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# VEGETATION SURVEYS IN THE CIRCUMBOREAL CONIFEROUS FORESTS: A REVIEW

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**Abstract:** As an introduction to the special issue "Vegetation of Circumboreal Coniferous Forests", a brief history is provided of the development and present state of floristic vegetation surveys of the boreal and mountain coniferous forests of Europe, northern Asia and North America. The focus is on forests assigned to the phytosociological class *Vaccinio-Piceetea* and closely related vegetation types.

**Keywords:** Boreal forests, Europe, Mountain forests, North America, Northern Asia, Phytosociology, Plant communities, Taiga, *Vaccinio-Piceetea*

## INTRODUCTION

The coniferous forest regions of Eurasia and North America constitute the greater part of the forested region of the northern hemisphere, exceeding 1000 km in width and occupying, together with the mountain coniferous forests, approximately 19 million km$^2$ (ARCHIBOLD 1995). They thus represent one of the largest forest formations in the world, and also one of the most sparsely settled. Climatically and phytogeographically, they are divided into numerous zones whose boundaries may be successfully modeled using various climatic indices (TUHKANEN 1984, RIVAS-MARTÍNEZ et al. 1999). The centres of diversity of these forests are in eastern Asia and western North America, but they also cover extensive areas in other parts of the northern hemisphere.

If we are to understand the diversity of the circumboreal coniferous forests, we must consider not only the true boreal forest, i.e., coniferous forests occurring in the boreal zone (TUHKANEN 1984), but also similar mountain coniferous forests at temperate latitudes. These forests share in common many species with true boreal forests and exhibit a profound degree of structural similarity in widely disjunct mountainous regions of the world. Characteristic is the dominance in these forests of coniferous trees of the genera *Abies*, *Larix*, *Picea*, *Pinus*, *Thuja* and *Tsuga* and often the presence of evergreen *Ericaceae* in the understory, especially *Vaccinium* spp. The moss layer is often well-developed and almost invariably dominated by widely distributed circumboreal species such as *Pleurozium schreberi* and *Hylocomium splendens*. In phytosociological terms, these forests are traditionally considered to belong to the class *Vaccinio-Piceetea* (BRAUN-BLANQUET et al. 1939). Excluded from the present review are the dry coniferous forests of Mediterranean regions and the steppe forests of the

American Cordillera and southern Siberia. These forests differ strongly from those defined above in their floristic composition, structure and ecology.

Contrary to popular belief, the coniferous forests – and in particular the boreal forests – do not represent a vast pristine forest zone. Forest fires annually consume hundreds of thousands of hectares of forest lands in North America and northern Eurasia, and constitute the major natural disturbance factor in the boreal forest biome (PAYETTE 1992). To this has been added in the 20th century large-scale deforestation in previously inaccessible regions of Siberia and Canada. While some of this logging is certainly sustainable and in fact can simulate processes of natural forest dynamics, there is a concern that excessive logging is leading to the fragmentation of forest ecosystems, and is posing a threat to biodiversity (ANGELSTAM 1998). The construction of logging roads and use of heavy equipment is in many regions resulting in potentially long-lasting damage to boreal soils. Ancient peatlands and waterlogged forests are being drained for logging or peat-mining (KELLOMÄKI 2000). There is also much discussion about the effect of climate change on primary production in boreal landscapes. Boreal forests are no less important than many tropical forests in their contribution to the atmospheric exchange of carbon dioxide (D'ARRIGO et al. 1987). Due to their valuable timber, coniferous forests represent an important economic base to many regions of Canada and northern Eurasia. The temperate mountain coniferous forests, for their part, have dramatically increased in significance in the 20th century as tourist destinations and are subjected to heavy recreation pressure, particularly in Europe, Japan and western North America.

Due to the increasing threats to boreal forests by a range of human activities, an ever-growing number of international projects concentrating on the conservation of biodiversity is being undertaken. These projects require a common basis for understanding biotope and ecosystem types for inventory and mapping purposes. However, they encounter at least three difficulties: (1) most of the studies on boreal forests have been from a silvicultural viewpoint and therefore are not suitable for assessing biodiversity; (2) the vegetation studies which have been undertaken have mostly taken place on a local scale, and therefore are of limited overall application; and (3) studies up until now have been mostly conducted within the context of many different scientific traditions, summarized in different languages, or have been confined by the imperatives of political boundaries. The need to build bridges between the different approaches was recognized early on. It was the topic of a much-cited forum in the Finnish forestry journal *Silva Fennica* in 1960, with a series of articles from the leading forest typologists and vegetation scientists of that time (Aichinger, Daubenmire, Ellenberg, Krajina, Sukachev and others) entitled, in their respective languages: "Can we find a common platform for the different schools of forest type classification?". More than forty years on, vegetation scientists still seek an answer to this problem.

