European Environment Agency

Europe's biodiversity

- biogeographical regions and seas

Biogeographical regions in Europe

The Boreal biogeographical region

- **numerous lakes, vast coniferous forests dominate**

(Draft chapter)

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CONTENTS

Summary

- The Boreal region is the largest biogeographical region of Europe.
- The climate is cool and mainly continental.
- It is Europe’s forest region, dominated by conifers. The forest area increases, getting more uniform and with less tree species and less biodiversity in the stands.
- The southern part with deciduous trees may slowly shift northwards with increasing temperature.
- The species rich small grassland patches are disappearing.
- Podzol and peat soils are dominant in many parts.
- 21 out of Europe's 24 largest lakes occur in the region.
- In summer the region houses vast populations of breeding migrating birds.
- The large European carnivors still inhabit the region, under severe pressure and facing opposing public interests (conservation, population control).
- The reindeer and wild living large grazing animals (elk, deer) strongly influence the habitat development in many forest and grassland areas.
- The region is the wild berry and mushroom region of Europe.

1. What are the characteristics of the Boreal biogeographical region?

1.1 General characteristics

Table 1: Statistics for the Boreal biogeographical region

Surface area ($km^{2)}$	Number of countries in region	National makeup of region by area	Population ($people/km^2$)	Main habitat type	Natural lakes
More than ¼ of Europe. 2 900 000, hereof 1 900 000 in the Russian Federation	8	RU 66 % SE 12 % FI 11 % BY 4 % EE 2 % LV 2 % LT 2 % NO 2 %	Less than 30 (2-3 in the north)	Forest and other wooded land 58 %	3/4 of Europe's 600 000 natural lakes 21 of Europe's 24 largest lakes

Source: compilation from various sources by ETC/NC, EEA and ETC/Water.

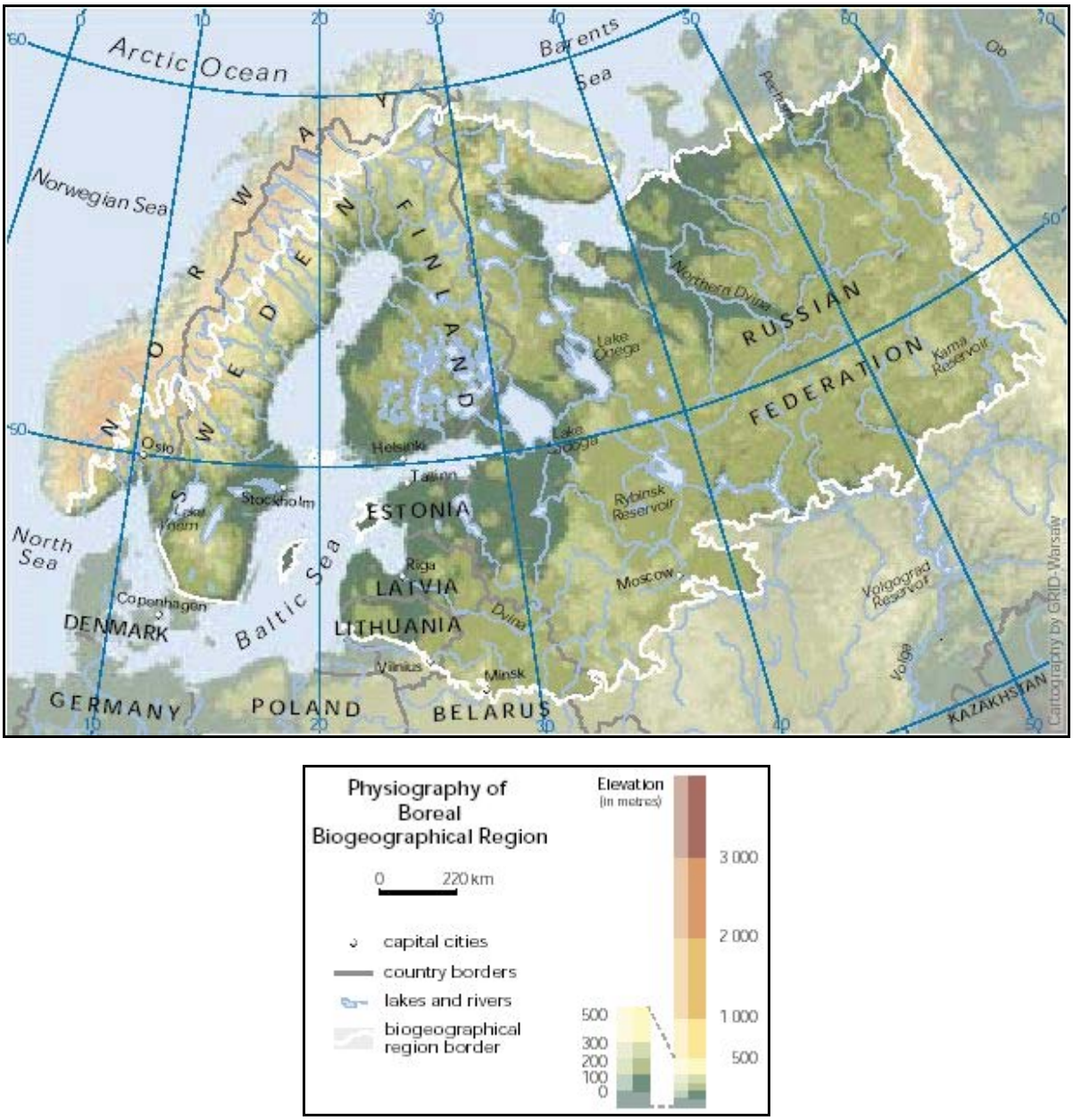
Note: RU: Russian Federation; SE: Sweden; FI: Finland; BY: Belarus; EE: Estonia; LV: Latvia; LT: Lithuania; NO: Norway.

The area treated in this chapter is the Boreal biogeographical region as defined by the European Commission and the Council of Europe for evaluation and reporting on nature conservation. In the south it borders on the Continental biogeographical region.

It covers around ¼ of Europe's territory and involves eight countries: south eastern Norway, the majority of Sweden, most of Finland, all Estonia and Latvia and the northern parts of Lithuania and Belarus. In the Russian Federation it stretches east to the Ural Mountains. It connects to two European Seas: the open Arctic Ocean via the White Sea and the semi-enclosed Baltic Sea.

It is the conifer dominated forest belt below the Fennoscandian alpine mountains and south of the Arctic biogeographical region, constituting part of the vast, circumpolar taiga belt of North America and Eurasia. It contains the sub-arctic Swedish, Finnish and southern Karelian parts of the Barents region as defined by the Barents Region Council.

Map 1: The Boreal biogeographical region physiography (elevation pattern, main lakes and rivers)



Source: EEA. UNEP/GRID Warsaw final map production.

1.1.1 Topography and geomorphology

Most of the Boreal region lies less 500 m above sea level, the main inhabited areas even below 200 m. Taiga forests and mires, numerous lakes and rivers form the characteristic mosaic landscapes of the Boreal region. Along the coasts bedrock archipelagos intermingle with low-lying brackish fens and grasslands.

The geology of the Boreal region is characterised by old weathered sedimentary rocks and bedrock, such as gneisses and granites. Glacial and post-glacial erosion and associated deposits have formed large undulating plains and rolling hills broken by occasional mountain outcrops and river valleys. The north European ice sheet carved out numerous depressions, which combined with the effects of a cool and moist climate, has resulted in an exceptionally large number of lakes, rivers and other wetlands. The massive ice layers depressed the land (more than 800 m). When the ice melted, large areas have been both

submerged and lifted out of the sea due to the combined effects of land uplift and sea rises during postglacial times.

In parts of the region the land uplift is still occurring at a rate of nearly 1 cm per year (http://www.sgu.se/search/index.htm search: uplift). It is felt mostly along the northern very shallow coast of the Baltic Sea, where strips of land gradually emerge from the sea, broad enough to induce cattle fencing and boat landing to be shifted outwards every generation, becoming naturally brackish fens and grasslands. These areas may be directly counter affected if a sea level rise will occur in the future. The highest uplift occurs in the area Höga Kusten in Sweden, which was declared a World Heritage area in 2001 with its high coast giving evidence of the uplift (more than 200 m). A map of the effect in the whole region is found at Chalmers University of Technology website (Sweden): http://www.oso.chalmers.se/popular/images/geo/uplift.html (22.11.2002)

The ice sheet wiped the land clean of most plants and animals, forcing them south and eastwards. Several species are still considered to be on a natural move back. This slow move is sometimes by-passed by human use of the same species (though often in other provenances) beyond the present natural distribution limits.

1.1.2 Soils

The young soils formed after the glaciation are generally shallow, with a poorly developed organic component. On well-drained ground, over large areas of the Boreal region, however, strongly layered, acidic podzol soils have formed as a result of organic acids leaching from the conifer needle litter. Leaching removes minerals from the characteristic podzols, resulting in reduced potential for plant growth. The leaching is enhanced by acidification. Where broad-leaved deciduous trees dominate in the southern part, especially near the Baltic Sea coast, richer brown soils with a better structure and balance of nutrients are more common. Paludification, the extensive formation of peat soils, is another typical feature of the region.

1.1.3 Boreal climate

The region has a cool-temperate, moist climate, varying from sub-oceanic in the west to sub-continental in the interior and the east. The most significant climatic factor for biodiversity is the length of the growing season, which defines the productive period, and the amount and duration of snow cover. The summer vegetation period varies between 100 days in the north and 200 days in the south. Precipitation varies between 500 and 800 mm per year, with extremes of 300 and 1 200 mm. Evaporation is low and prolonged periods of drought are rare. Snow covers the ground for several months during the winter. Average annual temperatures are generally low, but varies much over the region: with monthly mean temperatures varying from + 20 °C in the warmest months of the warmest areas to -15 °C in the coldest months in the coldest areas.

1.1.4 Population and settlement

The Boreal region is characterised by a striking contrast between increasingly large and heavily urbanised areas, situated mostly along the coasts and in the lowland plains along major rivers and lakes, and the vast forest dominated areas with a diminishing population.

The highest population density and urban development in the Boreal region in the big urban centres, such as Oslo, Stockholm, Helsinki, Riga, and Sankt Petersburg are found near the coast in the southern parts of the region. The largest urban centre of the region, Moscow, although inland, is also located in the southern part.

Human impact on biodiversity in the Boreal region is young, having started at the end of the last glaciation about 10 000 years ago. Agriculture is still dominating in the central and southern parts where terrain, soil conditions and climate are most suitable. Numerous small

family holdings with combined forestry and agriculture have been characteristic of much of the region. Agriculture reached its widest extent towards the end of the 19th century. It is now being intensified and concentrated to the main agricultural regions, while farmland in marginal areas is increasingly abandoned and the land returned to forest naturally or by planting. This process accelerated rapidly since the middle of the 20th century. The effect is a more uniform landscape with strong contrasts between open agricultural areas and closed forests.

