Botanica Pacifica. A journal of plant science and conservation. 2021. 10(1): 53–60
DOI: 10.17581/bp.2021.10108

RESEARCH PAPER

Forests of Japanese alder in the Russian Far East: the new association of the class *Alnetea japonicae* Miyawaki et al. 1977

Kirill A. Korznikov*, Valentina P. Verkholat & Pavel V. Krestov

Kirill A. Korznikov *
e-mail: korzkir@mail.ru

Valentina P. Verkholat
e-mail: val.verkholat@yandex.ru

Pavel V. Krestov
e-mail: krestov@botsad.ru

Botanical Garden-Institute FEB RAS,
Vladivostok, Russia

* corresponding author

Manuscript received: 12.02.2021
Review completed: 29.04.2021
Accepted for publication: 03.05.2021
Published online: 07.05.2021

ABSTRACT

We describe the new association *Lycopo lucidi–Alnetum japonicae* Korznikov, Verkholat & Krestov 2021 **ass. nov.** of the *Alnus japonica* swampy forests of the coastal plains and river valleys in the south of the Primorye Territory of Russia. The association includes two subassociations: *Lycopo lucidi–Alnetum japonicae typicum* Korznikov, Verkholat & Krestov 2021 **subass. nov.** and the preliminary delineated *Lycopo lucidi–Alnetum japonicae betuletosum davuricae* **subass. prov.** developing on gently sloping foothills with a lateral inflow of moisture and is transitional to zonal broad-leaved forests of the class *Quercetea mongolicae* Song ex Krestov et al. 2006. The association is classified to the alliance *Fraxino–Alnion japonicae* Miyawaki et al. 1977 described from Japan and belonging to the order *Alnetalia japonicae* Miyawaki et al. 1977 and the class *Alnetea japonicae* Miyawaki et al. 1977. We also validate the name of the association *Stellario longifoliae–Alnetum japonicae* Ohno in Miyawaki 1988 nom. inval. (art. 5) from Hokkaido Island, Northern Japan.

Keywords: vegetation, syntaxonomy, alder forest, swamp forest, Primorye Territory

РЕЗЮМЕ

Корзников К.А., Верхолат В.П. Крестов П.В. Леса из ольхи японской на российском Дальнем Востоке: новая ассоциация класса *Alnetea japonicae* Miyawaki et al 1977. Описана новая ассоциация *Lycopo lucidi–Alnetum japonicae* Korznikov, Verkholat & Krestov 2021 **ass. nov.**, объединяющая редкие сообщества влажных и заболоченных ольховых лесов (*Alnus japonica*) приморских равнин и речных долин юга Приморского края. Ассоциация включает две субассоциации: *Lycopo lucidi–Alnetum japonicae typicum* Korznikov, Verkholat & Krestov 2021 **subass. nov.** и предварительно описанная субассоциация *Lycopo lucidi–Alnetum japonicae betuletosum davuricae* **subass. prov.,** сообщества которой развиваются на склоновых участках с боковым притоком влаги и являются переходными к зональным широколиственным лесам класса *Quercetea mongolicae* Song ex Krestov et al. 2006. Ассоциация отнесена к описанному с территории Японии союзу *Fraxino–Alnion japonicae* Miyawaki et al. 1977 порядка *Alnetalia japonicae* Miyawaki et al. 1977 класса *Alnetea japonicae* Miyawaki et al. 1977.

Ключевые слова: растительности, синтаксономия, ольховые леса, заболоченные леса, Приморский край

Alnus japonica (Thunb.) Steud (Japanese alder), in contrast to the widely distributed in the Russian Far East species *Alnus hirsuta* (Spach) Turcz. ex Rupr. (Siberian alder), grows in the warmest areas of the region. The distribution of *A. japonica* marks the typical temperate bioclimatic zone in East Asia (Box & Fujiwara 2012). The whole range of the species corresponds to the area of the humid monsoon climate of the temperate zone of East Asia, stretched along the Pacific coast between 25 and 46°N. Outside Russia, Japanese alder is distributed in Korean Peninsula, Japanese Archipelago (including the Ryukyu Islands) and in China, from Jiangsu in the south to Jilin in the north, as well as in Taiwan (Li & Skvortsov 1999). In Russia, the species is known only in the south of the Primorye Territory, on Kunashir Island, and the southwestern tip of Sakhalin Island (no herbarium specimens). In the Primorye Territory, *A. japonica* occurs along the coast of the Sea of Japan from the border with the North Korea (the Khasan District of the Primorye Territory), to the Olga Bay (the Olga District) (Fig. 1). On the Khanka Lake Lowland, it forms hybrids with *A. hirsuta*, so the most typical plants of *A. japonica* are confined to the seacoast (Vorobyov 1968).

In the Russian Far East, alder forests occupy relatively small areas, do not have economic significance, and they were not usually considered in forest vegetation surveys and inventories (Ageenko 1969, Rosenberg & Vasiliev 1969). Forests of *Alnus hirsuta* were described comprehensively during the vegetation studies of some areas of the Russian Far East. The most informative descriptions of the *A. hirsuta* swamp forests, based on relevé tables, are provided for Kamchatka by Tyulina (2001), Neshataeva & Kukurichkin (2003) and Neshataeva (2009), with less detail – for the Primorye Territory by Kolesnikov (1938, 1956), Doronina (1967), Zhudova (1967), Vasiliev et al. (1984), for the Sakhalin Island by Kabanov (1940) and for the Kuril Islands by Vorobyov (1963) and Barkalov (2002, 2009).

Forests of *Alnus japonica* are less often mentioned in the Russian geobotanical literature (Kolesnikov 1956, Zhudova 1967, Kurentsova 1968, Krestov & Verkholat 2002). In the Primorye Territory, *A. japonica* forms locally distributed

communities usually classified into the formation "Japanese alder groves" (Kolesnikov 1956). Kurentsova (1968) noted that, despite the absence of extensive massifs, forests of Japanese alder, being interspersed with communities of other types, are a characteristic element of the vegetation of the south of Primorye Territory. Sochava (1946) considered *A. japonica* to be the most ancient relicts on the region, and considered the communities with the dominance of this species as depleted derivatives of "synusiae of hydrophilic formations of the Tertiary", which were dominated by such taxa as *Taxodium* Rich.

Expanding economic development of coastal plains and river valleys in the Northeast Asia has led to a reduction of alder swamps of *Alnus japonica* (Miyawaki et al. 1977, 1986, Miyawaki 1988, Ohno 1991, Fujita 1998, Lei & Ohno 2004, Kim & Lee 2017). Due to the relic nature and strong anthropogenic transformation, the remaining undisturbed and intact forest communities with the dominance of Japanese alder were proposed to be considered rare communities in the Primorye Territory (Krestov & Verkholat 2002).

This paper aims on evaluation of syntaxonomic position of *A. japonica* communities growing in the south of the Russian Far East in the system of floristic classification of vegetation in East Asia.

MATERIAL AND METHODS

This study is based on 11 original unpublished relevés of *Alnus japonica* forests made by V.P. Verkholat in the period from 1981 to 2001 and one previously published relevé by P.V. Krestov (Krestov & Verkholat 2002) in the continental part of range, and 1 original unpublished relevé by K.A. Korznikov from the Kunashir Island (Southern Kurils. The relevés from mainland are made on plots of 20×20 m in size. Within the sample plots, all vascular plants species and their cover were recorded. The abundance of plants is estimated on a six-point cover scale: 5 – 76–100 %; 4 – 51–75 %; 3 – 26–50 %; 2 – 6–25 %; 1 – 1–5 %; + – <1 %.

