Terrestrial ecosystems

Plant and animal life in Antarctica is very limited. There are very few flowering plants and there are no trees or bushes. Except in the sub-Antarctic, there are no native land animals larger than insects, and the diversity of invertebrates is low.

There are three reasons for this:

• the Southern Ocean isolates Antarctica from other land masses from where colonising organisms must come;

• within Antarctica, suitable ice-free sites for terrestrial communities are small and separated either by sea or ice which act as barriers to colonisation; and

• the land in summer has rapidly changing temperatures, strong winds, irregular and limited water and nutrient supply, frequent snow falls, and soil movement due to freezing and thawing.

Continental Antarctica

In continental Antarctica, water is the limiting factor for the survival of plants and invertebrates. Nevertheless, lichens and small invertebrates have been found on nunataks only a few hundred kilometres from the South Pole. In the Dry Valleys of Victoria Land, many areas have communities of plants living just beneath the surface of the rock. Here, layers of lichen, cyanobacteria and fungi survive because of light penetrating the rock crystal structure and water held as a microscopic film in the rocks.

The maritime Antarctic

In the maritime Antarctic, only two flowering plants grow south of 60°S: the Antarctic Hair Grass and the Antarctic Pearlwort. Throughout this zone, mosses mainly occupy the wetter areas with lichens in the drier and more exposed sites. Many of the potentially suitable coastal habitats for vegetation are occupied by penguin or seal colonies where trampling and excrement kill most plants. However, a green alga can tolerate the high nutrient conditions. Elsewhere, in the wetter soils, microscopic algae are abundant. Algae living on ice can produce green, yellow and red snow. Fungi occur as microscopic filaments in the soil and also occasionally as small clusters of toadstools amongst mosses. Micro-fungi and bacteria are responsible for the breakdown of dead plants to form simple soils, releasing nutrients into the ecosystem.

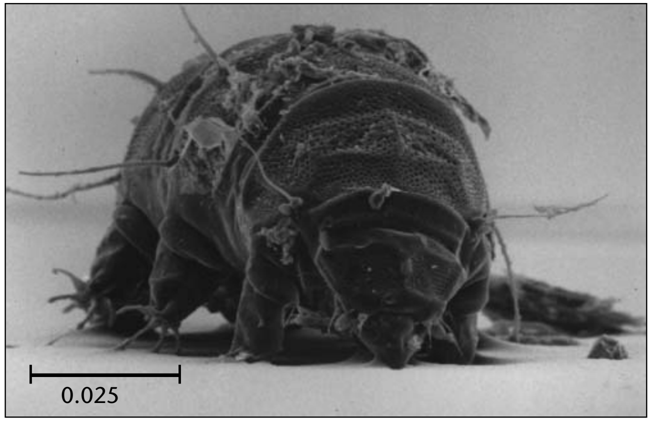
One of the major adaptations of Antarctic plants is their ability to continue photosynthesis and respiration at low temperatures, for many lichens below -10°C. The two flowering plants are perennials and take several years to reach maturity and reproduce. Flower development is initiated during one summer, with growth and seed production being completed in the next if it is warm enough.

Sub-Antarctic islands

On the sub-Antarctic islands, such as South Georgia, the climate is milder. This allows more extensive vegetation to grow near the coast where tussock grass is dominant and can reach 2 m high. Drier hillsides are covered by grasses or short shrub-like plants. Bogs are dominated by rushes and mosses, below which several metres of peat have accumulated. Dry windswept hills have scattered grasses, mosses and lichens. Many higher plants have been introduced to the sub-Antarctic islands by humans. At South Georgia about 25 introduced plant species survive today.

Antarctic and sub-Antarctic land animals

In the Antarctic, the terrestrial animals are very small and, as with the flora, the number of species is low. Most invertebrates live in moist soil or in vegetation. Small mites and springtails predominate. Two small midges occur in a few sheltered localities in the Antarctic Peninsula region. The largest invertebrate is the wingless midge (3–4 mm long) and most other animals are microscopic. These include protozoans, rotifers, tardigrades ('water bears'), and nematode worms. Many of the mites and springtails are found only in the Antarctic and are thought to have been there for a long time, surviving the last major glaciation in areas which avoided burial by ice. The invertebrates that have adapted often occur in great numbers. Many of the present-day arthropods avoid freezing by a process of supercooling which is aided by antifreezes in their body fluids. Some can prevent body-freezing to -35°C.



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Scanning electron microscope picture of Antarctic tardigrade

The sub-Antarctic islands have a more diverse and larger fauna, with animals such as beetles, spiders, flies and snails. A few of the larger islands have endemic land birds (e.g. the South Georgia pipit). All the land mammals on sub-Antarctic islands have been introduced by humans. Reindeer were introduced to South Georgia in 1911 and there are now about 2700. Rats live in tussock grass on many of the islands, and there are also mice. Cats were introduced to some islands to eradicate the rats and mice, but instead they killed small burrow-nesting petrels and ground nesting birds which were easier prey. Rabbits have overgrazed vegetation and caused soil erosion on several islands.

