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Problems in the Maintenance and Sustainable Use of Forest Resources in Priamurye in the Russian Far East

ZYRYANOVA Olga A.[1, 2] *, YABOROV Victor T.[3], ABAIMOV Anatoly P.[2], KOIKE Takayoshi[1], SASA Kaichiro[1] and TERAZAWA Minoru[4]

[1] Hokkaido University Forests, FSC, Hokkaido University, Sapporo 060-0809, Japan
[2] V.N.Sukachev Institute of Forest SB RAS, Academgorodok, Krasnoyarsk, 660036, Russia
[3] Far Eastern State Agricultural University, Blagoveshchensk, 675005, Russia
[4] Graduate School of Agriculture, Hokkaido University, Sapporo 060-8589, Japan

Abstract

The forests of Priamurye, located in the southwestern part of the Russian Far East, are of great environmental and social importance. They are diverse in space, time and species composition and have large wood stock, which was traditionally exploited for timber harvesting. They are also a source of medicinal, food and technical resources, as well as being a location for hunting. In recent decades the productivity of the forests has been decreasing. This is a result of forest policy based on profit-making from timber selling, and unsustainable methods of wood harvesting as well as on the disastrous impact of natural calamities such as forest fires, insect outbreaks and fungi infestations. In addition, the local forestry have faced a lack of co-ordination of federal and regional legislation, inadequate financing and the destruction of the forest management system during the period of reforms and the transition to a market-based economy. For sustainable use of the forest resources in Priamurye, a new system incorporating principles of practical forestry and forest management should be developed. The primary issues include: 1) the determination of the forms of forest ownership through the adoption of a new Forest Code of the Russian Federation; 2) the determination of sources and mechanisms for forestry financing, especially through forest resource lease; 3) the development of regional permanent forest surveying, fire protection and forest health monitoring systems.

Key words: Priamurye, forest resources, biodiversity threats, sustainable use and management

Introduction

The territory of the Priamurye occupies the upper and middle Amur River basin and is almost fully coincident with the Amurskaya administrative district, located in the southwestern part of the Russian Far East (Fig. 1). This is one of the most forested areas of the Russian Federation. The forests cover 31.64 mln. hectares, which make up about 64% of the district's territory (Yaborov 2000) and 26.6% of the total Far Eastern forested area (Tagil'tsev *et al.* 2004). The wood stock of Priamurye is estimated to be 2.03 billion m^3, which equates to 17% of the total wood stock in the Russian Far East. These forests are also rich in various foods and medicinal plants and provide technical resources and recreational possibilities, all of which have the potential for local industrial development and export commodities in the future (Kolesnikova *et al.* 2001, Kolomytsev 2004, Koryakin and Romanova 2001, Kurlovich 2001, Sukhomirov 2001, Philip'ev *et al.* 2001, Tagil'tsev *et al.* 2001, 2004). In order to conserve these forests as a viable natural resource, effective methods of forest management and sustainable use must be established.

At present, whilst Russia is in transition to a market-economy it is also in a major economic crisis. The former tightly controlled management, based exclusively on national ownership of forest resources, is ineffective under these changing conditions. Thus forestry faces negative consequences such as low cost of wooden resources and uncertainty in land ownership (The First State Report 1997). Government and local authorities follow direct use forest policy, seeking mainly to derive profit from timber selling. They fail to estimate indirect use value, option value or, moreover, non-use value of the forests and forest ecosystems.

Recently, wood harvesting and processing, as well as reforestation activities have declined. This has resulted in worsening social conditions and has created negative changes in the structure and dynamics of the forests (Korovin 1995, Perevertaylo 2004, Yaborov 2000). Urgent action is required in order to stabilize forestry and forest purchasing enterprises, and to conserve the forest environment and its resource potential. National programs of reforestation and forest protection highlighted this need for action, but there has been insufficient financial allocation to fulfill this need (Korovin 1995).

In this report, we summarize the current state of the forests in the Amurskaya administrative district, provide a short history of their usage and dynamics, describe the

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* Corresponding author: institute@forest.akadem.ru

