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A phytosociological survey of the boreal forest (*Vaccinio-Piceetea*) in North America

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Abstract

A survey of syntaxa of vegetation of North American boreal forests (class *Vaccinio-Piceetea*) is presented. This phytosociological survey, carried out combining the Braun-Blanquet method with numerical syntaxonomical analyses (cluster and correspondence analysis), describes the associations of the North American boreal forests, which have several species, varieties or vicariant species in common with their Eurasian counterparts, and can be placed in the class *Vaccinio-Piceetea*. By means of tabular and multivariate analyses, 2084 North American relevés were compared with 3273 relevés from European, Japanese and Korean boreal forest, to describe and typify 4 orders, 10 alliances and 37 associations. Diagnostic tables, ordination, clustering, and climatic, edaphic and biogeographical data were used to show floristic affinities among these syntaxa and interpret their distribution areas. Syntaxa were briefly characterized by their floristic composition, physiognomy, succession, zonation, and biogeographical distribution.
Nomenclature: Kartesz (1994) for North American taxa, except for conifers (Flora of North America 1993); Tutin et al. (1964–1980) for European taxa; Japanese and Korean nomenclature after Nakamura et al. (1994) and Song (1992), repectively. Canada Soil Survey Committee (1978) for soil names.

Introduction

A vast, almost continuous coniferous forest belt, the boreal forest or taiga, covers some 6.7 million km^2 across North America and Eurasia (Scott 1995). It includes about one-third of the world's forested land and 14% of the world forest biomass (Kauppi & Posch 1985). From Alaska to Newfoundland the boreal forest covers North America north of latitude 50°N, spanning more than 10° in many places (Elliott-Fisk 1988). Since this northern coniferous forest is a part of the larger Northern Hemisphere circumpolar boreal forest belt, the dominant genera are the same: *Picea, Larix, Abies* and *Pinus*. Hardwoods belonging to the genera *Populus* and *Betula* may become important after fire and disturbance.

Although the boreal forest is frequently described as a monotonous coniferous formation of uniform physiognomy and homogeneous floristic composition, it is in fact a complex mosaic of different plant communities, almost all of which are dominated by coniferous trees. White spruce (*Picea glauca*), black spruce (*P. mariana*) and tamarack (*Larix laricina*) are widely distributed, but the ranges of many boreal species are more limited and the composition of the forest changes regionally. Although there are no sharp discontinuities, changes in the dominant trees, and in the shrubby and herbaceous strata can be seen longitudinally and latitudinally throughout the forest.

Like any science, vegetation science uses classification to understand the laws of Nature, and organize knowledge. According to Krajina, 'Without classification there is no science of ecosystems and ecology. And, indeed, no science' (Krajina 1960). Unlike areas with a tradition of phytosociological and syntaxonomical studies, a comprehensive, hierarchical classifica-

tion of plant associations in North America has not yet been undertaken. Although classification is essential to systematic ecological studies as well as to the development of preservation and management plans, there is no widely accepted classification of North American forests (Vankat 1990).

The boreal forest zone was considered to be a climatic climax by Clements (1916) and Weaver & Clements (1938), who classified it as the Spruce-Larch forest, the *Picea-Larix* formation. The formation was divided into the *Picea-Larix* and the *Picea-Pinus* associations, with the *Betula-Populus* associes as the characteristic fire subclimax throughout the entire boreal forest, except for its western limits in Canada, where lodgepole pine *Pinus contorta* var. *latifolia* was considered to form the fire subclimax. The classification of Canadian forests by Halliday (1937) followed Clements'system with some modifications and ammendments. He used the term 'forest region' rather than 'formation' or 'climax', and divided the regions into forest sections, a section being a geographical distinction based on a broad uniformity of association, resulting from topography, soil, bed-rock, and local climate. This classification was reviewed and brought up to date by Rowe (1959).

The first approach to a syntaxonomical classification of the North American boreal forest was made by Braun-Blanquet et al. (1939), who had already recognized affinities between Eurasian and North American boreal plant communities. They classified the North American coniferous forests with their Eurasian counterparts in the order *Gaultherio-Piceetalia*. Although they had no stand surveys to work from, they provisionally proposed this order to group the boreal communities that replace the European *Vaccinio-Piceetalia* order in North America. Knapp (1957) proposed the class *Abieto-Picetea albae*, which includes the orders *Abieto-Piceetalia albae*, *Piceeto-Abietetalia fraseri* and *Pinetalia banksianae* to group the North American boreal forest associations. This proposal, not included in his later synthesis of North American vegetation (Knapp 1965), was not based on relevés and no typification was made. Consequently, Knapp's syntaxa are *nomina nuda* according to the Code of Phytosociological Nomenclature (Barkman et al. 1986).

Probably due to the influence of French and Eastern European phytosociologists, there are several classifications of the Canadian forests based on methods of the Zürich-Montpellier school. Grandtner and his students have done phytosociological classifications in eastern Canada, mainly in Quebec Province (Grandtner 1960, 1967, 1976; Jurdant & Roberge 1965; Lavoie 1968; Gadreau 1979; Sirois 1984; Lalumière & Thibault 1988).

Damman (1964) described some of the forests in Newfoundland and proposed syntaxa including those in which *Picea mariana* and *Abies balsamea* were dominant or at least important. Together with the association *Sphagno-Piceetum marianae* Grandtner 1960, Damman's associations were the first North American boreal syntaxa described with a syntaxonomical purpose. La Roi (1967) carried out a stratified classification of the boreal forests from Alaska to Newfoundland by sampling 60 stands selected on the basis of tree dominance and using the Braun-Blanquet method for stand surveys. Although the number of species that La Roi registered was comparatively small, and even though many of them were widely distributed, he found distinct regional differences in floristic composition. He later published a similar classification of the boreal forest using only the bryophyte flora (La Roi & Stringer 1976). Based on bryoflora and geography, the stands were classified into two physiognomical orders, six geographical alliances and ten associations distinguished by mosses and liverworts.

Most of the phytosociological studies in western Canada were carried out by Krajina and his graduate students in several excellent works on British Columbia vegetation, and most only studied the temperate Pacific coast (Krajina 1969; Wali & Krajina 1973; Hoefs et al. 1976; Pojar et al. 1987; Klinka et al. 1996). A complete phytosociological work on the Canadian boreal forest was carried out by Looman (1987b), whose classification was based on relevés made in a total of 882 sites located in the Canadian Prairie Provinces. Looman's syntaxonomical proposal included one order, three alliances and eight associations. Despite his good phytosociological information, he did not typify so his syntaxa must unfortunately be considered *nomina nuda*.

Lausi & Nimis (1991) carried out extensive work in the southern Yukon. Though their aim was basically phytogeographical, the data-taking protocol was based on the Braun-Blanquet relevé method. Multivariate, vegetational and phytogeographical analyses of the relevés led them to distinguish four forest types, later divided into communities, although they had no syntaxonomical aim. Several of these communities correspond to some of the floristic-sociological associations we found and discuss below.

Peinado et al. (1994a, 1997a) carried out two phytosociological studies describing Walter's zonobiomes along the Pacific drainage basin between northern California and Alaska, including some interior zones of British Columbia and the Yukon Territory. Recently, Peinado et al. (1997b) have described the climax associations in the boreal zone of western North America. However, the standardized description and typification of associations and other syntaxa according to the principles and rules of the Code of Phytosociological Nomenclature was avoided because it seemed that the establishment and typification of new syntaxa should be based on a very large number of relevés, representative of a comparatively broad area.

The 5357 relevés in the present paper allow us to propose a complete syntaxonomical grouping for most of the North American boreal forest, and compare its plant associations with other boreal syntaxa from other biogeographical regions. An additional aim of this paper is to continue with the successive approximations to the Syntaxonomy of western North America, the subject of previous papers (Peinado et al. 1994b, 1995a, b). This paper is the beginning of a series of articles being prepared on the Phytosociology of North America.

Readers who wish more detailed and specific information about the North American boreal areas and ecosystems are referred to: Walter (1985), Larsen (1980), Elliot-Fisk (1988), Barbour & Christensen (1993), Bailey (1995) and Scott (1995), for vegetation; Dice (1943), Daubenmire (1978) and Takhtajan (1986), for biogeography; Hopkins (1959), Hare & Hay (1974), Muller (1982), and Brouillet & Whetstone (1993) for climatology; and Oechel & Lawrence (1985) for ecophysiology.

Materials and methods

The field study was carried out according to the Braun-Blanquet approach (Braun-Blanquet 1979). The surveyed area stretched between Banff National Park in Alberta (where our southernmost relevé was registered at 52°21′ 46″ N, 116°05′ 60″ W) and into the Arctic Circle (northernmost relevé at 67°45′ 37″ N, 149°45′ 50″ W). Following the Canadian-40, Canadian-37, Alaska, Klondike and Dalton Highways, we explored all the forest access roads, tracks, trails or paths that were accessible to our 4-wheel drive vehicle. A total of 204 relevés were collected from boreal forest stands which appeared to be floristically and structurally homogeneous.

For each relevé, the cover/abundance data for all vascular plants[1] were recorded using the Braun-Blanquet (1979) scale. The size of the plots was based on the concept of the minimum area of relatively uniform stands (Westhoff & van der Maarel 1973), and was usually 200 m^2 for forest stands. The environmental data collected from each site noted its altitude in meters, exposure, aspect and geological substratum. Some data for soils (soil texture, thickness of organic horizon, depth to frozen soil horizon in July, and drainage) were also estimated.

Numerical and phytosociological analysis were used to classify our relevés up to association level (Peinado et al. 1996, 1997a, b). Next, these associations were combined in a rough table along with the other community types (called floristic groups, community types or associations according to the criteria of each author) from Europe (2758 relevés), Japan and Korea (515 relevés) and North America (1882 relevés) that were collected from the literature, and so 5357 relevés were finally used (Appendices 1 and

[1]Mosses, liverworts and lichens were registered in many relevés, but they have not been included in our analysis for different reasons. (a) Cryptograms form their own communities and develop thoroughly different adaptative strategies from those developed by trees, shrubs and grasses (Richardson 1981; Chopra & Kumra 1988; Vitt 1991). (b) Indiscriminately recording bryophytes and lichens (why not mushrooms or algae?) in the relevés will distort the analytical interpretations, since these plants can occupy very different microtopograhical positions in the same forest plot. For example, since the ground under *Picea mariana* muskegs is always formed by alternating hummocks and hollows (Lausi & Nimis 1991), the ecological conditions are very different on top of the hummocks (extreme aridity) with regard to the bottom of the hollows, where water stagnates. Hummocks are occupied by a lichen community dominated by *Cladonia* species, whereas hollows host submerged or half-submerged communities dominated by *Sphagnum* and other mosses. (c) In fact, a complete phytosociological syntaxonomy of the communities dominated by briophytes and lichens has been being developed from the beginning of Phytosociology as a science (for example, see Tüxen 1978). (d) The records of bryophytes and lichens accomplished by most authors always include edaphophytes and hygrophytes but usually exclude epiphytes. (e) The bryophytes and lichens generally used to characterize boreal forests are not absolutely exclusive to them, and most also appear as so far off as in the Spanish Mediterranean zones (for example *Pleurozium schreberi, Abietinella abietina, Drepanocladus revolvens, Cladonia amaurocraea, Sphagnum nemoreum*, and many others regarded as characteristic taxa of boreal forests). (f) Nevertheless including bryophytes and lichens can be justified in local studies since there are not usually enough plants to describe new associations. When studies are carried out on a global or regional level, it is obvious that regional differences in floristic composition will be distinct.

2)[2] For each community type and each vascular taxon, a synoptic coefficient of frequency was computed by dividing the total number of occurrences of each taxon by the total number of sites in each group. In this way, a synoptic phytosociological table was elaborated by scoring species in percentage or constancy classes (Braun-Blanquet 1979). When synoptic tables (e.g., Jahn 1985; Looman 1987a, b) were included the constancy of a species was determined by calculating the proportion of the number of relevés per synoptic table to the total number of relevés for a given community. The size of the final synoptic table (1041 taxa and 253 columns or community types) makes its publication very difficult but it is available from M. Peinado upon request, and partial data are shown in Tables 2 to 4. As a new step, this synoptic table was subjected to correspondence analysis (CA) in order to highlight relationships among all the registered community types.

Similarity and cluster analyses were used to compare the North American community types. Chord distance was computed between all pairs of communities on the basis of the constancy value of 617 species in the 103 registered North American community types. An agglomerative hierarchical procedure (weighted average method) was performed to define groupings. Clusters were subjectively delimited as indicated by major discontinuities. Each grouping was then phytosociologically analyzed for the occurrence of diagnostic taxa (characteristic and differential), and their syntaxonomical relationship at alliance and order level.

Numerical analyses were performed using the CANOCO (ter Braak 1990) and SYN-TAX 5.0 (Podani 1993) packages.

Results and discussion

The correspondence analysis of all 5357 relevés divided them into three large groups: European, Korean-Japanese and North American. Detailed analysis of the initial synoptic table shows that the separation into these three groupings is supported by exclusive plants in each one of them. Thus, of the 1041 plants considered in the table, 27.6% are exclusive to the European group, 13% to the eastern Asian group, and 49.8% to the North American group. In spite of their large number of exclusive plants, these continental groups still share a floristic background (Table 1). The most remarkable similarity occurs between the flora of eastern North America and eastern Asia. The relationship is also reinforced by a rather large number of identical or closely allied genera, and by closely related vicariant species (Takhtajan 1986; Nakamura et al. 1994).

The clustering of the North American relevés shown in Figure 1 separates them into nine groups. At the same time, those groupings can be gathered into three large sections: Western, Central, and Eastern, which – according to the analysis of the initial synoptic table – are supported by different floristic kengroups. These kengroups have been used as characteristic and differential taxa for alliances and orders in our syntaxonomical proposal (see below).

Though the floristic discontinuities among these sections affect the herbaceous and shrubby strata above all, there is also separation among the dominant trees. The Western Section coincides with the area of *Abies lasiocarpa*, *Pinus contorta* var. *latifolia* and *Picea engelmannii*. The Eastern Section is, fundamentally, the area where *Abies balsamea* is the dominant tree, and *Pinus banksiana* the principal fire tree. The Central Section is a transition zone, where trees of the other sections overlap, and consequently there are frequent hybrids. Numerous workers have reported hybridization between *Abies* and *Picea* at intermediate altitudes in the foothills and mountains of Alberta, eastern British Columbia and Montana (Moss & Pegg 1963; La Roi & Dugle 1968; Habeck & Weaver 1969; Achuff & La Roi, 1977; Hunt 1993; Taylor 1993; Peinado et al. 1997a, b). In addition to these, the distinctive tree of the Central Section could be *Abies bifolia*, but its area has been enlarged recently with the finding of some populations on the border between British Columbia, the Yukon Territory, and the Alaskan Panhandle (Peinado et al. 1997a).

These three sections coincide well with those found by La Roi (1967) in his analysis of 34 forest stands located in different sites between Alaska and Newfoundland. The Western Section corresponds to La Roi's western *Populus/Salix/Shepherdia* stand group, which occurs in northeastern British Columbia, the southern Yukon Territory, and Alaska. Our Central Section almost completely coincides with the *Lonicera/Rubus pubescens/Lathyrus ochroleucus* and *Lonicera/Vaccinium vitis-idaea-Geocaulon* groups, both centered around the Rocky Mts., in eastern British Columbia, Alberta, Manitoba and

[2] The only criterion for selecting the floristic groups taken from the existing literature was that they be defined through the use of floristic-sociological methods, which may in principle be incorporated into a hierarchical system.

Table 1. List of common taxa in boreal forests of Eastern Asia, Europe and North America. Figures are percentage occurrence of each species in European (EU), American (AM) and Eastern Asian (AS) recorded communities.

	EU	AM	AS		EU	AM	AS
Europe + America + Asia				*Deschampsia flexuosa*	81.7	3.9	–
Dryopteris carthusiana	11.5	16.5	63.0	*Carex magellanica*	3.9	8.7	–
Goodyera repens	13.5	34.0	13.0	*Carex pauciflora*	3.9	5.8	–
Listera cordata	16.4	20.4	30.4	*Drosera rotundifolia*	3.9	4.9	–
Lycopodium annotinum	55.8	55.3	8.7	*Equisetum palustre*	3.9	3.9	–
Lycopodium clavatum	2.9	11.7	2.2	*Deschampsia caespitosa*	41.4	2.9	–
Lycopodium complanatum	6.7	23.3	4.4	*Carex chordorrhiza*	33.7	2.9	–
Orthilia secunda	48.1	68.9	8.7	*Geum rivale*	15.4	2.9	–
Phegopteris connectilis	26.0	21.4	60.9	*Myrica gale*	5.8	2.9	–
				Poa pratensis	5.8	2.9	–
Europe + Asia				*Epilobium palustre*	4.8	2.9	–
Impatiens noli-tangere	2.9	–	2.2	*Galium triflorum*	2.9	40.8	–
				Equisetum arvense	2.9	30.1	–
America + Asia				*Chamaedaphne calyculata*	2.9	18.5	–
Oxalis montana	–	21.4	67.4	*Eriophorum angustifolium*	2.9	3.9	–
Maianthemum dilatatum	–	1.9	65.2	*Fragaria vesca*	37.5	1.9	–
Cornus canadensis	–	90.3	58.7	*Carex nigra*	11.5	1.9	–
Streptopus streptopoides	–	1.0	50.0	*Blechnum spicant*	8.7	1.9	–
Coptis trifolia ssp. *trifolia*	–	1.0	43.5	*Campanula rotundifolia*	7.7	1.9	–
Vaccinium ovalifolium	–	5.8	37,0	*Viola selkirkii*	6.7	1.9	–
Lycopodium obscurum	–	35.0	23.9	*Phleum alpinum*	5.8	1.9	–
Dryopteris dilatata	–	15.5	17.4	*Carex echinata*	3.9	1.9	–
				Menyanthes trifoliata	3.9	1.9	–
America + Europe				*Caltha palustris*	2.9	1.9	–
Vaccinium vitis-idaea	96.2	46.6	–	*Equisetum fluviatile*	2.9	1.9	–
Gymnocarpium dryopteris	49.0	33.0	–	*Phyllodoce caerulea*	2.9	1.9	–
Moneses uniflora	33.7	32.0	–	*Cinna latifolia*	1.9	24.3	–
Equisetum sylvaticum	26.9	43.7	–	*Carex disperma*	1.9	18.5	–
Vaccinium uliginosum	35.6	21.4	–	*Astragalus alpinus*	1.9	2.9	–
Epilobium angustifolium	12.5	52.4	–	*Astragalus umbellatus*	1.9	1.9	–
Empetrum nigrum ssp.	22.1	11.7	–	*Luzula acuminata*	60.6	1.0	–
hermaphroditum				*Mycelis muralis*	13.5	1.0	–
Carex vaginata	20.2	10.7	–	*Prunella vulgaris*	12.5	1.0	–
Galium boreale	10.6	28.2	–	*Dryopteris filix-mas*	11.5	1.0	–
Circaea alpina	10.6	13.6	–	*Ranunculus repens*	10.6	1.0	–
Corallorhiza trifida	10.6	13.6	–	*Carex rostrata*	4.8	1.0	–
Equisetum scirpoides	9.6	38.8	–	*Poa palustris*	3.9	1.0	–
Rubus chamaemorus	9.6	14.6	–	*Carex limosa*	2.9	1.0	–
Poa nemoralis	26.0	8.7	–	*Sambucus racemosa* var.	2.9	1.0	–
Arctostaphylos uva-ursi	8.7	30.1	–	*racemosa*			
Carex brunnescens	15.4	7.8	–	*Taraxacum officinale*	2.9	1.0	–
Andromeda polifolia	7.7	8.7	–	*Hieracium umbellatum*	1.9	1.0	–
Dryopteris expansa	26.0	6.8	–	*Thelypteris palustris*	1.9	1.0	–
Equisetum pratense	23.1	6.8	–	*Carex canescens* ssp.	1.0	12.6	–
Pyrola minor	19.2	6.8	–	*canescens*			
Juniperus communis var.	9.6	6.8	–	*Salix reticulata*	1.0	4.9	–
montana				*Cypripedium macranthos*	1.0	2.9	–
Pyrola chlorantha	6.7	28.2	–	*Dryopteris cristata*	1.0	2.9	–
Maianthemum bifolium	57.7	5.8	–	*Scirpus cespitosus*	1.0	2.9	–
Vaccinium oxycoccos	5.8	17.5	–	*Juncus trifidus*	1.0	1.9	–
Calamagrostis purpurascens	14.4	4.9	–	*Parnassia palustris*	1.0	1.9	–
Polygonum viviparum	9.6	4.9	–	*Pinguicula vulgaris*	1.0	1.9	–
Betula nana	4.8	22.3	–	*Carex bigelowii*	1.0	1.0	–
Salix glauca	4.8	18.5	–	*Cystopteris fragilis*	1.0	1.0	–
Comarum palustre	4.8	4.9	–	*Sanguisorba officinalis*	1.0	1.0	–

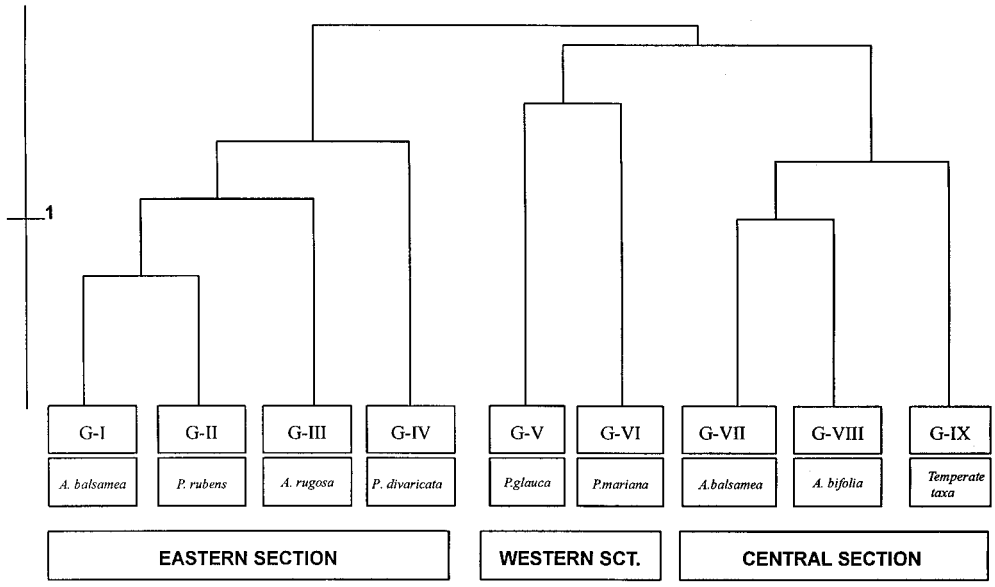

Figure 1. SYN-TAX classification (Dendrogram of the weighted average clustering) of the 103 North American community types, using all the vascular taxa included in them (617). Community types appear clustered into 9 groups, which are shown gathered into four sections according their geographical distribution.

Saskatchewan, that is to say, in the boreal-subalpine taiga transition of the Canadian Rockies. The Eastern Section corresponds to La Roi's eastern *Kalmia-Picea mariana* and *Abies balsamea* groups, which include all forests east of Lake Winnipeg, an area in which *Abies balsamea* occurs in every relevé as far west as Prince Albert National Park in Saskatchewan.

From a biogeographical point of view, all sections are based on different floristical elements. The Western Section is distinguished by some taxa endemic to Alasko-Yukonian sector (Peinado et al. 1997b), as well as by the named boreal northwestern element of the Yukon flora (Lausi & Nimis 1991). Furthermore, this section is also supported by some plants which belong to the temperate Vancouveran element (Takhtajan 1986; McLaughlin 1989) and also penetrate – following the eastward moving Westerlies (Brouillet & Whetstone 1993) - into the Alasko-Yukonian boreal forest. The Central Section is coincident with the northernmost part of the Montanian Province (Dice 1943), and is supported by the floristic element linked to the *Picea engelmannii* Province (Daubenmire 1978) and the Rocky Mountain Province (Takhtajan 1986).

Finally, our Eastern Section closely corresponds to two sections described by Daubenmire (1978): the Eastern Section of the *Picea glauca* Province, and the Northern Section of the *Picea rubens* Province. Both provinces are characterized by the co-dominance of *Abies balsamea* together with boreal (*Picea glauca, P. mariana, Betula papyrifera*) or subalpine trees (*Picea rubens, Betula alleghaniensis*), respectively. The floristic elements characterizing our Eastern Section clearly belong to the North American Atlantic Region (Takhtajan 1986).

Sections are also well differentiated from a climatic point of view. The Western Section belongs to the Polar Domain (Bailey 1995), a large zone whose climates – which are controlled by polar and arctic air masses – are characterized by low temperatures, severe winters, and low precipitation, most of which falls in summer. It is the driest domain of the North American boreal belt. Due to this limited precipitation, podsolization is rare in this domain and is restricted to some of the more humid areas like Cook Inlet, where podsols are the principal upland soils. Brunisols in the mesoboreal belt and cryosols in the supraboreal belt are zonal soils in this domain.

