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Changes in the Parcel Structure of Liana-Broadleaved Forests in Primorskii Krai over 20 Years

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Abstract—It is necessary to study the parcel structure dynamics of forests in Primorskii krai to identify the natural restoration patterns of a unique formation of the region: primary coniferous–broadleaved forests. As a result of economic activity, these forests, rich in relic elements, were replaced by secondary ones in most of the affected area. The studies were performed in the catchment area of the Komarovka River (Southern Primor'e, Ussuri district). The article presents the results of the study of the parcel structure of *broadleaved–linden with lianas hasel forb type of forest,* which is representative for the region and is the most complicated as far the derivative forests formation is concerned. The research was performed by the conventional method: a detailed description and mapping on a scale of 1 : 100 of all phytocoenosis layers on a permanent test plot (PTP), followed by a pairwise comparison of maps and isolation of parcels. An analysis of the phytocoenosis transformation over a 20-year period of restorative succession has shown that the main forest and taxation characteristics of the stand insignificantly changed. Aspen and a considerable part of linden almost completely disappeared from the stand, the latter being one of the main species of the local ecosystems. The positions of the underbrush and the tree species characteristic of primary coniferous–deciduous forests were strengthened. Changes in the parcel structure indicate the successful restoration of the primary forest type: two secondary complementary (small) parcels disappeared in the phytocoenosis, and one more parcel has joined the six conditionally—indigenous ones. There was also a natural enlargement of conditionally—indigenous parcels and the alignment of their boundaries. During the research process, a high indicator role of the herbaceous layer was revealed.

Keywords: parcel structure, forest-forming process, secondary broadleaved forests, primary coniferous–broadleaved forests, restorative succession, Primorskii krai

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INTRODUCTION

The preservation of functions of forest ecosystems under the conditions of predicted environmental changes is of crucial importance for all mankind. According to data of the United Nations, the total area of forests on the planet decreased by 3% from 1990 to 2015, and the annual rate of loss of forested area in the period from 2010 to 2015 amounted to 3.3 million ha per year (Keenan et al., 2015). Numerous publications are devoted to problems directly or indirectly related to the loss of biodiversity and the prevention of negative anthropogenic impact on forests (Isaev et al., 1997; Caspersen and Pacala, 2001; Hector and Bagchi, 2007; Gao et al., 2014; Usol'tsev, 2019; Lukina et al., 2020; Teben'kova et al., 2021; Elliot et al., 2022).

The targets outlined in the Strategic Plan of the Convention on the Biological Diversity of the Planet include the conservation and restoration of primary forests with high biodiversity potential (UNSPF, 2017). This completely corresponds to the long-term plans of Russia, which contains 46% of the world forest area (*Strategiya…,* 2014) and is characterized by the highest typological diversity of forest formations. They include coniferous–broadleaved forests of Primorskii krai, which determine the unique and original nature of the region. The absence of glaciation in prehistoric times and favorable modern conditions for plants caused a great abundance of relict and endemic species in coastal forests. The World Wildlife Fund included them in the list of especially valuable natural objects of the planet.

Dominants of coniferous–broadleaved forests are represented by Korean pine (*Pinus koraiensis*[1]) and Manchurian fir (*Abies holophylla*), which are accompanied by Amur linden (*Tilia amurensis*), Manchurian linden (*T. mandshurica*), heartleaf hornbeam (*Carpinus cordata*), Manchurian walnut (*Juglans mandshurica*), the prickly castor-oil tree (*Kalopanax septemlobus*), the Amur cork tree (*Phellodendron amurense*),

[1] Latin names of the species are indicated according to the summary "Vascular Plants of the Soviet Far East" (1985–1996).

and other numerous relics of the Manchurian flora. They are unable to quickly respond to environmental changes caused by anthropogenic factors. Communities with the listed species lose their environment-forming functions even in case of a small violation of the system integrity. They are now threatened with extinction (Kovalev et al., 2020).

As a result of long-term selective logging and fires, the area of the Far Eastern forests of Korean pine became 1.9 times smaller from 1929 to 2001 (Koryakin and Chelyshev, 2009). It decreased 1.4 times—from 3.04 to 2.16 million ha—in Primorskii krai from 1989 to 2010 (Sibirina, 2014) and continues to drop. Fires are the main modern factor of forest death. The type of forests of Korean pine changed in the area of more than 1.5 million ha in the region due to fires (Ivanov et al., 2022). Over-ripe pine forests in Primor'e were completely destroyed by the end of the 20th century (Petropavlovskii, 2004). Virgin fir forests, the northern border of which passes along Southern Primor'e, are preserved only in protected areas.

The secondary formation of broad-leaved forests has become one of the most widespread formations in the region since the second half of the 20th century. These forests in southern Primorskii Krai accounted for about 20% of the area of the state forest fund in the late 1900s (Kudinov, 2000). The portion of the area of forests dominated by broadleaved species is now already more than 22% (Distribution*...,* 2021).

Monitoring the status of ecosystems and the dynamics of ecosystem functions, or the forest formation process, is important for the timely identification of negative consequences caused by various factors and for making the right decisions to prevent and/or eliminate them. The study of the forest formation process is necessary to identify regularities of natural restoration of the indigenous coniferous–broadleaf formation. This is one of the main directions of the Far Eastern forestry (Petropavlovskii, 2004; Kovalev et al., 2020).

In this regard, the study and monitoring of the parcel structure, which reflects the community status in any period of its life, is of particular urgency. The analysis of the structure enables us to identify important functional features of the community at each ontogenesis stage, depending on forest growing conditions, forest-forming tree species, and the effects of exogenous and endogenous factors (Dylis, 1974; Mestre et al., 2017; Spicer et al., 2020).

Despite the relatively high general knowledge of the forests of Primor'e, many aspects of their functional and spatial organization are poorly studied. The research of the horizontal structure of forests in Primorskii krai were started by the famous geobotanist P.D. Yaroshenko in the middle of the 20th century (Ivanova et al., 1963) in the forests of the Ussuri Reserve. Twenty years later, they were continued by N.A. Krupyanko (1983). Similar studies were performed in fir-spruce forests of the Northern Sikhote-Alin (Komarova, 1978), pine–broadleaved forests of the Sikhote-Alin (Maksimova, 1987), and broad-leaved–pine forests of the middle (Komarova, 1993), southern, and northern Sikhote-Alin (Vosmishcheva and Perepelkina, 2015). The authors of these works investigated virgin forests. Most attention was paid to the mosaic pattern of the grass layer and to the correspondence of its morphology to the intracenotic environment. In the late 20th century and the early 21st century, the objects of studying spatial heterogeneity were represented by secondary forests of the Mountain Taiga Station of the Far Eastern Branch of the Russian Academy of Sciences (Moskalyuk, 2006, 2021; Moskalyuk and Tarasova, 2015). There are no published works on the dynamics of the parcel structure of forest phytocenoses in Primorskii krai.