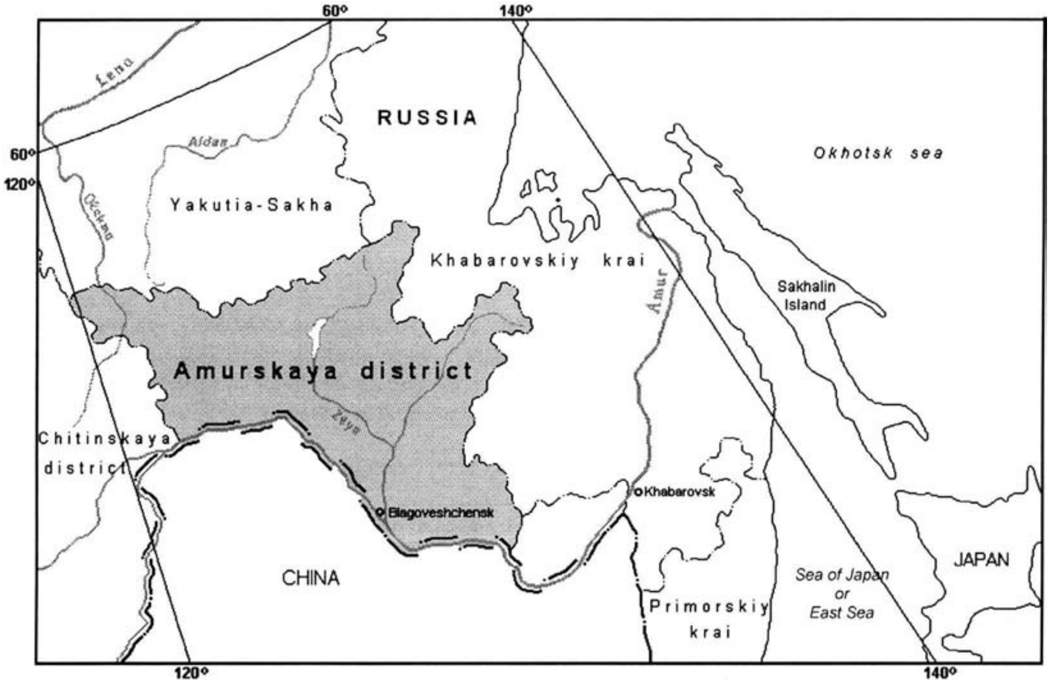

Fig. 1. Location of Priamurye (Amurskaya administrative district) in the Russian Far East.

main threats under changing economic conditions and outline the perspectives of forest maintenance and rehabilitation. New proposed methods of forest management are also discussed.

We follow the nomenclature of Latin names of both plant species and pest-insect names established by Czerepanov (1985) and Baranchikov *et al.* (2002), respectively.

Forests of Priamurye and the main tree species

Natural condition: This region is composed of different geomorphological units. The northern and western parts are mountainous, with elevations ranging from 50 m in the Amur River Valley to 2412 m in the Stanovoy range. The eastern part of the region is mostly lowlands, whilst the southern part includes extensive wet plains in the central Amur River Valley.

The configuration of the relief strongly affects the climatic features. In the north and west the climate is continental with severe winters, whilst towards the east the climate changes to subcontinental with cold winters and warm summers. The mean temperature of the warmest month (July) ranges from 15 to 20°C, and that of the coldest month (January) from -25 to -32°C (Zhakov 1982). Even though this is an interior region, it is influenced by Pacific air masses that go up the Amur River Valley in summer. In winter the extensive Siberian anticyclone controls the northwestern part of the region. Annual precipitation ranges from 400 mm in the west to 650 mm in the east, most of which falls in summer (Zhakov 1982).

Vegetation: The large topographic and climatic differences result in diverse vegetation. The zonal vegetation of the northern and western parts of the region is boreal forest, represented by various types of *Larix gmelinii* forest (Qian *et al.* 2003). It occupies 60-80 % of the forested area (Yaborov 2000). Most forest stands have a history of fire. By the mature age the fire can influence larch stand 2-3 times. *Pinus sylvestris* stands occur on drier or sandy sites (Qian *et al.* 2003) and are more abundant in the central and northwestern regions (Yaborov 2000). *Picea ajanensis* accompanied with *Larix gmelinii*, *Abies nephrolepis* and *Betula platyphylla* stands appear as small patches on different slopes throughout the region, usually near the timberline (Qian *et al.* 2003, Yaborov 2000). Mixed spruce-fir forests are distributed, mainly, in the mountainous north and northeast. The vertical zonation involves *Larix gmelinii* reaching 900-1000 m, *Pinus pumila* from 900 to 1300 m, and alpine tundra above 1300 m. In the south, on southerly slopes, broadleaved *Quercus mongolica* forests at 300-500 m may interrupt the larch forests and dark-conifer *Picea ajanensis* forests at 400-800 m.

Broadleaved and mixed cool temperate forests represent the zonal vegetation in the south, particularly in the Amur lowlands (Qian *et al.* 2003). *Pinus koraiensis*, *Quercus mongolica*, *Tilia amurensis*, *Betula davurica and B. costata* are major components of these forests. Despite physiognomic differences in zonal vegetation types, the presence of temperate species in the boreal forests is a characteristic feature of the region. Azonal vegetation in the region includes the extensive grass meadows in the Amur valley. Broadleaved forests dominated by *Ulmus japonica*, *Fraxinus mandshurica* and *Juglans mandshurica* as well as *Populus suaveolens*, *Chosenia arbutifolia*, *Salix rorida* and *S. udensis* occur widely in the valleys of the various Amur tributaries (Qian *et al.* 2003, Yaborov 2000).

Natural forests absolutely dominate in the forest cover with man-made forests being equal to 0.2% in area (Yaborov 2000). Endemic vascular species in the region include 13 plants (Qian *et al.* 2003).