The Central Section corresponds to the Northern Rocky Mountain Province of Bailey's Dry Domain, a humid area where precipitation averages 510 to 1020 mm per year concentrated in fall, winter, and spring, but summers are dry because westerly air masses draw the dry climate from the Pacific coast across the area (Daubenmire 1978; Brouillet & Whestone 1993; Bailey 1995). Brunisols in the mesoboreal belt, and podsols in the wetter subalpine belt are the

zonal soils in this section. The Eastern Section belongs to the Humid Temperate Domain, where climate is more humid than the other sections because it is governed by both tropical and polar air masses. Podsolization predominates in this rainier domain and thus podsols are the zonal soils.

Cluster analysis separated groups within the sections. The Eastern Section was divided into four great groups. Group I enclosed relevés in which spruces, *P. glauca* and *P. mariana*, are dominant or co-dominant with *Abies balsamea* and *Betula papyrifera*, i.e., they are the typical boreal forests and woodlands of the *Picea glauca* Province. Group II enclosed associations co-dominated by *Picea rubens*, *A. balsamea*, and *Betula alleghaniensis*, typical trees in subalpine and boreal-subalpine transition areas of the *Picea rubens* Province. Most of the broad group of plants associated with the dominant trees also occur in the deciduous temperate forests of eastern North America. Group III enclosed seven relevé-groups that are dominated by the eastern alder (*Alnus rugosa*), and closely correspond to the alder swamps belonging to the alliance *Alnion rugosae* (Damman 1964). Finally, Group IV enclosed five associations dominated by *Pinus banksiana* (= *P. divaricata*), a pyrophilous species that is considered characteristic of the alliance *Pinion divaricatae*, already proposed by Lavoie (1968) and Looman (1987b).

The Western Section was divided into two groups. Group V enclosed those relevés dominated by *Picea glauca* and/or *Pinus contorta* var. *latifolia*, that is to say, climax forests and their successional communities in which *P. contorta* var. *latifolia* and *Populus tremuloides* are typical fire tree species. Group VI enclosed *P. mariana* woodlands on wet sites.

The Central Section was also divided into two groups. Group VII enclosed five relevé-groups, which were all recorded on the western and northern slopes of the Rocky Mts., i.e., in the sub-boreal spruce biogeoclimatic zone (Wali & Krajina 1973) of British Columbia and Alberta. Group VIII enclosed the relevés of the Prairie Provinces. The main difference between both groups is the dominance of *Abies balsamea* in the latter, and of *Abies lasiocarpa* and *A. bifolia* in the former.

Group IX is far from all the rest. It exclusively enclosed our relevés registered in the subalpine belt of the Pacific Coastal Mts., between the Olympic Mts. (Washington State) and the Kenai Peninsula in Alaska. Although this group of subalpine relevés share some taxa with the boreal relevés, its remoteness is clear because of the absence of some species that are otherwise very common in the boreal forests of the Western Section; the most remarkable example is the absence of *Picea glauca, P. mariana*, and *Larix laricina* in the tree stratum, which is dominated by typical temperate trees such as *Abies amabilis, Picea sitchensis, Tsuga heterophylla* and *T. mertensiana*. Something similar occurs in the underlying strata, which lack common boreal elements (*Arctostaphylos uva-ursi, Betula nana, Calamagrostis canadensis, Coptis trifolia* ssp. *groenlandica, Chamaedaphne calyculata, Geocaulon lividum, Ledum groenlandicum, L. palustre* ssp. *decumbens, Mertensia paniculata, Petasites frigidus, Rosa acicularis* ssp. *sayi, Rubus chamaemorus, R. idaeus* ssp. *strigosus, Vaccinium myrtilloides, V. uliginosum, V. vitis-idaea*, and *Zygadenus elegans*). On the contrary, the undergrowth abounds with a set of plants that do not exist in the boreal forests (*Clintonia uniflora, Lupinus arcticus* ssp. *alpinus, Maianthemum racemosum* var. *racemosum, Menziesia ferruginea, Rosa woodsii, Rubus lasiococcus, Sorbus sitchensis, Tiarella trifoliata* var. *trifoliata, Vaccinium membranaceum, Valeriana sitchensis*, and others), emphasizing the close floristic affinities of these subalpine forests to the western temperate forests.

The phytosociological comparison between the boreal forests in North America, Europe, Korea and Japan indicates that all these boreal plant associations have so much in common that they must be included in the same class. The floristic background supporting this class is primarily constituted by the circumboreal elements (Table 1), which are the species common to Eurasia and America. Most of these taxa were considered by Braun-Blanquet et al. (1939) to be characteristic species of the Circumboreal order *Vaccinio-Piceetalia*. Nevertheless, that work already proposed a provisional order, *Gaultherio-Piceetalia*, to gather the undescribed associations of the boreal forests of eastern North America. The set of exclusive plants in the Eastern Section justifies the existence of that order (Table 2). On the other hand, western North American boreal forests also form an independent phytosociological order, *Arctostaphylo rubrae-Piceetalia glaucae*, which is based on the taxa belonging to the Western Section (Table 3).

The order *Piceetalia glauco-marianae*, based on the plants of the Central Section, is more debatable (Table 4). A characteristic group of plants exists for that section, but there are not so many as in either of the two other sections. Nevertheless, the phytoso-

Table 2. Synoptic table of the order *Gaultherio procumbentis-Piceetalia glaucae.* Roman figures indicate percentage classes: V = species occurring in 81–100% of the relevés, IV = 61–100%, III = 41–60%, II = 21–40%. Percentage class I is not shown.

Number of relevés	87	4	2	12	66	44	7	11	3	2	10	18	2	3	90	18
Association	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
1. Abietetum balsameae																
Dryopteris carthusiana	IV	–	–	–	–	–	–	V	–	–	–	–	–	–	–	–
Goodyera repens	IV	–	–	–	–	–	–	–	–	V	–	–	–	–	II	–
Listera cordata	III	–	–	–	–	II	–	–	–	III	–	II	–	–	–	–
Gymnocarpium disjunctum	III	–	–	–	–	–	III	III	II	V	–	–	–	–	–	–
2. Kalmio polifoliae-Abietetum balsameae																
Empetrum nigrum ssp. *nigrum*	–	IV	–	II	–	–	–	–	–	–	–	–	–	–	–	–
Phyllodoce caerulea	–	III	–	II	–	–	–	–	–	–	–	–	–	–	–	–
Coptis trifolia ssp. *trifolia*	–	III	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Agrostis mertensii	–	III	III	–	–	–	–	–	–	–	–	–	–	–	–	–
3. Alno crispae-Piceetum glaucae																
Alnus viridis ssp. *crispa*	–	–	V	–	II	–	–	–	–	–	–	II	–	–	–	–
Prenanthes trifoliolata	–	–	V	–	–	–	II	–	–	–	–	–	–	–	–	–
Huperzia lucidula	II	–	V	–	–	–	–	–	–	–	–	–	–	–	III	–
Scirpus caespitosus	–	II	V	–	–	–	–	–	–	–	–	–	–	–	–	–
Dryopteris austriaca	–	III	V	–	–	–	–	–	–	–	–	–	–	–	II	II
Platanthera dilatata	–	II	V	–	–	–	III	–	–	–	–	–	–	–	–	–
Epilobium palustre	–	–	III	–	–	–	–	–	–	–	–	–	–	–	–	–
Fragaria virginiana	–	–	III	–	–	–	–	–	–	–	–	–	III	II	–	–
Andromeda polifolia	–	–	III	–	–	–	–	–	–	–	–	–	–	–	–	–
Carex stricta	–	–	III	–	–	–	–	–	II	–	–	–	–	–	–	–
Vaccinium caespitosum	–	–	III	–	–	–	–	–	–	–	–	–	–	–	–	–
Viola adunca	–	–	III	–	–	–	–	–	–	–	–	–	–	II	–	–
Carex brunnescens	–	–	III	–	–	–	II	III	–	–	–	–	–	–	–	–
Carex scirpoidea	–	–	III	–	–	–	–	–	–	–	–	–	–	–	–	–
Carex bigelowii	–	–	III	–	–	–	–	–	–	–	–	–	–	–	–	–
Aster subspicatus	–	II	III	–	–	–	–	–	–	–	–	–	–	–	–	–
Vahlodea atropurpurea	–	II	III	–	–	–	–	–	–	–	–	–	–	–	–	–
Carex interior	–	II	III	–	–	–	–	–	–	–	–	–	–	–	–	–
4. Kalmio polifoliae-Piceetum marianae																
Kalmia polifolia	–	IV	V	IV	–	III	–	–	V	–	–	–	–	–	–	–
5. Kalmio angustifoliae-Piceetum marianae																
Kalmia angustifolia	II	–	–	–	V	V	III	–	II	III	V	V	V	II	III	IV
Vaccinium vitis-idaea	–	–	–	–	III	–	III	–	–	–	–	–	–	–	–	–
6. Sphagno-Piceetum marianae																
Carex trisperma	II	–	III	–	–	V	V	V	V	V	–	II	–	–	II	V
Maianthemum trifolium	–	–	III	–	–	V	–	–	–	–	–	–	–	–	–	–
Vaccinium myrtilloides	II	–	–	–	II	V	–	–	–	V	IV	V	–	II	II	III
Chamaedaphne calyculata	–	–	–	–	–	IV	–	–	V	–	–	–	–	–	–	–
Vaccinium oxycoccos	–	–	–	–	–	III	–	–	IV	–	–	–	–	–	–	–
7. Alno rugosae-Piceetum marianae																
Alnus incana ssp. *rugosa*	II	–	–	–	–	II	V	III	V	V	–	II	–	–	–	IV
Carex gynocrates	–	–	–	–	–	–	IV	–	–	–	–	–	–	–	–	–
Geum rivale	–	–	–	–	–	–	IV	–	–	–	–	–	–	–	–	–
Rhamnus alnifolia	–	–	–	–	–	–	IV	–	II	–	–	–	–	–	–	–

Table 2. Continued.

Number of relevés	87	4	2	12	66	44	7	11	3	2	10	18	2	3	90	18
Association	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Carex disperma	–	–	–	–	–	II	IV	III	II	III	–	–	–	–	–	–
Carex vaginata	–	–	III	–	–	–	IV	–	–	III	–	–	–	–	–	–
Drosera rotundifolia	–	–	–	–	–	–	III	–	–	–	–	–	–	–	–	–
Cirsium muticum	–	–	–	–	–	–	III	–	–	–	–	–	–	–	–	–
Bromus canadensis	–	–	–	–	–	–	III	–	–	–	–	–	–	–	–	–
Glyceria striata	–	–	–	–	–	–	III	–	II	–	–	–	–	–	–	–
8. Alnetum rugosae																
Carex intumescens	–	–	–	–	–	–	–	IV	–	–	–	–	–	–	–	–
Calamagrostis canadensis	II	II	III	–	–	II	–	IV	IV	III	–	–	–	–	–	–
Carex stipata var. *stipata*	–	–	–	–	–	–	–	III	–	–	–	–	–	–	–	–
Viola macloskeyi ssp. *pallens*	II	–	–	–	–	II	–	III	II	III	–	–	–	–	–	–
9. Kalmio polifoliae-Alnetum rugosae																
Myrica gale	–	–	–	–	–	–	–	–	V	–	–	–	–	–	–	–
Maianthemum trifolium	–	–	–	–	–	–	III	–	V	–	–	–	–	–	–	–
Larix laricina	–	–	–	III	II	III	IV	–	V	–	–	–	–	–	–	–
Comarum palustre	–	–	–	–	–	–	–	–	IV	–	–	–	–	–	–	–
Salix pedicellaris	–	–	–	–	–	–	–	–	IV	–	–	–	–	–	–	–
Andromeda polifolia var. *glaucophylla*	–	–	–	–	–	II	–	–	IV	–	–	–	–	–	–	–
Carex tenuiflora	–	–	–	–	–	–	II	–	IV	–	–	–	–	–	–	–
Betula pumila var. *glandulifera*	–	II	–	–	–	–	–	–	IV	–	–	–	–	–	–	–
Carex pauciflora	–	II	III	–	–	II	–	–	IV	–	–	–	–	–	–	–
10. Vaccinio angustifoliae-Thujetum occidentalis																
Thuja occidentalis	–	–	–	–	–	–	–	–	–	V	–	–	–	–	IV	IV
Platanthera obtusata	II	–	–	–	–	–	–	–	–	V	–	–	–	–	–	–
Aralia nudicaulis	III	–	–	–	–	–	–	–	–	V	–	–	–	V	V	III
Athyrium filix-femina var. *angustum*	III	–	III	–	–	–	–	–	–	V	–	–	–	–	II	–
Sorbus americana	III	–	–	–	II	II	–	II	–	V	–	–	–	–	–	–
Ribes hirtellum	–	–	–	–	–	–	–	–	–	III	–	–	–	–	–	–
Carex pedunculata	–	–	–	–	–	–	–	–	–	III	–	–	–	–	–	–
Galium tinctorium	–	–	–	–	–	–	–	–	–	III	–	–	–	–	–	–
Glyceria melicaria	–	–	–	–	–	–	–	–	–	III	–	–	–	–	–	–
Osmunda claytoniana	–	–	–	–	–	–	–	–	–	III	–	–	–	–	–	–
Viola renifolia	–	–	–	–	–	–	–	–	–	III	–	–	–	–	II	–
Petasites frigidus var. *palmatus*	–	II	–	–	–	–	–	–	–	III	–	–	–	–	–	–
Ranunculus lapponicus	–	–	–	–	–	–	–	–	II	III	–	–	–	–	–	–
Taxus canadensis	II	–	–	–	–	–	–	–	–	III	–	–	–	–	II	–
Galium asprellum	–	–	–	–	–	–	II	II	–	III	–	–	–	–	–	–
11. Comptonio-Pinetum divaricatae																
Pinus divaricata	–	–	–	–	–	–	–	–	–	–	V	V	V	V	–	–
Comptonia peregrina	–	–	–	–	–	–	–	–	–	–	V	–	–	–	–	–
Gaultheria procumbens	–	–	–	–	–	–	–	–	–	–	IV	–	–	–	–	II
Solidago puberula	–	–	–	–	–	–	–	–	–	–	III	–	–	–	–	–
12. Ledo groenlandici-Pinetum divaricatae																
Ledum groenlandicum	II	III	–	V	III	V	V	II	V	V	–	III	–	–	–	–

Table 2. Continued.

Number of relevés	87	4	2	12	66	44	7	11	3	2	10	18	2	3	90	18
Association	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
13. Gaylussacio baccatae-Pinetum divaricatae																
Gaylussacia baccata	–	–	–	–	–	–	–	–	–	–	–	–	V	–	–	–
Polypodium virginianum	–	–	–	–	–	–	–	–	–	–	–	–	V	–	–	–
Amelanchier stolonifera	–	–	–	–	–	–	–	–	–	–	–	–	V	–	–	–
Juniperus communis var. *depressa*	–	–	–	–	–	–	–	–	–	–	–	–	V	–	–	–
Aronia melanocarpa	–	–	–	–	–	II	–	–	–	–	–	–	V	–	–	–
Nemopanthus mucronatus	–	–	–	–	–	III	–	–	II	III	–	–	V	–	III	V
Solidago hispida	–	–	–	–	–	–	–	–	–	–	–	–	III	–	–	–
14. Carici pensylvannicae-Pinetum divaricatae																
Carex pensylvanica	–	–	–	–	–	–	–	–	–	–	–	–	–	V	–	–
Solidago juncea	–	–	–	–	–	–	–	–	–	–	–	–	–	V	–	–
Oryzopsis asperifolia	–	–	–	II	–	–	–	–	–	–	–	–	–	V	–	–
Solidago nemoralis	–	–	–	–	–	–	–	–	–	–	–	–	–	IV	–	–
Betula populifolia	–	–	–	–	–	–	–	–	–	–	–	–	–	IV	–	–
Rubus allegheniensis	–	–	–	–	–	–	–	–	–	–	–	–	–	IV	–	–
Lycopodium trystachium	–	–	–	–	–	–	–	–	–	–	–	–	–	IV	–	–
Apocynum androsaemifolium	–	–	–	–	–	–	–	–	–	–	–	–	–	IV	–	–
15. Piceo rubentis-Abietetum balsameae																
Streptopus roseus var. *perspectus*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	V	–
Acer pensylvanicum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	IV	–
Viburnum lantanoides	–	–	–	–	–	–	–	–	–	–	–	–	–	–	IV	–
Corylus cornuta	–	–	–	–	–	–	–	–	–	–	–	–	–	–	IV	–
Acer saccharum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	III	–
Pteridium aquilinum var. *latiusculum*	–	–	–	–	II	–	–	–	–	–	–	–	–	–	IV	–
Prenanthes altissima	–	–	–	–	–	–	–	–	–	–	–	–	–	–	III	–
Trillium erectum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	II	–
Chimaphila umbellata ssp. *cisatlantica*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	II	–
16. Thujo occidentalis-Abietetum balsameae																
Osmunda cinnamonea	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	IV
Higher syntaxa																
Maianthemum canadense	IV	III	III	III	III	II	II	III	–	III	II	III	V	–	V	III
Betula papyrifera	V	IV	III	II	II	II	II	II	–	V	–	III	V	–	V	IV
Abies balsamea	V	V	V	III	III	III	III	V	II	V	–	III	–	–	V	V
Trientalis borealis ssp. *borealis*	V	IV	V	II	II	II	IV	II	IV	V	–	III	–	–	V	III
Vaccinium angustifolium	III	IV	V	V	V	IV	III	–	–	V	V	V	V	V	–	–
Picea mariana	III	III	–	V	V	V	V	IV	II	V	–	III	V	–	–	V
Gaultheria hispidula var. *hispidula*	IV	II	III	III	IV	IV	IV	III	–	V	–	III	–	–	II	V
Coptis trifolia ssp. *groenlandica*	IV	–	V	III	II	IV	V	III	II	V	–	III	–	–	III	V
Clintonia borealis	IV	III	V	II	III	II	III	–	–	V	–	III	–	–	V	V
Viburnum nudum var. *cassinoides*	II	–	–	–	II	III	–	II	IV	–	–	II	V	–	III	V
Picea glauca	IV	V	V	–	II	–	–	II	–	–	–	II	–	–	III	–
Solidago macrophylla	II	III	V	II	–	–	III	III	–	III	–	–	–	–	–	–
Geocaulon lividum	–	III	V	–	II	II	–	–	II	–	–	II	–	–	–	–
Lonicera villosa	–	II	V	–	–	II	–	III	V	III	–	–	–	–	–	–
Cornus sericea ssp. *sericea*	II	–	–	–	–	II	II	IV	IV	V	–	–	–	–	–	–

Table 2. Continued.

Number of relevés	87	4	2	12	66	44	7	11	3	2	10	18	2	3	90	18
Association	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Viburnum edule	III	III	–	–	–	II	–	II	–	V	–	–	–	–	–	–
Viola blanda var. *palustriformis*	III	–	–	–	–	–	IV	III	–	V	–	–	–	–	II	–
Oxalis montana	II	II	III	–	–	–	–	–	–	–	–	–	–	–	IV	III
Acer spicatum	III	–	–	–	–	–	–	II	–	III	–	–	–	–	V	II
Phegopteris connectilis	II	–	V	–	–	–	–	II	–	III	–	–	–	–	II	–
Rubus idaeus ssp. *strigosus*	II	–	–	–	–	II	II	V	–	III	–	–	–	–	–	–
Vaccinium uliginosum	–	III	V	II	–	–	–	–	IV	–	–	–	–	–	–	–
Thalictrum pubescens	–	–	–	–	–	–	III	IV	II	III	–	–	–	–	–	–
Carex canescens ssp. *canescens*	–	II	–	–	–	–	III	III	II	–	–	–	–	–	–	–
Streptopus roseus var. *roseus*	III	III	V	–	–	–	–	–	–	III	–	–	–	–	–	–
Pinus strobus	–	–	–	–	II	–	–	–	–	–	–	II	–	–	II	II
Melampyrum lineare	–	II	–	II	–	–	–	–	–	–	III	III	V	IV	–	–
Moneses uniflora	III	II	–	–	–	–	–	–	–	III	–	–	–	–	–	–
Betula nana	–	III	V	IV	–	–	–	–	–	–	–	–	–	–	–	–
Carex leptonervia	–	–	–	–	–	–	III	II	–	III	–	–	–	–	–	–
Schizachne purpurascens	–	II	III	II	–	–	–	–	–	–	–	–	–	–	–	–
Lonicera canadensis	II	–	–	–	–	–	–	II	–	–	–	–	–	–	IV	–
Diervilla lonicera	–	–	–	–	–	–	–	–	–	–	II	II	–	–	IV	–
Sorbus decora	–	–	–	–	–	–	–	–	–	–	–	II	–	–	III	V
Monotropa uniflora	II	–	–	–	–	–	–	–	–	–	–	–	–	–	IV	II
Cypripedium acaule	–	–	–	–	–	–	–	–	–	–	–	–	–	IV	III	II
Acer rubrum	–	–	–	–	–	–	–	–	–	–	–	–	–	II	V	V
Trillium undulatum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	IV	III
Betula alleghaniensis var. *alleghaniensis*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	III	III
Aster acuminatus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	IV	III
Picea rubens	–	–	–	–	–	–	–	–	–	–	–	–	–	–	III	II
Lycopodium obscurum	III	–	–	–	–	–	–	–	–	–	–	–	–	–	IV	–
Aster macrophyllus	–	–	–	–	–	–	–	–	–	III	–	–	–	–	IV	–
Carex leptalea	–	–	–	–	–	–	–	III	III	–	–	–	–	–	–	–
Salix bebbiana	–	–	–	–	–	–	–	–	–	–	II	–	–	–	–	–
Companions																
Amelanchier bartramiana	III	IV	V	IV	II	II	–	–	II	III	–	II	–	–	II	III
Cornus canadensis	V	IV	V	III	IV	IV	V	III	II	V	–	IV	–	–	V	V
Linnaea borealis ssp. *longiflora*	V	IV	V	II	II	II	IV	III	II	V	–	III	–	–	–	–
Rubus pubescens	IV	II	V	II	–	II	V	V	V	V	–	–	–	–	II	–
Lycopodium annotinum	III	III	III	–	II	II	II	IV	–	V	–	–	–	–	–	–
Equisetum sylvaticum	II	–	–	–	–	II	IV	II	–	V	–	II	–	–	–	–
Orthilia secunda	III	II	–	–	II	–	–	–	–	III	–	II	–	–	–	–
Mitella nuda	II	–	–	–	–	–	IV	III	–	III	–	–	–	–	–	–
Deschampsia flexuosa	–	III	V	II	–	–	–	–	–	–	–	–	–	II	–	–
Populus tremuloides	–	–	–	–	–	–	–	–	–	–	III	III	–	II	III	–
Ribes lacustre	II	–	–	–	–	–	III	II	II	–	–	–	–	–	–	–
Galium triflorum	II	–	–	–	–	–	III	II	–	–	–	–	–	–	III	–
Carex magellanica	–	II	V	–	–	–	III	–	–	–	–	–	–	–	–	–
Cinna latifolia	II	–	–	–	–	–	II	III	–	–	–	–	–	–	–	–
Luzula parviflora	–	II	III	–	–	–	–	–	–	–	–	–	–	–	–	–
Sanguisorba canadensis	–	–	–	–	–	–	III	II	–	–	–	–	–	–	–	–
Epilobium angustifolium ssp. *angustifolium*	–	–	–	–	–	–	–	–	–	–	III	II	–	–	–	–
Fagus grandiflora	–	–	–	–	–	–	–	–	–	–	–	–	–	–	II	II
Amelanchier alnifolia	–	–	–	–	–	–	–	–	II	–	–	–	–	–	–	–

Table 3. Synoptic table of the orders *Arctostaphylo rubrae-Piceetalia glaucae* (1–11) and *Alnetalia tenuifoliae* (12–14). Roman figures as in Table 2.