Widely spread reindeer-based settlements and nomadic herding in the northern parts of the region are now increasingly shifting to all-year settlements and mobile herding.

1.2 Main influences

Main influences

The main influences on biodiversity are:

- climate change
- economic use of species
    - forestry
    - agriculture, grazingo
    - freshwater fishing
    - hunting
    - berry and mushroom harvesting

Other important influences are:

- infrastructure
- hydroelectricity
- peat mining
- contaminants
- tourism
- alien species

1.3 Main political instruments

Main political instruments

- The main political instruments of direct importance for biodiversity in the region are:
- the Arctic Council
- the Barents Region Council
- the Nordic Council and Council of Ministers
- the Bern convention (convention on the conservation of European wildlife and natural habitats)
- the Ramsar convention (convention on wetlands of international importance especially as waterfowl habitat)
- the Bonn convention (convention on migratory species)
- European Community regulations and directives concerning especially nature conservation (birds and habitats directives), biodiversity action plans, environmental action plans, common agricultural policy and its accompanying measures, EU forest policy programmes including the scheme on protection of forests against atmospheric pollution (Forest Focus)
- the convention on biological diversity (CBD)
- the convention on long-range trans-boundary air pollution (CLRTAP)
- the ministerial conference on protection of forests in Europe (MCPFE)

1.4 Biodiversity status

1.4.1 Ecosystems and habitat types

The Boreal biogeographical region is a transition zone from the climatic extremes of the Arctic region to milder regions of Europe.

Table 2: Main habitat types of the Boreal biogeographical region. Definition according to EUNIS Habitat Classification (top categories)

Agriculture and gardens	Grassland	Forest and other wooded land	Heath-land and scrubs	Wetlands (bogs and mires)	Rivers and lakes	Coastal and halophytic habitats
17 %	14 %	58 %	2 %	2 %, in some areas up to 50 %	6 %	<1 %

Source: Compiled by ETC/NC and EEA from Corine Land Cover (EEA) and PELCOM map (Pan-European Land Cover Monitoring, Alterra 1999, NL). June 2000

Note: Estimation based on 83 % of the region.

Table 3: Habitat types of European importance in Sweden and Finland in the Boreal biogeographical region. Flora, fauna and habitats directive, annex I (FFH AI)

Number of all FFH annex I habitat types present in the region in Sweden and Finland	84
Number of these FFH annex I habitat types shared with other regions	80 (of 84)
Number of FFH annex I habitat types only present in Sweden and Finland in the region (see below)	4 (of 84)
Habitat types:	
Natural forests of primarily succession stages of land upheaval coast	FFH AI code 9030
Boreal Baltic narrow inlets	FFH AI code 1650
Boreal Baltic sandy beaches with perennial vegetation	FFH AI code 1640
Baltic esker islands with sandy, rocky and shingle beach vegetation and sublittoral vegetation	FFH AI code 1610

Source: ETC/NC from FFH directive annexes. March 2000

- **Vast forests**

More than 58 % of the region is covered by forests and other wooded land. There are large differences among northern and southern types. Over 90 % of the forests are under management, though in very varying degrees. The tree limit does not go higher than around 300-500 m in many northern areas and falls towards the Arctic Sea. The forest health condition is crucial to the region (see 2.3.5 Contaminants – Forest condition). The effects of acidification still cause severe problems.

The taiga

Most of the boreal forests belong to the taiga type, dominated by a few conifer tree species, primarily Norway spruce (*Picea abies*) on moister ground and Scots pine (*Pinus sylvestris*) on drier ground. East of the White Sea, mainly closer to the mountains, Siberian conifer species like Siberian pine, fir, and larch (*Pinus sibirica, Abies sibirica, Larix sibirica*) may also occur. Deciduous species like birches (*Betula spp.*), aspen (*Populus tremula*), alders (*Alnus spp.*) and willows (*Salix spp.*) may occur as early successional forest stages (especially birches and aspen) or may form smaller stands among the conifers or along rivers and lakes. The European taiga forms the western part of the Eurasian taiga belt and relates to the taiga of USA and Canada.

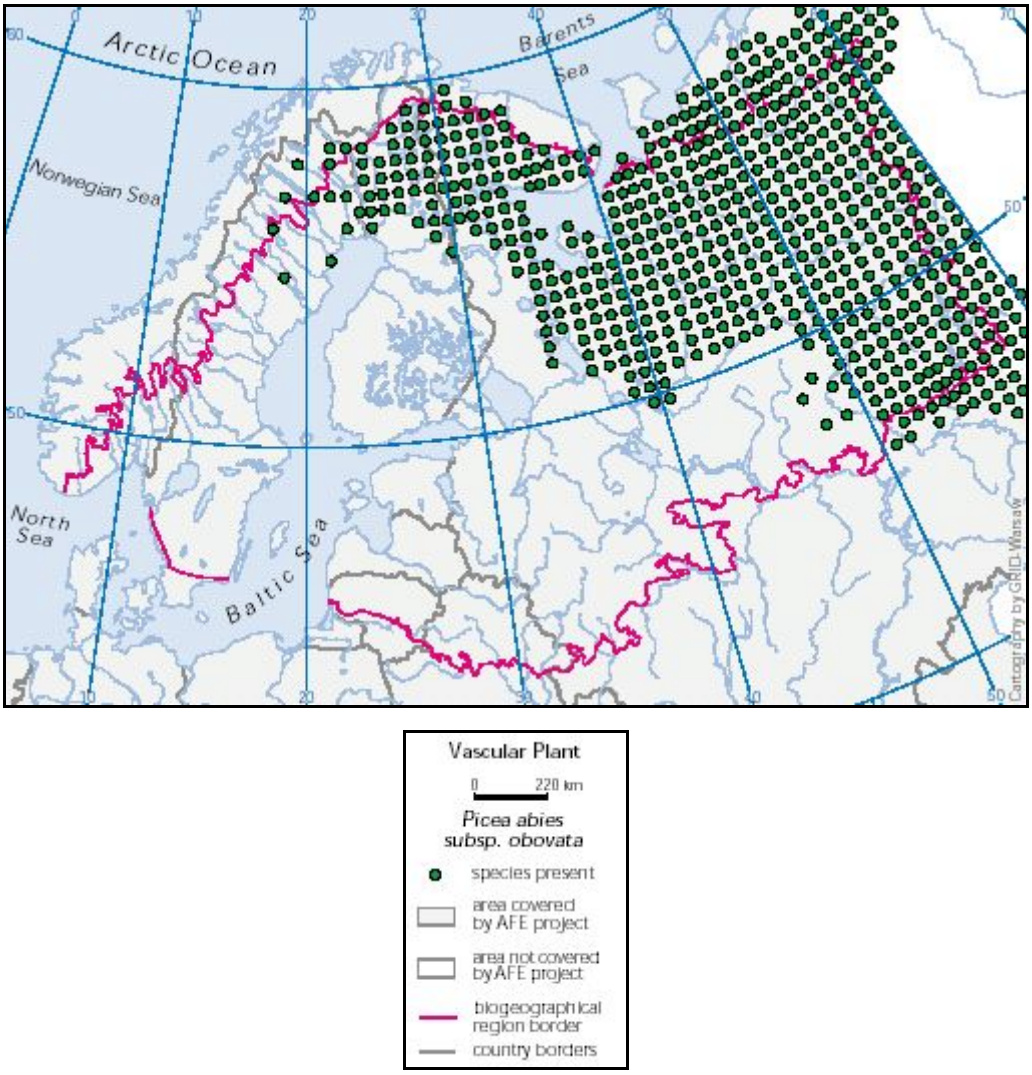
Photo: Boreal forest with oligotrophic lake and whooper swans (*Cygnus cygnus*)

Source: Benny Gensbøl/Biofoto.Danmark (BG 11608)

Vast forest areas were grazed by cattle until some decades ago. This has now diminished radically. The forest grazing kept forests open and with low litter accumulation, but it also made regeneration, both natural and by plantation very difficult. In the northern part large areas are still being grazed by reindeer. In many areas the large elk and deer populations influence the forest composition.

Towards the mountains in the Fennoscandian part of the Alpine region and the arctic tundra the forest is formed by birch (*Betula pubescens*) (including in the Kola Peninsula), while east of the White Sea this transitional zone is generally formed by Siberian spruce (*Picea abies ssp. obovata*) (Map 2).

Map 2: Siberian spruce (*Picea abies ssp. obovata*)



Source: ETC/NC based on data from Atlas Flora Europaea. Data extracted March 2000

In most of the boreal forest ecosystems, nutrients tend to be tied up in organic components of the ecosystems, either as live biomass in the dominating forest trees or as partially decomposed dead organic matter in litter and peat.

The vertical structure of mature boreal forests is generally simple, with a well-defined tree layer and a rather poorly developed shrub layer. The nutrient availability for the vegetation tends to be rather limited. The field layer is dominated by ericaceous dwarf shrubs (e.g. *Calluna* and the berry rich *Vaccinium*, *Empetrum* and *Rubus spp.*), varying from dry and poor lichen and *Calluna*-dominated pine forests to somewhat moister and richer *Vaccinium*-dominated spruce forests (the blueberry forest). Grasses and herbs are more common in the field layer on richer soils, tall herbs being especially characteristic for the rather uncommon richest forests. The bottom layer is often well developed, being dominated by bryophytes under moist conditions and lichens (e.g., *Cladonia, Cetraria spp.*) on drier ground with more accessible light. In moist old forests, an epiphytic vegetation of lichens and bryophytes is often well developed.

The blueberry and lichen-moss rich forests and other berry rich forest types decrease at present due to intensive forest management with heavy disturbance during felling and clearing, with gradually denser forest cover and high N-content.

Photo: Mixed conifer forest with lichens, mosses and berries

Source: Ulla Pinborg

The north European mixed forest

Stands of deciduous trees occur in the whole region, in the northern part mainly associated with special biotopes, often disturbed by fire or floods, or on particular soils. In the southern part of the region, various broadleaved deciduous trees (e.g., *Quercus spp., Acer platanoides, Carpinus betulus, Ulmus spp., Tilia cordata* and *Fagus sylvatica*) occur alone or intermixed with coniferous woodland to form the north European mixed forests. Most of the trees are climate sensitive and a gradual shift of their distribution limits northwards may serve as long-term indicators for climate change. The northern limit of those deciduous trees follows a narrow belt in Norway, spreading to several hundred km in the east towards Ural. In Sweden the transition belt is called the Limes norrlandicus (Swedish National Atlas: http://www.sna.se/webbatlas/index.html - search 'limes'; Sømme, 1960). It has its counterpart in the Limes labradoricus in Canada.