Characteristics of tree species

Larch (*Larix gmelinii*)

There is confusion over which *Larix* species occupies the Priamurye, owing to the great variability in its morphological features. Dylis (1961, 1981) considers the western race of *Larix dahurica* to occupy the Amurskaya district. Other researchers (Bobrov 1972, 1978, Koropachinskiy and Vstovskaya 2002) consider that both *Larix gmelinii* and *L. cajanderi* larch species occur and easily hybridize in this region. Some scientists consider all Far Eastern larch species and their hybrids under the specific epithets of "gmelinii" (Kurahashi 1988, Ishizuka *et al.* 1994, Martinsson 1995, Schmidt 1995, *et al.*) or "dahurica" (Krestov 2003).

Based on our own research, we hypothesize that the hybrids of *Larix gmelinii* and *L. cajanderi* prevail in Priamurye. However both parents' species also occur (Abaimov 1980, Abaimov and Koropachinskiy 1984, Abaimov *et al.* 1998a). Acknowledging that this requires further research and that the hybrids greatly resemble their parents, in order to avoid any confusion in this report we present the parent's *Larix gmelinii* as the main tree species in Priamurye.

Gmelin larch is widely distributed over the district territory, occurring on various site types from the bottom of the river valleys to the timberline in the mountains (Photo 1). This species makes up a large percentage of the local forests both in area and in wood stock (Table 1). The wide ecological range of larch can be explained by several of its eco-biological features, such as an ability to take up water even from relatively cold soil, its anatomical structure and metabolic adaptation of the fine roots, its tolerance of very low winter temperatures, its shallow root system and its ability to develop adventitious roots above the root collar (Abaimov *et al.* 1996, 1997, 1998a,b, 2000). Under favorable soil conditions larch trees can reach 30-35 m in height and 1 m in diameter at breast height while near the timberline it usually gets prostrate dwarf form. Larch performs best on gentle, moderately to poorly drained slopes or flats with fine-textured clayey podzolic soils under mesic and hydric soil moisture regimes (Abaimov *et al.* 1996, 1997, Yaborov 2000). Mountainous larch forests dominated by dwarf-shrubs *Ledum palustre* and *Vaccinium vitis-idaea* have maximal productivity of 270 m^3 per hectare.

Whilst *Larix gmelinii* can live 500 years or more, its longevity in the region usually does not exceed 250-300 years because of fungi diseases. The fungi infestation increases with aging, and the losses of harvesting wood from the decay begin to exceed annual tree stock increment after 110 years (Ageienko and Klintsov 1969). For this reason, 100-120-year old larch stands are considered the best to cut (Yaborov 2000).

Larch trees begin to produce seeds at 10 years of age, and an abundant seed crop occurs every 2 years (Yaborov 2000). Natural restoration is successful in all logged areas, except those covered with sedge or wheatgrass species. For successful regeneration to occur, the groups of larch trees are left uncut. It is necessary condition to get viable, i.e. with developed embryo, seeds due to cross-pollination inside tree groups.

Table 1. Distribution area and wood stock of the main tree species (Yaborov, 2000: data for January 01st, 1998).

Tree species	Area Thousand ha	Wood stock %
Conifers		
Gmelin larch (*Larix gmelinii*)	13,428.3	72.070
Scots pine (*Pinus sylvestris*)	685.3	2.740
Spruce (*Picea ajanensis and P. obovata*)	449.0	3.700
Fir (*Abies nephrolepis*)	47.1	0.370
Korean pine (*Pinus koraiensis*)	7.9	0.060
Hardwood species		
Mongolian oak (*Quercus mongolica*)	431.8	0.850
Stone birch (*Betula ermanii*)	53.2	0.180
Elm (*Ulmus japonica*)	13	0.007
Ash (*Fraxinus mandshurica*)	0.5	0.002
Amur cork tree (*Phellodendron amurense*)	0.1	0.002
Softwood species		
Birches (*Betula platyphylla, B. costata, B. davurica*)	4,932.1	15.890
Trembling poplar (*Populus tremula*)	163.3	0.820
Poplar (*Populus suaveolens*)	24.5	0.230
Basswood (*Tilia amurensis*)	19.0	0.120
Willows (*Salix sp.*)	18.7	0.080
Alder (*Alnus hirsuta*)	5.8	0.009
Shrubs	2,191.9	2.870
Totally	22,460.1	100.000

Note. In Russian forestry hardwood species are considered to have wood hardness of>40 MPa, while the hardness of softwood species does not exceed 40 MPa (Forest encyclopedia 1986).

Larch stands, especially in the south of the region, were significantly exploited by industrial fellings during the last 120 years. Additionally, fires, occuring every 3-5 years, killed larch saplings, resulting in changes to the tree species composition and even replacement of larch forests by secondary *Betula platyphylla* forests. Since the beginning of the 20th Century the total area of larch forests has decreased threefold (Yaborov 2000).

Scots pine (*Pinus sylvestris*)

Despite insignificant distribution, of only 3.1% of the forested area (Table 1), Scots pine forests are of greater commercial importance than larch forests. Pine stands are distributed, mainly, in the central and northwestern part of the Amur administrative district while in the east they occur in small patches on well-drained soils on the flats (Yaborov 2000). Pine trees form both pure and mixed stands with *Larix gmelinii*, *Quercus mongolica* and *Betula platyphylla. Picea ajanensis*, *Populus suaveolens* and *P. tremula* rarely occur as canopy trees.