The purpose of our research was to study the parcel structure and its transformation over the 20-year period in a *broadleaved–linden with lianas and hazel forb forest,* which is representative and the most complex of secondary forests in the south of Primorskii krai. To achieve this purpose, the species composition and features of the spatial distribution pattern of species and their groups were identified with the account of their allocation to particular microplots; the relationships between plant layers were studied; cenoelements within the layers and phytocenosis were identified and described in detail; and changes in structural elements in space and with time were analyzed.

OBJECTS AND METHODS

The research area is represented by the neighborhood of the village of Gornotaezhnoe (Ussuri district) within the Komarovka River basin, which is a component of the catchment basin of the Sea of Japan. According to the forest vegetation zoning by D.I. Nazimova (1995), the study area is assigned to *the zone of mixed broadleaved–coniferous forests with oak of the Far Eastern monsoon–continental sector.* According to the well-known botanical–geographical zoning by B.P. Kolesnikova (1969), the research area is included in *the southern subzone of the zone of mixed coniferous–broadleaved forests of the southern facies of Siberian pine forests with Manchurian fir of basins of rivers flowing into Peter the Great Bay.* The natural conditions of this subzone, as well as of the entire Southern Primor'e, are determined by the monsoon climate, the position relative to the Sea of Japan, and the domination of low-mountain relief with altitudes to 1000 m above sea level. The absence of ice sheet in prehistoric times and the favorable modern climate have caused a very great biological diversity at the species and the ecosystem levels.

Forests in the research area are mainly secondary and are typical for the areas of Southern Primor'e (Kudinov, 2000). Monodominant dry oak forests are

Fig. 1. Broadleaved-linden forest type with lianas, with hazel underbrush, and with forb layer. Fragment of an actinidia parcel in spring.

allocated to insolated southern slopes, and polydominant broadleaved forests are formed on shady northern slopes with a mild microclimate and high fertile evenly moistened soils. The absence of temperature inversion results in optimal forest growing conditions in the middle parts of shadow slopes. Polydominant Manchurian fir and hornbeam variants of cedar pine forests with thermophilous species of lianas—*Actinidia arguta* and *Actinidia* k*olomicta*—with wood reserves to 800 m^3/ha are formed there (Vasil'ev and Kolesnikov, 1962).

The object of research is broadleaved—linden with lianas hazel forb type of forest (Fig. 1) located 1.5 km northeast of the village in the middle part of the north-northeast slope. The forest occupies an area from 200 to 400 m from the slope foot. The slope surface is relatively level with terraced microrelief elements in the form of small convex parts and depressions; the slope inclination averages 15° and may vary from 5° to 40° in convex areas. The slope altitude is from 170 (foot) to 270 (watershed) m above sea level, and the length is 610 m.

Research methods. A 60 × 70 m PTP was laid in the liana phytocenosis in 1997–1998 and revised in 2018. Coordinates of the northeast corner of the test plot are 43°42′272″ N and 132°09′611″ E. The studies were performed in accordance with the recommendations by V.N. Sukachev (1961) and A.I. Utkin (1982). The size and shape of the test plot meet the requirements of *OST* 56-69-83 (1983); it includes more than 200 trees of the main forest-forming species and all the cenoelements of the phytocenosis structure.

The location and environmental conditions of the test plot were described in 1997, all trees were calculated, and their life status was determined. The inventory parameters of tree species were calculated by regional reference materials (*Spravochnik…,* 1990). The test area was preliminary divided into 10 × 10 m squares. Schematic maps on a scale of 1 : 100 were compiled for vegetation layers; they reflected the centers of tree trunks and crowns, projections of shrubs, and contours of microgroups of the grass layer. The lower layer was mapped the next summer, because herbs were strongly trampled during the works with the stand.

The herb layer is a highly informative indicator of environmental conditions in the phytocenosis (Nazimova et al., 2015; Rubtsov and Rybakova, 2019). Much attention was paid to the study of its horizontal pattern, which clearly reflects the interaction of factors of external and internal media with cenopopulations of species. A microgroup—a group of plants of one site with homogeneous species composition, projective cover, and life form—was taken as the main structural element of the layer. The contours of microgroups were reflected on the plan relative to the square boundaries and the location of the bases of trees and shrub groups. Mapping was performed from the third decade of May to the end of June, when ephemeroids did not completely disappear, and summer grasses grew to the point at which it was possible to determine the boundaries of their synusiae. The characteristics of microgroups (allocation to the microrelief, projective cover, habitus, and abundance of plants of each species by the Drude scale) were determined by the largest and most typical fragment. The minimal area of microgroups was 0.5 m^2.

The names of microgroups of the grass layer corresponded to the name of the dominant species (*Scutellaria, Thalictrum,* and *Adiantum*) or a group of codominant species with similar ecology (sedge, forbs, and small grass). When the projective cover was small, the name of the microgroup was supplemented by the word *sparse* (<60%) and by the words *rare* (<40%).

The main cenoelement of the phytocenosis is the parcel in the interpretation by N.V. Dylis (1969), because it is identified with the account of the characteristics of all layers and ecotope conditions. Parcels were distinguished on the basis of a pairwise comparative analysis of schematic maps and descriptions of layers. The objectivity of the specification of parcels was confirmed by the graph method. The floristic similarity between parcels was calculated by the Jacquard criterion, which characterized the similarity of

Table 1. Inventory parameters of growing stand

Species index	Number of trees per 1 ha		Mean				Area of trunk cross section, m^2 ha^{-1}		Reserve, m^3 ha^{-1}		Density (calculated by reserve)	
			diameter, cm		height, m							
	1997	2018	1997	2018	1997	2018	1997	2018	1997	2018	1997	2018
Ln	276	188	22.6	27.1	16.7	17.5	11.1	10.81	92.4	87.3	0.40	0.30
O	100	88	30.2	36.9	17.4	17.6	7.36	9.40	56.5	74.2	0.21	0.25
Mm	129	148	17.3	14.2	12.0	11.1	3.01	3.00	20.9	20.3	0.21	0.19
Asm, Asr	50	19	18.6	26.2	15.1	18.2	1.37	1.03	9.55	9.70	0.07	0.05
Wl	24	19	24.5	33.1	15.5	16.9	1.12	1.64	8.01	12.82	0.03	0.08
El, Ej	24	31	15.9	15.4	14.2	14.0	0.47	0.58	5.58	5.26	0.21	0.20
Ma	19	12	13.1	18.2	11.6	12.9	0.26	0.31	1.63	2.12	0.02	0.02
Hr	10	16	11.4	11.3	8.3	8.3	0.25	0.39	1.28	1.99	<0.01	<0.1
Tpc	9	9	22.9	30.5	15.1	16.5	0.29	0.52	2.13	4.09	0.01	0.02
Mkor	40	52	7.6	8.6	6.7	7.0	0.16	0.31	0.67	1.3	<0.1	<0.1
Pr	40	24	6.6	7.8	–	–	0.14	0.11	–	–	<0.01	<0.01
Mas	5	7	7.0	8.2	9.0	9.7	0.02	0.04	0.07	0.16	<0.01	<0.01
Bd	5	2	22.9	51.0	16.7	19.2	0.38	0.47	2.78	5.22	0.01	0.02
As	10	2	18.9	22.2	15.7	16.6	0.27	0.09	1.87	0.65	0.01	<0.01
Total	741	617	21.3	24.6	–	–	26.2	28.7	203.4	225.0	1.19	1.18