The relevés were sorted in the JUICE 7.0 software (Tichý 2002). For differentiation of syntaxa, we used a combination of diagnostic species. The diagnostic species for the new association of Japanese alder forest included taxa with a constancy of more than 40%, with the exception of a number of species of hygrophilous tall grass, which are characteristic of floodplain and valley forests in the south of the Far East ("riparian species").

In naming of the new syntaxa we followed the International Code of Phytosociological Nomenclature (Theurillat et al. 2021). The names of vascular plants are given according to the summary of Cherepanov (1995), with the exception of *Parasenecio hastatus* (L.) H. Koyama (= *Cacalia hastata* L.). The distribution of *Alnus japonica* is shown after Sokolov et al. (1974), Nedoluzhko & Skvortsov (1996), Global Biodiversity Information Facility (GBIF), and our original field data.

Figure 1 Distribution of *Alnus japonica* (Thunb.) Steud; incut – species records in Primorye Territory of Russia (circles) and location of vegetation samples (circles with crosses)

RESULTS

After tabular processing, the described communities were classified into the new association *Lycopo lucidi–Alnetum japonicae* **ass. nov.**, which includes two subassociations – *Lycopo lucidi–Alnetum japonicae typicum* **subass. nov.** and *Lycopo lucidi-Alnetum japonicae betuletosum davuricae* **subass. nov.**

***Lycopo lucidi–Alnetum japonicae* ass. nov. hoc loco**

Holotypus – relevé 5 in the table 1.

Synonyms: "formation the groves of Japanese alder" (Kolesnikov 1956).

Diagnostic species: *Alnus japonica*, *Astilbe chinensis*, *Lycopus lucidus*, *Osmundastrum asiaticum*, *Rabdosia excisa*, *Sedum aizoon*.

Dominant species: *Alnus japonica* (tree layer), *Filipendula palmata* (herb layer).

Structure. The tree stands, from 8 to 20 m high, are single-, less often, two-layered. The average canopy cover is 60 %. The shrub layer is sparse; its cover is usually less than 1 %. The herb layer is well developed, consists of 2–3 sublayers, the total cover reaches 90–100 %. The upper herb sublayer is formed by tall herbs (*Astilbe chinensis*, *Filipendula palmata*, *Parasenecio hastatus*, *Urtica angustifolia*). The middle sublayer is formed mostly by graminoids (*Calamagrostis langsdorffii*, *Carex appendiculata*, *C. dispalata*) and ferns (*Athyrium sinense*, *Osmundastrum asiaticum*). The third sublayer consists of forbs, the most noticeable are *Impatiens noli-tangere*, *Pilea mongolica*, *Truellum thunbergii*.

Ecology. The communities are confined to poorly drained lagoon-origin depressions behind the ancient dunes of the sea coasts. They occupy the lower parts of floodplains and near-surface areas in the lower reaches of rivers, wet deluvial aprons and gently-sloping valley boards. The soils are gleysoils, with a developed profile, the water table is high. The soil moisture regime is from wet to very wet. In the wetlands of the coastal plains, the association communities are surrounded by reed grass–sedge wet meadows (the class *Calamagrostietea langsdorffii* Achtyamov 1985). In river valleys, swamp forests of *Alnus japonica* gradually changes into riverside communities of the class *Salicetea sachalinensis* Ohba 1973, and on slopes of river valley boards and on deluvial

Table 1. Relevés of ***Lycopo lucidi–Alnetum japonicae* ass. nov.** (A), ***L.l.–A.j. typicum* subass. nov.** (B), and ***L.l.–A.j. betuletosum davuricae* subass. prov.** (C). Species of tree and shrub layers indexed, herbs are not.

Syntaxon	A	B	C
			Median value
Number of species	19 39	20 29	15 22	12 33	10 36	15 25	12 41	15 65	8 50	8 54	12 38	14 31	10 52
Tree layer height, m	70	60	80	60	40	60	90	40	60	60	60	60	60
Tree layer cover, %	<1	-	<1	3	5	-	<1	5	<1	<1	<1	2	<1
Shrub layer cover, %	90	95	100	100	100	30	90	100	100	100	100	98	100
Herb layer cover, %	107	97	101	104	98	103	108	105	99	102	106	Species frequency, %	
Number in database	1	2	3	4	5	6	7	8	9	10	11	12	
Running number													
Diagnostic species of the Class, Order, Alliance													
Alnus japonica (A1)	5	4	4	4	4	3	3	4	5	3	3	3	100	100	100
Alnus japonica (A2)	·	·	·	·	·	·	·	·	1	·	·	·	8	0	25
Alnus japonica (B)	+	·	+	+	+	1	·	+	·	+	·	·	58	75	25
Diagn. sp. comb. of the *Lycopo lucidi–Alnetum japonicae*															
Lycopus lucidus	+	+	1	·	3	+	+	+	4	2	+	+	92	88	100
Sedum aizoon	·	+	·	·	+	·	·	+	+	+	+	+	58	38	100
Astilbe chinensis	·	+	·	·	+	·	+	+	2	·	+	·	50	50	50
Rabdosia excisa	+	·	+	·	·	·	·	3	4	3	·	·	42	38	50
Lysimachia davurica	·	·	+	·	+	+	·	·	+	·	·	1	42	38	50
Osmundastrum asiaticum	·	·	+	·	+	·	·	3	·	·	3	3	42	38	50
Diagn. sp. comb. of the *L.l.–A.j. typicum*															
Truellum thunbergii	4	2	5	·	3	2	3	3	3	·	·	·	67	88	25
Carex appendiculata	3	+	3	5	4	3	5	4	·	·	·	·	67	100	0
Sanguisorba parviflora	·	+	+	2	2	+	+	2	·	·	·	·	58	88	0
Onoclea sensibilis	+	+	+	+	+	+	·	·	·	+	·	·	58	75	25
Pilea mongolica	·	+	3	2	+	·	+	·	1	·	·	·	50	63	25
Thelypteris palustris	+	·	·	+	·	+	·	1	+	·	·	·	42	50	25
Lycopus maackianus	·	·	·	+	+	+	1	·	·	·	·	·	33	50	0
Diagn. sp. comb. of the *L.l.–A.j. betuletosum davuricae*															
Betula davurica (A1)	·	·	·	·	·	·	·	·	1	·	2	2	25	0	75
Angelica cincta	·	+	·	·	·	·	·	·	2	+	+	+	42	13	100
Artemisia rubripes	·	+	·	·	·	·	·	·	3	+	+	+	42	13	100
Bistorta pacifica	·	·	·	·	+	·	·	·	+	1	+	+	42	13	100
Veratrum dahuricum	·	+	·	·	·	·	·	·	1	3	·	+	33	13	75
Accompanying species															
Fraxinus mandshurica (A1)	·	·	·	·	1	·	·	2	·	·	·	·	17	25	0
Fraxinus mandshurica (A2)	·	·	·	·	·	·	·	2	·	·	·	·	8	13	0
Fraxinus mandshurica (B)	·	·	·	·	+	·	·	·	·	·	·	·	8	13	0
Fraxinus rhynchophylla (B)	·	·	·	·	1	·	·	+	·	·	·	·	17	25	0
Quercus mongolica (A1)	·	·	·	·	·	·	·	·	·	·	1	1	17	0	50
Quercus mongolica (A2)	·	·	·	·	·	·	·	+	·	·	·	·	8	13	0
Quercus mongolica (B)	·	·	·	·	·	·	·	·	+	·	·	·	8	0	25
Juglans mandshurica (B)	+	·	·	·	·	·	·	+	·	·	·	·	17	25	0
Maackia amurensis (A1)	·	·	·	·	·	·	·	·	·	·	+	+	17	0	50
Sorbaria sorbifolia (B)	·	·	·	3	·	·	·	·	·	1	·	·	17	13	25
Corylus heterophylla (B)	·	·	·	·	·	·	·	·	·	·	+	+	17	0	50
Calamagrostis langsdorffii	1	+	1	2	2	4	4	2	1	1	+	+	100	100	100
Athyrium sinense	·	+	+	+	2	+	+	+	1	+	+	+	92	88	100
Filipendula palmata	·	2	3	2	3	+	2	2	·	4	3	3	83	88	75
Parasenecio hastatus	·	+	·	2	·	·	·	1	2	1	1	1	58	38	100
Impatiens noli-tangere	·	4	4	2	·	+	·	·	+	+	·	·	50	50	50
Urtica angustifolia	·	1	3	2	+	·	1	·	·	·	·	·	42	63	0
Cimicifuga dahurica	·	+	·	·	+	·	·	1	2	1	·	·	42	38	50
Truellum sieboldii	+	+	·	·	1	·	·	·	2	·	·	·	33	38	25
Angelica maximowiczii	+	·	·	1	+	·	·	+	·	·	·	·	33	50	0
Arisaema amurense	·	+	·	+	·	·	·	·	+	+	·	·	33	25	50
Lythrum salicaria	·	+	·	·	·	·	+	+	+	·	·	·	33	38	25
Carex dispalata	·	·	5	+	·	·	·	1	·	1	·	·	33	38	25
Caltha silvestris	·	·	·	3	·	1	·	+	·	2	·	·	33	38	25
Aster maackii	·	·	·	·	+	·	+	·	·	·	+	+	33	25	50
Maianthemum dilatatum	·	·	·	·	·	+	·	·	·	2	+	1	33	13	75
Convallaria keiskei	·	·	·	·	·	·	·	+	·	1	+	1	33	13	75
Disporum smilacinum	·	·	·	·	·	·	·	+	·	1	+	+	33	13	75
Hemerocallis middendorffii	·	·	·	·	·	·	·	+	·	+	+	+	33	13	75
Pteridium aquilinum	·	·	·	·	·	·	·	·	·	1	2	2	25	0	75
Thalictrum contortum	·	·	·	·	·	·	·	·	+	·	+	+	25	0	75
Lathyrus komarovii	·	·	·	·	·	·	·	·	·	+	+	+	25	0	75
Chamaenerion angustifolium	·	·	·	·	·	·	·	·	·	+	+	+	25	0	75
Anemonoides udensis	·	·	·	·	·	·	·	·	·	+	+	+	25	0	75
Calystegia sepium	·	·	·	·	·	·	·	·	·	+	+	+	25	0	75
Valeriana coreana	·	·	·	·	·	·	·	·	·	+	+	+	25	0	75
Impatiens furcillata	+	·	·	2	·	·	·	+	·	·	·	·	25	38	0
Rubia cordifolia	+	·	·	·	·	·	·	·	+	2	·	·	25	13	50
Parnassia palustris	+	·	·	·	·	+	+	·	·	·	·	·	25	38	0
Phragmites australis	·	1	·	+	·	·	5	·	·	·	·	·	25	38	0
Ligularia fischeri	·	+	·	+	·	·	·	·	1	·	·	·	25	25	25
Senecio cannabifolius	·	+	·	·	2	·	+	·	·	·	·	·	25	38	0
Aconitum sczukinii	·	+	·	·	·	·	·	·	·	+	·	+	25	13	50
Fimbripetalum radians	·	·	+	+	·	·	·	·	·	+	·	·	25	25	25
Geranium davuricum	·	·	·	+	+	·	1	·	·	·	·	·	25	38	0
Gentiana triflora	·	·	·	·	+	+	·	+	·	·	·	·	25	38	0
Potentilla freyniana	·	·	·	·	+	+	·	·	·	·	·	+	25	25	25
Viola acuminata	·	·	·	·	·	+	·	+	·	+	·	·	25	25	25
Asparagus schoberioides	·	·	·	·	·	·	·	+	+	+	·	·	25	13	50

