ISSN 1995-4255, Contemporary Problems of Ecology, 2017, Vol. 10, No. 7, pp. 812–821. © Pleiades Publishing, Ltd., 2017.
Original Russian Text © Yu.I. Man'ko, L.A. Sibirina, G.A. Gladkova, 2017, published in Lesovedenie, 2017, No. 3, pp. 163–175.

Application of the Initial Forest Survey Materials to Find the Key Intact Forest Sites in the Far East

Yu. I. Man'ko*, L. A. Sibirina, and G. A. Gladkova

Biology and Soil Science Institute, Far East Branch, Russian Academy of Sciences, Vladivostok, 690022 Russia

**e-mail: manko@ibss.dvo.ru*

Received February 9, 2016

Abstract—We provide a short review of the development history of the Far East and the first sampling plots initiated in various forest formations by A.G. Petrovich, a pioneer in forest studies of Primorye, right after its incorporation in 1870–1871. The sampling plots reflect the composition and productivity of typical forest sites, and thus could be used as etalons of intact forests. Protected areas in forests of the Far East should become the monitoring basis of forest-forming processes under natural and human-induced changes. The authors recommend organizing the growth plots in undisturbed and secondary forests there.

Keywords: Far East, forest planning, protected areas, monitoring, growth plots, forest ecosystems

DOI: 10.1134/S1995425517070095

The *Lesovedenie* journal (No. 5, 2015) published discussion articles by O. Smirnova et al. and AA Tishkov devoted to the biodiversity of forests in European Russia and the search for ways to restore it. The problems touched upon in them are very relevant for the forests of the Far East, which have been formed in other climatic conditions and have other historical dynamics, including those influenced by human activity.

By the time the Far East was annexed into Russian possessions (1858–1860), this vast territory was largely covered by forests that differed in composition of tree species from the forests of the central part of Russia. The aboriginal population, according to the testimony of the first researcher of the forests of the Amur River region, A.F. Budishchev (1898, pp. 28), was small: "of all local residents, there are hardly more than 10000 people of both sexes."

The peoples who lived in Primorye and the Amur River region were engaged in gathering, hunting, and fishing. They used wood for their own needs in a very small amount. Only a small number of people who lived in the lower reaches of the Amur River used the forest for construction. The rest of the population even in winter lived in yurts of birchbark or covered with peeled bark. Although the local population widely used wood products in everyday life, making household utensils, tools, and vehicles, and using wood for fuel, its impact on the forest was insignificant and was observed only near dwellings (camps) and nomad paths, which in the summer were rivers. Some small ethnic groups from birth to death were inextricably linked with the forest, finding shelter, food, and medicine in it. Foci of aboriginal population residence were confined to the valleys of large rivers (Khor, Bikin, Iman, Samarga, etc.), and also located along the Amur River.

More detailed information on the use of different types of trees and forest gifts by the indigenous peoples of the Far East can be found in the work of A.S. Sheingauz (1971), who summarized the materials published on this matter and calculated the approximate volumes of wood used. According to his calculations, the annual wood consumption in the entire Far East by the middle of the 17th century was about 300000 m^3, and it stayed at this level until the middle of the 19th century.

The animism of most indigenous peoples required strict adherence to certain norms of behavior in nature and a careful attitude to plants and animals, which undoubtedly contributed to the preservation of forests and biological diversity. However, the influence of man on forests was different in different parts of this vast territory and in different historical periods. The annexed territory, according to historians, was a kind of center of ancient cultures; moreover, A.P. Okladnikov put forward a hypothesis that this territory could be a part of the area where human development was taking place (History ..., 1989). In the Neolithic, the massive population of the territory of Primorye by ancient men took place, with the active development of the seacoast and river valleys, where long-term dwellings were built, which testifies to the settled way of life of their inhabitants. The economic basis for the settled life of the tribes that lived in Primorye and in the Amur River basin was fishing. However, the presence of tools such as hoes, hand stones, and pestles in the inventory of these tribes allowed the hypothesis of the emergence of agriculture here in the 3rd millennium B.C.

In the second half of the 1st millennium B.C., the wide distribution of products from iron begins and the further development of agriculture and cattle breeding takes place, leading to a significant increase in human exposure to vegetation. For example, in the Southern Primorye, in the area from Lake Khanka to the sea coast, there were settlements, the inhabitants of which, along with collecting, engaged in farming and cattle breeding (Primorsky Krai ..., 1997).

The forest vegetation experienced the strongest human impact in the south of the Far East during the time of the Bohai kingdom (7th–9th centuries), which occupied the basin of the Ussuri River, middle and lower Amur, sea coast to the south of the mouth of the Amur River, part of northeast China, and North Korea (Shavkunov, 1968), and the successor state of the Jurchen (12–13 centuries). The remains of ancient settlements, in many cases already overgrown with forests, have been preserved to the present day in the southern and even northern parts of Primorye, as well as in Amur oblast.

