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VEGETATION CLASSIFICATION

Diversity of South Manchurian mixed forests: alliance Carpino cordatae-Abietion holophyllae, class Quercetea mongolicae

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ABSTRACT

We classified temperate South Manchurian mixed forests (SMMFs) from the class Quercetea mongolicae, the order Tilio amurensis–Pinetalia koraiensis, and the alliance Carpino cordatae–Abietion holophyllae, using the Braun-Blanquet approach, and calculated diversity metrics for communities of different associations. The Querco mongolicae–Abietetum holophyllae represents mesic mixed forests dominated by *Abies holophylla*, *Pinus koraiensis*, with a complex of deciduous tree species. The new association Mitello nudae–Abietetum holophyllae encompasses SMMFs in the northern limit of their distribution with an admixture of boreal species. The new suballiance Filipendulo palmatae–Juglandenion mandshuricae unites two associations: Onocleo struthiopteridis–Juglandetum mandshuricae and Fraxino mandshurici–Abietetum holophyllae of SMMFs from eutrophic moist ecotopes. The association Rhododendro mucronulati–Betuletum schmidtii encompasses SMMFs of rocky ridges dominated by *Betula schmidtii* and *Quercus mongolica*. Two forest communities with no syntaxonomical rank: *Carex drymophila–Abies holophylla* and *Magnolia sieboldii–Abies holophylla* represent southern SMMFs on the Korean Peninsula.

Keywords: *Abies holophylla*, Braun-Blanquet, Carpino cordatae–Abietion holophyllae, cool-temperate climate, floristic diversity, North-East Asia, Quercetea mongolicae, Russian Far East, syntaxa

РЕЗЮМЕ

Дзизюрова В.Д., Лисицына А.Д., Корзников К.А., Дудов С.В., Петренко Т.Я., Крестов П.В. Разнообразие южно-маньчжурских смешанных лесов союза Carpino cordatae–Abietion holophyllae класса Quercetea mongolicae. Мы классифицировали южно-маньчжурские смешанные леса (ЮМСЛ) умеренного пояса, относящиеся к классу Quercetea mongolicae, порядку Tilio amurensis–Pinetalia koraiensis и союзу Carpino cordatae–Abietion holophyllae, в рамках подхода Браун-Бланке, и рассчитали метрики разнообразия для сообществ разных ассоциаций. Querco mongolicae–Abietetum holophyllae представляет собой мезофитные смешанные леса, образованные *Abies holophylla*, *Pinus koraiensis* и комплексом лиственных видов деревьев. Новая ассоциация Mitello nudae–Abietetum holophyllae охватывает ЮМСЛ на северной границе их распространения с участием бореальных видов. Новый подсоюз Filipendulo palmatae–Juglandenion mandshuricae объединяет две ассоциации: Onocleo struthiopteridis–Juglandetum mandshuricae и Fraxino mandshurici–Abietetum holophyllae, сообщества которых характерны для эутрофных влажных экотопов. Ассоциация Rhododendro mucronulati–Betuletum schmidtii объединяет ЮМСЛ на скалистых хребтах с доминированием *Betula schmidtii* и *Quercus mongolica*. Два лесных сообщества без синтаксономического ранга: *Carex drymophila–Abies holophylla* и *Magnolia sieboldii–Abies holophylla* представляют южные ЮМСЛ Корейского полуострова.

Ключевые слова: *Abies holophylla*, Браун-Бланке, Carpino cordatae–Abietion holophyllae, северная умеренная зона, флористическое разнообразие, Северо-Восточная Азия, Quercetea mongolicae, Российский Дальний Восток, синтаксоны

South Manchurian mixed forests (SMMFs) represent the forest ecosystems of the southern Russian Far East (south of 44°N), as well as parts of Heilongjiang and Jilin Provinces of Northeast China and the Korean Peninsula (Kim 1992, Kolbek et al. 2003, Krestov et al. 2006, Černý et al. 2015, Su et al. 2020). SMMFs are dominated by *Abies holophylla*, *Carpinus cordata*, *Pinus koraiensis*, *Quercus mongolica*, and *Tilia amurensis*, constitute the primary forest type in the region.

Scientific investigations of SMMFs in Russia and adjacent regions of China date back to the 1860s, initially spurred by logging activities (Budishchev 1867). Early forest classification efforts, pioneered by Ivashkevich (1915), laid the groundwork for regional forest typologies based on habitat type, dominant species, and ecosystem productivity (Ivashkevich 1916, 1927, 1933). Concurrently, a phytocenological approach emerged, classifying forests according to structure and composition (Vasilyev 1935, 1939, Kabanov 1937). While early classifications provided valuable insights, they lacked a unified hierarchical framework.

Subsequently, the "dynamic-geographical" approach gained prominence in the Soviet Far East, emphasizing forest succession and natural development processes (Kolesnikov 1956, 1958). Under this framework, SMMFs were categorized into montane and valley complexes, further subdivided into nine types along a moisture gradient (Vasilyev & Kolesnikov 1962). Despite its contributions, the approach had limitations, including reliance on expert judgement and indistinct forest type boundaries. Kolesnikov (1956) divided the mixed forests with Korean pine of the Russian Far East into three climatically distinct types: southern, with *Abies holophylla*, *Carpinus cordata* and other elements of the southern Manchurian flora; typical (middle), with species of the Manchurian flora; and northern, also with species of the Manchurian flora enriched with boreal species. Contemporary classifications continue to regard SMMFs as the southernmost variant of the zonal Korean pine–broadleaved forests (Krestov 2003, Ogureeva et al. 2012), reflecting their transitional ecological position within the region.

Since the 1990s, the Braun-Blanquet approach (Braun-Blanquet 1964) has been widely adopted for vegetation classification in China and Korea (Kim 1990, 1992, Song 1992, Takeda et al. 1994, Song et al. 1995, 1999). Kim (1992) classified the SMMFs as a distinct alliance within the class Quercetea mongolicae Song ex Krestov, Dzizyurova et Korznikov 2023, though he had acknowledged the limitations of his dataset. Subsequent studies (Gumarova et al. 1994, Krestov et al. 2006, 2023) refined the syntaxonomical system. The complex classification of Northeast Asia's temperate deciduous forests (Krestov et al. 2006) placed SMMFs within the alliance Carpino cordatae–Abietion holophyllae Kim ex Krestov, Dzizyurova et Korznikov 2023, the order Tilio amurensis–Pinetalia koraiensis Kim ex Krestov, Dzizyurova et Korznikov 2023. The alliance Carpino cordatae–Abietion holophyllae is characterized by a mix of temperate species thriving in humid conditions, with its northern distribution limit near 44°N (Krestov et al. 2006).

Despite extensive research, the syntaxonomy of SMMFs remains a subject of debate. One key controversy concerns the presence of Carpino cordatae–Abietion holophyllae communities in China and Korea. Some studies suggest that SMMFs in northeast China and North Korea share similarities with those in Russia (Vasilyev & Kolesnikov 1962, Kim 1990, 1992, Gumarova et al. 1994, Qian et al. 2003, Kolbek et al. 2003, Krestov & Verkholat 2003, Krestov et al. 2006), but direct evidence remains scarce. Detailed vegetation analyses in Northeast China have not confirmed the presence of Carpino–Abietion communities (Fujiwara & Harada 2015), though Su et al. (2020) documented Korean pine–broadleaved forests containing *Abies holophylla* in Heilongjiang and Jilin.

A second unresolved question is whether SMMFs should be classified within a single alliance or if their diversity necessitates broader differentiation. In Korea, Kolbek et al. (2003) and Černý et al. (2015) identified mountain forests dominated by *Abies holophylla*, *Pinus koraiensis*, and broadleaved species such as *Acer mono*, *Carpinus cordata*, and *Magnolia sieboldii*. These forests were assigned to the alliance Rhododendro schlippenbachii–Quercion mongolicae Song ex Takeda, Nakanishi et Choe 1994, within the order Aceri pseudosieboldiani–Quercetalia mongolicae Song ex Takeda, Nakanishi et Choe 1994. Another potential variant of SMMFs comprises *Abies holophylla* forests with *Sasamorpha borealis* in the understory, classified to the alliance Lindero obtusilobae–Quercion mongolicae Kim 1990, subordinated to the order Aceri pseudosieboldiani–Quercetalia mongolicae (Černý et al. 2015).

A third consideration is the increasing availability of data on species distribution and community composition, which has led to the appearance of new syntaxa. For instance, Petrunenko & Dzizurova (2024) recently published a vegetation classification for the Kedrovaya Pad' Nature Reserve, part of the Land of the Leopard National Park in southwestern Primorye, Russia. Their study identified two new associations and two subassociations within SMMFs, further contributing to our understanding of forest diversity in the region.

Renowned for their structural complexity and high diversity, SMMFs provide critical habitats for numerous rare and ecologically valuable species (Vasilyev & Kolesnikov 1962) including the critically endangered Amur leopard (*Panthera pardus orientalis* Schlegel 1857) and the southernmost populations of the Amur tiger (*Panthera tigris altaica* Temminck 1844). Beyond their ecological significance, SMMFs serve as the last remaining strongholds for these apex predators, whose survival depends on the preservation of intact forest ecosystems. SMMFs are recognized as ecosystems of significant conservation importance (Krestov & Verkholat 2003). However, extensive deforestation over the past century has led to a substantial decline in their extent (Krestov & Verkholat 2003, Wang et al. 2021). Currently, SMMFs face mounting threats from climate change, wildfires, and habitat fragmentation (Krestov & Verkholat 2003, Krestov et al. 2006, Dziziurova et al. 2022). A well-defined classification system is crucial for effective conservation planning and sustainable management.

This study aims to develop a broad-scale classification of SMMFs based on an extensive dataset of vegetation plots using the Braun-Blanquet approach. Specifically, we seek to: 1) revise and synthesize existing classifications of SMMFs; 2) determine the ecological characteristics of SMMFs; 3) assess diversity of SMMFs across different levels of organization (α-, β-, and γ-diversity), with a particular focus on their conservation value.

MATERIAL AND METHODS

Study area

The study area encompasses the warmest parts of the Manchurian ecoregion, situated between latitudes 35° and 44°N (Krestov et al. 2010, Ogureeva et al. 2012) (Fig. 1). The region falls within the cool-temperate zone of the Global Bioclimatic Zoning system (Box 2016) and experiences a monsoonal variant of the humid continental climate, as classified by Köppen climate classification (Peel et al. 2007). The Warmth Kira Index (WKI), a metric strongly correlated with vegetation distribution in maritime Asia (Kira 1949), is defined as the sum of monthly mean temperatures exceeding +5°C ranging from 52.6 to 62.3°C across the study area. Precipitation is concentrated in the summer months (July–September), while winters are cold and characterized by shellow snow deposits, dominated by continental air masses (Peel et al. 2007).

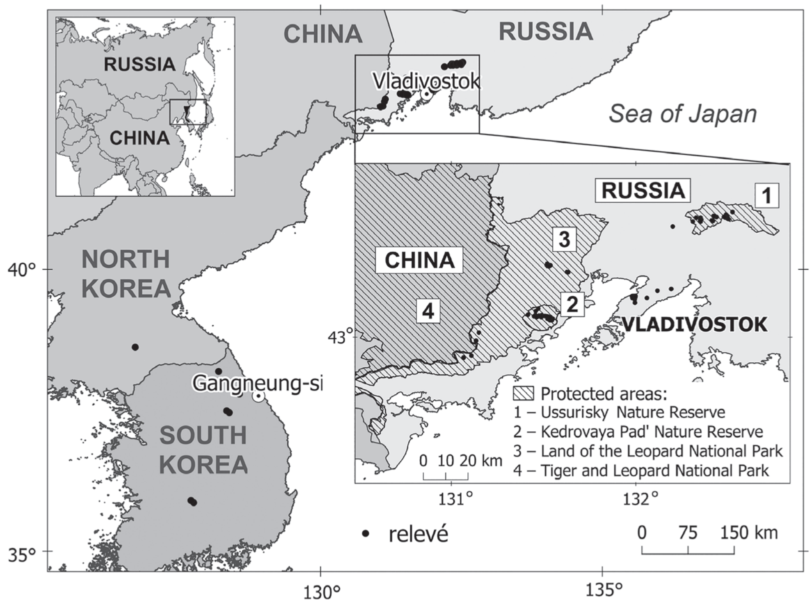

Figure 1 Study area. The dots on the maps represent the locations of the relevés

According to the Vladivostok weather station (43.12°N 131.92°E, 189 m a.s.l., WMO code 31960), the average daily maximum temperature and average precipitation during the warmest month (August) are +23.0°C and 153.0 mm, respectively, while during the coldest month (January), they are -16.3°C and 15.0 mm in the northern part of the study area. According to the Gangneung-si weather station (37.75°N 128.89°E, 27 m a.s.l., WMO code 47105), the average daily maximum temperature and average precipitation during the warmest month (August) are +28.6°C and 292.9 mm, respectively, while during the coldest month (January), they are -2.7°C and 47.9 mm in the southern part.

The dominant soil type in SMMF areas is brown forest soil (Semal 2007, Boyarkin & Kostenkov 2009, Kwon et al. 2021), classified as shallow and weakly developed mineral soils according to the World Reference Base for Soil Resources (Mantel et al. 2023).

In the northern part of their range, SMMFs are primarily found in lower montane belts, reaching elevations of up to 400 m a.s.l. (Vasilyev & Kolesnikov 1962). In contrast, in the southern part of the range, they occur at higher elevations, typically in upper montane zones and deep valleys, often exceeding 1000 m a.s.l. (Kim 1992, Kolbek et al. 2003, Černý et al. 2015).

SMMFs have undergone extensive anthropogenic disturbances, particularly over the past century (Krestov & Verkholat 2003, Yu et al. 2010, Wang et al. 2021). As a result, much of the original forest were replaced by secondary oak-dominated forests of the alliance Dictamno dasycarpi–Quercion mongolicae Kim ex Krestov, Dzizyurova et Korznikov 2023, within the order Lespedezo bicoloris–Quercetalia mongolicae Krestov, Song, Nakamura et Verkholat ex Krestov, Dzizyurova et Korznikov 2023, and the class Quercetea mongolicae (Dobrynin 2000, Krestov et al. 2006). The secondary oak forests are characterized by fire- and drought-tolerant mesic and xeromesic East Asian forest species, adapted to withstand prolonged dry periods (Krestov et al. 2006).

Vegetation data

For the analysis, we used 75 original vegetation relevés collected between 2020 and 2022 in Primorye Territory, Russia. The relevés were collected from Land of the Leopard National Park, Ussurisky Nature Reserve and various non-protected forest areas (Fig. 1). The plot size of each relevé was 20 × 20 m, and the abundance of species was estimated visually in percentages.

In addition to new original relevés, we incorporated 264 previously published and archival relevés of SMMFs and their successional derivatives (Gumarova et al. 1994, Kim 1992, Petrunenko & Dzizurova 2024). Archival data were sourced from: Botanical Garden-Institute FEB RAS (1972–2006, unpublished) (G.E. Kurentsova, P.V. Krestov, V.P. Verkholat), Institute of Botany CAS (2006–2018, unpublished) (V. Bažant, T. Černý, J. Doležal). Archive relevés encompass a broad geographical distribution, including: Russia (Kedrovaya Pad' and Ussuri Nature Reserves, Vladivostok vicinity, Gorno-Taezhnoe, Kravtsovka, and Mt. Livadiyskaya), North Korea (Mt. Hyangjeokbong), South Korea (Odaesan and Deogyusan National Parks, as well as various non-protected forested areas). The nomenclature of vascular plants follows the Plants of the World Online database (POWO 2025), except for the use of *Acer mono* Maxim. instead of *A. pictum* Thunb.

The relevés were compiled into a database using the Turboveg program (Hennekens & Schaminee 2001). For classification analysis, we selected 227 relevés of SMMFs based on the presence of diagnostic species from the orders Tilio amurensis–Pinetalia koraiensis and Aceri pseudosieboldiani–Quercetalia mongolicae, along with their subordinate syntaxa.

We compared the species richness of zonal SMMFs with their derivative communities, which have widely replaced the primary SMMFs and are classified within the order Lespedezo bicoloris–Quercetalia mongolicae and the alliance Dictamno dasycarpi–Quercion mongolicae. For this comparison, we selected 77 relevés from the alliance Dictamno dasycarpi–Quercion mongolicae, representing secondary broadleaved forests dominated by *Quercus mongolica*. These relevés excluded late-successional stages where species from diagnostic combinations of SMMFs had begun to reappear. A total of 35 transitional relevés containing diagnostic species from the primary Tilio amurensis–Pinetalia koraiensis and secondary Lespedezo bicoloris–Quercetalia mongolicae were excluded.

To characterize habitat conditions, we calculated morphometric topographic indices using 30-meter resolution elevation data from the Shuttle Radar Topography Mission (SRTM) (Watkins 2018):

TPI – Topographic Position Index (Weiss 2001);
TWI – Topographic Wetness Index (Beven & Kirkby 1979);

MRVBF – Multiresolution Index of Valley Bottom Flatness (Gallant & Dowling 2003);
MRRTF – Multiresolution Index of Ridge Top Flatness (Gallant & Dowling 2003).

The calculations were performed in the SAGA GIS software (version 9.3.2; Conrad et al. 2015).

Additionally, we incorporated climatic indices derived from the WorldClim v. 2.0 global climate model (Fick & Hijmans 2017):

WKI – Warmth Kira's Index (Kira 1949);
IC – Continentality Index (temperature difference between the warmest and coldest months);
Pn – Precipitation Negative Index (total precipitation in months with an average temperature below 0°C, indicating snowfall);
Pp – Precipitation Positive Index (total precipitation in months with an average temperature above 0°C, indicating rainfall).

Classification and ordination

We classified the relevés using the JUICE 7.0.84 program (Tichý 2002), combining species cover values from different vegetation layers into a single dataset. To group relevés with similar floristic compositions, we applied the modified TWINSPAN algorithm (Roleček 2009) with the following parameters: pseudospecies cut level – 10, threshold values – 0, 0.1, 0.3, 0.5, 1, 5, 15, 25, 50, 75, minimum group size – 2, specified number of clusters – 6, and the Simpson similarity measure. We then refined the classification using a second TWINSPAN analysis (Hill 1979) on the individual clusters obtained in the initial step. The results were compared with existing classification schemes and manually adjusted as necessary.

For each cluster, we calculated species fidelity values using the phi coefficient (Chytrý et al. 2002), with adjustments based on Fisher's exact test ($p > 0.05$). Species presence/absence data were used, and all clusters were scaled to equal size. Diagnostic species were identified based on fidelity values (phi ≥ 0.30) and constancy class (≥ II). We used a unified diagnostic species list without differentiating between characteristic and differentiating species.

The final classification consisted of eight clusters of relevés, as further subdivision did not yield clear syntaxonomic or ecological distinctions. We refined the ecological specificity of species based on the Regional Ecological Scales for Primorye Territory (Timoschenkova & Komarova 2001), the summary Vascular Plants of the Soviet Far East (Kharkevich 1985–1996), and the online resource Flora of China (Brach & Song 2006).

We present the classification results in a synoptic table using a standardized 5-point frequency scale with equal intervals. New syntaxa are described following the International Code of Phytosociological Nomenclature (ICPN) (Theurillat et al. 2021). Vegetation relevés for newly described syntaxa are presented using the Braun-Blanquet (1964) species cover scale, with an additional category "r" for single individuals (Dengler & Dembicz 2023): r = single individuals, 0.1 %; + = 0.2–1.0 %; 1 = 2–10 %; 2 = 11–25 %; 3 = 26–50 %; 4 = 51–75 %; 5 = 76–100 %.

To explore ecological differentiation among syntaxa, we performed non-metric multidimensional scaling (NMDS) of relevés using the metaMDS() function from the vegan 2.5-6 package (Oksanen et al. 2022) in the R software environment (R Core Team 2024). We applied 999 iterations, used Bray-Curtis dissimilarity as the distance measure, transformed the species cover matrix using Wisconsin double standardization, and selected half-change units for the 2-axis ordination space.

We assessed correlations between morphometric relief indices and climatic variables with the distribution of relevés using the envfit() function from the vegan package, visualizing results as vector projections onto the NMDS ordination.

Additionally, we performed NMDS to phytosociologically compare associations of the alliance Carpino cordatae–Abietion holophyllae (described in this study) with previously published Quercetea mongolicae associations. The input matrix was based on species constancy class values from our own synoptic table and from the dataset published by Krestov et al. (2006).

Diversity analysis

For all syntaxa with at least 10 standard 400 m² plots, we calculated α-, β-, and γ-diversity indices of vascular plant species following Whittaker (1972). For the forest types in Korea, we only calculated the community-specific species pools (γ-diversity) because the relevés in Korea were conducted on plots ranging from 100 to 1000 m². Direct comparisons of richness across these datasets were not appropriate due to significant differences in plot sizes.

We calculated α-diversity as the number of species recorded at each sampling point. To reflect the number of dominant species within each syntaxon, we also calculated Shannon's diversity index (H'), using the formula:

$$\mathrm{H}' = -\sum_i p_i \times \log10\, b\, p_i$$

where pi is the proportional abundance of species i, and b is the logarithm base. The index was calculated using the diversity() function from the R vegan package.

For β-diversity, we calculated the distance matrix using Jaccard and Sørensen indices from the Podani family (Podani & Schmera 2011), as well as their quantitative equivalents (Ruzicka's index and Bray-Curtis distance) (Legendre & De Cáceres 2013). The β-diversity was further decomposed into its replacement and richness difference components (Legendre 2014), using the beta.div.comp() function in R vegan package.

To estimate γ-diversity, we assessed both observed and predicted community-specific species pools. The predicted species pool helps estimate the total species diversity, including dark diversity – species that could potentially inhabit a particular habitat under suitable conditions but are currently absent (Lewis et al. 2017). The predicted species pool (Sp) was calculated using the following formula:

$$S_p = S_0 + \frac{a_1^2}{2a_2} \times \frac{N-1}{N}$$

where S_0 is the observed number of species, a_1 and a_2 represent the number of species occurring in only one or two plots, respectively, and N is the number of relevés in the group (Chao 1987). This was computed using the specpool() function from the R vegan package.

We compared α- and γ-diversity of SMMFs with the diversity of their successional derivatives – mixed broadleaved and monodominant oak forests.

To visually compare species richness and environmental conditions among syntaxa, we utilized box-and-whisker plots, histograms, and radar charts created with the ggplot2 package in R.

RESULTS

Communities identified

We identified 8 distinct clusters of relevés, classified into four associations and four subassociations within the alliance Carpino cordatae–Abietion holophyllae, the order Tilio amurensis–Pinetalia koraiensis, and the class Quercetea mongolicae (Table 1). However, two clusters could not be assigned to specific syntaxa due to the limited amount of data available. These clusters were described in general terms, based on the diagnostic taxa identified for each.

Magnolia sieboldii–Abies holophylla forest community

Diagnostic taxa: *Abies holophylla*, *Acer komarovii*, *Acer ukurunduense*, *Ainsliaea acerifolia*, *Arachniodes miqueliana*, *Aristolochia manshuriensis*, *Disporum smilacinum*, *Euonymus oxyphyllus*, *Hepatica nobilis* var. *japonica*, *Magnolia sieboldii*, *Meehania urticifolia*, *Neillia incisa*, *Rhododendron schlippenbachii*, *Sasamorpha borealis*, *Symplocos sawafutagi*, *Toxicodendron trichocarpum*, *Tripterygium regelii*, *Viburnum wrightii*, *Viola diamantiaca*.