On the most productive sites pine reaches a height of 30-35 m and a diameter of 60-80 cm, living a maximum of 300-350 years (Photo 2). High productivity (200 m^3 per hectare) is a characteristic of mountainous pine forest with *Vaccinium vitis-idaea* dominant in the dwarf-shrub layer (Yaborov 2000). Pine is a fast-growing species which begins to produce seeds after 8-12 years. The natural regeneration of Scots pine forests is considered to be successful, although the influence of fire is great.

Besides naturally regenerated forests, pine plantations were created on 87 thou hectares in the southeastern part of the region (Yaborov 2000). However, the impact of forest fires, flooding, excessive soil moisture and wild animals caused 50% mortality of the pine trees on these plantations.

During the last century, demand for timber resulted in extensive felling of pine forests. Disastrous fires also strongly affected the composition and structure of pine stands. Both the fellings and the fires have led to the exhaustion of commercially valuable pine wood stock and to the replacement of high-productive stands by secondary birch and oak forests or shrub vegetation as well as to the decrease of their area. Since 1913, the total area has been halved (Yaborov 2000). The scale of disturbance is so great that discussion of a possible total prohibition of Scots pine felling in the region is considered to be most urgent.

Spruce (*Picea ajanensis and P. obovata*) and fir (*Abies nephrolepis*) species

Mixed fir-spruce forests are the most significant from an industrial viewpoint. They occupy about 2 % of the forested area (Table 1) in the mountainous north and northeast regions.

Picea ajanensis (Ayan spruce or Yezo spruce) forms pure or fir-mixed stands on all mesic well-drained sites. Due to their great shade tolerance, spruce trees usually dominate in such mixed stands, prevailing both in the upper layer and in the wood stock. Ayan spruce usually forms structurally simple one or two-layer stands with poorly differentiated strata. Pure fir stands are rare, occuring in small patches on 0.2 % of the forested area (Yaborov 2000).

Spruce trees can reach 30 m in height and 100 cm in diameter and live to 350 years. They begin to produce seeds after 15-20 years in the outer space and after 30-40 years in the stand. Because of shallow rootage and thin bark, ground fires easily damage the lower branches and abundant flammable epiphytic lichens provide crown fires in spruce forests. All post-fire succession in the area of dark-conifer forest results in the formation of spruce stands, but various factors may deflect succession from the standard sequence (Krestov 2003).

Mixed spruce-fir-larch forests with green moss cover, occupying different slopes and highlands, have the highest productivity. Their natural regeneration is also successful. High mountainous spruce stands, accompanied usually by *Larix gmelinii*, have low productivity and sparse canopy. Dense shrub and herb layers prevent natural regeneration, and the number of seedlings is insufficient. These forests are of great protective significance. Regular catastrophic fires result in their replacement by larch-birch forests as well as in the development of tall-shrub vegetation. Fires also destroy the thin soil layer. The post-fire development of spruce forests through the larch stage remains poorly investigated in the Russian Far East (Krestov 2003). Spruce forests in the river valley have environmental importance only for water and soil protection.

Korean pine (*Pinus koraiensis*)

Despite both small wood stock and distribution (Table 1), pine forests from *Pinus koraiensis* have a particular status in Priamurye (Photo 3). They possess high quality wood, provide a habitat for wild animals, produce nutritive-rich pine nuts and unique medicinal plants as well as regulate and protect water levels and, indirectly, fish resources in the rivers (Yaborov 2000). The total wood stock of Korean pine is located in the most southeastern part of the region, near the border with China.

Under favorable conditions *Pinus koraiensis* reaches 35-40 m in height and 120 cm in diameter and lives to 400 years. Pure tree stands do not occur. Mixed (broadleaved-Korean pine) forests perform best on lower and middle slopes from sea level up to 800-900 m, coexisting and closely interacting with spruce, larch and oak forests (Krestov 2003). Mixed forests occupy the drained sites with nutrient-rich soils and mesic moisture regimes.

The mixed forests (various broadleaved trees and Korean pine) are of great scientific and conservational importance. They include the elements of both nemoral and boreal vegetation due to their climatic position as well as to their non-glaciated history (Krestov 2003). The diversity and the community structure of the mixed forests are really complex in space and time. In Priamurye the broadleaved-Korean pine forests represent the westernmost limit of the special Pan-Mixed Conifer-Broadleaved Forest zone (Tatewaki

1954-57, 1958) that also include the Hokkaido forests (Matsuda *et al.* 2002).

Having many strong competitors, the mixed broadleaved-Korean pine forests are characterized by very complex natural dynamics, even over the lifespan of one generation of pine tree, being controlled by different ecological factors (Krestov 2003). The development of a mixed tree stand goes through eight sequential stages (Kolesnikov 1956). Korean pine can regenerate intensively every 35-40 years (the so-called explosive regeneration), (Ivashkevich 1933, Solovyov 1958), even under the canopy. But only gap formation due to the natural death of old trees permits saplings to develop further. The basal area and total volume of Korean pine in the stands increase up to 300 years and then decrease (Krestov 2003). Under such stable conditions providing the possibility to both shade-tolerant nemoral species as well as the light-demanding species to complete their life cycles species diversity of mixed forests is maintained at a certain level.

