BOREAL FOREST, TUNDRA, AND PEAT BOGS

Sheila Hicks
Department of Geology, University of Oulu, Finland

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Summary

Tundra and boreal forests are found in the northernmost latitudes, occurring as circumpolar belts. Tundra is characterized by the presence of permanently frozen ground, treeless vegetation, and a diversity of communities reflecting edaphic, topographic, and microclimate conditions. During the Quaternary, tundra was most extensive in the glacial periods, when it fringed the ice sheets but, during the interglacials, as today, it is confined to the far north and the altitudinal areas above the tree line. Boreal forests are coniferous dominated forests, which occur where there is continuous snow cover in winter but no permafrost. The forest structure is simple with an under-story of dwarf shrubs and a thick ground layer of mosses beneath the tree canopy. Species of *Picea, Pinus,* and *Larix* dominate while *Betula, Alnus,* and *Populus* occur in the extremely oceanic areas. The boreal forest regions of today were covered by ice or tundra during the glacial periods and the boreal trees survived further south. The location of individual species was not necessarily the same during each cold period

and during the warmer interglacials the trees spread independently, at different rates, in different directions and at different times, so that the composition, and distribution of the forests was different in each interglacial. Climate conditions in the far north ensure that moisture is always abundant and so mires are more common in this biome than in others. Mires form where ground water is present at the land surface and, because of these waterlogged conditions, form peat. A distinction is made between bogs, which are ombrotrophic and fens, which are minerotrophic. Ombrotrophic raised bogs are common in the middle and south of the boreal zone, and minerotrophic aapa mires in the north. In the ecotone between the boreal forest and the tundra, palsas (peat mounds with an ice core), a variation of aapa mires, occur.

1. Introduction

Tundra and boreal forest are the most common biomes of northern latitudes, occupying the terrestrial, ice-free areas from the Pole southwards to around 60°N in Scandinavia and well south of 50°N in eastern North America. This is the circumpolar region of long, dark, snowy winters, and short, sometimes quite hot summers, with almost continuous daylight. Climatic conditions are such that moisture is always abundant and so peat bogs, or more generally mires, are more common here than in other biomes.

Because of the combination of harsh climate conditions and vast areas of wetland, the more northerly part of the region is only very sparsely populated and transport is often difficult. It is here, therefore, that some of the last remaining “wilderness” areas of the world are found. Some of these areas are being conserved and protected for the future, but others are coming under increasing pressure, not only from exploitation of mineral and hydro electric resources, but also from “adventure tourists”. This is also the area where a large number of ethnic minority groups still survive but for whom it is becoming increasingly difficult to maintain their traditional way of life. The more southerly part of the region has suffered far more from exploitation, the forests having provided building timber, fuel and tar in the past, and, additionally in the twentieth century, pulp for the paper industry.

Within this broad circumpolar belt there is a distinct zonation of vegetation types from the pole southwards, in relation to thermal conditions starting with the polar desert, proceeding through high and low Arctic tundra, and ending in the northern middle and southern boreal forests. This succession of vegetation types seen spatially today on a North–South transect is virtually the same as the succession of vegetation types which replaced each other in a temporal sequence in the interglacial periods following each of the Pleistocene glaciations. Both have the same underlying factor, increasingly warmer and more favorable growing conditions during the summer. (See *Temperate Forest).*

2. Characteristic Features of Tundra, Boreal Forests, and Peat Bogs at the Present-day

2.1 Tundra

Those terrestrial ice-free areas closest to the Pole in which no plant life exists are regarded as Polar desert. Tundra is the name applied to the generally flat treeless area of the Arctic, which is found south of the polar desert and north of the boreal forest. Tundra occurs where the ambient air temperature is below: 0 ºC for at least 7 months of the year and where there is continuous permafrost. This circum-Arctic belt extends much further south in North America, therefore, than it does in Fennoscandia, where the warming effect of the Gulf Stream is so strongly felt. The tundra-boreal forest boundary coincides with the summer position of the Arctic front.

The very short growing season, coupled with shallow soils and the prevalence of cryoturbation and solifluction, inhibits tree growth and the vegetation consists of low-growing woody herbaceous perennials, grasses, sedges, mosses, and lichens.

Figure 1. A tundra landscape in northern Canada.

Tundra vegetation is characterized by a diversity of communities, which reflect the edaphic, topographic, and microclimate conditions, with local variation often being related to the length of lie of the snow cover. Species diversity, the continuity of the vegetation cover and the height of the plants all increase with movement away from the pole. In the high Arctic, vegetation covers less than 50% of the land, bryophytes and lichens are important, and snow-patch catenae are characteristic. In the low Arctic, shrub tundra is characteristic and vegetation covers 80–100% of the land surface. Mosaics of mosses and sedges on the low lying wet areas, heaths, and dwarf shrubs on the more elevated drier areas intersperse with lichen covered fell-fields and exposed rocky ridges.