Ecosystems in Antarctic freshwater lakes

Resource TL2

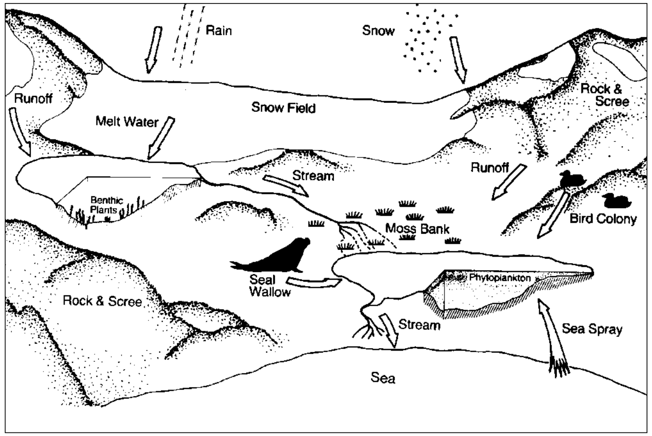
Lakes occur in most parts of the Antarctic, even deep under the Antarctic ice sheet. Most lakes, however, are found in the warmer coastal ice-free areas of Antarctica and may contain fresh or salt water or, in some cases, both.

Most lakes in Antarctica have formed in the depressions exposed by the retreat of glaciers. The British Isles have been ice-free for many thousands of years so the lakes here have had time to evolve. In contrast, Antarctic lakes are still developing as the ice retreats and are therefore comparatively young (less than 8000 years old) comprising simple, primitive ecosystems. There are no fish or other vertebrates in Antarctic lakes. It is often easier to understand how complex lake ecosystems function by first looking at simple ones. Thus, the simplicity of Antarctic lakes makes them important for scientific research.

Permanently frozen lakes in Antarctica

Lakes in continental Antarctica are mainly located near the coast where the harsh environmental conditions are less severe. A unique feature of some of these lakes is that they are permanently ice-covered and possess no outflow. They are effectively a closed system. All losses of water, gases and biological material occur through the thick ice cover, which loses ice by sublimation to the atmosphere as fast as fresh ice is formed underneath. The salts present in catchment soils can dissolve in melt water from glaciers or snowfields and drain into lakes and make them saline. However, fresh melt water also flows into the lakes and will lie on top of the heavier saline water. This produces a highly stable gradient of increasing salinity with depth. Phytoplankton and bacteria occur in distinct layers, with different groups of species adapted to the light, nutrient and salinity levels of each layer. The deepest areas receive very little light and contain virtually no oxygen. Here only highly specialised bacteria are found. The bottom layers are rich in nutrients but the stable nature of the water restricts mixing, so upper layers are very poor in nutrients. Most plant life occurs as thick mats of cyanobacteria, particularly in the shallow areas of these lakes where light levels can penetrate. Small invertebrates (e.g. tardigrades) live in these mats. The lakes are characterised by a lack of variety of both plants and animals and very low biological activity.

In the Dry Valleys of Victoria Land a special type of hypersaline lake is found. Here, evaporation exceeds precipitation so forming a lake whose bottom water can be 13 times more salty than sea water.



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The hydrological cycle in the maritime Antarctic

Seasonally frozen lakes in Antarctica

Lakes in the maritime Antarctic which undergo seasonal freezing can be classified into two main types according to their nutrient content. The principal type is extremely nutrient-poor with very clear water. Most of the plants and animals live on the lake bottom as it is here that nutrient levels are at their highest within the lake sediments. A second lake type is nutrient-rich and the many small plants and animals suspended in the water make it turbid. Here, very little light penetrates so plants cannot grow on the lake bottom. The high nutrient content is usually derived from the excreta of seals and birds living nearby. The fauna of these lakes consists only of invertebrate animals. The largest animal found is a fairy shrimp about 2 cm long. Lake animals are mainly associated with the plants growing on the lake bottom, although two species of tiny copepod crustaceans live in the water column. There are two main types of freshwater plants – algae and mosses. The algae occur either as phytoplankton in the water column, or as filaments which intertwine to form extensive mats over the lake sediments. In some clear lakes, aquatic mosses form large beds in deeper water. Their stems can grow up to 45 cm in length and the leaves are adapted to maximise capture of light for photosynthesis. The lakes are permanently cold, with water temperature never rising above 5°C all year. They are also usually ice-covered to a depth of 1 metre for 8–12 months each year, when there is no inflow or outflow of water.

Lakes in the sub-Antarctic

Lakes are usually more frequent on the sub-Antarctic islands because the climate here is wetter. Since the vegetation is more complex than in the Antarctic, there is a much greater variety of both plant and animal life. Most biological activity is located on the lake bed where extensive mats of mosses and algae occur. Several vascular water plants, such as water-weeds, grow in the lake shallows and carnivorous diving water beetles are the largest animals. However, many of these lakes are still ice-covered for several months each year and most receive only small amounts of nutrients from the surrounding land. Thus, insufficient food is produced to allow fish and other vertebrate animals to survive. Where seals and birds are numerous in lake catchment areas, lakes become enriched and dominated by phytoplankton.