Wood harvesting and fires are the most important disturbance factors in cool temperate forests. The pattern of tree stand development after cutting has similar dynamics to that of natural stand development. However, fire is a complicating factor that effects diversity in different ways, but always decreases it over the long term (Krestov 2003). Wildfires resulted in the development of stable secondary forests, dominated by self-regenerating long-living *Larix gmelinii*, or by fire tolerant pure *Quercus mongolica* stands. The latter are widespread in the densely populated areas where human activity insures regular fires.

Due to industrial harvesting and periodic fires the area of Korean pine forests have decreased 70 times since the beginning of the 20th Century (Yaborov 2000). At present wood harvesting of the pine trees is totally prohibited in the Amurskaya district. To conserve these forests and to promote natural regeneration, Korean pine seedlings grown from seeds in nurseries are planted on drained fertile soils.

Birch species
(*Betula platyphylla, B. ermanii, B. costata, B. davurica*)

White birch (*Betula platyphylla*) has the largest area among light-demanding species (Table 1). Being of low commercial value (Koike 1995), this tree is one of the composers of mixed forests and seral species in reforestation after clear cuttings and wildfires (Photo 4). Due to fast vegetative propagation on logged and burned sites the area of birch forests has increased 60 times since the beginning of the 20th Century, a trend that is continuing (Yaborov 2000).

On the fertile soils white birch reaches 27 m in height and 50 cm in diameter and lives to 120 years. It is a fast-growing tree species reaching harvesting age by 50-60 years. *B. platyphylla* is expected to be utilized for medical purposes in the future (Tagil'tsev *et al.* 2004).

Stone birch (*Betula ermanii*) forests form the belt ranging from 800 to 1100 m and are of soil-protective significance. Like white birch, ***B. costata*** is harvested in Priamurye. This tree species is more warmth and soil moisture demanding than the *B. platyphylla.* It also occupies burned areas successfully, but it is quite fire-intolerant (Yaborov 2000). ***B. davurica*** is an important composer of broadleaved and mixed cool temperate forests. It can accompany white birch in larch forests.

Representative species
(*Quercus mongolica, Fraxinus mandshurica, Tilia amurensis, Phellodendron amurense*)

Mongolian oak (*Quercus mongolica*) is one of the many broadleaved frees in Priamurye (Table 1), which are of commercial value due to high quality wood. Under favorable conditions oak frees reach 25 m in height and 80 cm in diameter. They usually form pure stands or mixed with *Betula davurica.* All components of the forest communities are drought and frost tolerant as well as fire resistant.

Owing to high sprout ability this oak is evident in burned and logged areas. Considering the easy collection of the seeds (acorns) it is recommended as a soil protective forest free after completion of coal mining activity, especially in the south of the Amurskaya district (Yaborov 2000).

Ash (*Fraxinus mandshurica*), **basswood** (*Tilia amurensis*), **Amur cork tree** (*Phellodendron amurense*), **elm (*Ulmus japonica*)** as well as Mongolian oak and **Manchurian nut tree** (*Juglans mandshurica*) are the main composers of the broadleaved forest. Moreover, they have their northern and northwestern range limits within the territory (Krestov 2003). All these species are of high commercial value due to wood quality, medicinal and edible properties (Berkutenko and Virek 1995, Gukov and Lichman 2004, Kadaev and Fruentov 1968, Sukhomirov 1986, Tagil'tsev *et al.* 2004). They are conserved in state protective areas. All felling of Amur cork tree, basswood and Manchurian nut tree is prohibited in the territory of the Amurskaya district (Yaborov 2000).

Shrubs and lianas

The shrub layer in Priamurye forests is rich and diverse. The most widespread species are *Aralia elata*, *Crataegus dahurica*, *Eleutherococcus senticosus*, *Padus avium*, *Rhododendron dauricum*, *Rosa acicularis*, *Salix caprea*, *Sorbus sibirica*, and *Viburnum sargentii.* All these species have wide usage in official medicine (State pharmaceutical indices 1989, State list of medicines 1993) and, especially, in folk medicine (Krebel' 1958, Vostrikova 1971). Some of them (*Eleutherococcus senticosus*, *Viburnum sargentii*) are of high decorative value (Koropachinskiy and Vstovskaya 2002) while wild berries of the others (*Crataegus dahurica*, *Sorbus sibirica*) are used to produce different saps and jams (Izmodenov 2001).

Actinidia kolomikta, *Schisandra chinensis* (Photo 5a) represent inter-layer plants in forest communities as lianas. They are known mainly as medicinal and decorative plants (Ageienko and Komissarenko 1960,

Table 2. The resources of wild berries and nuts (Yaborov, 2000).