In addition to direct use by the population of wood in everyday life (buildings, heating of dwellings, and making utensils) and handicraft production (metallurgy, pottery, glass making, making bricks, etc.), around large settlements there were lands associated with cultivated land and livestock, areas on which the size of the settlement and the occupation of the settlers depended on. According to A.P. Okladnikov (1959), the main occupation of the inhabitants of the Bohai state was agriculture, and, in the Jurchen time, which came after the fall of the Bohai state, in his opinion, agriculture was more developed than ever. The network of agricultural settlements and military-administrative centers extended into the depths of the forest and mountain regions of Primorye and even to the Amur. The northern Jurchen tribes used to live in the territory of the Primorye, supplying ginseng, cedar nuts, bellows, and other vegetable and animal products for export from the Jin state (Vorob'ev, 1975).

First and foremost, rich floodplain lands were used. To develop and expand the acreage and areas needed for cattle breeding, a slash-and-burn farming system was used. In the time of these civilizations, attempts were made to acclimatize some tree species that, in the wild, are still found in Primorye in the localities or in the areas of ancient settlements (Komarov, 1917; Strogii, 1934; Kolesnikov, 1955). B.A. Ivashkevich (1923) believed that, under the influence of man and the fires accompanying his activity, which began approximately from the 6th century, there were treeless spaces of the Prihanka plain in the place of mixed forests with a predominance of coniferous species, erroneously, as he considered, called steppes. According to the conclusion of botanist N.V. Shipchinsky (1955), a member of the expedition to the South Ussuri region in 1913, to whom V.L. Komarov instructed to understand the nature of the vegetation in this territory, "there were no and are no real steppes in the Southern Primorye" (p. 53), and the appearance of this formerly forest area was formed under the influence of ancient settlers; he showed how mixed forests in southwestern Primorye degraded to meadows of three types, in which trees and shrubs no longer participated, under the influence of deforestation factors.

G.E. Kurentsova (1962), the author of a number of articles and a monographic work on the vegetation of the Prikhanka plain, believed that the ancient population, whose traces of activity are present in this territory, could not change the natural forest-steppe nature of the vegetation, although it seems to us that agricultural activity could contribute to the strengthening of its gradualization. Secondary deciduous forests with a predominance of oak, widespread in this area at present, can be considered as heirs of the native forest vegetation, which gradually occupied abandoned land after the fall of ancient states. The high fire danger of this forest formation associated with the annual accumulation of a thick leaf litter, as well as the peculiarity of the climate of this territory, led to frequent forest fires, which prevented the restoration of native vegetation (Man'ko, 2011).

Forest fires, which usually accompanied economic activities, have at all times influenced forests not only in the Prikhanka plain, but also in large areas. For example, B.P. Kolesnikov (1938) assumed that the unique belt of xermesophilic oak forests that stretched along the coast of the Sea of Japan and was represented by secondary postfire forests perhaps was formed as far back as in the era of the Bohai kingdom. In general, he believed that the periodic destruction and restoration of the natural vegetation cover, which occurred in historical times, strengthened its diversity and mosaicism, which was primarily due to zonal and regional factors (Kolesnikov, 1955).

In addition, the complex ethnic composition of the population in eastern Asia led to frequent wars, which were accompanied by fires, which inevitably affected the forest vegetation.

With the fall of the state of the Jurchens as a result of the invasion of the Mongols, which destroyed its cities and settlements, the territory of the Amur River region before the arrival of the Russians was occupied mainly by a few aboriginal tribes scattered over a vast territory.

With regard to the low forest cover of the territory of the Amur Region, lying between the Zeya and Bureya rivers, S.I. Korzhinsky (1892) suggested that forests here used to be more common, but then they were destroyed by the native agricultural population "who lived in this region from time immemorial." This opinion was also supported by M.F. Korotkii (1912), which brings additional arguments in his favor. He associated the sparsely forested nature of this territory with the constant negative influence of the fires, and not with the peculiarities of the soil–climatic conditions. On the territory of the region there are remains of ancient settlements of the Daurian type, as well as burial mounds and burial grounds, the dates of which have not yet been established.

Thus, the vegetation cover of the Amur River region at the time of its accession to Russian possessions was inhomogeneous in terms of the degree of anthropogenic impact on it in past historical epochs. The least influence of man was exposed to forests in mountainous areas, remote from the centers of agriculture and civilization.

In 1859, on the initiative of the Governor General of Eastern Siberia, N.N. Muraviev, a special forest-management party was sent to the Far East with the highest permission to get information about the forests near the shores of the Eastern Ocean and the Amur River and its tributaries (Century ..., 1898). The main task assigned to the party was, first of all, in the allocation of forests suitable for shipbuilding. The forest-management party was headed by Staff Captain of the Foresters' Corps A.F. Budishev; it included reserve topographer M.M. Lubenskii and class topographers A.G. Petrovich and A.I. Korzun. The studies of the party covered the entire Amur River region along the entire system of its rivers and their watersheds and received extensive and diverse material, valuable not only for the knowledge of forests, but also for the overall geographic characteristics of the adjoining region. In addition to their general description, for the first time in the region, forestry-taxation methods (laying sampling plots and the selection of model trees, based on which the age and the growth of tree species and their quality were established) were used in the route research of forests. As a result, the party examined 6962000 dessiatines: Budishchev, 2790000; Lyubenskii, 2517725; Korzun, 746 875; and Petrovich, 907400 dessiatines. The cost of examining one dessiatine was only 0.07 kopecks. In addition, Budishchev compiled a map of the southern part of the Far East on a scale of 5 versts per inch, in which the Amur valley with the Ussuri tributary and the southern regions of Primorye is depicted in detail. The dashed line shows the boundaries of forests and reliably assesses the role of forest areas in individual areas (Starikov, 1964).