Lake Vostok – a great lake under the Antarctic ice

Resource TL3

Underneath the Russian Vostok research station in the centre of Antarctica there is a vast lake, covering an area of 14,000 km^2. It is 200 km long, in some places 500 m deep, and is buried beneath 4 km of the East Antarctic ice sheet. Lake Vostok is so large that the ice sheet floats on it and becomes entirely flat so enabling it to be detected from space. This allowed Russian and British scientists to establish the size of the lake using satellite radar altimetry in 1996. Lake Vostok has been isolated from the outside world for at least 500,000 years and is possibly a unique ecosystem containing unknown micro-organisms. Around 70 other sub-glacial lakes exist in Antarctica, so Lake Vostok may be part of a vast sub-surface hydrological system.

The formation of Lake Vostok

Scientists believe that the lake formed hundreds of thousands to millions of years ago after the Antarctic ice sheet had reached its present thickness. The existing lake has always been sealed from the atmosphere and formed due to a combination of the intense pressure of the ice sheet above lowering the melting point of its basal ice, and geothermal heating from the bedrock below, possibly enhanced by hot water vents.

Ice core studies at Vostok

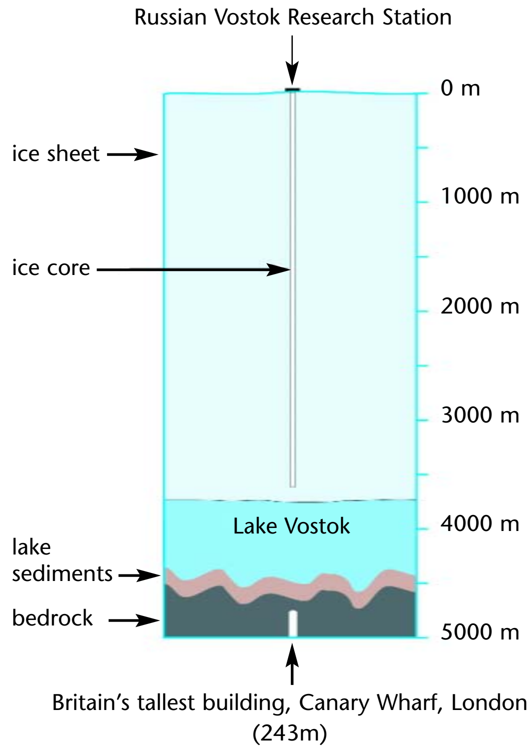
Since 1989, an international research programme has been drilling through the ice sheet at Vostok to obtain a detailed record of the climate history of the Earth. This drilling was stopped in 1998 when the drill reached a depth of 3623 m – the deepest ice core recovered anywhere in the world – about 120 m above Lake Vostok. Ice at this depth is approximately 500,000 years old. The borehole has been capped because of concerns that drilling fluids (a mixture of kerosene and anti-freeze) and surface micro-organisms in the fluids might contaminate the lake.

Is there life in Lake Vostok?

Microbiological studies of the Vostok ice core have found viable micro-organisms up to 200,000 years old, including bacteria, yeast, fungi and microalgae. Several of the microorganisms have never been seen before and have not yet been classified. There is therefore a ready source of microbes seeding the lake. Microbes released from the ice sheet will sediment out. The lake sediments could provide fascinating material for researchers, as well as being a highly valuable chronological record of events.

Several scenarios for the presence of life in Lake Vostok have been identified by scientists. The starting point in each case is that it is very unlikely that anything other than microbes will be present in the lake. Higher organisms need a substantial food supply to maintain their complex structures and, if the lake is as nutrient-poor as scientists believe, it will be unable to support organisms other than microbes. There is no guarantee that any life will be present, but scientists would still be interested in any fossil remains. However, it is likely that a range of micro-organisms will be found, particularly in the sediments as microbes tend to proliferate in the presence of surfaces. Such micro-organisms will have to be adapted to a permanently cold (-3°C), permanently dark, high-pressure environment with few nutrients or energy sources. One scenario suggests that specialist groups of bacteria may be able to use inorganic sources (e.g. sulphate, iron, or dissolved gases such as carbon dioxide) as energy and/or carbon sources and these bacteria would be well equipped to survive in the lake. Some of these, such as methane producing bacteria, were among the first microbes to develop on the early Earth and are commonly found in extreme environments today. A second scenario envisages geothermal activity providing heat energy and various inorganic substrates, which would facilitate microbial life around 'hotspots' in much the same way as is currently found at deep-sea hydrothermal vents.