While deciduous trees may move naturally north, tree planting is still dominated by conifers in the whole region, thus gradually changing the mixed woodlands towards a more uniform coniferous composition. However, at the same time as conifers dominate in planting the interest in augmenting the amount of deciduous trees is growing. The general problem of trees on the move is treated in the UNEP-WCMC project 'Forests in Flux'.

Natural rejuvenating factors

For several forest types, natural rejuvenation of the forest may be problematic and dependent on major disturbances such as forest fires, storms or insect outbreaks. Fire as a natural disturbance has been and is still shaping the structure of dry forest types dominated by Scots pine (*Pinus sylvestris*). These fires may occur as frequently as every 40 years and range over as much as 1 000 ha, though most fires are of a more limited extent. Areas of wet and moist forest types rarely burn, effectively constituting fire refuges on nearly 30-40 % of the forest area.

Natural forest fires are set by lightning. Up through history, until the last 100 years, traditional human activities also contributed significantly to fire frequency and patterns in most parts of the Boreal region. Now fire by accident or arson is a major factor.

Fires rejuvenate the forest over large areas and mobilise the nutrients tied up in various living and dead organic matter. Several forest tree species seem to germinate better after

fire. Both recently burned areas and fire refuges have great significance for forest biodiversity, as both types of areas provide particular habitat characteristics not readily available elsewhere. The extensive reduction of forest fires in recent years has reduced the availability of special habitats for fire adapted species. When fires occur in areas under modern forest management that often allows deep litter layers to form during the full life time of forest stands, fires may be very severe. Controlled fires are beginning to be considered as a positive forest management tool in this region.

Storm damage and large outbreaks of insect pests, killing smaller or larger groups of trees, are important rejuvenating forces on forest content and structure which strongly influence biodiversity. In riparian areas the forests are normally adapted to flooding, but extensive floods may disturb and restructure the forest. Otherwise, rejuvenation takes place by gap dynamics. This occurs when individual trees die and fall over in local patches, thereby freeing space for new recruits and opening the canopy for increased light and heat. Storm damage has so far not been considered a major risk for forests in the region despite several severe incidents during 1980-2001.

Very few remaining untouched forests

Today, only very limited forest areas remain without influence from human activities. Remaining forests under natural dynamics are therefore of great conservation value (BOX1). Most countries in the Boreal region are now mapping and monitoring such forests. The FAO conducted Temperate and Boreal Forest Resource Assessment 2000 (TBFRA2000) contains national data from all natural forests. However, there is no allocation of the information to regions and since the term 'natural forest' is being used differently, it is not possible to directly compare between countries and regions. In a UNEP-WCMC/WWF conducted score card analysis on forests and protection, 45 of the 50 largest forest protection areas occurred in the Russian Federation and Fennoscandia. However, the information cannot be attributed directly to any biogeographical region (UNEP-WCMC, European Forests and Protected Areas).

BOX1: Large natural taiga forests under pressure

The taiga is under pressure, even the most remote and natural areas such as the UNESCO Natural World Heritage Site of the *Virgin Komi Forests* in the Komi Republic of the Russian Federation. Situated on the western slope of the northern Ural Mountains, in the eastern part of the European Boreal biogeographical region, this large and remote area (3.28 mill. ha) covers boreal forests, farmland, tundra and mountains. It is constituted of the Pechoro-Ilychsky Nature Reserve (also a UNESCO Biosphere Reserve), the Yugyd Va National Park and various buffer zones and smaller reserves. The site represents a typical western taiga landscape with a mosaic of boreal forests, mires and streams, stretching from the western lowlands into the Ural Mountain foothills. Vegetation and fauna are rich and include a mix of European and Siberian species. The area covers a vast expanse of natural, so-called virgin boreal forest ecosystems, where natural ecological processes have operated with little human interference, and provides important habitats for many threatened species. Until recently the area has been under traditional local use. Over the last several decades however, increasing pressure from logging and other resource exploitation in the surroundings and the buffer zones threatens the ecological integrity of the area.

- **Mires, bogs and fens**

Over most of the region, wetlands such as mires, bogs and fens form characteristic landscape elements in mosaics with various forest types. In parts of northern Finland, mires cover almost 50 % of the surface area. Peat-rich mires are still abundant in Estonia and Latvia (Baltic Environment Forum, 2000), while Lithuania has lost around 70 % of such wetlands over 30 years.

Photo: Common crane (*Grus grus*)

Source: Lars Gejl/Biofoto. Danmark (LG 34240)

The diversity of mires is very high both in terms of habitat types and associated species. Mires are defined as waterlogged ground with a peat layer made up of partly decomposed vegetation, at least 30 cm thick. In this region, it can reach up to 10 m thickness. Mires which receive virtually all their water and nutrient input from precipitation are ombrogenous, while mires where some of the water and nutrients also come from the mineral soil are minerogenous mires or fens. The most common types of mire in the Boreal region are fens on level or gently sloping ground, often mixed with smaller areas of open water, raised bogs, and drier, firm ground. Characteristic ombrogenous raised bogs, with a central dome of accumulated peat, are mainly found in the southern part. In the most oceanic parts of the region, terrain-covering blanket bogs may occur. Special types of palsa mires, which are heaps of peat with a nucleus of ice, may be found in areas of permafrost, generally surrounded by fens. Various *Sphagnum* mosses dominate in bogs, but only a few vascular plants may be found there, such as species of sedges, cotton-grasses and rushes (*Carex, Eriophorum* and *Juncus spp.*), heather (*Calluna vulgaris*), and stunted Scots pines (*Pinus sylvestris*). Important plant species for animals are cloudberry (*Rubus chamaemorus*), cranberry (*Vaccinium oxycoccus*) and other berry-carrying dwarf shrubs. A special group of plants on bogs are the insect-eating sundews (*Drosera spp.*), which benefit from the extra nutrients in their animal diet. On rich fens a far greater range of species may be found, including orchids like the marsh helleborine (*Epipactis palustris*) and marsh orchids (*Dactylorhiza spp.*).

Although bogs and poor fens generally have rather few species, such habitats have great significance for several specialised species, including many of conservation interest. Of the most well-known are migrating birds such as common crane (*Grus grus*, Photo and BOX2) and wading birds like broad-billed sandpiper (*Limicola falcinellus*) and jack snipe (*Lymnocryptes minimus*). The remoteness and inaccessibility of many large mires provide important refuges for these sensitive species. Mires also provide special habitats for many species of insects and other invertebrates.

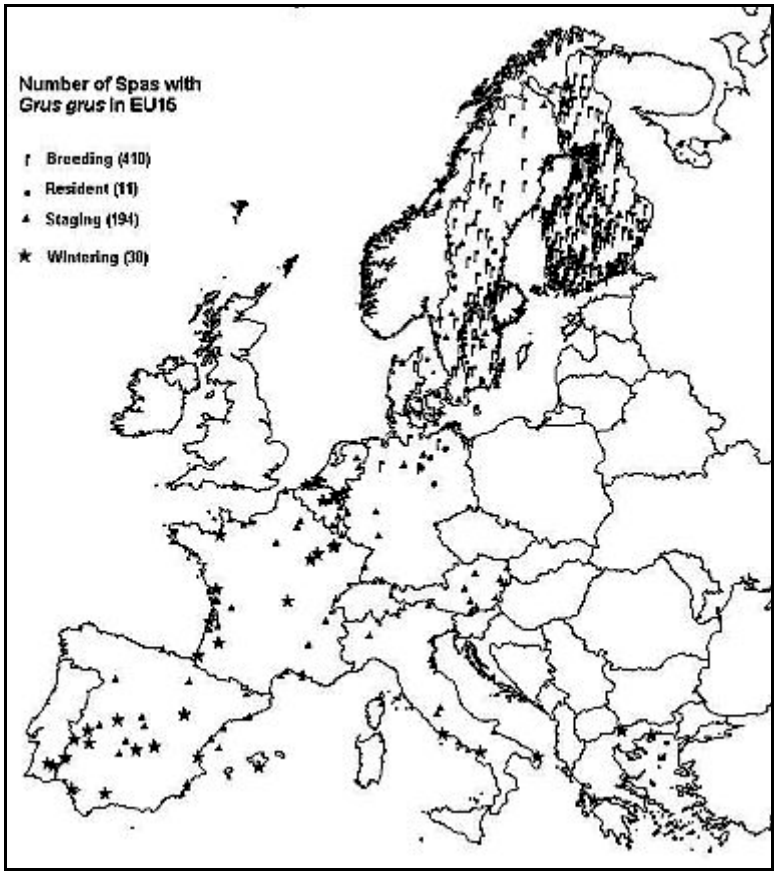
BOX 2: Common crane - success for birds and tourists between regions

The common crane (*Grus grus*) winters around the Mediterranean. In very early spring they migrate north through Europe along a western and central European flyway to the breeding places, mostly in remote mires in northern Europe (Russian Federation, Sweden). The example of the restoration of the Lake Hornborga in central Sweden shows how radically positive or negative human impacts on habitats can be on a species and how regions in Europe are inter-linked.

During early 19th century coinciding low water levels and large quantities of winter frozen potatoes around the Lake Hornborga in central Sweden offered a resting ground for large numbers of cranes coming along the western flyway from the Spanish Estremadura area, in the Mediterranean region where they feed off Holm Oak nuts in the winter. When the lake became overgrown and the potato growing stopped around 1950 the crane population fell greatly. From the early 1970s with only around 4-5 000 cranes intensive lake restoration and feeding (now more cereals than potatoes) has brought the annual total number of cranes resting to around 10-12 000. Cranes feed on crops and root fruits (potatoes) and the need for re-compensation measures has consequently risen. During the same period the annual number of spectators has reached above 150 000 in the spring. The enlarged number of birds has led to significantly expanded distribution of breeding cranes in the Boreal region during the 1990's, also more southerly than before.

Now the total crane population in Europe is estimated at more than 230 000. The crane migration along the central flyway can be seen when enormous numbers (more than 60 000 or 95 % of all cranes passing that flyway) stage in autumn in Hortobagy in northern Hungary in the Pannonian region. In France restoration of the Lac Der-Chantecoq in northern France has contributed to changes in the flyway and resting pattern in that region.

Map 3: Status in December 2000 of areas (SPAs) designated in EU15 countries under the birds directive for protection of the Common crane (*Grus grus*)



Source: ETC/NC core team, based on data reported by EU Member States to the Commission under the birds directive. December 2000.

Note: When SPAs will be designated in new EU Member States more central European areas will be added.