The works of the forest party, as was mentioned in the preface to the collection published on the basis of the results of its work, in addition to scientific interest, represent a rich material for forestry in the Amur River region and can serve as valuable guidance in the start of forest management in this region and its settlement. Unfortunately, the sampling plots laid by the forest-management party have not yet been found. Only in a few number of essays, Budishev, in addition to the general results of studying the composition and state of forests, cited information based on materials from more detailed studies (Collection ..., 1898, pp. 112–119, 383–394).

For example, when characterizing forests in the vicinity of the Imperatorskaya Gavan, based on the results of studying 12 sampling plots, he reported on the composition, stock, average age, average growth, and density of the stands. The evaluation of the forests near Nikolaevsk was based on the materials of 27 sampling plots of the size of a half-dessiatine with the selection of model trees "divided by size into classes." According to him, the average age (of the dominant trees) in primordial plantations of spruce and larch varied between 130 and 190 years, and there were trees of other ages. Less common were forest stands in which trees predominated of 80–100–120 years of age, while "in more or less abundance" there were trees under the age of 250 years. That is, there was talk of natural unevenly aged forests that are at different stages of age dynamics. Secondary forests, where the stand was burnt or completely cut down, were, according to Budishchev, almost of the same age (Collection ..., 1898, pp. 112–119). The age difference (with the predominance of trees in the older age) was also characteristic of the south-facing mixed multi-tree forests in the vicinity of Vladivostok, which is also established on the material of sampling plots (Collection ..., 1898, p. 295).

After the unexpected death of Budishchev, work on the allocation of ship forests in the province was entrusted to A.G. Petrovich (Man'ko, 2011). In one of his reports, a table with a characteristic of 34 sampling plots laid by him in 1870–1871 in various areas of the region and in different forest formations was found (RGIA DV[1], f. 1, op. 1, d. 521, p. 2). Since his main task was to allocate the timber woods and forests suitable for shipbuilding, the sampling plots were to characterize the typical forest areas without any traces of anthropogenic impact. Of the sampling plots laid by Petrovich, we selected 12 to characterize the natural stands belonging to different forest formations, believing that they characterized the pristine forests, by which we mean the natural forest areas unchanged throughout the life of the main forest formator (Man'ko, 2001). However, among the sampling plots of Petrovich, there were two, judging by the composition of the stand, related to the secondary forests. In one case, the oak was dominant in the thin-sized stand (the largest class of thickness was 15–19; the average age was 120 years) and the birch was black; in the other, the linden dominated and oak, maple, cork tree and aspen took part, the presence of which most likely indicated the postfire origin of the stand.

In a report of April 28, 1871, Petrovich reported to the military governor that he was presenting a list of sampling plots "calculated by me in the Zausuriysk Territory in addition to the forest descriptions of this land drawn up in 1866 by Lieutenant Colonel Budish-

[1] Russian State Historical Archive of the Far East (Vladivostok).

chev and in 1869 by me ...". According to him, the present state of forests and those stocks that can be disposed of when the correct economy is carried out in them are seen from the list.

This very valuable discovery in science allows us to obtain documentary evidence of the composition and condition of some forest areas almost 150 years ago and information on the taxation indicators of stands.

All the sampling plots of Petrovich had the size of a quarter of a dessiatine. They were used to estimate the thickness of the tree species; stock was determined for the model trees (unfortunately, it was not distinguished by species, but given in total in cubic feet); and the prevailing age and average and current yield of the stand were specified, as well as an approximate yield with one dessiatine of timber and factory logs in pieces, as well as firewood in cubic feet. The thickness of the trees is given according to the following steps (classes): 5–9, 10–14, 15–19, 20–24, 25–29, 30–34, and 35–39, but the unit of measurement is not indicated—either vershoks or inches. There were no thicker trees on sampling plots. Also, it is not specified what was meant by the thickness: diameter or circumference. According to the first Russian textbook on forest taxation by A.L. Rudzkoy (1880), trees are counted in thickness in vershoks, and it is noted that Russian taxators often resort to measuring the circumference; less often, measurements were made in inches. What is measured on the sampling plots of Petrovich (circle or diameter) remains unknown; the lack of information about the average diameter and stock for each tree species does not allow one to confidently answer this question. We are inclined to the fact that Petrovich measured the diameter of trees on sampling plots in inches.