Lake Vostok is buried beneath nearly 4 km of ice



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NASA proposals to explore Lake Vostok

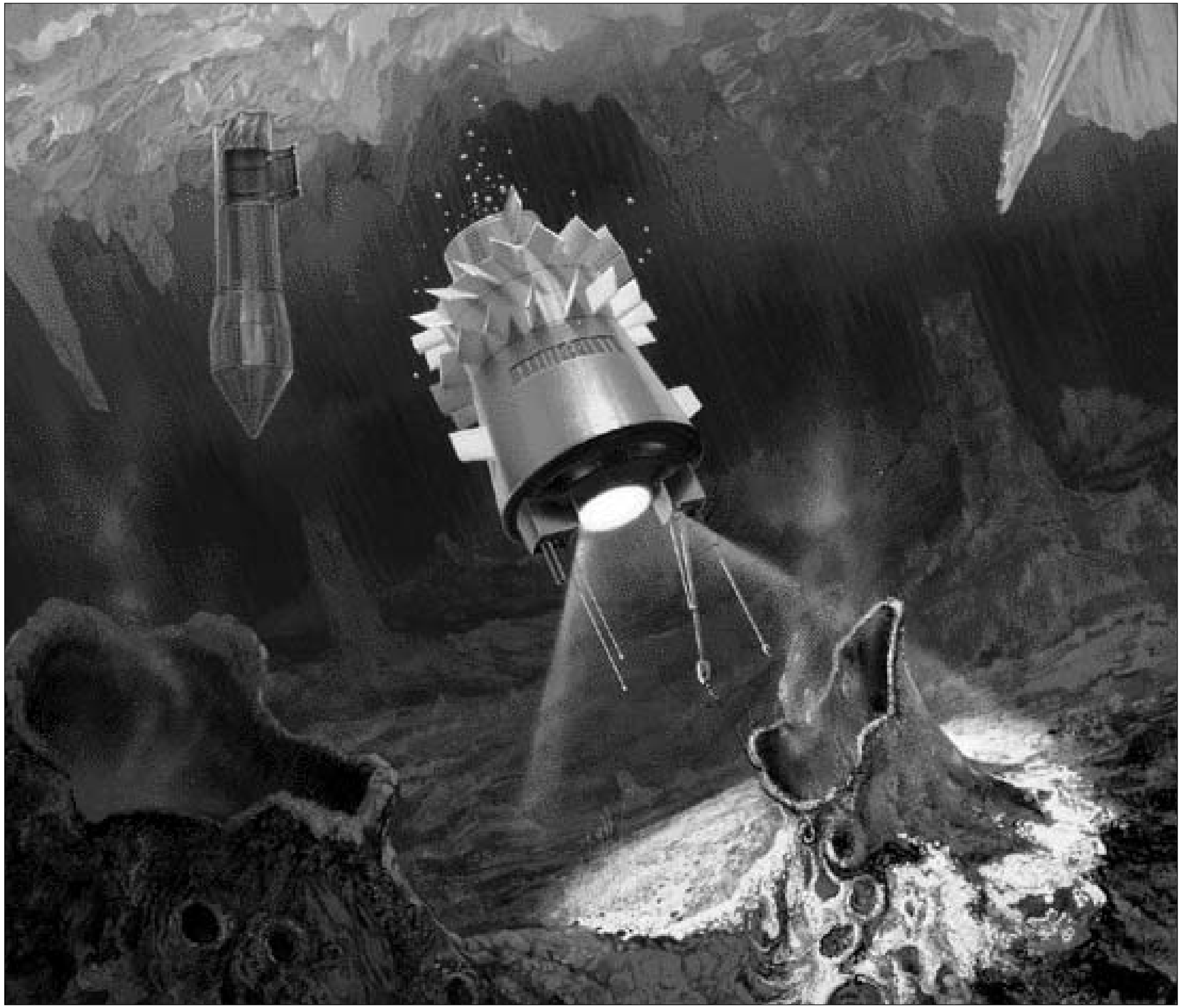
The American space agency, NASA, sees an analogue between Lake Vostok and a possible aquatic environment beneath the ice sheet on Europa, one of the moons of Jupiter. The NASA Jet Propulsion Laboratory at Pasadena has suggested testing a robot probe at Lake Vostok in 2001 before using it in a space mission to Europa. Currently, NASA are proposing that a hot water drill (the largest ever built) would melt a hole down through the ice sheet to within about 100 m of the lake. A thermal probe (a large cigar shaped device with a heater in its nose) would then melt its way through the remaining ice to the lake unwinding a fibre-optic communication cable behind it. The probe would sterilise itself using chemicals, which would later break down harmlessly, as it progresses. The ice would freeze and close again behind the probe so this would be a one-way trip, but communications would be maintained via the fibre-optic cable. Once the probe reached the lake it would release one or more mini-robots called 'hydrobots'. The 'hydrobots' would search for living organisms, test the water and lake sediments and take pictures.

A major challenge for NASA and other scientists will be to develop reliable life detection systems that can establish if microbes are living in the lake sediments, water or basal ice sheet without the need to return samples to the surface. New remote sensing systems will be needed as direct drilling into the lake to extract samples would constitute a significant threat to this pristine environment.