The inventory of plant diversity at various spatial scales is one of the keys to overall ecosystem description for conservation purposes. Because of its use of plant lists – basic tools of biodiversity research – phytosociology is eminently suited for a high-resolution bottom-up inventory of biological diversity which can be synthesized at multiple spatial scales. In this respect, it is superior to top-down approaches such as remote sensing or other physiognomic methods which emphasize gross vegetation attributes. Phytosociology lends itself to prioritizing conservation of rare biotopes at both local and regional levels as well as to understanding biodiversity patterns at landscape to continental scales. An example of an international habitat conservation project based mostly on phytosociological classification is the European Union Habitats Directive and the network Natura 2000 (DEVILLERS & DEVILLERS-TERSCHUREN 1996, DAVIES & MOSS 2002). The role of phytosociology in biogeographical syntheses of large areas is reflected in vegetation maps such as those for Europe (BOHN & NEUHÄUSL 2000) and North America (KÜCHLER 1964).

Despite their vast size and environmental significance, boreal forests have received comparatively little attention from phytosociologists. Their continuous distribution across the northern hemisphere points to the need for international cooperation in comparing vegetation types and prioritizing biotopes for conservation, as has been started for arctic vegetation by WALKER et al. (1994). In order to facilitate international cooperation towards a phytosociological overview of boreal and mountain coniferous forests, a workshop entitled "Vegetation Classification and Phytogeography of Circumboreal Coniferous Forests" was held in association with the 44th IAVS Symposium in Freising-Weihenstephan, Germany, on 29 July – 4 August 2001. The purposes of the workshop were to bring together researchers of boreal and mountain coniferous forests from different parts of the world, including Europe, North America, Siberia and the Far East, to discuss the state-of-the-art in this research, compare different methodological approaches, and support large-scale phytosociological surveys in coniferous forests.

The present paper provides an introduction to the special issue containing selected papers from this workshop. To augment these specific studies, we will here provide an overview of the history and geographical coverage of the work that has been done to date on the coniferous forests of the northern hemisphere from the standpoint of phytogeography and specifically vegetation classification. We emphasize here the most important vegetation studies, with the aim of providing the reader with a reference list of the key works. It is not intended to be an exhaustive review. For a helpful, though dated list of the general literature on all boreal forests we refer the reader to THANNHEISER et al. (1994).

In the following, we will first discuss the literature covering continents to subcontinents, moving on to works dealing with smaller areas. We start with European forests, where detailed floristic studies began, and conclude with the relatively recently investigated North American forests. The geographic distribution of the major works on boreal and mountain coniferous forest vegetation reviewed here is displayed in Figs. 1 and 2.

## EUROPE

The first detailed phytosociological studies of European coniferous forests were carried out already before the 1930s (e.g. SZAFER et al. 1923). As the data accumulated, BRAUN-BLANQUET et al. (1939) were able to compile a prodromus of coniferous forest associations. They were the first to propose the assignment of these associations to their own class, *Vaccinio-Piceetea.* Although they devoted most attention to the Alps and adjacent regions of Central Europe, with only tentative outlines of Fennoscandian and Russian boreal forests, their syntaxonomic proposals had a remarkable influence on further studies of European coniferous forests.

