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Impact of Climate Change on Plants, Animals & Man (II)

1. Introduction

Plants and animals require specific environmental conditions—such as the right temperature, moisture, and light levels—in order to thrive. Even small changes in environmental parameters can affect the reproduction and survival of a species. In turn, climate change can also result in changes in the distribution of organisms, affect the rich biodiversity and global food supply.

2. Learning Outcomes

(c) Explain how climate change affects plant distribution (vertical and latitude) and plant adaptations, including morphology and physiology.

(d) Discuss the consequences of global food supply of increased environmental stress resulting from climate change, including the effects on plants and animals of increased temperature and more extreme weather conditions.

(e) Explain how temperature changes impact insects, including increased temperature leading to increased metabolism and the narrow temperature tolerance of insects.

(h) Explain how global warming affects the spread of mosquito-borne infectious diseases, including malaria and dengue, beyond the tropics.

(i) Discuss the effects of increased environmental stress (including increased temperatures and more extreme weather conditions) as a result of global climate change, on habitats, organisms, food chains and niche occupation.

(j) Discuss how climate change affects the rich biodiversity of the tropics including the potential loss of this rich reservoir for biomedicines and genetic diversity for food.

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3. Effect of Climate Change on Physiology of Plants & Animals

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Effect of Climate Change on Plant Adaptations (Morphology & Physiology)

Alterations of CO_2 concentration, temperature and rain cycles can directly affect the biological processes such as photosynthesis, respiration, growth and composition of plant tissues.

Water availability is a major rate limiting factor for plant growth. At **high temperatures**, plants tend to experience **water stress**, and undergo **physiological** and **morphological changes**:

- reduction of water content and turgor, cell expansion slows down or ceases
- alteration in level of photosynthetic pigment (reduction or no pigmentation)
- rapid decrease in the amount of Rubisco which leads to lower activity of the enzyme
- increasing the ratio of roots to shoots; developing more roots in order to access more water, reducing leaf number and leaf area to lower transpiration rates
- stomatal closure
- number of stomata per leaf decreases to reduce transpiration. A plant that could get enough carbon dioxide with fewer stomata would have an advantage since it would be better able to conserve its water.

As such, photosynthetic rates decrease and **plant growth is retarded**. Under prolonged drought, many plants **dehydrate and die**.

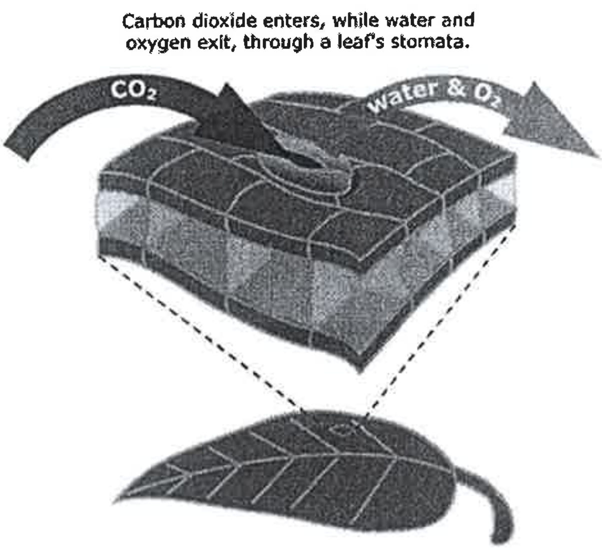


Fig. 1: Stomata allow carbon dioxide in, but they also let precious water escape.

Therefore, stomata closure is one of the first events in plants response to water deficiency. This limits gaseous exchange through stomata, reduces transpiration and arrests carbon assimilation that takes place during photosynthesis.

Although CO_2 assimilation and net photosynthesis decreases due to stomatal closure, the attainment of low transpiration rate and prevention of water losses from leaves is a good trade-off for survival in exchange of growth.

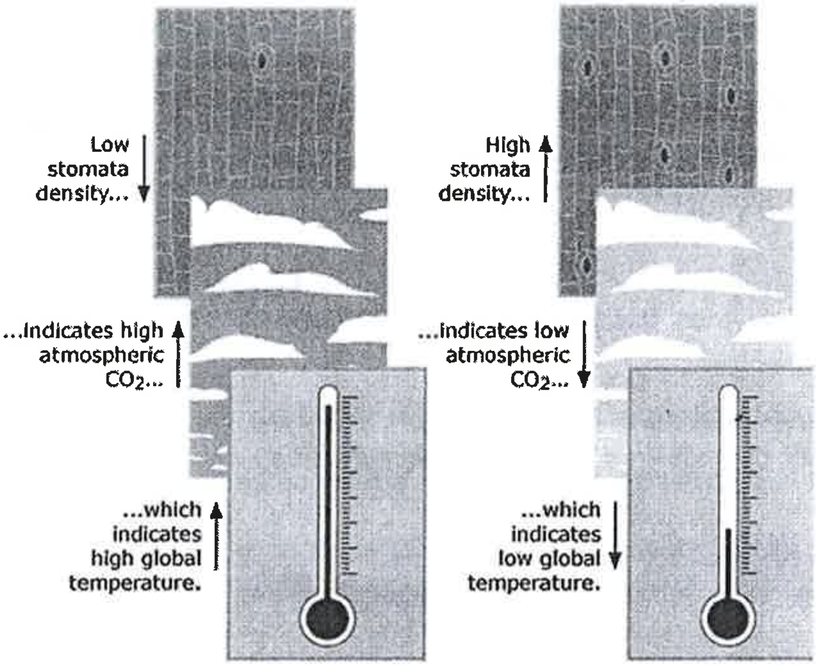


Fig. 2:
Correlation between stomata number, carbon dioxide level and temperature.

Typically, plant fossils with many stomata (low carbon dioxide) came from times of low global temperature, and fossils with few stomata (high carbon dioxide) came from times of high global temperatures.

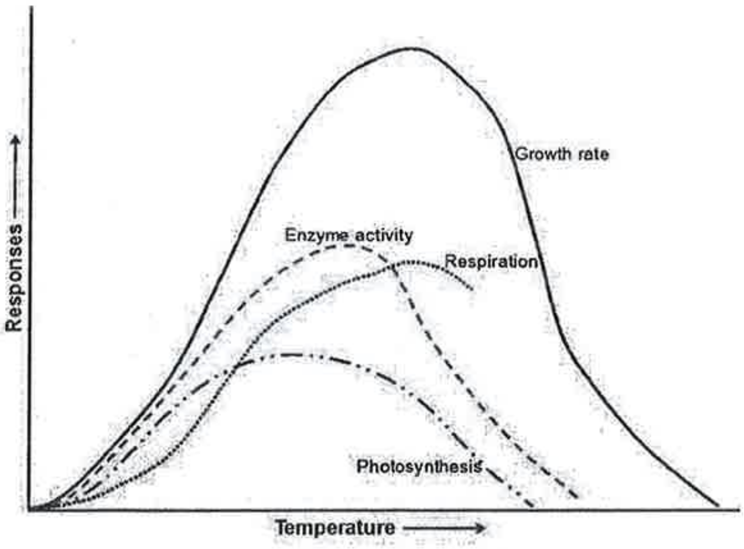


Fig. 3: Effect of temperature on plants.