Resource species	Total area, thousand ha	Possible harvesting area, thousand ha
Nut species		
Siberian dwarf-pine (*Pinus pumila*)	95.3	95.3
Corylus mandshurica	13.7	0.7
Berry species		
Red berry (*Vaccinium vitis-idaea*)	305.5	305.5
Blue berry (*Vaccinium uliginosum*)	136.6	132.0

Laptev 1971).

It was estimated that the resource stocks of these species range from just a few tons to several hundred tons (Tagil'tsev *et al.* 2004). However, both total stock and its harvesting share is not exactly known. It is one of the urgent problems facing forestry and forest management in the region.

Other forest resources

Herb medicinal plants, excluding wooden plants, are also numerous in Priamurye. Of the 140 herb species traditionally used in official or folk medicine or recently permitted for official usage (Kile 2004, Tagil'tsev *et al.* 2004), 62 species are harvested in the Amurskaya district (Yaborov 2000). Species such as *Panax ginseng* (Photo 5b), *Gastrodia elata* (Photo 5c), Inula japonica, are the endemics of the Russian Far East and are considered significant medicinal plants (Tagil'tsev *et al.* 2004).

The forests are rich in wild berries and nut resources (Table 2) as well as in mushrooms (200 species) and edible herbs (140 species). There are also many wild animals with such species as the sable, squirrel, fox, elk and reindeer being of the highest commercial value (Report on the environmental situation in Amurskaya 1998). About 200 bee plants provide the base for forest bee farming. Honey, fern and red berry are important export products to countries such as Japan and Korea.

Non-use value of the forests and forest ecosystems is of special significance for the local citizens. Sixty hot springs with unique mineral water are located in the Amurskaya district. In such areas and in the forests surrounding large cities the anthropogenic activity is getting higher year by year, leading to the destruction of the precious forests of Priamurye.

Short history of forest consumption and dynamics

Local aboriginals (nanaitsy, ul'chi, daury, nivkhi, etc.) traditionally used wood for their skills' promotion. However, they never damaged the forests, instead caring for them as their natural habitats.

The first reports of anthropogenic influences causing severe forest fires were during the Mongol invasion (1210-1235). During that period of time per capita forest was equal to $5m^3$ while total forest consumption over the Far East was estimated at 2.5-3 mln. m^3 (Yaborov 2000).

From the 13th to the 17th centuries, natural restoration of the forest and shrub vegetation occurred without visible human impact. Annual logging for construction and local population needs made up about 300 thou. m^3 by the mid 1600's (Yaborov 2000). At that time Russian people began to occupy vast territories near the Amur River. They built towns and

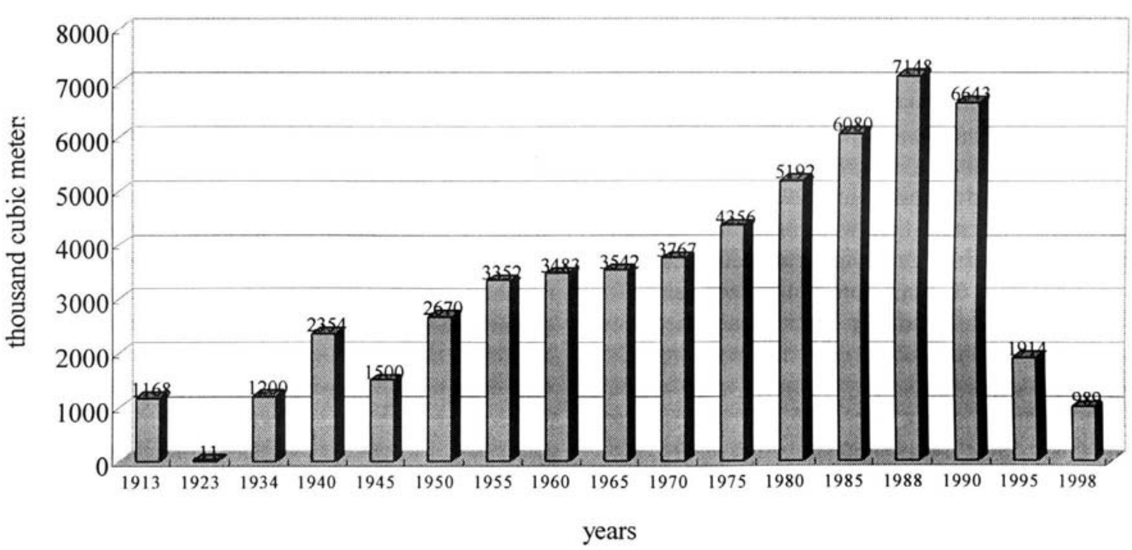

Fig. 2. Logged wood stock in Amurskaya administrative district throughout the 20th Century (Yaborov, 2000).

villages and created arable land by slash-and-burn methods. In the 19th Century fire occurrence significantly increased with severe forest fires occurring every 10-30 years. They absolutely destroyed mountain dark coniferous forests and steppe vegetation in the southern part of the region.

At the end of 19th Century the construction of the Amur railway accelerated the development of the local forest industry, in particular selective cutting. Since 1 km of the railway track required 300 m^3 of wood, forest harvesting increased in 1913 (Fig. 2). The number of forest fires also increased. Both the cuttings and the fires led to deforestation and the decrease of the conifers' share in the total stock.