Table 1. Continued.

Syntaxon	A	B	C
			Species frequency, %
Number in database	107	97	101	100	104	98	103	108	105	99	102	106			
Running number	1	2	3	4	5	6	7	8	9	10	11	12			
Artemisia stolonifera	·	·	·	·	·	·	·	+	·	·	2	1	25	13	50
Carex siderosticta	·	·	·	·	·	·	·	+	·	·	2	1	25	13	50
Trisetum sibiricum	·	·	·	·	·	·	·	+	·	·	+	+	25	13	50
Adenophora pereskiifolia	+	·	·	·	·	·	·	·	·	·	+	+	25	13	50
Athyrium filix-femina	+	+	·	·	·	·	·	·	·	·	·	·	17	25	0
Scirpus wichurae	+	·	+	·	·	·	·	·	·	·	·	·	17	25	0
Lunathyrium pycnosorum	1	·	·	·	·	+	·	·	·	·	·	·	17	25	0
Naumburgia thyrsiflora	+	·	·	·	·	+	·	·	·	·	·	·	17	25	0
Poa palustris	+	·	·	·	·	·	·	·	·	+	·	·	17	13	25
Calamagrostis brachytricha	r	·	·	·	·	·	·	·	·	·	+	·	17	13	25
Achnatherum extremiroientale	+	·	·	·	·	·	·	·	·	·	·	+	17	13	25
Saxifraga manchuriensis	·	+	·	·	·	·	·	+	·	·	·	·	17	25	0
Swertia veratroides	·	·	+	+	·	·	·	·	·	·	·	·	17	25	0
Symplocarpus renifolius	·	·	·	·	+	·	·	2	·	·	·	·	17	25	0
Galatella dahurica	·	·	·	·	+	·	·	+	·	·	·	·	17	25	0
Saussurea amurensis	·	·	·	·	+	1	·	·	·	·	·	·	17	25	0
Calla palustris	·	·	·	·	·	+	·	·	1	·	·	·	17	13	25
Hylotelephium pallescens	·	·	·	·	·	+	·	·	·	+	·	·	17	13	25
Viola verecunda	·	·	·	·	·	·	+	·	+	·	·	·	17	13	25
Cirsium schantarense	·	·	·	·	·	·	·	1	+	·	·	·	17	13	25
Rubus crataegifolius	·	·	·	·	·	·	·	1	·	1	·	·	17	13	25
Phlomoides maximowiczii	·	·	·	·	·	·	·	+	·	2	·	·	17	13	25
Circaea lutetiana	·	·	·	·	·	·	·	+	·	+	·	·	17	13	25
Veronicastrum sibiricum	·	·	·	·	·	·	·	+	·	+	·	·	17	13	25
Saussurea maximowiczii	·	·	·	·	·	·	·	·	1	·	·	+	17	0	50
Festuca extremiorientalis	·	·	·	·	·	·	·	·	·	+	+	·	17	0	50
Galium maximowiczii	·	·	·	·	·	·	·	·	·	+	·	+	17	0	50
Geranium maximowiczii	·	·	·	·	·	·	·	·	·	+	·	+	17	0	50
Astragalus ochotensis	·	·	·	·	·	·	·	·	·	+	·	+	17	0	50
Poa nemoralis	·	·	·	·	·	·	·	·	·	·	+	+	17	0	50
Miscanthus sacchariflorus	·	·	·	·	·	·	·	·	·	·	+	+	17	0	50
Carex pseudosabynensis	·	·	·	·	·	·	·	·	·	·	+	+	17	0	50
Trollius macropetalus	·	·	·	·	·	·	·	·	·	·	+	+	17	0	50
Thalictrum simplex	·	·	·	·	·	·	·	·	·	·	+	+	17	0	50
Aegopodium alpestre	·	·	·	·	·	·	·	·	·	·	+	+	17	0	50
Vicia unijuga	·	·	·	·	·	·	·	·	·	·	+	+	17	0	50
Athyrium yokoscense	·	·	·	·	·	·	·	·	·	·	+	+	17	0	50
Vicia cracca	·	·	·	·	·	·	·	·	·	·	+	+	17	0	50
Synurus deltoides	·	·	·	·	·	·	·	·	·	·	+	+	17	0	50
Spodiopogon sibiricus	·	·	·	·	·	·	·	·	·	·	+	+	17	0	50
Serratula coronata	·	·	·	·	·	·	·	·	·	·	+	+	17	0	50
Codonopsis lanceolata	·	·	·	·	·	·	·	·	·	·	+	+	17	0	50