The average rate of enzymatic reactions increases two-fold with every 10°C increase in temperature up to the optimum temperature (30 – 45°C for most enzymes). Beyond the optimum temperature, enzymes are irreversibly denatured, and plant death results ultimately. The most observed effect of heat stress on plants is the retardation of growth.

Global warming can also **affect the reproduction** of plants:

- High temperatures at flowering time **reduce pollen viability** in cereals - it has been found that rising temperatures cause a loss of pollen viability in maize.
- Deviation from optimal temperature **disrupts flowering process** and **affects seed production** in plants as well (e.g. rice and wheat).

Effect of Temperature on Body Size of Animals

Notes to self

Bergmann's rule states that, "in warm-blooded animals, races from warm regions are smaller than races from cold regions".

→i.e. body size become smaller in response to general warming and larger with cooling.

The larger surface areas relative to volume of smaller body sizes serve as efficient heat dissipaters in warm climates, while small body surface area relative to volume may help in heat conservation in cold climates.

Effect of Temperature on Insects' Metabolism

The body temperature of *ectotherms* fluctuates with environmental temperatures, and basic physiological functions such as locomotion, growth, and reproduction are strongly influenced by environmental temperature.

Growth and development are fuelled by metabolism. Metabolic rate is the consequence of many different biological reactions; **temperature governs metabolism through its effects on rates of these enzyme-catalysed biochemical reactions**.

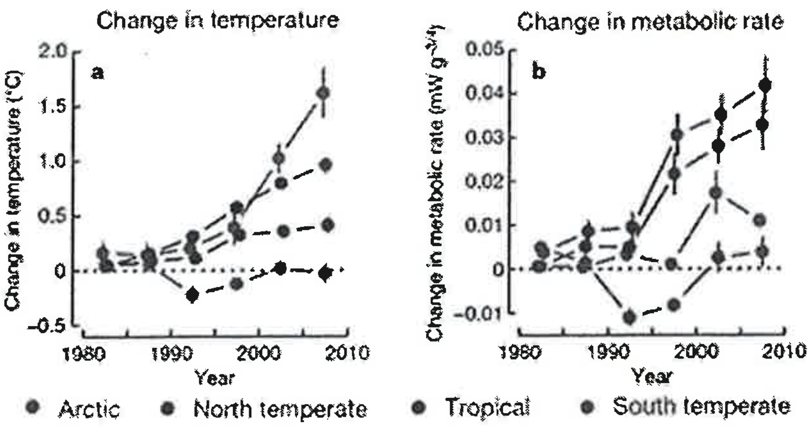


Fig. 4: Global changes in temperature and in metabolic rates of insects since 1980.

a) Changes in mean temperature (5-year averages) for Arctic, North temperate, South temperate and tropical regions.

b) Predicted absolute changes in metabolic rates by geographical region.

For processes governed by aerobic respiration, such as growth and development of most ectothermic animals, a **10°C increase** in temperature results in approximately **2.5-fold increase in developmental rate**.

It is well-documented that in ectotherms, rates of both *somatic growth* and *ontogenetic development* increase with increasing temperature. Therefore, the **time to maturity is shorter at higher temperatures**.

The majority of ectotherms **grow slower** but mature at a **larger body size** in **colder** environments. Compared to hot environments, cold environments allow ectotherms to reach a relatively large body size by **prolonging growth** and **delaying reproduction**.

Ectotherms: cold-blooded species such as insects and reptiles
Somatic growth: physical development of organism during adolescence.
Ontogenetic development: development of organism from time of fertilisation of the egg to the organism's mature form.

<u>Notes to self</u>

Narrow Temperature Tolerance of Insects

The difference between an organism's thermal optimum and its current climate temperature is known as the **thermal safety margin**.

For insect species, **thermal safety margins increase sharply with latitude**.

Species living in **tropic** environments (e.g. *Acyrthosiphon pisum*) that are already close to their physiological optimum have **small thermal safety margins**. Thus, even small amounts of warming will likely decrease performance, as tropical insects will thus approach near-lethal temperatures much faster. Many species also have small dispersal ranges which increase their **risk of extinction** through small changes in habitat or environment.

In contrast, species with **large thermal safety margins** are living in **temperate** environments that are on average cooler than their physiological optimal, and thus have broader thermal tolerance. With warmer winters, the insects will not all die out like they do now. Thus, warming may even **enhance their fitness** - they should experience initial increases in population growth rates and performance as temperatures rise. Since spring starts earlier, these also emerge even earlier. With summer lasting longer, the insects also persist in the environment for a month or so longer than before.

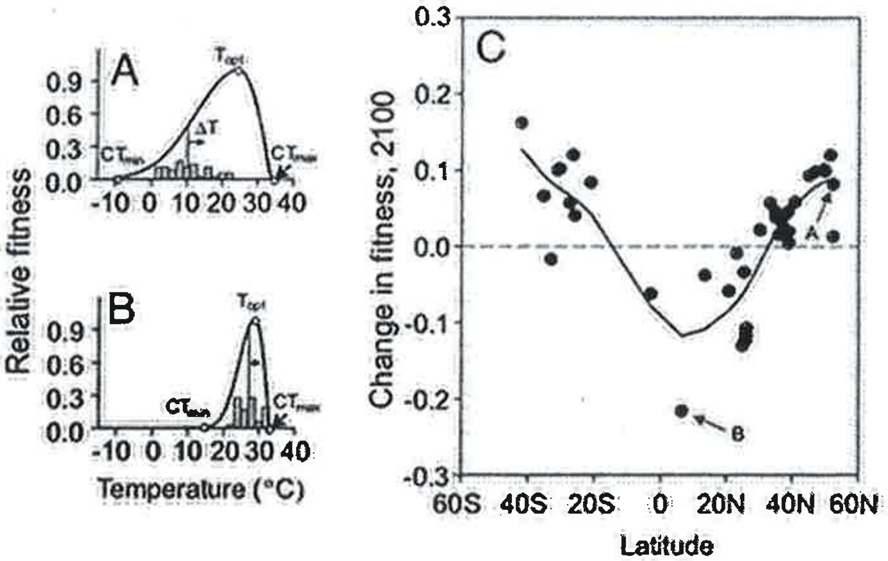


Fig. 5: Fitness curves for representative insect taxa from temperate (**A**) and tropical (**B**) locations, and (**C**) the predicted change in fitness because of climate warming for all insect species studied as a function of latitude. Fitness curves A and B are derived from measured intrinsic population growth rates versus temperature for 38 species. At mid to high latitudes, population growth rates are predicted to increase, indicating enhanced population fitness because of warming. In the tropics (i.e. low latitude), however, rates of population growth are expected to decrease by up to 20%, implying that warming will substantially reduce fitness.