Unfortunately, the characteristics of sampling plots (their numbering is given according to Petrovich) does not contain information about the lower tiers of plantations or features of the site of occurrence, and their geographical location is not specific. The calculations of the stands by Petrovich are given in Table 1. They allow us to determine the composition of the stands according to the number of trees. The names of tree species are given as they were given by the author. Sometimes they were refined according to the list of Budishchev (Collection ..., 1898, appendix, pp. 1–49), which he compiled in 1861, but there was still no needle fir, taken by foresters for spruce at that time. Table 2 shows the total stock, average and current yields of wood in cubic feet, the approximate number of timber and factory logs, and the stock of firewood as calculated by Petrovich.

As can be seen from Tables 1 and 2, the characterized stands differed in composition, stock, and commodity values of wood. An analysis of the distribution of trees on the thickness indicates that the stands were formed by trees of different ages and were at different stages of age dynamics. The "dominant age" in most sites was 80–90 years, and it was lower only in some areas: for example, on two sampling plots with the participation of pine (according to the modern nomenclature, omatsu) it was 70 years, and in a stand with a predominance of oak it was 50 years. On four trial plots (3, 29, 30, and 33) two generations were represented in the stand, young and old; the dominant age of the old generation reached 160–170 years.

Cedar-deciduous forests (sampling plots 29 and 30) were characterized by multibreed and the presence of two generations of Korean cedar; the dominant age of the older generation was estimated at 170 years. Sampling plots can be considered typical, since the total proportion of cedar, as was established by the investigations of Budishev and later works, in these forests usually does not exceed 40–50% in stock. The positions of cedar in the stand were stable, as is evidenced by its presence in thin-sized steps of thickness. The largest stock was recorded for these forests, 19 750 ft^3, on a dessiatine (513 m^3 per ha^{-1}, Table 2, sampling plot 29).

Black-spruce broadleaf forests, common in Southern Primorye, were composed of many tree species. Their characteristic feature (sampling plot 13) be considered the predominance of needle fir and the presence of heartleaf hornbeam, often dominant in the lower canopy of the stand. The age of the dominant generation of fir was 100 years. At sampling plot 3, where the needle fir predominated and cedar participated, attention was paid to the presence of two age generations at the age of 80 and 170 years, and coniferous species in the thin-sized part of the stand accounted for almost 50% of the trees, which indicated their stable positions. Judging by the sampling plots, in the forests of the Muravyov-Amursky Peninsula (the vicinity of Vladivostok) and on the western shore of Amur Bay, coniferous fir was the most common, which is undoubtedly associated with zonal conditions—at the latitude of Vladivostok and to the south, in coniferous–broadleaved forests, the prevailing species at the stages of their maturity and overmaturity was fir. This was evidenced by later studies by reserve forester M.I. Pyastushkevich, who in 1886 noted the domination of fir over the cedar in forests on the western shore of the Amur Bay and in the mountains (Man'ko, 2011).

Even with a quick look at the trial plots, the wide distribution of the Mongolian oak attracts attention—of 34 sampling plots, it was encountered on 23 in the composition of cedar and black-fir–broad-leaved, pine, and (more rarely) in spruce-broadleaved forests; oak was absent in typically valley habitats. In habitats fresh in terms of humidification, mixed stands usually grow in which oak, Manchurian ash and elm, often walnut, and cork tree participated (sampling plots 15 and 22). In some areas the oak prevailed. Even only on the basis of the sampling plots of Petrovich, we can conclude that the oak forests, which are now widespread in the most developed areas of Primorye, have

Table 1. Calculations of trees on sample plots laid in the territory of Primorsky krai in 1870–1871 by Petrovich

Species	Steps of thickness*							Total
	5–9	10–14	15–19	20–24	25–29	30–34	35–39	
Sampling plot 3, Muravyov-Amursky Peninsula, behind artillery buildings, the dominant age is 80 + 170 years								
Fir	4	7	2	1	4	–	1	19
Cedar	7	1	–	1	–	1	–	10
Ash	–	4	1	–	2	–	–	7
White birch	2	5	–	–	–	–	–	7
Walnut	2	3	–	–	–	–	–	5
Maple	3	1	–	–	–	–	–	4
Acacia	1	–	1	–	–	–	–	2
Total	**19**	**21**	**4**	**2**	**6**	**1**	**1**	**54**
Sampling plot 13, Tulyamu River, when descending from the big ridge, the dominant age is 100 years								
Spruce	2	7	11	–	3	–	1	24
Black birch	1	–	1	–	–	–	–	2
Maple	3	11	–	–	–	–	14	
Hornbeam	1	–	1	–	–	–	–	2
Ash	–	1	2	–	–	1	–	4
Cedar	–	2	7	–	–	–	–	9
Alder	7	3	–	–	–	–	–	10
White birch	–	3	4	–	–	–	–	7
Cork tree	1	2	–	–	–	–	–	3
Total	**15**	**29**	**26**	–	**3**	**1**	**1**	**75**
Sampling plot 15, the lower reaches of the Ambabela River, the dominant age is 60 + 110 years								
Oak	–	–	1	3	1	–	1	6
Elm	–	1	3	–	1	2	–	7
Ash	–	4	2	1	–	–	–	7
Maple	7	7	–	–	–	–	–	14
Hornbeam	3	1	2	–	–	–	–	6
Walnut	–	2	–	3	–	–	–	5
Total	**10**	**15**	**8**	**7**	**2**	**2**	**1**	**45**
Sampling plot 19, 8 versts from the Kamen-Rybolov, the dominant age is 70 years								
Pine	13	2	–	–	4	–	–	19
Oak	2	–	–	1	–	–	–	3
Walnut	3	–	–	–	–	–	–	3
Acacia	1	–	–	–	–	–	1	
Black birch	1	1	2	–	–	–	–	4
White birch	–	2	–	–	–	–	–	2
Alder	2	2	–	–	–	–	–	4
Ash	1	–	–	–	2	–	–	3
Maple	3	–	–	–	–	–	–	3
Total	**26**	**7**	**2**	**1**	**6**	–	–	**42**

