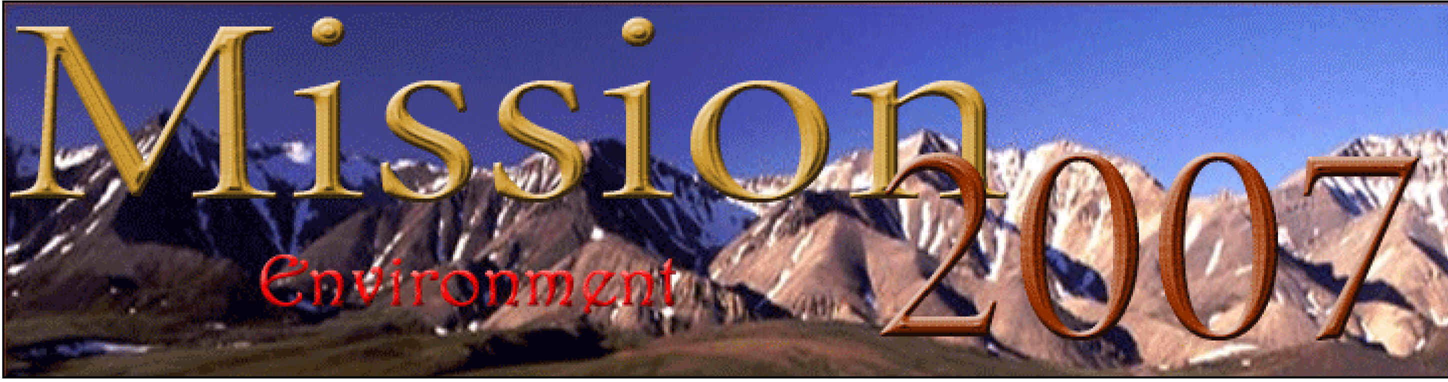


# Decomposers

Decomposers are basically microorganisms that feed on dead organic matters. They range from bacteria to fungi. They secrete enzymes to break down large organic matter such as starch, protein, fats and other materials that are present in living organisms. Because of their decomposition function, they are very important in the arctic ecosystem as they play a vital role in nutrient cycles.

## Decomposers

The cycling of materials such as carbon, water, and other nutrients is mainly dependent upon soil-dwelling decomposer organisms such as bacteria fungi, earthworms, and insects. Bacteria and fungi are the most abundant of the microbial decomposers, numbering in the billions in only one handful of soil!

As essential components of the environment, fungal and bacterial microbes break down dead and discarded organic materials, supplying a continuous source of nutrients for the plants in surrounding soil. In general, decomposers break down the proteins, starches, and other complex organic molecules that were all once the components of living organisms, and “as products of their own metabolism, [they] convert elements such as nitrogen, phosphorous, calcium, and sulfur into forms that can be utilized by plants” (Dirty, 2). According to several researchers at the University of Jyväskylä, "Reduction in the species diversity of the lowest levels (decomposer fungi) of the food web [become] particularly well manifested as reduced decomposition rate and stagnated nutrient dynamics." They also emphasized that certain variations of microorganisms can play a critical role in controlling nitrogen cycles and plant growth in general.

In addition, it is true that decomposer species tend to be rather resistent to changes in the availablitiy of organic material or changes to the environment in general, but they are still affected by several key factors. For instance, increases in temperature will cause more rapid decomposition reactions--just as would occur for most chemical reactions. However, too high of an increase in temperature affects the microbes adversely. Moisture is also usually favorable unless there is so much moisture that the living environment is waterlogged. When waterlogging occurs, some microbes will die while others thrive on the excess moisture. On the other hand, light tends to be bad for most decomposer microbes.

Concerning the issue of oil drilling on the North Slope of ANWR, one would expect an increase in the amount of organic as well as inorganic waste material in the local environment. This is important, because although fungi and microorganisms thrive off of organic materials such as animal flesh, fecies, dead plant matter, nut shells, etc., it is much harder and time consuming for them to decompose human-made materials that are either high in cellulose--i.e. cotton and paper-cardboard--or metallic or plastic. In fact, metals and plastics are almost impossible to decompose by the microorganisms and fungi--they break down primarily, and over a long period of time, due to weathering processes. Currently advances are being made in the development of biodegradable plastics, but there remains the majority of non-biodegradable plastics. Furthermore, if the diversity of decomposer species decreases in ANWR due to changes in their environment--whether the changes are related to climate, the introduction of oil drilling, or increases/decreases in populations of consumers--it can be assumed that all species that depend upon the decomposers are either directly or indirectly affected by such a flux.

