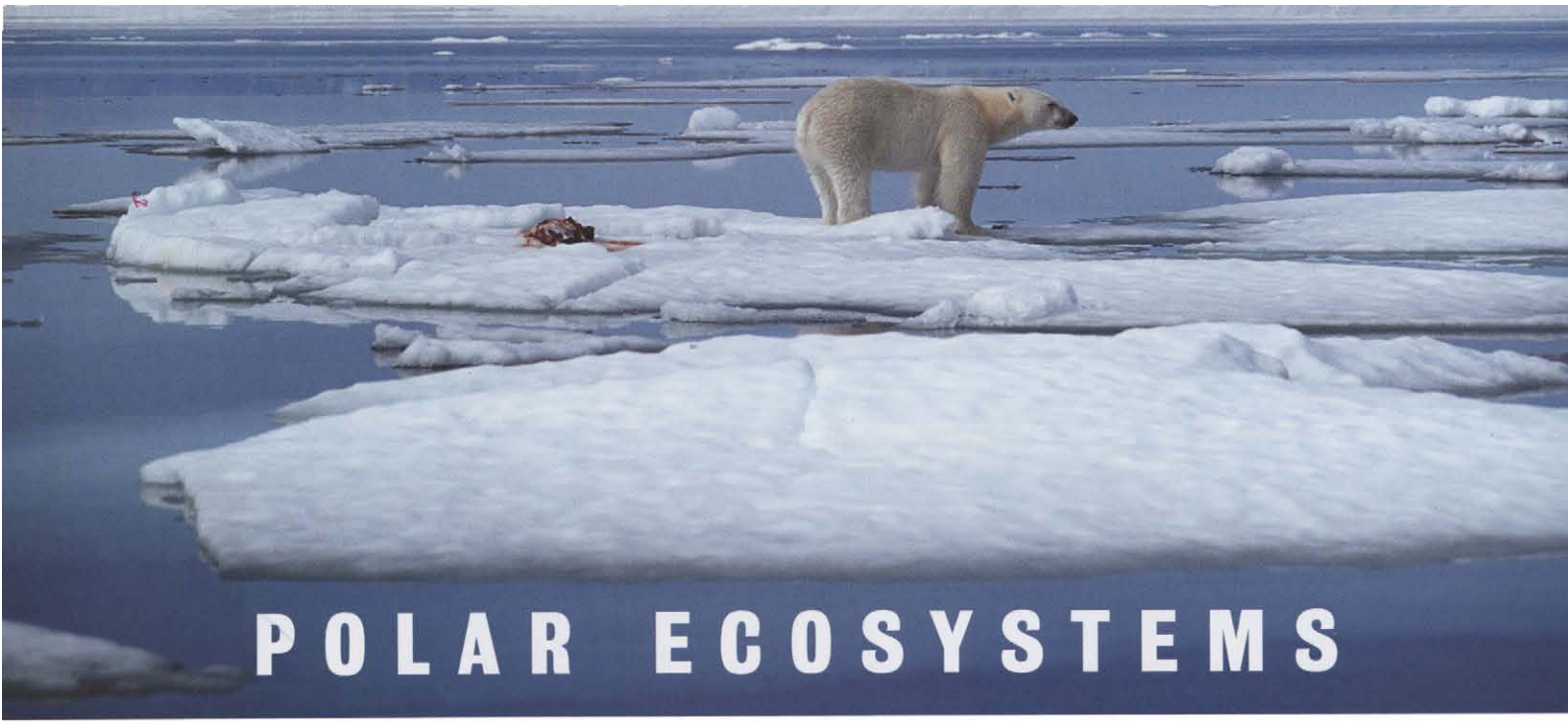


POLAR ECOSYSTEMS

The polar regions are the most remote places on Earth, yet their extreme conditions—cold, high, dry, windy, and largely removed from the public eye and political priority list—heighten their vulnerability. How the Arctic and Antarctica will respond to global environmental changes is a growing concern because these regions strongly influence the global climate system, hold a wealth of mineral and biological resources, and contain most of the world's freshwater as ice and permafrost. The fate of polar resources may signal dangers that will later become apparent in the rest of the world.