Climate Change Alters Timings of Seasonal Life Cycle Events

Notes to self

Many species take their cues about when to migrate, flower, nest or mate from seasonal changes in temperature, precipitation and daylight.

Global warming is confusing those signals – the changes in the climate force wildlife to alter life cycle and seasonal events. For example:

- American flowering plants like columbines and wild geraniums are blooming earlier than before.
- North American Fowler's toads are breeding six days earlier than they did a decade ago.
- Tree swallows (Tachycineta bicolor) are nesting and laying their eggs earlier.
- Birds are migrating and arriving at their nesting grounds earlier and in North America, one species of hummingbird has ceased to migrate.
- Marmots are ending their hibernations about three weeks earlier than they did 30 years ago.

Changes like these can lead to mismatches in the timing of migration, breeding and food availability - species might get out of synch with other species in their ecosystem or with other natural events.

4. Impact of Climate Change on Global Food Supply

Notes to self

Climate change affects agriculture in a number of ways - through changes in average temperatures, rainfall, and climate extremes (e.g. heat waves), changes in pests and diseases, atmospheric carbon dioxide, nutritional quality of some foods and changes in sea level.

Impact of Climate Change on Global Food Supply

The **effects of climate change on crops are unevenly distributed across the world**. In mid- to high-latitude regions, moderate warming benefits crop and pasture yields, but even slight warming decreases yields in seasonally dry and low-latitude regions.

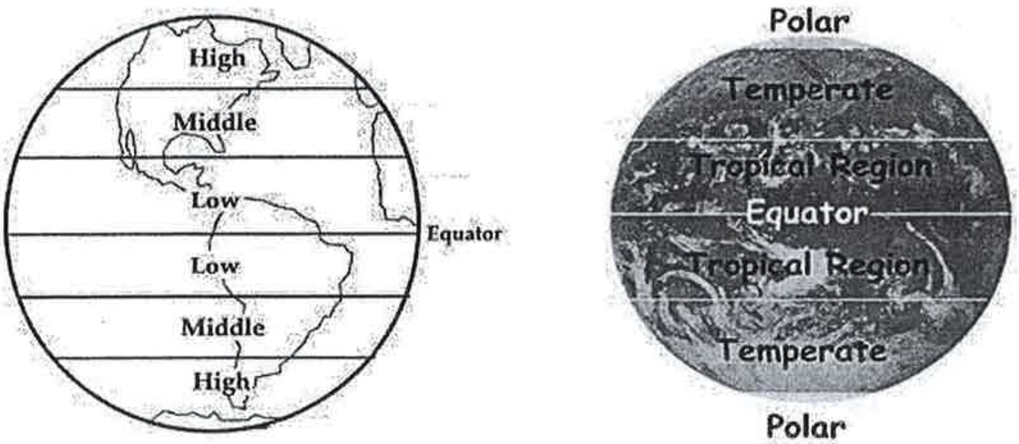


Fig. 6: Illustration of low, mid and high latitudes, as well as tropical, temperate and polar regions. Earth has three main climate zones – tropical, temperate and polar. The tropics are regions found near the equator and the climate is hot and wet all year. The temperate regions have warm summers and cool winters. The polar regions have cold and dry climates, with long and dark winters.

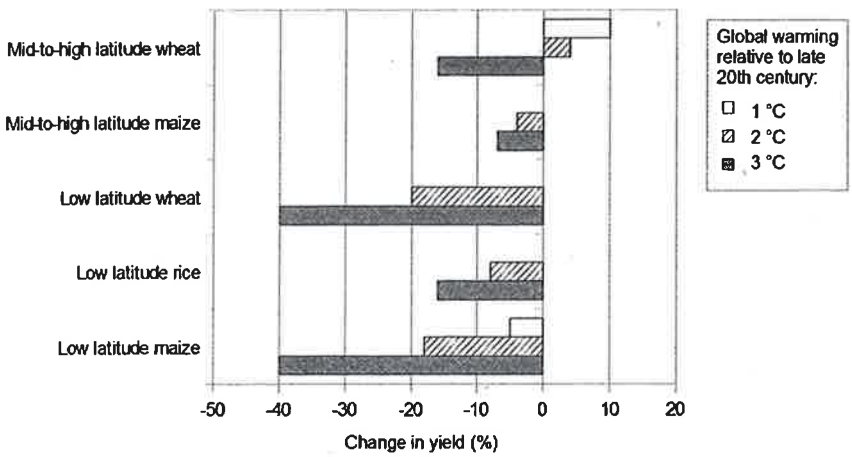


Fig. 7: Projected changes in crop yield at different latitudes with global warming.

Rain-fed crops in **low latitude countries** (e.g. Africa and Latin America) are near their maximum temperature tolerance. As such, their **yields for major cereals are likely to fall sharply** for even small temperature increases.

However, effects on crops in northern latitudes may be positive or negative. Marginal increases in temperature in **temperate regions or regions of higher altitude may benefit** leafy vegetable production as the temperature moves towards the optimum for seed germination.

Water is essential for plant growth. Too much or too little water at any particular growth stage reduces yield potential.

Notes to self

With droughts occurring more frequently because of global warming and 80% of world agriculture being rain-fed, changes in the amount and pattern of precipitation and evaporation will have a significant effect on global crop development and yield.

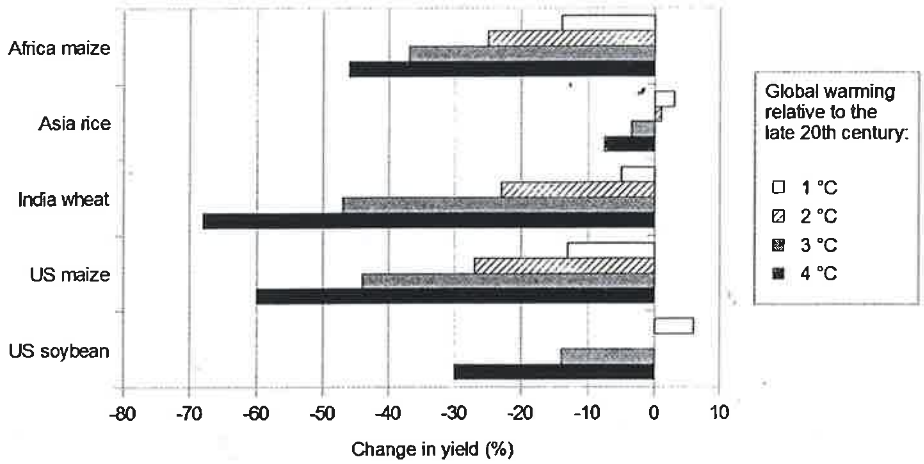


Fig. 8: Projected changes in yield of selected crops with global warming.

