INTERNATIONAL POLAR YEAR

Land and Life

Polar landscapes and polar terrestrial ecosystems extend from southern cold maritime islands to dry continental deserts in Antarctica and from tree line across the continental tundra to remote northern islands in the Arctic. Ice, in the forms of permafrost, snow, and ice cover, plays a dominant role in all these environments, and the biological communities survive through remarkable adaptations and extensive migration. Polar ecosystems also survive in alpine areas. The climatological and ecological pressures that act on mountain-top populations also act on the northern-most and southern-most ecosystems.

Permafrost

Land around the perimeter of the Arctic Ocean contains permafrost: continuous regions of soil frozen to depths of 500 to 1000 m. Under-ocean sediments around the Arctic coast, ice-free land on the Antarctic continent and sub-Antarctic islands, sediments under some Antarctic ice sheets, and some mountain regions also contain permafrost. At its southern edge, northern permafrost becomes thin and discontinuous. Seasonal thawing and freezing of the soil forms a shallow active layer that overlies the permafrost. In contrast, deep permafrost may have existed in a frozen state for thousands of years. Frozen soils have greater mechanical stability than unfrozen soils; hydrological systems, landscapes, ecosystems, and human structures have evolved or developed on the basis of this ice-cemented stability. Permafrost soils store vast amounts of organic carbon. As permafrost degrades, chemical and microbiological decomposition processes may convert the stored carbon to greenhouse gases.

Hydrologic Systems

A complicated series of lakes, ponds, wetlands, streams, and rivers modify polar landscapes, influenced by precipitation, small glaciers, ground water, and underlying permafrost. In general, hydrologic systems discharge to the ocean, carrying sediments and dissolved materials. Ice formation and break-up dates on many water systems control heat exchanges with the atmosphere, the productivity of aquatic ecosystems, and the migration and feeding of birds and animals. Snow accumulation and snowmelt influence land heating, soil moisture, and stream flows. The fresh waters support local and migratory birds, insect larval stages, and valuable fish; they also provide drinking water and transportation corridors for wildlife and humans. The strong role of ice in polar hydrologic systems, including snow, ice cover, and underlying frozen substrates, indicates high probability of change under a warming climate.

Vegetation

Terrestrial vegetation in polar regions survives despite extreme cold,

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long periods of darkness, and high exposures to UV B radiation. Plants in ice-free areas of the Antarctic continent also suffer desiccation and lack of soil. Tundra regions, lying over permafrost in the Arctic, contain low-lying plants but generally lack trees or shrubs. Microbial communities provide decomposition and recycling services to polar ecosystems by using unique physiological and biochemical capabilities developed to meet the challenges of polar habitats. In the Arctic, vegetation responds to climate change and to related disturbances including fires, insect outbreaks, and human-induced habitat fragmentation. Changes in the composition and biomass of polar vegetation will affect permafrost, carbon reserves, hydrological systems, polar and global biodiversity, wildlife populations, and, in the Arctic, habitability.

Birds and Animals

Land areas of the Antarctic continent contain invertebrates, but no terrestrial birds or animals. Arctic landscapes support local and migratory birds, freshwater fish, and animals well adapted to polar conditions. Arctic species often display different ecological forms and life histories depending on their situations and locations. In many Arctic terrestrial ecosystems, geese, lemmings, and muskox serve as the main grazers, shorebirds serve as the main insectivores, and fox and birds (owls, falcons, gulls) serve as the main predators. Arctic char serve as top predators in freshwater and as an important food resource for humans. Many birds migrate to the Arctic for summer feeding and breeding. Polar birds and animals face a multitude of pressures, including invasive competitors, exploitation, contaminants, habitat change, and climate variability and change. Although polar regions have low levels of pathogens and parasites, migratory birds carry diseases poleward.

Coastal Environments

Most exposed lands of Antarctica occur on islands or lie near the ocean. Most Arctic tundra vegetation zones lie within 100 km of the ocean. Ocean conditions, particularly the presence or absence of sea ice, have strong impact on polar terrestrial systems, especially in coastal zones. Exports of fresh water, nutrients, sediments, and contaminants from land to ocean, and most high-latitude human activities, occur in coastal regions. High-latitude coasts experience rapid erosion as permafrost degrades, sea ice moves or retreats, and wind and waves increase. Decomposition of carbon in offshore permafrost may release greenhouse gases while increases in river flows may alter regional and large-scale ocean circulation. Many coastal glaciers show changes, with impacts on meltwater and sediment flows and global impact on sea level.

Polar Extreme Environments

The harsh climates and exotic biology of Antarctic dry valleys provide an analogue to the more extreme environments of northern polar regions of Mars. Understanding how the Antarctic dry valleys record past climates and how dry valley biota survive will provide useful information during future explorations of Mars.

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Polar Lands Activity: Permafrost Demonstration

Materials:

- Two clear, wide-mouthed plastic containers or jars (approximately 500 mL each)
- Ice cubes
- Sand and local soil (enough to fill one jar with each)
- Toothpicks and modelling clay
- Water

Preparing the permafrost:

1. Put layers of wet sand in one jar and of wet soil in the other, filling each 1/3 full.
2. Place 3-5 ice cubes on top of the sand or soil, filling the jar to the 2/3 mark. This represents 'ice wedges' that form in cracks in the frozen soil as the permafrost expands and contracts with seasonal temperature changes. (See http://arctic.fws.gov/permcycl.htm for more information.)
3. Cover the ice with a second layer of sand or soil.
4. Moisten the entire sample with water and freeze for at least 24 hours.

Activity:

1. Construct two small structures from clay and toothpicks and place them on top of the frozen samples. Use the toothpicks to hold the structures in place.
2. Predict what you think will happen as the frozen soil and ice thaws? What will happen to the ice? …the soil? …the structures?
3. Allow the samples to thaw and note what happens.

Discussion questions:

1. How did the thawing of the permafrost affect your structures? Did the type of soil make a difference?
2. What happened to the surface of the ground when the permafrost thawed? How might this affect vegetation or animals in permafrost regions?
3. Permafrost contains large quantities of stored organic carbon. How might the thawing of permafrost affect levels of atmospheric greenhouse gases such as carbon dioxide and methane?

Find these and other educational materials in: Kaiser, 2010, Polar Science and Global Climate, An International Resource for Eduation and Outreach, ISBN 978 1 84959 593 3, www.pearson.co.uk.

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