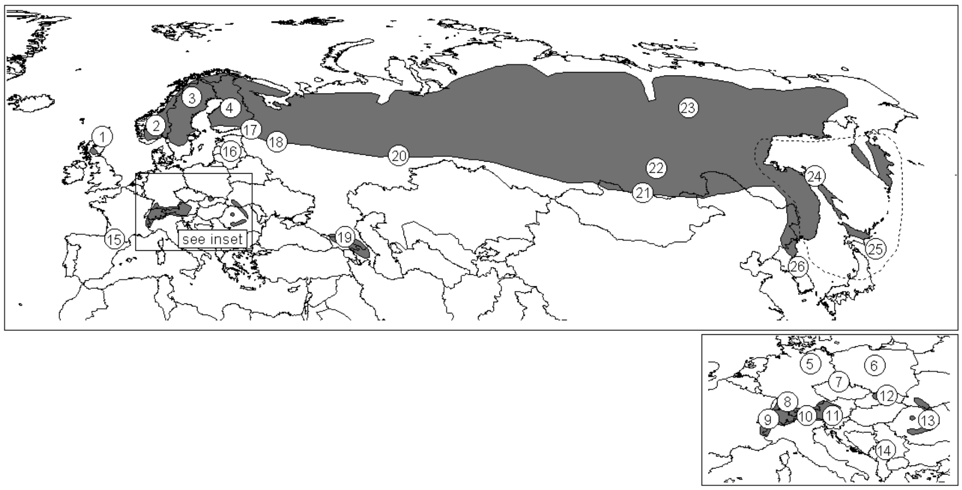


Fig. 1. Locations of selected major vegetation surveys in Eurasian coniferous forests. Shading indicates zone of boreal and mountain coniferous forests. 1 – McVean & Ratcliffe 1962, Birse 1982; 2 – Kielland-Lund 1981; 3 – Dierßen 1996; 4 – Kalela 1961, Kujala 1961, 1979, Oksanen & Ahti 1982; 5 – Passarge & Hofmann 1968, Berg et al. 2001; 6 – Matuszkiewicz 2001, 7 – Hartmann & Jahn 1967, Husová et al. 2002; 8 – Seibert 1992; 9 – Ellenberg & Klötzli 1972, Gensac 1970; 10 – Zukrigl 1973, Mayer 1974, Jahn 1977, Wallnöfer 1993, Ellenberg 1996, Exner et al. 2002; 11 – Zupančič 1999; 12 – Michalko et al. 1987; 13 – Borhidi 1971, Coldea 1991; 14 – Horvat et al. 1974, Zupančič 2000; 15 – Gruber 1978; 16 – Prieditis 1999; 17 – Passarge & Passarge 1972; 18 – Korotkov 1991; 19 – Korotkov 1995; 20 – Schubert et al. 1979; 21 – Hilbig 1995; 22 – Anenkhonov & Chytrý 1998; 23 – Ermakov et al. 2002; 24 – Krestov & Nakamura 2002 (dashed line); 25 – Miyawaki 1981–1989; 26 – Song 1991.

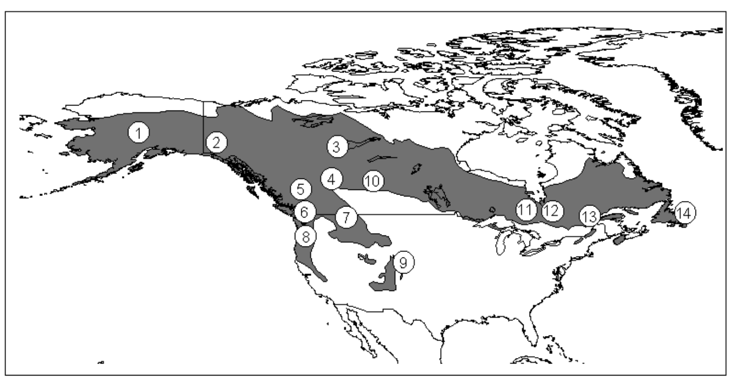

Fig. 2. Locations of selected major vegetation surveys in North American coniferous forests. Shading indicates zone of boreal and mountain coniferous forests. 1 – Viereck et al. 1992; 2 – Hoefs et al. 1975, Orlóci & Stanek 1979; 3 – Talbot 1982; 4 – Achuff & LaRoi 1977, Purchase & LaRoi 1983, Strong 2002; 5 – Wali & Krajina 1973, Klinka et al. 2002; 6 – Brooke et al. 1970; 7 – Spribille 1999, Stachurska-Swakoń & Spribille 2002; 8 – Becking 1954; 9 – Peet 1981; 10 – Looman 1987; 11 – Carleton & Maycock 1980; 12 – Gaudreault 1979; 13 – Ansseau & Grandtner 1988, Nakamura et al. 1994; 14 – Damman 1964.