Description: This forest community type represents the southern variant of SMMFs, characterized by *Magnolia sieboldii* in the tree layer and *Sasamorpha borealis* in the understory. The observed community-specific species pool contains 150 species, while the predicted species pool is 200 ± 19 species. These communities are typically found in the upper mountain belts, at elevations ranging from 650 to 1140 m a.s.l., and are situated on steep (30–35°) western (and occasionally northeastern) slopes (Fig. 2).

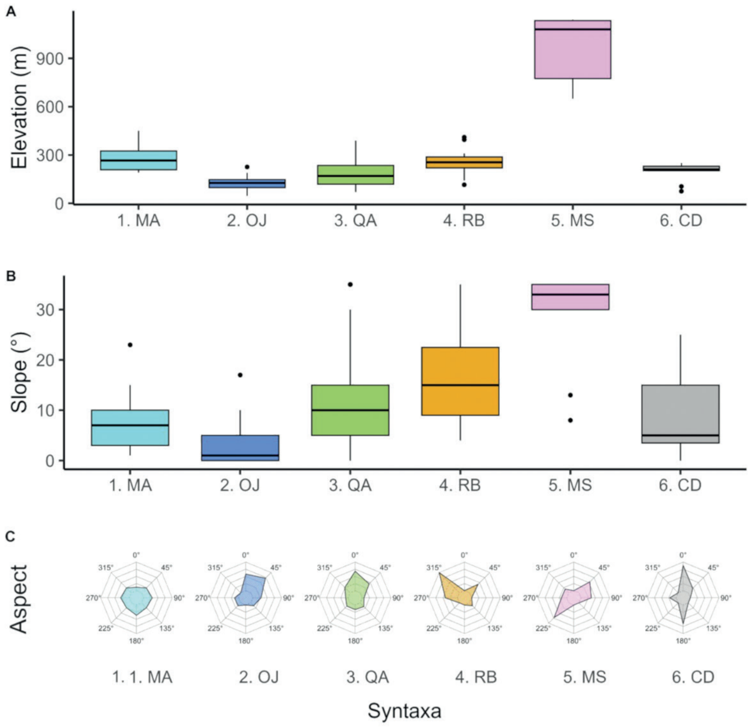

Figure 2 Position of communities in the landscape. Syntaxa: MA – Mitello nudae–Abietetum holophyllae; OJ – Onocleo struthiopteridis–Juglandetum mandshuricae; QA – Querco mongolicae–Abietetum holophyllae; RB – Rhododendro mucronulati–Betuletum schmidtii; MS – *Magnolia sieboldii–Abies holophylla*; CD – *Carex drymophila–Abies holophylla*

Carex drymophila–Abies holophylla forest community

Diagnostic taxa: *Abies holophylla*, *Artemisia sylvatica*, *Carex drymophila*, *Carex pediformis*, *Eleutherococcus sessiliflorus*, *Galium spurium*, *Iris uniflora*, *Malus sieboldii*, *Muhlenbergia japonica*, *Philadelphus schrenkii*, *Polemonium villosum*, *Pyrola japonica*, *Syringa oblata* subsp. *dilatata*, *Thalictrum tuberiferum*, *Trigonotis radicans* var. *sericea*, *Viburnum opulus* subsp. *calvescens*, *Vicia ramuliflora*, *Viola collina*.

Description: This forest community type is primarily distributed across the Korean Peninsula. The cluster includes 9 archival relevés from South Korea (Baengnyeonsa, Deogyusan) and 2 from North Korea (Hyangjeokbong). The observed community-specific species pool contains 159 species, while the predicted species pool is 211 ± 20 species. The relevés were recorded at low elevations, ranging from 75 to 250 m a.s.l., on slopes with varying steepness (5–25°) and exposition (Fig. 2). The community is characterized by species with diverse ecological preferences, and may exhibit artificial boundaries due to limited data.

Filipendulo palmatae–Juglandenion mandshuricae suball. nov. (Table A1 in Appendix 1, relevés 1–20)

Holotypus (nomenclatural type) – Onocleo struthiopteridis–Juglandetum mandshuricae Petrunenko et Dzizurova 2024 nom. mut. (see below).

Diagnostic taxa: *Aconitum alboviolaceum*, *Anemonoides glabrata*, *Athyrium crenulatoserrulatum*, *Brachybotris paridiformis*, *Carex accrescens*, *C. uda*, *Clematis fusca*, *Dioscorea nipponica*, *Filipendula palmata*, *Impatiens furcillata*, *Juglans mandshurica*, *Onoclea struthiopteris*, *Oxalis obtriangulata*, *Phellodendron amurense*, *Phlomoides maximowiczii*, *Sanicula rubriflora*, *Stellaria bungeana*, *Veratrum dahuricum*.

Species composition and structure: The forest stand is polydominant, composed of two to three tree layers. The first tree layer (20–27 m tall) includes the most common species: *Abies holophylla*, *Fraxinus mandshurica*, *Juglans mandshurica*, *Phellodendron amurense*, *Pinus koraiensis* and *Tilia amurensis*. The tallest trees in this layer include *Abies holophylla* and *Pinus koraiensis*, which may extend above the first layer. The second tree layer (12–15 m tall) is composed of *Acer mono*, *A. pseudosieboldianum* and *Syringa reticulata* subsp. *amurensis*, along with undergrowth species from the first tree layer. The third tree layer (8–10 m tall) includes *Acer mono* and *Carpinus cordata*. The shrub layer (0.5–4.5 m tall) is highly diverse, with species such as *Euonymus alatus*, *E. verrucosus*, *E. macropterus*, *Lonicera praeflorens*, *L. maakii*, *Berberis amurensis*, *Corylus sieboldiana* var. *mandshurica*, *Eleutherococcus senticosus*, *Philadelphus tenuifolius*, *Ribes maximowiczii*, *Viburnum sargentii*, *Weigela praecox*, *Zabelia biflora* and others. The herb layer has an average cover of 50 %, with common mesophytic species such as *Carex accrescens*, *C. auriculata*, *Diarrhena mandshurica*, and *Onoclea struthiopteris*. Mesohygrophytic species such as *Carex uda*, *Cardamine leucantha*, *Filipendula palmata*, *Sanicula rubriflora*, and *Impatiens furcillata* are also significant.

Table 1. Combined synoptic table of frequency class and fidelity (phi coefficient × 100, upper indices) for SMMFs. **Abbreviations: D.d.–Q.m.** – the species is also a diagnostic species of the alliance Dictamno dasycarpi–Quercion mongolicae; **Q.m.** – the species is also a diagnostic species of the class Quercetea mongolicae

Syntaxa number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Number of plots	11	11	24	16	16	36	31	82
Comm. *"Magnolia sieboldii–Abies holophylla"*								
Ainsliaea acerifolia	IV$^{(77.8)}$	·	·	·	·	·	·	·
Tripterygium regelii	IV$^{(77.8)}$	·	·	·	·	·	·	·
Euonymus oxyphyllus	III$^{(71.6)}$	·	·	·	·	·	·	·
Sasamorpha borealis	III$^{(71.6)}$	·	·	·	·	·	·	·
Magnolia sieboldii	III$^{(67)}$	·	·	·	I	·	·	·
Rhododendron schlippenbachii	III$^{(67)}$	·	·	·	I	·	·	·
Viburnum wrightii	III$^{(64.9)}$	·	·	·	·	·	·	·
Viola diamantiaca	III$^{(60.6)}$	·	I	·	·	·	·	I
Hepatica nobilis var. *japonica*	III$^{(51.4)}$	·	·	·	I$^{(14.6)}$	·	·	I
Acer komarovii	III$^{(44.9)}$	·	·	·	I	I	·	I
Meehania urticifolia	II$^{(57.7)}$	·	·	·	·	·	·	·
Toxicodendron trichocarpum	II$^{(57.7)}$	·	·	·	·	·	·	·
Disporum smilacinum	II$^{(53.9)}$	·	I	·	·	·	·	·
Arachniodes miqueliana	II$^{(49.7)}$	·	·	·	·	·	·	·
Aristolochia manshuriensis	II$^{(49.7)}$	·	·	·	·	·	·	·
Neillia incisa	II$^{(49.7)}$	·	·	·	·	·	·	·
Symplocos sawafutagi	II$^{(49.7)}$	·	·	·	·	·	·	·
Acer ukurunduense	II$^{(31.3)}$	·	·	·	·	II$^{(23.6)}$	·	I
Comm. *"Carex drymophila–Abies holophylla"*								
Carex drymophila	·	V$^{(93.3)}$	·	·	·	·	·	I
Thalictrum tuberiferum	·	V$^{(79.6)}$	I	·	·	·	·	I
Philadelphus schrenkii	II$^{(15)}$	V$^{(75.1)}$	·	·	·	·	·	·
Syringa oblata subsp. *dilatata*	·	V$^{(100)}$	·	·	·	·	·	·
Vicia ramuliflora	·	IV$^{(39.7)}$	I	II	I	I	II$^{(13.6)}$	I
Carex pediformis	·	III$^{(71.6)}$	·	·	·	·	·	·
Trigonotis radicans var. *sericea*	·	III$^{(71.6)}$	·	·	·	·	·	·
Muhlenbergia japonica	·	III$^{(63.9)}$	·	·	·	·	·	I
Viburnum opulus ssp. *calvescens*	·	III$^{(59.2)}$	·	·	·	·	·	I
Galium spurium	·	III$^{(53.2)}$	I$^{(12.6)}$	·	·	·	·	·
Pyrola japonica **(Q.m.)**	·	III$^{(48)}$	·	I	I	I	I	I
Viola collina	I	III$^{(36.3)}$	I	I	I	·	I	I
Polemonium villosum	·	II$^{(57.7)}$	·	·	·	·	·	·
Iris uniflora	·	II$^{(49.7)}$	·	·	·	·	·	·
Malus sieboldii	I	II$^{(47.6)}$	·	·	·	·	·	I
Artemisia sylvatica	·	II$^{(45.4)}$	I	·	·	·	·	·
Eleutherococcus sessiliflorus	I	II$^{(31.5)}$	I	·	·	I	I	I
Ass. Onocleo struthiopteridis–Juglandetum mandshuricae								
Brachybotrys paridiformis	I	·	V$^{(79.4)}$	.	.	I	I	I
Stellaria bungeana	·	·	V$^{(63.6)}$	I	.	I	II$^{(10.5)}$	I
Phlomoides maximowiczii	·	·	IV$^{(72.6)}$	.	.	I	.	I
Oxalis obtriangulata	·	·	IV$^{(61.2)}$	I	.	I	I	I
Geum aleppicum	·	·	III$^{(51.7)}$	I	.	.	.	I
Lonicera maackii	·	·	III$^{(47.2)}$	II	.	I	.	I
Viola acuminata	I	II	III$^{(23.1)}$	I	.	II	II	I
Ranunculus japonicus	·	·	II$^{(44)}$	.	.	.	I	.
Pseudostellaria japonica	·	·	II$^{(43.3)}$	.	.	.	.	.
Chrysosplenium sinicum	·	·	II$^{(43.1)}$	.	.	I	.	I
Geranium wilfordii	·	I	II$^{(36.9)}$	.	.	.	I	I
Ass. Fraxino mandshurici–Abietetum holophyllae								
Equisetum hyemale	·	·	I	V$^{(76.7)}$	·	I	I	I
Alnus hirsuta	·	·	I	IV$^{(73)}$	·	·	I	I
Carex dispalata	·	·	II$^{(18.9)}$	IV$^{(64)}$	·	I	·	·
Prunus padus	·	I	I	IV$^{(59.2)}$	·	·	I	I
Trigonotis radicans	·	·	I	IV$^{(53.1)}$	·	II	II	I
Lilium distichum	·	I	II	IV$^{(41.4)}$	I	I	II	I
Caltha palustris	·	·	I$^{(11.5)}$	III$^{(48.6)}$	·	I	I	·
Trisetum sibiricum	·	·	·	II$^{(54.7)}$	·	·	I	I
Carex umbrosa ssp. *pseudosabynensis*	·	·	·	II$^{(51)}$	·	I	I	·
Platanthera metabifolia	·	·	·	II$^{(47.5)}$	·	·	·	·
Lychnis fulgens	·	·	·	II$^{(44)}$	·	·	I	·
Pleurospermum uralense	·	·	I	II$^{(36.2)}$	·	I	II$^{(21.1)}$	I
Pedicularis resupinata	II$^{(19.5)}$	·	I	II$^{(31.8)}$	·	I	I	·
Suball. Filipendulo palmatae–Juglandenion mandshuricae								
Sanicula rubriflora	·	I	IV$^{(43.8)}$	II	·	I	I	II
Filipendula palmata	·	I	IV$^{(42.6)}$	IV$^{(33.9)}$	·	I	II	I
Carex accrescens	·	·	IV$^{(38.8)}$	III$^{(21.3)}$	·	I	II	I
Juglans mandshurica	·	III	IV$^{(20.4)}$	V$^{(31.6)}$	I	II	IV$^{(18.7)}$	II
Athyrium crenulatoserrulatum	·	·	III$^{(39.3)}$	II	·	I	I	I
Onoclea struthiopteris	·	·	III$^{(28.3)}$	IV$^{(35.9)}$	·	I	III$^{(17.3)}$	I
Phellodendron amurense	·	I	III$^{(23.7)}$	V$^{(42.7)}$	I	I	II	II
Dioscorea nipponica	·	I	III$^{(16.3)}$	IV$^{(35.9)}$	·	II	II	II
Carex uda	·	·	II$^{(31.4)}$	III$^{(38.9)}$	·	I	I	·
Aconitum alboviolaceum	·	·	II$^{(26.3)}$	III$^{(33.2)}$	·	I	I	I
Impatiens furcillata	·	·	II$^{(21.8)}$	II$^{(38.6)}$	·	I	I	I
Veratrum dahuricum	·	·	II$^{(20.8)}$	II$^{(27)}$	·	I	I	·
Clematis fusca	·	I	II$^{(20)}$	II$^{(28.1)}$	·	I	I	I
Anemonoides glabrata	·	·	II	II$^{(32.9)}$	·	I	I	I

Observed community-specific species pool – 325 species. Predicted species pool – 460 ± 40 species.

Ecology: Communities are typically found on river terraces, close to floodplains. They occupy flat areas or gentle slopes (average slope of 2°) with sufficient or even excessive moisture. The relevés were conducted at elevations ranging from 47 to 226 meters above sea level.

Distribution: Found in Russia, but can also occur in northeastern China near the Russian border and in North Korea.

Onocleo struthiopteridis–Juglandetum mandshuricae Petrunenko et Dzizurova 2024 nom. mut. nov. (Table A1 in Appendix 1, relevés 1–10), replaced name – Matteuccio struthiopteridis–Juglandetum mandshuricae Petrunenko et Dzizurova 2024

We performed a name mutation, according to Article 45 of the ICPN, as *Matteuccia struthiopteris* (L.) Tod. (first published in 1866 in Giorn. Sci. Nat. Econ. Palermo 1: 235) is a late synonym of *Onoclea struthiopteris* (L.) Roth (first published in 1794 in Ann. Bot. (Usteri) 10: 54) (POWO 2025). According to the principle of priority, the earlier valid name should be used as the name-giving taxon (Theurillat et al. 2021).

Nomenclatural type – relevé 13 in Table 7 on p. 106 in Petrunenko & Dzizurova (2024) (= relevé 10 in Table A1 in Appendix 1).

Diagnostic taxa: *Brachybotris paridiformis*, *Chrysosplenium sinicum*, *Geranium wilfordii*, *Geum allepicum*, *Lonicera maackii*, *Oxalis obtriangulata*, *Phlomoides maximowiczii*, *Pseudostellaria japonica*, *Ranunculus japonicus*, *Stellaria bungeana*, *Viola acuminata*.

Species composition: The observed species pool contains 273 species, and the predicted species pool is 360 ± 26 species. The average α-diversity is 67 ± 12 species per 400 m².

Ecology: Communities of this association occupy river terraces, near floodplains, with sufficient moisture that is not excessive.

Distribution: Found in Russia, but can also occur in northeastern China near the Russian border and in North Korea.

Fraxino mandshurici–Abietetum holophyllae Gumarova, Prokhorenko, Verkholat ex Krestov, Dzizyurova et Korznikov 2023 (Table A1 in Appendix 1, relevés 11–20)

Nomenclatural type – relevé 22 in Table 6 on pp. 111–117 (Krestov et al. 2006) (= relevé 14 in Table A2 in Appendix 1).

Diagnostic taxa: *Alnus hirsuta*, *Caltha palustris*, *Carex dispalata*, *C. umbrosa* subsp. *pseudosabynensis*, *Equisetum hyemale*, *Lilium distichum*, *Lychnis fulgens*, *Pedicularis resupinata*, *Platanthera metabifolia*, *Prunus padus*, *Trigonotis radicans*, *Trisetum sibiricum*.

Synonyms: Fraxino mandshurici–Abietetum holophyllae Gumarova, Prokhorenko et Verkholat, 1994, nom. ined.; Fraxino mandshurici–Abietetum holophyllae Gumarova, Prokhorenko et Verkholat ex Krestov, Song, Nakamura et Verkholat, 2006, nom. inval. (3o, 5a).

Table 1. Continued.

Syntaxa number	1	2	3	4	5	6	7	8
Ass. Rhododendro mucronulati–Betuletum schmidtii								
Betula schmidtii	I	·	·	·	V$^{(84.4)}$	·	·	I
Rhododendron mucronulatum	I	·	I	·	V$^{(82.6)}$	·	I	I
Carex callitrichos var. *nana* **(D.d.–Q.m.)**	I	·	I	I	V$^{(64.8)}$	I	I	I
Weigela florida	·	·	I	·	III$^{(66.4)}$	·	·	I
Halosciastrum melanotilingia	·	·	·	·	II$^{(47.5)}$	·	·	·
Lespedeza bicolor	·	·	I	·	II$^{(39.6)}$	I	I	I
Artemisia keiskeana	I	I	·	·	II$^{(36)}$	I	·	I
Calamagrostis arundinacea	I	·	·	·	II$^{(33.9)}$	·	I	I
Pyrola renifolia	·	·	·	I	II$^{(31.4)}$	I	I	I
Gymnocarpium dryopteris	·	I	I	I	II$^{(30.3)}$	I	I	I
Ass. Mitello nudae–Abietetum holophyllae								
Lamium album ssp. *barbatum*	·	·	III$^{(20)}$	I	·	V$^{(50.9)}$	III	I
Hylodesmum podocarpum ssp. *oxyphyllum*	·	·	·	·	·	IV$^{(68.7)}$	I	II
Circaea alpina	·	II	I	I	I	IV$^{(44)}$	I	II
Urtica thunbergiana	·	·	I	·	·	III$^{(57.4)}$	I	I
Chrysosplenium pilosum var. *valdepilosum*	·	·	II$^{(20.5)}$	·	·	III$^{(45.8)}$	·	I
Actinidia polygama	I	·	I	I	·	III$^{(43.4)}$	I	I
Mitella nuda	·	II	·	I	·	III$^{(36.7)}$	I	I
Athyrium monomachi	·	·	·	·	·	II$^{(57.6)}$	·	I
Picea jezoensis	·	·	·	I	·	II$^{(51.1)}$	·	I
Chelidonium asiaticum	·	·	I	·	·	II$^{(44.2)}$	·	I
Abies nephrolepis	·	·	I	I	I	II$^{(39.9)}$	I	I
Subass. Querco mongolicae–Abietetum holophyllae oxalidetosum acetosellae								
Athyrium spinulosum	·	II	I	II	II	I	IV$^{(28.8)}$	II
Paeonia obovata	·	II	·	I	·	II	III$^{(38)}$	I
Dryopteris expansa	·	·	I	II	I	I	III$^{(33.9)}$	I
Lathyrus humilis	·	·	I	·	·	I	II$^{(38.1)}$	I
Campanula punctata	·	II	I	I	·	I	II$^{(30.3)}$	I
Subass. Querco mongolicae–Abietetum holophyllae typicum, Ass. Querco mongolicae–Abietetum holophyllae and All. Carpino cordatae–Abietion holophyllae								
Dryopteris crassirhizoma	II	IV	IV	V$^{(27.8)}$	I	V$^{(21.2)}$	IV	V$^{(15.2)}$
Carpinus cordata **(Q.m.)**	V	V	IV	IV	II	V$^{(17.8)}$	V	V$^{(14.7)}$
Abies holophylla	V	V	IV	V	IV	V	V	V$^{(10.5)}$
Kalopanax septemlobus	II	I	II	III	III	III	V$^{(27.1)}$	IV$^{(17.1)}$
Acer barbinerve	III	V	III	V$^{(22.5)}$	·	V$^{(20.9)}$	V	IV
Acer mandshuricum	·	II	IV$^{(23.6)}$	V$^{(29.9)}$	·	V$^{(31)}$	III	III
Carex ussuriensis	·	V$^{(35.9)}$	I	IV$^{(23.8)}$	I	IV$^{(21.7)}$	IV$^{(20.7)}$	II
Viburnum sargentii	·	·	IV$^{(22.2)}$	V$^{(35)}$	I	III	V$^{(37.2)}$	II
Ord. Tilio amurensis–Pinetalia koraiensis								
Acer tegmentosum	II	III	III	III	IV	V	V	IV$^{(14.2)}$
Aegopodium alpestre	·	·	V$^{(58.4)}$	I	I	II	I	III$^{(14.5)}$
Berberis amurensis	I	I	III$^{(22.6)}$	II	I	I	III$^{(21.1)}$	II
Betula costata	·	·	III	IV$^{(28.7)}$	·	IV$^{(28.7)}$	IV$^{(28)}$	II
Carex auriculata	·	·	V$^{(23.1)}$	V$^{(30.9)}$	I	V$^{(29.4)}$	V$^{(25.9)}$	IV
Convallaria keiskei	·	V$^{(38.8)}$	II	IV	II	III	IV$^{(19.3)}$	III
Corylus sieboldiana var. *mandshurica*	III	V$^{(25.3)}$	II	IV	IV	II	IV	III
Diarrhena mandshurica	·	III	V$^{(34.5)}$	IV	·	II	IV$^{(24.3)}$	III
Eleutherococcus senticosus	·	IV	V	V	·	V$^{(29.9)}$	V	IV
Euonymus verrucosus	·	V$^{(28.8)}$	II	III	III	II	IV$^{(15.6)}$	III
Fraxinus chinensis ssp. *rhynchophylla*	III	IV	II	III	II	II	V$^{(23.9)}$	III
Philadelphus tenuifolius	·	·	V	V$^{(28.9)}$	II	V$^{(28.9)}$	V$^{(26.4)}$	V$^{(17.4)}$
Pinus koraiensis	IV	V	III	IV	IV	V$^{(20.9)}$	IV	V$^{(11.1)}$
Schisandra chinensis	·	V	II	V$^{(26.3)}$	IV	V	V$^{(21.1)}$	IV
Syringa reticulata ssp. *amurensis*	·	·	V	V$^{(34)}$	I	V$^{(27.7)}$	V$^{(29.1)}$	IV
Thalictrum filamentosum	II	V	V	V	II	V$^{(20.2)}$	V$^{(20.2)}$	V
Tilia amurensis	V	V	V	V	V	V	V$^{(11.8)}$	V
Ulmus laciniata	I	I	III	IV	·	V$^{(38.1)}$	IV$^{(22.7)}$	III
Viola selkirkii	I	III	II	IV	II	V$^{(31.2)}$	IV	IV
Waldsteinia maximowicziana	·	IV$^{(30.6)}$	II	III$^{(19.1)}$	I	I	III$^{(20.5)}$	I
Class Quercetea mongolicae								
Acer mono	II	V	V	V	III	V$^{(16.6)}$	V	V$^{(16.6)}$
Acer pseudosieboldianum	V	V	III	IV	V	V	V	V
Actinidia arguta	III	II	I	IV$^{(20.4)}$	I	II	IV$^{(24.6)}$	II
Alniaria alnifolia	I	IV	I	II	II	III	V$^{(31.8)}$	III
Athyrium yokoscense	II	I	II	I	III$^{(29.1)}$	I	II	I
Carex siderosticta	V	V	V	V	V	V	V$^{(10.1)}$	IV
Maianthemum dilatatum	·	·	II	I	III	IV$^{(25.9)}$	III	II
Maianthemum japonicum	·	I	III$^{(19.8)}$	V$^{(51.7)}$	.	I	III$^{(15.6)}$	I
Quercus mongolica	V	V	IV	IV	V$^{(16.9)}$	III	V$^{(13.6)}$	IV
Constant and indifferent species								
Aconitum sczukinii	·	·	III$^{(15.1)}$	V$^{(55.5)}$	·	I	IV$^{(33.6)}$	I
Aconitum stoloniferum	·	·	II$^{(25.5)}$	·	·	III$^{(45.1)}$	I	I
Actaea asiatica	I	II	II	IV	I	III	III	III
Actaea dahurica	I	·	II$^{(14.7)}$	III$^{(32)}$	I	I	III$^{(18.8)}$	I
Actinidia kolomikta	I	IV	II	V	III	V$^{(18.3)}$	V$^{(20.8)}$	IV
Adiantum pedatum	·	II	II	II	I	IV$^{(27.9)}$	III	III
Adoxa moschatellina	·	·	II	IV$^{(39)}$	·	I	III$^{(31.8)}$	I
Anemonoides udensis	·	·	·	II$^{(31)}$	·	II$^{(18.7)}$	I	I
Aralia elata	·	II$^{(25·1)}$	I	I	·	II$^{(15.7)}$	I	I
Arisaema amurense	II	I	V$^{(34.5)}$	V$^{(36)}$	·	III	IV	II

Species composition: This association is distinguished from the previous one by the composition of the herb layer, which includes hygrophytes with a broad distribution range, such as *Caltha palustris*, *Equisetum hyemale*, and *Pedicularis resupinata*. Other common species include *Asparagus schoberioides*, *Clematis fusca*, and *Filipendula glaberrima*.