Number of relevés	29	22	9	6	33	28	19	4	15	26	10	12	6	4
Association	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1. Hypno procerrimi-Piceetum glaucae														
Picea glauca	V	II	V	V	III	IV	V	IV	V	II	II	V	IV	–
Arctostaphylos uva-ursi	III	V	–	–	V	–	II	II	–	–	–	–	–	–
Shepherdia canadensis	IV	III	II	–	IV	–	–	–	II	–	II	–	III	–
Arctostaphylos rubra	III	–	–	–	–	III	V	–	II	III	II	–	IV	–
2. Pulsatillo patentis-Pinetum latifoliae														
Pinus contorta var. *latifolia*	II	V	–	–	–	–	–	–	–	–	–	–	–	–
Pulsatilla patens	–	IV	–	–	–	–	–	–	–	–	–	–	–	–
Festuca altaica	–	IV	–	–	II	–	II	–	–	–	–	–	–	–
Gentianella propinqua ssp. *propinqua*	–	III	–	–	–	–	–	–	–	–	–	–	–	–
Zygadenus elegans	II	III	–	–	–	–	–	–	–	–	–	–	–	–
3. Betulo kenaicae-Piceetum glaucae														
Betula papyrifera var. *kenaica*	–	–	V	–	–	–	–	–	–	–	–	–	–	–
Gymnocarpium dryopteris	–	–	IV	–	–	–	–	–	–	–	–	III	–	–
Alnus virdis ssp. *sinuata*	–	–	IV	–	–	–	–	–	–	–	II	–	–	–
Athyrium filix-femina ssp. *cyclosurum*	–	–	III	–	–	–	–	–	–	–	–	–	–	III
Streptopus amplexifolius	–	–	III	–	–	–	–	–	–	–	–	–	–	–
Lycopodium annotinum	–	–	III	II	–	II	–	II	–	–	–	–	–	–
4. Piceo glaucae-Betuletum neoalaskanae														
Betula neoalaskana	–	–	–	V	–	–	–	V	II	–	III	III	–	–
Alnus viridis ssp. *crispa*	–	–	–	V	–	–	–	II	III	–	–	V	–	–
5. Roso sayi-Populetum tremuloidis														
Populus tremuloides	II	II	–	–	V	–	–	–	II	–	–	II	III	–
Rosa acicularis ssp. *sayi*	III	III	III	V	IV	–	–	II	III	II	II	III	V	–
6. Betulo nanae-Piceetum glaucae														
Betula nana	–	–	–	–	–	V	III	III	–	IV	IV	–	–	–
Empetrum nigrum ssp. *hermaphroditum*	III	–	–	–	–	V	–	V	II	IV	III	–	–	–
Vaccinium uliginosum	–	–	–	II	–	IV	V	V	II	V	IV	–	–	–
Ledum groenlandicum	II	–	–	III	–	III	V	–	IV	V	V	III	–	–
7. Rhododendro lapponici-Piceetum glaucae														
Rhododendron lapponicum var. *lapponicum*	–	–	–	–	–	–	V	–	–	–	–	–	–	–
Dryas integrifolia ssp. *integrifolia*	–	–	–	–	–	–	IV	–	–	–	–	–	–	–
Pentaphylloides floribunda	–	–	–	–	–	II	IV	–	–	II	–	–	–	–
Pedicularis labradorica var. *labradorica*	–	–	–	–	–	–	III	–	–	–	–	–	–	–
Equisetum scirpoides	–	–	–	–	–	–	III	–	–	–	–	III	III	–
Salix myrtillifolia var. *myrtillifolia*	II	–	–	–	–	II	III	–	–	II	II	–	–	–
8. Loiseleurio procumbentis-Betuletum neoalaskanae														
Ledum palustre ssp. *decumbens*	–	–	–	–	–	III	–	IV	–	–	–	–	–	–
Loiseleuria procumbens	–	–	–	–	–	–	–	IV	–	–	–	–	–	–
Lycopodium complanatum	–	–	–	–	–	–	–	III	–	–	–	–	–	–
Betula x eastwoodiae	–	–	–	–	–	–	–	III	–	–	–	–	–	–
9. Piceetum glauco-marianae														
Picea mariana	–	–	–	II	–	–	II	–	V	V	V	–	–	–
Linnaea borealis ssp. *longiflora*	IV	V	III	IV	IV	–	–	–	III	–	–	IV	–	–
Lupinus arcticus ssp. *arcticus*	II	III	–	–	III	II	II	–	II	–	–	–	–	–

Table 3. Continued.

Number of relevés	29	22	9	6	33	28	19	4	15	26	10	12	6	4
Association	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
10. Rubo chamaemori-Piceetum marianae														
Rubus chamaemorus	–	–	–	–	–	–	–	–	–	IV	IV	–	–	–
11. Larici laricinae-Piceetum marianae														
Larix laricina	–	–	–	–	–	–	–	–	–	–	V	–	–	–
Equisetum sylvaticum	–	–	II	II	–	–	–	–	–	II	IV	–	–	–
12. Boschniakio rossicae-Alnetum crispae														
Pyrola asarifolia	–	–	–	–	–	–	–	–	–	–	–	IV	–	–
Ribes triste	–	–	III	III	–	–	–	–	–	–	–	IV	–	–
Boschniackia rossica	–	–	–	–	–	–	–	–	–	–	–	III	–	–
Aconitum delphiniifolium	–	–	–	–	–	–	–	–	–	–	–	III	–	–
13. Salici arbusculoidis-Alnetum tenuifoliae														
Anemone richardsonii	–	–	–	–	–	–	–	–	–	–	–	–	V	–
Salix arbusculoides	–	–	–	–	–	II	–	–	II	III	IV	–	V	–
Calamagrostis canadensis	–	–	–	–	II	–	–	–	–	–	–	IV	V	IV
Pyrola grandiflora	–	–	–	–	–	–	–	–	–	–	–	–	IV	–
Salix alaxensis	–	–	–	–	–	–	II	–	–	–	–	–	IV	–
Alnus incana ssp. *tenuifolia*	–	–	–	–	–	–	–	–	–	–	–	–	IV	III
Rumex arcticus var. *arcticus*	–	–	–	–	–	–	–	–	–	–	–	–	III	–
Platanthera obtusata	–	–	–	–	–	–	–	–	–	–	–	–	III	–
Populus balsamifera ssp. *balsamifera*	II	–	II	–	III	–	–	–	–	–	–	–	III	–
Hedysarum alpinum	II	–	–	–	–	–	–	–	–	–	–	–	III	–
Ribes hudsonianum	–	–	–	–	–	–	–	–	–	–	–	–	III	III
14. Urtico gracilis-Alnetum tenuifoliae														
Mentha arvensis	–	–	–	–	–	–	–	–	–	–	–	–	–	V
Urtica dioica ssp. *gracilis*	–	–	–	–	–	–	–	–	–	–	–	–	–	V
Viola aff. *orbiculata*	–	–	–	–	–	–	–	–	–	–	–	–	–	V
Lonicera involucrata	–	–	–	–	–	–	–	–	–	–	II	–	–	IV
Galium triflorum	–	–	–	–	–	–	–	–	–	–	–	–	–	IV
Mitella nuda	–	–	–	–	–	–	–	–	–	–	–	–	–	III
Cinna latifolia	–	–	–	–	–	–	–	–	–	–	–	–	–	III
Geum macrophyllum	–	–	–	–	–	–	–	–	–	–	–	–	–	III
Senecio triangularis	–	–	–	–	–	–	–	–	–	–	–	–	–	III
Thalictrum occidentale	–	–	–	–	–	–	–	–	–	–	–	–	–	III
Higher syntaxa														
Vaccinium vitis-idaea	II	IV	–	II	II	IV	III	V	IV	V	V	III	–	–
Geocaulon lividum	III	II	II	V	–	II	II	II	V	II	IV	II	–	–
Mertensia paniculata var. *paniculata*	III	II	III	III	III	II	–	–	IV	–	II	V	V	–
Salix glauca	II	–	II	III	III	III	III	–	IV	III	III	–	–	–
Viburnum edule	II	–	V	–	II	–	–	–	II	–	II	III	II	–
Agrostis exarata	–	–	II	II	–	–	–	–	–	–	III	–	–	–
Companions														
Epilobium angustifolium ssp. *angustifolium*	III	II	III	–	V	–	–	–	II	–	II	III	V	II
Cornus canadensis	–	II	V	II	II	II	–	–	II	II	II	–	–	IV
Equisetum arvense	–	–	IV	II	–	II	–	II	–	II	II	–	V	IV

ciological units are based not only on characteristic species, but also on differential taxa. There is a great number of taxa that can be used as differential plants for a Central order, because many Eastern Section plants reach their western limit in the Central Section. These plants can be used as differential species with regard to the Western order, and conversely.

Once the existence of these three orders is accepted, at least two large physiognomic, ecological and floristic groups can be established within each order. There is a group dominated by *Picea glauca*, or co-dominated by *P. glauca* and other trees (*Abies balsamea*, *A. bifolia*, *Betula papyrifera*, *Populus tremuloides*, and others), which constitute climax communities on soils without water influence. On the contrary, the other groups of associations thrive on soils with additional soil moisture (gleysols and cryosols), where *P. mariana* is always dominant or co-dominant. In these very open wet forests or woodlands *P. glauca*, *Abies lasiocarpa*, *A. bifolia* or *A. balsamea* can appear, but they are always scattered and poorly grown or even stunted. These wet subclimax associations can be used to constitute alliances (*-Piceion marianae*) that are characterized by an underlying strata dominated by Ericaceae and Cyperaceae (particularly C*arex sp. div.* and *Eriophorum sp. div*.).

Nevertheless, it is important to specify that *P. mariana* should not be considered strictly characteristic of these wet alliances, because it also prospers after fire, particularly in the rainiest zones. In Alaska and the Yukon, the driest zones of the American boreal forest (Dice 1943; Hopkins 1959; Hultén 1968; Hare & Hay 1974; Walter 1985), *P. mariana* remains practically relegated to zones with soil moisture, while the successional post-fire role is played by *P. contorta* var. *latifolia* and *Populus tremuloides*. Something similar occurs in the boreal zone of central Canada eastward into Quebec Province, where *Pinus banksiana* and *P. tremuloides* are successional fire trees. On the contrary, in the wettest zones of the East, in Newfoundland and eastern Quebec, *P. mariana* forms part of the climax forests, becoming co-dominant in some balsam fir forests, as well as serial after fires. The floristic composition of these black spruce forests is very similar to the ancient dominant forest, except for the temporary dominance of *P. mariana*. The range of sites occupied by this kind of successional *P. mariana* forest includes the range of other *Picea glauca* and/or *Abies* and *Betula* dominated forests, which always occur in undisturbed stands (Damman 1964). From a phytosociological point of view they are fire facies of *P. mariana* belonging to different climax forests.

Conclusions. Syntaxonomical proposal

The phytosociological study of the 2084 relevés obtained in the North American boreal forest from Alaska to Newfoundland allows us to propose the following syntaxonomical scheme according to the rules of the Code of Phytosociological Nomenclature (Barkman et al. 1986). Reasons for invalidity or illegitimacy of the synonyms are added in brackets; abbreviations correspond to the article or particular paragraphs of the Code. Alliances and orders are described through a short diagnosis, accompanied by the list of the differential and characteristic taxa. The description of new associations also includes a short diagnosis and a complete phytosociological table. In cases in which an association is proposed using references from other authors, only the type relevé (*lectotypus*) is included. This solution has been used for those cases in which there is enough written information on the association, even if its publication does not satisfy Article 1 of the Code. For validly published associations only the bibliographic reference, together with the chosen relevé type (*lectotypus*), has been included. When the original diagnosis of an association only contained a synoptic table but no relevés, nor references to validly published relevés, then a *lectotypus* could not be chosen. These associations require a *neotypus* that must be taken from the same geographical area as the relevés of the synoptic table.

Vaccinio-Piceetea Br.-Bl. 1939

Arctostaphylo rubrae-Piceetalia glaucae ordo novo hoc loco

Nomenclatural type: *Shepherdio canadensis-Piceion glaucae all. nova hoc loco.* Characteristic and differential taxa: *Agrostis exarata*, *Alnus viridis* ssp. *sinuata*, *Arctostaphylos rubra*, *Carex concinna*, *Dryas integrifolia* ssp. *integrifolia*, *Empetrum nigrum* ssp. *hermaphroditum*, *Equisetum scirpoides*, *Festuca altaica*, *Galium boreale*, *Hedysarum alpinum* var. *americanum*, *Lupinus arcticus* ssp. *arcticus*, *Mertensia paniculata* var. *paniculata*, *Pedicularis labradorica* var. *labradorica*, *Pentaphylloides floribunda*, *Pyrola asarifolia* ssp. *asarifolia*, *Salix arbusculoides*, *S. bebbiana*, *S. glauca* (diff.), *S. myrtillifolia* ssp. *myrtillifolia*, *S. planifolia*, *Spiraea stevenii*, *Tofieldia pusilla*, and *Zygadenus elegans*.

Table 4. Synoptic table of the order *Piceetalia glauco-marianae.* Roman figures as in Table 2.

Number of relevés	193	3	16	23	10	6	228	3
Association	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1. Arctostaphylo uva-ursi-Pinetum latifoliae								
Arctostaphylos uva-ursi	IV	–	II	–	IV	–	V	–
Leymus innovatus	IV	–	–	–	V	–	III	–
Salix bebbiana	III	–	–	–	–	–	III	II
Antennaria racemosa	III	–	–	–	–	–	–	–
Solidago multiradiata	III	–	–	–	–	–	–	–
Juniperus communis var. *depressa*	III	–	–	–	IV	–	–	–
2. Vaccinio membranacei-Piceetum glaucae x engelmannii piceetosum								
Vaccinium membranaceum	–	V	V	III	–	–	–	II
Picea glauca x engelmannii	II	V	II	V	III	–	–	–
Plantanthera orbiculata	–	IV	–	–	–	–	–	–
Moneses uniflora	–	IV	–	–	–	–	–	–
Chimaphila umbellata ssp. *occidentalis*	–	IV	IV	–	–	–	–	–
Goodyera oblongifolia	–	II	IV	–	–	–	–	–
Osmorhiza berteroi	–	II	II	–	–	–	–	–
3. Vaccinio membranacei-Piceetum glaucae x engelmannii lycopodietosum complanati								
Lycopodium complanatum	II	–	IV	II	–	–	II	–
Melampyrum lineare	–	–	III	–	–	–	–	–
Shepherdia canadensis	IV	–	III	–	V	–	II	–
4. Gymnocarpio dryopteridis-Abietetum lasiocarpae								
Gymnocarpium dryopteris	–	–	–	V	–	–	–	II
Abies lasiocarpa	II	–	–	IV	–	–	–	II
Tiarella trifoliata var. *unifoliata*	–	II	–	IV	–	–	–	–
Athyrium filix-femina ssp. *cyclosurum*	–	–	–	III	–	–	–	II
Streptopus roseus var. *roseus*	–	II	–	III	–	–	–	–
Actaea rubra	–	II	–	III	–	–	II	–
Sorbus sitchensis	–	II	–	III	–	–	–	–
Petasites frigidus var. *nivalis*	–	II	–	III	–	–	–	–
5. Abieti bifoliae-Piceetum engelmannii								
Picea engelmannii	–	–	–	–	V	–	–	–
Abies bifolia	–	–	–	–	IV	–	–	–
Aster conspicuus	–	–	II	–	IV	–	–	–
Vaccinium scoparium	–	–	–	–	III	–	–	–
6. Vaccinio vitis-idaeae-Abietetum balsameae x bifoliae								
Abies balsamea x bifolia	–	–	–	–	–	V	–	–
Sorbus scopulina	–	–	II	–	–	V	–	–
Rubus pedatus	–	II	–	III	–	V	–	–
Listera cordata	–	–	–	–	–	IV	–	–
Vaccinium vitis-idaea	II	–	–	–	II	IV	III	–
Dryopteris expansa	–	–	–	–	–	III	–	–
Empetrum nigrum ssp. *nigrum*	–	–	–	–	–	III	–	–
7. Trientalido latifoliae-Piceetum glaucae								
Trientalis borealis ssp. *latifolia*	–	–	–	–	–	–	V	–
Picea glauca	–	–	–	–	II	V	V	–
Cornus sericea ssp. *sericea*	II	–	–	III	–	–	V	–

Table 4. Continued.

Number of relevés	193	3	16	23	10	6	228	3
Association	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Lathyrus ochroleucus	II	–	–	–	–	–	III	–
Populus balsamifera ssp. *balsamifera*	II	–	–	–	–	–	III	–
Schizachne purpurascens	–	–	–	–	–	–	III	–
Carex trisperma	–	–	–	–	–	–	III	–
Dryopteris cristata	–	–	–	–	–	–	III	–
Lycopodium clavatum	–	–	–	–	–	–	III	–
Abies balsamea	–	–	–	–	–	–	II	–
8. Corno canadensis-Piceetum marianae								
Carex canescens ssp. *canescens*	–	–	–	–	–	–	–	V
Gaultheria hispidula	–	II	–	–	–	–	–	IV
Ribes hudsonianum	–	–	–	II	–	–	–	IV
Senecio triangularis	–	–	–	–	–	–	–	IV
Spiraea douglasii	–	–	–	–	–	–	–	IV
Carex disperma	–	–	–	–	–	–	–	IV
Comarum palustre	–	–	–	–	–	–	–	IV
Platanthera obtusata	–	–	–	–	–	IV	–	IV
Higher syntaxa								
Vaccinium myrtilloides	III	II	IV	II	–	V	III	IV
Pinus contorta var. *latifolia*	V	IV	IV	II	V	V	–	–
Pyrola asarifolia ssp. *asarifolia*	IV	II	–	III	III	–	V	IV
Viburnum edule	III	V	III	V	–	–	V	II
Lycopodium annotinum	–	IV	II	IV	–	V	II	–
Vaccinium cespitosum	II	II	II	–	–	III	–	II
Lonicera involucrata	–	II	–	V	II	–	II	IV
Rosa acicularis ssp. *sayi*	IV	II	–	–	–	–	IV	IV
Spiraea betulifolia var. *lucida*	II	IV	V	III	–	–	–	–
Petasites frigidus var. *palmatus*	–	–	–	–	II	IV	V	II
Alnus viridis ssp. *sinuata*	–	IV	III	III	–	–	–	II
Maianthemum canadense	III	–	II	III	–	–	V	–
Arnica cordifolia	II	II	–	–	III	–	IV	–
Geocaulon lividum	–	II	III	–	–	–	II	IV
Equisetum scirpoides	–	–	–	II	III	–	III	II
Calamagrostis canadensis	–	–	–	III	–	V	–	V
Amelanchier alnifolia	–	IV	III	III	–	–	II	–
Ribes lacustre	–	IV	–	V	II	–	–	–
Betula papyrifera	–	II	–	IV	–	–	IV	–
Rubus idaeus ssp. *strigosus*	III	–	–	III	–	–	IV	–
Mertensia paniculata var. *paniculata*	II	–	–	III	–	–	III	–
Ledum groenlandicum	–	–	–	–	II	IV	–	V
Picea mariana	–	–	–	–	–	IV	II	IV
Companions								
Linnaea borealis ssp. *longiflora*	V	V	V	V	V	V	V	V
Orthilia secunda	V	V	IV	IV	II	V	V	II
Cornus canadensis	IV	V	V	V	III	V	V	V
Epilobium angustifolium ssp. *angustifolium*	III	II	IV	IV	II	IV	V	V
Pyrola chlorantha	II	V	II	–	III	III	IV	–

Table 4. Continued.

Number of relevés	193	3	16	23	10	6	228	3
Association	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Mitella nuda	II	II	–	III	–	–	V	V
Populus tremuloides	II	IV	III	II	–	–	V	–
Rubus pubescens	–	II	II	V	–	–	IV	V
Galium triflorum	II	IV	–	V	–	–	IV	IV
Aralia nudicaulis	II	IV	IV	V	–	–	V	–
Maianthemum racemosum ssp. *amplexicaule*	–	V	III	IV	–	–	–	–
Oryzopsis asperifolia	IV	II	IV	–	–	–	III	–
Viola orbiculata	–	II	II	V	–	–	–	II
Equisetum sylvaticum	–	II	–	III	–	IV	IV	–
Equisetum arvense	–	IV	–	III	–	–	III	IV
Clintonia uniflora	–	V	IV	V	–	–	–	–
Tiarella trifoliata var. *trifoliata*	–	–	–	V	–	III	–	II
Rubus parviflorus	–	II	III	IV	–	–	–	–
Streptopus amplexifolius	–	–	–	IV	–	IV	–	II
Disporum hookeri	–	IV	–	III	–	–	–	II
Fragaria virginiana	III	–	–	–	III	–	IV	–

Boreal forest and woodland of western North America. Its area spreads from Alaska eastwards to the western slopes of the Rocky and McKenzie Mts. In the subalpine belt of these mountains it is replaced by forests belonging to the order *Piceetalia glauco-marianae*. The bioclimatic (bioclimatic belt and rainfall type), edaphic, geographic, and physiognomic diagnoses of the associations belonging to *Arctostaphylo rubrae-Piceetalia glaucae* are shown in Table 5.

Shepherdio canadensis-Piceion glaucae all. nova hoc loco

Nomenclatural type: *Hypno procerrimi-Piceetum glaucae* Hoefs et al. 1976 *corr.* Characteristic taxa (and differential with regard to *Ledo decumbentis-Piceion marianae*): *Abies lasiocarpa* (diff.), *Achillea millefolium* var. *borealis*, *Agropyron yukonense*, *Anemone patens* ssp. *multifida*, *Arnica cordifolia* (diff.), *Arctostaphylos uva-ursi* (diff.), *Artemisia campestris* var. *borealis*, *Astragalus alpinus*, *Athyrium filix-femina* ssp. *cyclosurum* (diff.), *Boschniakia rossica*, *Calamagrostis purpurascens*, *Calypso bulbosa*, *Circaea alpina* (diff.), *Cypripedium passerinum*, *Delphinium glaucum* (diff.), *Gentiana propinqua*, *Hedysarum boreale* ssp. *mackenziei*, *Juniperus communis* var. *depressa* (diff.), *J. nana*, *Listera borealis*, *Lycopodium complanatum* (diff.), *Oxytropis campestris*, *O. deflexa*, *Pedicularis sudetica* ssp. *interior*, *Pinus contorta* var. *latifolia* (diff.), *Ribes hudsonianum*, *R. triste* (diff.), *Shepherdia canadensis* (diff.), and *Solidago simplex* var. *nana*.

This alliance groups mesoboreal and supraboreal climax forests of western North America, as well as their successional deciduous (*Populus tremuloides*, *P. balsamifera*) or coniferous (*Pinus contorta* var. *latifolia*) forests and woods. They always live on well-drained soils (brunisols and regosols), and are replaced on soils with poor drainage and water stagnation (cryosols, gleysols, humid humisols) by associations belonging to the alliance *Ledo decumbentis-Piceion marianae*.

1. Hypno procerrimi-Piceetum glaucae Hoefs et al. 1976 *corr. hoc loco*

Syn.: *Hypno (procerrimi)-Abietinello (abietinae)-Piceetum glaucae* Hoefs et al. 1976 *nom. illeg.* (Art. 10).

Nomenclatural type: Hoefs et al. 1976: Table 15, rel. 10, *lectotypus*. Closely related communities: *Picea glauca-Hypnum procerrimum* community (Lausi & Nimis 1991); *Anemone multifida-Picea glauca* association (Peinado et al. 1997b).

Mesoboreal dry forest endemic to the southern part of the Alasko-Yukonian sector, which usually occupies sites with well drained, permafrost-free soils. All the *P. glauca* closed forests in mesoboreal areas with dry ombroclimate belong to this association because

Table 5. Bioclimatic, geographical, physiognomical and edaphic features of the associations belonging to *Arctostaphylo rubrae-Piceetalia glaucae* and *Alnetalia tenuifoliae*.

Associations	Bioclimatic belt	Rainfall types	Soil	Geographical range	Physiognomy
Artostaphylo rubrae-Piceetalia glaucae					
Shepherdio canadensis-Piceion glaucae					
Hypno procerrimi-Piceetum glaucae	Mesoboreal	Dry	Brunisols	Southern Alasko-Yukonian sector	White spruce forest
Pulsatillo patentis-Pinetum latifoliae	Mesoboreal	Semiarid-Dry	Brunisols & Regosol	Southern Alasko-Yukonian sector	Lodgepole pine forest
Betulo kenaicae-Piceetum glaucae	Mesoboreal	Subhumid	Podsols	South Central Alaska	Kenai birch-white spruce forest
Piceo glaucae-Betuletum neoalaskanae	Mesoboreal	Dry-Subhumid	Brunisols	Interior Alaska	Paper birch-white spruce forest
Roso sayi-Populetum tremuloidis	Mesoboreal	Dry-Subhumid	Brunisols	Southern Alasko-Yukonian sector	Quaking aspen forest
Betulo nanae-Piceetum glaucae	Supraboreal	Dry	Cryosols	Southern Alasko-Yukonian sector	Open white spruce forest
Rhododendro lapponici-Piceetum glaucae	Supraboreal	Dry	Calcareous Cryosols	Southern Alasko-Yukonian sector	Open white spruce forest
Loiseleurio procumbentis-Betuletum neoalaskanae	Supraboreal	Azonal	Lithic Regosols	Interior Alaska	Lichen-paper birch woodland
Ledo decumbentis-Piceion marianae					
Piceetum glauco-marianae	Azonal	Azonal	Gleyed Brunisols	Southern Alasko-Yukonian sector	Black spruce-white spruce forest
Lartici laricinae-Piceetum marianae	Supraboreal	Azonal	Gleysols	Southern Alasko-Yukonian sector	Black spruce-tamarack forest
Rubo chamaemori-Piceetum mariannae	Azonal	Azonal	Organic Cryosols	Southern Alasko-Yukonian sector	*Picea mariana* muskegs
Boschniakio rossicae-Alnetum crispae	Azonal	Azonal	Gleyed Brunisols	Southern Alasko-Yukonian sector	Green alder thickets
Alnetalia tenuifoliae, Alnion tenuifoliae					
Salici arbusculoidis-Alnetum tenuifoliae	Azonal	Azonal	Gleyed Regosols	Southern Alasko-Yukonian sector	Riparian alder forest
Urtico gracilis-Alnetum tenuifoliae	Azonal	Azonal	Gleyed Regosols	Southern Alasko-Yukonian sector	Riparian alder forest

Table 6. Hypno procerrimi-Piceetum glaucae Hoefs et al. *corr*. Type relevé: subass. *arctostaphyletosum rubrae*, rel. 356: St. Elias National Park, Alaska (623158 N, 1431717 W), July 17, 1994. Figures are cover/abundance values.