Since the 1930s many local descriptive studies of vegetation types have been carried out in different parts of Europe, many of them including coniferous forests. As early as the 1950s and 1960s, several researchers attempted syntheses of phytosociological data on larger geographic scales based on the growing data body from local studies. After the classical synthesis of vegetation data from southern Germany by OBERDORFER (1957) followed syntheses on a wider, international scale. Extensive data on forests of the Hercynian ranges north of the Alps were analyzed by HARTMANN & JAHN (1967). PASSARGE (1971) used relevés from different parts of (mainly Central) Europe to analyze variation in floristic composition in spruce forests along three major ecological gradients. JAHN (1977, see also 1985) provided an extensive and insightful review of plant communities of European spruce forests, based on the analysis of ca. 1900 relevés. An overview of major plant communities of European forests with an extensive bibliography is provided in a monograph by MAYER (1984).

Recently a preliminary overview of the diversity of Central and South European *Vaccinio-Piceetea* forests, with parametrization of selected vegetation units, was prepared as a demonstration project of the working group "European Vegetation Survey" by S. Pignatti and E. Dominici and posted on the Internet (http://151.100.43.131/Survey/vacc_aa.htm).

### Scotland

"Caledonian pine forest", i.e. the isolated westernmost outpost of coniferous (*Pinus sylvestris*) forest in Eurasia was studied in detail by MCVEAN & RATCLIFFE (1962) and BIRSE (1982). The structure and floristic composition of these forests was also summarized by RODWELL (1991).

### Norway and Sweden

In Norway and Sweden, several local studies of coniferous forests have been published (see DIERßEN 1996 and FREMSTAD 1997 for references). Papers of relevance for wider areas, with important syntaxonomic implications, include mainly those by KIELLAND-LUND (1967, 1973, 1981). The phytosociology of Scandinavian birch forests, which are closely associated with coniferous forests, was summarized by HÄMET-AHTI (1987). A synthesis of selected phytosociological data on Scandinavian forests was published by DIERßEN (1996). Phytosociological classification has not been the focus of Scandinavian forest researchers in recent decades. However, the boreal forests of the region count among the ecologically best-known in the circumboreal realm, with extensive research conducted on topics such as forest dynamics, soil processes and palaeobotany (ESSEEN et al. 1992, ENGELMARK & HYTTERBORN 1999).

### Finland

In Finland, the research of forest vegetation diversity has been dominated by the approach of Cajander (CAJANDER 1909, 1949), who recognized forest site types mainly according to vegetation structure and dominants of the herb and moss layers. Overviews based on this approach were presented by KALELA (1961) and KUJALA (1961, 1979). More recent studies have usually made use of numerical ordination or classification methods (e.g. OKSANEN &

AHTI 1982, KUUSIPALO 1985, LAHTI & VÄISÄNEN 1987, TONTERI et al. 1990). A local phytosociological study of Finnish forests following the Braun-Blanquet approach, including a comparison with the results of Cajander forest type classification, was provided by MATUSZKIEWICZ et al. (1995).

### Lowland areas of northern Central Europe

In the northern Central European lowlands the diversity of natural coniferous forests is rather low, represented primarily by *Pinus sylvestris* forests. Early studies of these forests were summarized by W. MATUSZKIEWICZ (1962). Subsequent studies from Poland, carried out mainly by Władysław and Jan M. Matuszkiewicz, culminated in a monograph of Polish forest plant communities by J.M. MATUSZKIEWICZ (2001). In northeastern Germany, phytosociological syntheses of data on pine forests were published in monographs by PASSARGE & HOFMANN (1968) and BERG et al. (2001). Phytosociological data on lichen-rich pine forests from Germany, Poland and the Czech Republic were compared by HUSOVÁ & ANDRESOVÁ (1992).

Spruce forests occurring in the lowlands adjacent to the southeastern coast of the Baltic Sea were described by J.M. MATUSZKIEWICZ (2001) for Poland and PRIEDITIS (1999) for Latvia.

### Mountainous areas of Central Europe

Undoubtedly, the highest diversity of European *Vaccinio-Piceetea* forests is harboured by the Alps. Already in the 1920s and 1930s, considerable effort was devoted to the research of coniferous forests in the Alps and Western Carpathians. Major syntaxa of coniferous forests and related *Pinus mugo* scrub that continue to be recognized to the present day, such as *Piceetalia excelsae*, *Piceion excelsae* and *Pinion mugo*, were described by PAWŁOWSKI et al. (1928) from the Tatra Mountains. This early period of research was summarized in the "Prodromus der Pflanzengesellschaften" by BRAUN-BLANQUET et al. (1939).