Table 1. (Contd.)

Species	Steps of thickness*							Total
	5–9	10–14	15–19	20–24	25–29	30–34	35–39	
Sampling plot 20, along Lake Khanka, 20 versts from the Turii Rog, the dominant age is 90 years								
Oak	10	4	–	–	–	–	–	14
Pine	3	1	2	–	–	–	–	6
Linden	18	19	13	4	–	–	–	54
Maple	2	1	–	–	–	–	–	3
Total	**33**	**25**	**15**	**4**	–	–	–	**77**
Sampling plot 21, along Lake Khanka between 7 and 5 posts, the dominant age is 130 years								
Oak	3	9	7	2	4	–	–	25
Linden	14	3	7	4	1	–	–	29
Pine	2	1	6	4	5	–	–	18
Total	**19**	**13**	**20**	**10**	**10**	–	–	**72**
Sampling plot 22, 8 versts from the Suifun post near Shchek (along the Suyfun River), the dominant age is 100 years								
Maple	7	2	–	–	–	–	–	9
Oak	–	1	3	4	1	3	–	12
Ash	1	5	1	–	–	–	–	7
Elm	3	4	–	–	–	–	–	7
Black birch	–	1	3	2	–	–	–	6
White birch	–	2	–	–	–	–	–	2
Walnut	–	1	1	–	–	–	–	2
Cork tree	1	–	2	1	–	–	–	4
Total	**12**	**16**	**10**	**7**	**1**	**3**	–	**49**
Sampling plot 27, Hoalidza Fanza, the dominant age is 80 years								
Ash	1	–	–	1	1	–	–	3
Cedar	–	1	–	1	–	–	–	2
Maple	2	5	2	2	–	–	–	11
Elm	3	6	2	1	4	16		
Cork tree	1	–	–	–	–	–	–	1
Pear	1	2	–	–	–	–	–	3
Linden	1	1	–	–	–	–	–	2
Total	**9**	**15**	**4**	**5**	**5**	–	–	**38**
Sampling plot 29, Yashetynsa River, the tributary of the Ulyakhe, the dominant age is 120 + 170 years								
Ash	1	3	1	–	1	–	–	6
Elm	2	3	–	1	2	–	1	9
Walnut	4	1	–	–	–	–	–	5
Linden	–	–	–	1	2	–	1	4

Table 1. (Contd.)

Species	Steps of thickness*							Total
	5–9	10–14	15–19	20–24	25–29	30–34	35–39	
Spruce	1	6	4	1	2	–	–	14
Cedar	5	5	–	1	–	3	2	16
Fir	6	2	3	1	–	–	–	12
Cork tree	1	1	–	–	–	–	–	2
Black birch	2	–	4	–	–	–	–	6
Oak	–	1	–	3	2	3	–	9
Total	**22**	**22**	**12**	**8**	**9**	**6**	**4**	**83**
Sampling plcot 30, near Sandogu Fanza, along the Sandogu River, the tributary of the Ussuri River, the dominant age is 100 + 170 years								
Oak	–	1	3	5	–	1	1	11
Black birch	–	3	–	1	–	–	–	4
Linden	2	–	2	–	–	–	1	5
Fir	4	2	–	–	–	–	–	6
Cedar	–	5	1	–	1	–	3	10
White birch	1	2	–	–	–	–	–	3
Elm	1	–	–	1	–	–	–	2
Maple	–	1	3	–	–	–	–	4
Total	**8**	**14**	**9**	**7**	**1**	**1**	**5**	**45**
Sampling plot 31, Kuandogu Fanza, along the Fuji river, the tributary of the Ussuri River, the dominant age is 100 years								
Spruce	–	6	4	1	–	1	–	12
Ash	7	5	–	–	–	–	–	12
Maple	–	1	–	–	–	–	–	1
Elm	–	3	13	4	5	–	–	25
White birch	–	–	1	–	–	–	–	1
Black birch	–	–	–	–	1	–	–	1
Total	**7**	**15**	**18**	**5**	**6**	**1**	–	**52**
Sampling plot 33, Paijinhung Fanza, along the Ulakhe River, the tributary of the Ussuri River, the dominant age is 40 + 160 years								
Ash	3	10	4	2	–	–	–	19
Walnut	–	5	3	–	–	–	–	8
Bird cherry	16	6	–	–	–	–	–	22
Poplar	–	–	–	–	–	1	1	
Elm	1	1	–	–	–	–	1	3
Willow	1	2	–	–	–	–	–	3
Acacia	1	–	–	–	–	–	1	
Total	**22**	**24**	**7**	**2**	**1**	**1**	**57**	