Managing the polar ecosystems requires cooperation. Eight countries share jurisdiction over the Arctic: Canada, Denmark/Greenland, Finland, Iceland, Norway, Russia, Sweden, and the United States. Antarctica is managed by interested countries on the basis of international agreements, although various countries have claims of sovereignty—some contested—over the continent, some sub-Antarctic islands, and adjacent territorial seas (UNEP 1999:327,329).

Extent of Polar Ecosystems

The areas surrounding the two poles have some things in common—cold climate, snow, and ice. Otherwise, their land and marine ecosystems are significantly different. A thick ice sheet covers the Antarctic continent; even during the summer season, only a few mountain and coastal areas are snow-free. The size of the ice sheet ranges from 4 to 19 million km^2, depending on the season; it is, on average, 2.3 km thick; and it represents 91 percent of the world's ice and the majority of the world's freshwater (GLACIER 1998; UNEP 1998:178). Surrounding Antarctica are open seas that have a productive shelf and upwelling areas where the shelf meets warmer waters. Other than about 4,000 researchers, Antarctica is uninhabited (Watson et al. 1998:89).

The Arctic, in contrast, consists of a large, deep ocean covered by drifting ice sheets a few meters thick. The land areas, which surround the ocean and are usually considered part of the Arctic region, are dominated by polar desert and tundra vegetation, although they include some prominent ice caps such as Greenland's inland ice. The Arctic's marine waters include the shallow and deep waters south and west of Alaska, the Barents Sea, and the northern Atlantic. The Arctic tundra is home to about 3.5 million people, many of whom make a living from marine and freshwater fishing, hunting, and reindeer husbandry (UNEP 1999:179).

Goods and Services from Polar Ecosystems

Although polar regions include some of the last large areas where human activity has not overtly altered the landscape, scientists have found solid evidence that human activities—often occurring in other parts of the world—are modifying polar environments and the goods and services they provide.

REGULATION OF GLOBAL CLIMATE, OCEAN CURRENTS, AND SEA LEVEL

Earth's vast polar ice sheets serve as a mirror, reflecting a large percentage of the sun's heat back into space, thus keeping the planet cool. Without the ice sheets, more heat from the sun would be retained in the ocean and more would be released into the atmosphere, feeding the warming process.

A warmer climate would also promote the release of more CO_2. For the past 10,000 years, tundra ecosystems in the Arctic have sequestered atmospheric carbon and stored it in the soil;

the tundra and boreal region store about 14 percent of the world's carbon (AMAP 1997:161). Some parts of the Arctic may now be sources of CO_2 emissions, however, because of the faster decomposition of dead plant matter in a warmer climate. If the permafrost under the tundra thaws, methane releases could also accelerate global warming (AMAP 1997:161).

The planet's weather patterns are driven largely by water circulation in the world's oceans, which is, in turn, driven by Arctic marine ecosystems. Warmer surface waters, including those from the nine major freshwater systems that drain into the Arctic Ocean, cool when they enter the North Atlantic (AMAP 1997:11). They become denser and sink to the bottom of the ocean—several million km^3 of water each winter—and slowly push water south along the bottom of the Atlantic. These water currents affect rainfall and climate worldwide (AMAP 1997:12).

The vast ice sheets in Antarctica and Greenland also control the world's sea level. If they shrink, sea level could rise, ocean currents could shift, and weather patterns could change and bring drought, severe storms, and the spread of tropical diseases.

Gradual disintegration and ice melt in polar regions are part of natural processes, but scientists are exploring the possibility that climate change may be altering those processes. Measures of ice thickness taken by U.S. submarines between the 1950s and 1970s compared with recent measurements indicate that the ice covering the Arctic Ocean may have thinned dramatically during the last few decades. The older submarine data showed an average thickness of 3.1 m, whereas data at the same sites in the 1990s show an average thickness of 1.8 m (Rothrock et al. 1999:3469). Satellite observations since the 1970s show the Arctic Sea cover to be shrinking at about 3 percent per decade (USGCRP 1999).