In the second half of the 20th century many local phytosociological studies of coniferous forests from this region appeared, often associated with habitat research in forestry, vegetation mapping or nature conservation surveys. For a wider area, the results are summarized in detailed overviews by JAHN (1977, 1985) and ELLENBERG (1996), for the Alps in monographs and surveys by GENSAC (1970), ELLENBERG & KLÖTZLI (1972), ZUKRIGL (1973), MAYER (1974), SEIBERT (1992), WALLNÖFER (1993), ZUPANČIČ (1999) and EXNER et al. (2002), for the Hercynian ranges north of the Alps by HARTMANN & JAHN (1967), SEIBERT (1992), JIRÁSEK (1996), NEUHÄUSLOVÁ et al. (1998) and HUSOVÁ et al. (2002), for the Western Carpathians by ZLATNÍK (1959) and MICHALKO et al. (1987), and for the Eastern and Southern Carpathians by BORHIDI (1971) and COLDEA (1991). The large databases of vegetation relevés available from this area have enabled numerical re-evaluations of previous classifications (WOHLGEMUTH et al. 1999, CHYTRÝ et al. 2002, EXNER et al. 2002).

### Southwestern Europe

The depauperate *Vaccinio-Piceetea* forests of the Pyrenees, situated beyond the distribution limit of *Picea abies* and mostly dominated by *Pinus uncinata*, were studied mainly by GRUBER (1978; see also RIVAS-MARTÍNEZ et al. 1991).

### Southeastern Europe

*Vaccinio-Piceetea* forests occur scattered in the cold karst dolines and subalpine belt of the Dinaric Mountains and of the mountain ranges in western Bulgaria. They harbour, in addition to *Picea abies*, endemic trees such as *Picea omorica*, *Pinus peuce* and *Pinus heldreichii*. An overview of these forests, based on the as yet few local studies, was given by HORVAT et al. (1974). A comparison of spruce forests of the Eastern Alps and the Dinaric Mountains was published by ZUPANČIČ (1999, 2000).

## RUSSIA AND NORTHERN ASIA

### Russia

The largest share of the world's boreal forest is found in Russia. KRYLOV (1898) gave the first definition of the term taiga and proposed subdivisions of the taiga forests on the basis of physiognomic and floristic criteria. One of the first phytosociological studies of Russian boreal forests was carried out by A.K. Cajander as early as the turn of the 20th century (CAJANDER 1903). Up until the 1980s, research into vegetation classification in Russia nearly exclusively followed the Sukachev approach (SUKACHEV & DYLIS 1964), which is close to that of Cajander. Sukachev delimited vegetation units according to dominants and strongly played down the importance of subordinate species for classification. Consequently, Russian researchers have rarely recorded total species composition of the stands in the form of relevés. Although this approach was suitable for the biogeographical description of the vast area of the Russian taiga, it often lacked the resolution to indicate ecological factors at a local scale. More important studies based on the Sukachev approach include LAVRENKO & SOCHAVA (1956), POBEDINSKII (1965), RYSIN (1975), GRIBOVA et al. (1980), SMAGIN et al. (1980) and SOCHAVA (1980). Russian literature up to the early 1970s was summarized by WALTER (1974).

The first studies that applied the Braun-Blanquet approach to the Russian taiga were performed by foreigners in northwestern Russia (PASSARGE & PASSARGE 1972) and the southern Urals (SCHUBERT et al. 1979). The internal application of the Braun-Branquet approach in Russia was triggered in the 1980s by Boris M. Mirkin, leading to several detailed phytosociological studies. Most of them were never published, however, being instead deposited as manuscripts in the All-Union Institute of Scientific and Technical Information in Moscow. A list of syntaxa proposed in these manuscripts, with short annotations, was compiled by KOROTKOV et al. (1991). The most noteworthy studies of this period include those by Solomeshch et al. from the southern Urals, Kustova from the Irtysh River valley in western Siberia, Zhitlukhina from the West Sayan Mts. in southern Siberia, Pestryakov et al. from the Yana River valley in northeastern Siberia, and Petelin from the Far East. However, very few studies on the *Vaccinio-Piceetea* forests have been published. Examples of the latter resulting from a more extensive research include the works of KOROTKOV (1991) on forests in the Valdai uplands near Moscow, KOROTKOV (1995) on the Caucasus, ANENKHONOV & CHYTRÝ (1998) on the northern Transbaikal area, and ERMAKOV et al. (2002) on central Yakutia. Extensive studies of related coniferous forest types in the hemiboreal zone of southern Siberia were summarized in a monograph by ERMAKOV et al. (2000). Updates on the progress of the vegetation survey of Russian forests were provided by KOROTKOV (1992) and KOROTKOV & ERMAKOV (1999).