Relevé No.	305	308	309	326	327	347	342	441	330	329	432	311	344	356	372	398
Altitude (decameters)	78	81	81	70	70	73	81	55	78	65	50	75	74	60	60	45
Area (m^2)	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Exposure	–	W	–	E	E	SW	E	–	–	–	SE	–	–	–	S	–
Number of plants	15	12	11	9	9	13	9	13	13	10	18	13	18	15	16	14
Hypno procerrimi-Piceetum glaucae: Differentiating floristic combination																
Picea glauca	2	4	4	4	4	3	4	3	4	4	4	3	4	4	1	4
Shepherdia canadensis	2	1	1	1	1	1	1	–	1	2	2	2	+	2	3	1
Arctostaphylos uva-ursi	3	2	2	1	1	1	+	1	2	2	2	1	–	2	2	–
Hypno procerrimi-Piceetum glaucae arctostaphyletosum rubrae																
Arctostaphylos rubra	–	–	–	–	–	–	–	–	–	2	1	2	2	1	1	3
Vaccinium vitis-idaea	–	–	–	–	–	–	–	2	–	–	1	–	+	1	1	1
Empetrum nigrum ssp. *hermaphroditum*	–	–	–	–	–	–	–	–	–	–	1	–	2	1	–	2
Ledum groenlandicum	–	–	–	–	–	–	–	–	–	–	2	–	1	–	1	3
Pentaphylloides floribunda	–	–	–	–	–	–	–	–	–	–	1	–	1	2	–	2
Salix myrtillifolia var. *myrtillifolia*	–	–	–	–	–	–	–	–	–	–	1	2	2	–	–	3
Vaccinium uliginosum	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	2
Arctostaphylo-Piceetalia glaucae, Shepherdio canadensis-Piceion glaucae																
Geocaulon lividum	2	1	–	–	+	–	+	1	2	–	2	1	+	2	–	+
Mertensia paniculata var. *paniculata*	–	1	–	1	–	1	1	1	–	–	1	–	–	–	1	–
Zygadenus elegans	1	1	–	–	+	1	+	–	+	–	–	1	–	–	1	–
Lupinus arcticus ssp. *arcticus*	1	1	–	–	–	–	–	–	+	–	2	–	2	1	–	–
Pinus contorta var. *latifolia*	3	2	2	–	–	–	–	–	–	–	–	1	–	–	–	–
Anemone patens ssp. *multifida*	–	–	–	1	–	1	1	–	–	1	–	–	–	–	–	–
Galium boreale	1	–	–	–	–	+	–	–	–	–	1	–	–	–	–	–
Pedicularis labradorica var. *labradorica*	–	–	–	–	–	–	–	–	+	–	–	–	+	–	–	1
Festuca altaica	–	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–
Saussurea angustifolia	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	1
Vaccinio-Piceetea																
Rosa acicularis ssp. *sayi*	1	+	1	–	–	–	1	1	–	+	1	–	–	1	1	–
Orthilia secunda	1	–	1	1	+	–	–	–	–	–	–	–	1	1	–	–
Hedysarum alpinum var. *americanum*	–	–	–	1	–	–	–	–	–	1	–	1	1	–	1	–
Salix glauca	–	–	–	–	–	–	–	1	–	–	2	–	–	–	2	–
Viburnum edule	–	–	–	–	–	2	–	1	–	–	–	–	–	–	2	–
Pyrola asarifolia ssp. *asarifolia*	–	–	–	–	–	–	–	–	1	–	–	–	1	1	–	–
Pyrola chlorantha	1	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–
Juniperus communis var. *depressa*	1	–	–	+	–	–	–	–	+	–	–	–	–	–	–	–
Dryas integrifolia ssp. *integrifolia*	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	–
Moneses uniflora	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–
Empetrum nigrum ssp. *nigrum*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–
Anemone narcissiflora ssp. *interior*	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–

Table 6 continued.

Relevé No.	305	308	309	326	327	347	342	441	330	329	432	311	344	356	372	398
Altitude (decameters)	78	81	81	70	70	73	81	55	78	65	50	75	74	60	60	45
Area (m^2)	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Exposure	–	W	–	E	E	SW	E	–	–	–	SE	–	–	–	S	–
Number of plants	15	12	11	9	9	13	9	13	13	10	18	13	18	15	16	14
Companions																
Linnaea borealis ssp. *longiflora*	2	1	2	–	1	+	–	1	2	1	–	2	–	1	1	–
Epilobium angustifolium	–	–	1	–	+	+	–	+	1	–	–	–	–	–	–	+
Salix brachycarpa	2	1	–	–	–	–	–	–	–	1	–	+	+	2	–	–
Populus tremuloides	–	–	1	–	+	2	–	2	1	–	–	–	–	–	–	–
Populus balsamifera ssp. *balsamifera*	–	–	–	–	–	1	–	–	–	–	–	–	1	–	1	–
Solidago spathulata	1	–	–	–	–	+	–	–	–	–	–	–	–	+	–	–
Pyrola asarifolia ssp. *bracteata*	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1	–
Calamagrostis rubescens	–	–	–	–	–	–	1	+	–	–	–	–	–	–	–	–
Fragaria virginiana	–	–	–	1	–	–	–	–	–	+	–	–	–	–	–	–
Salix reticulata ssp. *reticulata*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Cypripedium parviflorum	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–

their underwoods share several common co-dominant taxa, mainly *Hypno procerrimi* and *Anemone patens* ssp. *multifida*, and lack the supraboreal shrubs (see below: *Betulo nanae-Piceetum glaucae*). Most of our relevés (Table 6) were taken between Kluane Lake and Whitehorse, an area included in the Ruby Range Ecoregion, the driest zone of the southern Yukon (Oswald & Senyk 1977). Lausi & Nimis (1991) described the *Picea glauca-Hypnum procerrimum* community in this xeric-continental area as the climax vegetation on sandy brunisols derived from loess deposits. Its floristic and structural composition, a more or less closed forest with *P. glauca* (often with *Pinus contorta* var. *latifolia*) dominating an underwood in which *Shepherdia canadensis*, *Anemone multifida*, and *Arctostaphylos uva-ursi* stand out, closely correlates with the *Hypno procerrimi-Piceetum glaucae* association. The dominance of *Populus tremuloides* in two relevés, and the frequency and occasional dominance of lodgepole pine (*P. contorta* var. *latifolia)*, indicate the successional, post-fire role of these trees with regard to climatic climaxes (Bergeron & Dansereau 1993; Youngblood 1995), and correlate this association with its successional association *Roso sayi-Populetum tremuloidis.*

Besides the typical subassociation, which thrives on mesic soils, another subassociation, *arctostaphyletosum rubrae subass. nova hoc loco* (Nomenclatural type: Table 6, relevé 356), can be distinguished. This subassociation occurs on relatively wet soils (humid brunisols), mainly in those moderate soil depressions where drainage water sporadically accumulates. This subassociation can be regarded as transitional to the wetter forests of *Piceetum glauco-marianae* and the lack of *Picea mariana* differentiates it from *Piceetum glauco-marianae*.

2. Pulsatillo patentis-Pinetum latifoliae ass. nova hoc loco

Nomenclatural type: Table 7, rel. 442, *holotypus*. Closely related communities: *Pinus contorta*-lichen woodland and *Pinus contorta-Hylocomium splendens* communities (Lausi & Nimis 1991); *Pinus latifolia-Picea glauca* association (Peinado et al. 1997a).

As mentioned above, lodgepole pine forms fire subclimaxes in the western boreal zones. The serotinous cones of this pine, as well as those of *Pinus divaricata* and *Picea mariana*, give these species the advantage of an abundant seed supply to invade mineral soil bared by fire (Daubenmire 1978). Stands co-dominated by pines and white spruces can be considered fire facies of *Hypno procerrimi-Piceetum glaucae*. However, large stands of lodgepole pine also grow in the same area as the white spruce climax forest, but most of them occur on steep slopes with excessive drainage as well as on sandy soils. In late glacial time water draining off the melting ice deposited large sheets of infertile sands in the southern part of the

Table 7. Pulsatillo patentis-Pinetum latifoliae ass. nova. Type relevé: rel. 442, between Mayo and Stewart, Yukon Territory (633149 N, 1361122 W), July 23, 1994. Relevés 24–30 from Lausi & Nimis (1991; Table 7).

Relevé No.	442	447	449	24	25	26	27	28	29	30
Altitude (decameters)	54	52	65	?	?	?	?	?	?	?
Area (m^2)	200	200	200	200	200	200	200	200	200	200
Exposure	–	–	–	–	S	SW	SE	S	SE	E
Number of plants	14	14	14	8	8	9	11	10	12	13
Pulsatillo patentis-Pinetum latifoliae: Differentiating floristic combination										
Pinus contorta var. *latifolia*	3	2	2	2	4	4	4	4	4	4
Pulsatilla patens	1	1	1	1	1	1	1	1	1	1
Arctostaphylos uva-ursi	1	–	2	2	2	4	2	2	2	2
Arctostaphylo rubrae-Piceetalia glaucae, Shepherdio-Piceion glaucae										
Zygadenus elegans	1	1	1	–	–	–	1	1	1	–
Shepherdia canadensis	–	1	2	–	1	2	–	–	–	–
Festuca altaica	–	–	–	–	–	2	2	2	–	2
Calamagrostis purpurascens	–	–	–	1	2	1	–	–	–	–
Equisetum scirpioides	–	–	–	–	–	–	1	1	1	–
Pyrola asarifolia ssp. *asarifolia*	–	–	–	–	–	–	1	–	1	1
Lupinus arcticus ssp. *arcticus*	+	–	–	–	–	–	–	–	1	1
Hedysarum alpinum var. *americanum*	–	1	1	–	–	–	–	–	–	–
Mertensia paniculata var. *paniculata*	+	1	–	–	–	–	–	–	–	–
Oxytropis campestris var. *campestris*	–	–	2	–	–	–	–	–	–	–
Aconitum delphinifolium	1	–	–	–	–	–	–	–	–	–
Abies lasiocarpa	–	–	–	–	–	–	–	–	–	1
Pedicularis labradorica var. *labradorica*	–	–	–	1	–	–	–	–	–	–
Vaccinio-Piceetea										
Rosa acicularis ssp. *sayi*	1	–	1	–	–	1	1	1	1	1
Geocaulon lividum	–	1	1	–	1	1	–	–	1	1
Picea glauca	2	2	–	1	–	2	–	–	–	1
Vaccinium vitis-idaea	–	–	–	2	–	–	2	2	2	2
Picea mariana	2	–	2	–	–	–	–	–	–	–
Ledum groenlandicum	+	–	–	–	1	–	–	–	–	–
Salix glauca	–	1	+	–	–	–	–	–	–	–
Empetrum nigrum ssp. *nigrum*	–	–	–	–	–	–	1	–	–	–
Viburnum edule	–	–	–	–	–	–	–	–	1	–
Companions										
Linnaea borealis ssp. *longiflora*	1	1	–	2	2	–	2	4	2	2
Calamagrostis rubescens	+	1	1	–	–	–	–	–	–	–
Populus tremuloides	–	1	1	–	–	–	–	–	–	1

Additional taxa: *Corallorhiza trifida* (rel. 447: +), *Cornus canadensis* (rel. 442: 1); *Populus balsamifera* ssp. *balsamifera* (rel. 447: 1), *Salix hastata* (rel. 449: 1), *Solidago decumbens* (rel. 28: 1).

Alasko-Yukonian sector, and these sands now support edaphic subclimaxes of lodgepole pine belonging to *Pulsatillo patentis-Pinetum latifoliae*. Lacking the dense moss carpet that characterizes the true white spruce forest, these forests have a sparse ground cover in which fruticose lichens (*Cladonia, Stereocaulon, Thamnolia*; see Nimis 1981), isolated mosses (*Polytrichum piliferum* and *P. juniperinum*), and a few

mycotrophic ericaeous shrubs, mainly *Arctostaphylos uva-ursi*, are predominant.

3. Betulo kenaicae-Piceetum glaucae ass. nova hoc loco

Nomenclatural type: Table 8, rel. 374, *holotypus*. Closely related communities: *Betula neoalaskana-Picea glauca* association (Peinado et al. 1997a); *Betula kenaica-Picea glauca* association (Peinado et al. 1997b).

The optimum of this association, a mixed deciduous-coniferous forest dominated by *Picea glauca* and *Betula papyrifera* var. *kenaica*, corresponds to the zone with the highest precipitation and temperatures of the Alasko-Yukonian sector, that is to say, to forests stretching over the relatively warm basins of the Susitna and Matanuska Rivers (Alaska), a wide coastal plain almost completely open to oceanic influence of humid winds through Cook Inlet. The presence of some temperate, hygrophilous, and relatively thermophilous taxa such as *Gymnocarpium dryopteris*, *Athyrium filix-femina* ssp. *cyclosurum*, *Alnus viridis* ssp. *sinuata*, *Streptopus amplexifolius*, *Cornus canadensis* and *Lycopodium annotinun* is the differential feature of this association. Its area is permafrost-free and receives more precipitation than any other in the boreal part of western North America; when relevés of this association are plotted on a map of site locations most correlate with the Coastal Trough Humid Taiga Province described by Bailey (1995).

Most of the *Betula neoalaskana-Picea glauca* forests mentioned by us (Peinado et al. 1997a) belong to this association. It is characterized by Kenai birch (*Betula papyrifera* var. *kenaica*), a chiefly coastal species endemic to Alaska (Viereck & Little 1991). In the Alaskan interior it is replaced by Alaska paper birch (*Betula neoalaskana*), the characteristic tree of the next association.

4. Piceo glaucae-Betuletum neoalaskanae ass. nova hoc loco

Nomenclatural type: Table 9, rel. 408, *holotypus*. Closely related community: *Picea glauca/Betula papyrifera/Hylocomium splendens* community (Youngblood 1993).

This association corresponds to the interior white spruce-birch forest described by Viereck & Little (1991), which is found in the Tanana and Yukon basins, spreads over areas with an extremely continental climate in Alaska, and reaches the southern slopes of the Brooks Range, where it is altitudinally replaced by *Betulo nanae-Piceetum glaucae*. Besides the substitution of both birches, the absence of the above mentioned temperate and termophilous taxa differentiates this association from *Betulo kenaicae-Piceetum glaucae*.

In this association, as well as in *Betulo kenaicae-Piceetum glaucae*, those relevés with co-dominance of *Populus tremuloides* correspond to quaking aspen-white spruce stands, which are intermediate successional stages, with white spruce as the eventual climax. These intermediate populations have been described as quaking aspen-spruce mixed forest (Viereck et al. 1992).

The successional position of both birch-white spruce associations creates an interesting problem. According to Viereck et al. (1992), paper birch communities generally result from fires or other disturbances and will usually be replaced by *P. glauca* communities after passing through several types of spruce-birch mixtures. This would mean that the two previous associations would were transitional stages to eventual white spruce climaxes. However, the absence of the typical fire tree *Populus tremuloides* in almost all our relevés suggests that these paper birch-white spruce forests are climatic climaxes. Furthermore, mixtures of white spruce and birch in south-central and interior Alaska may be climax, and cover more than 42 million hectares (Viereck & Little 1992). Lastly, Youngblood (1995) has pointed out that paper birch-white spruce forests in central Alaska (his *Picea glauca/Betula papyrifera/Hylocomium splendens* community) generally developed as a result of rapid, concurrent establishment of conifer and birch trees, which never progress towards pure *P. glauca* stands. For a more detailed discussion of fire regimes and fires as a controlling process in Canadian boreal forest, see Payette (1992) and Bergeron & Dansereau (1993).

5. Roso sayi-Populetum tremuloidis ass. nova hoc loco

Nomenclatural type: Table 10, rel. 324**,** *holotypus*. Closely related communities: *Shepherdia canadensis-Populus tremuloides* community (Lausi & Nimis 1991); *Populus tremuloides/Shepherdia canadensis* community (Youngblood 1993).

Except for *Betula neoalaskana*, broadleaved deciduous trees never reach the supraboreal belt of the Alasko-Yukonian sector. On the contrary, these trees constitute typical communities in the mesoboreal belt. Except for those that are riparian, most of the decid-

Table 8. Betulo kenaicae-Piceetum glaucae ass. nova. Type relevé: rel. 374: Soapstone Road, Palmer Valley, Alaska (613957 N, 1490517 W), July 17, 1994.

Relevé No.	352	374	375	376	383	384	390	392	393	363
Altitude (decameters)	50	22	12	36	15	8	2	5	17	57
Area (m^2)	200	200	200	200	200	200	200	200	200	200
Exposure	E	–	–	S	SE	–	E	–	E	E
Number of plants	13	16	12	17	17	17	14	18	17	10
Betulo kenaicae-Piceetum glaucae:										
Differentiating floristic combination										
Betula papyrifera var. *kenaica*	2	3	4	4	3	2	4	4	4	1
Picea glauca	4	1	+	1	3	4	2	2	2	3
Viburnum edule	+	3	1	1	1	3	1	+	2	1
Gymnocarpium dryopteris	–	2	–	1	–	1	–	1	1	3
Athyrium filix-femina ssp. *cyclosurum*	–	3	–	2	–	–	–	1	4	–
Arctostaphylo rubrae-Piceetalia glaucae,										
Shepherdio-Piceion glaucae										
Alnus viridis ssp. *sinuata*	–	3	2	3	–	2	–	–	2	5
Mertensia paniculata var. *paniculata*	1	1	–	1	–	1	–	2	–	–
Ribes triste	–	–	–	2	–	1	1	+	1	–
Salix glauca	1	2	–	–	–	–	1	–	–	–
Spiraea stevenii	–	–	–	–	–	–	+	1	1	–
Shepherdia canadensis	+	–	–	–	2	+	–	–	–	–
Agrostis exarata	–	–	–	–	–	–	–	–	1	1
Arctostaphylos uva-ursi	–	–	–	–	2	–	–	–	–	–
Empetrum nigrum ssp. *hermaphroditum*	–	–	–	–	1	–	–	–	–	–
Zygadenus elegans	–	–	–	–	1	–	–	–	–	–
Pyrola asarifolia ssp. *asarifolia*	+	–	–	–	–	–	–	–	–	–
Vaccinio-Piceetea										
Lycopodium annotinum	–	–	+	+	1	–	1	–	1	–
Geocaulon lividum	1	–	–	–	1	+	1	–	–	–
Equisetum sylvaticum	–	–	–	–	–	–	–	2	2	–
Vaccinium ovalifolium	–	–	–	–	–	–	–	1	1	–
Rosa acicularis ssp. *sayi*	–	+	–	+	–	1	–	+	–	–
Lycopodium complanatum	–	–	–	–	–	–	2	–	–	–
Vaccinium vitis-idaea	2	–	–	–	–	–	–	–	–	–
Picea mariana	–	–	–	–	–	–	1	–	–	–
Orthilia secunda	1	–	–	–	–	–	1	–	–	–
Rubus pedatus	–	–	–	–	–	–	–	1	1	–
Companions										
Cornus canadensis	–	1	–	1	1	1	2	1	1	2
Equisetum arvense	–	2	1	2	–	1	–	1	2	+
Linnaea borealis ssp. *longiflora*	1	–	+	–	1	1	–	1	–	+
Epilobium angustifolium	–	1	–	–	–	1	1	–	–	1
Streptopus amplexifolius	–	2	–	–	–	–	+	+	+	–
Populus balsamifera ssp. *balsamifera*	–	3	3	–	2	–	–	–	–	–
Sorbus scopulina	–	–	–	1	+	–	–	+	–	–
Opopanax horridum	–	–	+	–	–	–	–	1	2	–
Aconitum delphinifolium ssp. *delphinifolium*	–	1	–	1	–	–	–	–	–	–
Aralia nudicaulis	–	–	–	–	+	1	–	–	–	–

Additional taxa: *Boschniakia rossica* (rel. 376: +), *Castilleja unalaschensis* (rel. 383): +, *Galium triflorum* (rel. 383: +), *Geranium erianthum* (rel. 374: 1), *Goodyera repens* (rel. 352: +), *Heracleum maximum* (rel. 376:1), *Poa pratensis* (rel. 375:1), *Populus trichocarpa* (rel. 383:3), *Populus tremuloides* (rel. 375: +), *Pyrola asarifolia* ssp. *asarifolia* (rel. 352: +), *Pyrola grandiflora* (rel. 384: 1) *Rosa nutkana* var. *hispida* (rel. 384: +), *Salix scouleriana* (rel. 375:2), *Trientalis europaea* ssp. *arctica* (rel. 376: +).

Table 9. Piceo glaucae-Betuletum neoalaskanae ass. nova. Type relevé: rel. 408, Livengood, Alaska (653008 N, 148422 W), July 20, 1994.

Relevé No.	408	409	424	411	418	423
Altitude (decameters)	20	27	15	30	24	16
Area (m^2)	200	200	200	200	200	200
Exposure	E	S	S	N	W	NW
Number of plants	14	14	17	18	11	17
Piceo glaucae-Betuletum neoalaskanae: Differentiating floristic combination						
Betula neoalaskana	5	2	2	4	2	1
Picea glauca	2	4	1	2	2	3
Alnus viridis ssp. *crispa*	+	2	2	2	+	+
Arctostaphylo rubrae-Piceetalia glaucae, Shepherdio-Piceion glaucae						
Salix glauca	1	2	1	–	–	1
Mertensia paniculata var. *paniculata*	–	1	1	–	–	1
Ribes triste	+	1	–	2	–	–
Agrostis exarata	–	2	–	1	–	–
Spiraea stevenii	1	–	–	1	–	–
Arctostaphylos uva-ursi	–	–	–	–	2	–
Salix arbusculoides	–	–	–	2	–	–
Equisetum scirpoides	–	–	–	–	–	2
Shepherdia canadensis	–	–	1	–	–	–
Galium boreale	–	–	1	–	–	–
Delphinium glaucum	–	–	1	–	–	–
Empetrum nigrum ssp. *hermaphroditum*	–	–	–	–	+	–
Vaccinio-Piceetea						
Geocaulon lividum	+	1	1	1	+	1
Rosa acicularis ssp. *sayi*	1	1	2	1	–	+
Ledum groenlandicum	1	–	–	1	–	+
Vaccinium uliginosum	–	–	–	2	2	–
Vaccinium vitis-idaea	–	–	–	–	2	1
Lycopodium complanatum	1	–	–	–	2	–
Equisetum sylvaticum	–	–	–	1	–	1
Picea mariana	–	+	–	–	–	2
Lycopodium annotinum	–	+	–	1	+	–
Petasites frigidus var. *nivalis*	–	–	–	1	–	+
Viburnum edule	–	–	2	–	–	–
Salix lanata ssp. *richardsonii*	–	–	–	+	–	–
Companions						
Linnaea borealis ssp. *longiflora*	1	1	–	1	–	+
Cornus canadensis	1	–	–	2	+	–
Equisetum arvense	–	–	+	–	–	2
Goodyera repens	–	+	–	–	–	+

Additional taxa: *Artemisia tilesii* ssp. *elatior* (rel. 424: +), *Cnidium cnidiifolium* (rel. 424: 1), *Epilobium angustifolium* (rel. 408: +), *Juniperus communis* var. *depressa* (rel. 408: +), *Huperzia selago* (rel. 411: 1), *Moneses uniflora* (rel. 423: +), *Orthilia secunda* (rel. 409: +), *Populus trichocarpa* (rel. 424: 2), *Populus tremuloides* (rel. 424: 2), *Rubus idaeus* ssp. *strigosus* (rel. 424: 1).

Table 10. Roso sayi-Populetum tremuloidis ass. nova. Type relevé: rel. 324, 30 miles west of Whitehorse, Yukon Territory, (605112 N, 1354024 W). July 13, 1994. Relevés 33, 34 and 38 from Lausi & Nimis (1991; Table 9).