Observed community-specific species pool – 228 species. Predicted species pool – 285.6 ± 21.5 species.

Ecology: Communities of this association are characteristic of moist habitats, typically found on gentle slopes with northern and eastern exposure or on flat areas in the lower parts of river terraces, near floodplains.

Distribution: Found in Russia, but can also occur in northeastern China near the Russian border and in North Korea.

Note: We did not calculate α- and β-diversity for this association because it was characterized using relevés with varying plot sizes (ranging from 400 to 2500 m²). We also did not analyse the landscape-level distribution of these communities due to the absence of exact coordinates in most relevés.

Rhododendro mucronulati–Betuletum schmidtii Petrunenko et Dzizurova 2024 (Table A2 in Appendix 1, relevés 1–20)

Nomenclatural type – relevé 9 in Table 6 on p. 105 (Petrunenko & Dzizurova 2024) (= relevé 13 in Table A2 in Appendix 1).

Diagnostic taxa: *Artemisia keiskeana*, *Betula schmidtii*, *Calamagrostis arundinacea*, *Carex callitrichos* var. *nana*, *Gymnocarpium dryopteris*, *Halosciastrum melanotilingia*, *Lespedeza bicolor*, *Pyrola renifolia*, *Rhododendron mucronulatum*, *Weigela florida*.

Species composition and structure: The forest stand typically consists of two layers. The first tree layer (12–28 m tall, mean 20 m) is dominated by *Betula schmidtii* and *Quercus mongolica*, often accompanied by *Betula pendula* subsp. *mandshurica*. The second tree layer (10–14 m tall, mean 12 m) is often dominated by *Acer pseudosieboldianum*, with *Abies holophylla*, *Carpinus cordata* and *Tilia amurensis* as accompanying species. The shrub layer (2–4 m tall) is dominated by *Rhododendron mucronulatum*. Other shrub species are less significant, but common ones include *Corylus sieboldiana* var. *mandshurica*, *Euonymus verrucosus*, *Lespedeza bicolor*, and *Weigela florida*. The herb layer is characterized by sedges, with *Carex callitrichos* var. *nana* and *C. siderosticta* forming the background. Other common species include *Artemisia keiskeana*, *Halosciastrum melanotilingia*, and young *Schisandra chinensis* plants. The average cover is 22 %, which is low.

Observed community-specific species pool – 111 species. Predicted species pool – 161 ± 20 species. The average α-diversity is 29 ± 11 species per 400 m² (300 m² in cases of smaller sample plot area).

Ecology: These communities are found in the upper and middle parts of steep (up to 35°) and moderately steep (10–20°) northwest- and northeast-facing slopes, as well as rocky ridges

Table 1. Continued.

Syntaxa number	1	2	3	4	5	6	7	8
Artemisia argyi var. *argyi*	II	.	II	III$^{(26.9)}$	.	I	III$^{(22.9)}$	I
Aruncus dioicus	.	II	II	V$^{(40.2)}$	I	III$^{(12.6)}$	III	I
Asarum sieboldii	II	V	IV	IV	I	V$^{(25.2)}$	IV	IV
Asparagus schoberioides	.	.	I$^{(13.1)}$	II$^{(25.1)}$	.	I	I	.
Aster scaber	I	.	I	II$^{(22.6)}$	.	I	III$^{(33.8)}$	I
Astilbe chinensis	III	.	IV$^{(29.5)}$	IV$^{(22.9)}$	.	II	III$^{(11.6)}$	I
Athyrium sinense	.	.	III	V$^{(41.8)}$	I	IV$^{(16.5)}$	V$^{(39.4)}$	III
Betula pendula ssp. *mandshurica*	.	II	I	III$^{(23.5)}$	II	I	III$^{(25)}$	I
Cardamine leucantha	.	III	IV$^{(17.9)}$	V$^{(30.5)}$	.	III	V$^{(25.3)}$	II
Carex lanceolata	I	III	III	II	III$^{(14.5)}$	I	III$^{(15.8)}$	I
Carex quadriflora	.	.	II	III	I	III$^{(19.4)}$	II	II
Carex rhizina subsp. *reventa*	.	.	I	IV$^{(32.8)}$	I	IV$^{(32.8)}$	III$^{(19.3)}$	II
Caulophyllum robustum	.	.	III$^{(21.1)}$	V$^{(44.7)}$	.	II	III$^{(18.3)}$	II
Chrysosplenium pilosum	.	I	I	III$^{(30.2)}$	.	I	II$^{(21.5)}$	I
Cirsium schantarense	.	I	I	IV$^{(50.2)}$	.	I	II$^{(18.2)}$	I
Deparia pycnosora	.	III	III$^{(12)}$	V$^{(41.7)}$	.	II	III	II
Deutzia parviflora var. *parviflora*	.	I	II	IV	I	IV$^{(25.4)}$	V$^{(30.1)}$	III
Diarrhena fauriei	.	.	I	II$^{(20.5)}$	.	I	II$^{(21.5)}$	I
Dryopteris goeringianum	.	.	II	II	.	III$^{(25.5)}$	II	I
Euonymus alatus	.	V$^{(33.1)}$	III$^{(11.7)}$	IV$^{(23)}$	.	III	III$^{(9.7)}$	I
Euonymus macropterus	II$^{(23.8)}$	.	I	II$^{(18.3)}$	I	.	I	I
Euonymus sachalinensis	II	I	I	II	II	IV$^{(39.9)}$	II	I
Filipendula glaberrima	.	.	I	II$^{(33.6)}$	.	I	I$^{(16.6)}$	I
Fraxinus mandshurica	I	I	V$^{(25.3)}$	V$^{(28.4)}$	I	V$^{(33.7)}$	III	III
Galium davuricum	I	IV	II	V$^{(25.1)}$	.	IV$^{(20.4)}$	IV$^{(14.9)}$	III
Heracleum dissectum	.	.	III$^{(20.4)}$	IV$^{(40.9)}$	.	I	III$^{(31.3)}$	I
Hylomecon vernalis	.	.	IV$^{(24.2)}$	IV	.	IV$^{(24.2)}$	IV	III
Impatiens noli-tangere	.	.	III$^{(32.2)}$	II	.	III$^{(22.2)}$	II	I
Isodon excisus	II	I	II	IV$^{(31.3)}$	I	I	III$^{(16.4)}$	I
Lonicera chrysantha	.	.	I	IV$^{(30.7)}$	I	III$^{(22.4)}$	III$^{(21.4)}$	II
Lonicera praeflorens	.	V$^{(25.1)}$	II	III	II	IV	IV$^{(16.9)}$	III
Maackia amurensis	II	IV$^{(33.4)}$	I	.	III	II	II	III$^{(8)}$
Maianthemum bifolium	.	V	II	IV	I	V$^{(27.1)}$	IV$^{(18.4)}$	IV
Nabalus tatarinowii	.	.	II	IV$^{(24.9)}$	.	III$^{(21.5)}$	IV$^{(31.8)}$	II
Osmundastrum cinnamomeum ssp. *asiaticum*	.	I	I	IV$^{(29.3)}$	II	I	IV$^{(31)}$	II
Oxalis acetosella	.	IV	III	V	I	V$^{(27.7)}$	IV	IV
Parasenecio hastatus	.	I	IV$^{(21.8)}$	IV$^{(26.7)}$	.	IV$^{(25.1)}$	III	II
Parasenecio praetermissus	I	III	III	IV	I	IV$^{(15)}$	III	III
Paris verticillata	.	III	I	III$^{(21.2)}$	.	IV$^{(33.2)}$	II	I
Phegopteris connectilis	.	II	I	IV$^{(33.6)}$	II	I	III$^{(18.3)}$	I
Phryma nana	I	V	II	III	I	V$^{(25.6)}$	IV	V$^{(20.8)}$
Plagiorhegma dubium	.	V$^{(34.5)}$	I	IV$^{(19.4)}$	.	II	IV$^{(28.5)}$	II
Polemonium chinense	.	.	II$^{(18.5)}$	I	.	II	III$^{(37.6)}$	I
Polystichum subtripteron	.	.	.	III$^{(26.9)}$	.	III$^{(29.4)}$	II	II
Prunus maximowiczii	II	II	.	III	.	IV$^{(22.5)}$	II	III$^{(14.6)}$
Pseudostellaria sylvatica	.	IV	II	IV	I	IV	V$^{(28.8)}$	III
Pyrus ussuriensis	I	.	I	III$^{(33.4)}$	.	I	II$^{(20.7)}$	I
Rhamnus davurica	.	I	II$^{(18.7)}$	II$^{(16.5)}$	.	I	II$^{(14.2)}$	I
Ribes mandshuricum	.	II	II	IV	.	V$^{(40.3)}$	IV$^{(25.2)}$	III
Ribes maximoviczianum	.	.	I	II	I	V$^{(48.4)}$	III$^{(23)}$	II
Rubia chinensis	.	.	III$^{(29.2)}$	I	.	II$^{(15.9)}$	II	I
Rubia cordifolia	.	.	II	II	.	III$^{(27.6)}$	II	I
Rubus crataegifolius	I	I	II	II$^{(20.4)}$	I	I	I	I
Saussurea subtriangulata	.	.	II	IV$^{(39.6)}$	I	II	IV$^{(33.5)}$	I
Scutellaria pekinensis var. *ussuriensis*	.	.	IV$^{(27)}$	III	I	III	III$^{(20.1)}$	II
Spiraea chamaedryfolia	.	II	I	III$^{(30.2)}$	I	I	III$^{(23.1)}$	II
Ulmus davidiana var. *japonica*	.	III	II	III$^{(24.2)}$	.	II	II	II
Urtica dioica subsp. *holosericea*	.	I	I	II	.	II$^{(14.4)}$	II	I
Valeriana fauriei	.	I	V$^{(33.3)}$	IV$^{(26.9)}$	.	II	V$^{(41.2)}$	I
Veronicastrum sibiricum	.	I	I	II$^{(24.4)}$	.	I	III$^{(39.4)}$	I
Viburnum sargentii	.	.	IV$^{(22.2)}$	V$^{(35)}$	I	III	V$^{(37.2)}$	II
Vitis amurensis	.	III	III	V$^{(21.5)}$	I	V$^{(21)}$	V$^{(25.9)}$	III
All. Dictamno dasycarpi–Quercion mongolicae								
Angelica cincta	.	.	I	II	.	I	II$^{(20.2)}$	I
Bupleurum longiradiatum	I	I	.	I	.	I	I	I
Carex rhizina subsp. *reventa*	.	.	I	IV$^{(32.8)}$	I	IV$^{(32.8)}$	III$^{(19.3)}$	II
Dictamnus dasycarpus	.	I	.	.	.	.	.	I
Fragaria orientalis	.	I$^{(33.1)}$	.	.	.	I	.	I
Geranium maximowiczii	.	.	I	I	.	I	II$^{(33.9)}$	.
Hemerocallis middendorffii	.	.	.	.	.	I	.	I
Polygonatum involucratum	I	II	I	.	I	IV$^{(36.6)}$	III	II
Vicia amurensis	.	I$^{(28.4)}$	.	.	.	.	.	.
Vincetoxicum ascyrifolium	.	II$^{(48.4)}$	.	.	.	.	.	I
All. Corylo heterophyllae–Quercion mongolicae								
Codonopsis lanceolata	I	I	.	.	.	.	I	I
Corylus heterophylla	.	.	.	.	.	.	.	I
Polygonatum odoratum	.	.	I	.	I	I	.	I
Potentilla freyniana	.	.	.	.	.	.	.	I
Spodiopogon sibiricus	.	.	.	.	I	.	.	.
Veratrum maackii	.	.	I	.	.	.	.	.
Other species								
Amphicarpaea edgeworthii	.	I	II	.	I	I	II$^{(20.9)}$	I
Anemonoides umbrosa	.	II	I	I	.	I	II$^{(12.3)}$	I
Betula dahurica	.	III$^{(32.7)}$	I	I	I	I	III$^{(23.8)}$	I
Celastrus flagellaris	.	.	I	I	.	I	II$^{(32.3)}$	I
Lathyrus komarovii	.	II	I	II	.	I	III$^{(29.9)}$	I
Lonicera maximowiczii	.	.	.	I	.	II$^{(28.3)}$	I	I

of watersheds. The sites are typically located at higher elevations compared to other SMMF associations in the Russian Far East. The relevés were carried out at elevations ranging from 115 to 1029 m a.s.l.

Distribution: The communities are found in Russia and the Korean Peninsula.

Mitello nudae–Abietetum holophyllae ass. nov. (Table A3 in Appendix 1, relevés 1–20)

Holotypus (nomenclatural type) – relevé 16 in Table A3 in Appendix 1.

Diagnostic taxa: *Abies holophylla*, *A. nephrolepis*, *Actinidia polygama*, *Athyrium monomachi*, *Chelidonium asiaticum*, *Chrysosplenium pilosum* var. *valdepilosum*, *Circaea alpina*, *Hylodesmum podocarpum* subsp. *oxyphyllum*, *Lamium album* subsp. *barbatum*, *Mitella nuda*, *Picea jezoensis*, *Urtica thunbergiana* subsp. *thunbergiana*.

Species composition and structure: The forest stand is polydominant, formed by trees of varying heights and comprises three layers. The first tree layer has an average height of 29 m (ranging from 26 to 36 m). It is dominated by broadleaved species such as *Quercus mongolica*, *Tilia amurensis*, and others, along with temperate conifers like *Abies holophylla* and *Pinus koraiensis*. Individual trees of *Abies holophylla* and *Pinus koraiensis* can grow up to 40–45 m, extending beyond the first tree layer. The second tree layer (15–25 m) is formed by *Acer mono* and boreal conifers such as *Abies nephrolepis* and *Picea jezoensis*, as well as younger individuals of species from the first layer. The third tree layer (8–14 m) is mainly composed of *Carpinus cordata*, with *Acer pseudosieboldianum*, *A. tegmentosum* and *A. ukurunduense* mixed in. The shrub layer (0.5–1.5 m tall) is dominated by *Deutzia parviflora*, *Eleutherococcus senticosus* and *Philadelphus tenuifolius* with high constancy. There are also young lianas like *Actinidia* spp. and *Schisandra chinensis*, although large lianas are rare in these communities. The herb layer has an average cover of 50 %. It includes species from the South Manchurian flora, such as *Aconitum stoloniferum*, *Hylodesmum podocarpum* subsp. *oxyphyllum*, *Polygonatum involucratum* and others, as well as some boreal species like *Circaea alpina*, *Dryopteris amurensis* and *Mitella nuda*. Ruderal species like *Chelidonium asiaticum* and *Urtica thunbergiana* subsp. *thunbergiana* are also present.

Observed community-specific species pool – 261 species. Predicted species pool – 324 ± 20 species. The average α-diversity is 68 ± 10 species per 400 m².

Ecology: Unlike other SMMF associations, which predominantly occupy northern and north-western slopes, the Mitello nudae–Abietetum holophyllae is found on slopes of all aspects, except for the northern one. These communities are typically found on slightly sloping areas with an average gradient of 7°. The relevés were made at elevations ranging from 191 to 450 m a.s.l.

Distribution: These communities are found in Primorye Territory, closer to the northern limit of the SMMFs.

Table 1. Continued.

Syntaxa number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Melica nutans	.	.	I	II$^{(24.1)}$	.	.	I	I
Milium effusum	.	I	I	II	.	I	II$^{(15.3)}$	I
Moehringia lateriflora	.	III	I	II	II	I	III$^{(29.2)}$	I
Osmorhiza aristata	I	.	I	.	.	II	II	II$^{(17.5)}$
Populus suaveolens	.	I	I	II$^{(27.7)}$	.	I	I	.
Potentilla fragarioides	.	I	II	I	I	I	II$^{(17.6)}$	I
Prunus sargentii	IV$^{(43.3)}$	.	I	I	I	.	III$^{(22.3)}$	I
Symplocarpus renifolius	.	.	.	I$^{(41)}$	.	.	.	.
Solidago virgaurea	II	.	I	II	II	I	II$^{(19.6)}$	I
Tilia mandshurica	I	II	I	I	I	I	I	II$^{(8.3)}$
Viburnum burejaeticum	.	II	I	II	.	I	.	I
Vicia unijuga	.	I	I	I	I	I	II$^{(21.4)}$	I
Viola orientalis	.	I	I	.	II$^{(28.3)}$	.	.	I

Querco mongolicae–Abietetum holophyllae Kim ex Krestov, Dzizyurova et Korznikov, 2023
(Table A4 in Appendix 1, relevés 1–20)

Nomenclatural type – relevé 17 in Table 6 on pp. 111–117 (Krestov et al. 2006) (= relevé 9 in Table A4 in Appendix 1).

Diagnostic taxa: *Abies holophylla*, *Acer barbinerve*, *A. mandshuricum*, *Carex ussuriensis*, *Carpinus cordata*, *Dryopteris crassirhizoma*, *Kalopanax septemlobus*, *Viburnum sargentii*.

Synonyms: Campanulo punctatae–Quercetum mongolicae Gumarova et al. 1994, nom. ined.; Polysticho tripteron–Pinetum koraiensis Gumarova et al. ex Krestov et al. ex Krestov, Dzizyurova et Korznikov 2023.

Species composition and structure: The forest stand is polydominant with a mix of nemoral conifers like *Abies holophylla* and *Pinus koraiensis* that extend beyond the main canopy, reaching 40–45 m in height. The first tree layer (27–33 m tall) includes various broadleaved species like *Betula davurica*, *Fraxinus mandshurica*, *Kalopanax septemlobus*, *Quercus mongolica*, *Tilia amurensis*, and *T. mandshurica*. The second tree layer (18–22 m tall) consists of *Acer mandshuricum*, *A. mono*, *A. tegmentosum*, *Alniaria alnifolia*, and *Prunus sargentii*. The third tree layer (8–14 m tall) is formed by *Acer pseudosieboldianum*, *Carpinus cordata* and *Fraxinus chinensis* var. *rhynchophylla*. The shrub layer (0.5–5.0 m tall) is well-developed, with common species like *Acer barbinerve*, *Corylus sieboldiana* var. *mandshurica*, *Deutzia parviflora*, *Philadelphus tenuifolius*, and *Lonicera praeflorens*. Woody lianas are regularly encountered, including *Actinidia arguta*, *A. kolomikta*, *A. polygama*, *Schisandra chinensis* and *Vitis amurensis*. The herb layer cover varies from 10 to 80 % depending on herbivore activity, and it consists of species from the South Manchurian flora. The main species in the herb layer include *Carex lanceolata*, *Dryopteris crassirhizoma*, *D. goeringiana*, *Hylomecon vernalis*, *Polygonatum involucratum*, *Valeriana fauriei*, *Vicia subrotunda*, and others.

Observed community-specific species pool – 371 species. Predicted species pool – 447 ± 22 species. The average α-diversity is 55 ± 14 species per 400 m².

Ecology: Communities of this association occupy mainly northern, northwestern, and northeastern slopes of moderate steepness (5–15°), in areas with sufficient moisture. These forests are found at elevations ranging from 65 to 389 m a.s.l.

Distribution: These forests occur in the southern foothills of the Sikhote-Alin Mountains (Przhevalsky Mountains, Livadiysky and Makarovsky Ridges), the Muravyov-Amursky Peninsula (around the city of Vladivostok), the Borisov Plateau, and possibly in North Korea. The distribution of the association is currently limited to small areas due to past fires, which have led to the formation of monodominant stands of *Quercus mongolica*.

Querco mongolicae–Abietetum holophyllae oxalidetosum acetosellae Gumarova et al. ex Krestov, Dzizyurova et Korznikov 2023 (Table A4 in Appendix 1, relevés 11–20)

Nomenclatural type – relevé 19 in Table 6 on pp. 111–117 (Krestov et al. 2006) (= relevé 16 in Table A4 in Appendix 1).

Diagnostic taxa: *Athyrium spinulosum*, *Campanula punctata*, *Dryopteris expansa*, *Lathyrus humilis*, *Paeonia obovata*.

Synonyms: Polysticho tripteron–Pinetum koraiensis caricetosum reventae Kim ex Krestov et al. 2023.

Species composition: The observed community-specific species pool is 249 species, and the predicted species pool is 316 ± 24 species.

Ecology: The communities of this subassociation represent SMMFs in the stages of post-fire succession, and the species composition reflects the adaptation to these conditions. It differs from the typicum subassociation by the presence of a complex of drought- and fire-resistant species, such as: *Betula davurica*, *Potentilla fragarioides*, *Vicia unijuga*.

