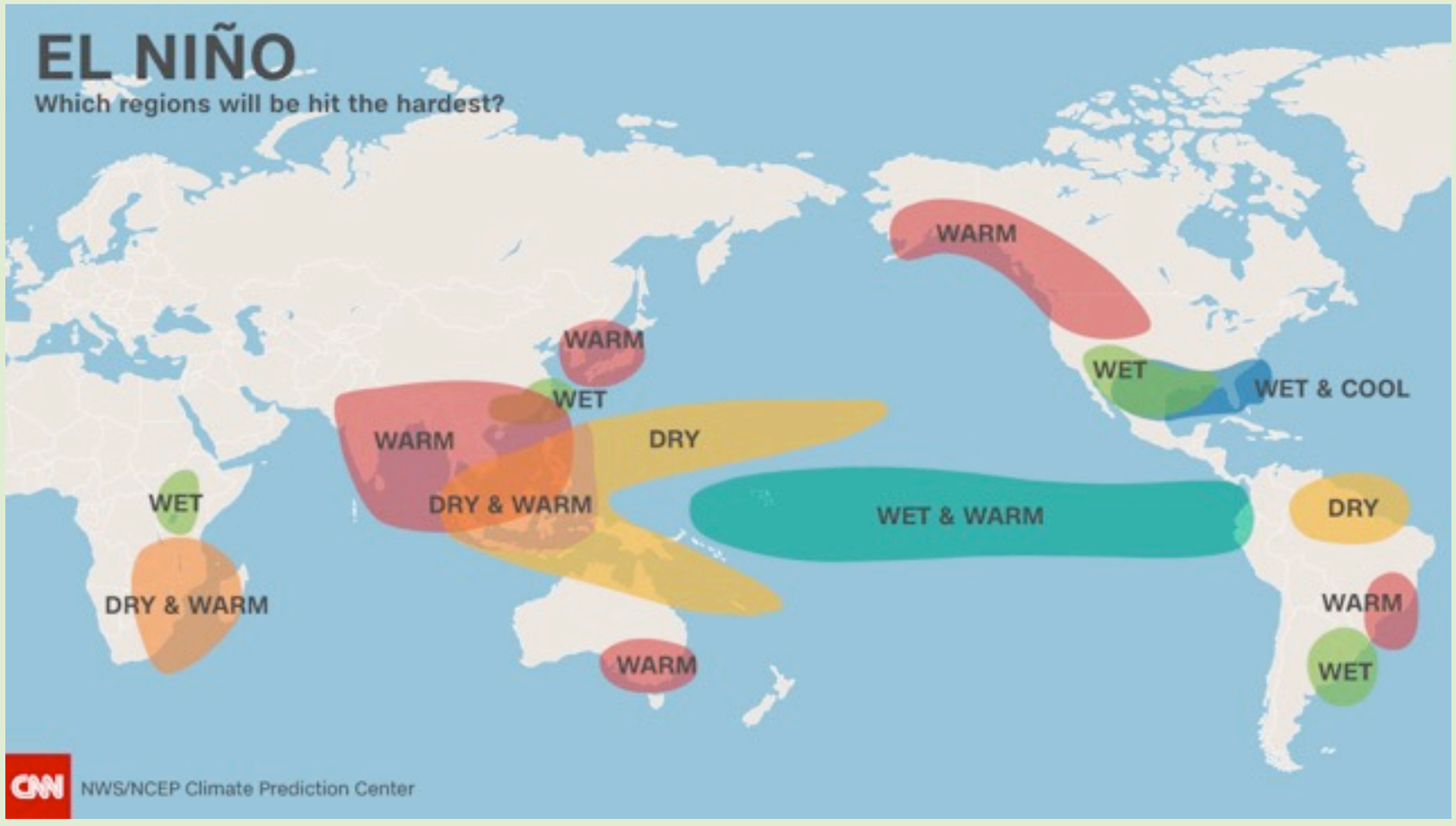


EL NIÑO YEAR

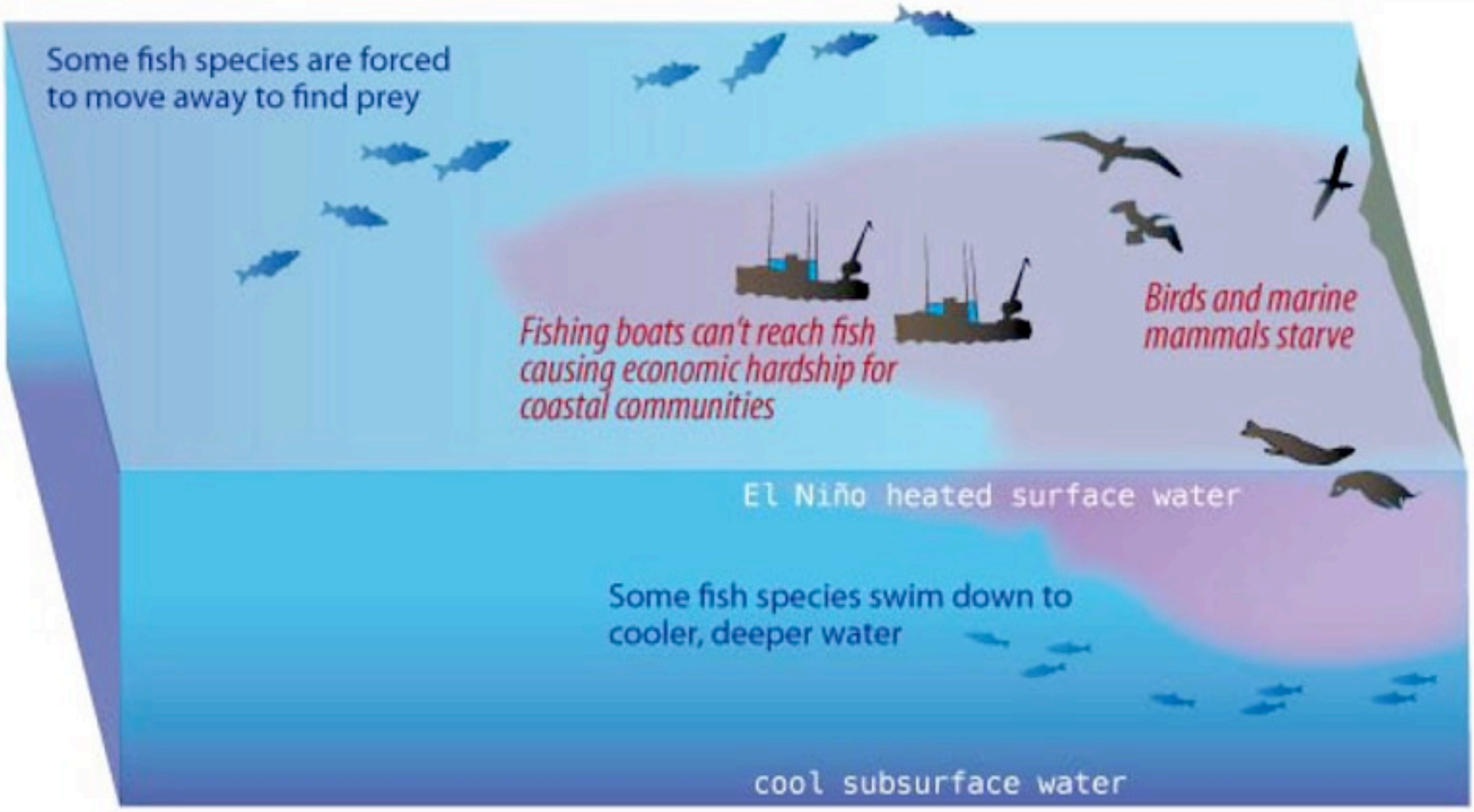


Source: Laonis Sayles depiction based on source data from National Oceanic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration (NASA) and various media reports.

Normally, lower pressure over Darwin, Australia and higher pressure over Tahiti encourages a circulation of air from east to west, drawing warm surface water westward and bringing precipitation to Australia and the western Pacific. When the pressure difference weakens, which is strongly coincidental with El Niño conditions, parts of the western Pacific, such as Australia experience severe drought, while across the ocean, heavy precipitation can bring flooding to the west coast of equatorial South America.



El Nino impacts living organisms and their ecosystems



The Impacts of El Nino are diverse and far reaching

Continental Drift (long term)

Continental drift is the movement of the Earth's continents relative to each other, thus appearing to "drift" across the ocean bed.