Southern outposts of Siberian taiga in the mountains of northern Mongolia were described by HILBIG (1995). A general overview of similar forests in adjacent parts of China may be found in WANG (1961).

### Far East

Coniferous forests of the Russian Far East, northeastern China, the Korean Peninsula and northern and central Japan are very similar to each other in terms of species composition, and can be considered as a distinctive, phytogeographically well defined type. Except for Japan, however, their phytosociological investigation started quite recently. A distinct problem in this region is the existence of political and language barriers which make it difficult to develop a unifying classification scheme. Useful and easily accessible English overviews of phytogeography and major vegetation patterns in this region can be found in GRISHIN (1995) for the Russian Far East, KONG & WATTS (1993) for the Korean Peninsula, and NUMATA et al. (1972) for Japan.

In Japan, phytosociological studies on coniferous forests in Hokkaido and subalpine areas of Honshu and Shikoku were initiated already in the 1940s (e.g. TATEWAKI 1944, SUZUKI 1964, JINNO & SUZUKI 1973). Various local studies were summarized in the compendium “Vegetation of Japan” (MIYAWAKI 1981–1989). A more recent study by KOJIMA (1991) applied the methodological approach of V.J. Krajina to the coniferous forest vegetation of Hokkaido.

In South Korea, SONG (1991) applied phytosociological methods to the study of subalpine coniferous forests. Recent accumulation of vegetation plot data from different parts of the Far East opened the way to synthesizing studies across national boundaries. SONG (1992) compared Korean and Japanese relevés and KRESTOV & NAKAMURA (2002) further extended these developments by including Russian data.

## NORTH AMERICA

One of the first overviews of the boreal forests of North America was that of HALLIDAY (1937), who concentrated on identifying and mapping clearly definable regional ecosystems. This work was revised by ROWE (1972), who provided maps, descriptions of the tree composition and geological and pedological attributes of the forest regions of Canada, including the broad-leaved forests. The works of Halliday and Rowe were standards in the development of concepts of regionality in northern North American forests.

These regional overviews were followed by floristic and phytogeographical studies across the same region. The overviews of KNAPP (1957, 1965) were the first to propose a subdivision of the Canadian forests on a floristic basis. One of the most comprehensive floristic studies of the boreal forests from east to west was the work of LAROI (1967, see also LAROI & STRINGER 1976). In recent decades various European phytogeographers have travelled through the region and published their own overviews of the boreal forests, achieving broadly similar results (PEINADO et al. 1998, RIVAS-MARTÍNEZ et al. 1999). This has been largely independent of an ongoing North American effort to refine the mapping of coniferous forests and other ecosystems. The most comprehensive overviews of the floristics, ecology and processes of the North American boreal forests are those of LARSEN (1980, 1982) and ELLIOTT-FISK (2000). Many unpublished phytosociological data are available for large areas of the Canadian boreal forests, far exceeding the amount of data which has been published. Forest relevés are stored in databases of regional Forest Service research branches from British Columbia to Newfoundland in varying formats.

### Eastern Canada and New England

One of the first detailed investigations into eastern boreal forests was the work of DAMMAN (1964) in the maritime forests of Newfoundland. The forest type classification of LOUCKS (1959–1960) was also an important contribution at around the same time.

Phytosociological work on northern North American forests had its start in eastern Canada, with the description of temperate and boreal forests by Miroslav M. Grandtner and his students at the Université Laval in Québec as early as the 1950s. The phytosociological tradition of the Braun-Blanquet approach has achieved the most acceptance in North America in Québec. Major monographic studies include those of GAUDREAULT (1979) on *Picea mariana* forests and ANSSEAU & GRANDTNER (1988) on *Abies balsamea* and *Picea rubens* forests. NAKAMURA et al. (1994) conducted a survey of boreal and mountain coniferous forests of northeastern North America and compared the floristics of the studied forests with those of Japanese coniferous forests. A review of the history and state of monitoring of Québec's forests was provided by GRANDTNER (1994), and a very useful review of the literature was provided in this work as well as by GRANDTNER & LUTZONI (1991).