Example: rice & wheat

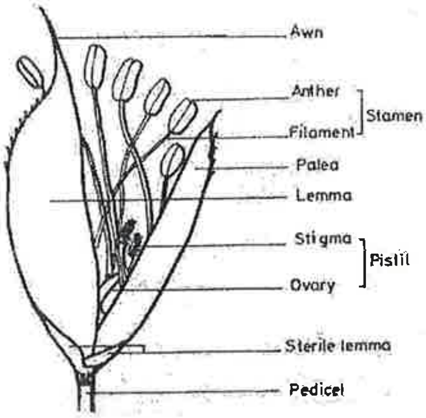


Fig. 9: A rice *spikelet* is the floral unit of rice plants.

- Rice spikelets that are exposed to temperatures of more than 35°C for about 5 days during the flowering period are **sterile and set no seed**. This reduces grain yield.
- Sterility is caused by **poor anther dehiscence** and **low pollen production**, and hence low numbers of germinating pollen grains on the stigma (Matsui *et al.*, 2000, 2001; Prasad *et al.*, 2006).

For some temperate cereal crops (e.g. winter wheat), a period of low winter temperature to initiate or accelerate the flowering process is required.

With global warming, **low flower bud initiation** results and this ultimately reduces the yield of the crops.

Notes to self

Global warming can alter the patterns of weeds, plant pests and pathogens.

Because of higher temperatures and humidity, there could be an increased pressure from insects and disease vectors. Insect pests and weeds may survive or even reproduce more often each year if cold winters no longer keep them in check. New pests may also invade each region as temperature and humidity conditions change. Lower-latitude pests may move to higher latitudes. This would cause new problems for farmers' crops previously unexposed to these species. Moreover, increased use of pesticides and fungicides may negatively affect human health.

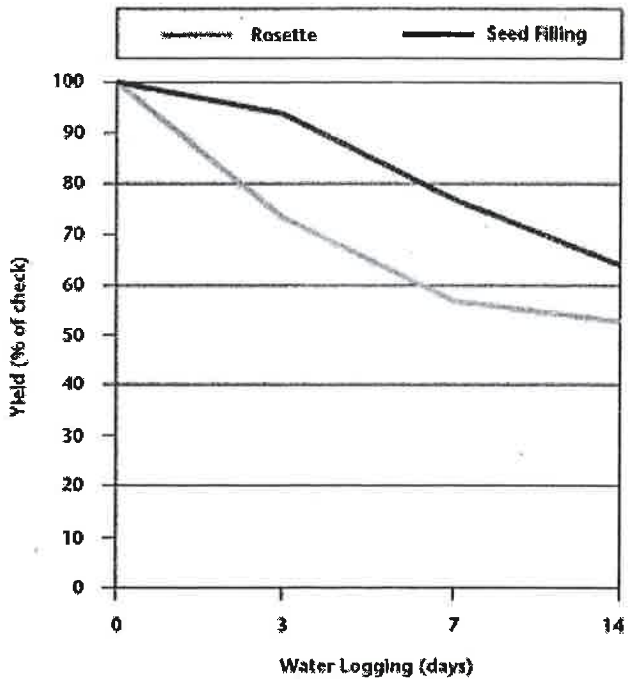
Global warming can lead to loss of arable land.

The warmer atmospheric temperatures observed over the past decades are expected to lead to a more vigorous hydrological cycle, including more extreme rainfall events. High precipitation and flooding can result in submergence and soil erosion that destroys vegetable plots, resulting in yield reduction.

Fig. 10: Effect of water logging on yield of canola plants.

The amount of yield loss will depend on the growth stage at the time of water logging, the duration of water logging and the temperature.

Water logging for seven days at the rosette growth stage can reduce plant height, while number of branches and seeds per pod decrease with three days or more of flooding. Water logging for three days or more during flowering reduces the number of pods per branch as well as seeds per pod. Higher temperature during water logging reduces plant growth and dry matter production. Water logging for seven days at seed filling decreases individual seed weight and oil content. High temperatures combined with water logging increases the detrimental effects on canola yield.



Arable land: land capable of being ploughed and used to grow crops.

Hydrological cycle: continuous process by which *water* is circulated throughout the Earth and its atmosphere; water passes from vapor in the atmosphere through precipitation upon land or water surfaces and ultimately back into the atmosphere as a result of evaporation and transpiration.

Impact of Climate Change on Livestock

Notes to self

Higher temperatures can result in causing **heat stress in animals**.

For instance, when cattle are under heat stress, farmers can expect their livestock to have:

- reduced grazing time (because animals might be seeking shade)
- reduced feed intake
- increase in body temperature
- increased sweating and panting
- weight loss

Over time, heat stress can increase vulnerability to disease, reduce fertility, and reduce milk production. Higher summer temperatures can lead to increase in livestock mortality, especially during transportation.

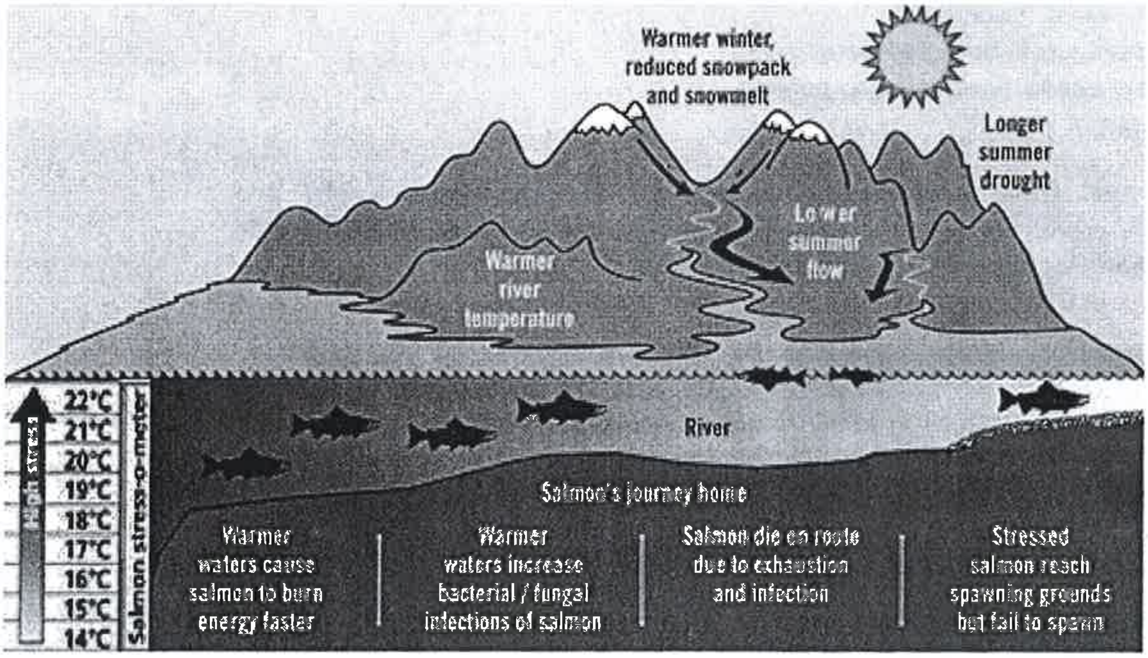
Fig. 11: **Holstein-Friesian cow and calf.** A change in average temperature over the hot dry period and a change in the number of extreme days will both likely lead to changes in dairy production. In dairy cows, heat stress reduces the amount of milk produced, reduces milk fat and protein content, and decreases reproduction rates.