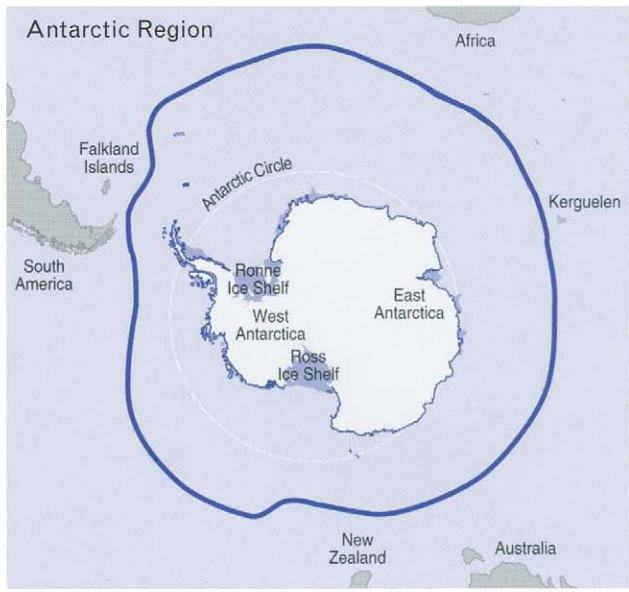
BIODIVERSITY

Hundreds of species are endemic to the Arctic, a place where organisms have adapted to the extremes of temperature, daylight, snow and ice found in polar regions. The Arctic also serves as habitat for several migratory bird species. Similarly, some islands of Antarctica have high levels of endemic species—some of New Zealand's southern islands are home to about 250 species, including 35 endemics. Still, much remains to be learned about the terrestrial fauna of the Antarctic, just as little is known about the fauna of the area's deep sea (UNEP 1999:183, 191, 192).

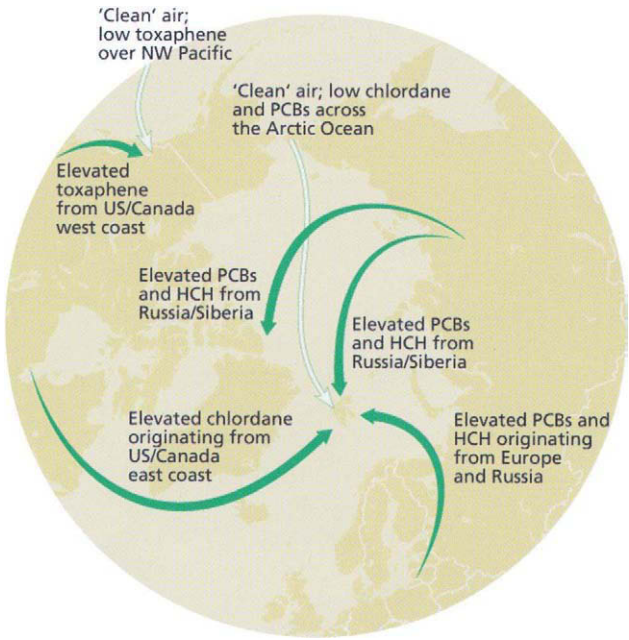
Pollution

Pollution may be the most immediate and evident threat to polar biodiversity. Airborne pollutants have turned the Arctic into a "sink" for contaminants from all over the world. Persistent organic pollutants (POPs) and other toxic chemicals travel on air, water, and wind currents until they settle in the Arctic, where they bioaccumulate in the food chain (AMAP 1997:viii). Radioactive materials have also accumulated in the Arctic; sources are fall-out from nuclear bomb tests, the accident at Chernobyl, and releases from European nuclear fuel reprocessing plants. For the general population in the Arctic and sub-Arctic, exposure to radioactive contamination is about five times higher than expected levels in a temperate area. Indigenous populations, who rely mainly on terrestrial food products, such as reindeer meat, have about 50 times higher exposure than other Arctic citizens (AMAP 1997:122–126).

The effects of POPs on wildlife are not fully understood, but it is clear that the biomagnification effects on certain species—birds, seals, polar bears, and others at the top of the food chain—are grave and will continue to worsen (UNEP 1999:184, 185). Polychlorinated biphenyls (PCBs), for exam-



Polar Pollution: Source regions for contaminated air



Source: AMAP 1997:79.

ple, are already found in polar bears in concentrations likely to affect their reproductive ability (AMAP 1997:89). People living in the polar regions exhibit similar high exposure to toxins with contaminant levels that can be 10–20 times higher than in most temperate regions (AMAP 1997:172). Numerous studies have linked even low-level or short-term exposure to dysfunction of the immune system, neurological deficits, endocrine disruption, and cancer.