• Profusion of lakes and rivers

There are hundreds of thousands of lakes in the region; at least 3/4 of the approximately 600 000 European natural lakes larger than 0.01 km^2 are located here. Most of them are small (less than 1 km^2). Of the 24 European largest natural lakes, 21 alone are located in the Boreal region. Lakes Ladoga and Onega in north western Russian Federation are the largest freshwater bodies of Europe and rank 18 and 22 in world order (Herdendorf, 1982). 17 constructed reservoirs with surfaces larger than 100 km^2 are located in the region, 10 of these within the Volga River system. The Rybinskoye Reservoir is the largest of the region (4 450 km^2) and the second largest in Europe (EEA, 1995).

Table 4: Estimated number of natural lakes in different surface area classes

Surface area (km^2)	Total in Europe	Karelian and Kola part of Russian Federation, Finland and Sweden
>400	24	21
>100	150	118
>10	2 000	1 350
>1	16 000	10 500
>0.1	100 000	60 000
>0.01	500 000 – 700 000	>400 000

Source: EEA, 1995

Many of the Boreal lakes are young, succeeding the glaciation period. Most of them are rather shallow, cold, clear, and oligotrophic with very low natural nutrient loads.

Only the largest lakes and those in mountain areas have mean depths exceeding 20 m. Most boreal lakes are covered by ice for several months each year, develop sharp temperature profiles during summer, and have pronounced turnover of water in spring and autumn. Many of the small lakes associated with forests or mires are heavily influenced by peat deposits and have a dystrophic character with high humus content. Several lowland lakes and watercourses have become increasingly influenced by agriculture, forest industry, urban runoff and wastewater and have developed a more eutrophic character as a consequence.

Oligotrophic lakes are specifically mentioned as habitat types of priority for conservation in the EU habitats directive and by the Bern convention. In the Boreal region this applies in particular to lakes poor in dissolved inorganic carbon, so-called *Lobelia* lakes, which contain a suite of characteristic macrophyte species such as isoëtids (plants with basal rosettes growing on the bottom of shallow waters in clear, naturally oligotrophic lakes). The occurrence of isoëtids is used as a quality indicator. Sweden estimates still to have around 8 000 naturally oligotrophic lakes, but the occurrence of *Lobelia* is decreasing.

Photo: Acidic oligotrophic lake with remnants of *Lobelia dortmanna*

Source: Ulla Pinborg

With the extensive bogs and mires, lakes and forests present in many river catchments of the region, there is a huge natural water storage capacity, resulting in a generally slow water release. However, the river flow in the Boreal region has heavy floods in spring and early summer, due to snow melt, while the flow is lowest in winter during the ice-bound period. In Fennoscandia rivers are rather fast-flowing and relatively small, draining local catchment areas. Many of the rivers in the Russian Federation are slow-moving because of very gentle gradients of terrain and are connected to large river systems like the Volga which drain major parts of the continent.

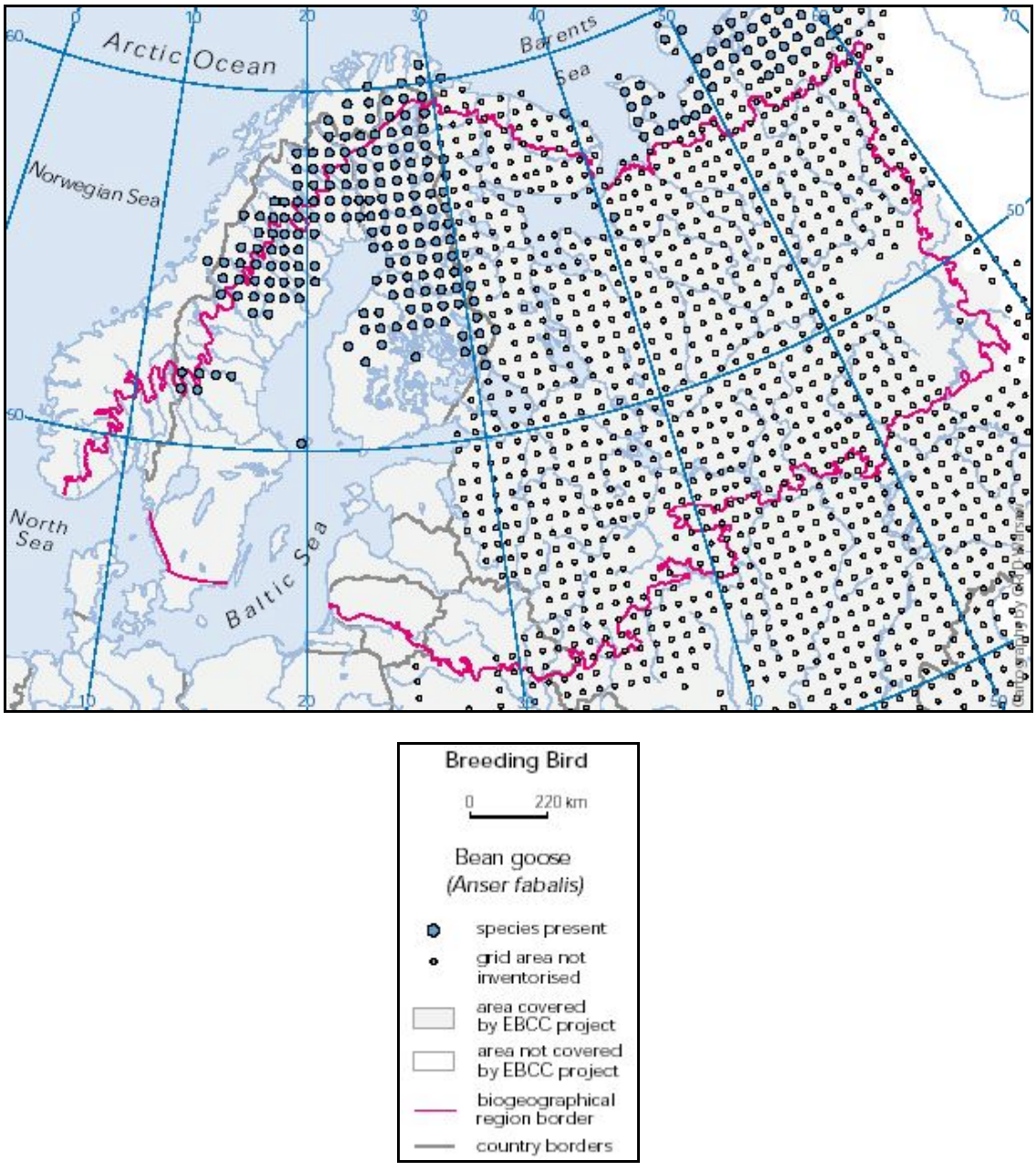
Several of the river systems in the region are connected artificially by canals: in the Russian Federation many of the large rivers are linked with canals, forming an extensive waterway network, and enabling navigation from e.g. the Baltic Sea to both the Black Sea and the Caspian Sea. The White Sea-Baltic Sea Canal enables passage from the White Sea to the Baltic Sea through Lake Onega, Lake Ladoga, and the Neva River. The 227 km long system, of which 37 km is man-made, reduces sea passage between Sankt Petersborg and Arkhangelsk by 4 000 km.

Species such as osprey (*Pandion haliaetus*), European beaver (*Castor fiber*) and European mink (*Mustela lutreola*), which used to be fairly widespread in Europe, now tend to have their major or only populations in association with lakes and rivers of the Boreal region, where they may encounter introduced populations of Canadian beaver (*Castor canadensis*) and American mink (*Mustela vison*).

The ringed seals (*Phoca hispida saimensis* and *Phoca hispida ladogensis*) of lakes Saimaa and Ladoga represent endangered subspecies, which may be considered post-glacial relicts. Boreal waterbodies are important breeding habitats for numerous birds, several of high conservation value and sensitive to disturbances, such as divers (*Gavia stellata, Gavia arctica*) and water birds like whooper swans (*Cygnus cygnus*), bean goose (*Anser fabalis*) and smew (*Mergus albellus*).

Boreal freshwater habitats are inhabited by substantial populations of economically important fish species of the families *Salmonidae, Cyprinidae*, and *Percidae*, as well as pike (*Esox lucius*) and burbot (*Lota lota*). There is a rich fauna of freshwater invertebrates, but few of these have been of substantial economic or conservation interest. The crayfish *Astacus astacus* and the mussel *Margaritana margaritifera* provide exceptions. Both of these species have been under traditional and partly modern exploitation with dangers of over-harvesting and are also under threat from changes in their habitat. Several invertebrate species have been used as indicators of environmental changes in freshwater, especially for acidification or eutrophication.

Map 4: Bean goose (*Anser fabalis*)



Source: ETC/NC based on data from EBCC (European Bird Census Council). Data extracted March 2000

- **Baltic coasts and islands**

Along the Baltic Sea the coast is low with coastal meadows forming important habitats in some areas, often as part of the still ongoing succession resulting from land uplift. Sandy

beaches occur but are not frequent. The coast of Sweden and Finland is rocky or with beaches of boulders.

The multitude of islands in the archipelagos around the coasts of Sweden and Finland, including the Åland Islands, are of particular interest with their often dry climate. The larger islands – Gotland, Öland (in the Continental region), Saaremaa, and Hiiumaa – with calcareous soil are housing habitats, with many species to be found otherwise in warm and dry, steppe-like habitats in other regions. Continued traditional agricultural management is a prerequisite for preserving many of these habitats. Several national parks and reserves have been set up to protect habitats of the islands.

• Grass-lands and tree-rich meadows

Permanent pastures, hay meadows and tree-rich meadows were formerly widespread, especially in small holdings, often in remote areas, in mosaics with forestry. These light open habitats with long continuity under the same special management type are very rich in specialist plants and associated insects. They are the habitat type in the most rapid change in the region (See 2.2.5).

1.4.2 Species

• Flora

There are about 1 800 indigenous vascular plant species in the Boreal region, most of them in the southern parts. The region provides important habitats for a large number of bryophytes, lichens and fungi. For instance, in Sweden alone there are about 1 200 species of bryophytes and 2 000 lichens. Many mire plants now have their main populations in the Boreal region, as such habitats have been considerably reduced in much of the rest of Europe. Similarly, several aquatic plants also have their main populations in the oligotrophic freshwater habitats of the Boreal region.

• Fauna

Table 5: Species in the Boreal biogeographical region covered by the European Atlas projects (western part of the region). Number of vertebrates

	Total	Amphibians	Reptiles	Mammals	Breeding birds
Number of species (1)	393	15	7	79 (2)	292
Number of species threatened at European level (1)	73	0	0	10 (2)	63

Source: EUNIS from European Atlases. Compiled by ETC/NC June 2000

Notes:
(1) Only present species are taken into account, extinct or introduced species as well as Cetaceans are excluded.
(2) Only the western 30 % of the total area of the Boreal biogeographical region is covered by the European Atlas of Mammals.