Environmental Impact Assessment

The possible contamination of Lake Vostok is a very important issue. Pollution by chemicals or fuels, or the introduction of surface micro-organisms would change the water for ever and compromise the lake's pristine status as well as future research. An international group of scientists has argued that rigorous protocols and cross-checks will be necessary to avoid pollution. Some scientists have recommended that a trial penetration should take place through a floating coastal ice sheet before work is permitted at Vostok or at other sub-glacial lakes in Antarctica.

At the 1998 Antarctic Treaty Consultative Meeting, Russia declared that a comprehensive Environmental Impact Assessment of the Lake Vostok research proposal would be produced and circulated for comment to other Antarctic Treaty nations before any further drilling was allowed to take place.


NASA

NASA plan to send a robot through the East Antarctic ice sheet to explore Lake Vostok.

Ecological effects of fur seals at Signy Island

Signy Island, on the South Orkney Islands (60°43′S, 45°36′W), is a small island (area about 20 km²) of exceptional ecological and biogeographical importance. The island has some of the most diverse and abundant terrestrial flora and fauna of any locality in the Antarctic because of its complex geology, extensive ice-free areas, cold and wet oceanic climate, and varied topography.

At Signy, a complex continuum of cryptogamic moss and lichen communities has developed ranging from 2m deep, 5000-year-old moss banks to extensive, closed wet moss carpets, lichen-rich fellfields and unique calcareous fellfields on marble soils. Antarctic Hair Grass and Antarctic Pearlwort are also widespread. Associated with the vegetation and their soils is a diverse invertebrate fauna. Vegetation is mainly confined to the coastal lowlands and sheltered north-facing slopes.

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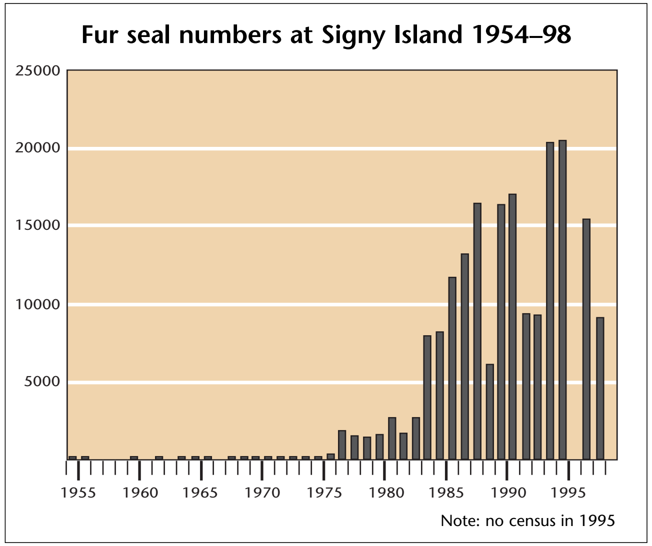
An Antarctic fur seal

Increase of the fur seal population at Signy Island

Since about 1980, both the terrestrial and freshwater ecosystems on Signy Island have been increasingly threatened by a dramatic increase in the number of Antarctic fur seals which come ashore each summer. This has had a serious effect on some of the research being carried out on the island, although at the same time creating new research opportunities.

Fur seals were the first marine resource in the Antarctic to be exploited. In the early 1800s fur seal skins were highly valued, and seals were killed in huge numbers. It has been estimated that by 1822 at least 1.2 million fur seals had been killed and the species virtually wiped out.

Sealing ceased in the early 1900s when seals could no longer be found. However, since then the fur seal has undergone a dramatic recovery. There are probably two main reasons for this. First, the massive reduction in whale stocks due to whaling has led to a consequent increase in the availability of krill, the main prey of the fur seal. Second, conservation measures have been adopted by the Antarctic Treaty nations to protect fur seals, including its designation as a Specially Protected Species under the Environmental Protocol.



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There is no record of fur seals on Signy Island before 1948, but since then numbers throughout the South Orkney Islands have increased considerably. At Signy Island, annual fur seal numbers have increased from a few dozen individuals during the 1950s and 1960s, to several hundred from 1969 to 1976 and from 1600 to 3000 from 1977 to 1983. By 1986 there were over 11,700 and by 1994 over 20,000. In 1997, numbers had dropped to about 9000. The densest aggregations of seals occur in the north-east and south-east of the island where the terrain is low with extensive areas of vegetation, and access is easy from numerous sheltered beaches. In places, the seals venture several hundred metres inland and to over 100 m altitude on hillsides. Between 1980 and 1987 there was an overall increase in numbers of 740%, although numbers fluctuate from year to year. Originally, all the seals coming ashore on the island were immature males from South Georgia, but now a small number of females breed there.