Tree species: Ln, Amur linden; Manchurian linden; O, Mongolian oak; Mm, mono maple (*Acer mono*); Asm, Manchurian ash; Asr, rhynofolious ash (*Fraxinus rhynchophylla*); Wl, Manchurian walnut; El, elm (*Ulmus laciniata*); Ej, elm (*U. japonica*); Ma, maakia (*Maackia amurensis*); Hr, heartleaf hornbeam; Tpc, prickly castor aralia; Mkor, Korean maple; Pr, Amur tree lilac (*Ligustrina amurensis*); Mas, mountain ash (*Micromeles alnifolia*); Bd, Dahurian birch (*Betula dahurica*); and As, aspen.

the plant cover of the plots (squares of PTP) by qualitative (species number) and quantitative (abundance of specie and projective cover) parameters (Dudenko, 2012). The names of parcels (by analogy with the names of forest types) included the names of edificatory species of stand and underbrush (in case the density of shrubs more than 0.6.) and of the background microgroup of the grass layer.

RESULTS AND DISCUSSION

The broadleaved—linden with lianas and hazel forb forest type[2] represents the final stage of regenerative succession. It was formed in place of a Manchurian (needle) fir—broadleaved forest that underwent selective logging and fire in the middle of the 20th century. It includes more than 110 species of higher vascular plants and differs from the previous community by the absence of Manchurian fir. Such forests are considered conditionally—indigenous (Man'ko, 1984; cited by Kudinov, 2000).

The transformation of the phytocenosis from 1997 to 2018 was related to the natural stand dynamics (Table 1). During this 20-year period, aspen (*Populus tremula*) almost completely disappeared from the community, and 63% of the previous number of ash (*Fraxinus mandshurica* and F. *rhynchophylla*) and maackia (*Maackia amurensis*) disappeared. Among the main species, linden was characterized by the greatest number of dead trees (about 32% of the total number); these were mainly over-mature and undersized trees. The number of dead trees was only 2.5% for oak (*Quercus mongolica*) and no more than 1% for walnut. The number of accompanying tree species typical for the coniferous—broadleaved forest increased: of hornbeam, maples (to the greatest rate of *Acer pseudosieboldianum*), elm (*Ulmus laciniata*), and mountain ash (*Micromeles alnifolia*). The formula of the composition (by reserve) slightly changed: 5Ln3O1Mm1(Asm, Asr) + (El, Ej), Wl, single Bd, Tpc, As, Ma, Hr in 1997 and 4Ln3O1Mm1Wl1(Asm, Asr) + (El, Ej), Bd, Tpc, single Ma, Hr in 2018. The species composition of the stand remained the same: 22 species and even distribution of trees over the area. The mean diameter of the stand increased by 2–3 units of thickness for trees of the first layer (the height was 16 m and more) and by 1–2 units for trees of the second layer.

The crown density is still high (0.95), but the degree of overlap of the crowns decreased due to tree death. As a result, the illumination under the forest

[2] Further, for brevity, *the broadleaved linden with liana vegetation, the hazel forb* forest type will be called "liana forest" based on its main feature, and the north-north-eastern slope will be called "northern slope."

canopy became better except for microplots with trees with crowns wound by actinidia. The improvement of light conditions caused an increase in the vitality of undergrowth and underbrush.

All tree species are represented in the undergrowth in sufficient quantities (about 7000 plants ha^{-1}). Small representatives of fir undergrowth were few on the slope at the end of the 20th century. They died early in the spring of 1998 after a ground fire. Leaf shrubs completely regenerated in a few years. The test plot was not affected by the fire.

Among the 11 species of shrubs, Manchurian hazel (*Corylus mandshurica*) and mock-orange (*Philadelphus tenuifolius*) dominated throughout the entire period of research, and common species were represented by Amur tree lilac, as well as *Viburnum burejanum*, in 2018 in particular. The total closeness of the underbrush increased by only 0.1 units: from 0.5–0.6 to 0.6–0.7, but the distribution of shrubs over the phytocenosis area became more uneven. The differences between the crown densities became more pronounced: from 0.1 (in damp areas at the bases of terraces and under trees with high crown density or with crowns wound by lianas) to 1.0 (places of tree fall). Sparse underbrush was also typical for areas with a convex and, thus, drier surface. In addition to scattered groups of mock-orange and hazel, there were single shoots of Amur barberry (*Berberis amurensis*), Sargent viburnum (*Viburnum sargentii*), and Manchurian currant (*Ribes mandshuricum*) less than 1 m in height in such ecotopes.

The number of revealed species in the herbal layer was 79 in 1998 and 74 in 2018: light-demanding and introduced species disappeared. The dominants were represented by poppy (*Hylomecon vernalis*), ferns, horsetail (*Equisetum hiemale*), and sedges (*Carex campylorhina*, *C. cf reventa,* and *C. siderosticta*). Microgroups of forbs and ephemeroid (in spring) complexes, which together occupied almost 70% of the phytocenosis area, remained predominant (Moskalyuk, 2021). The increased edificatory functions of the underbrush and of the young generation of broadleaved species was manifested in an increased mosaic pattern of the herbal layer: the number of microgroups in the horizontal structure of the layer increased from 52 to 67 over the 20-year period.

The main feature of the forest consists of the presence of adult actinidia lianas (*Actinidia arguta*), spread into crowns of trees of the first layer, and of short, usually creeping, lianas of *Schizandra chinensis* and *Vitis amurensis*.

There are no more than four to five parcels in primary coniferous–broadleaved forests with a formed structure (Maksimova, 1987). The parcel structure of the liana phytocenosis (Fig. 2) is not completely formed. In 1998, 12 parcels were distinguished in it, and 6 of them remained unchanged by 2018. Six parcels were replaced by four new ones. The contours of the parcels became more smoother (Fig. 2b), and the distribution of the area by parcels was more uniform. There were five basic (according to N.V. Dylis, 1969) parcels, which predominated in area in 1998, of size from 9.0 to 27.8% of the phytocenosis square. In 2018, their number increased to seven, with sizes from 9.3 to 18.7%. The total area of these parcels varied slightly: 77.5% in 1998 and 79.5% in 2018. The largest of the complementary parcels occupied 5.5% in 1998 and 6.7% in 2018.

The first place with respect to the occupied area in the community belonged (and belongs up to now) to a conditionally—indigenous **oak–linden poppy (1, poppy)**[3] **parcel**. Its area decreased 1.5 times by 2018, but still remained the largest (Fig. 3). Linden and oak predominated in its stand (the stand formula was 5Ln3O1(Asm, Asr)1Wl + (El, Ej), Pr. A slight inclination (5°–7°), which is smaller than in adjacent areas, favors the good illumination of the surface not only in spring, but also in summer. Poppy forms a dense cover with projective cover of 90–100% until June. In addition to it, anemone (*Anemonoides extremiorientalis*) is common in this parcel. Poppy completely disappears by the middle of summer, and a sparsely covered microgroup of forbs with a projective cover of 20–25% becomes the background.