Fig. 12: Shelter from the sun provided for cattle at a feedlot. Beef cattle in feedlots subject to heat stress can experience reduced health and a reduction in growth, influencing the amount of beef product sent to market.

Higher temperatures can affect the food availability of livestock.
Drought can result in the loss of pasture grazing land for livestock. For animals that rely on grain, decline in crop production yields due to drought could also become a problem.

Many marine species have certain temperature ranges at which they can survive. For example, in the Northwest warmer water temperatures may affect the lifecycle of salmon and increase the likelihood of disease. Combined with other climate impacts, these effects are projected to lead to large declines in salmon populations.

Notes to self



global warming → less snowpack formed → earlier melting of snow pack → less snowmelt during summer → lower sum flow. → lower water level → stranded salmon (cannot reach spawning grounds / juvenile cannot reach ocean).

Fig. 13: **Higher temperatures are likely to increase water temperatures, which could be harmful to salmon during spawning, incubation and rearing stages of their life cycle.**

→ accumulated snow in eg. mountainous areas.

Loss of snowpack and shrinking glaciers mean reduced stream flows in summer and fall. The survival rates of fish such as salmon and trout are known to diminish when water levels in rivers and streams are dangerously low – partly because with lower summer flow, bears can snag spawning salmon more easily in very shallow water, as the salmon struggle upstream.

snowmelt ↳ water from snow that has melted.

Lower summer flow also makes it difficult for returning salmon to reach spawning grounds and for juvenile fish to reach the ocean.

→ due to lesser water.

Warmer stream temperatures can lower the cardiovascular capacity of salmon, and the fish may become more vulnerable to disease and predators, with massive fish kills having occurred at or above 22°C.

warmer river temp → increased metabolic rate, increased depletion of energy reserves. → increased susceptibility & exposure to diseases. → heat stress. → less robust spawning rates.

Some salmon populations have declined as more intense spring floods have washed away salmon eggs laid in stream beds. Other species can migrate to cooler waters, but salmon usually return to their native rivers to spawn.

warmer, dryer conditions → forest fires → burn surface of streams. → soil erosion & siltation of nearby rivers → smother fish eggs + clog fish gills.

5. Effect of Climate Change on Plant Distribution & Animal Migration

Notes to self

As global temperatures rise, both animal and plant populations are projected to **gradually shift upward to higher elevations** and **toward northern latitudes** where temperatures are cooler in order to stay within their ideal range of environmental conditions.

a. Shift to Higher Elevations

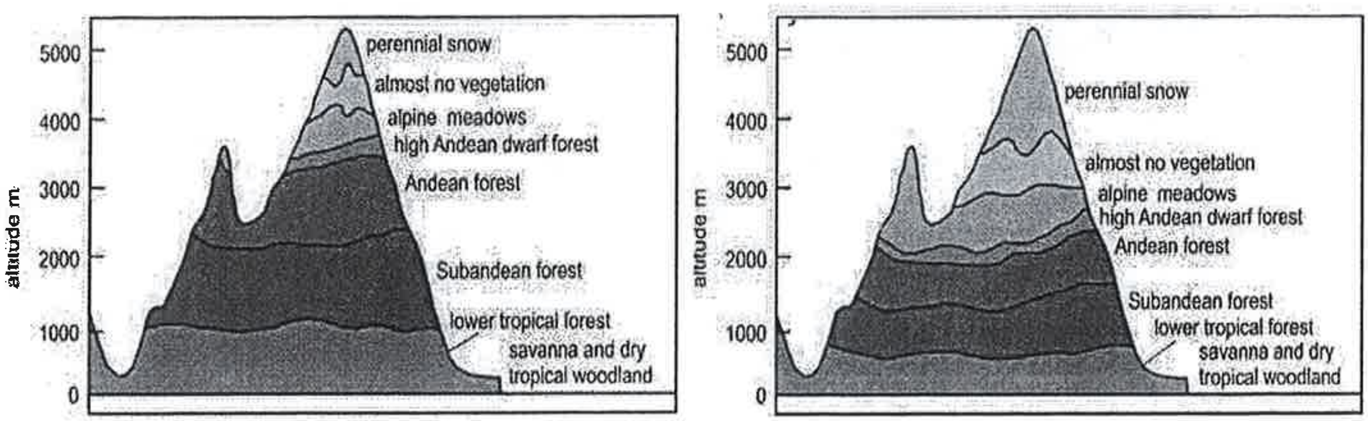


Fig. 14: Change in altitude of the zones of vegetation belts in the Columbian Andes of South America due to global warming, where each zone was about 1200 metres lower during the last glacial period as compared to present day. The average temperature drops as altitude increases, ~ 0.55°C per 100m.

According to a study done by scientists from the University of Basel, Swiss plants, butterflies and birds have moved 8 to 42 meters uphill between 2003 and 2010.

Fig. 15: The American pika, a small mammal that lives on Western mountaintops. It has adapted to life in mountainous areas that rarely get above freezing and **can die when exposed to temperatures as mild as 25.6°C**. As global warming increases average temperatures, the **pika is being forced to move to higher and higher altitudes** to find the tolerable alpine temperatures it calls home. Unlike many wildlife species that are shifting their ranges north in response to changing climate, **the pika and other alpine animals may soon run out of places to go.**

Trapped at the top, alpine wildlife is vulnerable to several of global warming's damaging effects, including vegetation changes, the invasion of new predators and pests, reduced winter snowpack and increases in extreme weather events.

b. Shift towards Northern Latitudes

Notes to self

Forests can be classed into three different types according to latitude – tropical, temperate and boreal forests.

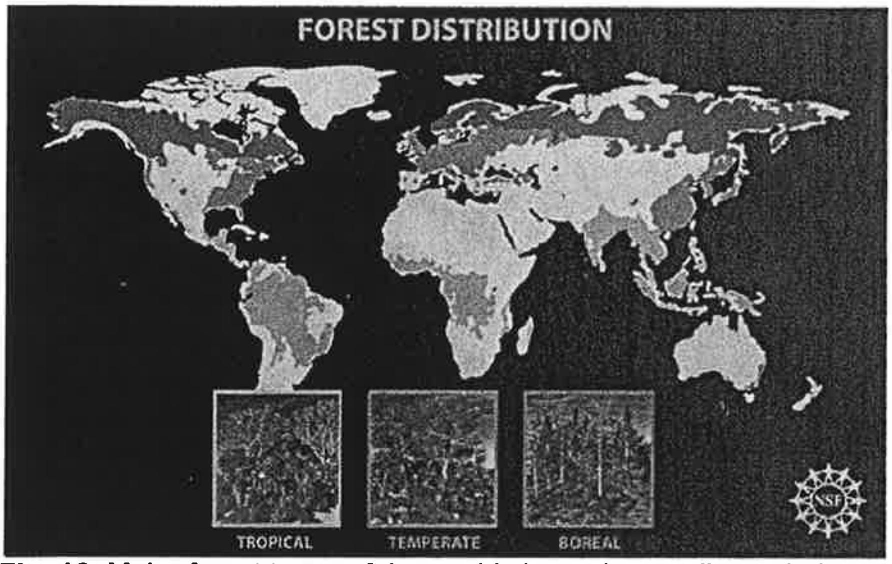


Fig. 16: Major forest types of the world classed according to latitude.