Single records: 1 – *Carex gynocrates* (+), *Eleocharis wichurae* (+), *Epilobium palustre* (+), *Filipendula glaberrima* (+), *Galium trifidum* (+), *Iris laevigata* (+), *Lathyrus pilosus* (+), *Lychnis fulgens* (+), *Lycopus uniflorus* (+), *Neomolinia mandshurica* (+), *Parathelypteris nipponica* (+), *Persicaria lapathifolia* (+), *Phellodendron amurense* A1 (1), *Sanguisorba tenuifolia* (+), *Scutellaria dependens* (+), *Viola epipsiloides* (+), *Viola langsdorfii* (+); **2** – *Geranium* sp. (+); **3** – *Carex pallescens* (2), *Equisetum arvense* (+), *Equisetum palustre* (+); **4** – *Polygonatum humile* (5); **5** – *Caltha palustris* (+), *Moehringia lateriflora* (+), *Polemonium chinense* (+); **6** – *Aquilegia oxysepala* (+), *Carex jankowskii* (+), *Carex meyeriana* (+), *Carex* sp. (+), *Corydalis buschii* (1), *Hypericum gebleri* (+), *Iris ensata* (+), *Menyanthes trifoliata* (+), *Primula pateńs* (+), *Ranunculus repens* (+), *Rosa maximowicziana* (1), *Sium tenue* (+); **7** – *Cicuta virosa* (+); **8** – *Acer mono* B (+), *Aralia elata* (+), *Calamagrostis angustifolia* (+), *Carex uda* (+), *Lonicera maackii* (1), *Milium effusum* (+), *Philadelphus tenuifolius* (+), *Saussurea grandifolia* (+), *Senecio litvinovii* (+), *Syringa amurensis* (1), *Trigonotis radicans* (1), *Viburnum sargentii* (2), *Viola amurica* (+), *Vitis amurensis* (+); **9** – *Astragalus incertus* (+), *Bidens tripartita* (+), *Clematis fusca* (+), *Glyceria lithuanica* (+), *Impatiens maackii* (1), *Oenothera biennis* (+), *Persicaria hydropiper* (+), *Rosa davurica* (+), *Senecio umbrosus* (+), *Serratula manshurica* (1); **10** — *Aconitum albo-violaceum* (+), *Anemonoides amurensis* (1), *Angelica dahurica* (+), *Artemisia gmelinii* (1), *Campanula cephalotes* (+), *Cardamine leucantha* (1), *Carex pallida* (+), *Cerastium pauciflorum* (+), *Cirsium setosum* (+), *Clematis mandschurica* (+), *Corydalis ambigua* (+), *Dioscorea nipponica* (+), *Heracleum dissectum* (1), *Lilium pensylvanicum* (+), *Matteuccia struthiopteris* (2), *Pedicularis resupinata* (+), *Polygonatum odoratum* (+), *Salix* sp. (+), *Sanicula rubriflora* (+), *Senecio umbrosus* (+), *Vicia amurensis* (+); **11** – *Galium maximowiczii* (+), *Lysimachia clethroides* (+), *Veronica daurica* (+); **12** – *Doellingeria scabra* (+).

Relevés authorship: **1** – P.V. Krestov, **2–12** – V.P. Verkholat
Locations and dates: 1 – Lazovsky Nature Reserve, Tachingousa Bay, lowland on ancient sea terrace; 28.08.2002; **2** – vicinity of Nakhodka, coast Tungus Bay; 18.09.1994; **3** – vicinity Lazovsky Nature Reserve, Melkovodnaya Bay, terrace on right bank of Kievka River; 17.08.1999; **4** – vicinity Lazovsky Nature Reserve, lowland near mouth of Kievka River; 18.08.1999; **5** – vicinity of Dushkino, valley of Kazachka River; 15.07.1991; **6** – Khasansky district, vicinity of Ryazanovka railway station, valley of Ryazanovka River; 04.06.1993; **7** – Nakhodka district, vicinity of Dushkino, valley of Kazachka River; 16.07.1991; **8** – Russky Island, coast Boyarin Bay; 09.09.2001; **9** – vicinity Nakhodka, Nakhodka Peninsula, valley of small unnamed river; 17.09.1994; **10** – Khasansky district, valley of small unnamed river, lower part of slope; 08.09.1993; **11** – Khasansky district, vicinity of Ryazanovka, coast of Boysmana Bay, Krasniy Utes Cape, lower part of gentle slope; 15.08.1981; **12** – Khasansky district, vicinity of Ryazanovka, coast of Boysmana Bay, valley of small unnamed river, lower part of gentle slope; 15.08.1981.

aprons – into zonal forests of the class *Quercetea mongolicae* Song ex Krestov et al. 2006. The herbs and undergrowth of the forests are periodically burned out during regular ground fires, which are particularly frequent in the spring period near urbanized areas.

Distribution. Along the coast of the Sea of Japan from the border with the North Korrea (42.30°N) to the Olga Bay (43.70°N) (Primorye Territory). The well-developed and large forests are located on the territory of the Lazovsky Nature Reserve, in the basin of the Razdolnaya River (ex-Suifun). The extensive open forests of *Alnus japonica* formed after regular fires occur in the Khasan and Shkotovo districts.

The association includes two subasociations.

***Lycopo lucidi–Alnetum japonicae typicum* subass. nov. hoc loco**

Holotypus – relevé 5 in table 1 (Fig. 2).

Synonyms: "formation of forested swamps with Japanese alder" (Zhudova 1967).

Diagnostic species: *Carex appendiculata*, *Lycopus maackianus*, *Onoclea sensibilis*, *Pilea mongolica*, *Sanguisorba parviflora*, *Thelypteris thelypterioides*, *Truellum thunbergii*.

Dominant species: *Alnus japonica* (tree layer), *Carex appendiculata*, *Impatiens noli-tangere*, *Truellum thunbergii* (herb layer).

Structure. The stand is single-layered, less often consists of two layers, 15 m high. The canopy cover is 60 %. In addition to *Alnus japonica*, it may include *Fraxinus mandshurica*, rarely *Quercus mongolica*. Shrubs do not form a closed layer, and often completely lack. In the herb layer, tall herb species of the riparian floral complex (*Filipendula palmata*, *Parasenecio hastatus*, *Urtica angustifolia*) are usually abundant. *Calamagrostis langsdorffii*, *Carex appendiculata*, *C. dispalata*, and sometimes, *Phragmites australis* form closed patches. Among forbs, *Impatiens noli-tangere* and *Truellum thunbergii* have the dense cover. The synusiae of tall herbs, graminoids and hygromesophilic forbs are clearly pronounced. The synusial differentiation of herb layer reflect the conditions of uneven soil moisture and a hummocky surface.