### The Great Lakes region

Farther to the west, around the western Great Lakes (Superior, Huron, Michigan), researchers from the Universities of Wisconsin and Minnesota have been instrumental in documenting the extensive coniferous forests of Ontario and the northern tiers of Michigan, Wisconsin and Minnesota. This is the classical centre of the continuum theory and Wisconsin-school phytosociology (cf. WHITTAKER 1978), and these methods are reflected in the gradient-based analysis of the vegetation. Landmark publications from these efforts include those of MAYCOCK & CURTIS (1960) and, with an emphasis farther north, CARLETON & MAYCOCK (1980). Other significant contributions include the detailed phytosociological study of JANSSENS (1967) and the more general work of BUELL & NIERING (1957) on the mixed coniferous-broadleaved forests of northern Minnesota.

### The western Canadian boreal forest: Manitoba to northeastern British Columbia

The vegetation of the boreal forests of the granitic Canadian Shield region in northern Canada received some attention in the 1950s and 1960s, but then until recently comparatively little study. In Manitoba, the forest type classification of MUELLER-DOMBOIS (1964) should be mentioned, as well as the contributions of RITCHIE (1956) and ROWE (1956). LOOMAN (1987) proposed a phytosociological classification for the forests across the region. Here, like in much of boreal Canada, new provincial forest classifications have been completed in recent years based on detailed floristic analysis, including those of ZOLADESKI et al. (1995) for Manitoba, BECKINGHAM et al. (1996) for Saskatchewan and BECKINGHAM & ARCHIBALD (1996) for northern Alberta. In all, these efforts entailed the gathering of several thousand high quality relevés in this region. More localized ecological studies were conducted by VAN GROENEWOUD (1960) and SWAN & DIX (1966). In northern Alberta, PURCHASE & LAROI (1983) reported on lowland boreal *Pinus banksiana* forests, while ACHUFF & LAROI (1977) examined the composition of upland *Abies balsamea-Picea glauca* forests with Rocky Mountain floristic affinities. ANNAS (1974) and KLINKA et al. (2002) provided detailed phytosociological analyses of the true boreal *Picea mariana* forests of northeastern British Columbia, east of the Rocky Mountains. In one of the first papers of its kind from the region, STRONG (2002) summarized forests of *Pinus contorta* with *Ledum groenlandicum* in a swathe from the Yukon to western Alberta based on numerical classification. Farther north, in the Northwest Territories, TALBOT (1982) provided a study of middle boreal coniferous forests in the vicinity of Great Slave Lake.

### Western North American Cordillera

The mountain forest vegetation of western North America counts among the most diverse and most intensively studied in the world, particularly in terms of its silviculture and fire ecology. Already as early as the 1920s, Finnish forest ecologists studied forest vegetation and established forest site types in British Columbia following the method of Cajander (ILVESSALO 1929, KUJALA 1945). Vladimír J. Krajina introduced the phytosociological approach in the late 1940s at the University of British Columbia, and through his work and the work of his many students, a large vegetation databank on western North American forests was built. Among the most important and best known monographs to come out of this effort were the works of BROOKE et al. (1970) and WALI & KRAJINA (1973). Biogeoclimatic ecosystem classification, a concept introduced by Krajina and based in part on these and other phytosociological studies (POJAR et al. 1987), was later adopted as the standard for provincial forest inventory and mapping in British Columbia. Using a bioclimatic approach, HÄMET-AHTI (1965) reviewed the complex vegetation zonation in western Canadian forests. On the American side of the border, phytosociological investigations of the forests following the Braun-Blanquet method started with studies of coastal *Pseudotsuga menziesii* forests in Washington and Oregon by BECKING (1954). PEET (1981) provided a detailed overview of compositional patterns in *Abies lasiocarpa-Picea engelmannii* forests in the Colorado Rocky Mountains. Recent contributions to western North American forest phytosociology include the works of PEINADO et al. (1997, 1998), RIVAS-MARTÍNEZ et al. (1999) and SPRIBILLE (1999). A phytosociological overview of the mountain forests of both the Pacific Northwest and British Columbia is provided by SPRIBILLE (2002). Excellent general overviews of the forests of the region include those of FRANKLIN & DYRNESS (1988) and FRANKLIN &

HALPERN (2000) for the forests of Oregon and Washington and the synopsis of Rocky Mountain forests by PEET (2000).