Several linden trees simultaneously died in the largest parcel area in the lower part of the test plot. Fragments of two parcels—of the adjacent *oak–linden with mono maple, with Amur tree lilac and hazel underbrush and with very rared herb cover* and of new parcel—*lime–maple with mock-orange underbrush and with very sparsed herb cover*—penetrated into the gaps.

Oak—linden with mono maple with Amur tree lilac and hazel in underbrush and with very *rared herb* cover (2, Amur-tree-lilac–hazel with *very rare herb cover*) parcel (Fig. 4) is one of the main conditionally—indigenous ones. It occupied and occupies several plots on the slope of 5°–7° or steeper. The formula of the stand composition is 5Ln3O1Mm1(Asm, Asr) + As, Hr, unit Ma. This parcel is distinguished by a very dense hazel layer and a few groups of maple (*Acer barbinerve*). Amur tree lilac was widely spread in it during the 20-year period. The height of shrubs reaches 4 m. Underbrush is a coedifier of the stand and strongly shades the surface and restricts the growth of grasses. Small forb synusia and single representatives of tall grasses are incorporated into the background very sparse microgroup of forbs (with projective cover to 20%). The form of Amur tree lilac becomes creeping on some microplots, where it replaces the grass layer. By 2018, the parcel area increased 1.2 times.

Broadleaved actinidia parcel with Amur tree lilac and hazel underbrush with very rare herb cover (3, actinidia) is one of the most typical for the phytoceno-

[3] First, the parcels common to 1998 and 2018 are described, then – separately for 1998 and 2018. In parentheses are given number and short name of the parcel.

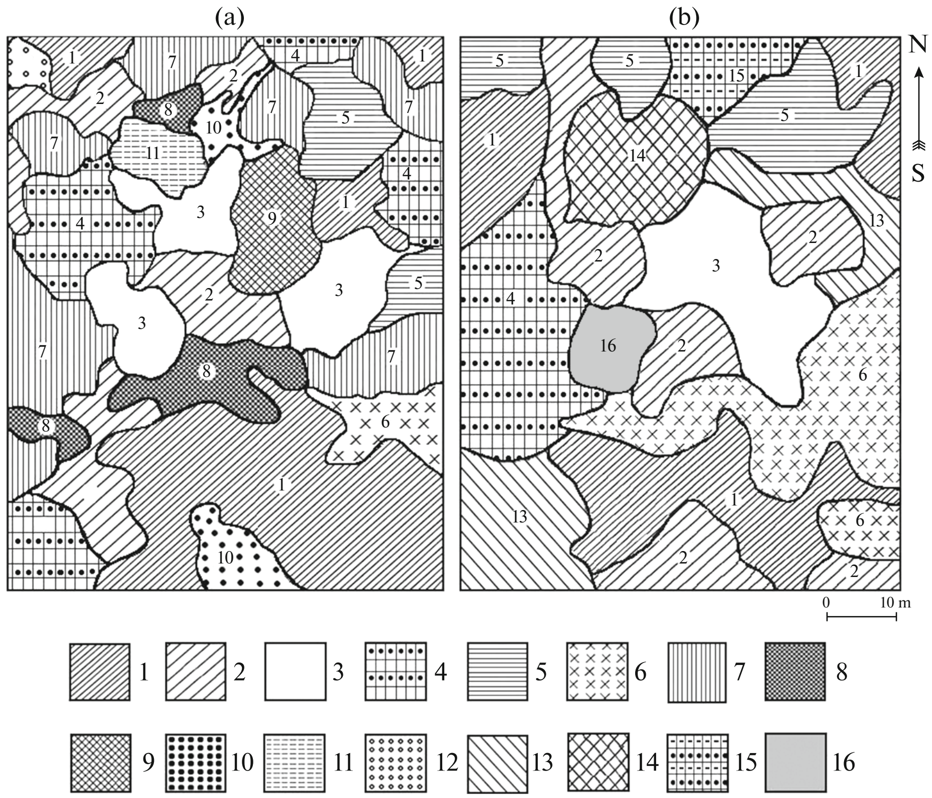

Fig. 2. Parcel structure of a broadleaved-linden phytocenosis with lianas, with hazel underbrush, and with forb grass cover. Parcels common for 1998 and 2018: (1) Oak–linden with poppy (*Hylomecon vernalis*) (27.8% of the phytocenosis area); (2) oak–linden with mono maple, Amur tree lilac, and hazel, with very sparse herb cover (12.5%); (3) broadleaved with actinidia, Amur tree lilac, and hazel, with very sparse herb cover (12.1%); (4) linden–oak with mono maple with rare forb–sedge cover (9.0%); (5) linden with Korean maple with forb–sedge grass cover (5.4%); (6) ash–broadleaved with sparse horsetail cover (2.5%). Parcels that disappeared by 2018: (7) oak–linden with mono maple with rare forb–sedge cover (16.1%), (8) mono-maple–linden with forb and starwort cover (5.5%), (9) broadleaved with actinidia with poppy (4.1%), (10) linden–oak with meadow rue and forbs (2.4%), (11) Maackia–prickly–castor–aralia with goat's–beard (2.0%), and (12) birch-linden with euonymus with forb–cover with sedge and meadow rue (0.6%). Parcels that appeared by 2018: (13) linden–mono–maple with mock-orange with rare herb cover (11.9%), (14) Maackia–prickly–castor–aralia with hazel with very rare herb cover (6.7%), (15) broad-leaved with actinidia and viburnum with rare herb cover (3.0%), and (16) oak with hazel with rare herb cover (1.6%).

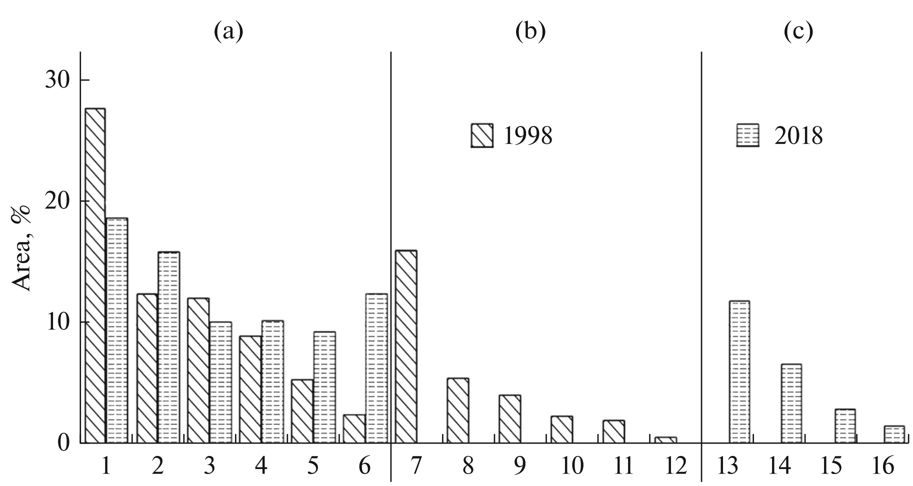

Fig. 3. Distribution of the area of phytocenosis by parcels in 1998 (a, b) and in 2018 (a, c). Names and numbers of parcels are given in Fig. 2.