Figure 2 Community of the ***Lycopo lucidi–Alnetum japonicae typicum* Korznikov subass. nov. hoc loco**, Primorsky Krai, Lazovsky Nature Reserve, Tachingouza Bay; photo by P.V. Krestov

Ecology. The communities of the subassociation are confined to the wettest habitats of the coastal plains and river valleys, with a high level of ground water and periodic stagnation of water above ground. *Carex appendiculata*, one of the species from the diagnostic combination with a high cover, is also a diagnostic species of the alliance of mesohydrophilic and hygrophilic floodplain meadows *Caricion appendiculatae* Achtyamov et al. 1985 (Akhtyamov 1995). Despite being confined to wet ecotopes, communities are prone to the ground fires, which often occur during the dry spring period, when abundant litter and sparse undergrowth burn out.

Distribution. Corresponds to the range of the association.

***Lycopo lucidi–Alnetum japonicae betuletosum davuricae* subass. nov. prov.**

The syntaxon is pre-allocated. The subassociation unites communities with the dominance of *Alnus japonica* on deluvial aprons, well moistened by lateral water inflow, but without stagnation. The stand is usually single-layered, dominated by *A. japonica*. *Betula davurica*, *Maackia amurensis*, and *Quercus mongolica* co-occurence. The height of the trees is 8–10 m; the canopy cover is 60 %. The shrub layer is open. In the species composition, there are species typical to *Lespedezo-Quercetalia mongolicae* Krestov et al. 2006, which is explained by the transitional nature of the communities from the class *Alnetea japonicae* to the class of zonal forest vegetation *Quercetea mongolicae*.

***Stellario longifoliae–Alnetum japonicae* Ohno ex Korznikov, Verkholat & Krestov ass. nov.**

Lectotypus hoc loco: Miyawaki 1988, table 18, relevé No. 43 (printed as a separate attachment without page numbers).

The name of the association *Stellario longifoliae–Alnetum japonicae* Ohno was published in Miyawaki 1988 (p. 186) but there is no nomenclatural type relevé (art. 5; Theurillat et al. 2021) given in that publication. For this reason, we have designated here a lectotype from relevés published in the original diagnosis:

Korznikov found *A. japonica* forest stands (12 m high) belonging to this association in the southern part of Kunashir Island, at the valley of the Golovnina River (43.7669°N 145.4936°E) in 2019. Plot number Kun45, area 100 m^2, species cover are given in percents: *Alnus japonica* (A1; 70), *A. japonica* (B; 2), *Hydrangea paniculata* (10), *Euonymus sieboldiana* (3), *Carex appendiculata* (40), *Osmundastrum asiaticum* (40), *Lysichiton camtschatcense* (20), *Viola* sp. (10), *Cirsium kamtschaticum* (7), *Thalictrum contortum* (5), *Senecio cannabifolius* (3), *Filipendula glaberrima* (1), *Angelica genuflexa* (1), *Phragmites australis* (1), *Aconitum* sp. (<1, and all following species), *Aruncus dioicus*, *Athyrium sinense*, *Calamagrostis langsdorffii*, *Geum macrophyllum*, *Impatiens noli-tangere*, *Polygonatum maximowiczii*, *Sambucus miquelii*, *Sanguisorba tenuifolia*, *Sasa senanensis*, *Scirpus wichurae*, *Senecio nemorensis*, *Symplocarpus renifolius*, *Trillium camschatcense*, *Truellum thunbergii*.

Overview of the syntaxonomical diversity of the *Alnus japonica* forests

For the first time, for the Russian Far East, the syntaxonomic diversity of the *Alnus japonica* forests is described. The existing syntaxonomical system has been added with one new association characteristic of the northern part of the Japanese alder dominated forests on the continental part of their distribution. One association described from Japan was validated. A hyerarchy of the modern syntaxonomical system of vegetation formed by *Alnus japonica* is represented in the following prodromus:

Class
Order
Alliance
Association
Subassociation

Alnetea japonicae Miyawaki, K. Fujiwara et Mochizuki 1977
Alnetalia japonicae Miyawaki, K. Fujiwara et Mochizuki 1977
Fraxino mandshuricae–Alnion japonicae Miyawaki, K. Fujiwara et Mochizuki 1977
Lycopo lucidi–Alnetum japonicae Korznikov, Verkholat et Krestov **ass. nov.**
Lycopo lucidi–Alnetum japonicae typicum Korznikov, Verkholat et Krestov **ass. nov.**
Lycopo lucidi–Alnetum japonicae betuletosum davuricae **subass. prov.**
Stellario longifoliae–Alnetum japonicae Ohno ex Korznikov, Verkholat et Krestov **ass. nov.**

DISCUSSION

Position in phytosociological classification

A syntaxonomy of the *Alnus japonica* forests is well developed in Japan. Communities dominated by Japanese alder belong to the azonal vegetation class *Alnetea japonicae* Miyawaki et al. 1977 – the Asian vicariant of the class *Alnetea glutinosae* Br.-Bl. et Tx. ex Westhoff et al. 1946 (Mucina et al. 2016). The order *Alnetalia japonicae* Miyawaki et al. 1977 with the alliance *Fraxino–Alnion japonicae* Miyawaki et al. 1977 (Miywaki et al. 1977, Fujiwara 1996) is subordinate to the class. The communities of the wetlands of Hokkaido and northern Honshu are sometimes considered to belong to the alliance *Carici-Alnion* Asano et al. 1969 (Vegetation... 1988, Ohno 1991, Fujiwara 1996).

Japanese phytosociologists include 8 associations and several unranked vegetation units ("*Alnus japonica* gesellschaft") into the above listed syntaxa of higher rank. Two other associations of forests with *A. japonica* from southern Japan are classified as zonal vegetation. According to different authors, this is either the class of warm-temperate evergreen forests *Camellietea japonicae* Miyawaki et Ohba 1963, or the class of temperate deciduous forests *Fagetea cretanae* Miyawaki et al. 1964 (Okuda 1978, Fujiwara 1996, Lei & Ohno 2004).

We consider the new association *Lycopo lucidi–Alnetum japonicae* to belong the class *Alnetea japonicae* and to be subordinate to its order and alliance. It should be noted, that in *Alnus japonica* forests from Japan, species of valley forests (the union *Ulmion davidianae* Suz.-Tok. 1954, the order *Fraxino-Ulmetalia* Suz.-Tok. 1967, the class *Fagetea crenatae*) present constantly and abundantly. At the same time, the absence of the "its own" species in the *A. japonica* formation in the Primorye Territory was first noted by Kurentsova (1968). The belonging of the communities to the class *Alnetea japonicae*, therefore, can be determined by

Table 2. Diagnostic species frequencies (%) of ***Lycopo lucidi–Alnetum japonicae*** Korznikov, Verkholat et Krestov **ass. nov.** (A) and two associations from Hokkaido: ***Alno–Fraxinetum mandshuricae*** Miyawaki ex Haneda et al. 1970 (B) and ***Stellario longifoliae–Alnetum japonicae*** Ohno ex Korznikov, Verkholat et Krestov