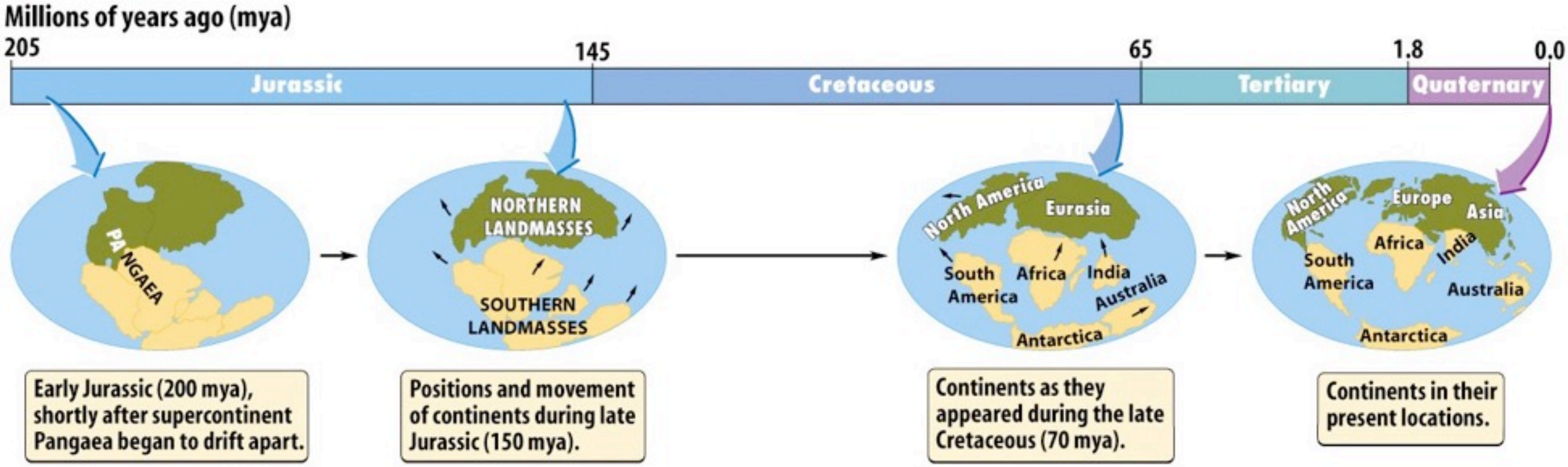
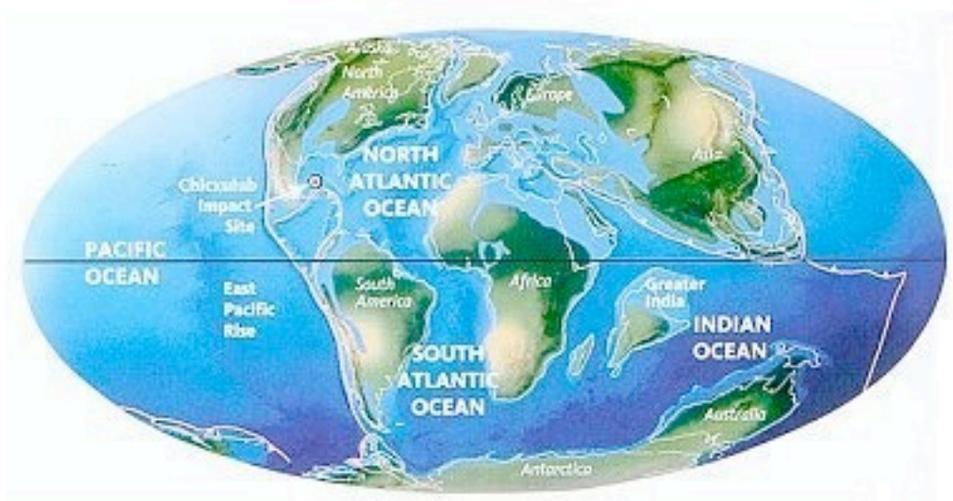


Figure 19-7 Discover Biology 3/e

Because of plate movement and changing abiotic conditions the different land masses have experienced different climates over time



End of Cretaceous Period, 65 MYA

Upper Jurassic Period, 150 MYA

Pre-Cambrian Period, 650 MYA

Early Carboniferous Period, 356 MYA

Because of plate movement the different land masses have brought distance species together and while separating others, this branch of biology deals with the geographical distribution of plants and animals

- Antarctica was once part of the ancient supercontinent of Gondwanaland

- It had a warmer, wetter climate with plants known as the Antarctic flora

- By 30-35 million years ago Antarctica was isolated geographically and climatically

- The much colder climate caused the Antarctic flora to die out

Learning Objectives:

LO 4.20 The student is able to explain how the distribution of ecosystems changes over time by identifying large-scale events that have resulted in these changes in the past. [See SP 6.2, 6.3]

LO 4.21 The student is able to predict consequences of human actions on both local and global ecosystems. [See SP 6.4]