Fig. 4. Fragment of the *Amur–tree–lilac*–hazel parcel with very rare herb cover.

sis. In 1998, it occupied three sites in the central part of the test plot, which adjoined the depression located across the slope. The formula of the stand composition is 4O3Ln2(Asm, ASr)1Wl, single Hr, Mm, Pr, Ma. Many trees are wound by actinidia lianas. The thickness of some of them at the base reaches 10–12 cm. Large lianas form many daughter ones. Not numerous small trees of the undergrowth and shrubs were strongly suppressed in 1998. In summer, it is always gloomy and damp in the parcel. The background is formed by forbs very sparse microgroup and leaf debris. In spring, the aspect is formed by poppy, and ephemeroids grow through the debris (*Adoxa moschatellina* L., *Allium monanthum, Ranunculus franchetii,* etc.).

Between the two sections of the parcel, the projective grass cover increased to 60% due to lighting through a large clearing formed as a result of the fall of an overripe linden. A secondary **broadleaved with actinidia with poppy (9)** parcel with very dense microgroups of poppy was identified at this site in 1998. After the clearing was overgrown with hazel, the parcel again became the *broadleaved with actinidia with Amur tree lilac and hazel underbrush with very sparse grass cover.*

After the death of several trees in neighboring parcels, light conditions in the actinidia very sparse parcel improved, and groups of hazel and Amur tree lilac were formed in two its sections. After that, the parcel name was added by the definition *with Amur tree lilac and hazel underbrush*. At the third site, *Viburnum burejanum* was spread and formed a group of 22 bushes from 0.8 to 1.6 m high. This became the basis for the specification of one of the smallest parcels in 2018 (Figs. 2b, 3): a secondary **broadleaved actinidia parcel with viburnum underbrush with very sparse grass cover (16).**

A linden–oak with mono maple parcel with rare forb–sedge cover (4, forb–sedge rare-cover) is conditionally–indigenous and the last of the five main ones described in 1998. The formula of the stand composition is 4Ln3O1Mm1(El, Ej)1As + Hr, single Pr. In 1998, it was located in different places of the test plot. It is characterized by a slightly convex surface with a slope direction downward and to the east, which results in drier conditions as compared to the rest phytocenosis. The sparse underbrush and very sparse grass layer typical for the parcel are apparently related not only to the great crown density, but also to competition for moisture and nutrients in soil. The underbrush of the parcel includes single bushes of currant and barberry in addition to common species.

During the 20-year period, aspen completely disappeared. Only one of four fragments of the parcel remained (Fig. 2), but the area of the parcel increased due to a fragment of secondary forb parcel with sedge attached to it. Mesophytic sedges and *Thalictrum filamentosum* grew and grow in very sparse grass layer together with forbs.

Parcel of linden with Korean maple with forb–sedge cover (5, Korean maple parcel) is also conditionally–indigenous. It is one of the few parcels whose formation is pronouncedly related to edaphic conditions, soil moisture in particular. The largest parcel section on the test plot is represented by a saucer-shaped microdepression bordered from the east and south by gentle slopes of a bench. The height of the slopes is 1.2–1.5 m, and the steepness is to 20°. In the west and downwards, the microdepression is gradually transformed into the main surface of the slope. The soil moisture in the parcel is much higher than in the adjacent area due to the redistribution of the slope runoff along the slope inclination.

Fig. 5. The grass layer of the forb-sedge parcel is dominated by moisture-loving *Carex campylorhina*.

The parcel stand is sparse and is represented by a small number of species; the formula of its composition is 8Ln1O1Mkor. The largest tree of Korean maple on the test plot grows and bears fruit. Transparent crowns of maples and tall lime trees let in enough light, and a dense grass layer is formed in most of the parcel area (the projective cover reaches 100%). The underbrush is sparse and is represented by small bushes of honeysuckle (*Lonicera praeflorens*), mock-orange, and bushy Korean maple.

High soil moisture is indicated by sedge (*Carex campylorhina*), the dominant of the grass layer of the parcel (Fig. 5). Mesophytic sedges—*Carex cf reventa* and *C. siderosticta*—are common. Forb–sedge and sparse sedge with forb microgroups are background-forming.

The parcel aspect was not changed during the 20-year period, except for a decrease in the abundance of meadow rue, which was a codominant of sedges in 1998. The parcel area increased 1.7 times (Fig. 3). It included two fragments of the secondary forb–sedge parcel due to the spread of *Carex campylorhyna* and the entire euonymus parcel.

The formation of the conditionally–indigenous **ash–broadleaved parcel with horsetail sparse cover (6, horsetail)** is assigned to particularly significant transformations of the parcel structure of the liana phytocenosis. The composition of its stand is 4(Asm, Asr)3Ln1O1Mm single Ma, Pr.

One microgroup with dense grass cover (with the abundance of *cop*^{3}*-soc*) and several microgroups with very sparse grass cover predominated by horsetail (*Equisetum hiemale*) were described in one place along the thalweg of the largest depression in 1998. Their total area comprised only 2.5% of the phytocenosis, but by 2018, after the death of several ash and linden trees, their area increased five times. The horsetail parcel moved aside the forb parcel with sedge and the poppy parcel occupied the entire depression and became one of the main parcels.

Horsetail now penetrates into adjacent parcels, indicating an increase in soil moisture. During the periods of snow melting and typhoons, small water flows seep out to the surface in places on the slope of the bench of the depression.

The background in the parcel is formed by microgroups with the maximal abundance (*cop*$^{2-3}$) of horsetail (Fig. 6). The single on the test plot small-grass false lily of the valley with forb sparse microgroup with the abundance of false lily of the valley (*Maianthemum bifolium*) of *cop*^{1} (by the Drude scale) is isolated in this parcel. False lily of the valley and horsetail are satellite species of indigenous forests and occur in many microgroups, where the abundance of each of them reaches *sol*.

Oak–linden parcel with mono maple with forb cover with sedge (7, forbs with sedge) is derivative and was the second largest one in the phytocenosis in 1998. Its habitats on the slope underwent a strong fire in the past. It is characterized by one of the most complicated composition of the stand (4Ln4O1(Asm, Asr)1Mm + As, single (El, Ej), Wl, Hr, Tpc) with overripe trees and aspen root shoots. The sparse herbal layer (the projective cover is 40%) was pronouncedly mosaic (17 microgroups). The background-forming microgroups included *the sedge one with meadow rue and forbs with sparse cover* and *the forb one with very rare herb cover*.