Association	A	B	C
Number of relevés	**12**	**20**	**26**
Diagnostic species of the *Lycopo lucidi–Alnetum japonicae* (Primorye Territory)			
Lycopus lucidus	92	35	27
Truellum thunbergii	67	65	85
Carex appendiculata	67		77
Sanguisorba parviflora	58		
Onoclea sensibilis	58	25	69
Sedum aizoon	58		
Pilea mongolica	50	10	42
Astilbe chinensis	50		
Thelypteris palustris	42		
Angelica cincta	42		
Artemisia rubripes	42		
Bistorta pacifica	42		
Rabdosia excisa	42		
Lysimachia davurica	42	20	62
Osmundastrum asiaticum	42	25	81
Lycopus maackianus	33		8
Veratrum dahuricum	33		
Diagnostic species of the *Alno–Fraxinetum mandshuricae* (Hokkaido, Japan)			
Lysichiton camtschatcensis		75	27
Filipendula camschatica		45	19
Lysimachia thyrsiflora		45	12
Dryopteris tokyoensis		45	12
Equisetum arvense	8	40	12
Carex parciflora		40	8
Trillium camschatcense		40	
Diagnostic species of the *Stellario longifoliae–Alnetum japonicae* (Hokkaido, Japan)			
Athyrium sinense	92	30	88
Spiraea salicifolia		15	85
Parathelypteris japonica		20	81
Equisetum fluviatile		20	65
Impatiens textorii		10	65
Ulmus japonica		20	35
Stellaria longifolia			69
Scutellaria dependens			58
Filipendula glaberrima			31
Diagnostic species of the *Fraxino-Alnion japonicae*			
Alnus japonica	100	95	96
Hosta rectifolia		60	69
Viola arcuata		55	31
Carex capillacea		15	38
Carex rhynchophysa		10	42
Stachys riederi var. japonica		20	35
Scutellaria yezoensis		15	31
Galium trifidum		5	27
Solanum megacarpum		20	12
Diagnostic species of the *Ulmion davidianae* (temperate broad-leaved riparian forests of the insular pat of Northeast Asia)			
Fraxinus mandshurica	17	70	85
Impatiens noli-tangere	50	35	73
Symplocarpus renifolius		35	23
Acer tataricum subsp. aidzuense		15	35
Eleutherococcus divaricatus		5	35
Syringa reticulata	8	10	23
Magnolia kobus		20	4
Viburnum sargentii		15	8
Cardiocrinum cordatum		15	8
Pachysandra terminalis		10	12
Urtica platyphylla		15	4
Other frequent species			
Calamagrostis langsdorffii	100	30	38
Phragmites australis	25	75	69
Senecio cannabifolius	25	50	58
Maianthemum dilatatum	33	50	23
Cicuta virosa	8	30	77
Lycopus uniflorus	8	30	77
Sanguisorba tenuifolia	8	25	62
Urtica angustifolia	42		31
Convallaria keiskei	33		8
Fimbripetalum radians	25	5	

ecological relevance and physiognomic criteria, and not only by floristic composition (Table 2).

Characteristics of *Alnus japonica* communities in the neighboring areas

Japan. The alder communities described in this study in the Primorye Territory floristically and ecologically are most similar to the communities of the associations *Alno–Fraxinetum mandshuricae* Miyawaki ex Haneda et al. 1970 (Honshu and Hokkaido Islands) and *Stellario longifoliae–Alnetum japonicae* Ohno in Miyawaki 1988 nom. inval. (Hokkaido) (Miyawaki et al. 1986, Miyawaki 1988) growing in northern Japan. The average height of the tree layer in those forests is about 20 m, the maximum – up to 30 m, canopy cover – 70 %. The average cover of the shrub layer is 30 %, in some communities, shrubs may be completely absent, or cover up to 90 % of the sample area. On average, the cover of herbs is 90 % (Miyawaki 1988). In addition to *Alnus japonica*, the species *Carex appendiculata*, *Lycopus lucidus*, *Onoclea sensibilis*, *Osmundastrum asiaticum*, *Thelypteris thelypterioides* and *Truellum thunbergii* are common to both Japan and Primorye Territory comminities. In *Alnus japonica* forests of insular sector, *Filipendula kamtchatica* replaces *Filipendula palmata*, grows *Lysichiton camtchatencse*, and *Symplocarpus renifolius* has much higher constancy.

Korea. In the vegetation survey of North Korea (Kolbek & Jarolimek 2013), Japanese alder forests are mentioned, but their characteristics and species lists are not given. The *Viburnum opulus* var. *calvescens–Alnus japonica* community is described from the territory of South Korea (Gyeongsangbuk-do Province, Kunwi County), confined to the swampy terraces of mountain river valleys (Kim & Lee 2017). The authors of the syntaxon provide the following list of diagntostic species: *Acer ginnala*, *Alnus japonica*, *Angelica gigas*, *Angelica decursiva*, *Lycopus lucidus*, *Viburnum opulus* var. *calvescens*. The stand is two-layered, with a mix of *Fraxinus mandshurica*, *F. rhynchophylla*, *Maackia amurensis*, and *Quercus mongolica*. The maximum height of the trees is 16 m; the average canopy cover is 70 %. The cover of the shrub layer is not less than 20 %, herb layer – 90–100 %. Among the species with high constancy, common with the forests of the southern Primorye Territory, are *Lycopus lucidus*, *Osmundastrum asiaticum* and *Truellum thunbergii*.

Northeast China. In Jilin Province, Japanese alder forests are confined to moist, poorly drained areas of floodplains and river valleys. The height of the stands is 16–20 m; the canopy cover is 60–80 %. In addition to alder, the stands may include the broad-leaved species: *Fraxinus mandshurica*, *Juglans mandshurica*, *Phellodendron amurense*, *Sorbus alnifolia*, *Ulmus japonica*. The shrub layer is formed by *Sorbaria sorbifolia*, *Salix integra*, *S. gracilistyla*. The herb layer is closed, the set of main species includes mainly mesohydrophilic and hygrophilic species: *Adenocaulon adhaerescens*, *Adenophora triphylla*, *Agrimonia pilosa*, *Artemisia selengensis*, *Aruncus dioicus*, *Astilbe chinensis*, *Boschniakia rossica*, *Caltha palustris*, *Carex schmidtii*, *Carex siderosticta*, *Circaea lutetiana*, *Filipendula palmata*, *Heracleum dissectum*, *Menispermum dauricum*, *Rabdosia excisa*, *Sanguisorba officinalis*, *Sium suave* (Qian et al. 2003).

Sakhalin and the Kurils Islands. On Kunashir Island, *Alnus japonica* is quite common, growing in the valleys of rivers and streams, along the shores of lakes and in swamps with *Picea glehnii* (Barkalov 2002, 2009). Vorobyov (1963) mentioned *Alnus japonica* communities ("in the swamp, small groups"), but did not give more information. The floristic composition of these communities is close to both associations from Hokkaido *Alno–Fraxinetum mandshuricae* and *Stellario longifoliae–Alnetum japonicae* and include species from diagnostic combinations of Japanese associations: *Filipendula glaberrima*, *Lysichiton camtschatcensis*, *Symplocarpus renifolius*, *Trillium camschatcense*. On Sakhalin, Japanese alder is extremely rare (Nedoluzhko & Skvortsov 1996). We have never found this species in natural communities and in herbarium collections from Sakhalin. The available information about the ecology and communities of *Alnus japonica* in the insular part of the Russian Far East is sketchy. Apparently, this species does not take a significant part in the composition of the vegetation cover and individual communities.

Primorye Territory. In the Lazovsky Nature Reserve (43°N 133.9°E), Zhudova (1968) allocated forests of Japanese alder in the formation "swamps dominated by *Alnus japonica*". Communities of this formation occur along the bottoms of small shallow valleys of watercourses without a developed channel, with steep banks and along the edges of peatlands, at the places where springs emerge. The height of the stands is 12–15 m, the undergrowth – 3–5 m. There are no shrubs. In the herb layer, *Calamagrostis langsdorffii*, *Carex cespitosa*, *Naumburgia thyrsiflora*, *Phragmites australis*, *Rubia jesoensis*, *Sanguisorba parviflora*, *Truellum thunbergii* are abundant. We consider the communities described by Zhudova (1968) to belong to the association *Lycopo lucidi–Alnetum japonicae*.