2.2 Boreal Forests

The boreal forest is the coniferous dominated forest, which occupies an almost continuous c.1000 km wide circumpolar zone to the south of the tundra. In Russia it is often referred to as taiga. Boreal forests are found where there is continuous snow-cover in winter but no continuous permafrost (in the most continental regions, however, spatially discontinuous permafrost is found). Summers in the boreal forest zone are reasonably warm but the winters are very cold, conditions to which conifers are well adapted, though some deciduous broad-leaved trees also occur (*Betula, Alnus, Populus*, and *Salix*). To the south temperate forests border the boreal forests. The boreal forest zone can be divided into southern, middle, and northern sections, each section having an increasingly shorter growing season; 160–175 days in the southern section, but only 100–140 days in the northern one. This decrease in temperature northwards is most clearly reflected in the gradual impoverishment of the ground flora associated with the forests. Within each section there is a gradient of forest types from dry to moist, reflecting oceanicity–continentality at the regional scale, but being related to soil type at the more local scale.

The forest structure is simple with a dense evergreen canopy, an under-story of low-growing ericaceous shrubs, and a thick ground layer of mosses and lichens.

Figure 2. In those pine forests of northern Europe which occur on poor acid soils the ground layer comprises a thick layer of lichens. The situation seen here is becoming a rarity as overgrazing by reindeer has destroyed the lichen cover over vast areas.

The shrub under-story can be very dense, particularly in areas where edaphic conditions ensure constant moisture. Compared with other forest types, species diversity is low. The dominant trees are *Picea mariana* and *Picea glauca* in North America, and *Betula pubescens, Pinus sylvestris,* and *Picea abies* in Europe. With movement eastwards into European Russia *Picea abies* is replaced by *Picea obovata*. Still further east larches dominate, *Larix sukaczewii* in the west, and eastwards successively *Larix sibirica* and *Larix gmelini*. The range of coniferous species is far fewer in Europe (2 only) than it is in Siberia (8 species) or North America, (6 species) and the interference with the natural vegetation by people is much greater.

Throughout the zone, where both *Picea* and *Pinus* occur together, *Picea* is found further north than *Pinus*. Fennoscandia forms an exception to this, however, in that *Pinus* extends much further north than *Picea*. The one other area where this is true is in the extreme northeast of Asia, where the dwarf pine *Pinus pumila* also grows further north than *Picea*.

Wild fires spread easily in the boreal forests, because of the quickly drying lichens in the undergrowth and the dwarf shrubs containing abundant etheric oils, but such fires are also an essential element of renewal. Fire stimulates the regeneration of many conifer species but it may still be disastrous if the climate is such that it only rarely allows the formation of germinating seed, as at the northern timberline. Birches (*Betula*), aspens and poplars, (*Populus*) and alders (*Alnus*) play a role in the natural succession following fires and other disturbances, but are also dominant in the extremely oceanic or extremely continental areas.

In addition to the latitudinal zone of boreal forest, forests with the same features occur as an altitudinal belt on most mountains. The situation of this altitudinal belt is similar; it forms the upper timberline beyond which treeless alpine communities closely related to tundra occur. Because the boreal forest belts on mountains are geographically widely separated from each other there is much more variation in the dominant conifer type from one mountain to the next than there is in the East– West variation within the latitudinal boreal forest zone.

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Biographical Sketch

Sheila Hicks is Reader in Quaternary Ecology at the University of Oulu, Finland. She graduated in Geography and Botany at the University of Leeds, U.K. and moved to Finland as a Post Doctoral Fellow. As a student she spent time in northern Sweden, Iceland and the Canadian Arctic and since then her interest has focused on the northern boreal areas of Fennoscandia. She uses the technique of pollen analysis to investigate vegetation history, including the impact of humans on this rather sensitive environment, and is a strong supporter of interdisciplinary (palaeoecology / archaeology) research. The sedimentary archives she has analyzed have been primarily peat deposits, but she has also monitored modern situations, thereby obtaining empirical data for use in quantified reconstructions of the past.

Dr Hicks is leader of the INQUA Work Group "Pollen Monitoring Programme" (PMP) and Chairperson of the European Pollen Database (EPD). She has been responsible for co-coordinating a large, multidisciplinary, European project "FOREST," (Forest Response to Environmental Stress at Timberlines) which used a range of dendroecological methods, coupled with pollen analysis, to look at the effect of climate on trees growing at the timberline. She is also involved in the PAGES initiative CAPE (Circum -Arctic Paleo-Environments) and a Nordic Arctic Research Programme project concerned with high temporal resolution pollen records of past northern and Arctic vegetation. She has taught and lectured in many parts of Europe and travels extensively.