In terms of migration latitude-wise, boreal forests could shift into the tundra, while being displaced by temperate forests and grasslands. The fate of tropical forests is uncertain, but some future climate scenarios indicate possible large losses.

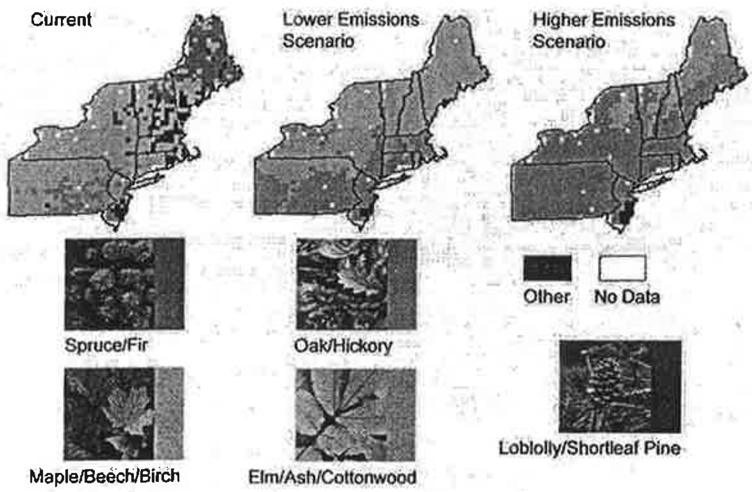


Fig. 17: Tree species in the Northeast USA are shifting northward. The range of spruce/fir, maple, elm/ash/cottonwood forests are shrinking and being replaced by oak/hickory forest in most of the region, and by loblolly/shortleaf pine forest in the southernmost areas. Maps of the Northeast USA show the distribution of several types of trees under the current conditions, a lower emissions scenario, and a higher emissions scenario. Under current conditions, there is a wide variety of trees in forests across the Northeast.

Under the lower emissions scenario, the map becomes predominately Maple, Beech and Birch, with a significant portion of Oak and Hickory. The Spruce and Fir disappear completely from the map. Under the higher emissions scenario, only northern New York, New Hampshire, Vermont and Maine have Maple, Beech and Birch trees. Oak and Hickory dominate the large majority of the region under the higher emissions scenario. Under both the lower and higher emissions scenario, the map of tree species shows that there will be significantly less diversity than the current conditions.

Notes to self

Where forests will gain or lose ground depends on the regional characteristics of their environment, including water availability and temperature, and one other crucial factor – how fast the species can migrate.

Plants are more sedentary than animals and, thus, may be in greater risk of being affected by changes in the climatic conditions as compared to animals. The **rate of climate change is likely to exceed the migration rates of most plant species**. The replacement of dominant species by locally rare species may require decades, and **extinctions may occur** when plant species cannot migrate fast enough to escape the consequences of climate change.

Birds common in Florida like the cardinal, mockingbird and Carolina wren have steadily moved farther north, and are now found regularly in New England and Canada.

Fig. 18: According to scientists, the red fox is spreading northward in response. to a warmer climate.

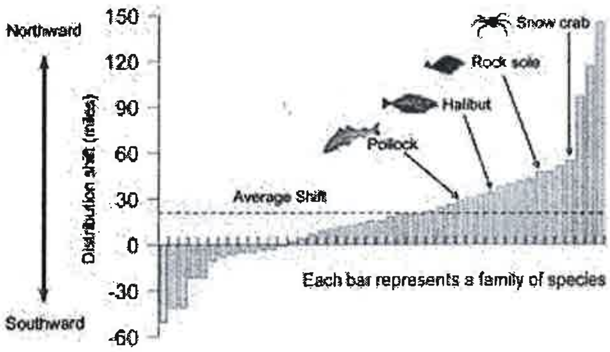


Fig. 19: The ranges of marine species have shifted northward as waters have warmed.

Many marine species have certain temperature ranges at which they can survive. The warming of the Atlantic Ocean is causing many fish species to shift north towards once cooler waters so they can live within their temperature range.

Since 1970, climate change has been impacting global fisheries by driving species towards cooler, deeper waters. Global fisheries catches were increasingly dominated by warm-water species as a result of fish migrating towards the poles in response to rising ocean temperatures. In the tropics, climate change meant fewer marine species and reduced catches, with serious implications for *food security*.

Impact of Temperature Changes on Distribution of Insects

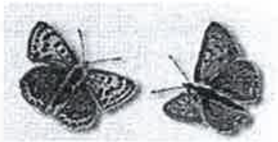
Notes to self

With the warmer climate, many species including insects would migrate northward or expand their range upwards to find a climate similar to their old one, so as to remain within their temperature tolerance ranges.

Ecologists have already documented a shift towards the north in many species of insects. For instance, two-thirds of 35 butterfly species assessed in Europe shifted their ranges northwards by 35–240 km.

Fig. 20: The northern range of the Sooty Copper butterfly ended in Austria, but it can now be found in Estonia where it had never been seen before.

Therefore, because of global warming, some species of insects would adapt by migrating. Inability of insects to adapt to the warmer temperatures could lead to extinction, or a sharp drop in total population.



Global Warming & Spread of Mosquito-borne Disease beyond the Tropics

Temperature is an important factor in the spread of malaria and other mosquito-borne diseases. Research shows that mosquitoes that can carry malaria, dengue fever and other tropical diseases have expanded their ranges in recent decades.

With warming temperatures, mosquito borne diseases like malaria and dengue fever may become **increasingly common in more northerly regions**.

e.g. the return of dengue fever carrying mosquitoes to Key West Florida in 2009, after an absence of more than 75 years, has been blamed partly on warming-induced insect migration. The chances that people living in temperate climates could contract dengue are increasing as the mosquito vector's range expands.

Increases in temperature and precipitation can lead to increased abundance of the mosquito vector of dengue, *Ae. aegypti*, by increasing their development rate, decreasing the length of reproductive cycles, stimulating egg-hatching, and providing sites for egg deposition. Higher temperature further abets transmission by shortening the extrinsic incubation period of the dengue virus in the mosquito.