Relevé No.	324	360	373	404	448	453	455	33	34	38
Altitude (decameters)	67	48	59	7	66	54	81	?	?	?
Area (m)	200	200	200	200	200	200	200	200	200	200
Exposure	–	–	SE	N	NE	E	–	E	S	E
Number of plants	12	13	12	12	14	16	11	9	16	17
Roso sayi-Populetum tremuloidis: Differentiatingfloristic combination										
Populus tremuloides	4	4	4	4	4	3	1	4	4	4
Rosa acicularis ssp. *sayi*	2	1	1	1	1	1	1	1	2	2
Picea glauca	1	2	1	1	1	2	4	–	1	–
Arctostaphylo rubrae-Piceetalia glaucae, Shepherdio canadensis-Piceion glaucae										
Arctostaphylos uva-ursi	4	–	2	–	1	–	2	2	2	2
Shepherdia canadensis	–	–	3	+	1	–	1	2	2	1
Mertensia paniculata var. *paniculata*	–	–	1	1	–	1	–	1	1	1
Salix scouleriana	–	–	1	–	2	2	–	2	–	–
Betula neoalaskana	–	1	–	3	–	2	–	–	–	–
Pinus contorta var. *latifolia*	–	–	–	–	–	2	2	–	–	2
Lupinus arcticus ssp. *arcticus*	–	2	–	–	–	–	–	1	–	2
Salix glauca	–	–	–	2	1	–	–	–	–	–
Pyrola asarifolia ssp. *asarifolia*	–	1	–	–	–	–	–	–	–	1
Achillea millefolium var. *borealis*	1	–	–	–	–	–	–	1	–	–
Galium boreale	+	–	–	1	–	–	–	–	–	–
Juniperus communis var. *depressa*	–	–	–	–	–	–	–	–	2	–
Anemone patens ssp. *multifida*	1	–	–	–	–	–	–	–	–	–
Equisetum scirpoides	–	–	–	–	–	1	–	–	–	–
Anemone narcissiflora ssp. *interior*	–	–	–	–	–	–	1	–	–	–
Zygadenus elegans	–	–	–	–	–	–	–	–	1	–
Arnica cordifolia	–	–	–	–	–	–	–	–	–	1
Carex concinna	–	–	–	–	–	–	–	–	–	1
Pedicularis labradorica var. *labradorica*	–	–	–	–	–	–	–	–	–	1
Hedysarum alpinum var. *americanum*	–	–	–	–	–	–	–	–	–	1
Ribes hudsonianum	–	–	–	–	–	–	–	–	1	–
Vaccinio-Piceetea										
Viburnum edule	–	2	2	1	2	4	–	–	2	–
Orthilia secunda	–	1	–	–	–	1	1	–	–	1
Geocaulon lividum	–	1	–	–	–	1	–	–	–	–
Ledum groenlandicum	–	–	–	–	+	–	–	–	–	–
Alnus viridis ssp. *crispa*	–	–	–	–	–	2	–	–	2	–
Calamagrostis canadensis	–	–	–	–	–	–	–	–	1	–
Companions										
Epilobium angustifolium	1	1	1	1	1	1	1	–	2	1
Linnaea borealis ssp. *longiflora*	–	1	1	–	1	1	2	–	2	1
Populus balsamifera ssp. *balsamifera*	–	–	2	–	–	–	–	–	2	1
Geranium erianthum	–	–	–	–	–	–	–	1	1	1
Cornus canadensis	–	1	–	–	–	1	–	–	–	–
Equisetum arvense	–	–	–	1	–	1	–	–	–	–

Additional taxa: *Astragalus americanus* (rel. 373: 1), *Calamagrostis rubescens* (rel. 448: 2), *Castilleja unalaschensis* (rel. 360: 1), *Delphinium brachycentrum* (rel. 404: +), *Dryas drummondii* (rel. 448: +), *Fragaria virginiana* (rel. 324: 1), *Linum lewisii* (rel. 324: +), *Pulsatilla patens* (rel. 448: 1), *Pyrola chlorantha* (rel. 45 5: 1), *Salix brachycarpa* (rel. 324: 1), *Solidago spathulata* (rel. 324: +).

uous stands are secondary to fires and replace *Picea glauca* climaxes. The white spruce-dominated associations are considered to be the climax vegetation on the well-drained uplands and flood plains in much of interior Alaska. In the upland, white spruce stands occasionally may regenerate directly after fire, but, more commonly, white spruce replaces successional hardwood stands (Viereck et al. 1992). *Roso sayi-Populetum tremuloidis* is a mesoboreal association, successional to climax forests belonging to the two previous associations. Its structure is nearly pure, an almost complete dominance of quaking aspen, with *Populus balsamifera* as an occasional dominant or co-dominant. The undergrowth is very similar to that of the white spruce climax forests. Young populations of quaking aspen are common along roads, trails, forest edges, and recently burned sites.

However, *Populus tremuloides* is not an exclusively post-fire tree, because it also can occur as part of a stable xeric community on extremely dry sites, chiefly very steep, usually southern, exposed rocky slopes of the mesoboreal belt of interior Alaska. These edaphic subclimax woods have been described as an 'open quaking aspen forest' (Viereck et al. 1992), and are closely related to the variant with *Galium boreale* of the *Shepherdia canadensis-Populus tremuloides* community described by Lausi & Nimis (1991).

6. Betulo nanae-Piceetum glaucae ass. nova hoc loco
Nomenclatural type: Table 11, rel. 341, *holotypus*. Closely related communities: *Picea glauca-Rhytidium rugosum* community (Lausi & Nimis 1991); *Betula nana-Picea glauca* association (Peinado et al. 1997b). *P. glauca* and *P. mariana*, the dominant trees in the North American boreal forest, have very similar ranges but occupy different habitats. While the black spruce (*P. mariana*), frequently stunted, grows in both the bogs or muskegs and on the uplands of the Alasko-Yukonian sector, the white spruce (*P. glauca*) prefers well-drained soils (Elliott-Fisk 1988; Lausi & Nimis 1991). Though the white spruce generally grows best on nutrient-rich, permafrost-free, well-drained soils (brunisols or podsols), the forests it forms on cryosols (Douglas 1974; Lausi & Nimis 1991) are characterized by an underwood similar to that of the *P. mariana* muskeg: *Betula nana*, *Ledum groenlandicum*, *Rubus chamaemorus*, *Pentaphylloides floribunda*, *Arctostaphylos rubra*, *Vaccinium uliginosum*, among others. *P. glauca* forests with this floristic composition occur on north-facing slopes, at higher altitudes and near the northern distribution limit of the species, that is to say, in the supraboreal belt. At lower altitudes and in the southern limit of the boreal forest (that is to say, the mesoboreal forest), *P. glauca* stands typically lack these undergrowth species.

Betulo nanae-Piceetum glaucae is a supraboreal and acidophilous association that constitutes the climax vegetation of the Alasko-Yukonian sector. This association, very common on well-drained sites, dominates almost all the supraboreal belt. It is physiognomically similar to other *P. glauca* forests, but has more shrub cover because of the more open tree canopy. The shrub layer is characterized by the usually dominant presence of *Betula nana*, normally with an admixture of willows and different ericaceous shrubs. This shrubby underwood clearly reveals the existence of seasonally frozen ground and correlates this association with the *Picea glauca-Salix glauca* community (Douglas 1974) and the *Picea glauca-Rhytidium rugosum* community described in the same area over winter-frozen brunisols (Lausi & Nimis 1991), as well as with the 'open white spruce forest' (Viereck et al. 1992).

Besides the typical subassociation, there is another subassociation (*ledetosum decumbentis subass. nova; n*omenclatural type: Table 11, rel. 396) found in the upper horizon of the supraboreal belt. In this subassociation *Ledum palustre* ssp. *decumbens* replaces *Ledum groenlandicum*, and *Alnus viridis* ssp. *crispa* is also differential. On the Alasko-Yukonian timberline dense thickets of *Vaccinium uliginosum*, *V. vitis-idaea*, *A. viridis* ssp. *crispa* and *Betula nana* belong to this subassociation (relevés 419, 430, 414; relevés 434 and 435 correspond to the oroboreal facies of this subassociation), in which, moreover, individual and frequently stunted *P. glauca* are characteristic. The Alasko-Yukonian timberline differs from the other supraboreal timberlines of North America in that there are no black spruce. The reason for the absence of this species has not been explained (Arno & Hammerly 1990), but can perhaps be related with the low precipitation in this sector.

7. Rhododendro lapponici-Piceetum glaucae ass. nova hoc loco
Nomenclatural type: Table 12, rel. 460, *holotypus*. Closely related community: *Picea glauca-Rhododendron lapponicum* community (Lausi & Nimis 1991).

This is another supraboreal association that thrives on seasonal cryosols, and replaces the *Betulo nanae-Piceetum glaucae* on calcareous slopes.

Table 11. Betulo nanae-Piceetum glaucae ass. nova. Type relevés: association, rel. 341: Kluane National Park, Yukon Territory (610031 N, 1381521 W), July 14, 1994; subassociation *ledetosum decumbentis*, rel. 396: Chulitna, Denali State Park, Alaska (631756 N, 1491202 W), July 19, 1994.

Relevé No.	331	332	337	338	339	340	341	355	433	396	419	430	414	434	435
Altitude (decameters)	70	76	95	90	78	86	92	102	90	48	30	93	39	106	101
Area (m^2)	200	200	200	200	200	200	200	200	20	20	20	20	20	50	50
Exposure	–	E	E	–	NE	E	NE	–	SW	–	E	SW	N	N	N
Number of plants	12	14	18	17	21	19	21	15	15	21	6	11	7	16	14
Betulo nanae-Piceetum glaucae: Differentiating floristic combination															
Betula nana	3	2	4	4	3	2	2	3	3	2	3	2	3	3	3
Empetrum nigrum ssp. *hermaphroditum*	1	3	2	1	2	2	2	2	2	2	–	–	+	1	1
Vaccinium vitis-idaeae	1	2	–	–	1	–	1	1	2	2	1	2	+	1	2
Picea glauca	1	3	2	3	3	4	3	3	3	2	–	+	–	–	–
Vaccinium uliginosum	2	2	–	–	–	–	1	2	2	3	2	2	3	1	–
Ledum groenlandicum	2	3	–	–	1	+	2	2	1	–	–	–	–	–	–
Betulo nanae-Piceetum glaucae ledetosum decumbentis															
Ledum palustre ssp. *decumbens*	–	–	–	–	–	–	–	–	2	2	2	2	2	1	1
Salix arbusculoides	–	–	–	–	–	–	–	–	1	2	–	1	1	–	–
Alnus viridis ssp. *crispa*	–	–	–	–	–	–	–	–	–	–	1	2	+	–	–
Petasites frigidus var. *nivalis*	–	–	–	–	–	–	–	–	1	1	–	1	–	–	–
Carex albonigra	–	–	–	–	–	–	–	–	–	+	–	–	–	1	1
Polygonum bistorta var. *plumosum*	–	–	–	–	–	–	–	–	–	–	+	1	–	1	–
Betulo nanae-Piceetum glaucae ledetosum decumbentis (Oroboreal facies)															
Cassiope tetragona ssp. *tetragona*	–	–	–	–	–	–	–	–	–	–	–	–	–	+	2
Dryas octopetala ssp. *octopetala*	–	–	–	–	–	–	–	–	–	–	–	–	–	2	2
Loiseleuria procumbens	–	–	–	–	–	–	–	–	–	–	–	–	–	1	2
Salix arctica	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1
Salix phlebophylla	–	–	–	–	–	–	–	–	–	–	–	–	–	2	2
Pedicularis langsdorfii ssp. *arctica*	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1
Arctostaphylo rubrae-Piceetalia glaucae, Shepherdio canadensis-Piceion glaucae															
Arctostaphylos rubra	2	2	–	+	2	–	2	2	–	1	–	–	–	2	2
Pentaphylloides floribunda	3	+	2	–	–	–	+	1	–	1	–	–	–	–	–
Mertensia paniculata var. *paniculata*	–	–	1	1	1	+	1	–	1	–	–	–	–	–	–
Salix myrtillifolia var. *myrtillifolia*	2	–	2	–	2	–	1	1	–	–	–	–	–	2	–
Lupinus arcticus ssp. *arcticus*	–	–	–	1	+	–	1	–	–	–	–	–	–	–	–
Sanguisorba canadensis	–	–	2	2	–	–	–	–	–	2	–	–	–	–	–
Aconitum delphiniifolium	–	–	1	1	–	–	–	–	–	–	–	–	–	1	–
Shepherdia canadensis	+	–	–	–	2	2	–	–	–	–	–	–	–	–	–
Galium boreale	–	–	1	1	–	+	–	–	–	–	–	–	–	–	–
Festuca altaica	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–
Pedicularis labradorica var. *labradorica*	–	–	–	–	–	–	–	1	–	1	–	–	–	–	–
Artemisia arctica ssp. *arctica*	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–
Spiraea stevenii	–	–	–	–	–	–	–	–	1	1	–	–	–	–	–
Arctostaphylos uva-ursi	–	–	–	–	+	2	–	–	–	–	–	–	–	–	–
Hedysarum alpinum var. *americanum*	–	–	–	–	–	+	1	–	–	–	–	–	–	–	–
Arnica cordifolia	–	–	–	–	+	+	–	–	–	–	–	–	–	–	–
Agrostis exarata	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Juniperus communis var. *depressa*	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–
Pyrola asarifolia ssp. *asarifolia*	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–
Zygadenus elegans	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–

Table 11. Continued.

Relevé No.	331	332	337	338	339	340	341	355	433	396	419	430	414	434	435
Altitude (decameters)	70	76	95	90	78	86	92	102	90	48	30	93	39	106	101
Area (m^2)	200	200	200	200	200	200	200	200	20	20	20	20	20	50	50
Exposure	–	E	E	–	NE	E	NE	–	SW	–	E	SW	N	N	N
Number of plants	12	14	18	17	21	19	21	15	15	21	6	11	7	16	14
Vaceinio-Piceetea															
Salix glauca	–	2	3	2	3	3	3	2	2	–	–	1	–	–	–
Rubus arcticus ssp. *acaulis*	–	–	1	1	–	+	1	–	–	1	–	–	–	–	–
Moneses uniflora	–	1	–	–	+	+	+	–	1	–	–	–	–	–	–
Geocaulon lividum	1	2	–	1	2	–	–	–	–	–	–	–	–	–	–
Salix reticulata ssp. *reticulata*	–	–	2	–	–	–	+	1	–	1	–	–	–	–	–
Lycopodium annotinum	–	–	1	–	–	–	–	–	1	–	–	–	–	–	–
Trientalis europaea ssp. *arctica*	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–
Equisetum sylvaticum	–	–	1	–	–	–	–	+	–	–	–	–	–	–	–
Orthilia secunda	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–
Rubus chamaemorus	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–
Rubus pedatus	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–
Picea mariana	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–
Companions															
Equisetum arvense	–	1	1	+	–	1	1	–	+	1	–	–	–	–	–
Cornus canadensis	–	1	1	–	1	1	–	–	–	1	–	–	–	–	–
Linnaea borealis ssp. *longiflora*	–	–	–	–	1	1	1	–	–	–	–	–	–	–	–
Populus balsamifera ssp. *balsamifera*	–	–	–	–	1	+	+	–	–	–	–	–	–	–	–
Epilobium angustifolium	–	–	–	+	+	1	–	–	–	–	–	–	–	–	–
Solidago multiradiata	–	–	–	–	–	–	+	–	–	+	–	–	–	–	–

Additional taxa: *Campanula uniflora* (rel. 435: 1), *Hierochloe alpina* (rel. 435: 1), *Salix lutea* (rel. 355: 2), *Valeriana dioica* (rel. 355: 2).

8. Loiseleurio procumbentis-Betuletum neoalaskanae ass. nova hoc loco

Nomenclatural type: Table 13, rel. 417, *holotypus*. Closely related communities: Paper birch woodland (Viereck et al. 1992).

This association is a woodland almost exclusively constituted by multistemmed and rather stunted paper birches, which grow scattered among prostrate shrubs, and over a dense carpet of fruticose lichens (genera *Cladonia, Cladina, Stereocaulon, Cetraria)* and a few xeric mosses such as *Polytrichum juniperinum* and *P. piliferum*. The other dominant tree species, *P. glauca*, is generally no more than 10 m tall and is also well scattered. In spite of the presence of *B. neoalaskana* and *P. glauca*, this association floristically separates from *Piceo glaucae-Betuletum neoalaskanae* because of the presence of supraboreal taxa such as *Empetrum nigrum* ssp. *hermaphroditum*, *Betula nana*, *Ledum palustre* ssp. *decumbens*, *Vaccinium uliginosum*, and, particularly, of *Loiseleuria procumbens*, a plant typical of the oroboreal tundra.

This association occurs on permafrost free, very dry soils (lithic regosols), mainly on rocky outcrops of the upper horizon of the supraboreal belt, where it alternates, on crysosols, with *Betulo nanae-Piceetum glaucae ledetosum decumbentis.* From the air this community is easily seen because light-coloured lichens clearly dominate on the better-drained soils.

This community corresponds to the 'western *Stereocaulon paschale* lichen woodland' described by Kershaw (1977). *Sterocaulon paschale* tends to dominate open lichen woodland in western Canada, a role taken over by *Cladina* species in the east (*Kalmio angustifoliae-Piceetum marianae cladonietosum alpestris*). These woodlands are considered fire climaxes (Kershaw 1977) but others consider them

Table 12. Rhododendro lapponici-Piceetum glaucae ass. nova. Type relevé: rel. 460, Summit Pass, Stone Mountain Provincial Park, British Columbia (583858 N, 1244354 W), July 24, 1994. Relevés 8–13 from Lausi & Nimis (1991; Table 5).

Relevé No.	458	460	356	346	348	8	9	10	11	13
Altitude (decameters)	81	122	100	75	76	?	?	?	?	?
Area (m^2)	200	200	200	200	200	200	200	200	200	200
Exposure	W	SW	–	–	–	SW	NE	NE	NE	–
Number of plants	19	16	19	14	19	12	10	15	13	13
Rhododendro lapponici-Piceetum glaucae: Differentiating floristic combination										
Picea glauca	3	1	2	+	2	2	2	2	2	2
Rhododendron lapponicum var. *lapponicum*	2	1	1	+	1	1	2	2	1	1
Dryas integrifolia ssp. *integrifolia*	2	2	1	–	1	–	–	2	1	2
Arctostaphylo rubrae-Piceetalia glaucae, Shepherdio-Piceion glaucae										
Arctostaphylos rubra	1	1	+	2	2	1	2	2	2	2
Pentaphylloides floribunda	–	1	1	1	2	1	1	1	–	1
Salix myrtillifolia var. *myrtillifolia*	1	1	1	2	2	–	–	–	–	2
Carex concinna	2	1	–	–	–	1	1	–	1	–
Equisetum scirpoides	–	–	–	–	–	2	1	1	2	–
Lupinus arcticus ssp. *arcticus*	–	–	1	+	1	–	–	1	–	–
Pedicularis labradorica var. *labradorica*	–	–	1	–	–	–	–	1	1	–
Galium boreale	+	–	–	–	–	–	1	–	1	–
Empetrum nigrum ssp. *hermaphroditum*	–	–	2	1	–	–	–	–	–	–
Arctostaphylos uva-ursi	+	2	–	–	–	–	–	–	–	–
Betula papyrifera var. *neoalaskana*	+	–	–	–	1	–	–	–	–	–
Juniperus communis var. *depressa*	+	2	–	–	–	–	–	–	–	–
Pyrola asarifolia ssp. *asarifolia*	–	–	–	1	1	–	–	–	–	–
Pinus contorta var. *latifolia*	+	1	–	–	–	–	–	–	–	–
Campanula uniflora	1	–	–	–	–	–	–	–	–	–
Festuca altaica	–	–	–	–	–	–	1	–	–	–
Hedysarum alpinum var. *americanum*	–	–	–	–	1	–	–	–	–	–
Mertensia paniculata var. *paniculata*	–	–	–	–	–	1	–	–	–	–
Salix arbusculoides	1	–	–	–	–	–	–	–	–	–
Saussurea angustifolia	–	–	–	–	1	–	–	–	–	–
Shepherdia canadensis	+	–	–	–	–	–	–	–	–	–
Zygadenus elegans	+	–	–	–	–	–	–	–	–	–
Vaccinio-Piceetea										
Ledum groenlandicum	2	1	2	3	2	2	–	2	2	1
Vaccinium uliginosum	–	–	2	2	2	1	2	2	2	2
Salix glauca	1	+	–	1	1	–	1	1	1	2
Vaccinium vitis-idaeae	–	–	1	2	1	1	–	1	–	–
Betula nana	–	+	2	–	+	1	–	1	–	–
Picea mariana	–	–	–	3	3	2	–	–	–	1
Equisetum palustre	–	–	–	–	–	–	–	1	1	1
Mitella nuda	–	–	–	–	–	–	–	1	1	–
Geocaulon lividum	1	–	–	+	–	–	–	–	–	–
Companions										
Salix lutea	–	–	+	–	1	–	–	–	–	–
Saxifraga tricuspidata	+	+	–	–	–	–	–	–	–	–

Additional taxa: *Andromeda polifolia* (rel. 13: 1), *Carex albonigra* (rel. 356: 3), *Eriophorum vaginatum* (rel. 13: 1), *Juniperus horizontalis* (rel. 460: 2), *Ledum palustre* ssp. *decumbens* (rel. 356: 1), *Pedicularis lanata* ssp. *lanata* (rel. 356: 1), *Polygonum viviparum* (rel. 356: 1), *Salix pyrifolia* (rel. 348: 1), *Salix reticulata* ssp. *reticulata* (rel. 356: 1), *Saxifraga aizoides* (rel. 460: 1).

Table 13. Loiseleurio procumbentis-Betuletum neoalaskanae ass. nova. Type relevé: rel. 417, Dalton Highway, Alaska (670020 N, 1501709 W), July 20, 1994.

Relevé No.	417	418	421	422
Altitude (decameters)	33	24	40	40
Area (m^2)	100	100	100	100
Exposure	NW	W	N	S
Number of vascular plants	9	9	12	12
Loiseleurio procumbentis-Betuletum neoalaskanae: Differentiating floristic combination				
Betula neoalaskana	2	2	3	3
Empetrum nigrum ssp. *hermaphroditum*	3	1	2	2
Vaccinium uliginosum	2	2	1	+
Vaccinium vitis-idaea	1	2	1	2
Loiseleuria procumbens	2	−	+	+
Higher syntaxa				
Picea glauca	1	2	−	+
Ledum palustre ssp. *decumbens*	1	−	+	2
Betula × *eastwoodiae*	−	−	3	3
Betula nana	+	−	2	−
Lycopodium complanatum	−	2	−	1
Arctostaphylos uva-ursi	−	2	−	−
Geocaulon lividum	−	1	−	−
Lycopodium annotinum	−	−	−	1
Rosa acicularis ssp. *sayi*	−	−	−	1
Campanula uniflora	1	−	−	−
Carex albonigra	−	−	1	−
Companions				
Equisetum arvense	−	−	−	1
Hierochloe alpina	−	−	1	−
Luzula spicata	−	−	1	−
Salix phlebophylla	−	−	1	−
Alnus viridis ssp. *crispa*	−	+	−	−
Mosses & Lichens				
Stereocaulon pascale	4	5	5	5
Polytrichum juniperinum	3	5	4	4
Polytrichum piliferum	1	5	4	4
Peltigera apthosa	4	5	5	5
Thamnolia vermicularis	4	5	5	5
Cetraria cucullata	4	5	5	5
Cladina sp. *div.*	4	5	5	5

stable climaxes, particularly where soil moisture is limited (Larsen 1980; Rowe 1959; Elliott-Fisk 1988; Scott 1995). A 250-year post-fire chronosequence in the northern limits of lichen woodland in Quebec suggests that well drained lichen woodlands are self-perpetuating in the absence of fire (Morneau & Payette 1989). Studies within fire free 3000-year-old relict spruce-lichen woodlands in northwestern Quebec show little tendency towards closure and therefore also lend support to the hypothesis that open lichen woodland is self-perpetuating (Payette & Morneau 1993). These data suggest that *Loiseleurio procumbentis-Betuletum neoalaskanae*, which is always restricted to lithosols on rocky or alluvial outcrops, must be regarded as an edaphic, not a climatic, climax.

Ledo decumbentis-Piceion marianae all. nova hoc loco

Nomenclatural type: *Rubo chamaemori-Piceetum marianae ass. nova, holotypus.* Characteristic and differential taxa: *Betula* × *eastwoodiae*, *Carex aquatilis*, *C. capillaris*, *C. gynocrates*, *C. scirpoidea*, *Equisetum variegatum*, *Eriophorum brachyantherum*, *E. vaginatum* ssp. *spissum*, *Ledum palustre* ssp. *decumbens*, *Petasites frigidus* var. *nivalis*, *P. sagittatus*, *Rubus arcticus* ssp. *acaulis*, *Salix reticulata* ssp. *reticulata* (diff.), *Senecio lugens*, *Vaccinium caespitosum*, and *Vaccinium microphyllum*. Differential with regard to *Shepherdio canadensis-Piceion glaucae*: *Chamaedaphne calyculata*, *Larix laricina*, *Rubus chamaemorus*, and *Vaccinium oxycoccos*.

Because the very shallow root system of *P. mariana* allows it to exist in areas where there is a high permafrost table (Elliott-Fisk 1988), forests (generally open) and woodlands physiognomically dominated by this tree thrive on wet soils (gleysols, cryosols), mainly on sites where permafrost hampers water drainage. Black spruce associations can be climaxes in the wetter areas of eastern North America. However, in the drier areas of the Alasko-Yukonian sector, as well as in central Canada, these associations are usually linked to wet soils and must therefore be regarded azonal vegetation. Nevertheless, in some of the wetter areas of the Alasko-Yukonian supraboreal belt, black spruces can also be a climatic climax (see *Rubo chamaemori-Piceetum marianae*). In these sites Viereck (1970) pointed out that permafrost may be due to vegetational dynamics, and that some old *P. mariana* old stands may represent the final stage of a successional series.

9. Piceetum glauco-marianae ass. nova hoc loco

Nomenclatural type: Table 14, rel. 301, *holotypus.* Closely related community: *Picea mariana-Ledum groenlandicum* community (Lausi & Nimis 1991);

Table 14. Piceetum glauco-marianae ass. nova. Type relevés: association, rel. 301: 30 Km south of Upper Liard, British Columbia (594930 N, 1290756 W). July 11, 1994; subass. *petasitetosum palmati*, rel. 454: Liard River, British Columbia (593301 N, 12626381 W), July 24, 1994; subass. *vaccinietosum uliginosi*, rel. 416: mile 185, Dalton Highway, Alaska (672338 N, 1500600 W), July 20, 1994.