**Species:**

Although it is true that “no one has yet detailed all the species of fungi that live in Alaska” and “several thousand species of fungi exist, but scientists have only described about 50,000,” much can be said about the characteristics and effectiveness of these incredible decomposers. (http://www.gi.alaska.edu/ScienceForum/ASF15/1562.html)

According to the book Ecology of Arctic Environments, research has shown that frost free days and varying levels of nitrogen in soil are not greatly important to the survival of fungi, while temperature, moisture and pH are. In addition, it appears that the cold of the arctic may “have a selective effect” on certain species such as Chrysosporium pannorum. As for arctic fungal species in general, several studies have illustrated that “fungal h yphal length increased with increasing soil moisture and temperature, and decreasing soil pH” (Woodin and Marquiss).

Unfortunately for our purposes, the fungal species lists and biomass values that are available are almost all composed from the research efforts of the Tundra Biome group of the IBP, and are therefore from the long ago period of 1964-1974. Species known to have been studied by the Tundra Biome group include Eriophorum and Carex (Woodin and Marquiss).

**General Characteristics:**

Suffice to say, “fungi, the subjects in this kingdom, live in the woods, in refrigerators, on rocks, and between our toes. Without them, the natural world would cease to function.”
Fungi are part of a very interesting kingdom. In fact, it is so diverse and complex that they are the only species that make up the kingdom. To function on a regular basis, fungi digest their food through the use of extracellular fluids. In other words, digestion occurs outside of their bodies. The extracellular fluids that they excrete are acids and enzymes that act to break down organic material. They then absorb the simple molecules of food through their cell walls, because they do not have stomachs.

Furthermore, many fungal species exist in symbiotic relationships with vegetation such as trees. An example of such a relationship occurs when fungi beneath the soil cling on to tree roots, resulting in roots that are coated with hairy fungi called mycorrhizae. The fungi help trees and other plants absorb minerals (http://www.gi.alaska.edu/ScienceForum/ASF15/1562.html).

Furthermore, "decomposer microorganisms require a balance of carbon and nitrogen that requires a far greater turnover of nitrogen accompanying carbon dioxide production…in order to simultaneously meet energetic and nutritional needs" (Reynolds et. al, 311). Plants even compete both with each other and with soil microbiota for the nitrogen and nutrients released through decomposition. Therefore, when the availability of nitrogen is lower, it is harder for a variety of plants to survive.

Investigations on decomposition in the arctic have been conducted primarily by Flanagan and Scarborough as part of the Tundra Biome project that occurred from 1964-74. They stated that the best soil pH for cellulose decomposition by about 60% of Alaskan strains was between 4.5 and 5 (acidic), while a slightly more basic pH of 6 was best for the decomposition of pectin and starches (Woodin and Marquiss).
It is observed that the "fungal species composition in arctic environments is very similar to those in temperate latitudes, although the isolates are often adapted to low temperatures" (Woodin and Marquiss). Nevertheless, in the extreme soils that are more characteristic of the North Slope (aka the 1002 region—that which is in debate for oil drilling), fungal biomass is clearly seasonal and may overall be lower than that which is found in temperate ecosystems.

At the University of Alaska Fairbanks, the Institute of Arctic Biology scientists are attempting to determine the "characteristics of tundra and forest fungi that allow them to live in cold soils and to release nitrogen and phosphorus as they decompose organic remains."  The resistance of fungi to oil spills or other environmental disturbances must be investigated and known, for "if the stability of the fungi is undermined, an entire forest or tundra grazing land can be destroyed.

Although the relationships between nutrient mineralization, microbial immobilization, and plant uptake still need to be better documented and understood, enough is known about Alaska's tundra to understand conditions that affect the resident decomposer species (Reynolds, et. al).