The parcel disappeared by 2018 after the death of aspen and the formation of better lightning conditions of the ecotope. Its area was distributed between adja-

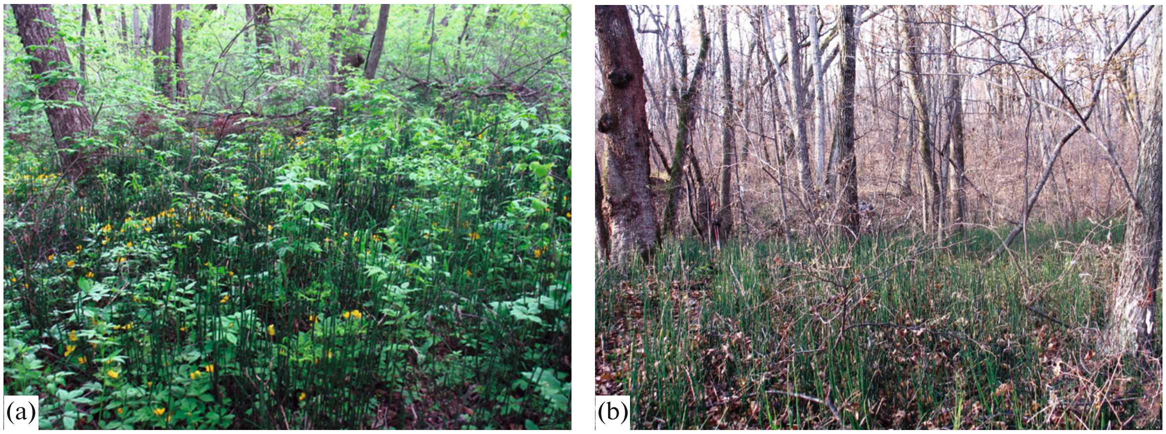

Fig. 6. Horsetail parcel in summer (a) and autumn (b) 2018.

Fig. 7. Maackia—prickly—castor—aralia parcel with goat's—beard (a) and Maackia—prickly castor—aralia parcel with hazel with very rare herb cover (b) replacing it.

cent parcels (Fig. 2). The largest fragment jointed with the conditionally—indigenous forb parcel with sedge with very sparse grass cover. Eleutherococcus became common in its underbrush in addition to hazel and mock-orange, and single isolated shoots of barberry and Sargent viburnum appeared. The number of microgroups in the grass layer decreased to 9.

Two secondary parcels, which disappeared by 2018, were allocated to newly violated microplots: **mono maple—linden parcel with forb and starwort cover (8, starwort)** and **maackia—prickly—castor—aralia parcel with goat's—beard in cover (11, goat's beard)**. The starwort parcel occupied several sites: one on a small plot of new burnt area spread to the edge of the test plot and the rest in places of dead trees. It was well distinguished by microgroups of starwort (*Stellaria bungeana*) that formed monocommunities or in combination with forbs. The parcel was absent in 2018, but starwort occurred in other microgroups.

The goat's beard parcel (Fig. 7a) strongly differed from the surrounding ones. It was formed in place of a dead very old large linden. Prior to its death, the goat's beard parcel was probably a fragment of the neighbor actinidia parcel with very sparse grass cover. The stand composition was simple but unusual: 7Tpc2Ma1Pr. A well-formed high maakia and a huge old prickly castor-oil trees surrounded by several thin trees of Amur tree lilac grew in the parcel. The crowns of the fallen linden and the prickly castor-oil trees were densely wound by actinidia lianas. In 1998, dry branches of the linden tree formed a high brush pile, from which strained dead lianas were stretched to prickly castor-oil tree.

The sparse underbrush included mock-orange, hazel, honeysuckle, and eleutherococcus. Shrubs and undergrowth were strongly suppressed, and seedlings and self-seeding were absent. Goat's beard (*Aruncus dioicus*) prevented the penetration of other species into the parcel. The background-forming microgroup composed only of goat's beard with the projective cover of 100%. Meadow rue and starwort with forbs occurred only in its peripheral part.

As the crowns of trees surrounding the gap closed, the thickets of goat's beard were replaced by hazel. Over the 20-year period, the goat's beard parcel was replaced by the **maakia–prickly–castor–aralia parcel with hazel with very rare herb cover (14),** which was additionally spread over the sites of the neighboring starwort, meadow rue, and partially actinidia parcels (Fig. 7b). Poorly developed eleutherococcus plants additionally shaded the surface under the strongly closed hazel canopy. The goat's beard microgroup was replaced by the *forb microgroup with very sparse grass cover* with fragments of previous microgroups. The pile of brushwood and a huge fallen trunk completely disappeared.

Linden–oak meadow rue parcel with forbs (10, meadow rue) was one of the few parcels with a dense grass layer in 1998. Like the forb parcel with sedge, it was significantly damaged by fire in the past, as is evidenced by the presence of aspen in the stand composition (the stand composition formula is 6O3Ln1As + Mm, single Ma). A significant amount of decomposed wood remains was recorded in the areas under meadow rue microgroups, which enabled us to suggest the allocation of this plant to soils with increased organic matter content. Meadow rue abundance was also great in the area with good side lighting: near the gap with goat's beard. *Thalictrum filamentosum* is a typical species of coniferous–broadleaved forests. It was present in many microgroups of the liana phytocenosis over the 20-year period, but its abundance decreased everywhere with the increase in the closeness of underbrush. The meadow rue parcel was combined with one of the conditionally–indigenous parcels or with the secondary **oak parcel with hazel with rare herb cover (14)**. The largest fragment of the meadow rue parcel (Fig. 2) was replaced by the conditionally–indigenous *Amur-tree-lilac-hazel parcel with very sparse grass cover*. Almost the entire area in the secondary parcel under hazel crowns is occupied by a *meadow rue microgroup* with very sparse grass cover.

The birch–linden euonymus parcel with forb grass cover with sedge and meadow rue (12, euonymus) was

Fig. 8. Mock-orange parcel with very sparse grass cover formed on a plot with dead trees.

the smallest in the phytocenosis in 1998. It was located in a local microdepression similar to that described in the Korean maple parcel. The formula of the stand composition was 5Ln5Bd, single Pr. The only overripe birch tree (*Betula davurica*) in the parcel grew and continues to grow at the edge of the slope of the microdepression. *Euonymus maximovicziana* in this parcel formed groups of two or three thin trees reaching 6 m in height. By 2018, three of five lime trees died, a lot of skeletal branches in the birch crown dried, and euonymus and Amur tree lilac completely dried up. The abundance of forbs and meadow rue sharply decreased in the grass layer, and sedge (*Carex campylorhina*) became the dominant. The euonymus parcel became one of the fragments of the Korean maple parcel.

The linden–mono maple parcel with mock-orange with rare herb cover (13) is the last of seven conditionally–indigenous parcels isolated in 2018. Mono maple is the main species of its stand. This parcel differs from parcels with dense hazel underbrush by lower humidity of habitats, which favored the growth of mock-orange in it after the formation of better lightning conditions (Fig. 8). It forms here pure groups or is mixed with eleutherococcus. The canopy density of the underbrush is 0.8–0.9, and the height of the bushes reaches 3.0 m. The *forb microgroup with very sparse grass cover* is background-forming.

CONCLUSIONS

(1) The broadleaved-linden forest type with lianas, with hazel underbrush and with forb grass cover, is a derivative formation of mixed broadleaved forests restored in place of indigenous Siberian pine and fir–

broadleaved forests in the south of Primorskii krai. It was formed in optimal forest-growing conditions and is characterized by a complicated floristic composition, including 22 tree species, 11 shrub species, 3 lianas, and more than 80 species of herbs.