Table 6: Species of European importance in EU Member States Sweden and Finland in the Boreal biogeographical region. Birds directive, annex I (B AI) and flora, fauna and habitats directive, annex II (FFH AII)

Number of all birds directive annex I species and sub-species present in the Boreal biogeographical region in Sweden and Finland (March 2000). Limited to breeding bird species	80
Number of all FFH annex II species and sub-species present in Sweden and Finland in the Boreal biogeographical region	99
Number of all FFH annex II species and sub-species in Sweden and Finland in the Boreal biogeographical region, per group	
Mammals	13
Reptiles	0
Amphibians	1
Fishes	4
Invertebrates	30
Vascular Plants	35
Mosses/Liverworts	16

Source: ETC/NC from FFH directive annexes. March 2000. (European Commission, NATURA2000)

Mammals

79 of Europe's around 270 mammal species occur in the Boreal region. Among these are the four large predators of international interest: brown bear (*Ursus arctos*), wolverine (*Gulo gulo*), lynx (*Lynx lynx*), and wolf (*Canis lupus*) The Russian populations act as reservoirs for these species. Important populations of smaller predators, as well as of the large ungulates elk (*Alces alces*) and forest reindeer (*Rangifer tarandus fennicus*) add to the richness of the boreal biodiversity. Just over a quarter of the boreal mammals (excluding whales) are listed in annex II of the Bern convention. Most of these are bats (13 species), most of the rest are carnivores.

The elk and reindeer have fundamental impacts on many habitats of the Boreal region through their feeding on trees and bushes or on grass and lichens. The effects are only now being generally recognised. It is a delicate balance between too much and too little grazing. Browsing by elk is severely limiting the rejuvenation of pines in many parts of the western Boreal region. The reindeer population consists of both domesticated, semi-domesticated and wild animal herds, that are part of the populations of both the Arctic and the Boreal biogeographical regions. 25 % of the elk calves are taken by carnivors, mostly by bear.

Protection versus control of the large predators is a very sensitive political issue, leading to serious conflicts about their management, such as for the wolf in Sweden with its very small population (upwards of 50 animals) and in Finland (100 individuals in 1999). The wolves in Norway and Sweden belong to an isolated population with a low recruitment rate, different from the Finnish population, which receives influxes from the Russian population. The wolf population in Belarus is around 3 000 and wolves are also frequent in the Baltic States.

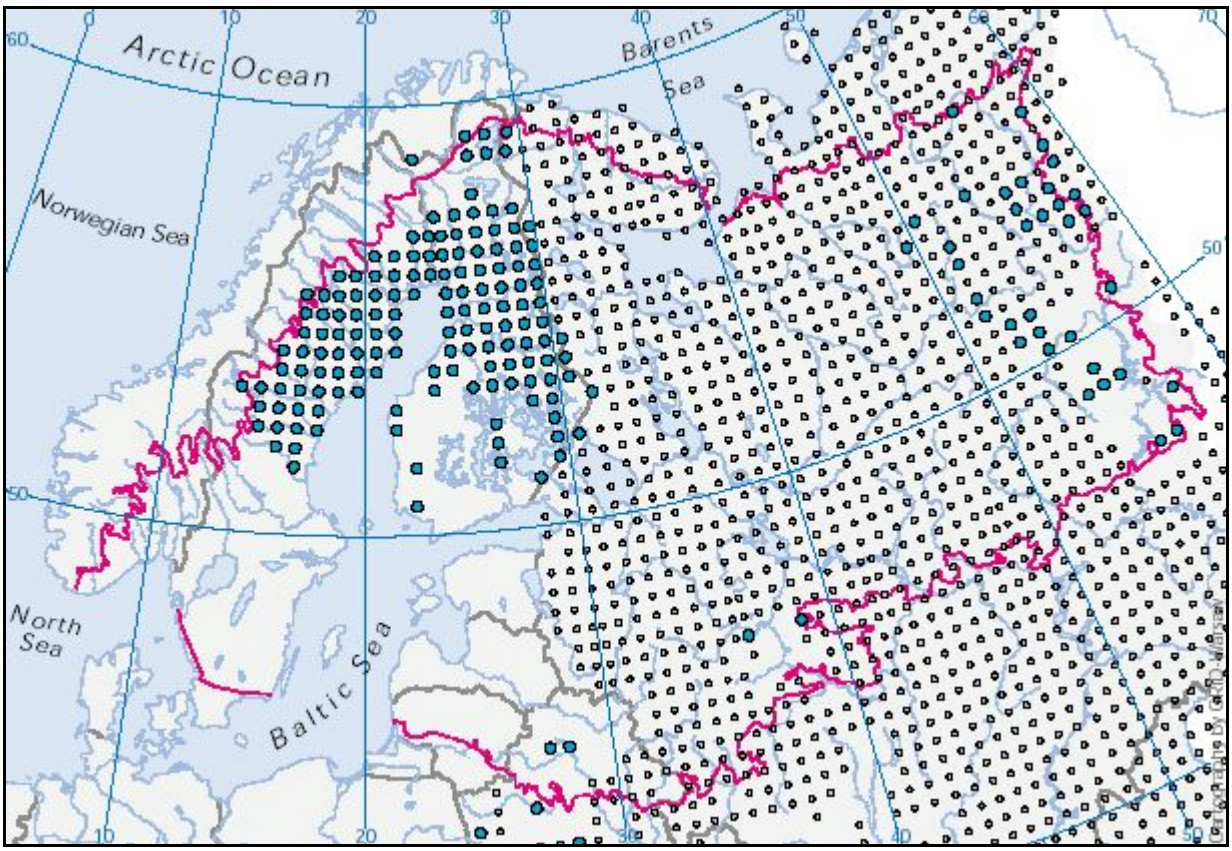
Damage by predators to reindeer was estimated for the 1990's in Finland and Sweden. For the period 1991–1998 in Finland around 13 000 reindeer were killed by bear, wolf, wolverine or lynx. During 1992–1997 eagles were estimated to have killed 2 400 reindeer. Damage recompensation payments were 7 million FMK in 1998. In Sweden 12 % of reindeer calves are estimated to have been taken by predators, with 35 million SKR set aside for damage compensation for 1999.

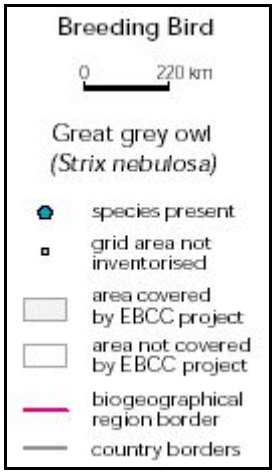
Birds

About half of the around 513 European bird species (around 270 species) have some part of their breeding range in the Boreal region. The composition varies within the region. In the Russian Federation the sparrow group (*Passeriformes*) constitutes around 46 % and the plovers (*Charadriformes*) around 17 % of 160 species.

For several bird species associated with large forests, mire areas and oligotrophic lakes, the region is especially important because it provides a rich supply of such habitats which have been reduced in amount or quality elsewhere in Europe. Examples of such species are woodpeckers, forest grouse, and various water and wading birds. Many species are also of direct conservation interest, including several of mainly Siberian origin, such as great grey owl (*Strix nebulosa*), ural owl (*Strix uralensis*), three-toed woodpecker (*Picoides tridactylus*), Siberian jay (*Perisoreus infaustus*), Siberian tit (*Parus cinctus*), and red-flanked bluetail (*Tarsiger cyanurus*). Around 60 % of the boreal species are listed in annex II of the Bern convention, illustrating their international conservation importance.

Map 5: Great grey owl (*Strix nebulosa*)





Source: ETC/NC based on data from EBCC (European Bird Census Council). Data extracted March 2000

Reptiles and amphibians
Reptiles and amphibians are very sparsely represented in the Boreal region, with about 22 species, or about 10 % of the European species. Most occur in the southern part of the region, near the Baltic Sea. About half of the species are considered to be of particular conservation interest in all Europe, according to annex II of the Bern convention.

Freshwater fish
Freshwater fish constitute about half of the more widely distributed species in Europe and have considerable economic importance, especially the salmonid species. See 1.4.1 Ecosystems and habitat types - Profusion of lakes and rivers.

Invertebrates
It is not possible to assess the proportion of invertebrate species in the Boreal region compared to the rest of Europe. However, it appears that for some insect groups like moths and various dipterous insects (mosquitos, flies), the Boreal region is rich in species, perhaps surpassing the richness of some of the otherwise highly diverse biogeographical regions further south in Europe.

2. What is happening to biodiversity in the Boreal biogeographical region?

2.1 Climate Change

The Boreal region may expect an overall increase in average annual temperatures of at least 2 °C over the next 50 years, varying from about 1 °C in the south-western part to as much as 3 °C in the north-east. Most of this increase in temperature may occur in winter. Precipitation may also increase, mainly in the western areas, which already have fairly high precipitation. Decrease in the period of ice cover on lakes and in the Baltic Sea may have large effects on wetlands, lakes and rivers and the coasts. In the Baltic countries ice break of rivers has moved two weeks earlier over 80 years (1920–1997) (Baltic Environment Report, 2000, Finnish Environment web site).
The consequences of such changes for the biodiversity of the region are difficult to predict. Forest trees and other plants will probably grow faster as a result of increased temperatures, longer growing season and increased precipitation. However, increased temperature stress may also result. In addition, the rates of decomposition are likely to increase. Such changes may give improved opportunities for southern species and species with broad habitat requirements. Various pests and pathogens may also receive better conditions for invasion and settlement. Native, cold-tolerant species, which are also often sensitive to disturbance and competition from more aggressive species, will probably retreat in distribution and have reduced populations. For some species changes are already visible such as for the number of migrating species now wintering more northerly than earlier: in Belarus the number of regularly wintering water birds has gone up from around 12 to 35 (Belarus, 1998).

The southern part of the Boreal region is part of the northern European mixed forest region, where deciduous trees begin to appear in conifer stands. The distribution of the deciduous trees may shift northwards with increasing temperature.

The boreal ecosystems are thus likely to change considerably over a rather short time, with respect to both ecosystem processes and species composition. At a global scale, another major concern is the possibility for feedbacks in the release of greenhouse gasses if increased decomposition rates lead to faster breakdown of the huge stores of carbon in

boreal forest trees and peat deposits. The balance between increased forest growth and increased decomposition rate with increasing temperature in the Boreal region appears to be one of the critical factors in the global climate system (ICP Forest website; UNEP/Grid Arendal website).

