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other fish species cross from the marine to the freshwater ecosystem to breed. Polar bears den on land in snow banks, but only survive by hunting, almost exclusively out on the sea ice. Seals make dens on sea ice and hunt in the ocean. Indigenous peoples – relying heavily on the integrity of ecosystem services – use living resources across all the Arctic’s marine, terrestrial and freshwater ecosystems and habitats: the sustainability of their cultures therefore directly depends on sustaining its biological resources. Ecosystem functioning and integrity strongly depend on the diversity and activity of the soil, flora, fauna, and microbes. But little is known about this diversity, how it will change and what the consequences will be in a changing environment.

Ecological balance

Arctic biodiversity is experiencing increasing stress from sources including climatic warming and associated melting of sea ice, pollution and the transport of contaminants, habitat fragmentation from development, over-harvesting of wildlife, and invasive species. Species adapt to some degree to these stresses, but their relatively small number in the Arctic means that the ecological balance may critically depend on only one or two of them, rather than on several with overlapping ecological roles, as in lower latitudes. Losing one or two species can therefore lead to the collapse of an entire food web, and unbalance an entire ecosystem.

Warming trends, and resulting fluctuations in snow cover and lake/river ice, are impacting ecosystems from the base of the food webs upwards. Changes in the abundance of mosses and lichens will probably lead to changes in the migratory patterns of reindeer and ►

Life at the Extreme

VITALY CHURKIN describes the fragility of biodiversity in the Arctic and says that conserving it is a global challenge and responsibility

Life in the Arctic has adapted to extreme conditions of seasonal darkness and cold, followed by a brief intense burst of growth during a short summer season when food becomes plentiful. Arctic animals must therefore survive long periods when food is limited or unavailable, or migrate to more southerly latitudes. When sunlight reaches the oceans in the spring, plankton rapidly bloom, creating a burst of growth in Arctic marine ecosystems. Similarly, the growth of plants on land begins a summer feast for terrestrial animals, allowing the breeding and raising of young, and enabling storage for the coming winter.

Arctic biodiversity generally boasts relatively few species compared to lower latitudes – although they often have large populations – reflecting high

genetic, morphological and behavioural diversity. Highly specialised phytoplankton and sea ice algae species form the foundation of the marine food webs: they are specially adapted to extremes of darkness and cold, and to the freshwater–brine conditions of the sea ice – ocean interface. Mosses and lichens, similarly specially adapted to the Arctic, are the foundation for many terrestrial food webs.

Intricately linked

Terrestrial, freshwater and marine Arctic biodiversity are intricately linked through the interplay between terrestrial and marine species, habitats and ecosystems. Seabirds nest on land but may feed on fish and invertebrates in the ocean, lakes and rivers. Salmon, arctic char and several

caribou, their breeding behaviour and population dynamics. Reindeer herding and caribou hunting is vital to the economic and cultural sustainability of many indigenous communities. Lemmings and voles, relying on mosses and lichens for food, are also affected by change – which in turn impacts raptors like the snowy owl and carnivores like the Arctic fox. Polar bears and seals are under threat from the reduction of sea ice, and the indigenous communities that hunt them are finding that their numbers are declining.

Invasive species

More southerly flora and fauna are shifting northwards as the climate warms, moving into niches occupied by Arctic species – as are bacteria and viruses to which northern species have never been exposed, and against which they have no immunity. The Arctic Ocean prevents terrestrial species already living at the northernmost coastal boundaries of their habitats moving further north, so those along the northern Arctic coasts are now among the most threatened in the world by invasive species, declining food resources and loss of habitat.

One of the greatest changes of all is expected to occur when scrubs and trees invade the tundra, displacing its habitats and species. In some places, where the forest is near the Arctic Ocean coast, this displacement will be complete, as the invading vegetation brings a new flora and fauna. This major change in biodiversity will, in turn, lead to increased warming since forests absorb and retain more heat than reflective snow and tundra vegetation.

More than 80% of the approximately 370 indigenous settlements in the Arctic tundra regions are on the coasts. Early melting of sea ice and late freezing of lake and river ice are disrupting migration and hunting patterns, while increasing diseases of fish and plants are endangering the quality of food.

Sustainable development in the Arctic is one of the primary goals of the Arctic Council – a high-level

intergovernmental forum comprised of the eight Arctic countries (Canada, Denmark, Finland, Iceland, Norway, Russia, Sweden, and the USA), six indigenous peoples' organisations (Aleut International Association, Arctic Athabaskan Council, Gwich'in Council International, Inuit Circumpolar Conference, Russian Association of Indigenous Peoples of the North (RAIPON) and Saami Council) and official observers (including France, Germany, the Netherlands, Poland, the United Kingdom, IGOs, NGOs, and other international bodies).

The Arctic Climate Impact Assessment (ACIA), recently completed under the Council's aegis, thoroughly assessed the current and potential future impacts of climate change and UV-B radiation on biodiversity. The Council's Conservation of Arctic Flora and Fauna Working Group (CAFF) is mandated to protect Arctic biodiversity and establish marine and terrestrial protected areas. Working closely with indigenous communities – whose active participation is crucial to achieving sustainable development – it is launching the Circumpolar Biodiversity Monitoring Programme (CBMP).

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The purpose of the CBMP – which was fully endorsed by the Arctic Council ministers in November 2004 – is conserving Arctic biological diversity through an international network of coordinated efforts to halt or significantly reduce Arctic biodiversity loss, and providing information for the sustainable use of the Arctic's living resources for the indigenous peoples of the Arctic and other Arctic residents, as well as stakeholders inside and outside the region. One of the primary ways CAFF will collect status and trend

information on Arctic biodiversity is through cooperating with indigenous communities and launching circum-Arctic community-based monitoring initiatives.

Monitoring natural and anthropogenic impacts to the food webs and ecological functions of the Arctic environment and ecosystems, provides critical information about the status and trends of species and the integrity of the food webs on which they depend for survival. This directly relates to the socio-economic and cultural stability of Arctic resident societies.

Sustainable development

Preserving the Arctic's biodiversity cannot be achieved by the Arctic countries alone. The migration of birds and marine mammals link the integrity of its biodiversity and ecosystems to all other regions of the globe. 279 of the approximately 450 species of birds which have bred in the Arctic region seasonally migrate to other parts of the globe, reaching everywhere except the Antarctic interior. Thirty reach southern Africa, 26 reach Australia and New Zealand, and 22 reach southern South America, while several pelagic species reach the southern oceans. Virtually all the world's major ecosystems support Arctic breeding birds: they occupy every major habitat in every major region.

The CBMP will help signatory countries meet the Millennium Development Goals – particularly Goal 7, ensuring environmental sustainability and the target of significantly reducing the rate of biodiversity loss by 2010. Conserving Arctic biodiversity is a global challenge, touching virtually all the world's major terrestrial and marine ecosystems, and requiring a high level of international cooperation. Balanced ecosystem functioning and services are inextricably linked to sustainable development. This fundamental principle is the foundation for long-term conservation and sustainable use of Arctic biodiversity, and for the sustainable development of Arctic communities ■

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