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Research in the Lapland Biosphere Reserve

Lapland State Reserve *(Laplandskiy Zapovednik)* was established in 1930 to protect the northern taiga and mountain tundra, and particularly to conserve the Kola reindeer *(Rangifer tarandus* L.*)*. In 1985 it was further designated a Biosphere Reserve by UNESCO. It is situated just north of the Arctic Circle on the Kola Peninsula, which separates the White and Barents seas (Figure 1). The reserve covers about 280,000 ha, its size having been doubled in 1983 to compensate for damage from industrial emissions (of which more below). Fifty-two percent is forested, 28% is mountainous, lakes comprise 4%, and the rest is wetlands, elfin birch woodland, and so forth.

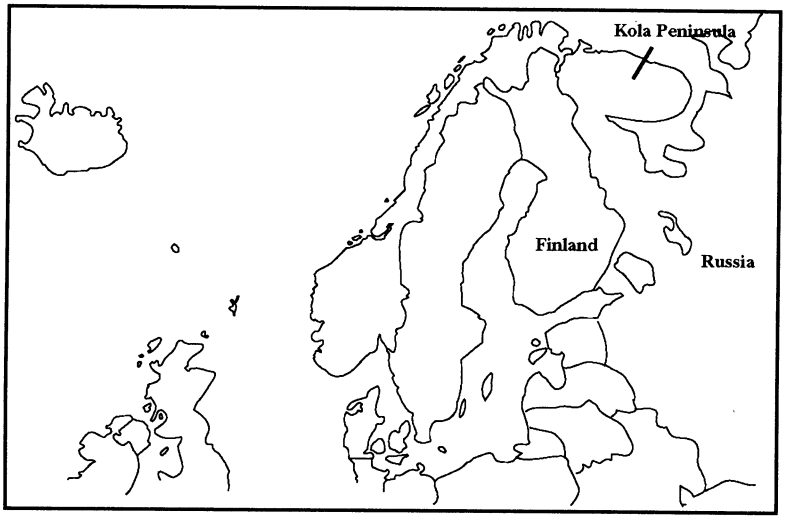

Figure 1. Map of northern Europe showing the location of the Kola Peninsula.

The reserve is national property, and most uses within it are strictly controlled. (Between 1951 and 1958 the reserve was closed and some of its pine forests were cut and burnt.) Now, all economic activity, including recreational use, touring, fishing, hunting, and gathering, are forbidden. There are no settlements except for the forest guard stations along the reserve's boundary. There are also no roads; traffic is realized only by snowmobiles in winter along appointed routes, mainly along the boundary. One travels through the reserve mainly on foot. There is a staff of 40, including 18 guards and nine scientists, operating on a budget of 265 million rubles (about US$66,000).

Broken terrain prevails in the reserve, with hills, river valleys, and five small mountain ranges with altitudes of about 600 to 1,100 m. The highest summit, Abr-Chorr at the north end of the Chuna range, rises to 1,114 m. Eight river–lake systems drain into both the Barents and White seas. Except for the higher mountain tops, the bedrock is cov-

ered almost wholly by quaternary deposits. Podzols and peat bog soils predominate.

The climate is subarctic maritime. Winters are long but comparatively mild (average January temperature: -12.3 degrees C.); the snow season runs 140-160 days with depths averaging 130 cm, and ice forms on the lakes to thicknesses of 100 cm. Summers are cool and short (average July temperature: 14.1 degrees C.). The winds, seldom calm, are frequently strong. Precipitation averages 490 mm annually.

Northern taiga, coniferous, and mixed forests prevail below the altitudinal timberline. Small shrubs and ground lichens grow in the mountainous areas, and plants specific to marshes and other wetlands are found in those habitats. Some 523 species of vascular plants are known from the reserve, including 13 rare species: the lichen *Lasallia rossica* Domb.; the ferns *Woodsia alpina* (Bolt.), *Cryptogramma crispa* (L.), and *Polystichum lonchitis* (L.); and the flowering plants *Calypso bulbosa* (L.), *Pseudorchis albidus* (L.), *Saxifraga tenuis* (Wahlenb.), *Cassiope tetragona* (L.), *Diapensia lapponica* (L.), *Cotoneaster cinnabarina* Juz., *Epilobium alsinifolium* Vill., *Myosotis frigida* (Vestergr.), and *Veronica fruticans* Jacq.

The reserve is inhabited by 31 species of mammals, including the Kola reindeer, elk, brown bear, wolf, pine marten, ermine, squirrel, wolverine, European beaver, and Norwegian and wood lemmings. There are 192 species of birds, five of which are listed in the Red Data Book as threatened or endangered: the osprey, sea and golden eagles, gyrfalcon, and peregrine falcon. There are also two species of reptiles, one of amphibians, and 15 of fish. Invertebrates are not yet studied well enough. So far, 18 orders and 95 families of terrestrial invertebrates are known.