Distribution: Found in Russia, but can also occur in North Korea.

Querco mongolicae–Abietetum holophyllae typicum Kim ex Krestov, Dzizyurova et Korznikov, 2023 (Table A4 in Appendix 1, relevés 1–10)

Nomenclatural type – relevé 17 in Table 6 on pp. 111–117 (Krestov et al. 2006) (= relevé 9 in Table A4 in Appendix 1).

Diagnostic taxa: *Abies holophylla*, *Acer barbinerve*, *A. mandshuricum*, *Carex ussuriensis*, *Carpinus cordata*, *Dryopteris crassirhizoma*, *Kalopanax septemlobus*, *Viburnum sargentii*. The diagnostic taxa are the same as those of the Querco mongolicae–Abietetum holophyllae.

Synonyms: Querco mongolicae–Abietetum holophyllae aceretosum tegmentosae Kim ex Krestov et al. 2023; Polysticho tripteron–Pinetum koraiensis typicum Kim ex Krestov et al. 2023.

Species composition: The observed community-specific species pool is 333 species, and the predicted species pool is 434 ± 29 species.

Ecology: Communities of this subassociation represent minimally disturbed SMMFs on slopes of all aspects. These are typical forest stands with no significant signs of disturbance.

Distribution: Found in Russia, but can also occur in North Korea.

We depicted the diversity of SMMFs relevés in Primorye Territory within the NMDS scatterplot (Fig. 3). The axis NMDS1 represents a gradient of warmth and moisture, which is influenced by the variability in relief. The NMDS1 spans a sequence of associations, ranging from Rhododendro mucronulati–Betuletum schmidtii in the driest conditions to Onocleo struthiopteridis–Juglandetum mandshuricae in the most humid conditions. NMDS1 shows a strong positive correlation with several variables: the Kira's warmth index (WKI) (NMDS1 = 0.99, p = 0.002), the valley bottom flatness index (MRVBF) (NMDS1 = 0.99, p = 0.001), and the topographic wetness index (TWI) (NMDS1 = 0.97, p < 0.001). Additionally, NMDS1 shows a strong negative correlation with the topographic position index (TPI)

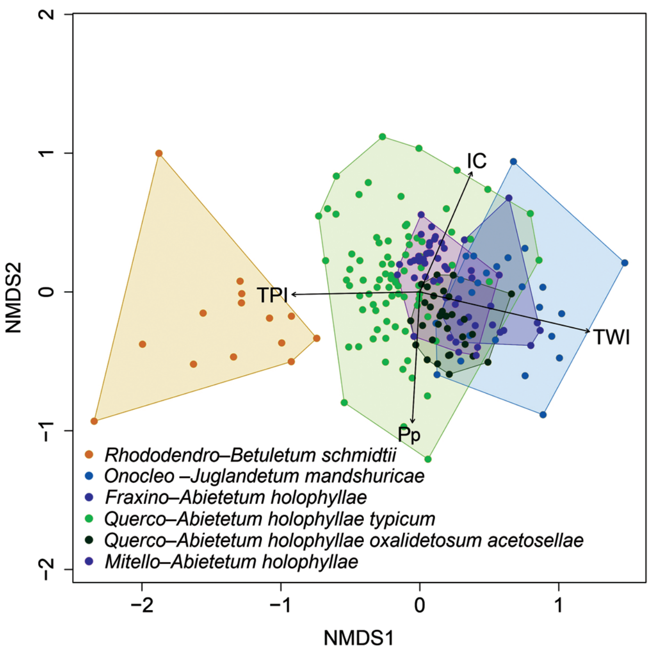

Figure 3 Results of the non-metric multidimensional scaling (NMDS) for phytosociological relevés (stress = 0.21), with the projection of environmental factor vectors: IC – Continentality Index, Pp – precipitation sum in months with an average temperature above 0°C, TPI – Topographic Position Index, TWI – Topographic Wetness Index. The length of each vector is proportional to the value of the determination coefficient from the multiple linear regression of the corresponding environmental indicator

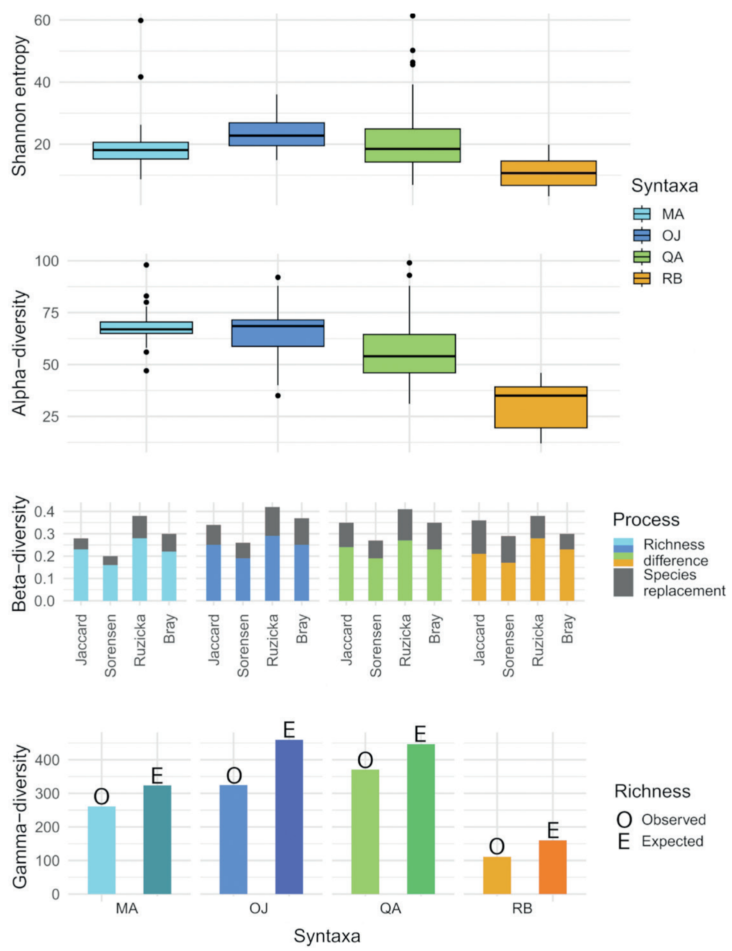

Figure 4 Biodiversity of syntaxa. MA – Mitello nudae–Abietetum holophyllae; OJ – Onocleo struthiopteridis–Juglandetum mandshuricae; QA – Querco mongolicae–Abietetum holophyllae; RB – Rhododendro mucronulati–Betuletum schmidtii

(NMDS1 = -0.99, p = 0.002). The associations Querco mongolicae–Abietetum holophyllae and Mitello nudae–Abietetum holophyllae occupy an intermediate position in the ordination diagram and show a high degree of nestedness. The axis NMDS2 reflects a gradient of continentality, with IC (continentality index) exhibiting a strong positive correlation (NMDS2 = 0.92, p = 0.001), while Pp (precipitation sum in months with positive temperatures) shows a negative correlation (NMDS2 = -0.99, p < 0.001). Pn (precipitation sum in months with negative temperatures) and MRRTF (ridge top flatness index) did not show significant correlations with the ordination axes.

Floristic diversity

A large variation in α-diversity was observed in the zonal communities of Querco mongolicae–Abietetum holophyllae (55 ± 14 species per plot). These mesic SMMFs include the highest observed number of species (γ-diversity). However, the communities are relatively heterogeneous both in terms of species composition and species contribution (β-diversity) (Fig. 4, Table A5 in Appendix 1).

The most floristically rich SMMF communities are Onocleo struthiopteridis–Juglandetum mandshuricae, occupying well-hydrated flatlands and gentle slopes of floodplain terraces (67 ±12 species per plot), and Mitello nudae–Abietetum holophyllae, found on sufficiently moist soils in the northern part of the SMMF range (68 ±10 species).

The tree layer of Onocleo struthiopteridis–Juglandetum mandshuricae forests exhibits the highest species richness, and Shannon's diversity index reflects polydominance (co-dominance of multiple species). In contrast, Mitello nudae–Abietetum holophyllae forests show relatively low canopy dominance. The communities are also the most homogeneous, as indicated by their low β-diversity (Fig. 4).

We found the lowest α-diversity in Rhododendro mucronulati–Betuletum schmidtii forests with 30 ± 11 species of vascular plants. However, there is high heterogeneity in species composition within the described communities of this association, as evidenced by the highest Jaccard and Sørensen indices (Fig. 4).

The comparison of diversity between SMMFs (alliance Carpino cordatae–Abietion holophyllae) and their successional derivatives (alliance Dictamno dasycarpi–Quercion mongolicae) revealed that the observed γ-diversity (species pool) of the Carpino cordatae–Abietion holophyllae in the Russian Far East comprises 460 vascular plant species (predicted: 651 ± 50), increasing to 545 species (predicted: 700 ± 39) when including South Korean SMMFs. In contrast, the Dictamno dasycarpi–Quercion mongolicae forests show lower diversity, with an observed pool of 381 species (predicted: 450 ± 9). Mean α-diversity was also higher in the Carpino cordatae–Abietion holophyllae forests (59

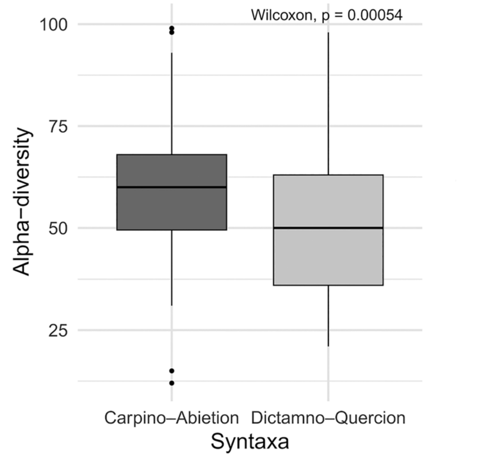

Figure 5 Scatter and mean values of α-diversity of SMMFs (Carpino–Abietion) and their derivatives (Dictamno–Quercion)

species) than in the Dictamno dasycarpi–Quercion mongolicae (51 species), confirming significantly greater species richness in primary SMMFs ($p < 0.05$, Fig. 5).

SMMF communities consist of an average of 7 ± 3 tree species per site, and 9 ± 5 shrub and woody liana species. In contrast, secondary deciduous forests are formed by only 3 ± 2 tree species, and the shrub diversity in these sites averages 7 ± 5 species. Unlike the Carpino cordatae–Abietion holophyllae forests, lianas in secondary deciduous forests, with few exceptions, do not extend into the tree layer.

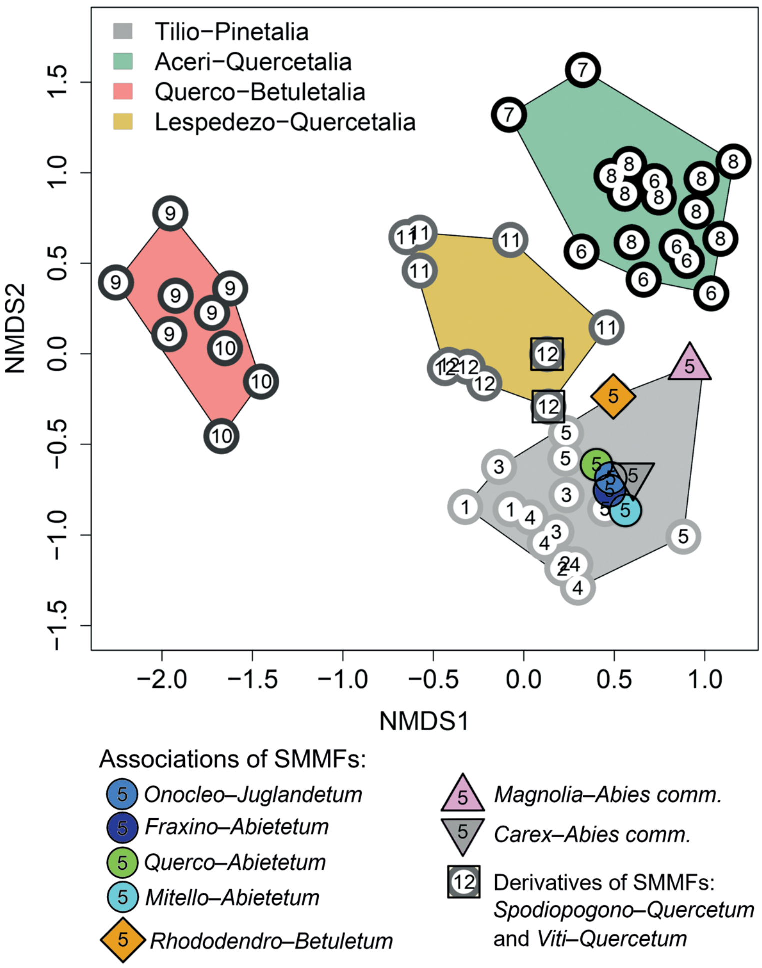

Figure 6 NMDS for new associations (highlighted with symbols) compared with previously described associations from the classes Quercetea mongolicae and Querco mongolicae–Betuletea davuricae (stress = 0.11). The numbers indicate alliances: Ord. Tilia amurensis–Pinetalia koraiensis: 1 – Rhododendro daurici–Pinion koraiensis, 2 – Abieti nephrolepidis–Pinion koraiensis, 3 – Tilio amurensis–Pinion koraiensis, 4 – Phrymo asiaticae–Pinion koraiensis, 5 – Carpino cordatae–Abietion holophyllae; Ord. Aceri pseudosieboldiani–Quercetalia mongolicae: 6 – Rhododendro schlippenbachii–Quercion mongolicae, 7 – Rhododendro mucronulati–Pinion densiflorae, 8 – Lindero obtusiloba–Quercion mongolicae; Ord. Querco mongolicae–Betuletalia davuricae: 9 – Kitagawio terebinthaceae–Betulion davuricae, 10 – Ligulario fischeri–Betulion davuricae; Ord. Lespedezo bicoloris–Quercetalia mongolicae: 11 – Corylo heterophyllae–Quercion mongolicae, 12 – Dictamno dasycarpi–Quercion mongolicae

DISCUSSION

SMMFs among other syntaxa of the Quercetea mongolicae

We propose classifying the entire diversity of SMMFs within the alliance Carpino cordatae–Abietion holophyllae, based on the combination of diagnostic species. The syntaxonomic position of the association Rhododendro–Betuletum schmidtii was undefined according to the vegetation classification of the Kedrovaya Pad' Nature Reserve (Petrunenko & Dzizurova 2024). We concluded to subordinate the association to the alliance Carpino cordatae–Abietion holophyllae. The alternative solutions, the Corylo heterophyllae–Quercion mongolicae and the Dictamno dasycarpi–Quercion mongolicae are not supported by the floristic analysis and the diagnostic species combinations (Fig. 6).

We also examined two forest communities based on archive data from the mountainous regions of South Korea. High-altitude SMMFs with *Sasamorpha borealis* (*Magnolia sieboldii–Abies holophylla* forest community) correspond to the forest type that Černý et al. (2015) proposed to classify under the alliance Lindero obtusilobae–Quercion mongolicae of the order Aceri pseudosieboldiani–Quercetalia mongolicae. Černý et al. (2015) also described high-altitude SMMFs featuring a larger set of species from the South Manchurian flora and more southern species such as *Ainsliaea acerifolia*, *Magnolia sieboldii*, and *Tripterygium regelii* (alliance Lindero obtusilobae–Quercion mongolicae). The communities correspond to the *Carex drymophila–Abies holophylla* forest community described here. According to our data, these forests may be found at relatively low altitudes of around 300–400 m a.s.l.

The NMDS results and diagnostic taxa analysis indicate that the *Carex drymophila–Abies holophylla* forest community should be subordinated to the alliance Carpino cordatae–Abietion holophyllae (Fig. 6). The syntaxonomical position of the *Magnolia sieboldii–Abies holophylla* forest community is less clear, but we suggest considering these forests within the Carpino cordatae–Abietion holophyllae due to the large number of diagnostic taxa from this alliance in the tree layer (Table 1, Fig. 6).

We synonymize the association Querco mongolicae–Abietetum holophyllae with Polysticho tripteron–Pinetum koraiensis Krestov, Dzizyurova et Korznikov 2023, based on cluster analysis results, as they do not separate into distinct groups and exhibit a high degree of floristic similarity and ecological homogeneity. These conclusions were based on the analysis of 113 geobotanical relevés covering all parts of the Russian range of SMMFs. The NMDS diagram (Fig. 6) reflects the similarity of the new associations of the alliance Carpino cordatae–Abietion holophyllae (No. 5, highlighted with symbols) with previously identified associations of this alliance (No. 5 without contour).

We found parallels between our new classification scheme with the forest types identified by Vasilyev & Kolesnikov (1962). The association Mitello nudae–Abietetum holophyllae corresponds to the Manchurian fir-mixed forest type with *Abies nephrolepis* (Fig. 7, I) described by Vasilyev & Kolesnikov (1962). The subassociation Querco mongolicae–Abietetum holophyllae typicum share corresponds to the Manchurian fir-mixed forest type with mixed shrubs and *Betula costata* with *Acer* spp. and *Philadelphus tenuifolius* (Fig. 7, II, III, VI). The subassociation Querco mongolicae–Abietetum holophyllae oxalidetosum acetosellae corresponds to Manchurian fir-mixed forest type with *Corylus* spp. and *Weigela florida* (Fig. 7, IV). The association Rhododendro mucronulati–Betuletum schmidtii corresponds to Manchurian fir-mixed forest type with *Lespedeza bicolor* and *Weigela florida* on well-drained upper, steep slopes (Fig. 7, V). The association Onocleo struthiopteridis–Juglandetum mandshuricae represents Manchurian fir-mixed forest type with *Acer* spp. and *Impatiens noli-tangere* (Fig. 7, VII). The association Fraxino mandshurici–Abietetum holophyllae corresponds to Manchurian fir-mixed forest type with *Syringa reticulata* subsp. *amurensis* and *Fraxinus mandshurica*, occupying low areas of river terraces inundated or briefly flooded by river waters (Fig. 7, VIII).

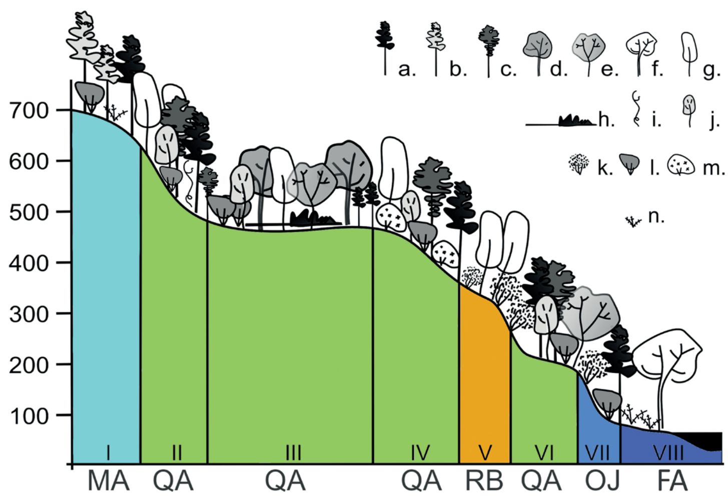

Figure 7 Structure and types of SMMFs in Russia (based on Vasilyev & Kolesnikov 1962, Kolbek et al. 2003). Letters: a – *Abies holophylla*, b – *A. nephrolepis*, c – *Pinus koraiensis*, d – *Quercus mongolica*, e – *Acer* spp., f – *Fraxinus mandshurica*, g – *Betula* spp., h – died *Abies holophylla*, i – liana, j – *Carpinus cordata*, k – *Lespedeza bicolor*, l – *Corylus* spp., m – *Weigela florida*, n – fern. Plot type: I – drained upper parts of slopes of all exposures and watersheds, II – middle parts of moderately drained gentle and moderately steep slopes of all exposures, III – moderately drained flat areas of slopes (shown here is one of the stages of natural dynamics), IV – upper and middle parts of drained slopes of various steepness of all exposures, V – well-drained upper steep parts of southern slopes, VI – poorly drained slopes of various steepness of all exposures, VII – drained steep slopes of river terraces, VIII – gently sloped poorly drained areas of river valleys. Syntaxa: MA – Mitello nudae–Abietetum holophyllae; QA – Querco mongolicae–Abietetum holophyllae; RB – Rhododendro mucronulati–Betuletum schmidtii; OJ – Onocleo struthiopteridis–Juglandetum mandshuricae; FA – Fraxino mandshurici–Abietetum holophyllae

SMMFs diversity

South Manchurian mixed forests are widely recognized as floristically rich ecosystems and rank among the most diverse temperate forests globally (Vasilyev & Kolesnikov 1962, Kurentsova 1973, Krestov & Verkholat 2003, Krestov et al. 2006). Vasilyev & Kolesnikov (1962) estimated that their total vascular plant diversity might reach up to 1000 species. However, this number was overestimated. For example, the Land of the Leopard National Park, which encompasses a range of habitats including SMMFs, broadleaved forests, *Larix gmelinii* var. *olgensis* stands, *Pinus densiflora* forests, shrublands, and meadows, hosts a total of 1143 vascular plant species (Marchuk 2021). In our dataset, the observed number of vascular plant species within SMMFs is 545, with a predicted species pool of 670 ± 39.

The γ-diversity of SMMFs is comparable to other temperate forest ecosystems. For instance, the zonal cool-temperate broadleaved and mixed forests of Hokkaido (Japan), classified within Fagetea crenatae Miyawaki, Ohba et Murase 1964, comprise 474 species (Miyawaki et al. 1988).

Numerous studies have highlighted floristic and structural parallels between the forests of East Asia and eastern North America (Graham 1972, Boufford & Spongberg 1983, Box & Fujiwara 2012, Loidi et al. 2025). A comparison of two 400 m² relevés – one in an SMMF near Vladivostok and another in a mixed forest with *Pinus strobus* in Bronte Creek, Ontario (43°N) – revealed substantial floristic similarity at the family and genus levels. Both plots were species-rich: 87 vascular plant species were recorded in the SMMF, and 74 in the North American counterpart (Box & Fujiwara 2012).

Forests similar to SMMFs of Western Eurasia belonged to the class Querco roboris–Fagetea sylvaticae Br.-Bl. & Vlieger in Vlieger 1937 (Prokopenko 2013) represent the most floristically rich natural temperate forests in the European part of Russia, yet they contain 45 % fewer species than SMMFs, with γ-diversity reaching only 255 vascular plant species (Smirnova 2017). This disparity can be attributed to the fact that the distribution range of SMMFs was not subjected to extensive Pleistocene glaciations (Clark et al. 2009), unlike European forests, which experienced repeated ice sheet advances that severely reduced their biodiversity refugia (Willis & Van Andel 2004). Climate reconstructions further confirm the persistence of forest-steppe landscapes in southern Primorye during the Last Glacial Maximum, supporting the long-term stability of SMMFs refugia (Evstigneeva et al. 2025).

Recent comparative studies of the diversity of temperate deciduous forests in North America, Europe and East Asia by Loidi et al. (2025) showed that East Asian forests had the highest floristic richness, especially among woody species, while Europe was characterised by the richest herbaceous component. North America showed the lowest average phylogenetic turnover, followed by East Asia and Europe. The exceptional diversity of woody, gymnosperm and ferns in East Asia may be due to their ancient origin in the geological history of the biome. In contrast, the high diversity of herbaceous species in European forests probably reflects post-glacial environmental filtering shaped by human influence and the grassland-forest interrelations. These patterns reflect the evolutionary legacy of temperate deciduous forests, coased by their formation history in bioclimaticaly similar conditions.