(2) The analysis of the research results shows that the broadleaved-linden forest type is sustainably derived and has entered the final stage of regenerative succession. The participation of the main species (linden and ash) in the stand composition decreased from 1997 to 2018, aspen almost completely disappeared, the positions of species typical for coniferous–broadleaved forests (heartleaf hornbeam, Mongolian oak, Manchurian walnut, etc.) became stronger, and the edificatory functions of the underbrush (Manchurian hazel, mock-orange, and viburnum) increased. The forestry and inventory parameters of the stand slightly changed.

(3) The transformation of the role of tree–shrub layers by 2018 caused a strong restructuring of the parcel structure of the liana phytocenosis, indicating the progress of the forest formation:

(a) we revealed 16 parcels during the research period: 12 in 1998 (6 conditionally–indigenous and 6 derivatives); 10 in 2018 (7 and 3, respectively); 6 parcels remained common, all of them were conditionally–indigenous, and 1 parcel was added to them in 2018;

(b) there was a natural enlargement of parcels and alignment of their boundaries;

(c) the number of main (predominant by area) parcels increased from five to seven, and the area increased from 77.5 to 88.8% of the phytocenosis area;

(d) all conditionally–indigenous parcels became the main ones in 2018, occupying from 9.3 to 18.7% of the phytocenosis area;

(e) the most significant transformations in the parcel structure include the disappearance of the largest derivative parcel: the forb parcel with sedge, which mixed with adjacent parcels, a strong increase in the area of the horsetail parcel typical for coniferous–broadleaved forests, and the change of the goat's beard parcel by hazel parcel with very sparse grass cover.

(4) The formation of the parcel structure of forest communities on the northern slopes in Southern Primor'e is primarily determined by ecotopic conditions (microrelief and soil moisture), and then by cenotic factors (restriction of light penetration to the surface by community edifiers). There is no relation between the species composition of the tree–shrub layers and the pattern of parcels.

(5) The grass layer is the most dynamic component of phytocenosis and is a reliable indicator of the transformation of intracenotic conditions. In response to an increase in the density of tree and shrub layers, the area of parcels with microgroups with dense grass cover (the projective cover >60%) decreased five times over the 20-year period; the number of parcels with light-demanding species decreased (*Aruncus dioicus, Carex reventa, Disporum viridescens, Hylomecon vernalis, Stellaria bungeana,* etc.), and the amount of parcels with shade-tolerant and moisture-loving species became greater (*Equisetum hyemale, Adiantum pedatum, Carex campylorhina, Caulophyllum robustum,* etc.).

(6) The broadleaved-linden forest differs from the previous indigenous fir–broadleaved forest type only by the absence of *Abies holophylla* and *Pinus koraiensis,* which is explained by the impact of periodic ground fires and remote sources of seeds. For the final restoration of the indigenous forest, fire prevention and measures to promote natural renewal are necessary. They should be planned, taking into account the parcel structure of the phytocenosis.

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ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This work does not contain any studies involving human and animal subjects.

CONFLICT OF INTEREST

The author of this work declares that she has no conflicts of interest.

REFERENCES

Caspersen, J.P. and Pacala, S.W., Successional diversity and forest ecosystem function, *Ecol. Res.*, 2001, vol. 16, no. 5, pp. 895–903.

Distribution of forest area and timber stocks by predominant species and age groups as of 01/01/2021), Information on the procedure for providing information from the state forest registry of Primorsky Krai. https://primorsky.ru/authorities/executive-agencies/departments/forestry/folder2/.

Dudenko, G.A., Ecological and coenotic structure of secondary forests in southern Primorye, *Extended Abstract of Cand. Sci. (Biol.) Dissertation*, Ussuriisk: Primorsky State Agric. Acad., 2012.

Dylis, N.V., *Struktura lesnogo biogeotsenoza* (Structure of the Forest Biogeocoenosis), Moscow: Nauka, 1969.

Dylis, N.V., Structural and functional organization of biogeocenotic systems and its study, in *Programma i metodika biogeotsenologicheskikh issledovanii* (Program and Methodology of Biogeocenological Research), Moscow: Nauka, 1974, pp. 14–23.

Elliot, T., Goldstein, B., Gómez-Baggethun, E., Proença, V., and Rugani, B., Ecosystem service deficits of European cities, *Sci. Total Environ.*, 2022, vol. 837, p. 155875 https://www.sciencedirect.com/science/article/abs/pii/S0048969722029722.

Gao, T., Hedblom, M., Emilsson, T., and Nielsen, A.B., The role of forest stand structure as biodiversity indicator, *For. Ecol. Manage.*, 2014, vol. 330, pp. 82–93.

Hector, A. and Bagchi, R., Biodiversity and ecosystem multifunctionality, *Nature*, 2007, vol. 448, no. 7150, pp. 188–190.

Isaev, A.S., Nosova, L.M., and Puzachenko, Y.G., Biological diversity of Russian forests – the programme of action, *Lesovedenie*, 1997, no. 2, pp. 3–13.

Ivanov, A.V., Ivanova, E.V., and Gamaeva, S.V., Changes in the diversity of conifer–broadleaf forests of Southern Primorye resulting from selective logging and fires, *Russ. J. Ecol.*, 2022, vol. 53, no. 2, pp. 83–90.

Ivanova, I.T., Yaroshenko, P.D., and Berstyukova, K.P., Microphytocenoses of some communities of coniferous-deciduous forests of Primorye, *Komarovskie Chteniya*, 1963, vol. 11, pp. 58–85.

Keenan, R., Reams, G., Achard, F., De Freitas, J., Grainger, A., and Lindquist, E., Dynamics of global forest area: results from the FAO Global Forest Resources Assessment 2015, *For. Ecol. Manage.*, 2015, vol. 352, pp. 9–20.

Kolesnikov, B.P., Vegetation, in *Yuzhnaya chast' Dal'nego Vostoka* (Southern Part of the Far East), Moscow: Nauka, 1969, pp. 206–250.

Komarova, T.A., On the horizontal heterogeneity of fir-spruce small-grass-fern forests of northern Sikhote-Alin, *Ecology*, 1978, no. 1, pp. 42–49.

Komarova, T.A., Change of the synusia structure of the dwarf shrub and grass layer during post-fire successions, *Bot. Zh.*, 1993, vol. 78, no. 6, pp. 86–95.

Koryakin, V.N. and Chelyshev, V.A., Modern characteristics of forests, in *Sovremennoe sostoyanie lesov Rossiiskogo Dal'nego Vostoka i perspektivy ikh ispol'zovaniya* (Current State of Forests of the Russian Far East and Prospects for Their Use), Khabarovsk: Dal'nevost. Nauchno-Issled. Inst. Lesn. Khoz., 2009, pp. 15–34.

Kovalev, A.P., Alekseenko, A.Y., Lashina, E.V., and Kachanova, T.G., The need for changing priorities in logging successional Korean pine-broadleaved forests of the Far East, *Sib. Lesn. Zh.*, 2020, no. 2, pp. 3–13.