Assessment of fur seal impact on the terrestrial environment

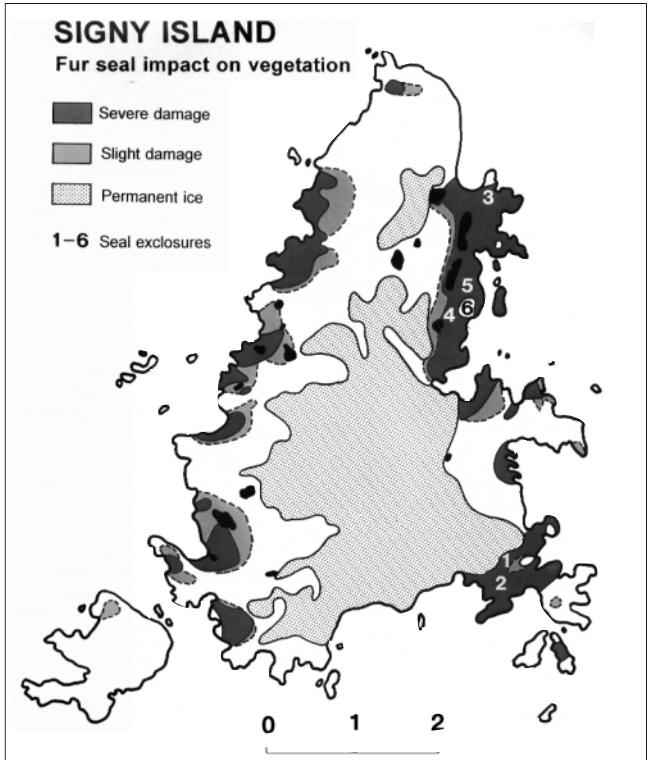
The rapid increase of fur seals has had a devastating effect on the vegetation over large areas of Signy Island. Damage is caused by the trampling action of these highly mobile seals, which disrupts loosely attached mosses and lichens. The faeces produced by the seals also kills plants, which are adapted to very low nutrient conditions. Between 1984 and 1987, about 30 to 45% of the seal population occurred in the low undulating north-east of the island where an estimated 75% of the vegetation (excluding precipitous areas) has been either completely destroyed or is in various stages of destruction and removal. Loss of the moss and lichen vegetation has been very apparent and there has been near eradication of fellfield, carpet bog, moss turf banks and mixed moss cushions in some areas. Soils in areas frequented by fur seals are disturbed and there is substantial nitrogen enrichment from their faeces, as well as acidification of the substrata. This results in rapid colonisation by nitrogen loving green algae, especially sheets of *Prasiola crispa*. This alga is particularly tolerant of physical impact and is also the dominant plant associated with sea bird colonies and elephant seal wallows. Elsewhere, eutrophication of freshwater systems has greatly modified the water chemistry and microbiota of streams and lakes.

Even in the low hills there has been a substantial reduction in the abundance of the dominant plant species caused by seal activity. Extensive stands of mosses and lichens have disappeared. Soil pH has dropped significantly and *Prasiola* has again colonised the nitrogen-enriched bare ground and moribund moss, especially on the wetter ground.

Long-term implications

Much of the lowland environment of Signy Island is undergoing a rapid and possibly irreversible biotically induced transformation. The results of a study carried out by BAS scientists between 1985–94 using fenced seal exclosures (see map on this page for their location) and unfenced plots has shown that the terrestrial ecosystem is dominated by slow growing species which have no resilience against disturbance. Their ability to recover to their previous condition is unlikely to be achievable within a century. If the fur seal population continues to increase the future of much of Signy Island's abundant, diverse and often unique terrestrial and freshwater biota, and the ecosystems in which they live, will be in jeopardy. This could also have a serious impact on the nature and direction of the BAS's research programme on the island. In addition, human health and safety may be at risk since these seals can be highly aggressive and several attacks on people, both on land and in lakes, have occurred. These problems will become even more serious if a large breeding population of fur seals establishes itself on the island. No measures are being taken to reduce the seal numbers, but an attempt to protect small experimental plots from their direct influence is being made by the erection of wire mesh fences.

The fur seal impact at Signy Island presents a major ecological problem, with particularly serious long-term consequences for the island's lowland terrestrial and freshwater ecosystems. It poses an important question for conservationists and scientists as to which species of Antarctic flora and fauna, as well as their different habitats, merit protection. For example, should fur seals continue to be given total protection from disturbance as a Specially Protected Species under the Environmental Protocol when their numbers are now approaching over 3 million in Antarctica? Should the exceptional terrestrial and freshwater ecosystems on Signy Island be given greater protection from fur seals by introducing carefully controlled exclusion fencing or seal culling? While a culling programme may not be desirable, it may be the only way to limit the impact of these animals on the terrestrial environment of the island. Such a management policy would be very difficult to agree politically.



Source: BAS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Moss banks and toadstools are very vulnerable to disturbance by fur seals

Conclusions

The most immediate threat to the environment on Signy Island is the rapidly increasing non-breeding population of fur seals. The large summer influx of seals has severely damaged terrestrial vegetation and caused eutrophication of freshwater lakes. The situation is giving cause for serious concern and, if allowed to follow its natural course, will probably have a catastrophic and irreversible effect on the island's terrestrial and freshwater ecosystems.