Comparison of species richness among different SMMF associations reveals considerable variation depending on topographical position. As noted by Box & Fujiwara (2012), species richness in forests is strongly influenced by both topography and substrate characteristics. It tends to be higher in temporarily waterlogged lowlands and on gentle slopes, and lower on rocky slopes with shallow soils – a pattern corroborated by our findings.

The α-diversity of secondary oak-dominated forests within the alliance Dictamno dasycarpi–Quercion mongolicae is significantly lower than that of SMMFs. These forests support fewer species, with less than half the diversity of SMMFs in terms of stand composition. They are also depleted in lianas compared to SMMFs.

CONCLUSIONS

In this study, we provided the syntaxonomical revision of SMMFs based on an extensive dataset of the vegetation relevés. As a result of the quantitative classification, we described the new association of northern SMMFs Mitello nudae–Abietetum holophyllae. We also described a new suballiance Filipendulo palmatae–Juglandenion mandshuricae, which unites associations of bottom-valleys forests within the alliance Carpino cordatae–Abietion holophyllae.

The syntaxonomical system of SMMFs

Class
Order
Alliance
Suballiance
Association
Subassociation

Quercetea mongolicae Song ex Krestov, Dzizyurova et Korznikov 2023

Tilio amurensis–Pinetalia koraiensis Kim ex Krestov, Dzizyurova et Korznikov 2023

Carpino cordatae–Abietion holophyllae Kim ex Krestov, Dzizyurova et Korznikov 2023

Eu-Carpino cordatae–Abietenion holophyllae 2025

Mitello nudae–Abietetum holophyllae Dzizyurova, Lisitsyna, Korznikov, Dudov, Petrenko et Krestov 2025

Rhododendro mucronulati–Betuletum schmidtii Petrunenko et Dzizurova 2024

Querco mongolicae–Abietetum holophyllae Kim ex Krestov, Dzizyurova et Korznikov 2023

Querco mongolicae–Abietetum holophyllae typicum Kim ex Krestov, Dzizyurova et Korznikov 2023

Querco mongolicae–Abietetum holophyllae oxalidetosum acetosellae Gumarova, Prohorenkot et Verkholat ex Krestov, Dzizyurova et Korznikov 2023

Carex drymophila–Abies holophylla forest comm.

Magnolia sieboldii–Abies holophylla forest comm.

Filipendulo palmatae–Juglandenion mandshuricae Dzizyurova, Lisitsyna, Korznikov, Dudov, Petrenko et Krestov 2025

Fraxino mandshurici–Abietetum holophyllae Gumarova, Prokhorenko, Verkholat ex Krestov, Dzizyurova et Korznikov, 2023

Onocleo struthiopteridis–Juglandetum mandshuricae Petrunenko et Dzizurova 2024 nom. mut. nov.

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APPENDIX

Table A1. Suballiance Filipendulo palmatae–Juglandenion mandshuricae **suball. nov.** (selected 10relevés of each association)

Association	**Onocleo struthiopteridis–Juglandetum mandshuricae**										**Fraxino mandshurici–Abietetum holophyllae**									
Table number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9 ****	**10 ***	**11**	**12**	**13**	**14 ***	**15**	**16**	**17**	**18**	**19**	**20**
Juice number	158	161	173	188	194	523	525	526	527	528	116	117	118	120	121	122	123	124	125	126
Author code	VV	PE	PE	PE	PE	DV, KR	DV, KR	PE	PE	PE	GU	GU	GU	GU	GU	GU	GU	GU	GU	GU
Year	2005	2014	2015	2016	2016	2018	2018	2015	2016	2016	1994	1994	1994	1993	1994	1994	1994	1994	1994	1994
Sample area, m²	400	400	400	400	400	400	400	900	900	900	NA	NA	NA	400	NA	NA	NA	NA	NA	NA
Elev. (m)	NA	117	47	83	98	123	NA	70	95	130	NA	NA	NA	130	NA	NA	NA	NA	NA	NA
Aspect	NA	113	–	–	–	–	–	90	–	315	45	13	360	–	–	–	–	90	–	–
Slope	NA	2	0	0	0	0	0	3	0	5	7	5	5	0	0	0	0	2	0	0
Tree cover	99	90	80	65	50	NA	NA	50	60	80	80	90	70	60	70	60	60	70	80	60
Stand height	NA	30	30	NA	NA	NA	NA	25	28	26	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Shrub cover	80	10	10	15	11	NA	NA	40	30	15	55	35	11	30	15	40	10	55	15	30
Shrub height	NA	NA	NA	NA	NA	NA	NA	4.5	4.5	2.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Herb cover	NA	40	50	65	60	NA	NA	80	30	40	65	60	10	80	65	55	70	65	45	35
Location	KP	KP	KP	KP	KP	KP	KP	KP	KP	KP	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA
Spec. num.	71	61	69	74	65	60	35	70	59	66	110	101	100	88	111	91	104	91	97	90
Diagnostic species of the ass. Onocleo struthiopteridis–Juglandetum mandshuricae																				
Brachybotrys paridiformis	+	+	+	+	r	1	1	+	+	1	·	·	·	·	·	·	·	·	·	·
Chrysosplenium sinicum	·	·	·	1	1	1	1	1	1	·	·	·	·	·	·	·	·	·	·	·
Geranium wilfordii	+	·	·	1	+	·	·	·	1	·	·	·	·	·	·	·	·	·	·	·
Geum aleppicum	+	+	·	+	+	·	·	·	r	·	·	·	·	+	·	·	·	·	·	·

Table A1. Continued.

Table number	1	2	3	4	5	6	7	8	9 **	10 *	11	12	13	14 *	15	16	17	18	19	20
Oxalis obtriangulata	+	+	+	+	+	·	·	r	r	·	·	+	·	·	·	·	·	+	+	·
Phlomoides maximowiczii	+	·	·	+	+	1	1	1	+	1	·	·	·	·	·	·	·	·	·	·
Stellaria bungeana	1	+	+	1	+	1	1	+	1	+	·	·	·	+	·	·	·	+	+	·
Viola acuminata	+	·	+	+	·	+	·	r	·	+	·	·	·	+	·	+	·	+	·	·
Diagnostic species of the ass. Fraxino mandshurici–Abietetum holophyllae																				
Alnus hirsuta	·	·	·	·	·	·	·	·	1	·	1	+	1	+	+	1	+	+	1	+
Caltha palustris	·	·	·	·	·	·	·	+	·	·	1	1	+	·	+	1	1	·	·	·
Carex dispalata	1	·	·	1	·	·	·	·	1	·	·	1	1	+	1	1	1	1	1	1
Equisetum hyemale	·	·	·	·	·	·	·	·	·	·	1	·	1	1	1	+	3	1	1	1
Lilium distichum	·	·	+	·	·	r	·	+	·	·	·	+	+	+	1	1	+	+	·	·
Pedicularis resupinata	+	·	·	·	·	·	·	·	·	·	+	·	+	+	·	+	·	·	+	+
Prunus padus	+	·	·	·	·	·	·	·	·	·	+	·	·	+	+	+	+	+	+	+
Trigonotis radicans	·	·	·	·	·	·	·	·	·	·	+	+	+	+	+	+	+	+	·	+
Trisetum sibiricum	·	·	·	·	·	·	·	·	·	·	+	+	·	·	·	·	+	·	·	+
Diagnostic species of the suball. Filipendulo palmatae–Juglandenion mandshuricae																				
Aconitum alboviolaceum	+	+	·	·	r	·	·	r	·	·	·	·	·	+	+	+	·	1	+	+
Athyrium crenulatoserrulatum	3	3	·	1	1	·	·	4	+	·	·	·	·	·	·	+	·	1	+	·
Carex accrescens	1	1	+	·	+	r	·	r	r	·	1	·	·	+	·	+	+	·	·	·
Carex uda	+	·	·	·	+	·	·	+	+	·	+	+	·	+	·	1	1	+	·	+
Filipendula palmata	+	·	·	+	+	r	·	+	+	r	+	·	1	1	+	1	+	1	1	+
Impatiens furcillata	+	·	·	+	·	·	·	·	1	·	+	+	·	+	·	+	1	·	+	·
Juglans mandshurica	3	·	·	1	1	3	·	3	·	1	+	+	+	1	3	+	·	1	+	+
Onoclea struthiopteris	3	·	1	1	3	·	·	·	+	+	1	+	·	1	1	1	+	·	·	+
Phellodendron amurense	1	1	·	1	1	·	·	·	1	·	+	+	+	1	1	1	+	4	3	·
Sanicula rubriflora	1	+	+	1	1	·	·	1	1	+	+	·	·	1	+	1	·	+	+	·
Diagnostic species of the all. Carpino cordatae–Abietenion holophyllae																				
Abies holophylla	1	3	3	1	1	1	·	·	·	·	+	3	3	4	3	+	1	+	+	1
Acer barbinerve	·	1	1	·	·	·	·	1	1	·	1	1	1	1	1	·	1	1	1	1
Acer mandshuricum	3	+	·	1	1	+	·	1	1	·	+	·	+	1	+	1	1	5	+	1
Carex ussuriensis	·	·	·	·	·	·	·	·	·	·	+	+	+	+	1	·	+	+	+	1
Carpinus cordata	·	3	1	1	+	·	·	1	1	1	4	3	1	1	+	·	·	·	·	+
Dryopteris goeringianum	·	+	1	·	·	+	+	·	·	+	·	·	·	·	·	+	·	+	+	·
Kalopanax septemlobus	·	+	·	·	·	·	·	·	1	1	+	+	·	·	·	·	·	·	·	+
Diagnostic species of the ord. Tilio amurensis–Pinetalia koraiensis																				
Acer tegmentosum	·	+	1	·	·	·	·	·	1	1	1	1	+	·	·	+	+	·	·	+
Aegopodium alpestre	1	1	1	1	1	1	1	r	+	+	·	·	+	·	·	·	·	·	·	·
Berberis amurensis	·	·	1	1	·	·	·	1	1	·	·	·	·	+	·	·	·	+	+	+
Betula costata	·	1	·	1	·	1	1	·	·	·	+	1	1	·	1	·	+	+	·	·
Carex auriculata	3	1	+	+	1	+	·	+	·	r	1	1	+	1	1	1	+	3	1	1
Convallaria keiskei	·	·	+	·	·	·	·	·	·	r	1	1	1	+	·	·	+	·	+	+
Corylus sieboldiana var. *mandshurica*	·	·	1	·	·	1	1	·	·	1	·	·	·	1	1	·	1	+	1	1
Diarrhena mandshurica	·	+	+	r	+	r	·	+	r	r	+	+	+	1	·	+	·	·	+	+
Eleutherococcus senticosus	+	+	1	+	+	1	1	1	·	1	1	·	+	+	1	1	·	1	1	1
Euonymus verrucosus	+	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	+
Fraxinus mandshurica	+	r	1	1	1	1	·	1	1	1	3	3	5	1	1	4	4	1	4	4
Philadelphus tenuifolius	+	1	1	+	+	1	1	1	·	1	3	1	1	1	1	1	1	1	1	1
Pinus koraiensis	·	1	·	1	·	·	·	·	·	·	+	1	+	+	1	·	1	·	·	4
Thalictrum filamentosum	1	r	1	+	1	+	+	1	·	1	1	1	1	1	1	+	+	1	+	1
Schisandra chinensis	+	·	1	·	·	r	·	+	·	+	+	+	+	1	1	+	+	+	1	+
Syringa reticulata subsp. *amurensis*	1	·	1	1	1	4	1	1	1	·	1	1	1	3	1	3	1	4	5	1
Ulmus laciniata	·	·	·	1	·	·	·	1	1	1	·	·	1	+	+	·	+	3	+	+
Viola selkirkii	·	·	·	·	·	·	·	r	·	r	+	+	·	+	·	+	+	+	·	+
Waldsteinia maximowicziana	·	·	1	·	·	·	·	·	·	·	1	1	+	·	1	·	·	1	1	1
Diagnostic species of the cl. Quercetea mongolicae																				
Acer mono	5	1	3	4	1	3	1	1	1	1	1	3	1	3	4	5	1	1	+	3
Actinidia arguta	·	·	·	·	·	·	·	·	·	·	1	1	1	+	+	·	+	·	·	·
Athyrium yokoscense	·	·	1	+	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·
Alniaria alnifolia	·	·	·	·	·	·	·	·	·	·	·	+	+	·	·	·	·	·	·	·
Carex siderosticta	+	1	+	+	+	1	·	+	r	r	+	+	1	1	+	+	+	+	+	+
Dryopteris crassirhizoma	+	1	·	+	+	·	·	+	·	·	4	1	1	1	1	+	+	1	1	1
Maianthemum japonicum	·	+	+	·	·	r	·	1	·	·	1	+	+	+	1	1	+	1	+	+
Phegopteris connectilis	·	·	·	·	·	·	·	·	·	·	1	+	+	·	·	+	+	·	·	+
Pyrola japonica	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Other species																				
Lamium album subsp. *barbatum*	+	+	·	+	+	1	1	·	·	+	·	·	·	+	·	+	·	·	·	·
Rubia chinensis	+	·	·	1	+	r	·	·	·	r	·	·	·	·	·	·	·	·	·	+
Aconitum stoloniferum	·	+	·	+	·	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·
Chrysosplenium pilosum var. *valdepilosum*	·	+	1	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Ranunculus japonicus	·	·	·	1	+	·	·	r	·	·	·	·	·	·	·	·	·	·	·	·
Paris verticillata	·	·	·	·	·	·	·	·	·	·	+	+	·	+	+	·	+	·	·	·
Cirsium schantarense	·	·	·	·	·	·	·	·	·	·	+	+	·	+	·	+	·	+	+	+
Carex rhizina subsp. *reventa*	+	·	·	·	·	·	·	·	·	·	+	+	1	1	1	1	+	+	1	+
Polystichum tripteron	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	+	1	·	·	·
Prunus maximowiczii	·	·	·	·	·	·	·	·	·	·	1	·	+	·	+	·	+	+	·	·
Actinidia kolomikta	·	·	·	·	·	·	·	1	·	·	+	1	1	1	+	+	1	·	·	+
Plagiorhegma dubium	·	·	·	·	·	·	·	·	·	r	+	+	+	1	·	+	+	·	+	+
Lonicera chrysantha	·	+	·	·	·	·	·	·	·	·	+	+	+	+	1	·	·	·	·	+
Carex umbrosa subsp. *pseudosabynensis*	·	·	·	·	·	·	·	·	·	·	1	1	1	1	+	·	·	·	+	·
Lychnis fulgens	·	·	·	·	·	·	·	·	·	·	+	+	·	+	·	·	+	·	·	·
Isodon excisus	·	·	·	·	·	1	1	·	·	+	1	1	·	+	·	+	+	+	1	1
Symplocarpus renifolius	·	·	·	·	·	·	·	·	·	·	·	·	1	·	·	·	4	·	·	1
Deutzia parviflora var. *parviflora*	·	1	·	·	·	·	·	·	·	·	+	+	1	+	·	·	+	+	·	1
Ribes mandshuricum	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1	·	+	1	1	+
Osmundastrum cinnamomeum subsp. *asiaticum*	·	·	1	·	·	·	·	·	·	·	+	3	4	+	+	·	1	·	+	1
Spiraea chamaedryfolia	·	·	·	·	·	·	·	·	·	·	·	·	+	·	1	+	·	·	+	+
Aruncus dioicus	·	+	·	·	·	1	1	r	·	·	1	3	1	+	1	+	1	1	+	1
Anemonoides udensis	·	·	·	·	·	·	·	·	·	·	1	1	·	·	+	+	·	·	·	·
Betula pendula subsp. *mandshurica*	·	·	1	·	·	·	·	·	·	·	·	·	1	1	·	·	3	1	1	+

Table A1. Continued.

Table number	1	2	3	4	5	6	7	8	9 **	10 *	11	12	13	14 *	15	16	17	18	19	20
Euonymus sachalinensis	·	·	·	·	·	·	·	·	·	·	1	1	+	·	·	·	·	·	·	·
Pyrus ussuriensis	·	·	·	·	+	·	·	·	·	·	·	+	+	1	·	·	+	+	+	·
Filipendula glaberrima	·	·	·	·	·	·	·	·	·	·	·	1	·	·	1	1	1	·	·	·
Euonymus macropterus	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	+	·	+
Solidago virgaurea	·	·	·	·	·	·	·	·	·	·	·	+	+	+	·	·	·	·	·	·
Pleurospermum uralense	·	·	·	·	·	·	·	·	·	·	·	+	·	+	+	+	·	·	·	·
Athyrium spinulosum	·	·	·	·	·	·	·	·	·	·	+	+	1	·	1	·	·	·	·	·
Platanthera metabifolia	·	·	·	·	·	·	·	·	·	·	+	·	·	+	·	·	·	·	+	+
Arisaema amurense	1	1	+	+	r	r	·	+	+	r	1	+	+	+	1	1	+	1	1	+
Tilia amurensis	1	1	1	1	1	5	4	1	·	1	3	1	1	4	3	·	1	+	+	1
Cardamine leucantha	+	+	·	+	+	+	·	r	·	r	+	+	+	1	+	+	1	+	+	+
Deparia pycnosora	+	+	+	·	+	+	·	1	·	1	1	1	+	1	1	1	1	1	·	+
Viburnum sargentii	1	·	1	1	·	+	+	1	1	·	3	1	1	+	+	·	+	+	1	1
Hylomecon vernalis	·	1	+	+	+	1	1	1	+	·	·	+	·	1	1	1	+	1	+	+
Astilbe chinensis	+	·	+	+	·	r	r	+	·	r	+	+	+	+	+	+	+	+	·	+
Caulophyllum robustum	·	+	1	+	·	1	1	1	·	+	1	1	+	+	+	+	·	+	1	1
Athyrium sinense	·	·	+	·	+	1	1	·	·	1	1	+	1	1	1	1	1	1	1	+
Aconitum sczukinii	1	·	+	·	+	·	·	·	+	r	+	+	+	+	+	+	+	+	+	+
Valeriana fauriei	+	+	+	+	+	·	·	+	·	+	+	+	+	1	+	+	·	·	+	+
Euonymus alatus	+	·	1	+	+	·	·	+	·	·	+	+	+	+	1	+	+	1	+	+
Parasenecio hastatus	·	+	·	+	·	r	·	r	r	r	+	+	·	+	+	+	+	+	+	+
Scutellaria pekinensis var. *ussuriensis*	+	+	+	+	+	1	1	r	+	·	+	+	+	+	·	+	+	·	·	·
Vitis amurensis	+	·	+	+	+	r	·	·	·	1	1	1	1	1	+	·	+	·	+	+
Asarum sieboldii	+	+	+	+	+	·	·	+	·	·	·	+	·	+	+	+	+	+	+	+
Parasenecio praetermissus	+	+	·	·	+	1	1	·	1	1	+	+	1	·	+	+	·	·	·	+
Saussurea subtriangulata	·	·	+	·	·	·	·	+	·	+	+	+	+	+	+	+	+	+	·	+
Galium davuricum	+	·	·	·	·	·	·	·	·	r	+	+	+	+	+	+	+	+	+	+
Oxalis acetosella	·	+	+	+	1	·	·	·	·	·	+	+	1	·	+	1	·	+	+	1
Quercus mongolica	·	·	1	·	·	1	1	1	·	1	+	1	+	1	+	·	+	·	·	1
Dioscorea nipponica	+	+	·	1	+	+	+	·	·	·	·	+	·	+	+	·	+	+	·	+
Heracleum dissectum	+	·	·	·	+	·	·	·	·	r	+	+	·	+	+	+	·	1	+	+
Impatiens noli-tangere	+	+	·	+	+	1	1	r	·	+	+	·	·	+	+	·	·	·	·	·
Maianthemum bifolium	·	+	1	·	·	·	·	·	·	·	+	1	1	1	·	1	+	+	·	1
Acer pseudosieboldianum	·	1	1	·	·	·	·	1	·	·	+	1	+	+	·	·	+	·	+	1
Pseudostellaria sylvatica	·	·	+	·	·	·	·	r	·	·	+	+	+	+	+	+	+	·	·	+
Ulmus davidiana var. *japonica*	1	·	·	1	1	·	·	·	·	·	+	·	1	1	·	3	+	3	1	·
Actaea dahurica	·	·	·	+	·	1	1	·	+	+	+	+	·	+	·	·	+	+	·	·
Carex lanceolata	·	·	1	+	·	1	·	r	·	·	·	+	1	+	·	·	·	·	+	+
Rhamnus davurica	1	·	1	+	+	·	·	·	·	·	·	·	·	+	·	+	+	+	+	·
Nabalus tatarinowii	·	+	·	+	·	·	·	·	·	·	+	·	·	+	+	1	·	+	+	+
Adoxa moschatellina	·	+	·	+	·	·	·	·	·	r	+	+	·	+	+	+	+	·	·	·
Fraxinus chinensis subsp. *rhynchophylla*	·	·	1	+	·	+	+	·	·	·	+	+	+	+	·	·	·	·	·	+
Phryma nana	·	+	+	·	·	·	·	·	·	+	+	·	+	+	·	+	·	+	·	+
Artemisia argyi var. *argyi*	·	·	·	·	·	·	·	·	·	+	+	·	+	1	·	+	·	1	+	+
Rubus crataegifolius	·	·	·	+	·	·	·	·	+	·	·	·	+	+	+	+	·	+	·	+
Rubia cordifolia	·	·	·	·	+	·	·	+	·	r	·	·	·	+	+	+	·	+	+	·
Anemonoides glabrata	·	·	1	·	·	·	·	r	·	·	1	+	·	·	1	+	·	·	+	+
Lonicera maackii	1	·	·	1	1	1	·	·	1	·	·	·	·	·	·	+	·	1	3	·
Carex quadriflora	+	1	·	·	·	·	·	·	·	·	·	·	·	·	+	+	·	1	+	+
Actaea asiatica	·	·	·	·	·	r	·	·	·	·	+	+	·	+	+	·	·	·	+	+
Adiantum pedatum	·	·	+	·	·	1	1	·	·	+	·	·	·	+	+	·	+	·	·	·
Chrysosplenium pilosum	+	·	·	·	·	·	·	·	·	·	+	·	·	+	+	+	+	·	·	+
Veronicastrum sibiricum	·	·	·	·	·	·	·	·	·	r	+	+	·	+	·	+	·	+	·	·
Lonicera praeflorens	+	·	·	·	+	·	·	·	·	·	·	·	1	1	+	·	·	·	·	+
Clematis fusca	·	·	·	·	·	·	·	1	·	·	+	+	·	·	·	+	·	+	·	+
Aster scaber	·	·	·	·	·	·	·	·	·	r	·	·	·	+	·	·	·	+	+	+
Carex arnellii	1	·	·	1	·	·	·	·	·	·	·	·	·	1	·	·	1	·	·	1
Populus suaveolens	·	·	·	·	·	·	·	·	1	·	·	·	·	·	+	+	·	1	1	·
Circaea lutetiana	+	·	·	+	·	·	·	·	·	·	·	·	·	·	·	+	+	+	·	·
Polemonium chinense	·	·	+	+	·	·	·	·	r	·	+	·	·	·	·	·	+	·	·	·
Urtica dioica subsp. *holosericea*	·	·	·	·	·	·	·	·	r	·	+	·	·	·	·	+	1	·	·	·
Asparagus schoberioides	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	+	+	+	·
Melica nutans	+	·	·	·	·	·	·	r	·	·	·	+	·	·	·	·	·	·	+	·
Trillium sp.	·	·	+	·	·	·	·	·	·	·	+	+	·	+	·	·	·	·	·	·
Potentilla fragarioides	·	·	+	·	·	·	·	·	·	r	·	·	·	+	·	+	·	·	·	·
Ribes maximowiczianum	·	·	·	·	·	·	·	+	·	·	+	·	·	·	·	·	·	·	·	+
Viburnum burejaeticum	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	+	+	·
Lathyrus komarovii	·	·	·	·	·	·	·	·	·	·	·	+	+	·	·	·	·	·	·	+
Adenocaulon himalaicum	·	·	·	·	·	·	·	·	+	·	·	·	·	·	+	+	·	·	·	·
Veratrum dahuricum	·	·	·	·	·	·	·	·	·	·	1	1	·	·	·	+	·	·	·	·
Milium effusum	·	·	+	+	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·
Moehringia lateriflora	·	·	·	·	·	·	·	·	·	r	+	+	·	·	·	·	·	·	·	·
Thalictrum aquilegiifolium var. *sibiricum*	·	·	·	·	·	·	·	·	·	·	+	·	+	·	·	·	·	·	+	·
Bupleurum longiradiatum	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	+	+	·
Vicia ramuliflora	·	·	+	·	·	·	·	·	·	·	·	+	·	·	·	·	+	·	·	·
Maianthemum dilatatum	·	·	·	·	·	·	·	+	·	·	+	·	·	·	·	+	·	·	·	·
Euphorbia esula subsp. *esula*	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	+	+
Diarrhena fauriei	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	+	·	·
Ranunculus franchetii	+	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+	·	·	·	·
Cynanchum acuminatum	·	+	·	+	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·
Betula dahurica	·	·	·	·	·	+	+	·	·	·	·	·	·	·	·	·	+	·	·	·
Pseudostellaria japonica	·	+	·	·	+	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Amphicarpaea edgeworthii	·	+	·	·	+	·	·	·	·	r	·	·	·	·	·	·	·	·	·	·
Galium pseudoasprellum	·	·	·	+	+	·	·	·	r	·	·	·	·	·	·	·	·	·	·	·
Stipa pekinensis	+	·	·	·	·	·	·	·	·	·	+	·	·	+	·	·	·	·	·	·
Thalictrum tuberiferum	·	·	·	·	+	+	·	·	·	r	·	·	·	·	·	·	·	·	·	·

Found in 1 or 2 relevés: *Aconitum taigicola* 4: +, 8: 1; *Actinidia polygama* 13: +; *Adenophora pereskiifolia* 8: r, 19: +; *Adonis amurensis* 15: +; *Agrimonia coreana* 5: +; *A. pilosa* 18: +; *Allium monanthum* 15: +; *A. ochotense* 8: r; *Alnus japonica* 16: +; *Anemonoides amurensis* 15: +, 16: +;

Table A1. Continued.