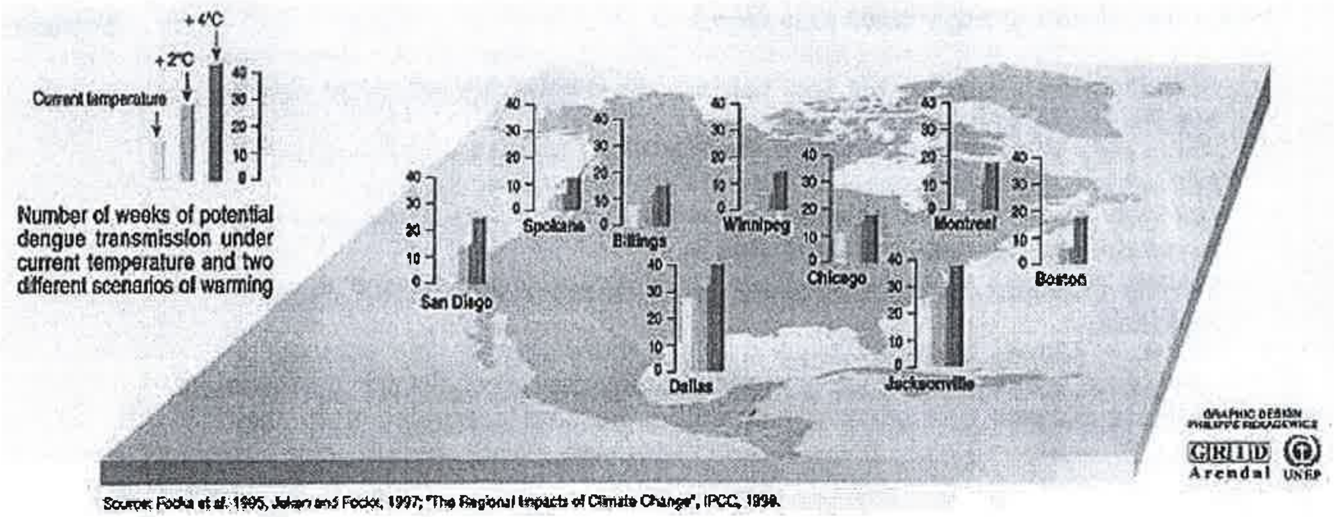


Fig. 21: Projected dengue transmission in North America with rising temperatures. Although dengue is most common in tropical regions, with warmer climate, mosquito vectors would be present for a larger portion of the year in North America and the incidence of dengue would likely increases there as well. This figure depicts the number of weeks of the year potential dengue transmission in various North America cities with the current temperature (yellow), with 2°C warming (light orange) and with 4°C warming (dark orange).

The mosquito vector of the malaria parasite, *Anopheles* mosquito, thrives in regions with warm temperatures, humid conditions, and high rainfall. Warm temperatures are also required for malaria parasites to complete their growth cycle within the *Anopheles* mosquitoes. With global warming, malaria may expand into new regions.

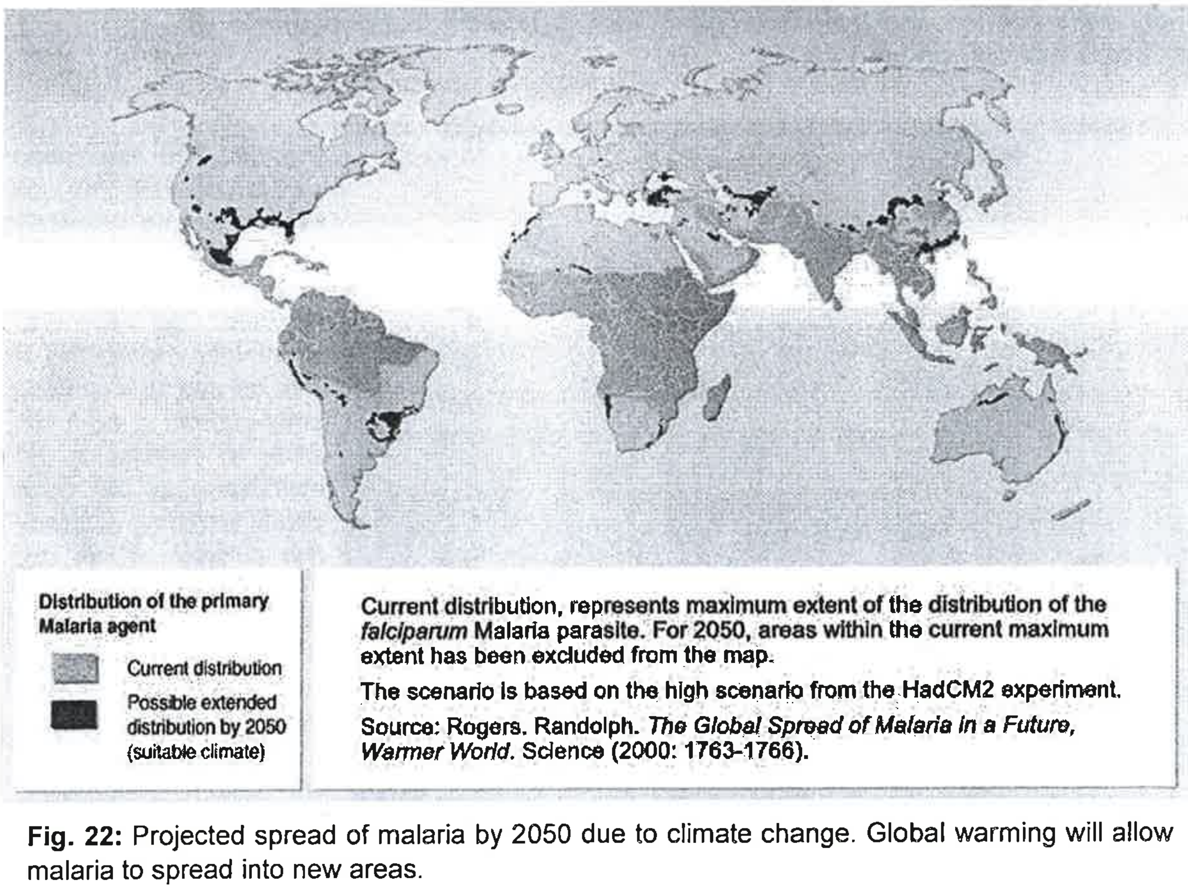


Fig. 22: Projected spread of malaria by 2050 due to climate change. Global warming will allow malaria to spread into new areas.

Problems migrating organisms may face:

Notes to self

- Some migrating species will find that they must compete with other native species for food and other resources.
- There may also be new predators the migrating species have to deal with – and will be unable to, since they have not fully adapted to the region.
- Not only predators, but possible exposure to new forms of disease may inhibit the effectiveness of their migration.
- Inability to adapt to these changes could severely impede the species' migration.
- However, moving into new areas may put these species into competition with other species over food and other resources. These shifts can also cause ecological disruptions as predators become separated from their prey.

6. Impact of Climate Change on Biodiversity

What if organisms are unable to adapt or migrate in response to climate change?

Approximately 20 – 30% of plant and animal species assessed so far are likely to be at increased **risk of extinction** if global average temperature increases by more than 2.7 - 4.5°F (IPCC).