Terrestrial and freshwater lake ecosystems

Worksheet 11

Very few plants or animals can survive on land in the extreme conditions of Antarctica. The lack of water and large variations in temperature, day length and sunlight mean that only highly specialised plants and animals can cope. Terrestrial and freshwater ecosystems are therefore very simple. Food chains are short and lack significant predators. This worksheet provides an overview of Antarctic terrestrial and freshwater ecosystems, looks at the challenges of exploring lakes buried deep under the Antarctic ice sheet and examines the links between the land and the sea.

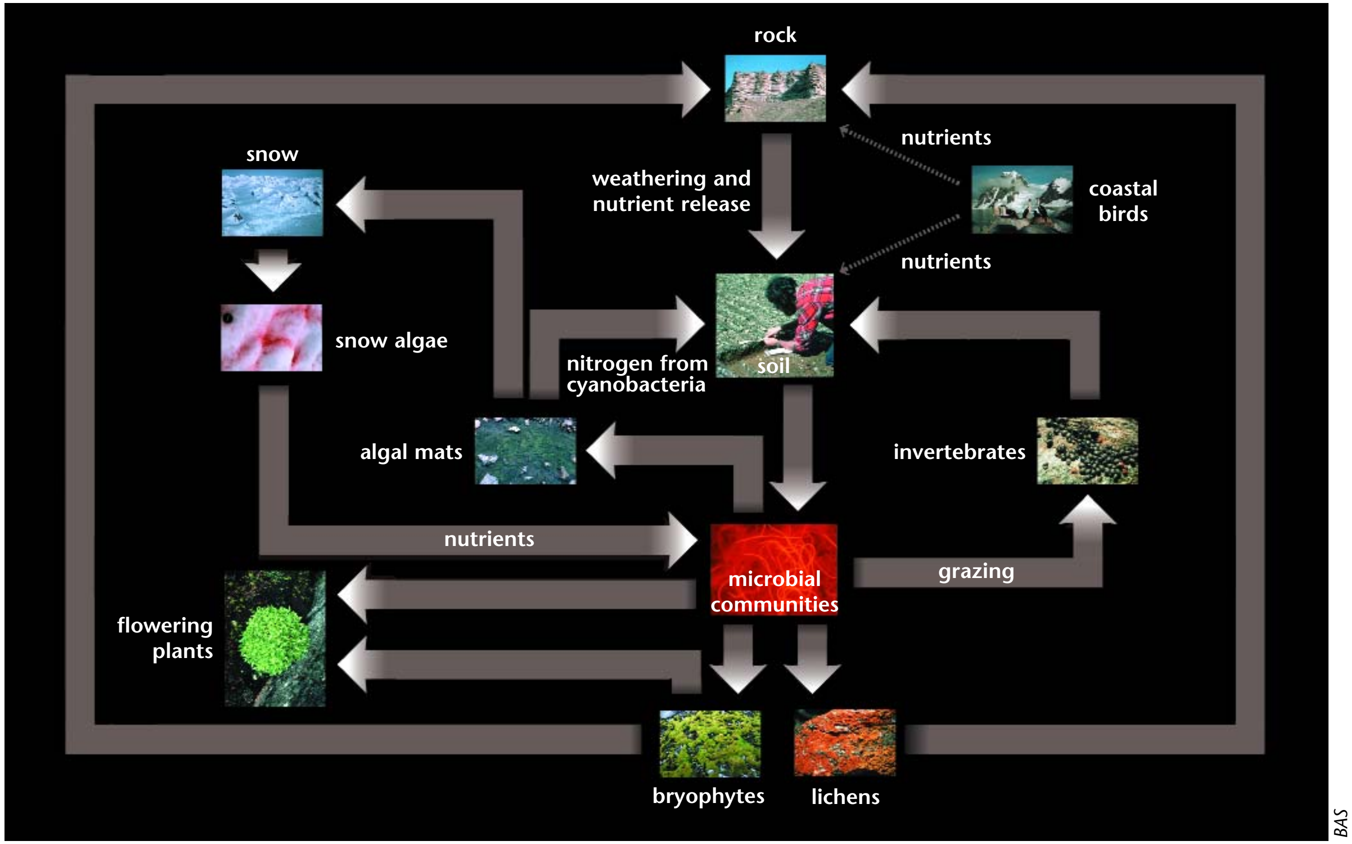
Terrestrial plants

The ice sheet itself is almost sterile, although single-celled algae can grow on coastal snowfields and stain the surface red, green or yellow. However, in continental Antarctica, lichens and sometimes mosses, can survive on the mountains (nunataks) protruding through the ice. Only about 30 different species of moss and 125 species of lichens are found in all of continental Antarctica, including coastal areas.

In the ice-free, cold desert of the Dry Valleys in Victoria Land certain crystalline rocks contain remarkable 'endolithic' ecosystems comprising cyanobacteria, lichen, algae and fungi that have survived for thousands of years.

The greatest diversity of species and the most extensive stands of vegetation are found in the maritime Antarctic. Here the number of species of moss recorded increases to 75 and of lichens to about 150. At favourable ice-free locations on the Antarctic Peninsula and nearby islands two species of higher plants grow. They are the Antarctic Hair Grass and the Antarctic Pearlwort.