Anemonoides sp. 16: +; *A. umbrosa* 4: +, 19: +; *Angelica cincta* 18: +, 19: +; *A. dahurica* 9: +; *Aralia elata* 13: +, 14: +; *Artemisia sylvatica* 9: r; *Asyneuma japonicum* 18: +; *Athyrium filix-femina* 1: 1; *Campanula punctata* 13: +; *Carex filipes* var. *oligostachys* 1: +; *Carex* sp. 9: r; *Carpesium triste* 15: +, 16: +; *Celastrus flagellaris* 18: +; *Chelidonium asiaticum* 9: r; *Chloranthus quadrifolius* 10: +; *Chrysosplenium flagelliferum* 2: 1; *C. ramosum* 1: 1; *Circaea alpina* 12: +; *C. cordata* 2: +, 11: +; *Clematis brevicaudata* 18: +; *C. serratifolia* 19: +; *Corydalis buschii* 16: +; *C. gigantea* 19: +; *C. ochotensis* 9: r, 20: +; *Crawfurdia volubilis* 14: +; *Cypripedium calceolus* 14: +; *C. macranthos* 14: +; *Deutzia glabrata* 6: 1, 7: +; *Diplazium sibiricum* 6: 1, 7: 1; *Disporum smilacinum* 3: +; *D. viridescens* 6: r; *Dryopteris expansa* 11: 1, 12: 1; *Equisetum pretense* 3: +, 17: +; *E. sylvaticum* 14: +; *Euphorbia sieboldiana* 5: +; *Festuca extremiorientalis* 9: r; *Fritillaria usuriensis* 16: +; *Gagea nakaiana* 15: +, 16: +; *Galium spurium* 1: +; *Geranium maximowiczii* 3: +, 16: +; *Geranium* sp. 8: r; *G. wlassovianum* 6: r, 7: r; *Hypericum ascyron* 20: +; *Kitagawia terebinthacea* 18: 1, 19: 1; *Lactuca raddeana* 11: +; *L. triangulata* 10: r; *Lilium* sp. 4: +; *Liparis makinoana* 18: +; *Lonicera maximowiczii* 17: +, 18: +; *L. ruprechtiana* 10: 1; *Melica grandiflora* 14: +; *Menispermum dauricum* 19: +; *Micranthes manchuriensis* 4: +, 16: +; *Onoclea sensibilis* 14: +, 17: +; *Oreorchis patens* 11: +, 12: +; *Persicaria dissitiflora* 9: +; *P. thunbergii* 9: r; *Pilea mongolica* 5: +; *Polygonatum acuminatifolium* 10: r; *P. humile* 11: +; *Polygonum thunbergii* 16: +; *Potentilla centigrana* 17: +; *Primula sieboldii* 16: +; *Prunus sargentii* 11: 1, 12: +; *Pteridium latiusculum* 18: +; *Ranunculus grandis* 9: r; *Rhododendron mucronulatum* 10: r; *Salix arbutifolia* 9: 1; *Sanicula chinensis* 2: +, 18: +; *Saussurea grandifolia* 14: +; *S. umbrosa* 13: +; *Schizachne purpurascens* subsp. *callosa* 12: +, 18: +; *Schizopepon bryoniifolius* 1: +, 9: r; *Sorbaria sorbifolia* 9: 1; *Synurus deltoids* 8: +; *Tilia mandshurica* 10: 1; *Urtica thunbergiana* 5: +, 9: 1; *Veratrum oxysepalum* 3: +, 8: 1; *Vicia unijuga* 10: r; *Viola collina* 6: r, 16: +; *V. orientalis* 8: r; *Zabelia biflora* 3: 1, 8: 1.

Coordinates (N, E): 1 – 43.107, 131.52; 2 – 43.118, 131.49; 3 – 43.103, 131.54 ; 4 – 43.111, 131.53; 5 – 43.113, 131.52; 6 – 43.121, 131.41; 7 – 43.13215, 131.49687; 8 – 43.09885, 131.55197; 9 – 43.11831, 131.50774; 10 – 43.152, 131.50691; 14 – 43.252, 132.12; 11–13 and 15–20 – no available data.

Locations: KP – Kedrovaya Pad' Nature Reserve, KV – vicinity of the village of Kravtsovka, MA – Muraviov-Amurskiy peninsula (Vladivostok vicinity).

Authors of relevés: DV – Violetta D. Dzizyurova, GU – Rezeda R. Gumarova et al. 1994, KR – Pavel V. Krestov, PE – Ekaterina A. Petrunenko, VV – Valentina P. Verkholat.

*nomenclatural type.

**nomenclatural type of the rejected subassociation – Matteuccio struthiopteridis–Juglandetum mandshuricae chrysosplenietosum villosi Petrunenko et Dzizurova 2024.

Table A2. Association Rhododendro mucronulati–Betuletum schmidtii.

Table number	1	2	3	4	5	6	7	8	9	10	11	12	13*	14
Juice number	52	167	172	175	179	181	183	190	231	238	501	502	519	520
Author code		PE	PE	PE	PE	PE	PE	PE	DV, PT	KR, LA	DV, KR	DV, KR	PE	PE
Date	2011	2014	2015	2015	2015	2015	2015	2016	2023	2023	2018	2018	2014	2014
Sample area, m²	NA	300	400	300	400	300	300	300	400	400	400	400	300	300
Elev. (m)	1029	142	288	115	170	220	253	264	288	410	310	255	395	248
Aspect	275	23	315	248	45	45	315	135	300	300	315	345	315	300
Slope	19	NA	15	30	4	10	7	25	8	50	NA	NA	NA	15
Tree cover	NA	70	60	70	60	60	60	80	90	80	NA	NA	90	70
Stand height	NA	25	20	19	23	24	19	28	24	13	12	NA	18	20
Shrub cover	NA	20	15	30	10	25	30	25	20	20	NA	NA	80	40
Shrub height	NA	2	NA	2	2	2.5	2.5	2.5	3.5	3	2	NA	3.5	4
Herb cover	NA	15	20	10	20	20	30	15	30	40	20	NA	20	20
Location	Kor	KP	KP	KP	KP	KP	KP	KP	NP	NP	NP	NP	KP	KP
Spec. num.	16	25	40	23	46	28	40	35	37	33	15	12	26	18
Diagn. spp. of the ass. Rhododendro mucronulati–Betuletum schmidtii														
Betula schmidtii	+	1	·	1	3	1	1	1	1	4	3	5	4	·
Carex callitrichos var. *nana*	·	2	+	1	+	1	+	+	2	1	1	1	2	2
Rhododendron mucronulatum	+	2	1	3	+	2	2	1	1	2	4	3	4	3
Diagn. spp of the all. Carpino cordatae–Abietenion holophyllae														
Abies holophylla	1	1	+	1	2	2	2	2	2	1	·	·	·	·
Carpinus cordata	·	·	·	·	+	·	·	2	1	1	·	·	1	·
Kalopanax septemlobus	·	1	+	·	1	+	1	1	r	·	·	·	·	·
Diagn. spp. of the ord. Tilio amurensis–Pinetalia koraiensis														
Acer tegmentosum	·	+	1	·	1	+	+	r	+	r	·	·	+	·
Convallaria keiskei	·	·	+	·	+	+	·	·	r	·	·	·	·	·
Corylus sieboldiana var. *mandshurica*	·	·	1	2	+	1	1	1	1	+	·	·	1	r
Euonymus verrucosus	·	1	+	·	+	+	1	1	·	·	·	·	r	1
Philadelphus tenuifolius	·	·	1	·	·	+	+	+	·	+	·	·	·	·
Pinus koraiensis	·	1	+	1	1	1	1	2	·	·	·	·	1	1
Schisandra chinensis	·	+	1	·	+	·	+	1	r	r	·	·	r	+
Thalictrum filamentosum	·	·	+	·	+	·	·	·	+	r	·	·	·	·
Diagnostic species of the cl. Quercetea mongolicae														
Acer mono	·	·	·	·	1	·	·	1	r	·	·	+	·	+
Alniaria alnifolia	·	1	·	·	1	·	+	1	·	·	·	·	·	·
Athyrium yokoscense	·	·	+	1	+	+	1	·	r	1	+	·	·	·
Carex siderosticta	·	+	1	1	1	1	1	1	1	1	r	1	1	1
Other species														
Acer pseudosieboldianum	+	2	2	4	1	3	2	2	4	2	·	r	2	1
Quercus mongolica	1	3	3	3	3	3	3	2	5	1	2	1	1	3
Maianthemum dilatatum	·	·	1	·	1	1	1	1	+	·	·	·	r	+
Tilia amurensis	3	1	2	1	1	·	2	2	r	1	·	1	1	2
Acer komarovii	·	+	·	·	+	1	·	·	·	·	·	·	·	·
Actinidia kolomikta	·	·	+	·	+	·	+	·	r	r	·	·	+	·
Artemisia keiskeana	·	·	+	1	·	·	+	·	·	1	1	·	·	·
Athyrium spinulosum	·	·	·	·	·	·	1	·	r	1	·	·	·	·
Betula pendula subsp. *mandshurica*	·	1	1	·	1	1	1	·	·	·	·	·	·	·
Calamagrostis arundinacea	·	·	+	·	·	+	+	+	·	·	r	·	·	·
Carex lanceolata	·	r	1	·	1	·	1	+	·	+	·	·	·	r
Euonymus sachalinensis	+	·	·	·	·	·	·	·	r	·	r	·	·	·
Fraxinus chinensis subsp. *rhynchophylla*	·	1	·	+	+	·	+	1	+	·	·	·	·	·
Gymnocarpium dryopteris	·	·	·	·	·	+	·	·	r	r	·	·	r	·
Halosciastrum melanotilingia	·	·	+	·	·	+	+	+	·	·	·	·	·	·

Table A2. Continued.

Table number	1	2	3	4	5	6	7	8	9	10	11	12	13*	14
Hepatica nobilis var. *japonica*	·	·	1	·	·	·	1	+	·	·	·	·	·	·
Lespedeza bicolor	·	·	+	+	·	·	+	·	·	·	+	r	·	·
Lonicera praeflorens	·	·	1	·	+	·	1	·	+	r	·	·	·	·
Maackia amurensis	·	+	·	+	+	+	+	1	+	·	·	·	·	·
Melampyrum roseum	·	·	·	+	·	·	·	·	·	·	+	r	·	·
Moehringia lateriflora	·	+	·	·	+	·	·	+	·	·	·	·	r	r
Osmundastrum cinnamomeum ssp. *asiaticum*	·	·	·	·	+	1	+	+	+	·	·	·	·	·
Parasenecio praetermissus	·	+	+	·	·	·	·	·	·	1	·	·	·	·
Phegopteris connectilis	·	·	+	·	+	+	+	·	·	·	·	·	·	·
Phellodendron amurense	+	·	·	·	·	·	·	·	·	·	·	·	·	·
Pyrola renifolia	·	·	+	·	+	+	+	·	·	·	·	·	·	·
Solidago dahurica	·	·	·	·	·	·	·	·	r	·	·	·	r	r
Solidago virgaurea	·	·	+	·	+	+	+	r	·	·	·	·	·	·
Viola orientalis	·	·	+	·	+	·	·	+	·	·	·	·	·	r
Weigela florida	·	1	·	+	1	+	·	·	·	1	1	+	1	·

Found in 1 or 2 relevés: *Achnatherum* sp. 9: r; *Actinidia arguta* 1: +, 5: +; *Adiantum pedatum* 10: r; *Aegopodium alpestre* 9: r, 10: r; *Agastache rugosa* 1: +; *Amphicarpaea edgeworthii* 8: +; *Aruncus dioicus* 11: +; *Asarum sieboldii* 7: +, 10: r; *Atractylodes lancea* 3: +, 7: +; *Berberis amurensis* 9: r; *Carex auriculata* 3: +; *C. erythrobasis* 10: +; *C. quadriflora* 7: +; *C. rhizina* subsp. *reventa* 9: 1, 10: r; *Carex* sp. 8: +; *C. ussuriensis* 10: r; *Circaea alpina* subsp. *caulescens* 10: +; *Corydalis ochotensis* 1: +; *Crepidiastrum chelidoniifolium* 1: +; *Dryopteris crassirhizoma* 11: r; *D. expansa* 5: +; *Fraxinus mandshurica* 3: 1, 10: r; *Gentiana zollingeri* 6: +; *Juglans mandshurica* 10: 1; *Kitagawia terebinthacea* 4: +, 12: r; *Lepisorus ussuriensis* 11: r, 12: +; *Lilium distichum* 10: r; *Lindera obtusiloba* 1: 2; *Liparis kumokiri* 5: +; *Lonicera chrysantha* 3: +, 7: 1; *Lysimachia europaea* 3: +, 7: +; *Magnolia sieboldii* 1: +; *Maianthemum bifolium* 10: +; *Orthilia secunda* 5: +; *Phellodendron amurense* 1: +; *Phryma nana* 5: +, 11: r; *Polemonium caeruleum* 11: r; *Polygonatum involucratum* 4: +, 10: r; *P. odoratum* 4: +, 7: +; *Populus tremula* 2: +; *Potentilla fragarioides* 4: +; *Prunus sargentii* 5: 1; *Pteridium latiusculum* 9: r; *Pyrola japonica* 10: r; *Rhododendron schlippenbachii* 1: +; *Ribes maximoviczianum* 5: +; *Rubus crataegifolius* 9: r; *Saussurea grandifolia* 11: r; *S. subtriangulata* 5: +, 8: +; *Saxifraga rotundifolia* 10: r; *Schizachne purpurascens* subsp. *callosa* 11: r; *Scutellaria pekinensis* var. *ussuriensis* 2: +, 10: +; *Solidago dahurica* 9: r; *Spiraea chamaedryfolia* 11: +; *Spodiopogon sibiricus* 4: +; *Tilia mandshurica* 9: +; *Viburnum sargentii* 8: +; *Vicia ramuliflora* 13: r; *V. subrotunda* 4: +; *V. unijuga* 9: r; *Viola collina* 5: +; *Vitis amurensis* 5: +, 8: r; *Waldsteinia ternata* 2: +, 10: +; *Weigela subsessilis* 1: +; *Woodsia polystichoides* 11: r; *W. taishanensis* 12: r.

Coordinates (N, E): 1 – no data available; 2 – 43.103, 131.53; 3 – 43.091, 131.54 ; 4 – 43.10971, 131.53748; 5 – 43.09431, 131.54153; 6 – 43.0929, 131.54004; 7 – 43.09166, 131.544; 8 – 43.09885, 131.52211; 9 – 43.025019, 131.14911; 10 – 43.384752, 131.522053; 11 – 43.07783, 131.42659; 12 – 43.14592, 131.4958; 13 – 43.10831, 131.48776; 14 – 43.09653, 131.53224. **Locations:** KP – Kedrovaya Pad' Nature Reserve, Kor – South Korea, NP – Land of the Leopard National Park.

Authors of relevés: DV – Violetta D. Dzizyurova, KR – Pavel V. Krestov, LA – Anastasiya D. Lisitsyna, PE – Ekaterina A. Petrunenko, PT – Tatyana Ya. Petrenko.

*nomenclatural type (holotypus).

Table A3. Association Mitello nudae–Abietetum holophyllae **ass. nov.** (selected 20 relevés).

Table number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16*	17	18	19	20
Juice number	80	82	130	135	143	148	290	292	293	294	295	296	297	298	299	301	304	305	306	310
Author code	GU	GU	GU	GU	KU	KU	VD	VD	VD	VD	VD	VD	VD	VD	VD	VD	VD	VD	VD	PE
Year	1994	1994	1994	1994	1976	1976	2022	2022	2022	2022	2022	2022	2022	2022	2022	2022	2022	2022	2022	2014
Sample area, m²	NA	NA	NA	NA	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
Elev.	NA	NA	200	200	NA	NA	310	340	325	297	329	305	200	215	239	230	241	191	264	192
Aspect	157	180	210	135	NA	NA	270	292	270	180	200	245	75	106	68	24	325	93	210	270
Slope	13	13	15	12	NA	NA	7	7	7	12	10	7	2	2	1	7	10	1	3	10
Tree cover	70	70	99	99	NA	NA	40	40	65	60	40	30	60	50	35	30	45	60	50	60
Stand height	NA	NA	28	29	NA	NA	33	34	27	23	27	31	27	29	29	28	20	28	33	24
Shrub cover	10	5	30	3	NA	NA	50	1	30	15	20	20	25	25	25	30	20	13	20	10
Herb cover	35	45	50	30	NA	NA	70	60	75	45	20	65	75	55	60	50	50	50	30	80
Location	MA	MA	SA	SA	KP	KP	UR	UR	UR	UR	UR	UR	UR	UR	UR	UR	UR	UR	UR	BP
Spec. num.	92	88	54	49	37	67	68	56	65	76	68	69	72	58	65	66	66	75	80	99
Diagnostic species of the ass. Mitello nudae–Abietetum holophyllae																				
Abies holophylla	3	1	1	3	1	+	2	2	3	2	2	3	1	+	+	1	1	1	3	1
Abies nephrolepis	·	·	·	·	+	1	2	·	·	·	·	·	2	1	1	2	+	1	+	·
Actinidia polygama	·	+	·	·	·	·	+	+	+	+	·	+	+	·	+	+	+	+	r	·
Athyrium monomachi	·	·	·	·	·	·	+	1	1	+	r	·	1	+	1	+	·	+	·	·
Chelidonium asiaticum	·	·	·	·	·	·	·	·	·	r	r	+	·	·	·	·	·	·	r	r
Circaea alpina	·	·	+	+	·	+	+	+	r	·	+	+	1	·	r	r	r	·	r	·
Hylodesmum podocarpum subsp. *oxyphyllum*	+	+	·	·	·	·	r	+	r	+	r	r	+	+	+	·	+	+	+	r
Lamium album subsp. *barbatum*	+	+	1	+	+	+	r	·	+	r	+	+	r	·	+	+	+	r	+	+
Mitella nuda	·	·	·	1	·	+	+	r	+	·	·	·	·	r	·	+	·	+	+	·
Urtica thunbergiana	·	·	1	·	·	·	·	·	r	+	·	3	·	r	r	·	r	r	r	·
Diagnostic species of the all. Carpino cordatae–Abietenion holophyllae																				
Acer barbinerve	·	·	1	1	+	1	2	+	2	r	+	+	1	1	+	1	+	+	+	r
Acer mandshuricum	·	·	1	1	+	+	1	1	+	+	+	1	+	+	1	+	1	1	+	·
Carex ussuriensis	·	+	+	·	1	·	·	·	·	+	·	r	+	+	+	+	r	+	+	+
Carpinus cordata	5	5	1	3	1	1	3	4	3	3	4	4	1	3	2	2	3	1	3	3
Dryopteris goeringianum	·	·	1	+	·	+	r	·	r	·	·	+	·	·	·	·	·	·	+	+
Kalopanax septemlobus	·	+	·	·	+	·	+	r	r	·	+	+	·	·	r	r	·	·	r	·
Diagnostic species of the ord. Tilio amurensis–Pinetalia koraiensis																				
Acer tegmentosum	+	+	·	1	+	+	+	r	+	·	r	·	r	r	r	+	+	+	+	+
Aegopodium alpestre	·	·	·	·	·	·	·	1	·	·	·	·	+	·	·	+	+	·	·	2
Betula costata	·	1	·	1	+	1	1	·	r	3	r	r	2	r	3	1	·	1	+	·
Carex auriculata	1	+	1	+	·	+	+	+	·	+	r	r	1	1	+	+	+	1	+	+
Convallaria keiskei	+	+	·	+	·	·	·	·	·	r	·	·	·	r	·	·	·	·	+	+
Corylus sieboldiana var. *mandshurica*	·	·	+	·	+	1	+	·	·	·	·	·	r	·	·	·	·	r	·	·
Diarrhena mandshurica	+	+	+	+	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Eleutherococcus senticosus	+	1	+	1	+	1	1	+	+	+	+	1	1	+	1	1	+	+	+	1
Euonymus verrucosus	+	·	+	1	·	·	·	·	·	·	+	·	+	+	·	+	·	r	·	+
Fraxinus mandshurica	+	·	1	1	+	+	+	1	+	1	+	+	+	r	1	r	r	3	+	r

Table A3. Continued.