2.2 Economic use of biological resources

2.2.1 Hunting

Traditionally, the most severe threat to mammals and birds in the Boreal region was tied to unsustainable harvesting of game for food and fur. The originally wide-spread sable (*Martes zibellina*) was virtually exterminated from European boreal forests about 1600. Only efforts to reintroduce the species to European Russia in the mid-1900s have secured its continued existence here. During most of the 1900s the brown bear (*Ursus arctos*) and the wolf (*Canis lupus*) were also virtually exterminated from most of Norway and Sweden, mainly to avoid their predation on livestock. Hunting is now strictly regulated, and extermination of species due to over-exploitation alone is unlikely, though wolf control versus conservation of a freely developing population has caused intense discussions in Norway, Sweden and Finland. The wolf is being hunted in the Russian Federation and the other countries with less restrictions.

Extensive hunting of game (elk (*Alces alces*), roe deer (*Capreolus capreolus*), various forest grouses, hares, and to some extent fur-bearing predators) is widespread, both for local subsistence and recreation. After having been low in many areas such as in Sweden and Finland during the mid 1900 the elk population increased much both due to game management and changes in forest practices, giving large quantities of meat but also causing serious damages to forest and fields as well as road and rail accidents. The elk population is now being regulated in many areas to both maintain hunting and to avoid damages. The meat harvest from elk and deer in the Boreal region is considerable. It is mostly used for local consumption and may in northern areas amount to 30-50 % of the meat used. In Sweden 32 000 elks were shot in 1959/60, topping during the 1980s with 143 000 in 1984/1985, decreasing to 101 000 in 1998/1999. Additionally 219 000 roe deer were shot 1998/1999 (numbers also include the high figures from continental part of Sweden). The wild boar population is highest in the central southern part of the region, but is gradually spreading over the region again. More than 15 000 wild boar (Sus scrofa) were shot in Latvia and Lithuania in 1998-1999.

2.2.2 Berry, mushroom and lichen harvesting

Though no direct comparison is possible between countries, harvesting of wild living food resources like berries (mainly *Vaccinium* and *Rubus* species, wild cherries and roan) and mushrooms is important in many areas for economic and recreational purposes, though the amounts have decreased over the last decades: Sweden reports that 75 million litres of berries picked in 1977 (5-7 % of the total berry amount) fell to 23 million litres in 1997, and 21,8 million litres mushrooms in 1977 fell to 15,3 million litres in 1997 (Skogsvårdsorganisationen, 2000). It is estimated that the availability of both berries and mushrooms has fallen because of higher N deposition and darker forests, but the interest in picking has also fallen. The high importance of berries and mushroom picking in Finland, Belarus and the Russian Federation is assumed to maintain its importance. In Belarus (whole country) around 100 species of edible mushrooms are gathered. Lichens (mainly *Cladonia* and *Cetraria* species) and mosses are also highly important natural resources, mainly for reindeer grazing. The lichens and the mosses are increasingly harvested for decorations for domestic and export use.

2.2.3 Freshwater fishing

Subsistence, commercial, and recreational fishing of several species of anadromous and freshwater fish is intensive in many lakes and rivers. The economic value of the freshwater fish varies greatly. Lakes in Belarus (both Boreal and Continental regions) provide around 1

500 t fish, 75 % of all freshwater fish caught (Belarus, 1998). However, this only constitutes around 50 % of the commercial fishing of the 1950s.

Stocking of rivers with especially salmon has led to large fishing incomes, but a very strong influence on the genepool of the natural salmon. Fish stocking in natural lakes and rivers is widespread and transfer of fish between water bodies is an old tradition. A growing number of increasingly larger fish farms is established.

2.2.4 Forestry. A key influence on biodiversity

Forestry is now the main factor influencing land use and landscape structure of the wider countryside of most of the Boreal region. In Fennoscandia, as in most other European countries, the growing stock of the main forest trees is increasing, partly as a reflection of the intense forest management with increasing use of selected hardy and fast-growing provenances and various cultivation techniques, partly as a result of increased CO_2 and N-content and possibly also because of some temperature increase.

Today, the major economic use of forest resources is focused on timber and other wood-based products for the sawmill and pulp/paper industries, harvested from a few tree species (mainly spruce, pine and birch). The use of woody material as biofuel has increased considerably both in industry and households during the last decades. Sweden estimates an increase from around 3 million t in 1980 to more than 20 million t in 1998 (Skogsvårdsorganisationen, 2000). Willows are planted for biofuel in limited, but increasing areas, mainly on previous agricultural land.

Current forestry practices are still varied, depending on access to technology, economic constraints, ownership structures and the structure and productivity of the land itself. Nevertheless, the basic model of clear cutting and forest stand management, often with planting of non-native tree species or provenances, is widely applied and has a tendency of reducing biodiversity in spite of recent efforts taken to make forestry more ecologically sound. Restrictions on the maximum size of clear cuttings in Sweden and Finland have reduced the problem somewhat. However, the re-growth of bushes and trees in clearings has served to increase the elk and deer populations. This has resulted in more damage to new plantings and natural wild tree and bush growth and to crops.

In Sweden, large areas have been planted with the exotic species lodgepole pine (*Pinus contorta*): around 27 000 ha in 1980, peaking in 1986 at 35 000 ha, but reduced to only around 2-3 000 ha 1996-1998 (of a total of 136 000 ha forest planted 1998). In spite of the reduction in new plantings, the lodgepole pine area will remain significant for several decades.

In both Finland and Sweden large wetland areas and humid forests have been drained by ditching, mainly to improve forest growth. In Finland it is considered, that more than 50 % of the wetland area has been influenced. Both Sweden and Finland used to apply forest fertilisation and chemical pest control (mainly herbicides) on a large scale in the 1970–80s, but this has since been considerably reduced.

The Russian Federation has had extensive exploitation of its boreal forest resources, primarily in areas close to industry and transport infrastructure. However, large areas of boreal forest are still in a near natural state. Considerable conservation interests are at stake over the next few years, depending on the development of forestry in the Russian Federation. The Russian Forest Code from 1997 aims at zoning forests for cutting or protection.

2.2.5 Agriculture

Agricultural intensification, abandonment and change

Arable agriculture and much of animal husbandry have primarily been concentrated to the southern parts of the region on the best soils and most accessible land. Over the last 50 years there has been a large increase in farming intensity and productivity on optimal agricultural land as elsewhere in Europe.

Parallel to this intensification, whole marginal farms or agricultural areas in remote northern or highland areas have been abandoned on a large-scale, mostly leading to natural or managed reforestation. Both processes, intensification and abandonment, lead to a less varied landscape and to radical changes in ecosystem processes. The highest decline concerns the permanent grasslands and tree-rich meadows with long-term management.

This has led to a high interest in conservation of especially natural and semi-natural hay meadows and pastures. By 2000 inventories had been performed in Sweden, Finland and Estonia, but were lacking elsewhere. EU agro-environmental funds have been used in Sweden and Finland to co-finance continuation of management. The remaining areas under traditional grazing or haymaking are considered to be only around 200 000 ha in Sweden, around 10 000 ha in Finland and around 200 000 ha in Estonia; in all three countries with a falling tendency. In Sweden, around 90 % of the most highly valued permanent grassland areas are still maintained, 80 % of the areas getting EU subsidies under CAP (the common agricultural policy) to support continued management. In the biodiversity action plans for all three countries the maintenance and restoration of such habitats are considered priority tasks. In Russian Karelia around 150 000 ha are hay meadows and pastures, with a stable tendency from around 1975 to 1998 (Ikonen and Lammi, 2000). In Belarus meadow areas have been reduced over 35-40 years with around 50 % (mostly along rivers), to around 800 000 ha, hay meadows and pastures being about equal in cover (the information covers both the Boreal and the Continental regions) (Belarus, 1998). Though the figures are not directly comparable because definitions of meadows and pastures vary, the trend is clear, that open permanent grasslands are in strong decline, and this is a matter of concern from a biodiversity protection perspective.

As in many other parts of Europe, the number of cattle on grass has decreased in the rural areas. A change to sheep grazing for a period is normal, before the land is afforested. Around urban areas the number of recreation horses continues to increase, securing grazing on many farms around cities. Deer farming has been introduced at a small scale, mostly in the Russian Federation.

Reindeer herding

In the northern parts of the Boreal region, reindeer husbandry is still considered an important activity, conducted partly on a subsistance and partly on a commercial basis by the Saami. Traditional management systems, where grazing on common land is an important element, combined with aspects of a modern monetary economy, have led to concentration and severe overstocking and overgrazing in many parts of the reindeer management area. It also leads to conflicts with transport infrastructures and with established farming.

Photo: Crossing of infrastructures - reindeer and people on the move

Source: Sven Halling/Biofoto. Danmark (SHA 2317)

The density of lichens, primary reindeer winter food, has been seriously depleted in some parts of the region. Lichen cover may take 30-50 years to recover if grazed very deeply. In Sweden the number of reindeer in 1920-1929 were 208 000, peaking in 1993/94 with 279 000, falling to 227 000 in 1998. The number slaughtered fell from 95 000 in 1994/95 to 61 000 in 1996/97. In Finland the numbers were close to 150 000 during the 1960-1980, peaking during 1980s with around 230-250 000 and falling to around 200 000 in the 1990s. Plans for sustainable reindeer management are made, but are difficult to adhere to. The Chernobyl accident significantly affected large areas utilised by reindeer. The numbers concern the whole of Sweden and Finland.

2.3 Other major pressures on biodiversity

2.3.1 Infrastructure development

The transport infrastructure network is only very dense and heavily used in the urbanised areas of the region. However, even in the remote areas fragmentation of previously large and contiguous biotopes may result in divided and less suitable habitats for populations of large carnivores and birds requiring large territories. The fragmentation also increases the edge effects for remaining forests, affecting local climate conditions of importance for bryophytes and lichens, as well as making it easier for generalist species to reach the interior of forests or mires. Continued development of transport between the main population centres of the Boreal region can be foreseen (including shifts from rail to road transport), and the pressure on biodiversity from such development is likely to increase, especially as still more remote areas will be crossed.
Large numbers of animals are killed by traffic on roads and railways and by collisions with electric power lines. Several of the countries have taken mitigating measures into planning for new roads and railways such as fencing and to a limited extent constructing eco-ducts. Since the 1980s larger roads in Sweden have increasingly been fenced in on both sides, preventing a large number of traffic accidents for humans and for animals (mainly elk and deer), but leading to isolation of populations of the animals (Photo). The decrease in accidents is clear, but the isolation effect is not documented yet (IENE, 2001).

Photo: Road fencing in Sweden

Source: Ulla Pinborg

2.3.2 Hydroelectricity

In Fennoscandia and the Russian Federation very few rivers remain unaffected by hydropower development. In Fennoscandia, about 2/3 of the entire hydropower development potential has been exploited. Only two large rivers are entirely free from human regulation, Kalix river in Sweden and Torne river on the border between Sweden and Finland. Many plans exist to exploit more of the remaining hydropower potential. The construction of hydroelectric power stations has had very severe impacts on the Finnish natural salmon population: only three salmon spawning rivers are left in a natural state, while the native population has been destroyed in 17 former salmon rivers. (Eriksson and Hedlund, 1993; Wahlström, Hallanaro and Manninen, 1996).