The area of one sample plot is a quarter of a dessiatine. * Units are not specified in the original source.

Table 2. General characteristics of sampling plots laid by Petrovich in 1870–1871

Sampling plot	Number of trees, pcs.		Total wood stock			From 1 dessiatine (approximately)							Yield			
	per 1 dessiatine	per 1 ha*	ft³		m³ per ha⁻¹	timber logs		factory logs		fuelwood			ft³ per 1 dessiatine		m³ per ha⁻¹	
			on one sampling plot	per 1 dessiatine		number, pcs.	length, sazhens	number, pcs.	length, sazhens	ft³	m³ per ha⁻¹	% of total stock	average	current	average	current
3	216	198	2180	8750	226.7	50 10	3–5 5–6	80	3–6	4250	120.35	48.6	90 + 10	120	2.59	3.11
13	300	275	2464	9750	253.1	100 20	3–5 5–7	60	2–5	7500	194.7	76.9	97	97	2.49	2.49
15	180	165	2319	9250	240.2	–	–	100	3–7	4250	110.3	45.9	130 + 10	150	3.63 + 0.26	3.91
19	168	154	1323	5250	136.3	20	3–5	10	2–4	4250	110.3	80.9	75	75	1.95	1.95
20	308	282	1348	5500	142.9	10	3–4	10	2–3	5000	129.9	90.9	60	60	1.56	1.56
21	288	264	3316	13250	344.2	60	3–5	40	2–4	10000	259.8	75.5	100	100	2.60	2.60
22	196	180	1733	7000	181.7	–	–	100	2–5	4000	103.8	57.1	70	60	1.82	1.56
27	152	139	1719	6750	175.4	8	3–5	80	3–5	4000	103.9	59.2	85	75	2.21	1.94
29	332	305	4913	19750	512.8	100 20	3–5 5–7	80	2–6	1275	33.1	6.4	100 + 45	100	2.60 + 1.16	2.60
30	180	165	2666	10500	272.6	35 10	3–5 6–7	45	2–5	7500	194.7	71.4	90 + 10	90	2.34 + 0.26	2.34
31	208	191	2667	10500	272.6	45	3–5	110	3–6	5500	142.8	52.4	105	90	2.73	2.34
33	228	209	1510	6000	155.9	–	–	60	2–5	4000	103.9	66.7	105 + 10	130	2.73 + 0.26	3.38

* Data calculated by the authors. 1 m^3 = 35.31466672 ft^3; 1 dessiatine = 1.09 ha; 1 sazhen = 2.1336 m.

appeared on the site of more complex forests and are secondary in origin.

Pine forests, formed by omatsu, were common in the vicinity of Lake Khanka and farther south. The dominant age of the stands is 70–90 years (sampling plots 19 and 20). At sampling plot 21, where linden and oak prevailed and pine accounted for about 22%, it is 130 years.

In the valley forests, the stands were at different stages of succession shifts. At sampling plot 33 from the first willow–poplar tree stand, there remained single large poplar trunks 160 years in age and older, and, in the new younger generation, ash is prevalent and elm and walnut participate and have grown in connection with the decay of the stand of bird cherry with the participation of willow. In another area, the first settler breeds completely disappeared from the stand (sampling plot 27; the dominant age is 80 years), and elm and maple began to predominate. These sampling plots characterize the natural shifts occurring in forest plantations in connection with the change in the alluvial regime and the attainment of the age of extinction by the representatives of the first generation who inhabited sand and pebble bars. The stock in the valley forests depended on the age of the stand. It reached 270 m^3 in an elm and ash forest, with spruce participation at the age of 100 years.

Sampling plots of Petrovich with the significant participation of spruce are confined to high-floodplain river terraces and upland fringes, where Korean spruce usually grows. Perhaps, in the described stands, the Ayan spruce also participated, forming a high-altitude vegetation belt in the Sikhote-Alin mountains and descending into valleys. In a stand with a predominant age of 100 years, spruce has cohabitated with elm (sampling plot 31), and, in the second case (sampling plot 29), two generations aged 120 and 170 years were represented in the stand and about 50% of the trees accounted for coniferous species (cedar, spruce, and Khingam fir); elm, ash, linden, walnut, oak, cork tree, and black birch (it was probably a yellow birch, for black birch is characteristic of drier habitats) participated in the stand. The participation of white birch in many stands may indicate the possible mineralization of the soil surface due to some disturbances in the stand. The shortest series of tree distribution in thickness was represented in the stand with the dominance of oak at the age of 120 years, and it ended with step 15–19 (stock of 77 m^3 per ha^{-1}); in the other case, in the stand with the prevalence of linden and the participation of pine, the series ended with step 20–24 (stock of 108 m^3 per ha^{-1}).