Relevé No.	300	301	307	351	426	444	451	452	454	457	465	427	429	406	416
Altitude (decameters)	60	60	65	60	33	54	60	63	46	86	62	69	80	18	29
Area (m^2)	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Exposure	–	–	–	NW	–	SE	–	–	–	–	–	N	SW	–	W
Number of plants	12	10	10	12	10	18	17	20	20	19	14	11	14	14	11
Piceetum glauco-marianae:															
Differentiating floristic combination															
Picea glauca	4	1	1	2	2	3	3	3	3	3	4	2	1	1	1
Picea mariana	2	4	4	2	3	1	2	1	1	1	1	2	3	3	3
Geocaulon lividum	1	1	1	1	1	1	2	1	1	+	–	2	–	1	–
Ledum groenlandicum	–	1	2	–	2	1	–	2	1	–	2	2	1	2	1
Vaccinium vitis-idaea	–	+	2	1	1	+	1	–	1	–	–	2	2	2	1
Piceetum glauco-marianae petasitetosum palmati															
Alnus viridis ssp. *crispa*	–	–	–	–	–	–	1	1	2	–	2	–	–	1	2
Lupinus arcticus ssp. *arcticus*	–	–	–	–	–	–	1	1	1	–	–	–	–	–	–
Petasites frigidus var. *palmatus*	–	–	–	–	–	–	1	+	1	1	1	–	–	–	–
Piceetum glauco-marianae vaccinietosum uliginosi															
Empetrum nigrum ssp. *hermaphroditum*	–	–	–	2	–	–	–	–	–	–	–	2	2	1	2
Ledum palustre ssp. *decumbens*	–	–	–	–	–	–	–	–	–	–	–	–	1	1	1
Vaccinium uliginosum	–	–	–	–	–	–	–	–	–	–	–	2	3	1	2
Arctostaphylo rubrae-Piceetalia glaucae,															
Ledo decumbentis-Piceion marianae															
Salix glauca	–	1	–	–	–	1	2	2	2	2	2	1	1	2	2
Mertensia paniculata var. *paniculata*	–	–	–	1	1	1	1	1	1	+	1	1	–	+	–
Arctostaphylos rubra	1	1	1	–	–	1	–	–	–	–	–	–	–	+	–
Shepherdia canadensis	–	–	+	–	–	1	1	–	2	–	–	–	–	–	–
Betula papyrifera var. *neoalaskana*	–	–	–	–	+	–	–	–	1	–	–	–	–	+	1
Salix arbusculoides	–	–	–	–	–	1	–	–	–	1	–	–	1	–	–
Galium boreale	+	–	–	–	–	–	–	1	1	–	–	–	–	–	–
Pinus contorta var. *latifolia*	–	–	–	–	–	–	2	2	–	–	–	–	–	–	–
Pentaphylloides floribunda	–	–	–	–	–	1	–	–	–	2	–	–	–	–	–
Salix myrtillifolia var. *myrtillifolia*	–	–	1	–	–	–	–	–	–	2	–	–	–	–	–
Pedicularis labradorica var. *labradorica*	–	–	–	–	–	–	–	1	–	+	–	–	–	–	–
Petasites frigidus var. *nivalis*	–	–	–	–	–	–	–	–	–	–	–	–	+	–	+
Alnus viridis ssp. *sinuata*	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–
Equisetum scirpioides	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–
Spiraea stevenii	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–
Festuca altaica	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–
Tofieldia pusilla	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–
Zygadenus elegans	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–
Vaccinio-Piceetea															
Rosa acicularis ssp. *sayi*	–	–	–	–	–	+	1	1	1	1	–	–	1	1	–
Viburnum edule	–	–	–	+	–	–	1	1	1	–	–	–	–	–	–
Orthilia secunda	–	–	–	–	–	1	–	1	1	–	–	–	–	–	–
Moneses uniflora	–	1	–	–	–	1	1	–	–	–	–	–	–	–	–
Betula nana	–	–	–	–	–	–	–	–	–	2	–	–	2	–	–
Equisetum sylvaticum	–	–	–	1	–	–	–	–	–	–	2	–	–	–	–
Arctostaphylos uva-ursi	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–

Table 14 continued.

Relevé No.	300	301	307	351	426	444	451	452	454	457	465	427	429	406	416
Altitude (decameters)	60	60	65	60	33	54	60	63	46	86	62	69	80	18	29
Area (m^2)	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Exposure	–	–	–	NW	–	SE	–	–	–	–	–	N	SW	–	W
Number of plants	12	10	10	12	10	18	17	20	20	19	14	11	14	14	11
Juniperus communis var. *depressa*	–	–	–	–	–	–	–	+	–	+	–	–	–	–	–
Lycopodium complanatum	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–
Pyrola chlorantha	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Listera cordata	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–
Corallorhiza trifida	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–
Companions															
Linnaea borealis ssp. *longiflora*	2	1	–	1	1	1	–	1	1	–	–	–	–	–	–
Cornus canadensis	–	–	+	–	+	–	1	1	1	–	1	–	–	–	–
Epilobium angustifolium	–	–	+	–	–	–	+	+	1	–	–	+	–	–	–
Populus tremuloides	1	–	–	–	+	–	–	–	2	–	–	2	–	–	–
Leymus af. cinereus	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–
Salix myrtillifolia var. *cordata*	–	–	–	–	–	–	–	–	–	1	+	–	–	–	–

Additional taxa: *Anemone multifida* (rel. 300: +), *A. parviflora* (rel. 300: +), *Mitella nuda* (rel. 465: 1), *Populus balsamifera* ssp. *balsamifera* (rel. 351: 1), *Ribes triste* (rel. 429: +), *Rubus pubescens* (rel. 465: 1), *Salix brachycarpa* (rel. 351: 2), *S. hastata* (rel. 451: 1), *S. lucida* ssp. *caudata* (rel. 457: 2), *Salix lucida* ssp. *lasiandra* (rel. 465: 2), *Solidago spathulata* (rel. 457: +).

closed black spruce-white spruce forest (Viereck et al. 1992).

Stands of this association have a tree cover almost entirely constituted by *P. glauca* and *P. mariana*, and occasionally either scattered *Betula papyrifera* var. *neoalaskana* or *Populus balsamifera*. Under the dense canopy of the dominant trees there is a well developed bryoid layer, dominated by *Sphagnum sp. div.* with a locally high cover of lichens, and permafrost can be found at depths of 50–60 cm even in summer. The thick organic layer and the shallow root systems of the trees make this forest very sensitive to windstorms and other disturbances, which uproot many trees.

Piceetum glauco-marianae is a subhygrophytic association thriving in the wet depressions of the mesoboreal and supraboreal belts of the Alasko-Yukonian sector. Stands of this association are very common on flood-plain terraces and at the bases of slopes where drainage is only slightly impeded and there is no peat accumulation. Therefore, stands of this association can be regarded as transitional between pure white spruce associations (*Shepherdio canadensis-Piceion glaucae*) on well drained soils, and open black spruce muskegs (*Rubo chamaemori-Piceetum marianae*) on poorly drained soils with limited peat accumulation. Despite its transitional role, this association is floristically supported. The constant presence of *P. mariana* is differential with regard to the *Shepherdio canadensis-Piceion glaucae* associations. The absence or low frequency of *B. nana* and *Pentaphylloides floribunda*, is differential with regard to *Betulo nanae-Piceetum glaucae*, whereas the absence of *Rubus chamaemorus* and the presence of *P. glauca* are differential from *Rubo chamaemori-Piceetum marianae.*

Besides the typical subassociation, there are two other subassociations. The subassociation *petasitetosum palmati subass. nova* (Nomenclatural type: Table 14, rel. 454; *Alnus viridis* ssp. *crispa*, *Lupinus arcticus*, and *Petasites frigidus* var. *palmatus* are differential taxa) occurs in the upper horizon of the mesoboreal belt. The subassociation *vaccinietosum uliginosi subass. nova* (Nomenclatural type: Table 14, rel. 416; *Vaccinium uliginosum*, *Ledum palustre* ssp. *decumbens*, and *Empetrum nigrum* ssp. *hermaphroditum* are differential plants) corresponds to stands of this association in the supraboreal belt.

10. Rubo chamaemori-Piceetum marianae ass. nova hoc loco

Nomenclatural type: Table 15, rel. 394, *holotypus*. Closely related communities: *Picea mariana-Sphagnum* and *Picea mariana-Ledum palustre* communities (Lausi & Nimis 1991); open black spruce for-

Table 15. Rubo chamaemori-Piceetum marianae ass. nova. Type relevé: rel. 394: Denali State Park, Alaska (625353 N, 1494407 W), July 19, 1992.

Relevé No.	391	394	349	350	358	353	359	381	440	420
Altitude (decameters)	5	36	82	71	40	75	67	14	45	42
Area (m^2)	200	200	200	200	200	200	200	200	200	200
Exposure	–	–	–	–	N	–	–	–	–	–
Number of plants	12	20	11	13	13	11	15	13	13	11
Rubo chamaemori-Piceetum marianae:										
Differentiating floristic combination										
Picea mariana	2	3	3	2	3	3	4	3	3	4
Rubus chamaemorus	2	2	+	+	1	1	1	1	1	2
Vaccinium uliginosum	2	2	2	2	2	2	+	1	–	1
Vaccinium vitis-idaea	1	1	2	2	1	–	1	1	2	2
Arctostaphylo rubrae-Piceetalia, Ledo decumbentis-Piceion marianae										
Empetrum nigrum ssp. *hermaphroditum*	2	1	1	–	–	1	2	–	–	–
Petasites frigidus var. *nivalis*	–	1	1	1	–	–	–	–	+	1
Spiraea stevenii	–	2	–	–	–	–	2	1	–	1
Salix arbusculoides	–	2	–	–	–	–	2	2	–	–
Betula papyrifera var. *neoalaskana*	–	–	1	–	–	–	–	1	–	+
Agrostis exarata	–	–	–	–	1	–	–	–	–	–
Ledum decumbens	2	–	–	–	–	–	–	–	–	2
Alnus viridis ssp. *sinuata*	–	–	–	+	3	–	–	–	–	–
Pentaphylloides floribunda	–	1	–		2	–	–	–	–	–
Eriophorum brachyantherum	–	–	–	–	–	–	–	–	2	+
Alnus viridis ssp. *crispa*	–	–	–	–	–	–	–	–	2	–
Salix myrtillifolia var. *myrtillifolia*	–	–	–	–	–	2	–	–	–	–
Lupinus arcticus ssp. *arcticus*	–	–	–	–	–	1	–	–	–	–
Petasites sagittatus	–	–	–	–	–	–	1	–	–	–
Mertensia paniculata var. *paniculata*	–	–	–	+	–	–	–	–	–	–
Pyrola asarifolia ssp. *asarifolia*	–	+	–	–	–	–	–	–	–	–
Vaccinio-Piceetea										
Ledum groenlandicum	–	–	3	3	2	2	2	1	2	–
Equisetum sylvaticum	–	–	1	1	–	–	2	+	1	1
Betula nana	1	2	–	–	–	2	2	2	–	2
Salix glauca	–	–	1	–	1	2	2	–	2	–
Lycopodium annotinum	–	–	1	1	–	–	1	1	–	–
Geocaulon lividum	–	–	–	2	1	1	–	–	1	–
Rosa acicularis ssp. *sayi*	–	–	–	1	–	–	1	–	–	–
Rubus pedatus	–	1	–	–	–	–	–	1	–	–
Empetrum nigrum ssp. *nigrum*	–	–	–	–	2	–	–	–	–	–
Listera cordata	–	1	–	–	–	–	–	–	–	–
Orthilia secunda	–	1	–	–	–	–	–	–	–	–
Picea glauca	–	–	–	–	1	–	–	–	–	–
Oxycocco-Sphagnetea										
Vaccinium oxycoccos	1	2	–	–	–	–	–	–	1	–
Carex pauciflora	1	1	–	–	–	–	–	–	–	–
Drosera anglica	1	1	–	–	–	–	–	–	–	–
Chamaedaphne calyculata	2	–	–	–	–	–	–	–	2	–
Kalmia microphylla	2	–	–	–	–	–	–	–	–	–
Salix fuscescens	–	1	–	–	–	–	–	–	–	–
Companions										
Cornus canadensis	–	1	–	–	–	1	1	2	–	–
Equisetum arvense	–	2	–	–	1	–	–	–	–	–
Salix brachycarpa	–	–	–	2	–	–	–	–	–	–

est (Viereck et al. 1992); *Rubus chamaemorus-Picea mariana* association (Peinado et al. 1997b).

Rubo chamaemori-Piceetum marianae includes open forests (muskegs) of poor soils having small, frequently dwaved, black spruce trees as the only dominant species, a ground cover of bryophytes (*Sphagnum sp. div.*, *Pleurozium schereberi*, *Hylocomium splendens*) and fruticose and foliose lichens, and an open to nearly continuous cover of dwarf shrubs dominated by *Vaccinium uliginosum*, *V. vitis-idaea*, *Ledum groenlandicum*, *Betula nana*, *Arctostaphylos glauca*, and *Pentaphylloides floribunda*. *Chamaedaphne calyculata* and *Vaccinium oxycoccos* are common on wetter soils. Common herbs are *Rubus chamaemorus*, *Equisetum sylvaticum*, and *E. arvense*. This association often occurs on soils with nutrient-poor stagnated water, either in oligotrophic ombrogenous bogs or in the mesotrophic topogenous bog borders where seepage is almost nil, and on the edges of islands of mineral soils rising out of extensive eutrophic peat bogs (these occupied by communities belonging to the class *Oxycocco-Sphagnetea*).

In the mesoboreal belt this association is rare, and is restricted either to cold flats or valleys where there is permafrost or where the soil over bedrock is shallow. In the supraboreal belt it also thrives over vast areas of poorly drained and cold terrain, but it is also characteristic of some cold north-facing slopes where the permafrost drops only a short distance in summer. Therefore, this association can be regarded as a climatic climax in these supraboreal sites, but a hygrophytic association, or edaphic climax, on poorly drained cryosols of the supraboreal and mesoboreal belts.

11. Larici laricinae-Piceetum marianae ass. nova hoc loco

Syn.: *Piceo marianae-Laricetum laricinae* Looman 1988 *nom. nudum* (Art. 5).

Nomenclatural type: Table 16, rel. 402, *holotypus*.

This association is an open mixed forest of stunted tamaracks (*Larix laricina*) and black spruces with a shrub layer of *Betula nana*, *Empetrum nigrum* ssp. *hermaphroditum*, *Ledum groenlandicum*, *Vaccinium uliginosum* and *V. vitis-idaea*, growing on wetlands of the supraboreal belt of interior Alaska. Because this and *Rubo chamaemori-Piceetum marianae* occur on sites with poor drainage, both share similarities in species composition. However, in contrast to the latter the tamarack-black spruce association is restricted to sites with telluric ground water, and often occupies bog borders influenced by seeping water. The strong presence of *Salix arbusculoides*, a very common erect shrub or small tree forming dense thickets along streams and rivers in interior Alaska, is a good indicator of the fluvisols or gleysols on which this association thrives. Furthermore, *L. laricina* is considered a typical species of the interior Alaskan wetlands (Barbour & Christensen 1993; Archibold 1995), and black spruce-tamarack stands are found on wet lowlands in interior Alaska (Viereck et al. 1992).

In interior Alaska this community is restricted to the drainage basin between the Brooks Range on the north and the Alaska Range on the south. Most of our relevés were registered along the Tanana River, but, given the distribution area of tamarack (Viereck & Little 1991), scattered stands of this association are also common in the Yukon river basin.

Besides the typical Alasko-Yukonian subassociation, we recognize the subassociation *loniceretosum involucratae subass. nova* (Nomenclatural type: Table 16, rel. 471), which occurs in eastern British Columbia and can be considered transitional to wetland communities belonging to the central alliance *Piceion marianae*. In the Prairie Provinces Looman (1987b) described the association *Piceo marianae-Laricetum laricinae*, but there are no significative differences between that association and the subassociation *loniceretosum involucratae*.

Larici laricinae-Piceetum marianae is a supraboreal association. However, relevé 450 lacks the supraboreal taxa *Vaccinium uliginosum* and holds the mesoboreal *Viburnum edule*, suggesting the presence of this association in the upper horizon of the mesoboreal belt.

12. Boschniakio rossicae-Alnetum crispae ass. nova hoc loco

Nomenclatural type: Lausi et Nimis 1991: Table 9, rel. 7, *lectotypus*. Closely related community: *Betula papyrifera-Alnus crispa* community (Lausi & Nimis 1991); closed tall alder shrub (Viereck et al. 1992).

Dense thickets of American green alder (*Alnus viridis* ssp. *crispa*) covering drainageways on steep slopes of the mesoboreal Alasko-Yukonian sector belong to this association. It is dominated by shrubby alders, although scattered trees (*P. tremuloides*, *B. neoalaskana*, *P. glauca*) may overtop the shrub canopy, but cover is always low. Herbaceous cover may be sparse or dense, and common plants in this layer include *Calamagrostis canadensis*, *Equisetum scirpoides*, *Gymnocarpium dryopteris*, *Mertensia*

Table 16. Larici laricinae-Piceetum marianae ass. nova. Type relevés: association, rel. 402, 10 miles south of Nenana, Alaska (642027 N, 1490243 W), July 19, 1994; subassociation *loniceretosum involucratae* rel. 471, between Grande Cache and Hinton, Alberta (535549 N, 1184502 W), July 26, 1994.

Relevé No.	402	403	405	425	450	463	464	466	470	471
Altitude (decameters)	11	7	16	22	15	67	50	42	120	76
Area (m^2)	200	200	200	200	200	200	200	200	200	200
Exposure	–	–	NW	–	–	–	–	–	–	–
Number of plants	14	16	19	18	18	15	11	13	12	19
Larici laricinae-Piceetum marianae: Differentiating floristic combination										
Larix laricina	1	3	1	2	2	2	3	1	2	1
Picea mariana	3	3	3	2	2	2	1	3	2	3
Ledum groenlandicum	2	2	1	2	1	3	3	2	2	2
Vaccinium vitis-idaea	1	1	1	1	2	1	1	2	2	1
Larici laricinae-Piceetum marianae loniceretosum involucratae										
Rubus pubescens	–	–	–	–	–	–	–	–	1	1
Lonicera involucrata	–	–	–	–	–	–	–	–	1	1
Arctostaphylo-Piceetalia glaucae, Ledo decumbentis-Piceion marianae										
Rubus chamaemorus	–	–	–	1	–	1	1	1	1	1
Salix arbusculoides	1	2	1	2	–	–	–	–	2	2
Salix glauca	1	–	1	+	+	–	–	–	–	2
Betula neoalaskana	1	2	+	1	1	–	–	–	–	–
Empetrum nigrum ssp. *hermaphroditum*	–	1	–	2	+	+	–	–	–	–
Alnus viridis ssp. *sinuata*	–	–	3	–	–	–	+	–	–	+
Chamaedaphne calyculata	1	–	–	1	–	–	2	–	–	–
Mertensia paniculata var. *paniculata*	–	–	1	–	1	–	–	–	–	1
Arctostaphylos rubra	–	1	1	+	–	–	–	–	–	–
Vaccinium oxycoccos	–	–	–	–	1	–	–	–	–	1
Eriophorum brachyantherum	–	–	–	1	–	+	–	–	–	–
Salix myrtillifolia v. myrtillifolia	–	–	–	–	+	–	–	–	–	1
Betula × *eastwoodiae*	2	–	–	–	–	+	–	–	–	–
Pedicularis labradorica v. labradorica	–	–	–	–	–	–	–	1	–	–
Salix bebbiana	–	–	–	–	–	–	–	1	–	–
Petasites sagittatus	–	–	–	–	–	–	–	–	–	1
Pentaphylloides floribunda	–	–	1	–	–	–	–	–	–	–
Vaccinio-Piceetea										
Equisetum sylvaticum	2	1	–	–	3	2	2	2	2	–
Betula nana	2	–	2	+	–	1	–	2	–	2
Geocaulon lividum	1	1	1	+	1	1	1	–	–	–
Vaccinium uliginosum	1	+	1	1	–	1	–	1	–	–
Carex limosa	–	–	–	–	–	1	1	2	–	–
Picea glauca	–	–	1	–	3	–	–	–	–	–
Viburnum edule	–	–	–	–	1	–	–	–	–	1
Rosa acicularis spp. *sayi*	–	+	–	–	1	–	–	–	–	–
Shepherdia canadensis	–	+	–	–	–	+	–	–	–	–

Table 16 continued.

Relevé No.	402	403	405	425	450	463	464	466	470	471
Altitude (decameters)	11	7	16	22	15	67	50	42	120	76
Area (m^2)	200	200	200	200	200	200	200	200	200	200
Exposure	–	–	NW	–	–	–	–	–	–	–
Number of plants	14	16	19	18	18	15	11	13	12	19
Companions										
Cornus canadensis	–	+	1	–	1	–	–	–	–	–
Equisetum arvense	–	+	–	–	2	–	–	–	–	–
Kalmia microphylla	–	–	–	–	–	1	1	–	–	–
Kobresia myosuroides	1	1	–	–	–	–	–	–	–	–
Petasites frigidus v. palmatus	–	–	–	–	1	–	–	1	–	–
Epilobium angustifolium	–	–	–	–	–	–	–	–	+	1

Additional taxa: *Alnus viridis* ssp. *crispa* (rel. 405: 1), *Delphinium brachycentrum* (rel. 405: 1), *Maianthemum trifolium* (rel. 466: 1), *Petasites hyperboreus* (rel. 470: 1), *Petasites sagittatus* (rel. 471: 1), *Ribes triste* (rel. 425: 1), *Platanthera hyperborea* (rel. 425: +), *Populus tremuloides* (rel. 405: +), *Ranunculus lapponicus* (rel. 470: +), *Saussurea angustifolia* (rel. 425: +), *Sibbaldia procumbens* (rel. 471: 1).

paniculata, *Aconitum delphinifolium*, and *Linnaea borealis*. Because *Boschniakia rossica* is an obligate parasite of *Alnus*, it is characteristic of this association.

These dense thickets of American alder are common on steep slopes, drainages and avalanche tracks. Therefore, they are edaphic subclimax or stable vegetation in these habitats.

Alnetalia tenuifoliae Wali & Krajina 1973
Nomenclatural type: *Alnion tenuifoliae* Wali & Krajina 1973, *lectoypus*.

Alnion tenuifoliae Wali et Krajina 1973
Nomenclatural type: *Urtico gracilis-Alnetum tenuifoliae* Wali & Krajina 1973 *corr., lectotypus*. Characteristic taxa of alliance and order: *Alnus incana* ssp. *tenuifolia*, *Populus balsamifera* ssp. *balsamifera*, *Ribes hudsonianum*, *Salix arbusculoides*.

Associations of this alliance are broadleaved forests and willow shrubs thriving on river valleys, including sandy bottoms and gravelly flood plains, terraces, and coarse alluvial fans throughout the Alasko-Yukonian sector. These associations are mainly mesoboreal and supraboreal, but they can penetrate into the oroboreal belt, always along major river basins. They are absent from the Vancouveran Province because they are replaced by red alder riparian forests (*Alnetalia oreganae*, undescribed) from southeastern Alaska southwards. In the Rocky Mountain sector and in the Prairie Provinces they are replaced by associations belonging to the alliance *Populion deltoidis* Looman 1987b *nom. nudum*

The bioclimatic (bioclimatic belt and rainfall type), edaphic, geographic, and physiognomic diagnoses of the associations belonging to *Alnetalia tenuifoliae* are shown in Table 5.

13. Salici arbusculoidis-Alnetum tenuifoliae ass. nova hoc loco
Nomenclatural type: Lausi & Nimis 1991: Table 9, rel. 2, *lectotypus*. Closely related community: *Salix arbusculoides-Alnus incana* community (Lausi & Nimis 1991).

Deciduous forest, co-dominated by *Alnus incana* ssp. *tenuifolia* and *Populus balsamifera S. balsamifera*, with lower presence of *P. tremuloides*. Common tall shrubs or small trees are *Salix arbusculoides* and *S. alaxensis*. Typical boreal dwarf shrubs are absent, but there is a more or less dense layer of forbs dominated by *Calamagrostis canadensis*. The presence of some hygrophytic species such as *Arctostaphylos rubra*, *Pentaphylloides floribunda*, and *Carex aquatilis*, indicates flooding. Soils are well drained, gravelly, and permafrost free gleyic regosols.

This is the typical riparian forest of the Alasko-Yukonian sector. Southeastwards, in northeastern British Columbia, it is replaced by *Urtico gracilis-Alnetum tenuifoliae.*

14. Urtico gracilis-Alnetum tenuifoliae Wali & Krajina 1973 *corr. hoc loco*
Syn.: *Urtico (dioicae)-Matteucio (struthiopteridis)-Alnetum tenuifoliae* Wali & Krajina 1973 *nom. illeg.* (Art. 10).

Nomenclatural type: Wali & Krajina 1973: Table 8, rel. 2, *lectotypus*.