2.3.3 Peat mining and mire ditching

Peat mining and ditching of mires to allow the mining was used during the 1800 to mid-1900s in most of the region, firstly on a limited local scale but ending up in very large scale operations. When left to natural regeneration many of the least exploited areas have developed into oligotrophic bog or dwarf shrub complexes, albeit disturbed ones. Disturbed raised bogs, however, are not likely to regenerate due to different moisture regimes and less *Sphagnum* growth today than when they were initially formed.

In Finland and Sweden, extraction of peat for fuel or power generation has had a renaissance during recent decades; together they extract 8-12 million m^3 of peat yearly. The peat is also being harvested for use in gardening and agriculture at a considerable scale. The peat extraction is presently mostly performed by stripping peat areas horizontally, gradually lowering the peat surface uniformly over large areas till close to the mineral layer. On such areas regeneration will often be by afforestation or agriculture. In Sweden 20 % of all mires are estimated to have been influenced by peat mining at some time. Peat cutting in the Baltic States is at present low, but may grow, considering the existing large amounts of peat containing wetlands and export interests.

2.3.4 Tourism

Tourism in the Boreal region is largely connected to the most populated areas and the coasts. However, the wide rights of access to land which exist in much of the region

allowing tourists a larger freedom of access and of freedom to camp or use lakes and rivers than in the rest of Europe attracts many individual tourists (Sweden, Finland, Norway). Freshwater fishing is a major eco-tourism sector and the pressure for active fish stocking programmes is strong.

2.3.5 Contaminants

Forest condition

Monitoring of forest health condition as expressed by defoliation has gradually been implemented in the Boreal region in Finland, Norway, Sweden, Estonia, Latvia, Lithuania and Belarus. In the Russian Federation only Kaliningrad and the Sankt Petersburg area were monitored in 1994-1995). This happens as part of the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) and the associated European Union scheme on the protection of forests against atmospheric pollution (under the UN/ECE convention on long-tange transboundary air pollution, CLTRAP). The ICP 2002 Executive Report shows that defoliation continues to be a severe pressure on forest ecosystems of the Boreal region, both for deciduous trees and conifers (ICP, 2002).

Mosses and lichens as pollution indicators

In the 1960s it was registered in Sweden and Finland that mosses and lichens growing close to industries with high heavy metal or other air borne polluting emissions had high concentrations of these substances or that they decreased in occurrence or even disappeared. These groups of species therefore came into wide use as indicator species for air pollution and forest condition. Some of the first usages were around the nickel works on the Russian border to Finland and Norway. The influence from the nickel-copper smelters on the Kola Peninsula still has radically negative impact on the ecosystems. The two most affected areas are situated at the border between the Arctic and the Boreal region. The trees are without needles and the ground bare, caused by emissions of acidifying sulphur dioxide. Effects on nearby streams and lakes are not as immediately visible, but real. Mayflies and other acid-sensitive animals, including fish, are threatened (Arctic monitoring and assessment programme).

Acidification of the most sensitive area in Europe

Fennoscandia and the Kola Peninsula are the most sensitive areas to acidification in Europe because of the low natural buffer capacity and nutrient levels of most of the soil and waters.

Pollutants such as SO_2, NO_X and various other chemical compounds from combustion processes started to reach the Boreal region from continental Europe and Britain already in the early part of the 19^{th} century. The resulting effects on freshwater fish were noticed already around 1920, but it was not until the 1960-70's that the large-scale, regional acidification in the south-western part of the Boreal region was recognised. Waters with pH below 5 are generally devoid of fish. Of the 85 000 Swedish lakes larger than 0.01 km^2 around 25 % are in a state where they only contain organisms capable of living under acid conditions. During the winter the pH value is below 5 in more than 6 000 of the lakes. The effects are extermination of certain species, in particular salmonid fish like atlantic salmon (*Salmo salar*) and brown trout (*Salmo trutta*), as well as changes in species composition and ecosystem processes.

Though deposition of acidifying substances from central and western Europe is decreasing, and some lakes and rivers show slight increases in pH, the acidic heritage in the soil and water bodies is still strong and will persist for a long time. Of the acidic Swedish lakes, around 40 % or around 90 % of the total acidic lake surface were under improvement by liming by 1997 (some started already in the 1970's). 500 more lakes are limed to protect downstream waters and around 10 % of acidic streams are limed. This is the largest liming programme of the world, though also Norway, Finland and Canada have such programmes. Sweden will continue liming, using around 200 000 t crushed limestone per year. The effects, positive as well as negative have been much debated with no clear conclusions as yet (Swedish Environment Protection Agency, 2001).

In boreal forest soils like podzols, natural acidification occurs. Deposition of acidifying pollutants has been shown to increase this natural acidification, which may also be increased by the vegetation such as conifers. The long-term effects on the terrestrial vegetation are less well documented than for aquatic ecosystems. The effects from acidification and the fertilisation effect of nitrogen are also masking each other, further complicating responses due to variation in geology and soils of different buffering capacity.

Effects of air borne fertilisation from nitrogen compounds can be seen in the south-western part of the Boreal region where nitrogen deposition has lead to an increase in grasses like purple moor-grass (*Molinia caerulea*). Mushroom production in the most affected forests has declined.

Radiation
Effects following the Chernobyl accident in 1986 are still measurable in the Boreal regions ecosystems through contamination of terrestrial and aquatic food chains, including reindeer, game, berries and fungi, wild resources which were and still are intensively used in many parts of the region. The Swedish Radiation Protection Institute reported in 2001 that fungi and also fish from oligotrohic shallow lakes still contain high doses of Cs-137 (*Caesium*), although it is falling (slowly) in elk and berries. The number of reindeer carcasses discarded as meat for human consumption was around 80 % in the year after the incident. The numbers condemned was low and falling slowly after 10 years, much because of supportive feeding with uncontaminated fodder before slaughter (Moberg, 2001). Figures do not exist specifically for the Russian Federation, Ukraine and Belarus part of the Boreal region, but in the UNDP and UNICEF report on 'The Human consequences of the Chernobyl Nuclear Accident' (UNDP and UNICEF, 2002) it is indicated that the main threat to health from current and future exposure to radiation concerns a distinct group of people who live in contaminated areas, produce their own milk and depend to a significant degree on wild mushrooms, berries and game.

2.4 Alien species

Although the wildlife is dominated by native species, a considerable number of birds and mammals have been introduced or have escaped and several have succeeded in establishing wild living populations. Game birds like pheasants (*Phasianus colchicus*) and various water birds have established large natural populations. Since its introduction in the 1930's the populations of Canada geese (*Branta canadensis*) has increased considerably and is now considered a problem in some areas, mainly tied to aggressive behaviour and faecal pollution of beaches and water. Several mammals have been introduced for hunting and economic exploitation, for instance white-tailed deer (*Odocoileus virginianus*), fallow deer (*Dama dama*), Canadian beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), racoon dog (*Nyctereutes procyonoides*) and American mink (*Mustela vison*). The latter two are predatory species considered as pests on local wildlife, but even the rodents and the deer species may create local problems by damage to vegetation and river banks (muskrat). Several species of fish have for centuries been introduced beyond their natural distribution limits. Most of these are salmonid and cyprinid fish, amongst them a small number of North American species. With the introduction of the signal crayfish (*Pacifastacus leniusculus*) followed the crayfish pest, which is still spreading and has led to virtual extinction of the normal crayfish in many waters of the region (Weidema, 2000).

The attitude to re-introduction varies much among the countries. Re-introductions have been tried out for several animals: around 80 European beaver (*Castor fiber*) were transferred from Norway to Sweden (extinct there from 1871) in the 1920–1930's. Now some 200 000 beaver are spread over most of the country, some recently exported to Austria for release to the Danube. The wild boar (*Sus scofa*) has been continuously living in the wild in some parts of the region, while extinct in the northern part such as Sweden. Here the boar escaped from game parks in the 1980's. This re-introduction has been officially accepted and much of the former range is already now inhabited and conflicts with landowners begin to appear.

Over the centuries, a large number of vascular plant species have been introduced, either for production or accidentally as weeds in connection with agriculture, forestry and horticulture, or via transportation of goods. Many have only become naturalised to a limited extent, but several have meant radical changes. Belarus reports as an example that more than 120 new predominantly invasive vascular plants have been found (Belarus, 1998). All countries have during the 1990s collected information and begun working towards national programmes, based on case studies such as in Finland (Kurtto, *et al.*, 2000). A Nordic Network on Introduced Species (NNIS) serves as information web site to national and international institutions. For the Baltic Sea a database is situated in Lithuania (Baltic Sea Alien Species Database). In 2001 and 2002 several of the countries of the region (Belarus, Estonia, Lithuania, Norway, Russian Federation, Sweden) have reported to the convention on Biological Diversity on alien species and the main problems.

Lodgepole pine (*Pinus contorta*) has been very widely planted in Swedish forests. From the outset it was considered unlikely that it could become naturalised. In recent years, however, it has begun to spread. A potentially large problem with respect to the ecological and genetic integrity of the boreal forest species is represented by non-native provenances of local forest trees (mainly Norway spruce (*Picea abies*) of continental European origin). These have been widely used in forestry in the 1950-60s and interbreed with native provenances.

3. Policies at work in the Boreal biogeographical region

3.1 Nature protection

3.1.1 International collaboration

The Boreal biogeographical region is covered by several types of international collaboration, where biodiversity is an important issue: circumpolar arctic, Nordic and Baltic, European Community and wider European collaboration.

- **The Arctic Council**

In the most northern part of the Boreal region Sweden, Finland and the Russian Federation are all members.

- **The Nordic Council and Council of Ministers**

include in the Boreal region Sweden and Finland and collaborate with the Baltic States and the Russian Federation, mainly in Karelia and in the Sankt Petersburg region.
In 2001, the Nordic Council passed a resolution for a Nordic strategy for sustainable development in the region and adjacent areas for the period 2001-2020, including sustainable use of biological resources, securing large unbroken and virgin tracts of nature and safeguarding genetic stocks such as of salmon.

- **The Baltic Council of Ministers**

facilitates the cooperation between the governments of Estonia, Latvia and Lithuania and collaborates with Helcom and the Nordic Council of Ministers.

- **PEBLDS (Pan-European Biological and Landscape Strategy)**

facilitates cooperation among countries of all Europe, especially in European preparation for the CBD COP meetings (Conferences of parties to the convention on biological diversity).

The main conventions with direct influence on biodiversity in the region:

- **The Ramsar convention**

signed by all countries of the Boreal region.