The stock in the sampling plots was generally small; at most sites it did not exceed 300 m^3 per ha^{-1} (Table 2). When assessing sampling plots, the requirements for estimating the commodity structure of the stand were very high. As a result, the proportion of fuelwood in a number of sampling plots reached 80 and even 90%; in sampling plot 29 (Table 2) this indicator was slightly higher than 6%.

CONCLUSIONS

In general, we believe that the sampling plots laid during the first forest-management works, even though they were not complete with the necessary information, are of continuing scientific value and can serve as documentary material for identifying reference areas of natural forests. This is the only reliable information that attests to the composition and productivity of complex multitree stands formed in cedar, spruce, and black-birch–broad-leaved and other mixed forests with tree species with different life-cycle lengths and with different ecological requirements and phytocenotic roles. All this determines the complex dynamics of the generation change and the change in the entire forest community, which occurs cyclically with ecotopic conditions relatively stable in the main indicators. In the valley ecotopes, characterized by high dynamism, the age shifts become irreversible due to the change in the location of the site in the floodplain, accompanied by a change in the frequency of floods (or the cessation of their effect), as well as changes in drainage and the nature of humidification of habitats.

Concerning the issue of whether reserves and other categories of specially protected natural sites can be benchmarks for biodiversity in relation to the forest territories of the Far East, we believe that, in most of the protected areas of the region, there are areas of intact plant communities that need to be stocked and put into permanent sampling plots. Permanent sampling plots characterizing forest areas with continuous natural development without strong forest destructive factors affecting the forest formation process are especially valuable, as is shown by our studies (Man'ko et al., 2010). Of equal scientific value, evidently, are permanent sampling plots in areas with secondary vegetation. In general, specially protected natural sites should become a base for monitoring the forest-forming processes currently occurring under the influence of natural factors (years with different degrees of humidification and heat supply and with devastating effects of typhoons, floods, etc.) and the direct and indirect impact of anthropogenic activities. The materials accumulated so far on the state of the main forest formations of the region, as well as on the biology and ecology of the leading forest-forming trees, make it possible to solve (upon ecological and economic necessity) issues of restoring the biodiversity of forest ecosystems depending on the degree of their transformation. It should be borne in mind that biodiversity in the process of natural shifts (age, recovery-age, century-old) undergoes constant changes; in some cases they are characterized by cyclicity and in others they occur irreversibly in connection with large-scale changes in natural processes. Therefore, in our opinion it is impossible to build an ideal model for the degree of completeness of biodiversity and the role of individual species in such a community; it can only be a dynamic model with a predominance of the main long-living forest-forming species with its characteristic permanent enhancement and even loss of individual species.

REFERENCES

Budishchev, A.F., General insight on the main local conditions of Amur krai for forests and Russian settlements, in *Sbornik glavneishikh ofitsial'nykh dokumentov po upravleniyu Vostochnoi Sibir'yu. Tom 5. Lesa Priamurskogo kraya. No. 1. Opisanie lesov Primorskoi oblasti* (Collection of General Official Documents for the Administration of Eastern Siberia, Vol. 5: Forests of Amur Krai, No. 1: Description of Forests in Primorskaya Oblast), Khabarovsk: Tipogr. Kants. Priamursk. General-Gubernatora, 1898, pp. 3–49.

Istoriya Dal'nego Vostoka SSSR s drevneishikh vremen do XVII veka (The History of Far East of Soviet Union from Ancient Times until 17th Century), Krushanov, A.I., Ed., Moscow: Nauka, 1989.

Ivashkevich, B.A., Forests of Primorye, in *Primor'e. Ego priroda i khozyaistvo* (Primorye: Nature and Economics), Vladivostok, 1923, part 1, pp. 77–87.

Kolesnikov, B.P., Vegetation of the eastern part of Central Sikhote-Alin, *Tr. Sikhote-Alinskogo Zapoved.,* 1938, no. 1, pp. 25–207.

Kolesnikov, B.P., *Ocherk rastitel'nosti Dal'nego Vostoka* (Description of Vegetation of the Far East)*, Khabarovsk*: Khabarovsk. Knizhn. Izd., 1955.

Komarov, V.L., Types of vegetation cover of South Ussuri region, in *Trudy pochvenno-botanicheskikh ekspeditsii po issledovaniyu kolonizatsionnykh raionov Aziatskoi Rossii. Chast' 2. Botanicheskie issledovaniya 1913 g.* (Transactions of Soil-Botanical Expeditions for Analysis of Colonized Regions of Asian Russia, Part 2: Botanical Studies of 1913), St. Petersburg: Uprav. minist. Zemledeliya, 1917, no. 2, pp. 1–216.