Gaultherio procumbentis-Piceetalia glaucae Br.-Bl. et al. *ordo novo hoc loco*

Syn.: *Gaultherio-Piceetalia* Braun-Blanquet et al 1939 *nom. nudum* (Art. 3b). Nomenclatural type*: Gaultherio procumbentis-Piceion glaucae all. nova*, *holotypus.* Characteristic and differential taxa: *Abies balsamea* (diff.), *Acer rubrum* (diff.), *Acer spicatum* (diff.), *Alnus rugosa*, *Aster macrophyllus*, *Betula alleghaniensis* var. *alleghaniensis*, *Carex brunnescens*, *C. trisperma*, *Clintonia borealis*, *Coptis trifolia* ssp. *groenlandica*, *Cypripedium acaule*, *Dryopteris austriaca*, *Gaultheria procumbens, Gymnocarpium disjunctum, Kalmia angustifolia*, *Lonicera canadensis*, *L. villosa*, *Monotropa uniflora* (diff.), *Nemopanthus mucronata*, *Phegopteris connectilis*, *Pinus resinosa* (diff.), *Pteridium aquilinum* var. *latiusculum*, *Pyrola minor* (diff.), *Rhamnus alnifolia*, *Sambucus racemosa* var. *pubens*, *Schizachne purpurascens*, *Solidago macrophylla*, *Sorbus americana*, *S. decora*, *Streptopus roseus* var. *roseus*, *Thuja occidentalis*, *Trientalis borealis* ssp. *borealis*, *Vaccinium angustifolium*, *Viburnum nudum* var. *cassinoides*, and *Viola blanda* var. *palustriformis.*

Subalpine (also reaching the upper horizon of the montane belt, mainly on cold, north facing slopes) and boreal associations of eastern North America. The distribution area of this order needs to be exactly delimited, but, roughly, it spreads from Newfoundland westwards to the eastern slopes of the Rocky Mts., where it is replaced by associations belonging to the order *Piceetalia glauco-marianae*. Probably the best criterion for delimiting the area would be to make it coincident with the area of *Abies balsamea*.

The bioclimatic (bioclimatic belt and rainfall type), edaphic, geographic, and physiognomic diagnoses of the associations belonging to *Gaultherio procumbentis-Piceetalia glaucae* are shown in Table 17.

Gaultherio procumbentis-Piceion glaucae all. nova hoc loco

Nomenclatural type: *Abietetum balsameae* Damman 1964, *holotypus.* Characteristic taxa (and differential with respect to *Viburno cassinoidis-Piceion marianae*): *Agrostis mertensii*, *Aster subspicatus*, *Athyrium filix-femina* var. *angustum* (diff.), *Carex interior*, *C. leptonervia*, *C. pauciflora*, *Circaea alpina* (diff.), *Huperzia lucidula* (diff.), *Osmunda claytoniana*, *Oxalis montana*, *Pinus strobus* (diff.), *Platanthera dilatata*, *Ribes hirtellum*, *Scirpus caespitosus*, *Taxus canadensis* (diff.), *Vaccinium ovalifolium*, *Vahlodea atropurpurea*, *Viburnum opalum* var. *americanum*, *Viola macloskeyi* ssp. *pallens*, and *V. selkirkii.*

This alliance corresponds to the *Picea glauca-Abies balsamea* forest (Vankat 1990), and groups mesoboreal and supraboreal climax forests of eastern North America, that is to say, those thriving on mesic soils, because on sites with water seepage or stagnation these associations are replaced by others belonging to the alliances *Alnion rugosae* and *Viburno cassinoidis-Piceion marianae*. On disturbed or burned sites as well as in xeric places they are replaced by associations of the alliance *Pinion divaricatae.*

15. Abietetum balsameae Damman 1964

Syn.: *Betulo papyriferae-Abietetum balsameae* sensu Gaudreau 1979; *Abies balsamea-Picea glauca* community Nakamura et al. 1994.

Nomenclatural type: Damman 1964: Table 2, rel. 710, *lectotypus.*

The next subassociations have been described: *hylocomietosum splendentis* Damman 1964 (Nomenclatural type: Damman 1964: Table 2, rel. 732, *lectotypus*); *rubetosum pubescentis* Damman 1964 (Nomenclatural type: Damman 1964: Table 2, rel. 737, *lectotypus*); *caricetosum trispermae* Damman 1964 (Nomenclatural type: Damman 1964: Table 2, rel. 831, *lectotypus*); *dryopteridetosum spinulosae* Damman 1964 (Nomenclatural type: Damman 1964: Table 2, rel. 763, *lectotypus*).

16. Kalmio polifoliae-Abietetum balsameae ass. nova hoc loco

Nomenclatural type (*lectotypus*): To validate this association according to Article 1 of the Code, we transcribe the type relevé from Sirois (1984, Table 30, rel. 1). Mount Albert, Quebec, 12/7/1981, 1060 m elevation, northern exposure. *Abies balsamea* 2, *Picea glauca* 1, *Empetrum nigrum* 3, *Betula papyrifera* 1, *Vaccinium uliginosum* 2, *Betula nana* 1, *Ledum groenlandicum* 1, *Phyllodoce coerulea* 1, *Betula occidentalis* 2, *Harrimanella hypnoides* 1. With index +: *Agrostis mertensii*, *Carex canescens*, *Dryopteris carthusiana*, *Juncus trifidus*, *Kalmia polifolia*, *Lycopodium annotinum*, *Oxyria digyna*, and *Salix herbacea*.

Supraboreal forest of eastern Canada (Quebec Province). *Kalmia polifolia* replaces *K. angustifolia* in this association. In addition, the presence of

Table 17. Bioclimatic, geographical, physiognomical and edaphic features of the associations belonging to *Gaultherio procumbentis-Piceetalia glaucae*.

Associations	Bioctimatic belt	Rainfall types	Soil	Geographical range	Physiognomy
Gaultherio procumbentis-Piceion glaucae					
Abietetum balsameae	Mesoboreal	Subhumid	Podsols	Newfoundland-Quebec	Balsam fir-white birch forest
Kalmio polifoliae-Abietetum balsameae	Supraboreal	Subhumid	Podsols	Newfoundland-Quebec	Balsam fir forest
Alno crispae-Piceetum glaucae	Supraboreal	Subhumid	Gleysols	Quebec	White spruce krummholz
Viburno cassinoidis-Piceion marianae					
Kalmio angustifoliae-Piceetum marianae	Mesoboreal	Humid	Organic Podsols	Newfoundland-Quebec	*Kalmia*-black spruce forest
Kalmio polifoliae-Piceetum marianae	Supraboreal	Humid	Organic Podsols & Cryosols	Newfoundland-Quebec	*Kalmia*-black spruce forest
Sphagno-Piceetum marianae	Azonal	Azonal	Oligotrophic Gleysols	Newfoundland-Quebec	*Picea mariana* muskegs
Alnion rugosae					
Alno rugosae-Piceetum marianae	Azonal	Azonal	Mesotrophic Gleysols	Newfoundland-Quebec	Black spruce swamp
Alnetum rugosae	Azonal	Azonal	Eutrophic Gleysols	Newfoundland-Quebec	Alder swamp
Vaccinio angustifoliae-Thujetum occidentalis	Azonal	Azonal	Calcareous Histosols	Quebec	White cedar swamp
Pinion divaricatae					
Comptonio peregrinae-Pinetum divaricatae	Mesoboreal	Azonal	Sandy Regosols	Quebec	Open Jack pine forest
Ledo groenlandici-Pinetum divaricatae	Supraboreal	Azonal	Organic Podsols & Cryosols	Quebec	Jack pine forest
Carici pensylvanicae-Pinetum divaricatae	Upper montane	Azonal	Sandy Regosols	Quebec	Mixed Jack pine forest
Gaylussacio baccatae-Pinetum divaricatae	Mesoboreal	Azonal	Folisols	Quebec	Flagged Jack pine woodland
Asteri acuminati-Piceion rubentis					
Piceo rubentis-Abietetum balsameae	Subalpine	Humid	Podsols	Northern Appalachian Mts.	Red fir subalpine forest
Thujo occidentalis-Abietetum balsameae	Subalpine & Montane	Azonal	Calcareous Histosols	Northern Appalachian Mts.	White cedar-balsam fir swamp

some supraboreal taxa, such as *Betula nana*, *Empetrum nigrum*, *Vaccinium uliginosum*, *Phyllodoce coerulea* and *Juncus trifidus*, is differential with regard to *Abietetum balsameae*.

17. Alno crispae-Piceetum glaucae ass. nova hoc loco
Nomenclatural type (*lectotypus*): To validate this association according to Article 1 of the Code, we transcribe the type relevé from Sirois (1984, Table 33, rel. 1). Mount Albert, Quebec, 8/8/1981, 1010 m elevation, eastern-northeastern exposure. *Picea glauca* 3, *Alnus viridis* ssp. *crispa* 2, *Abies balsamea* 2, *Betula nana* 2, *Scirpus caespitosus* 1. With index +: *Agrostis mertensii*, *Amelanchier bartramiana*, *Andromeda glaucophylla*, *Aster subspicatus*, *Athyrium filix-femina*, *Betula papyrifera*, *Calamagrostis canadensis*, *Carex brunnescens*, *C. interior*, *C. pauciflora*, *C. paupercula*, *C. stricta*, *C. trisperma*, *Clintonia borealis*, *Coptis groenlandica*, *Cornus canadensis*, *Deschampsia flexuosa*, *Dryopteris carthusiana*, *Epilobium palustre*, *Geocaulon lividum*, *Habenaria dilatata*, *Huperzia lucidula*, *Kalmia polifolia*, *Lonicera villosa*, *Maianthemum trifolium*, *Oxalis montana*, *Phegopteris connectilis*, *Rubus pubescens*, *Solidago macrophylla*, *Streptopus roseus*, *Trientalis borealis*, *Vaccinium angustifolium*, *V. uliginosum*, *Vahlodea atropurpurea*, and *Viola adunca*.

The broad arctic timberline zone of eastern Canada is composed of the boreal tree-line species *P. glauca* and *P. mariana*, along with the subalpine and boreal balsam fir (Hare 1950). Together they form a dense krummholz called 'tuckammor' (Arno & Hammerly 1990) on the highest peaks of Newfoundland (Pruitt 1970) and southeastern Quebec (Sirois 1984). On well-drained soils the krummholz belong to *Kalmio polifoliae-Abietetum balsameae*, and is replaced by *Alno crispae-Piceetum glaucae* on gleysols. *Kalmio polifoliae-Piceetum marianae* replaces both associations on sites with water stagnation.

Viburno cassinoidis-Piceion marianae all. nova hoc loco
Nomenclatural type: *Kalmio angustifoliae-Piceetum marianae* Damman 1964, *holotypus*. Characteristic and differential taxa: *Anemone quinquefolia*, *Aronia melanocarpa*, *Epigaea repens*, *Eriophorum virginicum*, *Galium asprellum*, *Maianthemum trifolium*, *Rhododendron canadense*, *Salix humilis*, *Salix pyrifolia*, and *Spiraea alba* var. *latifolia*. Differential with regard to *Gaultherio-Piceion glaucae*: *Chamaedaphne calyculata*, *Larix laricina*, *Rubus chamaemorus*, and *Vaccinium oxycoccos*.

This alliance includes the eastern boreal forests with poor soils where black spruce is the main tree species. They thrive on cryosols, or on oligotrophic wet sites (peaty gleysols) when found in bog borders where water stagnates. In these wet habitats, they alternate with the *Alnion rugosae* associations, but these are restricted to sites with telluric ground water (Damman 1964). From a zonal point of view, the associations of *Viburno cassinoidis-Piceion marianae* are usually transitional between the climax forests of *Gaultherio procumbentis-Piceion glaucae* and the deep bogs which do not support forests but do support shrubby or herbaceous *Oxycocco-Sphagnetea* communities.

18. Kalmio angustifoliae-Piceetum marianae Damman 1964
Syn.: *Pleurozio schreberi-Piceetum marianae* Gadreau 1979; *Piceetum marianae* Damman 1964.

Nomenclatural type: Damman 1964: Table 1, rel. 739, *lectotypus.* Closely related community: Eastern *Kalmia*-black spruce forest group (La Roi 1967).

Besides the typical subassociation, we recognize the subassociation *cladonietosum alpestris* Damman 1964 (Nomenclatural type: Damman 1964: Table 1, relevé 7130, *lectotypus.* Syn.: *Cladonio stellaris-Piceetum marianae* Blouin 1970; *Cladino-Piceetum marianae* Nakamura et al. 1994).

19. Kalmio polifoliae-Piceetum marianae ass. nova hoc loco
Syn.: *Kalmio-Piceetum marianae* Looman 1987b *nom. nudum* (Art. 5).

Nomenclatural type (*lectotypus*): To validate this association according to Article 1 of the Code, we transcribe the type relevé from Sirois (1984, Table 31, rel. 2). Mount Albert, Quebec, 27/7/1982, 960 m elevation, eastern exposure. *Abies balsamea* 5, *Picea mariana* 2, *Deschampsia flexuosa* 3. With index 1: *Amelanchier bartramiana*, *Arctostaphylos uva-ursi*, *Betula nana*, *Vaccinium angustifolium*. With index +: *Clintonia borealis*, *Campanula rotundifolia*, *Coptis groenlandica*, *Empetrum nigrum*, *Juncus trifidus*, *Kalmia polifolia*, *Ledum groenlandicum*, *Linnaea borealis* ssp. *longiflora*, *Maianthemum canadense*, *Melampyrum lineare*, *Oryzopsis asperifolia*, *Phyllodoce coerulea*, *Rubus pubescens*, *Solidago macrophylla*, *Trientalis borealis*, and *Vaccinium uliginosum*.

Betula nana, *Kalmia polifolia*, *Phyllodoce coerulea*, and *Vaccinium uliginosum* are, among others, differential species of this supraboreal association that altitudinally replaces the association 18.

20. Sphagno-Piceetum marianae Grandtner 1960
Syn.: *Sphagno-Laricetum laricinae* Gauthier 1967 *nom. nudum* (Art. 1); *Kalmio angustifoliae-Piceetum marianae sphagnetosum capillacei* Damman 1964.
Nomenclatural type: Grandtner 1960: Table 2, rel. 3, *lectotypus*.

Alnion rugosae Damman 1964
Nomenclatural type: *Alnetum rugosae* Damman 1964, *lectotypus*. Characteristic taxa: *Aster puniceus*, *Carex canescens* ssp. *canescens*, *C. intumescens*, *C. leptalea*, *C. leptocarpa*, *Cirsium muticum*, *Geum rivale*, *Glyceria striata*, and *Thalictrum pubescens*.

Associations of this alliance occur on sites with retarded drainage. However, in contrast to *Viburno cassinoidis-Piceion marianae* associations they are restricted to sites with telluric ground water.

21. Alno rugosae-Piceetum marianae Damman 1964
Syn.: *Sphagno-Piceetum marianae alnetosum rugosae* Lafond 1964; *Sphagno-Alnetum rugosae* Gadreau 1979.

Nomenclatural type: Damman 1964: Table 4, rel. 745, *lectotypus.*

22. Alnetum rugosae Damman 1964
Syn.: *Sphagno girgensohnii-Alnetum rugosae* Gadreau 1979 *nom. nudum* (Art. 3b).

Nomenclatural type: Damman 1964: Table 4, rel. 722, *lectotypus*.

23. Kalmio polifoliae-Alnetum rugosae ass. nova hoc loco
Syn.: *Sphagno-Laricetum laricinae alnetosum rugosae* Gadreau 1979 *nom. nudum* (Art. 3b).

Nomenclatural type: Gadreau 1979, Table 80, rel. 2, *lectotypus.* Differential taxa: *Andromeda polifolia*, var. *glaucophylla*, *Kalmia polifolia*, *Vaccinium uliginosum*.

Dense thickets of *Alnus rugosa* and *Myrica gale*, with scattered tamaracks (*L. laricina*), that thrive on gleysols influenced by seepage water (Gadreau 1979). This association replaces *Alnetum rugosae* in the supraboreal belt of Quebec Province.

24. Vaccinio angustifoliae-Thujetum occidentalis ass. nova hoc loco
Syn.: *Rhamno-Thujetum occidentalis* Blanchet 1965 *nom. nudum* (Art. 1); *Abieti balsameae-Thujetum occidentalis* Blanchet 1965 *sensu* Gadreau 1979 *nomen nudum* (Art. 4 and 5); *Alno rugosae-Abietetum balsameae* Lalumière 1979 *nom. nudum* (Art. 1); *Alno rugosae-Abietetum balsameae* Lalumière & Thibault 1988 *nom. nudum* (Art. 5).

Nomenclatural type: Gadreau 1979, Table 75, rel. 1, *lectotypus*. Differential taxa with regard to other associations of *Alnion*: *Aster macrophyllus*, *Platanthera obtusata*, *Streptopus roseus* var. *roseus*, *Thuja occidentalis*, and *Viola renifolia*.

This calcicolous association lives in wet sites of the mesoboreal belt of Quebec Province. For a complete floristical and ecological description of this association see Gadreau (1979: 227; sub *Abieti balsameae-Thujetum occidentalis* Blanchet 1965 *sphagnetosum* variante à *Carex trisperma* prov.).

Pinion divaricatae Lavoie 1968
Syn.: *Vaccinio-Pinion divaricatae* Looman 1987b.
Nomenclatural type: *Comptonio-Pinetum divaricatae* Lavoie 1968, *lectotypus*. Characteristic and differential taxa: *Apocynum androsaemifolium*, *Melampyrum lineare*, *Pinus banksiana* (*P. divaricata*), *Solidago puberula*.

This pine forest – the *Pinus banksiana* forest of Vankat (1990) – is usually considered to be a fire subclimax, and replaces the climax associations of *Gaultherio procumbentis-Piceetalia glaucae* and *Piceetalia glauco-marianae* after fires or clear-cutting. Furthermore, *P. banksiana* also may be edaphic climax on sandy soils (Daubenmire 1978).

Besides the next associations, Looman (1988) described three more: *Oryzopsio-Pinetum banksianae*, *Betulo papyriferae-Pinetum banksianae*, and *Pino banksianae-Populetum tremuloidis.* All of them are *nomina nuda* (Art. 5, 7).

25. Comptonio peregrinae-Pinetum divaricatae Lavoie 1968
Nomenclatural type: Lavoie 1968: Table 1, rel. 2, *lectotypus*.

26. Ledo groenlandici-Pinetum divaricatae Lavoie 1968
Syn.: *Pleurozio schreberi-Pinetum banksianae* Gadreau 1979.

Nomenclatural type: Lavoie 1968: Table 1, rel. 21, *lectotypus*.

27. Gaylussacio baccatae-Pinetum divaricatae
Lavoie 1968
Nomenclatural type: Lavoie 1968: Table 1, rel. 26, *lectotypus*.

28. Carici pensylvannicae-Pinetum divaricatae
Lavoie 1968
Nomenclatural type: Lavoie 1968:Table 1, rel. 24, *lectotypus*.

Asteri acuminati-Piceion rubentis all. nova hoc loco
Nomenclatural type: *Piceo rubentis-Abietetum balsameae* Jurdant 1969, *holotypus*. Characteristic and differential taxa: *Acer pensylvanicum* (diff.), *A. rubrum* (diff.), *A. saccharum* (diff.), *Aster acuminatus*, *Chimaphila umbellata* ssp. *cisatlantica*, *Maianthemum racemosum* var. *racemosum*, *Medeola virginiana*, *Osmunda cinnamomea* (diff.), *Picea rubens*, *Polygonatum pubescens*, *Streptopus roseus* var. *perspectus*, *Thuja occidentalis*, *Trillium erectum*, *T. undulatum*, *Tsuga canadensis* (diff.), and *Viburnum lantanoides*.

This alliance includes associations from the subalpine and montane (only in the upper horizon) belts of the northern Appalachians. These mountains are contiguous with the uplands of eastern Quebec and Labrador, and boreal plants from northeastern Canada spread southwards along the highest summits of the northern Appalachians. Balsam fir and paper birch, together with *P. rubens* constitute the climax forest on the subalpine and upper montane belts in Canada (southern Quebec, Nova Scotia, Prince Edward Island) and the United States (Mount Katadin in Maine; White Mts. in New Hampshire; Green Mts. of Vermont, and the Adirondacks of New York). White spruce is restricted to the northernmost zones of the alliance area. Black spruce become common only in the krummholz and stunted-tree belts, where it dwells with balsam fir and paper birch (Arno & Hammerly 1990). *Betula alleghaniensis*, *Acer pensylvannicum*, *A. rubrum*, *A. saccharum*, *Tsuga canadensis* and even *Fagus grandifolia*, become co-dominant on the upper horizon of the montane belt.

The area of this alliance corresponds to the northern section of the *Picea rubens* Province (Daubenmire 1978), and its climate is humid-perhumid (annual precipitation averages 1900 mm), with fog (daytime cloud cover averages 75%), high humidity (average relative humidity exceeds 85% for every month of the year), sleet, and summer rain (Bliss 1963). Despite these significative differences with regard to the drier boreal climate, *A. balsamea*, *B. papyrifera*, *P. mariana*, and many ferns and seed plants of the undergrowth show close floristic affinities with the boreal forest.

Red spruce, *P. rubens*, also occurs in the southern Appalachians (the southern section of Daubenmire's *P. rubens* Province), where it shares co-dominance with *Abies fraseri* in those areas with peaks rising above about 1740 m (Daubenmire 1978). However, the affinity of this *Picea rubens-Abies fraseri* forest with the boreal flora is nearly nil, and it must be included as a subalpine alliance of the temperate class *Aceri sacchari-Fagetea grandifoliae*.

29. Piceo rubentis-Abietetum balsameae Jurdant 1969
Syn.: *Abieti balsameae-Betuletum papyriferae* Lafond 1964 *nom. nudum* (Art. 1); *Betulo luteae-Abietetum balsamei* Jurdant 1969; *Betulo papyriferae-Abietetum balsameae* Jurdant 1968; *Abieto balsameae-Piceetum rubentis* Gauthier 1970; *Abieti balsameae-Populetum tremuloidis* Blouin & Grandtner 1971; *Betulo papyriferae-Abietetum* Marcotte 1973; *Oxali-Abietetum* Marcotte 1973; *Oxali-Abietetum* Marcotte et Grandtner 1974; *Betulo papyriferae-Abietetum* Marcotte et Grandtner 1974; *Abieti balsameae-Aceretum rubri* Grandtner et al. 1975 *sensu* Lalumière et Thibault 1988.

30. Thujo occidentalis-Abietetum balsameae Jurdant 1959 *ex* Blouin & Grandtner 1971
Syn.: *Dicrano-Abietum thujetosum occidentalis* Jurdant 1959 *nom. nudum* (Art. 1); *Thujo occidentalis-Abietetum balsameae* (Jurdant 1959) Blouin 1970 *nom. nudum* (Art. 1).

Piceetalia glauco-marianae Wali & Krajina 1973
Syn.: *Piceetalia glaucae-marianae* Krajina 1969 *nom. nudum* (Art. 8); *Pino-Piceetalia* Looman 1987b *nom. nudum* (Art. 3f, 3g, 5).

Nomenclatural type: *Gymnocarpio dryopteridis-Abietion lasiocarpae* Wali & Krajina 1973 *em., lectotypus*. Characteristic and differential taxa: *Leymus innovatus*, *Lonicera involucrata*, *Oryzopsis pungens*, *Picea albertiana* (*P. glauca* × *engelmannii*), *Trientalis borealis* ssp. *latifolia*. Differential: (a) with regard to the western order *Arctostaphylo rubrae-Piceetalia glaucae*: *Abies balsamea*, *Carex disperma*,

C. trisperma, *Coptis trifolia* ssp. *groenlandica*, *Corylus cornuta* var. *cornuta*, *Cypripedium acaule*, *Diervillea lonicera*, *Dryopteris carthusiana*, *Gaultheria hispidula* var. *hispidula*, *Listera cordata*, *Lycopodium obscurum*, *Maianthemum canadense*, *Oxalis montana*, *Prunus virginiana*, *Pteridium aquilinum* var. *latiusculum*, *Ribes glandulosum*, *Salix discolor*, *Sambucus racemosa* var. *pubens*, *Sorbus americana S. decora*, *Streptopus roseus* var. *roseus*, and *Vaccinium myrtilloides*; (b) with regard to the eastern order *Gaultherio procumbentis-Piceetalia glaucae*: *Abies lasiocarpa*, *Arctostaphylos rubra*, *A. uva-ursi*, *Athyrium filix femina* ssp. *cyclosurum*, *Carex concinna*, *Corallorhiza trifida*, *Delphinium glaucum*, *Equisetum scirpoides*, *Hedysarum alpinum* var. *americanum*, *Pentaphylloides floribunda*, *Pinus contorta* var. *latifolia*, *Salix arbusculoides*, *S. myrtillifolia* ssp. *myrtillifolia*, and *Zygadenus elegans.*

Mesoboreal and subalpine associations in the Northern Rockies sector, and in central Canada. The area in which the associations of this order flourish can be divided in two portions: subalpine, corresponding with the true Northern Rockies sector, and boreal, which corresponds to the southernmost zones of the Circumboreal region (Takhtajan 1986) in central Canada, that is to say, the Canadian Prairie Provinces (Alberta, Manitoba and Saskatchewan).