Krupyanko, N.A., Synusial structure of the herbaceous layer in cedar of the Ussuriysk reserve, *Bot. Zh.*, 1983, vol. 68, no. 10, pp. 1385–1392.

Kudinov, A.I., *Dubovo-kedrovye lesa Yuzhnogo Primor'ya i ikh dinamika* (Oak-Cedar Forests of Southern Primorye and Their Dynamics), Ussuriisk: Primorsky State Agric. Acad., 2000.

Lukina, N.V., Geras'kina, A.P., Gornov, A.V., Shevchenko, N.E., Kuprin A.V., Chernov T.I., Chumachenko S.I., Shanin V.N., Kuznetsova A.I., Teben'kova, D.N., Gornova, M.V., Biodiversity and climate regulating functions of forests: current issues and prospects for research, *Vopr. Lesn. Nauki*, 2020, vol. 3, no. 4, pp. 1–90.

Maksimova, V.F., Mosaic elements of the grass layer in the cedar-broad-leaved forests of the Middle Sikhote-Alin, in *Kedrovo-shirokolistvennye lesa Dal'nego Vostoka* (*biogeotsenoticheskii aspekt*) (Cedar-Broad-Leaved Forests of the Far East (Biogeocenotic Aspect)), Vladivostok: Dal'nevost. Otd. Akad. Nauk SSSR, 1987, pp. 79–85.

Mestre, L., Toro-Manríquez, M., Soler, R., Huertas-Herrera, A., Martínez-Pastur, G., and Lencinas, M.V., The influence of canopy-layer composition on understory plant diversity in southern temperate forests, *For. Ecosyst.*, 2017, vol. 4, no. 6, p. 13. https://forestecosyst.springeropen.com/articles/10.1186/s40663-017-0093-z.

Moskalyuk, T.A., Coenotic structure and monitoring of the forests of the Far East, *Materialy IV Mezhdunarodnoi konferentsii "Rasteniya v mussonnom climate"* (Proc. IV Int. Conf. "Plants in a Monsoon Climate"), Vladivostok, 2006, pp. 78–82.

Moskalyuk, T.A., Transformation of the herbaceous layer over 20 years of restoration succession in broadleaved forests with lianas in the south of Primorye territory, *Komarovskie Chteniya*, 2021, мol. 69, pp. 26–78.

Moskalyuk, T.A. and Tarasova, I.S., Structure of the herbal tier in broad-leaved forest of the Southern Maritime Province at year term, in *Zhivotnyi i rastitel'nyi mir Dal'nego Vostoka* (Fauna and flora of the Far East), Vladivostok: Dal'nevost. Otd. Akad. Nauk SSSR, 2015, vol. 24, pp. 37–54.

Nazimova, D.I., Climatic ordination of forest ecosystems as the basis for their classification, *Lesovedenie*, 1995, no. 4, pp. 63–73.

Nazimova, D.I., Konovalova, M.E., Danilina, D.M., Ponomarev, E.I., Stashkevich, N.Y., and Baboi, S.D., The study of forest dynamics in the pergumid climate of Western Sayan mountains (Ermakovsky research station of V. N. Sukachev Institute of Forest, Russian Academy of Sciences, Siberian Branch), *Sib. Lesn. Zh.*, 2015, no. 4, pp. 3–17.

OST 56-69-83, *Ploshchadi probnye lesoustroitel'nye* (Trial Forest Management Areas), Moscow: TsBNTI Gosleskhoza SSSR, 1983.

Petropavlovskii, B.S., *Lesa Primorskogo kraya* (Forests of Primorye territory), Vladivostok: Dal'nauka, 2004.

Rubtsov, M.V. and Rybakova, N.A., Dynamics of parcel structure of forest phytocoenoses in regenerating spruce population in boreal birch forests, *Lesovedenie*, 2016, no. 5, pp. 323–331.

Sibirina, L.A., Risk of loss habitat of the broadleaved-Korean pine forests by the irrational forest management, *Materialy VIII Mezhdunarodnogo ekologicheskogo foruma "Priroda bez granits"* (Proc. VIII Int. Ecol. Forum "Nature Without Borders"), Vladivostok: Dal'nevost. Fed. Univ., 2014, pp. 404–406.

Sosudistye rasteniya sovetskogo Dal'nego Vostoka (Vascular Plants of the Soviet Far East), Kharkevich, S.S., Ed., St. Petersburg: Nauka, 1985–1996, vols. 1–8.

Spicer, M.E., Mellor, H., and Carson, W.P., Seeing beyond the trees: a comparison of tropical and temperate plant growth forms and their vertical distribution, *Ecology*, 2020, vol. 101, no. 4, p. e02974.

Spravochnik dlya taksatsii lesov Dal'nego Vostoka (Guide to the Far-East Forests Taxation), Khabarovsk: Dal'nevost. Nauchno-Issled. Inst. Lesn. Khoz., 1990.

Strategiya i Plan deistvii po sokhraneniyu biologicheskogo raznoobraziya Rossiiskoi Federatsii (Strategy and Action Plan for the Conservation of Biological Diversity of the Russian Federation), Moscow: Min. Prir. Resur. Ekol. Ross. Fed., 2014. https://www.cbd.int›doc›world›ru-nbsap-v2-ru

Sukachev, V.N. and Zonn, S.V., General principles and program of forest types study, in *Metodicheskie ukazaniya k izucheniyu tipov lesa* (Guidelines for the Study of Forest Types), Moscow: Akad. Nauk SSSR, 1961, pp. 1–104.

Teben'kova, D.N., Lukina, N.V., Chumachenko, S.I., Danilova, M.A., Kuznetsova, A.I., Gornov, A.V., and Gagarin, Yu.N., Multifunctionality and biodiversity of forest ecosystems, *Lesovedenie*, 2019, no. 5, pp. 341–356.

UNSPF: United Nations strategic plan for forests 2017–2030 and quadrennial programme of work of the United Nations Forum on Forests for the period 2017–2020: Resolution adopted by the Economic and Social Council on 20 April 2017. https://www.iucn.org/sites/dev/files/content/documents/strategic_plan_2017_2030.pdf.

Usol'tsev, V.A., Biodiversity in ecosystems: a brief analysis of the problem, *Eko-Potentsial, Biol.*, 2019, vol. 1, no. 25, pp. 9–47.

Utkin, A.I., Methods of researching the primary productivity of forests, in *Biologicheskaya produktivnost' lesov Povolzh'ya* (Biological Productivity of Forests of the Volga Region), Moscow: Nauka, 1982, pp. 59–71.

Vasil'ev, N.G. and Kolesnikov, B.P., *Chernopikhtovo-shirokolistvennye lesa Yuzhnogo Primor'ya* (Black-Fir-Broad-Leaved Forests of Southern Primorye), Moscow: Akad. Nauk SSSR, 1962.

Vozmishcheva, A.S. and Perepelkina, P.A., The influence of synusia of the herb-shrub layer on the parameters of undergrowth in northern and southern broad-leaved cedar forests, *Sovrem. Probl. Nauki Obraz.*, 2015, no. 6. https://www.science-education.ru/ru/article/view?id=23338.

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