Pivotal in the development of vegetation science in western North America has been the forest habitat typology of Rexford Daubenmire (DAUBENMIRE 1952, PFISTER & ARNO 1980), which has provided site classifications of nearly all of the coniferous forests of the western Cordillera from New Mexico and Arizona to the Canadian border. This system is used by the U.S. Forest Service and has achieved widespread acceptance. An overview of the major works on western North American coniferous habitat types is provided by WELLNER (1989).

### Alaska and Yukon

Ecologists and phytogeographers have long shown interest in the boreal forests of Alaska, but few phytosociological studies have been published. Perhaps the most comprehensive reference on Alaskan forests is the Alaska Vegetation Classification (VIERECK et al. 1992). Another important source on the ecology of Alaskan forests is VAN CLEVE et al. (1986). HOEFS et al. (1975) and ORLÓCI & STANEK (1979) provide overviews of forest types in the southern part of the adjacent Yukon Territory of northwestern Canada.

## THE PRESENT SPECIAL ISSUE

This special issue includes selected papers on the classification of boreal and mountain coniferous forests from Europe, northern Asia and North America. Some of these papers were presented at the Freising workshop, while others were stimulated by discussions during and following the meeting. EXNER et al. (2002) present a numerical analysis of *Picea abies* and *Abies alba* forests of the Austrian Alps and compare the results with the typologies proposed by earlier authors. CHYTRÝ et al. (2002) demonstrate a new statistical approach to determination of diagnostic species in large phytosociological databases, using a data set of *Picea abies* forests of the Eastern Alps, Western Carpathians and the Bohemian Massif. ERMAKOV et al. (2002) present the results of studies in *Larix cajanderi* and *Pinus sylvestris* forests in central Yakutia, the most continental part of Siberia. They compare their results with available data on similar forests of Siberia and outline syntaxonomic solutions. KRESTOV & NAKAMURA (2002) summarize the existing information on *Picea jezoensis*, *P. glehnii*, *Abies sachalinensis* and *A. nephrolepis* forests in the Russian Far East and northern Japan and develop a large-scale classification scheme. SPRIBILLE (2002) synthesizes relevé data on mountain forests with *Abies lasiocarpa*, *Picea engelmannii*, *Tsuga heterophylla*, *Thuja plicata*, *Abies amabilis* and *Tsuga mertensiana* in British Columbia and the northwestern United States and proposes a new syntaxonomic scheme. Finally, STACHURSKA-SWAKOŃ & SPRIBILLE (2002) outline a new classification of the montane and subalpine forests of *Pseudotsuga menziesii*, *Abies bifolia* and *Picea engelmannii* in the Whitefish Range of Montana.

This series of papers not only fills several gaps in knowledge of boreal forest vegetation, it also clearly demonstrates the differences in the state-of-the-art of vegetation surveys of boreal forests in different parts of the world. In Central Europe, there are large numbers of relevés recorded with more or less standardized procedures, and many of them are already available in electronic databases. A strong phytosociological tradition in this region has resulted in the description of numerous syntaxa, which are now being subjected to revisions based on large data sets. In Russia and North America, large gaps remain in the geographical coverage of sampled areas. Existing relevés have been recorded using varying methodologies and only some of them contain records with full species composition. Still, the studies presented in this special issue show that at least for some areas the data are sufficient to conduct synthetic studies over comparatively large areas. It is evident from the presented papers that Braun-Blanquet syntaxonomy can indeed serve as a common platform for different approaches which used to dominate vegetation surveys in different parts of the northern hemisphere.

These developments are promising for the long-term goal of a broad scale synthesis of circumboreal coniferous forests. New comprehensive vegetation databases such as SynBioSys Europe (www.synbiosys.alterra.nl/eu/) of the European Vegetation Survey (RODWELL et al. 1995) and the U.S. VegBank (www.vegbank.org) can play a key role in this effort, as well as institutions and individuals who possess local and regional vegetation databases. A number of methodological issues will have to be resolved prior to a circumboreal synthesis. However, with currently growing international cooperation, the development of a common platform for a broader understanding of the circumboreal coniferous biome is becoming increasingly achievable.

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