Resource Extraction

Natural resource extraction is a growing threat to the biodiversity of polar ecosystems. Oil exploration is increasing, for example, and already its track record for pollution control includes 103 major pipeline failures in the Russian Federation between 1991 and 1993 (AMAP 1997:150). Natural resource extraction also causes damage to tundra, which is vulnerable to vehicular traffic. During the summer season, only the top few feet of soil melt, creating a layer of very wet soil between the permafrost and the thin vegetative cover. Erosion of the top vegetation easily leads to large-scale soil erosion that, because of Arctic ecological and climatic conditions, will take centuries to repair, while inducing further melting of the permafrost.

Ozone Depletion

It is not clear how ozone depletion in polar regions will affect biodiversity. Ozone depletion is more pronounced near the poles than elsewhere in the world. In 1985, a massive ozone hole was discovered over Antarctica in the spring. In recent years, ozone depletion over the Arctic has also been evident in smaller, less frequent holes (generally a few hundred kilometers in diameter, lasting a few days each), but the trend was clearly one of decreasing ozone levels through the 1990s in all seasons (Fergusson and Wardle 1998:8, 19; UNEP 1999:177). Ultraviolet (UV) radiation levels estimated in the spring, compared to the 1970s, are now about 130 percent higher in Antarctica and 22 percent higher in the Arctic (UNEP 1998:1). Polar ecosystems' heightened exposure to the sun's harmful UV-B rays could increase the incidence of cataracts and eye and skin cancer for humans, adversely affect plants and plankton accustomed to low-UV radiation, and perhaps harm algae at the base of the marine food web (UNEP 1998:xi–xiii).

Climate Change

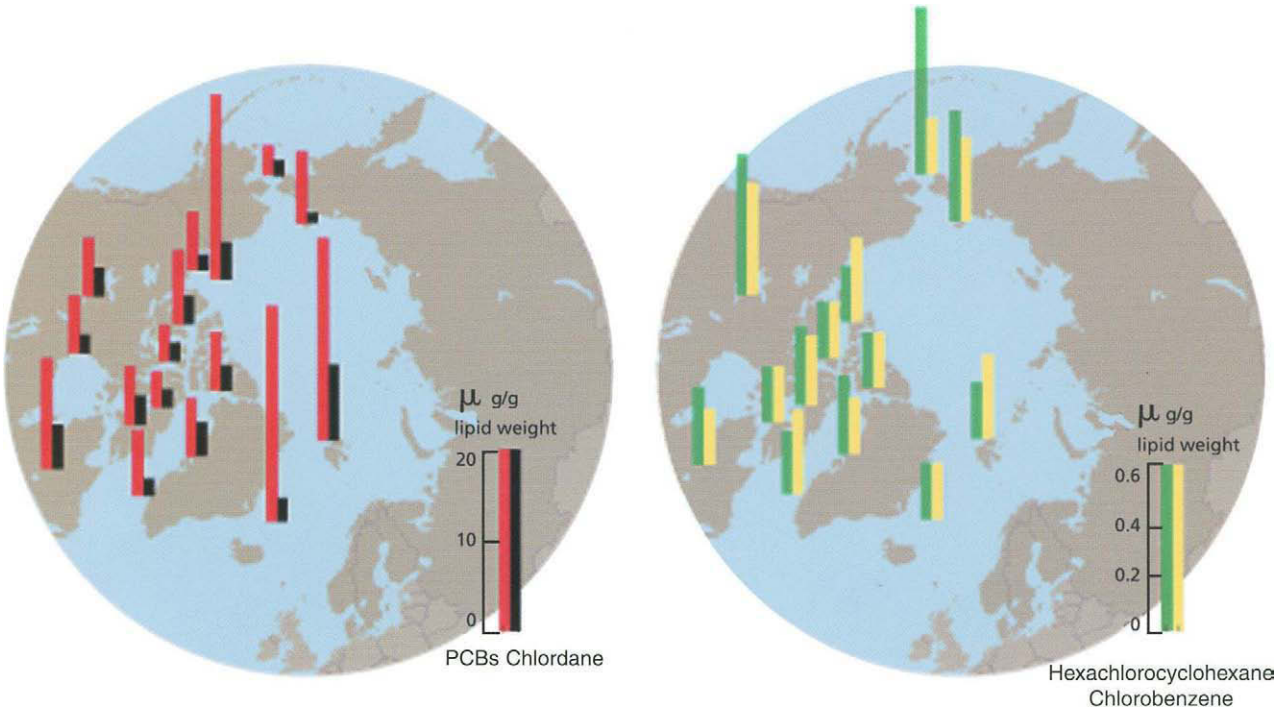
The effect of climate change on polar biodiversity is another unknown. Warmer temperatures could convert tundra to boreal forests, change migration patterns of polar bears and caribou, alter the distribution of some small mammals whose food sources may be disrupted, and change fish species composition, among other effects (Watson et al. 1998:95–99).