Zhudova also pointed out that under conditions of greater moisture, *Alnus japonica* forms shrubby communities with *Carex schmidtii*, heather shrubs (*Ledum hypoleucum*, *Vaccinium uliginosum*) and a cover of *Sphagnum* mosses. She assigned them to a group of "shrubby bogs" formations. Similar communities with stunted thickets of *Alnus japonica* are known for bog massifs of northern Japan (Shinsho 1982, Fujita 1998). In our opinion, such communities should be positioned as part of the syntaxa of non-forest bog vegetation.

CONCLUSION

Swampy and moist forests of *Alnus japonica* are formed in the warmest areas of the southern part of the Russian Far East, where this species is located near the northern border of its range. Communities dominated by Japanese alder are assigned to the new association *Lycopo lucidi–Alnetum japonicum*, which we consider to belong to the alliance *Fraxino mandshuricae–Alnion japonicae*, the order *Alnetalia japonicae*, the class *Alnetea japonicae*. Currently, the association occurs on small area, as its habitats have been transformed during the anthropogenic transformations of river valleys and coastal plains. Forests belonging to the subassociation *Lycopo lucidi–Alnterum japonicum typicum* are confined to highly moist, poorly drained habitats of river floodplains and coastal plains. On the gently sloping terrains with a strong lateral inflow of water, slightly different communities are formed in composition and structure, which we refer to the preliminary revealed the subassociation *Lycopo lucidi–Alne-*

tum japonicum betuletosum davuricae, which is a transition to the zonal forests of the class *Quercetea mongolicae*. In the Russian part of the range, Japanese alder is also present in the flora of southwestern Sakhalin Island (doubtful) and Kunashir Island. In Kunashir Island, Japanese alder forms communities close to the associations *Alno–Fraxinetum mandshuricae* and *Stellario longifoliae–Alnetum japonicae* from Hokkaido.

LITERATURE CITED

Ageenko, A.S. (ed.) 1969. *Forest of the Far East*. Lesnaya promyshlennost', Moscow. 390 pp. (in Russian). [Леса Дальнего Востока / отв. ред. А.С. Агеенко. 1969. М.: Лесная промышленность. 390 с.].

Akhtyamov, M.H. 1995. *Syntaxonomy of meadow vegetation of the basin of the Amur River*. Dalnauka, Vladivostok, Khabarovsk. 200 pp. (in Russian). [Ахтямов М.Х. 1995. Синтаксономия луговой растительности бассейна реки Амур. Владивосток, Хабаровск. 200 с.].

Barkalov, V.Yu. 2002. Study of vegetation. In: *Plants and animals of the Kuril Islands (Materials of Intertnational Kuril Project)* (S.Yu Storozhenko, V.V. Bogatov & A.S. Lelei, eds), pp. 35–66. Dalnauka, Vladivostok (in Russian). [Баркалов В.Ю. 2002. Очерк растительности // Растительный и животный мир Курильских островов (Материалы Международного курильского проекта) / под ред. С.Ю. Стороженко, В.В. Богатого и А.С. Лелея. Владивосток: Дальнаука. С. 35–66.].

Barkalov, V.Yu. 2009. *Flora of the Kuril Islands*. Dalnauka, Vladivostok, 468 pp. (in Russian). [Баркалов В.Ю. 2009. Флора Курильских островов. Владивосток: Дальнаука. 468 с.].

Box, E.A. & K. Fujiwara. 2012. A comparative look at bioclimatic zonation, vegetation types, tree taxa and species richness in Northeast Asia. *Botanica Pacifica* 1(1):5–20.

Cherepanov, S.K. 1995. *Vascular plants Russia and adjacent states*. Mir i semya, Saint-Petersburg. 992 pp. (in Russian). [Черепанов С.К. Сосудистые растения России и сопредельных стран. СПб.: Мир и семья. 992 с.].

Distribution maps of vascular plants in Hokkaido, Japan. 2013. URL: http://www.hinoma.com/maps/

Doronina, Yu.A. 1967. Vegetation cover of the southern part of the Sikhote-Alin Nature Reserve. In: *Proceedings of the Sikhote-Alin Nature State Reserve, vol. 4*, pp. 246–305, Vladivostok (in Russian). [Доронина Ю.А. 1967. Растительный покров южной части Сихотэ-Алинского государственного заповедника // Труды Сихотэ-Алинского государственного заповедника. Владивосток. Вып. 4. С. 246–305].

Fujita, H. 1998. Characteristics of the soil and water table in an *Alnus japonica* (Japanese alder) swamp. In: *Coastally restricted forests* (A.D. Laderman, ed.), pp. 187–198, Oxford University Press, New York.

Fujiwara, K. 1996. Classification of plant communities of the "Vegetation of Japan 1980–1989". *Bulletin of the Institute of Environmental Science and Technology, Yokohama National University* 22:23–80.

GBIF.org (06 May 2021) *GBIF Occurrence Download* https://doi.org/10.15468/dl.7psxp8

Kabanov, N.E. 1940. *Forest vegetation of Northern Sakhalin*. Vladivostok, 210 pp. (in Russian). [Кабанов Н.Е. 1940. Лесная растительность северного Сахалина. Владивосток. 210 с.].

Kim, J.W. & S. Lee. 2017. Hwasan wetland vegetation in Gunwi, South Korea: with a phytosociological focus on alder (*Alnus japonica* (Thunb.) Steud.) forests. *Korean Journal of Ecology and Environment* 50(1):70–78.

Kolbek, J. & I. Jarolimek. 2013. Vegetation of the northern Korean Peninsula: classification, ecology and distribution. *Phytocoenologia* 43(3–4):245–327.

Kolesnikov, B.P. 1938. Vegetation of eastern slopes of the middle part of the Sikhote-Alin. In: *Proceedings of the Sikhote-Alin Nature State Reserve, vol. 1*, pp. 25–208, Moscow (in Russian). [Колесников Б.П. 1938. Растительность восточных склонов среднего Сихотэ-Алиня // Труды Сихотэ-Алинского государственного заповедника. М. Вып. 1. С. 25–208].

Kolesnikov, B.P. 1956. List of forest formations of Primorye and Priamurye. In: *For the 75th anniversary of academician V.N. Sukachev*, pp. 286–329. Izdatel'stvo AN SSSR, Moscow, Leningrad (in Russian). [Колесников Б.П. 1956. Конспект лесных формаций Приморья и Приамурья // Академику В.Н. Сукачеву к 75-летию со дня рождения. М., Л.: Издательство АН СССР. С. 286–329].

Krestov, P.V. & V.P. Verkholat. 2002. *Rare plant communities of the Amur Region*. DVO RAN, Vladivostok, 200 pp. (in Russian). [Крестов П.В., Верхолат В.П. 2002. Редкие растительные сообщества Приморья и Приамурья. Владивосток: ДВО РАН. 200 с.].

Krestov, P.V., J.-S. Song, Yu. Nakamura & V.P. Verkholat. 2006. A phytosociological survey of the deciduous temperate forests of mainland Northeast Asia. *Phytocoenologia* 36(1):77–150.

Kurentsova, G.E. 1968. *Vegetation of the Primorye Territory*. Dal'nevostochnoe knizhnoe izdatel'stvo, Vladivostok, 191 pp. (in Russian). [Куренцова Г.Э. 1968. Растительность Приморского края. Владивосток: Дальневосточное книжное издательство. 191 с.].

Lei, Y. & K. Ohno. 2004. Ecological studies on Japanese alder (*Alnus japonica*) forests on Southern Kanto Plain, Central Japan – syntaxonomy and correlation between the growth of several vegetation units and ground water. *Hikobia* 14:197–210.