Wildlife that already live at high altitudes or latitudes, such as the American pika or polar bears in the Arctic, may find themselves with nowhere to go. As climate change melts sea ice, the U.S. Geological Survey projects that **two thirds of polar bears will disappear by 2050.**

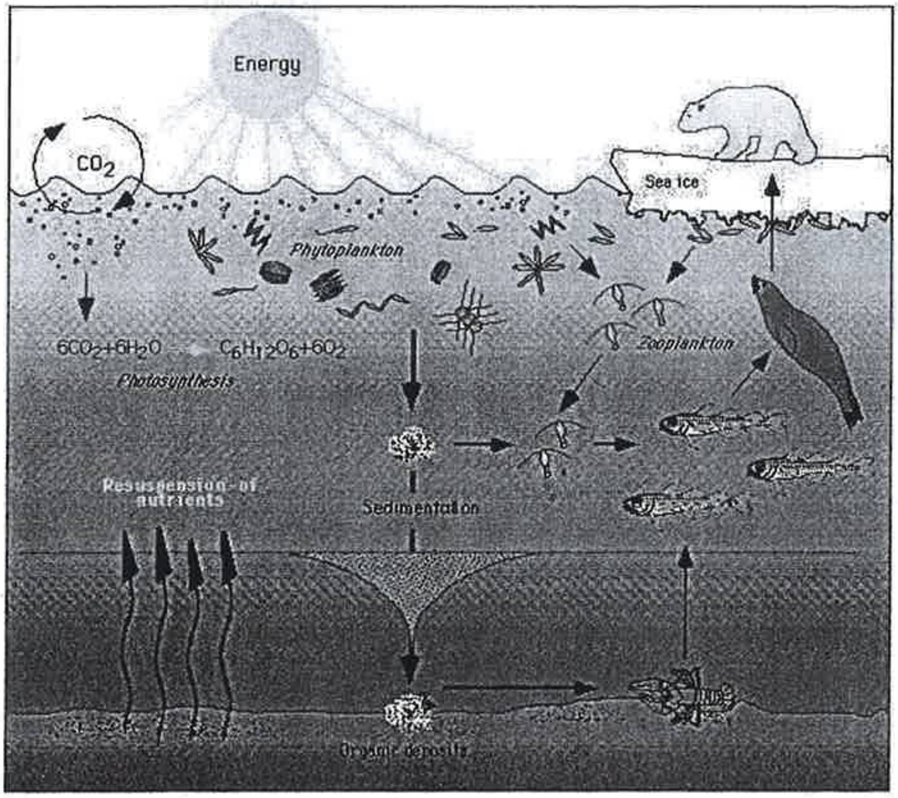


Fig. 23: The Arctic food web is complex. The loss of sea ice can ultimately affect the entire food web, from algae and plankton to fish to mammals. The melting of sea ice due to increased temperatures in the Arctic leads to declines in the abundance of ice algae which thrive in nutrient-rich pockets in the ice. These algae are eaten by zooplankton, which are in turn eaten by Arctic cod, an important food source for many marine animals, including seals. As seals are eaten by polar bears, declines in sea algae can contribute to declines in polar bear populations.

Example: Death of Coral Reefs

Notes to self

Warmer water place stress on corals which are sensitive to temperature changes. If water temperatures stay higher than usual for many weeks, the zooxanthellae that corals depend on for some of their food leave their tissue - **coral bleaching**. Without zooxanthellae, corals turn white because zooxanthellae give corals their color. White, unhealthy bleached corals are weak and less able to combat disease.

Fig. 24: Bleaching of coral reefs due to warmer temperatures.

As climate change continues, coral bleaching will become more common, and the overall health of coral reefs will decline.

With acidification of the ocean due to increased CO_2 emission, corals cannot absorb the calcium carbonate they need to maintain their skeletons and the stony skeletons that support corals and reefs will dissolve.

Fig. 25: Healthy coral polyps take up calcium carbonate from the ocean water to build their skeletons (left). Coral skeleton being damaged by ocean acidification (right).

If nothing is done to reduce CO_2 emissions, more corals will be damaged. By 2050, live corals could become rare in tropical and sub-tropical regions due to the combined effects of warmer water and increased ocean acidity. The loss of coral reefs will reduce habitats for many other sea creatures, and it will disrupt the food web that connects all the living things in the ocean.

Example: Loss of Biomedicines

Notes to self

Over a quarter of all pharmaceutical products come from rainforest produce – they have provided treatments for diseases like leukemia, glaucoma, malaria, Hodgskin's disease, snake bites, along with breast, cervical and testicular cancer, and are presently used in research for a possible treatment for AIDS.

Fig. 26: Cacao tree with cocoa beans. The cocoa tree is a tropical tree native to South America. Cocoa butter obtained can be used in medicine for creams and suppositories. Chocolate is also made from cocoa.

Fig. 27: Curare vines. Curare is used in medicine as a muscle relaxant and in Parkinson's disease.

It is calculated that 140 species of plants, animals and insects are lost every day as they become extinct from the loss of rainforest land through fires, logging, urbanization and intensive mono-cultivation.

In the last half century, 25% and over 50% of the Amazon rainforest and rainforest across on Earth have been lost respectively. These questions remain: how many possible cures are we losing and how many miracle drugs have we already lost?

Fig. 28: *Calophyllum lanigerum var austrocoriaceum*. Calanolide A, a complex natural product, is obtained from the bark and latex of *Calophyllum lanigerum var austrocoriaceum*. It is now undergoing clinical trials for the treatment of HIV infection. When extracts of this plant was discovered to show good anti-viral activity towards HIV, researchers returned to the original site where the tree was found in the island of Borneo in the Malaysian State of Sarawak. However, the tree was gone, cut down for firewood or building purposes. Fortunately, an intense search led to additional samples located in the Singapore Botanic Garden - the British had planted several collected specimens over a century ago. Medical research narrowly escaped a major scientific loss.

Example: Loss of Genetic Diversity of Foods

Notes to self

Approximately 80% of the foods we eat come from the tropical rainforest in some way.

These include avocados, coconuts, squash, yams, bananas, plantains, mangoes, pineapple, citrus fruits, chocolate, vanilla, ginger, peppercorns and cinnamon. Some other foods grown in the rainforest also include nuts, coffee, tea, rice and corn.

Genetic diversity in crop production is vital to the sustainability of a food source. Without consistent mutation, a species cannot continue to thrive in the face of disease or pestilence.

The majority of the world's food sources come from a mere one hundred and thirty species of plants, and of those, wheat, sorghum, maize, barley, rice and soybeans contribute to 55% of the average daily caloric intake.

Without genetic variability among the genetic strains, there is little chance that the world's food supply will be able to fight off adversity. The impact of biodiversity loss on food production is visible in that from 1981 to 2002, nearly 44 million combined tons of wheat, barley and corn had been reduced from the world's food supplies due to climate change.

Genes from wild plants can be used to fortify modern varieties against this vulnerability. Without rainforests, this opportunity is lost, as is the chance to develop entirely new food plants.