- **The Helsinki convention**

Ratification in the Boreal region has been done by: Estonia, Finland, Sweden, Latvia,

Lithuania, the Russian Federation and by the European Community. Though mostly concerning the Baltic Sea, it also covers coastal biotopes.

• **The Bern convention** (Council of Europe)
signed by all countries of the Boreal region except the Russian Federation and Belarus.

• **The Bonn convention**
signed only by Norway, Finland, Latvia and Sweden, while the Russian Federation is associated.

• **The EU birds directive and the flora, fauna and habitats directive**
Sweden and Finland are Member States. (European Commission, NATURA2000)

• **The European Union external and cross-border policies for the Baltic Sea, the Arctic Sea Region and north western part of the Russian Federation**
is termed the Northern Dimension, aiming at increasing cooperation. It covers several themes, including environment and operates mainly through projects. An action plan was adopted in 2000. (European Commission. Northern Dimension)

• **The convention on biological diversity**
signed by all countries of the region

3.1.2 Protected areas

Areas designated for nature protection may be protected by national instruments as well as under international instruments.

Internationally protected areas

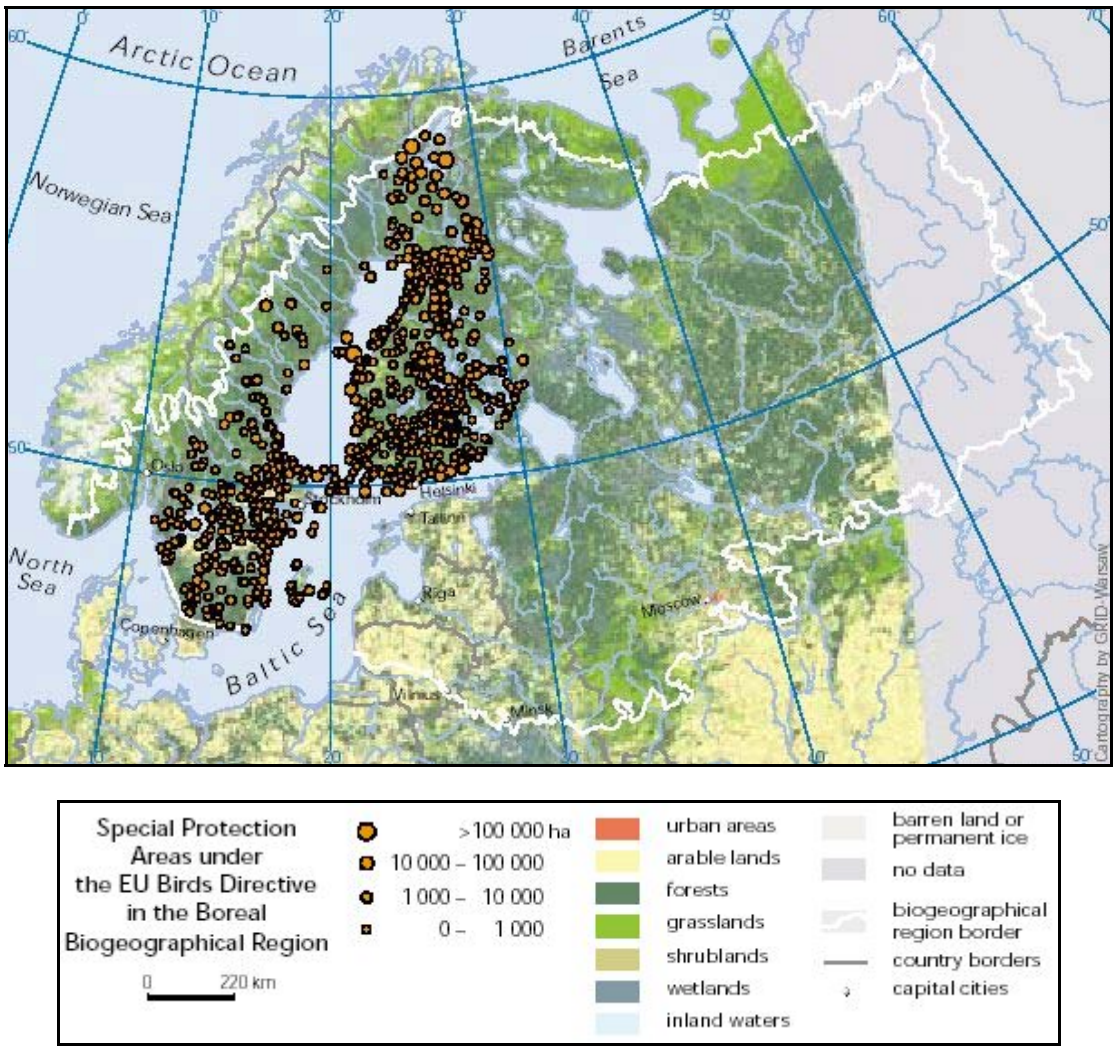
Several of the international and European Community instruments lead to area based protection on nature.

Ramsar sites
A large number of sites in the Boreal region have been designated under the Ramsar convention. These are focused on various coastal and inland wetlands (both lakes and mires) with surrounding area. They are rather small in area and are mainly localised in the western part of the region. They cover important breeding and migration sites for water and wading birds (Ramsar sites database). All Ramsar sites are also NATURA2000 sites.

The Bern convention. The EMERALD Network
The designation of sites under the EMERALD Network of the Bern convention is initiated as pilot projects: finished in 1999 in the Russian Federation. Started in 1999-2000 in Estonia and Latvia. It will complement the EU NATURA2000 Net of bird areas and habitat areas and in Estonia and Latvia serve as background for NATURA2000.

European Community NATURA2000 Network
By June 2001 EU Member States Finland and Sweden had proposed 759 (FI: 449; SE: 310) Special Protected Areas (SPAs under the birds directive), covering more than 30 000 km^2 and by February 2002 3 882 (FI:1 368; SE: 2 514) Sites of Community Interest (pSCIs under the habitats directive) covering more than 51 000 km^2, all to become part of the NATURA2000 Network. These sites are generally based on existing national parks and nature reserves. A number of species in the Boreal region are also identified to be of European conservation concern by the EU directives. However, very few of them are limited to the Boreal region. Estonia, Latvia and Lithuania are preparing for NATURA2000.

Map 6: Specially Protected Areas (SPAs) under the EU birds directive. Only for EU Member States Sweden and Finland



Source: ETC/NC compiled from European Commission birds directive database. March 2001

UNESCO Biosphere reserves and World Heritage sites

Apart from the Virgin Komi Forests site (BOX1), there is a small number of other Biosphere reserves in the region, covering a range of sites from the Ural Mountains to the Baltic Sea, and from the tundra to the temperate zone. These include a variety of ecosystems from north boreal to temperate broad-leaved forest, lakes, mires, and Baltic islands. Due to their size and internal ecological variety, they also contain a large number of species of conservation interest.

Helsinki convention (Helcom)

A Helcom project under the working group Helcom Habitat is identifying areas of special interest for nature conservation in the Baltic area (BSPAs). The coastal sites correspond to a large degree, though not fully with NATURA2000 site proposals and with Ramsar sites.

Bilateral conservation cooperation

Several of the nationally designated conservation areas in the Boreal region are in border regions. To some extent these conservation areas are seen in context with efforts to manage conservation interests across the border. One prominent example of such cooperation is the Oulanka and Paanajärvi national parks, in Finland and Russian Karelia respectively. The unregulated Torne river along the border of Sweden and Finland is managed by the two countries together.

Nationally protected areas

All the countries in the region have a wide number of protected areas which fall under national protection. Data on Nationally protected areas is a priority dataset for countries collaborating with the European Environment Agency: Norway, Sweden and Finland and is extended to cover also Estonia, Latvia and Lithuania. However, the information is not yet available for the region as such.

3.1.3 Red Lists

International red lists in the region

A Helcom red list of species was produced in 1998 as part of the collaboration under the Helsinki convention and is being used for the designation of Baltic Special Protection Areas (BSPAs).

A Nordic red list from 1995 covered species in Sweden and Finland in the region. (Nordic Council of Ministers, 1995). The list is not being updated because national lists exist in all countries and many of the species or habitats are included in international or EU legal instruments or red data books.
An overview of red lists is kept by the European Topic Centre for Nature Protection and Biodiversity.

National red lists

All countries in the region have developed and update national Red Lists of threatened species and in some cases also of threatened habitat types. The number of species groups considered varies, but increases annually. Some of the lists have been produced and updated for several decades.

3.1.4 Integration of biodiversity in socio-economic practices

Forest management and certification

Several European countries have initiated a process to develop criteria and indicators to promote sustainable management of forests and their biodiversity (SFM). This initiative (formerly called the 'Helsinki process', now the Pan-European Forest Process) is particularly relevant to the Boreal region, with its vast forests under heavy exploitation. As a follow-up, various initiatives have been taken to certify forestry operations according to standards of sustainable use. These mainly involve restrictions on extent and location of clear cutting and various cultivation measures: for instance, avoiding certain valuable habitats, and leaving particular habitat elements intact, such as specific old trees and dead wood. The effects of these certification schemes are already being felt by the forest industry, as customers become more demanding with respect to forest management for biodiversity. The certification schemes operate with rather simplified criteria, however, and the real consequences for biodiversity are rarely monitored directly. The interest in forest certification is growing in the region, especially in Norway, Finland, Sweden and Latvia.

Genetic resources

NESB
Nordic Environmental Specimen Bank (NESB) is a collaboration between the Nordic countries including Greenland and the Faroe Islands under the Nordic Council of Ministers with a goal to making environmental specimens more accessible for environmental research: heavy metal impact on birds' eggs over time; genepools (DNA) set-up over time (NESB, 2001)

NGB
Nordic Gene Bank for Plants (NGB, 1994) under the Nordic Council of Ministers and its Baltic counterparts store genetic material of interest to Nordic agriculture and horticulture.

NGH
Nordic Gene Bank for Farm Animals (NGH, 1984) under the Nordic Council of Ministers concerns mostly livestock.

3.2 Research and monitoring

Relations to the Arctic and Barents Councils
For the part of the Boreal region falling under the Arctic Council and Barents Councils several major programmes are managed. See the chapter on the Arctic Biogeographical region for: CAFF and AMAP programmes.

NNIS
Nordic Network on Introduced Species under the Nordic Council of Ministers is a network of institutions informing on introduced species via a web page. (Weidema, 2000)

Programmes under the convention on long-range trans-boundary air pollution (CLRTAP)
Monitoring and research on forest ecosystem structure and function are taking place in a number of sites in the Boreal region by the various International Co-operative Programmes (ICP Forests and ICP Integrated Monitoring of Ecosystems). The state and trends in biodiversity of freshwater and forests are also being thoroughly documented. The Fennoscandian countries have been very active in this work. (See 2.3.5 under Forest condition)

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