Table number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16*	17	18	19	20
Philadelphus tenuifolius	1	1	2	1	+	1	2	1	1	1	1	1	1	2	1	1	1	1	1	1
Pinus koraiensis	1	+	3	2	1	1	2	2	2	1	3	r	1	2	3	1	2	1	2	1
Schisandra chinensis	1	1	+	+	+	·	·	+	+	1	1	1	1	·	+	1	1	·	+	r
Syringa reticulata subsp. *amurensis*	1	+	·	·	·	+	1	+	1	1	+	+	r	1	1	1	+	+	1	1
Thalictrum filamentosum	1	1	1	1	1	1	1	+	1	+	+	+	1	1	1	1	+	1	+	4
Ulmus laciniata	+	+	+	1	+	+	+	2	+	2	+	+	+	+	1	+	1	+	1	·
Viola selkirkii	+	·	+	·	+	+	1	1	1	1	+	+	+	+	+	+	+	+	+	r
Diagnostic species of the cl. Quercetea mongolicae																				
Acer mono	+	+	4	2	+	1	2	+	1	2	1	1	1	2	2	3	1	1	2	1
Actinidia arguta	+	+	+	·	+	·	·	·	·	·	·	·	1	·	·	1	+	·	·	·
Alniaria alnifolia	+	+	·	·	+	·	·	·	+	r	·	·	+	+	r	+	r	+	+	r
Carex siderosticta	+	+	+	+	+	+	+	+	·	+	+	·	+	+	r	+	+	+	+	r
Dryopteris crassirhizoma	·	+	1	2	1	+	3	3	3	2	1	1	1	2	3	2	3	2	2	·
Other species																				
Acer pseudosieboldianum	1	+	·	·	+	+	1	·	r	1	2	1	1	·	1	1	1	+	1	1
Maianthemum dilatatum	+	·	·	·	·	·	+	·	+	·	·	r	r	+	+	+	r	+	+	·
Tilia amurensis	+	3	1	1	+	+	2	1	·	·	+	r	1	3	1	1	2	1	r	1
Quercus mongolica	3	4	+	1	·	·	1	·	·	r	r	r	·	·	·	·	r	·	r	3
Ribes mandshuricum	+	+	+	+	+	1	+	+	+	1	+	+	+	+	+	+	r	+	+	·
Asarum sieboldii	1	+	+	+	·	+	r	+	+	+	+	r	r	+	+	+	+	+	+	+
Oxalis acetosella	·	·	+	+	1	+	1	1	1	+	+	+	+	1	+	+	+	1	+	1
Phryma nana	·	·	+	+	·	+	+	+	1	+	+	+	+	+	+	+	+	+	+	1
Maianthemum bifolium	·	1	+	+	1	1	+	+	+	+	r	+	+	+	+	+	+	1	+	+
Ribes maximoviczianum	·	·	+	+	+	+	+	+	+	+	+	+	·	+	+	+	+	+	1	+
Vitis amurensis	+	+	+	+	+	+	+	r	r	+	+	r	+	·	+	·	r	r	r	r
Actinidia kolomikta	·	·	·	·	+	+	+	+	+	r	+	+	1	1	+	1	1	+	·	r
Deutzia parviflora var. *parviflora*	·	+	+	·	·	+	·	r	+	·	·	+	1	r	1	1	1	r	+	+
Carex rhizina subsp. *reventa*	1	3	·	+	1	·	+	·	r	+	+	r	r	+	r	+	+	+	+	1
Galium davuricum	+	+	+	+	1	1	·	·	·	·	·	r	+	+	r	r	·	+	+	+
Euonymus sachalinensis	·	·	·	·	·	·	+	+	+	+	+	+	+	1	+	+	+	+	+	·
Hylomecon vernalis	·	·	·	+	·	·	+	+	+	+	+	+	·	+	+	+	+	r	+	1
Polygonatum involucratum	·	+	·	+	+	+	·	r	+	r	+	r	·	·	·	+	·	r	+	r
Lonicera praeflorens	+	+	+	+	·	1	·	r	r	+	1	+	+	1	r	1	+	·	+	·
Athyrium sinense	+	+	+	+	·	·	+	·	·	r	r	·	r	·	+	r	+	+	·	+
Parasenecio hastatus	+	+	+	+	·	+	·	r	+	+	r	·	·	·	·	·	r	·	+	r
Adiantum pedatum	·	·	1	+	·	+	1	1	1	+	r	·	·	+	+	+	1	·	+	+
Parasenecio praetermissus	·	1	+	·	·	·	1	1	1	·	+	·	+	·	+	+	·	+	+	+
Paris verticillata	+	+	·	·	·	·	r	r	r	r	r	r	r	·	r	r	·	r	r	r
Prunus maximowiczii	·	+	+	·	·	·	r	r	·	r	+	+	r	·	+	r	·	·	1	·
Pseudostellaria sylvatica	+	+	·	·	·	·	·	+	r	r	r	r	·	+	r	r	·	r	r	r
Nabalus tatarinowii	+	·	+	·	+	+	·	·	r	+	·	+	·	·	·	r	·	·	1	r
Actaea asiatica	·	·	+	·	·	·	+	·	·	+	·	+	·	·	·	+	+	·	+	+
Viburnum sargentii	1	+	·	+	+	+	+	·	·	r	+	·	·	·	·	+	+	+	·	+
Lonicera chrysantha	·	+	·	·	+	1	·	r	+	+	+	+	·	·	·	+	·	·	·	r
Cardamine leucantha	+	+	1	+	·	·	r	·	·	r	+	+	·	·	r	·	·	+	+	+
Polystichum subtripteron	·	·	1	+	+	·	+	1	+	·	·	·	·	+	2	·	1	·	·	·
Arisaema amurense	+	+	1	·	·	+	+	·	·	+	·	r	r	r	·	·	·	r	·	·
Rubia cordifolia	+	·	+	·	·	+	r	·	r	·	·	·	r	+	·	·	·	r	r	r
Aconitum stoloniferum	·	·	·	·	·	·	·	r	·	r	+	r	r	·	·	·	·	+	+	r
Impatiens noli-tangere	·	·	·	·	·	+	·	+	+	r	r	r	r	+	·	r	·	·	·	·
Aruncus dioicus	+	·	·	·	·	·	·	·	+	r	+	r	·	·	·	·	+	1	r	+
Scutellaria pekinensis var. *ussuriensis*	+	+	+	+	1	+	r	·	·	r	·	·	·	·	·	·	·	r	·	·
Carex quadriflora	·	·	1	+	·	·	r	·	·	·	r	·	1	+	+	·	·	+	r	r
Chrysosplenium pilosum var. *valdepilosum*	·	·	·	·	·	·	·	+	+	+	r	+	r	·	r	·	r	r	r	·
Fraxinus chinensis ssp. *rhynchophylla*	1	1	+	+	·	+	·	·	·	·	·	·	·	·	·	·	·	·	+	·
Euonymus alatus	+	+	·	·	·	·	r	·	·	·	·	·	·	+	·	·	r	+	r	r
Valeriana fauriei	1	+	·	+	·	·	+	·	+	+	·	r	·	r	·	·	·	+	r	+
Rubia chinensis	+	+	·	·	·	·	·	·	+	r	·	r	+	·	·	·	·	·	·	·
Picea jezoensis	·	·	·	·	+	+	1	·	·	·	·	·	2	1	1	+	1	1	·	·
Plagiorhegma dubium	1	1	·	+	·	·	·	·	·	·	r	·	·	·	·	·	r	·	·	·
Juglans mandshurica	·	+	·	·	·	·	·	·	·	·	·	r	·	·	·	·	r	·	1	·
Maackia amurensis	·	+	·	+	·	·	r	·	·	·	+	·	·	·	·	·	+	r	+	r
Deparia pycnosora	·	·	·	·	·	+	·	·	·	+	·	·	+	·	+	·	+	+	+	·
Caulophyllum robustum	·	·	·	+	·	·	·	+	·	+	·	·	·	·	·	+	·	·	r	r
Paeonia obovata	·	+	+	·	·	·	·	·	r	·	r	·	·	·	·	·	r	·	r	r
Urtica dioica subsp. *holosericea*	·	·	1	·	·	+	·	·	·	·	·	+	·	·	r	·	·	·	·	·
Aralia elata	·	·	+	·	·	·	·	+	·	·	·	+	·	·	·	·	·	·	·	·
Saussurea subtriangulata	+	+	·	·	·	+	·	·	+	+	·	·	·	·	·	·	r	·	+	·
Dioscorea nipponica	+	+	·	+	·	·	·	·	·	+	·	·	·	·	·	·	·	·	+	·
Ulmus davidiana var. *japonica*	·	+	1	·	·	·	·	·	·	·	·	·	+	·	r	·	·	r	·	·
Viola acuminata	+	+	·	·	·	·	·	·	·	·	·	r	·	·	·	·	·	·	r	r
Astilbe chinensis	+	+	·	·	·	·	r	·	·	·	·	·	·	+	+	·	+	·	·	·
Lonicera maximowiczii	·	·	+	·	·	·	·	·	·	r	r	+	·	·	·	·	·	·	·	·
Polemonium chinense	+	+	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·
Acer ukurunduense	·	·	·	·	·	·	1	·	·	·	·	·	·	·	·	+	1	·	·	·
Trigonotis radicans	·	·	+	+	1	·	·	·	·	·	·	·	+	r	·	·	·	·	·	·
Osmorhiza aristata	·	·	1	+	·	·	·	r	r	r	·	·	·	·	·	·	·	·	·	·
Anemonoides udensis	·	·	·	·	·	·	·	r	r	r	r	r	·	·	r	r	·	·	·	·
Anemonoides umbrosa	·	+	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	r	r	+
Chloranthus quadrifolius	·	·	1	+	·	·	·	·	·	1	1	·	·	·	·	·	·	·	·	+
Artemisia argyi var. *argyi*	·	+	·	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+
Lilium distichum	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	r	·	+
Achudemia japonica	·	·	·	·	·	·	·	·	·	·	·	·	+	r	r	·	·	·	·	·
Athyrium spinulosum	+	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+
Rubus crataegifolius	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r
Viburnum burejaeticum	·	·	·	·	·	+	·	·	·	r	·	·	·	·	·	·	·	·	+	+
Angelica cincta	+	·	·	·	·	+	·	·	·	r	·	·	·	·	·	·	·	·	·	·
Vicia ramuliflora	+	·	·	·	·	·	·	·	·	·	r	·	·	·	·	·	·	·	r	·
Filipendula palmata	·	·	+	+	·	·	·	·	·	·	·	·	·	r	·	·	·	r	·	·

Table A3. Continued.

Table number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16*	17	18	19	20
Dryopteris amurensis	·	·	·	·	·	·	+	r	·	·	·	·	3	·	·	·	·	·	·	·
Calamagrostis species	·	·	·	·	·	·	·	·	·	r	·	·	+	·	·	·	·	·	r	·
Solidago virgaurea	·	+	·	+	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Onoclea struthiopteris	·	+	·	+	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Cirsium schantarense	·	+	·	+	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Isodon excisus	+	+	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Chrysosplenium pilosum	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+
Potentilla fragarioides	1	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+
Heracleum dissectum	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r
Aconitum species	·	·	·	·	·	·	·	r	r	·	·	·	·	·	·	·	·	r	·	·
Milium effusum	·	·	·	+	·	·	·	·	·	·	·	r	·	r	·	·	·	·	·	r
Phegopteris connectilis	+	·	·	·	·	·	+	·	·	·	·	·	+	·	+	·	·	·	·	·
Lathyrus komarovii	+	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Cynanchum acuminatum	+	+	·	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Osmundastrum cinnamomeum subsp. *asiaticum*	·	·	·	+	·	·	·	·	·	·	·	·	+	·	+	·	·	·	·	·
Gymnocarpium dryopteris	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	·	r	·	1
Diplazium sibiricum	·	·	·	·	·	·	·	·	+	·	r	+	·	·	·	·	·	·	·	·

Found in 1 or 2 relevés: *Aconitum alboviolaceum* 1: +, 6: +; *A. sczukinii* 1: +, 2: +; *A. volubile* 3: +, 4: +; *Actaea erythrocarpa* 13: +; *Adenophora pereskiifolia* 1: +; *Adonis amurensis* 20: +; *Adoxa moschatellina* 20: r; *Amphicarpaea edgeworthii* 1: +, 11: r; *Anemonastrum baicalense* 20: r; *Anemonoides amurensis* 20: r; *A. glabrata* 1: +; *A. raddeana* 20: +; *Anemonoides* sp. 9: r; *Angelica dahurica* 3: +, 4: +; *Anthriscus sylvestris* 5: +; *Artemisia keiskeana* 1: +; *Aster ageratoides* 7: r; *A. scaber* 1: +, 2: +; *Asyneuma japonicum* 6: +, 20: r; *Athyrium crenulatoserrulatum* 4: +; *A. filix-femina* 3: +; *A. yokoscense* 20: +; *Berberis amurensis* 4: +, 6: +; *Betula davurica* 1: 1; *B. pendula* subsp. *mandshurica* 2: +, 4: +; *Brachybotrys paridiformis* 20: 3; *Bupleurum longiradiatum* 1: +, 20: r; *Caltha palustris* 13: +; *Campanula glomerata* subsp. *speciosa* 4: +; *C. punctata* 1: +, 2: +; *Carex accrescens* 2: +, 20: 1; *C. callitrichos* var. *nana* 2: +, 20: r; *C. dispalata* 6: 1; *C. erythrobasis* 20: r; *C. lanceolata* 2: +; *C. uda* 3: +; *C. umbrosa* subsp. *pseudosabynensis* 1: +; *Carpesium triste* 7: r, 10: +; *Celastrus flagellaris* 3: +; *Chelidonium majus* 3: +; *Chimaphila japonica* 4: +; *Chrysosplenium flagelliferum* 9: r; *C. ramosum* 3: +; *C. sinicum* 17: r; *Circaea cordata* 10: r; *C. lutetiana* 1: +, 2: +; *Climacium japonicum* 13: 1, 18: +; *Crataegus maximowiczii* 1: +; *Diarrhena fauriei* 1: 1; *Enemion raddeanum* 20: r; *Equisetum hyemale* 14: r, 18: r; *Euphorbia esula* 1: +; *E. sieboldiana* 10: r; *Filipendula glaberrima* 6: +; *Fimbripetalum radians* 20: r; *Gagea triflora* 20: r; *Gentiana zollingeri* 20: r; *Geranium maximowiczii* 1: +; *Hemerocallis middendorffii* 1: +; *Hypericum ascyron* 1: 1, 2: 1; *Lathyrus humilis* 1: +, 2: +; *Lespedeza bicolor* 2: +; *Lonicera maackii* 12: +; *Lysimachia clethroides* 1: +; *L. europaea* 13: +; *Maianthemum japonicum* 20: 1; *Malaxis monophyllos* var. *monophyllos* 5: +, 6: +; *Moehringia lateriflora* 2: +; *Ostericum maximowiczii* 4: +; *Oxalis obtriangulata* 20: r; *Panax ginseng* 17: r; *Paris quadrifolia* 3: +, 4: +; *Phedimus aizoon* 20: r; *Phellodendron amurense* 5: +, 7: 1; *Phlomoides maximowiczii* 20: r; *Pleurospermum uralense* 20: +; *Polygonatum acuminatifolium* 20: 1; *Populus suaveolens* 1: +; *P. tremula* 2: +; *Pyrola japonica* 5: +; *Pyrus ussuriensis* 1: +, 10: r; *Ranunculus franchetii* 20: r; *Rhamnus davurica* 18: +; *Sambucus racemosa* 11: r, 12: r; *Sanicula rubriflora* 3: 1; *Saussurea grandifolia* 20: 1; *S. neoserrata* 13: +; *Sorbaria sorbifolia* 13: +, 16: +; *Spiraea betulifolia* 16: +; *S. chamaedryfolia* 20: +; *Stellaria bungeana* 1: +; *Taxus cuspidata* 7: r; *Thalictrum minus* 11: +; *Tilia mandshurica* 18: +; *Veronicastrum sibiricum* 2: +; *Vicia subrotunda* 20: +; *V. unijuga* 1: +, 2: +; *V. venosa* 4: +; *Viola sacchalinensis* 3: +; *Waldsteinia maximowicziana* 2: 1; *Zabelia biflora* 3: +.

Coordinates (N, E): 1–6 – no available data; 7 – 43.651261, 132.437569; 8 – 43.631115, 132.417643; 9 – 43.632931, 132.410937; 10 – 43.654154, 132.42374; 11 – 43.656075, 132.424085; 12 – 43.657102, 132.421042; 13 – 43.659368, 132.493777; 14 – 43.657461, 132.491701; 15 – 43.665058, 132.488809; 16 – 43.641303, 132.498381; 17 – 43.677578, 132.524205; 18 – 43.652, 132.5; 19 – 43.65, 132.49; 20 – 43.49969, 131.56081.

Locations: BP – Borisov Plateau, KP – Kedrovaya Pad' Nature Reserve, MA – Muraviov-Amurskiy peninsula (Vladivostok vicinity), SA – Sikhote-Alin Mountains, UR – Ussurisky Nature Reserve.

Authors of relevés: DV – Violetta D. Dzizyurova, GU – Rezeda R. Gumarova et al. 1994, KU – Galina E. Kurentsova, PE – Ekaterina A. Petrunenko.

*nomenclatural type (holotypus).

Table A4. Association Querco mongolicae–Abietetum holophyllae (selected 10 relevés of each subassociation).

Subassociation	Querco mongolicae–Abietetum holophyllae typicum									Querco mongolicae–Abietetum holophyllae oxalidetosum acetosellae										
Table number	**1****	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9 ***	**10****	**11**	**12**	**13**	**14**	**15**	**16***	**17**	**18**	**19****	**20**
Juice number	108	134	146	211	234	236	278	291	517	518	79	81	84	85	86	88	90	93	98	104
Author code	GU	KR	KU	DV, PT	KR, LA	KR, LA	DV	DV, PT	Kim	Kim	GU	GU	GU	GU	GU	GU	GU	GU	GU	GU
Year		1994	1976	2023	2023	2023	2020	2022	1990	1990	1994	1994	1994	1994	1994	1992	1994	1994	1992	1994
Sample area, m²	400	NA	400	400	400	400	400	400	750	750	NA	NA	NA	NA	NA	400	NA	NA	400	NA
Elev.	125	200	NA	315	175	148	65	389	250	200	NA	NA	NA	NA	NA	140	NA	NA	180	NA
Aspect	337	135	NA	NA	320	–	22	275	180	360	225	203	180	202	180	225	180	203	360	360
Slope	10	15	NA	NA	10	0	5	7	2	15	15	20	10	20	12	12	40	12	16	5
Tree cover	80	99	NA	70	50	70	20	30	NA	NA	50	70	80	50	60	80	70	90	80	80
Stand height	NA	29	NA	28	32	26	29	32	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Shrub cover	35	10	NA	3	0	10	25	15	NA	NA	55	15	5	55	60	5	8	5	20	15
Shrub height	NA	NA	NA	1.5	–	5	1	1.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Herb cover	25	20	NA	60	2	50	25	80	NA	NA	70	30	10	15	30	25	35	30	35	35
Location	MA	SA	KP	NP	NP	NP	BGI	UR	UR	UR	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA
Spec. num.	59	49	43	47	45	46	53	55	61	54	92	87	88	89	97	93	78	92	99	77
Diagnostic species of the subass. Querco mongolicae–Abietetum holophyllae oxalidetosum acetosellae																				
Campanula punctata	·	·	·	·	·	·	·	·	·	·	+	+	+	+	+	+	·	1	·	·
Dryopteris expansa	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	1	·	1	1
Lathyrus humilis	·	·	·	·	·	·	·	·	+	+	+	1	+	+	·	+	1	+	·	·
Diagnostic species of the Querco mongolicae–Abietetum holophyllae and Carpino cordatae–Abietenion holophyllae																				
Abies holophylla	1	1	+	3	3	2	3	2	1	2	1	1	1	1	5	1	3	5	1	+
Acer barbinerve	1	1	1	·	·	·	+	1	1	2	+	·	1	+	1	+	+	·	1	1
Acer mandshuricum	+	+	+	r	·	1	·	3	·	1	·	·	·	+	·	·	·	·	·	+
Carex ussuriensis	·	1	·	·	r	·	·	+	1	2	·	·	+	1	+	1	·	·	+	1
Carpinus cordata	5	1	·	1	3	2	3	3	1	2	4	5	+	4	5	5	4	1	3	4
Dryopteris goeringianum	·	·	1	·	·	·	·	r	·	+	·	·	·	+	·	·	·	+	·	·
Kalopanax septemlobus	+	1	·	r	1	r	+	+	+	·	+	1	+	1	+	+	+	1	1	1

Table A4. Continued.