The sub-Antarctic islands are more richly vegetated because of the milder climate. On South Georgia, for example, there are about 175 species of moss and 180 species of lichens. Vascular plants dominate the vegetation near the coasts of these islands, including stands of tussock grass.



The simple food web characteristics of the maritime Antarctic terrestrial ecosystem

Terrestrial animals

The vegetation in Antarctica supports a very limited fauna, which is dominated by mites and small flightless, primitive insects. However, where the vegetation is abundant large numbers of mites and springtails, as well as microscopic animals such as protozoans, rotifers and tardigrades can be found. On the Antarctic Peninsula and adjacent islands there are two species of midge. These are the largest terrestrial animals.

> **Task 1** Using the information provided in Resource TL1 and the terrestrial food web shown on this page, construct an ecosystem diagram showing the species that can be found at each trophic level.

Life in the lakes

Freshwater lakes are common in the maritime Antarctic. They support a relatively diverse ecosystem. Although most lakes are covered by ice 1 m thick for much of the year, plants can grow in them all year round. The bottoms of these lakes can be covered in dense mats of aquatic moss and blue-green algae. There are no freshwater fish or frogs. However, the lakes do support plankton, small crustaceans (e.g. fairy shrimps), worms and rotifers.

The coastal lakes near penguin rookeries and seal haul outs become contaminated by organic matter, nitrogen and phosphorus. This has the effect of encouraging dense layers of phytoplankton in the water which prevents light reaching plants at the bottom of the lake.

Certain areas of continental Antarctica such as the Dry Valleys contain remarkable saline lakes, which are so salty they are almost sterile.

Task 2 Resource TL2 describes the ecosystems which can be found in freshwater lakes. Write a short essay (maximum 2 pages A4) entitled:
'Compare and contrast the ecosystems that develop in Antarctic lakes which are permanently frozen over with those which experience only seasonal ice cover. Show how any differences are related to environmental conditions.'

Lake Vostok

In 1996, Russian and British scientists announced that they had discovered a vast freshwater lake the size of Northern Ireland buried beneath four kilometres of ice in the centre of Antarctica. Named Lake Vostok, after the Russian station above it on the surface of the ice, it is probably at least 500,000 years old and may be a unique habitat for ancient bacterial life. An international team of scientists is now debating ways to explore the lake. However, this must be done without introducing ice drilling fluids and surface bacteria which would pollute the lake's pristine waters. Specialists from NASA are interested in using the project to test ice drilling equipment which it hopes to send to Europa – an ice-covered moon of the planet Jupiter – to search for alien life.

Task 3 Resource TL3 describes Lake Vostok and its immense scientific value. It also explains how scientists are planning to explore the waters of this hidden lake.

- Imagine you are the project leader of the international science team which wants to probe the lake. Write a short Environmental Impact Assessment (EIA) of your team's research proposal. The report is to go to the annual Antarctic Treaty Consultative Meeting. Reference to Resource TL3 and Worksheet 14 on Environmental Protection should help you write your EIA.
- As a class discuss the major environmental impacts and scientific benefits of exploring Lake Vostok. Some environmentalists believe that drilling should not be allowed in order to preserve a unique and pristine part of Antarctica, while scientists believe that it will provide a unique opportunity to study life forms that have been cut off from the evolution seen in the rest of life on Earth.
- Carry out a poll of the class to see who thinks drilling should take place and who thinks it should not. Which point of view won?

Links between land and sea

Terrestrial and freshwater ecosystems are greatly influenced by the sea and by species which are part of the marine ecosystem. Spray, blown by strong winds, increases salt concentrations in soil, vegetation and fresh water near the coast. Penguins, seals and several species of seabird all breed, rest or moult on land and transfer nutrients to the land and lakes. Also, the heavy trampling of many birds and seals, together with heavy deposition of excrement, churns up the ground and can damage and destroy both land and freshwater vegetation.

Ecological effects of increasing fur seal populations

Since the early 1980s there has been a rapid population growth of Antarctic fur seals in Antarctica. This has led to considerable damage to terrestrial and freshwater ecosystems, particularly moss beds which the seals haul out on.

BAS

A male fairy shrimp (*Branchinecta gaini*)

Task 4 Read Resource TL4 which discusses the effects caused by the increasing fur seal population at Signy Island. Answer the following questions:

- Why has the fur seal population increased so rapidly (consider factors such as the depletion of whale stocks through whaling, legal protection of fur seals under the Antarctic Treaty System, changes in environmental conditions)?
- What are the effects of the fur seals on both terrestrial and freshwater ecosystems?
- Can the impacted ecosystems ever be expected to recover?
- What control measures could be used to limit the impacts, and how might these be implemented through the Antarctic Treaty System?

As a class, discuss the options that might be open to decision-makers to control fur seals. One of the options you should consider is culling seals. Justify the choice of the best options.

Lessons for management

The strong linkages between the land and the sea in Antarctica shows that management of natural resources must be done in an integrated way. This means, for example, that protection of the fur seal needs to take into account the effects of this policy on other species living in the Antarctic.