In the 20th Century there were three more periods (1940, 1950 and 1988) of heightened forest harvesting closely related with periods of increased wood needs (Fig. 2 Photo 6). But actual wood volume harvested annually was always 1.8-3.5 times less than annual allowable stock being sharply decreased by 9.2-18.7 times over the last decade (Table 3). The level of the utilization was very low: only 3-73% of the annual allowable wood stock was cut and delivered to the consumers at different years, declining regularly, especially by 1995-1998 (Table 3). The conifers are usually utilized more thoroughly (11-55%) than the other species (Table 3). Such large wood losses happened due to existing methods of harvesting and transportation (Photo 7).

Insufficient cutting of softwood species, especially white birch, has led to the increase in their distribution by 2.7% since 1966 while preferable harvesting of the conifers has resulted in the decrease of their area by 12.8% over the same period of time (Yaborov 2000).

Overall, since 1978 only the forested area has been increasing. This is a reflection of the changing approaches to forestry which began in the early 1970's, with increasing emphasis on forest management and reduction in the levels of the commercial harvest (Sheingauz 1996). All other parameters of forest productivity had worsened since 1966 (Table 4). This was as a result of the previous forest policy, existing methods of clear cuttings and periodic forest fires as well as of natural features of the forests. For example, total wood stock of the mature and overmature stands decreased by 474 mln. m^3. Of these the commercial, mainly conifer, wood made up 149.6 mln. m^3 while average wood losses during harvesting were estimated to be 25 % or 37.4 mln. m^3 (Yaborov 2000). Thus, 287 mln. m^3 of the stock in the mature and overmature stands were destroyed by fires, insect outbreaks and fungi infestations. Additionally, destruction of young conifer forests by fires can result in the essential decrease of wood harvesting in the near future. Areas such as the traditionally exploited forested areas surrounding the Trans-Siberian railway, as well as in

Table 3. Forest logging and utilization over the period of 1965-1998 (Yaborov, 2000).

Years	Annual allowable stock, thou cubic meters				Wood volume harvested, thou cubic meters				Level of wood utilization, %			
	Total	Conifers	Hardwood species	Softwood species	Total	Conifers	Hardwood species	Softwood species	Total	Conifers	Hardwood species	Softwood species
1965	11997.0	8955.0	457.0	2585.0	3436.0	3101.0	29.0	306.0	29.0	35.0	6.0	12.0
1980	11494.0	7798.0	200.0	3496.0	4801.0	4544.0	13.0	239.0	43.0	58.0	7.0	7.0
1985	10915.0	7663.0	200.0	3052.0	5695.0	5320.0	51.0	324.0	52.0	68.0	21.0	11.0
1990	10915.0	7663.0	200.0	3052.0	6057.0	5572.0	18.0	467.0	55.0	73.0	9.0	15.0
1995	15838.0	11555.0	53.0	4230.0	1715.0	1595.0	2.0	118.0	11.0	14.0	4.0	3.0
1998	15838.0	11585.0	53.0	4230.0	848.2	743.5	2.8	102.0	5.4	6.4	5.2	2.4

Note. The definition "level of wood utilization" in Russian forestry means the share of actually harvested wood compared to the total allowable stock and is calculated as the ratio of these two parameters (in percent).

Table 4. Forest productivity dynamics over the period of 1966-1998 (Yaborov, 2000).

Parameters of productivity	Years						
	1966	1973	1978	1983	1988	1993	1998
Forested area, thousand hectare	19,351.9	19,948.0	20,851.2	21,244.2	21,777.0	21,852.9	22,460.1
Total wood stock, million cubic meters	2,098.55	1,813.43	971.57	1,938.67	1,986.02	1,953.84	1,991.97
Mean age of the stands, years	84	83	85	70	80	79	77
Wood stock of the mature and overmature stands, million cubic meters	1,474.01	1,081.98	489.40	1,004.50	987.56	955.66	999.94
Average wood stock per 1 hectare of the forested area, cubic meters	108	94	97	98	97	89	89
Average wood stock per 1 hectare of the mature and overmature stands, cubic meters	134	128	132	133	131	130	130
Average wood stock increment per 1 hectare of the forested area, cubic meters	1.34	1.23	1.40	1.39	1.38	1.36	1.20

the Amur, Zeya and Bureya river basins will be affected by this (Yaborov 2000).

The main threats to the forests and forest biodiversity

At present, in addition to the disastrous methods of wood harvesting, a criminalization of timber felling may also cause severe ecological and environmental disasters. According to estimations, about 50% of the harvested timber in the region is illegal (The First State Report 1997). Protected wood trees, such as *Phellodendron amurense*, *Pinus koraiensis*, *Tilia amurensis* represent the most valuable and are cut first (Progunkov 2004). A lack of good country roads leads to the concentration of clear-cutting areas using heavy machinery just near arterial roads.