Korotkii, M.F., Description of vegetation of Zeisk-Bureinskii district of Amur oblast, in *Trudy Amurskoi ekspeditsii. No. 16. Botanicheskie issledovaniya 1910 g.* (Transactions of Amur Expeditions, No. 16: Botanical Studies of 1910), St. Petersburg, 1912, pp. 1–149.

Korzhinskii, S.I., A report on the studies of Amur oblast as the land colony, *Izv. Vost.-Sib. Otd., Russ. Geogr. O-va,* 1892, vol. 23, nos. 4–5, pp. 73–138.

Kurentsova, G.E., *Rastitel'nost' Prikhankaiskoi ravniny i okruzhayushchikh ee predgorii* (Vegetation of Cis-Khankai Plain and Surrounding Areas), Moscow: Akad. Nauk SSSR, 1962.

Man'ko, Yu.I., The virgin forests of Russian Far East, *Vestn. Dal'nevost. Otd., Ross. Akad. Nauk,* 2001, no. 4, pp. 3–10.

Man'ko, Yu.I., *Lesnoe delo na rossiiskom Dal'nem Vostoke. 1859–1922* (Forestry on the Russian Far East: 1859–1922), Vladivostok: Dal'nauka, 2011.

Man'ko, Yu.I., Kudinov, A.I., Gladkova, G.A., Butovets, G.N., Zhabyko, E.V., and Orekhova, T.P., *Lesa zapovenika "Ussuriiskii" (monitoring dinamiki)* (Forests of Ussuriiski Nature Reserve: Dynamics), Vladivostok: Dal'nauka, 2010.

Okladnikov, A.P., *Dalekoe proshloe Primor'ya* (Far Past of Primorye Region), Vladivostok: Dal'nevost. Knizhn. Izd., 1959.

Primorskii krai. Kratkii entsiklopedicheskii spravochnik (Primorskii Krai: Brief Encyclopedic Dictionary), Ermakov, E.V., Ed., Vladivostok: Dal'nevost. Gos. Univ., 1997.

Rudzkii, A.L., *Lesnaya taksatsiya. Pocobie dlya lesnichikh i taksatorov pri material'noi i denezhnoi otsenke lesosek* (Forest Inventory: Manual for Forest Rangers and Registers for Material and Monetary Evaluation of Forest Logging Areas), St. Petersburg: Izd. A.F. Devrien, 1880.

Sbornik glavneishikh ofitsial'nykh dokumentov po upravleniyu Vostochnoi Sibir'yu. Tom 5. Lesa Priamurskogo kraya. No. 1. Opisanie lesov Primorskoi oblasti (Collection of General Official Documents for the Administration of Eastern Siberia, Vol. 5: Forests of Amur Krai, No. 1: Description of Forests in Primorskaya Oblast), Khabarovsk: Tipogr. Kants. Priamursk. General-Gubernatora, 1898, 2nd ed.

Shavkunov, E.V., *Gosudarstvo Bokhai i pamyatniki ego kul'tury v Primor'e* (Balhae Kingdom and Its Cultural Monuments in Primorye), Leningrad: Nauka, 1968.

Sheingauz, A.S., Exploration of forests and consumption of forest resources at the Far East until half of 19th century, *Sb. Tr. Dal'nevost. Nauchno-Issled. Inst. Lesn. Khoz.,* 1971, no. 11, pp. 11–29.

Shipchinskii, N.V., *Moi puteshestviya (My Journeys)*, Moscow: Geografgiz, 1955.

Smirnova, O.V., Zaugol'nova, L.B., and Korotkov, V.N., Theoretical bases for optimization of the function of biodiversity of forest cover: modern concepts, *Lesovedenie*, 2015, no. 5, pp. 367–378.

Starikov, G.F., One hundred years of the Far Eastern map of the forester A.F. Budischev, *Lesn. Khoz.,* 1964, no. 5, p. 86.

Stoletie utverzheniya lesnogo departamenta. 1798–1898 (The 100 Anniversary of Forest Department, 1798–1898), St. Petersburg, 1898.

Strogii, A.A., *Derev'ya i kustarniki Dal'nego Vostoka, ikh lesovodstvennye svoistva, ispol'zovanie i tekhnicheskoe primenenie* (Trees and Scrubs of the Far East: Properties and Technical Use), Khabarovsk: Dal'nevost. Kraevoe Izd., 1934.

Tishkov, A.A., How and what to protect the biodiversity of forests in European Russia? Replica of the supporter of current biogeography, *Lesovedenie*, 2015, no. 5, pp. 379–387.

Vorob'ev, M.V., *Chzhurzheni i gosudarstvo Tszin' (X v.–1234 g.). Istoricheskii ocherk* (Chzhurzheni and Jin State (10th Century–1234 Year): Historical Description), Moscow: Nauka, 1975.

Translated by S. Avodkova

SPELL: OK