The Northern Rockies sector extends from the northwestern part of Yellowstone National Park in southern Montana north to Jasper National Park in Alberta. This sector contains numerous species typical of the Cascade Mts. because it is relatively moist as a result of the strong oceanic influences of the eastwards moving Westerlies (Brouillet & Whestone 1993), and this provokes a maximum interchange between plants of the oceanic and continental climates (Daubenmire 1978; Peet 1988). Thus, the characteristic subalpine trees *A. lasiocarpa*, *A. bifolia*, and *P. engelmannii* penetrate westward into oceanic climates, even reaching, in the case of *A. lasiocarpa*, the highest summits of the Olympic Mts. in Washington (Peinado et al. 1997a, b).

The subalpine portion lacks *A. balsamea* and *P. mariana*. *P. glauca* is scarce and the dominant spruce is *P. engelmannii*. However, many of the spruces scored in our own relevés showed intermediate characteristics between *P. glauca* and *P. engelmannii*, reflecting hybridization where the species overlap. These spruces appear on tables as *P. glauca* × *engelmannii*, but they have also been labelled *P. albertiana* in the literature.

The far northern portion – the boreal mountain region of Arno & Hammerly (1990) – occurring beyond the migratory paths of the Pacific air masses, where the climate becomes typically boreal, has subalpine forests intermixed with the lowland boreal forest. The common montane and subalpine species *A. bifolia* and *P. engelmannii* regularly hybridize with their boreal counterparts (Achuff & La Roi 1977; Peet 1988; Barbour & Christensen 1993), and these hybrids can be used as characteristic species of different associations. This portion usually lacks *A. bifolia*, and the dominant fir is *A. balsamea*, but intermediate populations (*A. bifolia* × *balsamea*) are common in transitional areas. *P. glauca* becomes dominant on xeric and mesic soils, and *P. mariana*, which is usually absent in the subalpine portion, again dominates in wet sites.

The order includes two alliances: *Gymnocarpio dryopteridis-Abietion lasiocarpae* (subalpine and boreal forests on xeric and mesic soils), and *Piceion marianae*, which includes boreal stunted *P. mariana* forests on bogs and wet sites. The bioclimatic (bioclimatic belt and rainfall type), edaphic, geographic, and physiognomic diagnoses of the associations belonging to this order are shown in Table 18.

Gymnocarpio dryopteridis-Abietion lasiocarpae Wali & Krajina 1973 *em. hoc loco*

Syn.: *Pinion contortae* and *Piceion glaucae* Wali & Krajina 1973 (Art. 25); *Hypno (procerrimi)-Abietinello (abietinae)-Piceion glaucae* Hoefs et al. 1976; *Piceion glaucae* Looman 1987b.

Nomenclatural type: *Gymnocarpio dryopteridis-Abietetum lasiocarpae* Wali & Krajina 1973 *em. et corr., lectotypus*. The emendation concerns the fusion of the alliances *Pinion contortae*, *Piceion glaucae* and *Gymnocarpio-Abietion lasiocarpae*. Characteristic and differential taxa: *Abies lasiocarpa*, *Aster ciliolatus*, *Aster conspicuus*, *Calamagrostis rubescens*, *Dryopteris expansa*, *Elymus trachycaulum*, *Lathyrus ochroleucus*, *Lonicera dioica* var. *canescens*, *Picea engelmannii* (diff.), *Ribes americanum*, *R. oxyacanthoides*, *Shepherdia canadensis* (diff.), *Sorbus scopulina*, *Spiraea betulifolia* var. *lucida*, *Symphoricarpos occidentalis*, *Thalictrum venulosum*, *Vaccinium membranaceum* (diff.), and *Viola canadensis* var. *rugulosa*.

31. Gymnocarpio dryopteridis-Abietetum lasiocarpae Wali & Krajina 1973 *em. et corr. hoc loco*

Syn.: *Ptilio (cristae-castrensis)-Gymnocarpio (dryopteridis)-Abieto (lasiocarpae)-Piceetum glaucae* and *Gymnocarpio (dryopteridis)-Oplopanaco (horridi)-*

Table 18. Bioclimatic, geographical, physiognomical and edaphic features of the associations belonging to *Piceetalia glauco-marianae.*

Associations	Bioclimatic belt	Rainfall types	Soil	Geographical range	Physiognomy
Gymnocarpio dryopteridis-Abietion lasiocarpae					
Gymnocarpio dryopteridis-Abietetum lasiocarpae	Subalpine	Humid	Podsols	Northern Rockies S. (West)	Subalpine fir forest
Arctostaphylo uva-ursi-Pinetum latifoliae	Subalpine	Dry-Subhumid	Brunisols & Regosols	Northern Rockies S. (West)	Lodgepole pine forest
Vaccinio membranacei-Piceetum glaucae × *engelmannii*	Lower Subalpine	Subhumid	Podsols	Northern Rockies S. (West)	White spruce subalpine forest
Abieti bifoliae-Piceetum engelmannii	Subalpine	Subhumid	Podsols	Northern Rockies S. (Central)	Subalpine fir forest
Vaccinio vitis-idaeae-Abietetum balsameae × *bifoliae*	Subalpine	Subhumid	Podsols & Luvisols	Northern Rockies S. (North)	Subalpine fir forest
Trientalido latifoliae-Piceetum glaucae	Mesoboreal	Dry	Brunisols	Northern Rockies S. (North)	White spruce forest
Piceion marianae					
Corno canadensis-Piceetum marianae	Azonal	Azonal	Gleysols & Cryosols	Northern Rockies S.	*Picea mariana* muskeg

Abieto (lasiocarpae)-Piceetum glaucae Wali & Krajina 1973 *nom. illeg.* (Art. 10).

Nomenclatural type: Wali & Krajina 1973: Table 6, rel. 1, *lectotypus* (*Picea glauca* should be replaced by *P. glauca* × *engelmannii* on the relevés).The emendation concerns the fusion of the two mentioned synonyms.

32. Arctostaphylo uva-ursi-Pinetum latifoliae Wali & Krajina 1973 *corr. hoc loco*

Syn.: *Cladonio (gracilis)-Arctostaphylo (uvae-ursi)-Vaccinio (myrtilloidis)-Pinetum contortae* Wali & Krajina 1973 *nom. illeg.* (Art. 10); *Vaccinio-Pinetum contortae* Looman 1987 *nom. nudum* (Art. 5).

Nomenclatural type: Wali et Krajina 1973: Table 3, rel. 2, *lectotypus* (*Picea glauca* should be replaced by *P. glauca* × *engelmannii* on the relevés).

33. Vaccinio membranacei-Piceetum glaucae × *engelmannii* Wali & Krajina 1973 *corr. hoc loco*

Syn. : *Pleurozio (schreberi)-Ptilio (cristae-castrensis)-Vaccinio (membranacei)-Piceetum glaucae* Wali & Krajina 1973 *nom. illeg.* (Art. 10).

Nomenclatural types: subassociation *piceetosum glaucae* × *engelmannii*, Wali & Krajina 1973: Table 4, rel. 2, *lectotypus*; subassociation *lycopodietosum complanati* (= *Pleurozio (schreberi)-Ptilio (cristae-castrensis)-Vaccinio (membranacei)-Piceetum glaucae populo (tremuloidis)-pinetosum contortae* Wali & Krajina 1973: Table 4, rel. 19. *Picea glauca* should be replaced by *P. glauca* × *engelmannii* on the relevés of both subassociations.

34. Abieti bifoliae-Piceetum engelmannii ass. nova hoc loco

Syn.: *Piceetum albertianae* Looman 1987b *nom. nudum* (Art. 5 and 8).

Nomenclatural type: Table 19, rel. 480, *holotypus*.

Abieti bifoliae-Piceetum engelmannii is the subalpine climax forest of the central portion of the Northern Rockies sector. The landscape constituted by this association is an open parkland, with clumped pyramidal trees interspersed among meadows, heaths, and grasslands. Engelmann spruce and subalpine fir are the dominant trees. The undergrowth includes the spreading shrub *Shepherdia canadensis*, the prostrate shrubs *A. uva-ursi* and *Juniperus communis* var. *depressa*; dwarf *Vaccinium scoparium* is widespread and very abundant, with the herb layer usually including *Arnica cordifolia*, *Aster conspicuus*, *Leymus innovatus*, *Linnaea borealis* ssp. *longiflora*, and *Pyrola chlorantha*.

Table 19. Abieti bifoliae-Piceetum engelmannii ass. nova. Type relevé: rel. 480, Jasper National Park (523335 N, 1174130 W), Alberta, Canada. July 26, 1994.

Relevé No.	479	480	482	483	484	485	472	476	477	481
Altitude (decameters)	175	200	140	170	145	140	130	122	132	150
Area (m^2)	200	200	200	200	200	200	200	200	200	200
Exposure	S	SW	S	S	N	–	NW	–	SW	SW
Number of plants	11	18	20	13	25	18	18	16	16	13
Abieto bifoliae-Piceetum engelmannii:										
Differentiating floristic combination										
Picea engelmannii	2	2	5	2	3	3	2	3	+	1
Juniperus communis var. *depressa*	3	3	1	2	+	–	–	–	2	2
Abies bifolia	1	2	+	2	+	3	1	–	–	–
Picea glauca × *engelmannii*	2	2	–	–	2	–	–	–	–	–
Piceetalia glauco-marianae,										
Gymnocarpio dryopteridis-Abietion lasiocarpae										
Pinus contorta var. *latifolia*	2	+	–	2	3	3	2	3	3	4
Shepherdia canadensis	1	1	3	–	2	2	+	2	–	3
Leymus innovatus	1	2	1	1	1	1	–	2	1	–
Arctostaphylos uva-ursi	2	2	–	2	–	–	1	–	2	2
Aster conspicuus	–	–	1	–	1	–	1	1	1	1
Pyrola asarifolia ssp. *asarifolia*	–	–	1	–	–	1	–	1	1	–
Arnica cordifolia	–	–	1	–	1	2	–	1	–	–
Equisetum scirpoides	–	–	–	–	1	1	–	–	–	–
Lonicera involucrata	–	–	1	–	–	1	–	–	–	–
Pentaphylloides floribunda	–	1	–	–	+	–	–	–	–	–
Arctostaphylos rubra	–	–	–	1	–	–	–	–	–	–
Lathyrus ochroleucus	–	–	–	–	–	–	–	1	–	–
Listera cordata	–	–	1	–	–	–	–	–	–	–
Vaccinium membranaceum	–	–	–	–	–	–	–	–	+	–
Zygadenus elegans	–	–	–	1	–	–	–	–	–	–
Spiraea betulifolia var. *lucida*	–	–	–	–	–	–	–	–	1	–
Achillea millefolium var. *borealis*	1	–	–	–	–	–	–	–	–	–
Galium boreale	–	–	–	–	+	–	–	–	–	–
Vaccinio-Piceetea										
Pyrola chlorantha	1	1	–	–	1	1	–	–	–	–
Salix glauca	–	1	–	–	–	2	2	–	–	–
Ledum groenlandicum	–	–	–	2	2	2	–	–	–	–
Orthilia secunda	–	–	1	–	–	–	–	1	–	1
Betula nana	–	1	–	–	+	–	1	–	–	–
Petasites frigidus var. *palmatus*	–	–	–	–	+	1	1	–	–	–
Picea glauca	–	–	–	2	–	–	3	–	–	–
Vaccinium vitis-idaea	–	–	–	–	1	–	1	–	–	–
Viburnum edule	–	–	–	–	–	–	–	1	–	–
Lycopodium annotinum	–	–	–	–	+	–	–	–	–	–
Companions										
Linnaea borealis ssp. *longiflora*	1	–	1	1	1	2	1	1	–	1
Cornus canadensis	–	–	1	–	1	2	1	1	–	–
Vaccinium scoparium	–	2	–	2	2	2	–	–	–	–
Fragaria virginiana	–	1	1	–	1	–	–	1	–	–

Table 19 continued.

Relevé No.	479	480	482	483	484	485	472	476	477	481
Altitude (decameters)	175	200	140	170	145	140	130	122	132	150
Area (m^2)	200	200	200	200	200	200	200	200	200	200
Exposure	S	SW	S	S	N	–	NW	–	SW	SW
Number of plants	11	18	20	13	25	18	18	16	16	13
Menziesia ferruginea	–	–	–	–	2	2	–	1	–	–
Rosa woodsii	–	–	–	–	1	–	–	1	1	–
Ribes lacustre	–	–	1	–	–	–	–	–	+	+
Castilleja miniata	–	–	–	–	1	–	–	–	1	1
Epilobium angustifolium	–	+	1	–	–	–	1	–	–	–
Empetrum nigrum ssp. *nigrum*	–	–	–	1	–	–	1	–	–	–

Additional taxa: *Aconitum delphinifolium* (rel. 472: 1), *Alnus viridis* ssp. *sinuata* (rel. 477: +), *Antennaria racemosa* (rel. 481: 1), *Astragalus americanus* (rel. 482: 1), *Cassiope tetragona* (rel. 480: 1), *Corallorhiza mertensiana* (rel. 476: 1), *Festuca occidentalis* (rel. 477: 1), *Geocaulon lividum* (rel. 482: 1), *Goodyera oblongifolia* (rel. 477: +), *Hieracium albiflorum* (rel. 485: +), *Melampyrum lineare* (rel. 477: 1), *Mertensia paniculata* var. *paniculata* (rel. 472: 1), *Phyllodoce glanduliflora* (rel. 480: 2), *Platanthera obtusata* (rel. 482: 1), *Populus tremuloides* (rel. 482, +), *Rubus pubescens* (rel. 472: +), *Salix scouleriana* (rel. 481: 2), *Solidago multiradiata* (rel. 480: 1), *Solidago spathulata* (rel. 481: +).

Under drier conditions, such as rocky places, and steep or south facing slopes, lodgepole pine becomes dominant. The driest sites lack *A. bifolia*, and lodgepole pine and Engelmann spruce constitute edaphic facies (relevés 476, 477, 481).

One of the most characteristic plant communities of the subalpine belt from the Rocky Mountains (Peet 1988) westward to the leeward slopes of the Pacific Border System (Fonda & Bliss 1969; Daubenmire 1978; Pojar & Mackinnon 1994) are spruce and subalpine fir dominated forests that have received different names: Rocky Mountain *Abies lasiocarpa-Picea engelmannii* forest and Engelmann spruce-subalpine fir zone (Krajina 1965), *Abies lasiocarpa* zone (Franklin & Dyrness 1988), *Picea engelmannii-Abies lasiocarpa* forest (Vankat 1990), and Merriam's Hudsonian Life zone (Barret 1962). Though *A. lasiocarpa* has classically been considered the unique co-dominant subalpine fir in this widespread subalpine area, firs scored in our relevés from Jasper and Banff National Parks show the typical features of *A. bifolia* as summarized by Taylor (1993). Its presence and co-dominance allow us to define this new association.

35. Vaccinio vitis-idaeae-Abietetum balsameae × bifoliae ass. nova hoc loco

Nomenclatural type: Achuff & La Roi 1977, Table 5, rel. 7, *lectotypus*. Closely related community: *Rubus-Ptilium* community type Achuff & La Roi 1977.

Six of the nineteen *Abies* populations rated by Achuff & La Roi (1977) showed intermediate features between *A. balsamea* and *A. lasiocarpa*. These intermediate stands were situated at higher altitudes (above 1200) in Swan Hills and the Pelican Mts., Alberta. According to the present understanding of the genus *Abies*, *A. lasiocarpa* does not occur in Alberta and these intermediate spruces should be classified as *A. balsamea* × *bifolia* (Hunt 1993). This hybrid spruce is (together with *Rhododendron albiflorum*) characteristic of *Vaccinio vitis-idaeae-Abietetum balsameae* × *bifoliae*, the climax association in the subalpine belt of the northeastern Rocky Mts. and in other isolated subalpine zones of the Athabasca River basin in northern Alberta. Relevés 6, 7, 9, 10 and 29 on Table 5 published by Achuff & La Roi (*l.c.*), correspond to this association but *A. balsamea* should be replaced by *A. balsamea* × *bifolia* on the relevés.

36. Trientalido latifoliae-Piceetum glaucae ass. nova hoc loco

Nomenclatural type: Achuff & La Roi 1977, Table 5, rel. 12, *lectotypus*. Closely related communities: *Lonicera-Symphoricarpos-Vacinium vitis-idaea-Geocaulon* and *Lonicera-Rubus pubescens-Lathyrus* stand-groups La Roi 1967; *Cornus-Linnaea*, *Calamagrostis*, and *Viburnum-Hylocomnium communities* Achuff & La Roi 1977; *Vaccinio-Piceetum glaucae* and *Betulo papyriferae-Piceetum glaucae* Looman 1987b *nom. nudum* (Art. 5).

All the *Abies* populations rated by Achuff and La Roi (1977) in the foothills and plains (below 1200 m) of northern Alberta closely correspond to *A. balsamea*, which is characteristic (together with *Lathyrus ochroleucus*) of this mesoboreal association, the climax on the lowlands of Alberta, Manitoba and Saskatchewan.

Piceion marianae Wali & Krajina 1973
Syn.: *Piceo marianae-Laricion laricinae* Looman 1987 *nom. nudum* (Art. 5).

Nomenclatural type: *Corno canadensis-Piceetum marianae* Wali & Krajina 1973 *em. et corr., lectotypus*. Characteristic and differential taxa: *C. canescens* ssp. *canescens* (diff.), *C. capitata*, *C. chordorhiza*, *C. lasiocarpa* var. *americana*, *Comarum palustre* (diff.), *Eriophorum angustifolium*, *Glyceria borealis*, *Muhlenbergia glomerata*, *Salix monticola*, *S. pedicellaris*, and *Viburnum rafinesquianum*. Differential taxa with regard to *Ledo decumbentis-Piceion marianae*: *Arceuthobium pusillum*, *Calamagrostis canadensis*, *Cornus sericea* ssp. *sericea*, *Kalmia polifolia*, *Oryzopsis asperifolia*, *Pinus banksiana*, *Rubus idaeus* ssp. *strigosus*. Differential taxa with regard to *Viburno cassinoidis-Piceion marianae*: *Agrostis exarata*, *Betula* × *eastwoodiae*, *Carex capillaris*, *C. concinna*, *C. scirpoidea*, *Eriophorum brachyantherum*, *Hedysarum alpinum* var. *americanum*, *Lupinus arcticus*, *Petasites frigidus* var. *nivalis*, *Rhododendron lapponicum*, *Salix planifolia*, *Senecio lungens*, *Spiraea stevenii*, *Tofieldia pusilla* and *Zygadenus elegans*.

At the present time, the only association of this alliance that can be typified is *Corno canadensis-Piceetum marianae*. The other association belonging to this alliance, *Piceo marianae-Laricetum laricinae* Looman 1987 (mesoboreal association of the Prairie Provinces; differential taxa *Symphoricarpos albus*) is *nomen nudum* (Art. 5), and can not be validated because the only known table is synoptic (Art. 7).

37. Corno canadensis-Piceetum marianae Wali & Krajina 1973 *em. et corr. hoc loco*
Syn. : *Sphagno (nemorei)-Pleurozio (schreberi)-Ptilio (cristae-castrensis)- Hylocomio (splendentis)-Corno (canadensis)-Piceetum marianae* and *Sphagno (plumulosi)-Tomentypno (nitentis)-Betulo (pumilae)-Piceetum marianae* Wali & Krajina 1973 *nom. illeg.* (Art. 10); *Betulo glanduliferae-Piceetum marianae* Looman 1987 *nom. nudum* (Art. 5). Nomenclatural type: Wali & Krajina 1973: Table 7, rel. 35, *lectotypus*. The emendation concerns the fusion of the two first mentioned syntaxa.

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Appendix 1

Appendix 1. Source of relevés for American boreal forest data. NR=Number of relevés

Association	NR	Source
Abietetum balsameae	32	Damman 1964, Table 2
	10	La Roi 1967, Tables 5, 7, 9, 11 (col. 25–34)
	30	Gadreau 1979, Table 21 (rel. 1–13) and Table 34
	4	Gadreau 1979, Table 21 (rel. 14–17)
	11	Gadreau 1979, Table 49
Abieti bifoliae–Piceetum engelmannii	9	Field work
Alnetum rugosae	6	Damman 1964, Table 4 (col. 5–10)
	5	Gadreau 1979, Table 83 (rel. 1–5)
Alno crispae–Piceetum glaucae	2	Sirois 1984, Table 33
Alno rugosae–Piceetum marianae	4	Damman 1964, Table 4 (col 1–4)
	3	Gadreau 1979, Table 80
	10	Hoefs et al 1976, Table 15
Arctostaphylo uva-ursi–Pinetum latifoliae	10	Wali & Krajina 1973, Table 3
	183	Looman 1987, Table 2
Betulo kenaicae–Piceetum glaucae	10	Field work
Betulo nanae–Piceetum glaucae	28	Field work
Boschniakio rossicae–Alnetum crispae	12	Lausi & Nimis 1991, Table 9 (rel. 7–18)
Carici pensylvannicae–Pinetum divaricatae	3	Lavoie 1968, page 404, col. 23–25
Comptonio–Pinetum divaricatae	10	Lavoie 1968, page 404, col. 1–10
Corno canadensis–Piceetum marianae	3	Wali & Krajina 1973, Table 7, (rel. 2–4)
Gaylussacio–Pinetum divaricatae	2	Lavoie 1968, page 404, col. 26–27
Gymnocarpio dryopteridis–Abietetum lasiocarpae	15	Wali & Krajina 1973, Table 5
	8	Wali & Krajina 1973, Table 6
Hypno peocerrimi–Piceetum glaucae	19	Field work
Kalmio angustifoliae–Piceetum marianae	5	Nakamura & al. 1994, Table 3 (col. 2)
	26	Damman 1964, Table 1
	16	Damman 1964, Table 3
	5	La Roi 1967, Tables 6, 8, 10, 12 (col. 23–26)
	14	Gadreau 1979, Table 1
Kalmio polifoliae–Abietetum balsameae	4	Sirois 1984, Table 30
Kalmio polifoliae–Alnetum rugosae	3	Gadreau 1979, Table 80
Kalmio polifoliae–Piceetum marianae	8	Nakamura & al. 1994, Table 3 (col. 1)
	4	Sirois 1984, Table 31
Larici laricinae–Piceetum marianae	10	Field work
Ledo groenlandici–Pinetum divaricatae	9	Lavoie 1968, p. 404, col. 11–19
	5	La Roi 1967, Tables 6, 8, 10, 12 (col. 18–22)
	4	Gadreau 1979, Table 16
Loiseleurio procumbentis–Betuletum neoalaskanae	4	Field work
Piceetum glauco–marianae	15	Field work
Piceo glaucae–Betuletum neoalaskanae	6	Field work
Piceo rubentis–Abietetum balsameae	90	Lalumière & Thibault 1988, Table 18, (col. 18–20, 22, 23, 25, 26, 28)

Appendix 1. Continued

Association	NR	Source
Pulsatillo patentis–Pinetum latifoliae	3	Field work
	19	Lausi & Nimis 1991, Table 7 (rel. 22–40)
Rhododendro lapponici–Piceetum glaucae	5	Field work
	14	Lausi & Nimis 1991, Table 5 (rel. 1–14)
Roso sayi–Populetum tremuloidis	6	Field work
	27	Lausi & Nimis 1991, Table 9 (rel. 32–58)
Rubo chamaemori–Piceetum marianae	26	Field work
Salici arbusculoidis–Alnetum tenuifoliae	6	Lausi & Nimis 1991, Table 9 (rel. 1–6)
Sphagno–Piceetum marianae	8	Grandtner 1960, Table 2
	8	Jurdant & Roberge 1965, Table 28
	28	Gadreau 1979, Tables 60, 90 and 95
Thujo occidentalis–Abietetum balsameae	5	Lalumière & Thibault 1988, Table 18, col. 30
	13	Lalumière & Thibault 1988, Table 18, col. 31
Trientalido latifoliae–Piceetum glaucae	159	Looman 1987, Table 4
	37	Looman 1987, Table 3 (col. 3)
	24	Achuff & La Roi, 1977, Table 5 (except for rel. 6, 7, 9, 10, 26, 29)
	4	La Roi 1967, Tables 5, 7, 9, 11 (col. 10–17)
Urtico gracilis–Alnetum tenuifoliae	4	Wali & Krajina 1973, Table 8
Vaccinio angustifoliae–Thujetum occidentalis	2	Gadreau 1979, Table 75
Vaccinio membranacei–Piceetum glaucae × *albertianae*	19	Wali & Krajina 1973, Table 4
Vaccinio vitis-idaeae–Abietetum balsameae × *bifoliae*	6	Achuff & La Roi, 1977 Table 5 (rel. 6, 7, 9, 10, 26, 29)

Appendix 2

Appendix 2. Bibliographical source, number of tables and number of relevés for European and Asian boreal forests

Source	No. tables	No. relevés
Europe		
Falinski & Pedrotti 1990	1	6
Jahn 1985	11	1639
Kielland-Lund 1981	49	458
Mäkirinta 1990	7	70
Matuszkiewicz et al. 1995	9	72
Mehus 1986	18	270
Olson 1974	3	34
Øvstedal 1985	5	59
Passarge & Passarge 1972	5	21
Prieditis 1993	3	129
Asia		
Song 1991	8	74
Song 1992	6	151