FOOD PRODUCTION

The Arctic marine waters are among the richest fishing regions in the world and a major contributor to the world's fish catches. In much of Newfoundland, Greenland, Iceland, the Faroe Islands, and northern Norway, fishing is the primary livelihood (Hamilton et al. 1998:28). Local populations, particularly rural indigenous communities, are particularly reliant on hunting and fishing. Indigenous groups comprise about 50 percent of the population of Arctic Canada; and in some regions of the Yukon as much as one-third of the population lives off the land and another 30 percent support their families with activities that are not part of the cash economy (AMAP 1997:57). In much of Arctic Russia, reindeer meat is the primary food source and herding the main occupation. Secondary food sources may include moose, brown bear, bighorn sheep, alpine hare, ducks, geese, and other birds and fish.

Several polar fish stocks have been adversely affected in recent years, including salmon, cod, northern char, herring, and capelin. In the Faroe Islands, for example, cod landings decreased from about 200,000 tons to less than 70,000 tons between 1987 and 1993 after Faroese investments in catching and processing led to overfishing (Hamilton et al. 1998:30). Sometimes poaching is the biggest problem; Patagonian toothfish harvests have been driven to the brink of collapse in the Antarctic in the last 6–7 years because of illegal fishing

Polar Bears at Risk: Persistent organic pollutant (POPs) levels in polar bear tissues at several arctic locations



Source: AMAP 1997:89

and lax catch-limit enforcement. In 1997 the reported legal catch of Patagonian toothfish was 10,245 tons; the illegal catch was estimated at more than 100,000 tons in the Indian Ocean sector of the Southern Ocean alone (UNEP 1999:176).

RECREATION

There is a growing desire to explore polar areas. In the early 1990s, more than a million tourists were drawn to the Arctic (UNEP 1999:182). About 10,000 visited Antarctica in 1998–99, and a more than 50 percent increase to almost 16,000 was projected for 1999–2000 (IAATO 2000). Those may seem small numbers relative to the vast areas, but they have the potential for detrimental effects. Tourists are thought to frighten wildlife like breeding penguins in Antarctica, leave behind garbage, and create noise and pollution.

FEEDBACK

The poles are important to the world as early indicators of the pressures we are placing on global resources. For example, we can use analyses of the condition of the Arctic to better understand stratospheric ozone production, atmospheric cleansing, and pollution transport in northern latitudes. The massive ice sheets also serve as a kind of "time capsule" of information about volcanic activity, storminess, solar activity, and atmospheric composition (Stauffer 1999:412). Ice cores recently excavated from Vostok station in East Antarctica show that atmospheric concentrations of carbon dioxide and methane, two important greenhouse gases, are higher now than they have been in the past 420,000 years (Petit et al. 1999:429).

The Bottom Line for Polar Ecosystems. The polar ecosystems are still relatively unmodified when compared to other ecosystems, but their once-pristine condition already shows signs of climate change and other pressures. The effects of climate change are greater in polar regions than anywhere else on Earth. It is still unclear whether the ice thinning that has been observed in select areas is part of a natural climate variation or the result of human activities; nor is it clear whether the overall mass of the world's polar ice sheets is growing, shrinking, or fluctuating within normal parameters. But polar regions provide ample evidence of warming via ice cores and glacier retreat (Watson et al. 1998:90–91). Meanwhile, the immediate disruption caused by pollution and unsustainable levels of commercial fishing of some stocks is significant and growing.