Basically, low temperatures, the existence of permafrost, low nutrient input and frequent waterlogged conditions result in a reduced rate of organic matter turnover and cycling of organically bound nutrients. In addition, the accumulation of dead organic matter enhances these conditions which inhibit decomposition. Meanwhile, soil temperature and water regimes also affect anaerobic respiration by decomposers in the tundra soil. Normally, warmer temperatures will increase respiration rates and increased levels of moisture will as well, but if an environment is overly saturated, decomposer activity is inhibited. In such saturated sites, there are larger accumulations of organic matter due to the limit on decay and peat tends to form. For example, the Imnavait Creek watershed in northern AK normally has a layer of organic matter overlying mineral soil that ranges from 10-40 cm in thickness, due to its rather low rate of decay (Reynolds et. al).

Ice microbial communities, although for the most part poorly understood, are challenged physiologically and ecologically by meltwater fluxes. Basically, in the summer low-salinity meltwater promotes the flushing of a substantial fraction of the sea-ice microbial habitat. Due to steadily increasing temperatures in the arctic, such freshwater immersion may be increasing in duration and extent as precipitation and snow melt amounts increase (http://siempre.arcus.org/4DACTION/wi_pos_displayAbstract/6/440).
A pleasant reflection from a woman who once visited the arctic:

"I was in for a surprise when we looked at the bottom of the ice core sample. I grew up in Michigan and spent my winters boring fishing holes into Lake Huron, so I was familiar with freshwater ice. But unlike that ice, the bottom surface of sea ice is not smooth. It has a very rough surface and is distinctly greenish-brown in color. The color is caused by a large increase in biological material --mostly algae such as diatoms .

The color also comes from dissolved organic material that supports the growth of bacteria. There is a surprisingly high diversity of viruses and fungi as well. Crustaceans feed on the several hundred different species of algae that live in this bottom-most layer of ice, and fish feed on the crustaceans. It's a complex food web. Yet standing here on the icy surface, you'd never know this ecosystem was there. You have to penetrate down through the ice to have any chance of discovering it (http://www.astrobio.net/news/print.php?sid=467)."
Plant growth can be limited by a lack of organic compounds in the soil, an effect that occurs because decomposing matter takes longer as it becomes integrated into the soil. Due to the even slower function of decomposition in cool climates, soil is slow to recover from any disturbances caused by the force of erosion, animals, or humans.

Even so, the freezing and thawing that takes place over the course of a year in the arctic actually speeds the access for bacteria and fungi to the insides of cells of dead plants and animals. This can happen because when a cell freezes, the water in its tissue expands, therefore breaking cell walls and making it possible for materials to diffuse in and out of the cells once the tissue thaws. Despite this activity, the extreme cold of the arctic has the net effect of slowing decomposition (http://www.blm.gov/education/00_resources/articles/alaskas_cold_desert/classroom.html).

Ocean currents and the proximity to land are both factors upon which nutrient distribution in water depends. The weathering of rocks on land causes many of these nutrients to be carried into the ocean by rivers, which is why many of the most nutrient rich oceanic areas are near river mouths. In addition, the decay of plant and animal material by bacterial processes recycles the nutrients. Therefore, the areas on the Coastal Plain at 1002 where the rivers empty into the ocean are highly concentrated with nutrients and in turn attractive habitat for birds and other wildlife to find nutrition (oceanexplorer.noaa.gov/explorations/ 02arctic/welcome.html).

**Basic Population Dynamics:**

It has been found that populations of soil bacteria in tundra areas are very close to the same as those found in other regions “and no types unique to tundra regions have been recognized” (Woodin and Marquiss). However, estimates of bacterial biomass are greatly influenced by the unreliability of plate and direct microscopic counts as well as the difficulty in figuring out “whether the cells are alive, dead, or in a non-culturable but viable state” (Woodin and Marquiss). Efforts to make direct counts of bacterial biomass have demonstrated that biomass increases with decreasing latitude, as is evidenced by the counts made from oven-dried soil which range from 2.26 $\mu g\ g^{-1}$ at Stordalen to 8600 in a horizon at Moor House (Woodin and Marquiss).

According to information compiled by Reynolds etc. al, “current levels of soil moisture appear close to optimum for decomposition…any net changes in soil moisture may decrease carbon mineralization.” They also reported on recent simulations performed under various climate change scenarios. The simulations suggest that there is a “large potential variability compared to current carbon and nitrogen dynamics, depending on the rates and directions of changes in soil moisture and temperature regimes.”