Table number	1**	2	3	4	5	6	7	8	9 *	10**	11	12	13	14	15	16*	17	18	19**	20
Diagnostic species of the ord. Tilio amurensis–Pinetalia koraiensis																				
Acer tegmentosum	+	1	·	·	·	·	+	·	·	+	+	·	+	·	+	+	·	·	+	+
Aegopodium alpestre	·	·	1	+	+	1	·	·	·	·	·	·	·	·	·	·	·	·	+	·
Berberis amurensis	·	·	·	·	r	·	·	·	+	·	·	·	+	·	·	+	+	+	+	+
Betula costata	1	·	·	·	r	·	·	+	·	·	+	+	·	1	+	1	+	·	4	3
Carex auriculata	+	+	1	+	·	+	+	1	·	·	·	+	1	1	+	1	1	1	1	1
Convallaria keiskei	·	+	+	·	·	·	·	·	+	·	+	1	+	·	1	+	1	1	+	+
Corylus sieboldiana var. *mandshurica*	·	1	1	·	·	·	·	·	+	+	+	·	1	+	1	·	·	1	1	+
Diarrhena mandshurica	+	·	+	·	·	·	+	·	+	1	+	+	·	+	+	+	·	+	·	+
Eleutherococcus senticosus	1	·	1	r	·	·	+	1	·	+	+	+	+	+	1	+	·	+	+	+
Euonymus verrucosus	·	+	·	·	·	·	·	·	+	·	+	+	+	·	1	+	·	+	+	·
Fraxinus mandshurica	1	+	1	·	·	·	+	+	+	·	·	·	·	·	+	+	·	·	+	+
Syringa reticulata ssp. *amurensis*	+	·	1	·	+	1	+	1	2	+	1	+	1	+	1	+	·	·	1	1
Philadelphus tenuifolius	1	1	1	+	·	·	2	1	+	1	1	1	1	+	1	+	1	1	1	1
Pinus koraiensis	3	3	+	2	1	1	3	1	2	3	+	·	1	+	1	1	1	+	·	·
Schisandra chinensis	1	+	1	·	·	·	+	+	1	+	1	1	1	1	1	1	1	1	1	1
Thalictrum filamentosum	1	1	·	+	r	·	1	1	+	1	1	1	1	1	1	1	1	1	1	1
Ulmus laciniata	1	·	·	·	·	·	2	1	·	+	·	+	+	+	+	+	·	·	+	+
Viola selkirkii	1	·	1	+	r	1	+	1	+	+	+	·	+	+	+	+	+	+	+	+
Waldsteinia maximowicziana	·	·	·	·	+	·	·	·	+	·	+	1	·	·	+	·	1	·	·	3
Diagnostic species of the cl. Quercetea mongolicae																				
Acer mono	+	1	+	3	1	2	1	1	+	1	+	1	1	3	1	1	+	1	1	+
Actinidia arguta	1	·	·	·	r	+	·	·	+	·	+	+	+	+	1	+	·	·	1	1
Alniaria alnifolia	+	+	·	·	1	·	+	·	+	·	+	+	+	+	+	+	+	1	+	·
Athyrium yokoscense	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	+
Carex siderosticta	+	+	·	·	+	+	+	·	+	+	1	1	+	1	1	1	1	1	+	+
Dryopteris crassirhizoma	1	·	+	1	+	r	2	3	+	2	·	+	+	+	1	+	+	·	1	1
Pyrola japonica	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	+	+	·	·
Maianthemum japonicum	·	·	·	·	·	·	1	·	·	·	·	·	·	·	+	·	+	1	+	·
Other species																				
Athyrium spinulosum	+	·	·	1	·	·	·	·	·	·	+	+	+	+	1	+	1	1	+	+
Paeonia obovata	·	·	·	·	·	·	·	·	·	+	+	+	+	+	+	·	+	+	·	+
Viburnum sargentii	·	+	·	·	·	·	·	·	+	·	+	1	+	+	·	+	+	+	+	+
Astilbe chinensis	+	·	·	·	·	r	·	·	·	·	+	+	·	·	·	+	+	·	+	·
Fraxinus chinensis ssp. *rhynchophylla*	·	·	·	·	·	1	+	r	·	·	1	1	1	1	1	+	+	1	·	+
Tilia amurensis	1	1	+	1	3	1	2	+	+	+	1	3	1	1	3	1	+	1	3	1
Acer pseudosieboldianum	1	4	·	2	r	1	·	1	2	+	1	+	1	1	+	+	4	3	1	1
Maianthemum bifolium	·	+	·	·	·	·	+	·	+	+	1	1	+	·	+	1	1	1	+	+
Quercus mongolica	·	4	·	·	2	·	·	·	3	1	4	3	5	1	3	4	3	4	+	1
Parasenecio praetermissus	+	·	+	1	·	·	·	+	+	+	+	+	·	+	1	·	·	1	+	+
Phryma nana	·	·	·	2	r	·	2	1	+	1	+	·	·	+	+	+	+	1	+	+
Oxalis acetosella	1	·	·	1	r	·	+	1	+	1	·	·	·	·	1	1	+	+	1	1
Asarum sieboldii	+	·	·	·	r	·	+	+	+	+	+	+	+	+	+	1	+	1	1	+
Actinidia kolomikta	1	·	·	·	·	·	2	+	·	+	1	+	1	+	+	1	1	+	1	1
Deutzia parviflora var. *parviflora*	+	·	1	1	r	r	·	+	·	+	+	·	1	+	·	+	+	+	+	+
Lonicera praeflorens	·	+	·	r	·	·	+	·	+	+	+	+	1	+	1	+	·	+	+	·
Ribes mandshuricum	1	·	·	·	·	·	+	+	·	+	·	·	+	+	+	+	·	+	+	+
Hylomecon vernalis	+	·	+	r	·	·	2	+	·	·	·	·	·	·	1	+	·	1	1	1
Prunus maximowiczii	·	·	·	·	·	·	·	r	·	+	·	·	+	·	+	+	·	·	·	·
Pseudostellaria sylvatica	·	·	·	r	·	r	r	·	·	·	+	+	1	+	+	+	+	1	1	+
Vitis amurensis	1	+	+	·	·	r	·	r	+	+	+	+	1	1	1	+	1	+	1	1
Actaea asiatica	·	·	·	·	·	·	·	+	+	+	+	+	+	·	1	·	·	·	+	+
Galium davuricum	·	+	·	·	·	r	·	·	+	+	+	+	+	+	+	+	+	1	+	·
Adiantum pedatum	·	·	+	1	+	·	+	+	·	+	·	·	+	·	·	·	·	·	1	·
Maackia amurensis	·	+	·	·	r	·	·	·	+	+	·	+	1	·	+	+	·	+	·	·
Ribes maximoviczianum	+	·	1	·	·	·	·	+	·	·	·	·	·	·	·	+	·	·	+	1
Polygonatum involucratum	·	+	·	·	r	·	1	·	·	·	+	+	+	+	1	+	·	+	·	·
Maianthemum dilatatum	·	·	·	r	+	·	+	+	·	·	·	·	·	·	·	·	1	1	+	+
Plagiorhegma dubium	·	+	·	·	·	·	·	·	·	·	+	+	+	+	1	1	1	1	·	+
Arisaema amurense	+	·	·	+	·	·	+	·	·	·	·	+	·	·	+	·	·	1	+	·
Athyrium sinense	+	·	·	·	·	·	+	·	·	·	1	+	1	+	+	+	+	1	1	1
Valeriana fauriei	·	·	·	r	·	·	·	·	·	+	+	+	+	+	+	1	+	+	+	+
Cardamine leucantha	+	·	·	r	·	·	+	·	+	+	+	+	+	+	1	+	·	1	1	·
Nabalus tatarinowii ssp. *tatarinowii*	·	·	·	·	·	·	1	·	·	·	+	+	+	·	+	+	·	+	+	+
Saussurea subtriangulata	+	·	·	·	·	·	·	·	·	·	+	+	·	·	·	+	+	·	+	+
Aconitum sczukinii	+	·	·	·	·	·	·	·	·	·	+	+	·	+	+	+	·	·	+	+
Osmundastrum cinnamomeum ssp. *asiaticum*	+	·	·	·	·	·	·	·	·	·	·	·	+	·	·	+	1	·	+	+
Juglans mandshurica	+	·	·	·	1	3	·	·	·	·	+	+	1	1	1	+	·	+	+	+
Carex rhizina subsp. *reventa*	·	·	1	·	·	+	·	+	·	·	3	3	1	1	1	+	1	1	1	·
Heracleum dissectum	+	·	·	·	·	·	·	·	·	·	+	+	+	·	·	+	+	1	·	+
Scutellaria pekinensis var. *ussuriensis*	·	·	·	r	r	1	·	·	·	·	+	·	+	+	·	+	·	+	+	·
Betula pendula subsp. *mandshurica*	·	·	·	·	1	·	·	·	·	·	·	+	1	1	·	+	+	·	·	+
Moehringia lateriflora	·	·	·	·	·	·	·	·	+	·	·	+	+	+	·	·	1	+	+	+
Adoxa moschatellina	+	·	·	r	·	r	·	·	·	·	·	·	·	·	+	+	·	1	+	+
Caulophyllum robustum	+	·	·	·	·	·	·	+	·	·	·	+	·	·	·	+	·	+	+	+
Veronicastrum sibiricum	·	·	·	·	·	·	·	·	·	·	·	+	+	+	+	+	·	+	·	+
Euonymus alatus	·	·	·	·	·	·	·	·	+	+	+	·	·	+	+	+	+	+	·	·
Artemisia argyi var. *argyi*	·	+	·	·	·	·	·	·	·	·	1	1	+	1	+	+	·	·	·	·
Carex lanceolata	·	2	·	·	·	·	·	·	+	·	+	·	+	+	+	+	·	·	·	+
Lonicera chrysantha	·	·	1	·	·	·	·	+	·	·	+	+	·	·	·	·	·	+	+	+
Polemonium chinense	·	·	·	·	·	·	·	·	+	·	+	·	+	·	+	·	+	+	+	+
Aster scaber	·	·	·	·	·	·	·	·	·	·	+	+	+	+	+	+	+	+	·	·
Spiraea chamaedryfolia	·	+	·	·	·	·	·	·	·	+	+	+	1	·	1	·	·	+	1	·
Lathyrus komarovii	·	·	·	·	·	·	·	·	+	·	+	+	·	+	+	+	+	+	1	·
Phegopteris connectilis	·	·	·	·	·	·	+	·	+	·	+	·	·	·	·	+	1	·	1	1
Deparia pycnosora	1	·	1	·	·	·	·	·	·	+	·	·	·	·	·	·	1	·	+	+
Parasenecio hastatus	+	+	+	·	·	·	·	+	·	·	·	·	+	+	+	·	·	+	·	·
Isodon excisus	·	·	·	·	·	·	·	·	·	+	+	+	+	+	+	+	·	+	+	·
Betula davurica	·	·	·	·	·	·	1	·	·	1	+	·	·	+	+	·	+	1	·	·

Table A4. Continued.

Table number	1**	2	3	4	5	6	7	8	9 *	10**	11	12	13	14	15	16*	17	18	19**	20
Prunus sargentii	·	·	·	+	·	·	+	·	·	·	+	·	·	·	·	·	·	·	+	+
Lamium album subsp. *barbatum*	·	·	·	·	·	·	·	r	·	·	+	+	·	+	+	·	·	+	·	·
Aruncus dioicus	·	·	·	·	·	·	2	·	·	·	·	·	·	·	·	+	+	·	1	+
Onoclea struthiopteris	·	·	·	r	·	·	·	·	·	·	·	·	·	+	·	·	·	·	+	·
Actaea dahurica	·	·	·	·	·	·	·	·	·	·	·	·	+	+	+	·	·	1	·	·
Polystichum subtripteron	1	·	·	·	·	·	·	1	·	·	·	+	+	+	·	+	+	·	1	·
Solidago virgaurea	·	·	·	·	·	·	·	·	·	·	+	·	+	+	·	+	+	·	+	+
Phellodendron amurense	·	·	·	1	1	2	·	·	·	·	·	+	+	·	+	+	·	·	·	+
Vicia ramuliflora	·	·	·	·	·	·	·	·	+	·	·	+	+	+	+	+	·	·	+	·
Carex accrescens	·	·	1	·	·	r	·	·	·	·	·	·	·	·	+	·	·	+	+	·
Chrysosplenium pilosum	+	·	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·
Ulmus davidiana var. *japonica*	·	·	+	·	·	1	·	·	+	·	+	·	·	·	1	·	·	1	·	·
Paris verticillata	·	·	·	·	·	·	+	·	·	+	·	+	+	·	+	·	·	1	·	·
Rubia chinensis	·	·	·	·	·	·	·	+	·	·	+	·	·	·	+	·	+	+	+	·
Cirsium schantarense	·	·	·	·	·	·	·	·	·	·	+	+	+	·	·	+	+	·	+	·
Filipendula palmata	+	·	+	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·
Pyrus ussuriensis	·	·	·	·	·	·	·	·	·	·	+	·	·	·	+	·	·	+	+	+
Geranium maximowiczii	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	+	1	+	·	·
Dioscorea nipponica	·	+	·	r	·	·	·	·	+	·	+	+	+	·	+	·	·	+	·	·
Viola acuminata	·	·	·	·	·	·	·	·	+	·	+	·	·	+	+	·	·	·	·	·
Rubia cordifolia	·	·	·	r	r	r	·	·	·	·	·	+	·	+	·	·	+	·	·	·
Stellaria bungeana	·	·	·	·	·	·	·	·	·	·	·	·	·	+	1	·	·	+	·	·
Celastrus flagellaris	·	·	·	·	·	·	·	·	·	·	·	·	+	·	+	·	·	·	+	·
Urtica dioica subsp. *holosericea*	·	·	·	·	·	·	+	·	·	·	·	·	+	·	+	·	·	·	·	·
Pleurospermum uralense	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	+	+	·	+	·
Potentilla fragarioides	·	·	·	·	·	·	·	·	·	·	+	+	·	·	·	+	+	·	·	·
Euonymus sachalinensis	·	+	·	·	·	·	2	+	·	·	·	·	+	·	·	·	·	·	+	·
Diarrhena fauriei	·	·	·	·	·	·	·	·	·	·	+	·	+	·	·	·	+	·	+	·
Vicia unijuga	·	·	·	·	·	·	·	·	·	·	+	1	·	+	·	+	+	·	·	·
Carex quadriflora	·	·	·	r	·	·	·	r	·	·	·	·	·	·	·	·	·	·	·	1
Impatiens noli-tangere	+	·	·	r	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·
Angelica cincta	·	·	·	·	·	·	·	·	·	·	+	+	·	·	+	+	+	+	+	·
Amphicarpaea edgeworthii	·	·	·	·	·	·	·	·	·	·	+	+	·	+	+	·	·	·	·	·
Osmorhiza aristata	·	·	·	r	·	·	·	+	·	·	·	·	·	·	+	·	·	·	+	·
Lilium distichum	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+	·
Trigonotis radicans	·	·	·	·	·	·	·	·	+	+	·	·	·	·	·	·	+	·	·	·
Anemonoides umbrosa	·	·	·	·	·	·	·	·	+	·	+	+	·	·	+	·	·	·	·	·
Milium effusum	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+	·	·
Euphorbia esula subsp. *esula*	·	·	·	·	·	·	·	·	·	·	·	+	·	+	+	·	+	·	·	·
Filipendula glaberrima	·	·	·	·	·	r	·	·	·	·	·	·	·	·	·	·	+	1	·	·
Euonymus macropterus	+	·	·	·	·	·	·	·	·	·	+	·	·	·	·	+	·	·	·	·
Actinidia polygama	1	·	·	·	·	·	·	+	·	·	·	+	·	+	·	·	·	·	·	·
Aralia elata	·	·	·	·	·	·	·	+	1	·	·	+	·	·	+	·	·	·	+	·
Melica nutans	·	+	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	+	·	·
Carex callitrichos var. *nana*	·	·	·	·	r	·	·	·	·	·	+	·	+	·	·	+	·	·	+	·
Bupleurum longiradiatum	·	+	·	·	·	·	·	·	·	·	+	·	·	·	·	+	+	·	·	·
Arisaema serratum var. *serratum*	·	·	·	·	+	r	·	·	·	·	+	·	·	·	·	·	·	·	·	+
Athyrium crenulatoserrulatum	1	·	·	+	+	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Circaea alpina	·	·	·	·	·	·	·	+	·	1	·	·	·	·	·	+	·	·	+	+
Hylodesmum podocarpum ssp. *oxyphyllum*	·	·	·	·	·	·	+	+	·	·	·	·	·	·	+	·	·	·	·	·
Hypericum ascyron	·	·	·	·	·	·	·	·	·	·	+	+	+	·	·	·	·	·	·	·
Lespedeza bicolor	·	+	·	·	·	·	·	·	·	·	+	+	·	·	·	·	+	·	·	·
Tilia mandshurica	·	·	·	·	1	·	+	1	1	·	·	+	·	·	·	·	·	+	·	·
Corydalis ochotensis	·	·	·	·	r	r	·	·	·	·	·	·	·	·	·	+	·	·	·	·
Saussurea grandifolia	·	·	·	·	r	·	·	·	+	·	·	·	·	+	·	·	·	·	·	·
Mitella nuda	·	+	·	·	·	·	·	r	·	2	·	·	·	·	·	·	·	·	·	·
Chrysosplenium sinicum	·	·	·	+	r	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·

Found in 1 or 2 relevés: *Acer ukurunduense* 1: +; *Aconitum alboviolaceum* 1: +, 3: +; *A. axilliflorum* 6: r; *A. ochotense* 3: +; *A. stoloniferum* 8: r; *A. taigicola* 7: +; *Adenocaulon himalaicum* 7: 2; *Adenophora pereskiifolia* 11: +, 13: +; *Agrimonia pilosa* 11: +; *Anemonoides glabrata* 1: +; *A. udensis* 18: +; *Artemisia keiskeana* 2: +; *Asarum heterotropoides* 12: +, 14: +; *Asparagus schoberioides* 18: +; *Athyrium monomachi* 8: +; *Betula schmidtii* 4: 1; *Calamagrostis arundinacea* 14: +; *Caragana ussuriensis* 2: +; *Carex disperma* 6: 1; *C. drymophila* 9: 1, 10: 1; *C. erythrobasis* 5: +, 6: 1; *C. umbrosa* subsp. *pseudosabynensis* 17: +; *C. vaginata* var. *petersii* 5: r; *Carpesium triste* 14: +; *Chimaphila japonica* 2: +; *Chloranthus quadrifolius* 15: 1, 18: +; *Circaea alpina* subsp. *caulescens* 5: r; *C. cordata* 9: 1; *C. lutetiana* 12: +, 14: +; *Codonopsis lanceolata* 12: +; *Crataegus maximowiczii* 12: +, 13: +; *Cynanchum acuminatum* 11: +, 12: +; *Dictamnus dasycarpus* 2: +; *Diplazium sibiricum* 6: r; *Dryopteris amurensis* 7: +; *Epipactis papillosa* 5: r, 15: +; *Equisetum pratense* 14: +; *Gagea nakaiana* 18: +; *Galium boreale* 13: +; *G. maximowiczii* 6: r; *Geranium wilfordii* 7: +, 9: +; *Gymnocarpium dryopteris* 20: +; *Lactuca triangulata* 11: +; *Liparis kumokiri* 6: r; *Lonicera maackii* 3: +, 6: 1; *L. maximowiczii* 3: 1, 15: +; *Lychnis fulgens* 18: +; *Malaxis monophyllos* var. *monophyllos* 4: r; *Malus mandshurica* 10: +; *Melampyrum setaceum* 2: +; *Micranthes manchuriensis* 16: +; *Monotropa hypopitys* 17: +; *Muhlenbergia japonica* 9: +; *Neottia papilligera* 18: +, 19: +; *Oxalis obtriangulata* 4: r; *Pedicularis resupinata* 11: +, 16: +; *Persicaria lapathifolia* 6: r; *Pilea mongolica* 6: 1; *Poa alta* 10: +; *Polystichum braunii* 19: +; *Populus suaveolens* 14: +; *P. tremula* 14: +; *Prunus maackii* 3: +. *P. padus* 19: +; *Pseudogalium paradoxum* 4: r; *Pteridium latiusculum* 12: +; *Pyrola rotundifolia* 14: +, 19: +; *Ranunculus franchetii* 4: r; *Rhamnus davurica* 17: +; *Rhododendron mucronulatum* 2: +; *Rubus crataegifolius* 6: r, 13: +; *Sanicula chinensis* 7: +; *S. rubriflora* 3: +, 14: +; *Saxifraga rotundifolia* 4: r, 6: r; *Synurus deltoides* 14: +; *Trisetum sibiricum* 19: +; *Urtica thunbergiana* 3: +, 4: +; *Veratrum dahuricum* 19: +; *Viburnum burejaeticum* 3: +, 9: +; *Vicia venosa* 2: +; *Viola collina* 9: +, 15: +; *V. rossii* 5: r, 6: r; *V. sacchalinensis* 2: +; *Zabelia biflora* 2: +, 13: +.

Coordinates (N, E): 1 – 43.204, 131.99; 4 – 43.386412, 131.52299; 5 – 42.887267, 131.065794; 6 – 42.889475, 131.067057; 7 – 43.2180296, 131.9870343; 8 – 43.630768, 132.41906; 9 – 43.6, 132.2; 10 – 43.6, 132.; 16 – 43.187, 132; 19 – 43.212, 132.06; 2–3, 11–15, 17–18, 20 – no available data.

Locations: BGI – forest area of the Botanical Garden-Institute FEB RAS, KP – Kedrovaya Pad' Nature Reserve, MA – Muraviov-Amurskiy peninsula (Vladivostok vicinity), NP – Land of the Leopard National Park, SA – Sikhote-Alin Mountains, UR – Ussurisky Nature Reserve.

Authors of relevés: DV – Violetta D. Dzizyurova, GU – Rezeda R. Gumarova et al. 1994, Kim – Jon-Won Kim 1990, KR – Pavel V. Krestov, KU – Galina E. Kurentsova, LA – Anastasiya D. Lisitsyna, PE – Ekaterina A. Petrunenko, VV – Valentina P. Verkholat.

* nomenclatural type.

** nomenclatural type of the rejected syntaxa: 1** – Polysticho tripteron–Pinetum koraiensis typicum Gumarova et al. ex Krestov et al. 2023; 10** – Querco mongolicae–Abietetum holophyllae aceretosum tegmentosae Kim ex Krestov et al. 2023; 19** – Polysticho tripteron–Pinetum koraiensis caricetosum reventae Gumarova et al. ex Krestov et al. 2023.

Table A5. Average coefficients of similarity of syntaxa

Suballiance Association Subassociation	Overall β-diversity	Total replacement diversity	Total richness diversity
Jaccard			
Mitello nudae–Abietetum holophyllae	0.28	0.23	0.05
Filipendulo palmatae–Juglandenion mandshuricae	0.34	0.25	0.09
Onocleo struthiopteridis–Juglandetum mandshuricae	0.34	0.28	0.06
Fraxino mandshurici–Abietetum holophyllae	0.27	0.19	0.08
Querco mongolicae–Abietetum holophyllae	0.35	0.24	0.11
Querco mongolicae–Abietetum holophyllae typicum	0.35	0.27	0.08
Querco mongolicae–Abietetum holophyllae oxalidetosum acetosellae	0.29	0.23	0.06
Rhododendro mucronulati–Betuletum schmidtii	0.36	0.21	0.15
Sørensen			
Mitello nudae–Abietetum holophyllae	0.20	0.16	0.04
Filipendulo palmatae–Juglandenion mandshuricae	0.26	0.19	0.07
Onocleo struthiopteridis–Juglandetum mandshuricae	0.26	0.22	0.05
Fraxino mandshurici–Abietetum holophyllae	0.21	0.15	0.06
Querco mongolicae–Abietetum holophyllae	0.27	0.19	0.08
Querco mongolicae–Abietetum holophyllae typicum	0.27	0.21	0.06
Querco mongolicae–Abietetum holophyllae oxalidetosum acetosellae	0.21	0.16	0.05
Rhododendro mucronulati–Betuletum schmidtii	0.28	0.17	0.12
Ruzicka's index			
Mitello nudae–Abietetum holophyllae	0.37	0.28	0.10
Filipendulo palmatae–Juglandenion mandshuricae	0.42	0.29	0.13
Onocleo struthiopteridis–Juglandetum mandshuricae	0.42	0.29	0.13
Fraxino mandshurici–Abietetum holophyllae	0.40	0.31	0.09
Querco mongolicae–Abietetum holophyllae	0.41	0.27	0.14
Querco mongolicae–Abietetum holophyllae typicum	0.41	0.28	0.13
Querco mongolicae–Abietetum holophyllae oxalidetosum acetosellae	0.36	0.30	0.06
Rhododendro mucronulati–Betuletum schmidtii	0.37	0.28	0.10
Bray-Curtis distance			
Mitello nudae–Abietetum holophyllae	0.30	0.22	0.08
Filipendulo palmatae–Juglandenion mandshuricae	0.37	0.25	0.12
Onocleo struthiopteridis–Juglandetum mandshuricae	0.36	0.25	0.11
Fraxino mandshurici–Abietetum holophyllae	0.33	0.25	0.08
Querco mongolicae–Abietetum holophyllae	0.35	0.23	0.12
Querco mongolicae–Abietetum holophyllae typicum	0.35	0.24	0.11
Querco mongolicae–Abietetum holophyllae oxalidetosum acetosellae	0.29	0.24	0.05
Rhododendro mucronulati–Betuletum schmidtii	0.30	0.23	0.07