A considerable part (roughly 30%) of the reserve is affected by sulfur dioxide, nickel, and copper emissions from the nearby Severonickel Smelter Complex. In fact, mean sulfur dioxide concentrations exceed the background in an area of at least 2,500 sq km around the smelter. Severonickel was built in 1935, and since 1947 has been producing nickel and copper. Another grave anthropogenic problem is poaching.

What follows is a sketch of the results of scientific research done by reserve staff. Over the years many scientists from different organizations have worked in the Lapland Reserve. The aim of this section is to give a clear view of the activity of the reserve's own science department.

Reindeer. The study of the Kola reindeer was the main emphasis at first, beginning with the foundation of the reserve in 1930. Reindeer were almost exterminated in the Kola Peninsula by the end of the 19th century. Thanks to the protection afforded by the reserve, their numbers increased to 12,640 by 1966-67. That number was excessive, resulting in degradation of the lichen pastures. Animals were underfed, the birth rate decreased, mortality increased, and as a result the population declined over the next 18 years. In 1972 reindeer began leaving the reserve because the lichens were so depleted, and their numbers were driven down even further by overhunting in the adjacent territory. The population in the reserve fell to 168 in 1982. Now there are more than 600, in consequence of a rehabilitation of the lichen pastures and the prohibition of hunting. The reserve holds a great osteological collection of reindeer and elk, with about 800 pieces.

Small mammals. There is a fifty-year record of observations of small mammals in the reserve. They have been seriously hurt by the Severonickel emissions. Twenty percent of the species have disappeared, and various damaging effects have been noted in some of those remaining: populations have fallen, reproduc-

tion has been depressed and onset of puberty delayed, mass deaths have been noted, heavy metals have accumulated in tissues, and chromosome aberrations have been found in tissues. The severity of all of these disturbances increases as one moves closer to the smelter.

Beaver reintroduction. In 1934, fourteen beaver from Voronezhskiy Reserve were released in the Lapland Reserve. Their numbers reached 132 by 1947 before they overpopulated the reserve's suitable habitat. This, along with the closing of the reserve in the 1950s, nearly resulted in their disappearance. Between 1970 and 1990 they numbered about 16-20. It is thought that perhaps the expansion of the reserve in 1983 will help to increase their numbers.

Birds and fish. As with mammals, the reserve's birds and fish have shown a variety of adverse impacts from the smelter's emissions. More bird species nest on the ground because of damage to the forest canopy. Bird numbers in affected areas are five to six times lower than elsewhere. Heavy metals have accumulated in tissues of adults, young, and eggs. All disturbances increased with increasing proximity to the smelter. Fish are affected by a "volley" of heavy metals that comes during the annual snowmelt, and their growth, fertility, quality of spawn, and population structure have been adversely affected.

Plants. The reserve's herbarium represents fifty years of collecting. The inventory of higher plants is complete and, in the main, published; the inventory of mushrooms and fungi is also done but has not been published. Epiphyte lichens have been used to monitor air pollution since the 1970s. Polluted zones have been mapped out according to lichen damage.

Heavy metals sampling. Snow sampling is probably the most widespread method of estimating heavy metals concentration on the landscape. Nickel and copper deposition has been found in appreciable amounts in an area of more than 5,000 sq km, with concentrations exceeding the background by many times over 2,000 sq km. Forest and peat bog soils are sampled over half of the reserve, in parts of the town of Monchegorsk, and a considerable part of the non-reserve area affected by the smelter's emissions. The soils in all these investigated areas are contaminated by nickel and copper. In and around Monchegorsk the concentration exceeds the background by 50-80 times. All samples are now being analyzed for other heavy metals. Laboratory experiments on soils samples are also carried out. Nickel and copper accumulation in edible wild berries and mushrooms has been studied since 1987. A belt 20-30 km wide and 70-80 km long exhibits nickel concentrations in berries and mushrooms ten times higher than sanitary standards, thus rendering these plants unsuitable as food. Concentrations in lichens are also being analyzed.

The size and spatial dynamics of sulfur dioxide, nickel, and copper pollution is thus being studied over a wide range of media. In general, emissions from Severonickel are affecting an area of about 3,000 sq km. The zones of concentration in different media tend to coincide with each other. This lends credence to the results of the research and indicates that a vast area around the smelter is being affected by the uninterrupted, massive airborne emissions. The Lapland Reserve research program continues to broaden, with more natural media, pollutants, and territory being studied.

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