Li, P.C. & A.K. Skvortsov 1999. Betulaceae In: *Flora of China, vol. 4 (Cycadaceae through Fagaceae)* (Z.Y. Wu & P.H. Raven, eds.), pp. 286–313, Science Press, Beijing; Missouri Botanical Garden Press, St. Louis.

Miyawaki, A., K. Fujiwara & R. Mochizuki 1977. Tabellenheft vegetation der Ubayashiki on N-Honshu (Iwate-Präfektur). *Bulletin of the Yokohama Phytosociological Society* 7:1–82 (in Japanese with German synopsis).

Miyawaki, A., S. Okuda, K. Ohno & S. Suzuki 1986. Vegetation der Halbinsel Shimokita (Nord-Honshu) und Süd-Kameda (Süd-Hokkaido). *Contribution from the Department of Vegetation Science, Environmental Science and Technology, Yokohama National University* 176:1–157 (in Japanese with German synopsis).

Miyawaki, A. (ed.) 1988. *Vegetation of Japan. Vol. 9. Hokkaido*. Shibundo, Tokyo, 563 pp. (in Japanese with German and English synopses).

Mucina, L., H. Bültmann, K. Dierßen, J.-P. Theurillat, T. Raus, A. Čarni, K. Šumberová, et al. 2016. Vegetation of Europe: hierarchical floristic classification system of vascular plant, bryophyte, lichen, and algal communities. *Applied Vegetation Science* 19(1): 3–264.

Nedoluzhko, V.A. & A.K. Skvortsov. 1996. Betulaceae. In: *Vascular plants of the soviet Far East, vol. 8* (S.S. Kharkevich, ed.), pp. 9–28, Nauka, Saint Petersburg (in Russian). [Недолужко В.А., Скворцов А.К. 1996. Сем. Березовые – Betulaceae // Сосудистые растения советского Даль-

него Востока / отв. ред. С.С. Харкевич. Санкт Петербург: Наука. Т. 8. С. 9–28).

Neshataeva, V.Yu. & G.M. Kukurichkin. 2003. Rare communities of *Alnus hirsuta* (Betulaceae) in the Kikhchik River Basin (Western Kamchatka). *Botanicheskii Zhurnal* 88(10):90–99 (in Russian with English abstract). [Нешатаева В.Ю., Кукуричкин Г.М. 2003. Редкие растительные сообщества ольхи пушистой (*Alnus hirsuta*) (Betulaceae) в бассейне р. Кихчих (Западная Камчатка) // Ботанический журнал. Т. 88, № 10. С. 90–99].

Neshataeva, V.Yu. *Vegetation of Kamchatka Peninsula*. KMK, Moscow, 537 pp. (in Russian). [Нешатаева В.Ю. 2009. Растительность полуострова Камчатка. М.: КМК, 537 с.].

Ohno, K. 1991. A vegetation-ecological approach to the classification and evaluation of potential natural vegetation of the *Fagetea crenatae* region in Tohoku (northern Honshu), Japan. *Ecological Research* 6:29–49.

Qian, H., X.-Y. Yuan & Y.L. Chou. 2003. Forest vegetation of Northeast China. In: *Forest vegetation of Northeast Asia* (J. Kolbek, M. Šrůtek & E.O. Box, eds), pp. 181–230, Springer, the Netherlands.

Rozenberg, V.A. & N.G. Vasil'yev. 1969. Forests of the Primorye Territory. In: *Forests of the USSR, vol. 4* (V.Z. Gulisashvili et al., eds), pp. 621–667, Nauka, Moscow (in Russian). [Розенберг В.А., Васильев Н.Г. 1969. Леса Приморского края // Леса СССР / под ред. В.З. Гулисашвили и др. М.: Наука. Т. 4. С. 621–667].

Shinsho, H. 1982. Note on the alder thickets – *Alnus japonica* Steud. – in Kushiro Moor, eastern Hokkaido II. *Research Report of Kushiro City Museum* 9: 27–36 (in Japanese with English abstract).

Sochava, V.B. 1946. Issues of florogenesis and phylocoenogenesis of Manchurian mixed forest. In: *Materials of flora and vegetation history of the USSR, vol. 2* (M.M. Il'in, ed.), pp. 283–320, Nauka, Moscow, Leningrad (in Russian). [Сочава В.Б. 1946. Вопросы флорогенеза и филоценогенеза маньчжурского смешанного леса // Материалы по истории флоры и растительности СССР / отв. ред. М.М. Ильин. М., Л.: Наука. Т. 2. С. 283–320].

Sokolov, S.Ya., O.A. Svyazeva & V.A. Kubli. 1977. *Areals of trees and shrubs of USSR, vol. 1*. Nauka, Leningrad, 162 pp. (in Russian). [Соколов С.Я., Связева О.А., Кубли В.А. 1977. Ареалы деревьев и кустарников СССР. Л.: Наука. Т. 1. 162 с.].

Tachibano, H. & K. Ito 1980. Phytosociological studies of the Sarobetsu Mire in the northern part of Hokkaido, Japan. *Journal of the Graduate School of Environmental Science, Hokkaido University, Sapporo* 1(3):73–134.

Theurillat J.-P. & J. Moravec. 1992. Index of new names of syntaxa published in 1989. *Folia Geobotanica & Phytotaxonomica* 27(1):69–101.

Theurillat, J.-P., W. Wilner, F. Fernández-González, H. Bültmann, A. Čarni, D. Gigante, L. Mucina & H. Weber. 2021. International code of phytosociological nomenclature. 4th edition. *Applied Vegetation Science* 24(1):e12491.

Tichý, L. 2002. JUICE, software for vegetation classification. *Journal of Vegetation Science* 13(3):451–453.

Tyulina, L.N. 2001. *Vegetation of the Western Kamchatka coast (Proceedings of the Kamchatka Institute of Ecology and Nature Management, vol. 2)*. Kamchatsky pechatny dvor, Petropavlovsk-Kamchatky, 304 pp. (in Russian). [Тюлина Л.Н. 2001. Растительность западного побережья Камчатки. Труды Камчатского института экологии и природопользования. Петропавловск-Камчатский: Камчатский печатный двор. Вып. 2. 304 с.].

Vasilyev, N.G., S.S. Kharkevich & Yu.B. Shibnev. 1984. *The "Kedrovaya Pad" Nature Reserve*. Lesnaya promyshlennost', Moscow, 197 pp. (in Russian). [Васильев Н.Г., Харкевич С.С., Шибнев Ю.Б. 1984. Заповедник «Кедровая падь». М.: Лесная промышленность. 197 с.].

Vorobyov, D.P. 1963. *Vegetation of the Kuril Islands*. Izdatel'stvo AN SSSR, Moscow, Leningrad, 92 pp. (in Russian). [Воробьев Д.П. 1963. Растительность Курильских островов. М., Л.: Издательство АН СССР. 92 с.].

Vorobyov, D.P. 1968. *Wild growing trees and shrubs of the Far East*. Nauka, Leningrad, 277 pp. (in Russian). [Воробьев Д.П. 1968. Дикорастущие деревья и кустарники Дальнего Востока. Л.: Наука. 277 с.].

Zhudova, P.V. 1967. Vegetation and flora of the Sudzukhinsky Nature State Reserve. In: *Proceedings of the Sikhote-Alin Nature State Reserve, vol. 4*, pp. 7–245, Vladivostok (in Russian). [Жудова П.В. 1967. Растительность и флора Судзухинского государственного заповедника Приморского края // Труды Сихотэ-Алинского государственного заповедника. Владивосток. Вып. 4. С. 7–245].