Moreover, local people gather wild forest berries, mushrooms, ferns and nuts, resulting in an increase in fire occurrence and damage to wildlife habitats (Izmodenov 2001, Lysoon 2004, Yaborov 2000). Amateur hunters go poaching in the Amur Taiga for bears, whose paws are considered a delicacy by southeastern people (Skripova 2001), as well as for tigers, whose bone, together with bear's bile, are important components of Tibetan medicines (Bazaron *et al.* 1984).

Insufficient financial support from the Federal government leads to the situation where natural forest conditions are not accurately and systematically monitored. Numerous wildfires (43% of the total number) made by forest visitors cannot be detected at the onset, and spread over vast territories. The Amurskaya district is considered to be one of the most fire-dangerous regions in Russia (The First State Report 1997, Yaborov 2000), with 17,793 wildfires in an area of 1338 thousand hectares registered over a fifty-year period (1949-1998) (Yaborov 2000). This equates to an average of 356 fires annually with the mean area of each fire estimated at 75 hectares (Yaborov 2000). There are two fire-dangerous periods a year: late spring (April-May) and early autumn (August-September). The area of burned stands is estimated to be 4-5 (Sheingauz 1996) or even 7.5 times higher (Korovin 1995) than the harvested area.

Both illegal clear-cuttings and scattered forest fires resulted in the loss and fragmentation of natural habitats. Vulnerable and rare species, such as *Panax ginseng*, *Gastrodia elata*, *Rhodiola rosea*, are threatened with extinction.

Insect pests and fungi infestations are also severe natural calamities in the forests of Priamurye (The First State Report 1997). Periodic outbreaks of Siberian moth (*Dendrolimus superans sibiricus*), gypsy moth (*Lymantria dispar*) and nun moth (*Lymantria monacha*) result in the death of tree stands while such wood boring pests as black fir sawyer beetle (*Monochamus urussovi*) and spruce bark beetle (*Ips typographus*) usually infest fire and insect-weakened or overmature trees, greatly decreasing wood quality (Ageienko and Klintsov 1969). Stem fungi infestation by *Phaeolus schweinitzii*, *Phellinnus hartigii*, *Porodaedalea chrysoloma* and *Fomitopsis pinicola* also resulted in significant (15-19%) losses of wood. It is reported that of the total forested area in the Amurskaya district, 324.6 thou hectares with 5.4 mln. m^3 of wood stock was infected by pest-insects and different diseases by the beginning of 1999 (Yaborov 2000). This situation is the result of inadequate funding, damaging harvesting techniques and the lack of both sanitary logging and permanent forest health monitoring.

Further considerations

The Priamurye territory of the Russian Far East is one of the richest forest resource regions in the Russian Federation. The forested area makes up 22460.1 thousand hectares and the total wood stock is equal to 1991.97 million cubic meters. The per capita forest stock is estimated to be 1.9 thousand m^3 in an area of 21.8 hectares (Yaborov 2000). Non-timber resources and non-use value of the forests are also essential.

But in the last 30 years all the main parameters of forest productivity have been regularly decreasing due to natural calamities and anthropogenic activities. And only an insignificant part of the forests - 0.6% of their total area - is conserved in state reserves (Yaborov 2000).

What should be undertaken to maintain and to improve these precious natural forests? Studies of the responses of tree species to the timing and severity of natural and anthropogenic disturbances should be undertaken in order to predict their growth accurately (Bazzaz 1979, Mooney and Gulmon 1983). This is an important task for the forest scientists and plant ecologists whose role is underestimated under existing economical conditions (Korovin 1995). Moreover, the system and principles of practical forestry and forest management, which remain unsolved despite adopting the Principles of Forest Legislation (Regulations 1993), should be changed. The most urgent among these are issues connected with the legal status of the forests, such as the mechanism of forestry financing and the development of national forest regulation. The first step in the decision is to adopt, as soon as possible, a new Forest Code of the Russian Federation that must delineate a clear conception of the legislative status of the forests and forms of property ownership.

The previous regime of central financing of forestry as an expense of the national budget seems to be kept in part, replaced by a multichannel system of financing, based on forest revenue. One of the most acceptable mechanisms for economic forest utilization is recognized to be through forest resource leases (Regulations 1993). According to this document, lease-holders are the legal owners (which may include foreign parties or individuals) and have the rights to forest utilization. The forest leases can be extended up to 50 years and may be renewed. State regulation of forest activities and the management of forests must be carried out by specially authorized state agencies, that are not connected to the production activity (Korovin 1995).

To provide effective forest management, an information database documenting the state and dynamics of the forests, their growth and yield patterns as well as information on ecosystem responses to the anthropogenic and natural disturbances should be developed in the Amurskaya administrative district. Raising the level of forest fire protection requires solving a series of urgent problems, such as strengthening aviation and ground forest fire services, increasing manpower assignments for fire fighting crews and extending the area of fire-controlled territory (Yaborov 2000). A forest health monitoring system should also be developed in the region.

Thus, a new system of forest management in Priamurye, which combines market mechanisms and national regulation in areas of forest utilization, regeneration and protection, is closely dependent on its creation in Russia. The development of such a system is a very long and complex process that requires changes not only in legislation, but also in economic and social structures.

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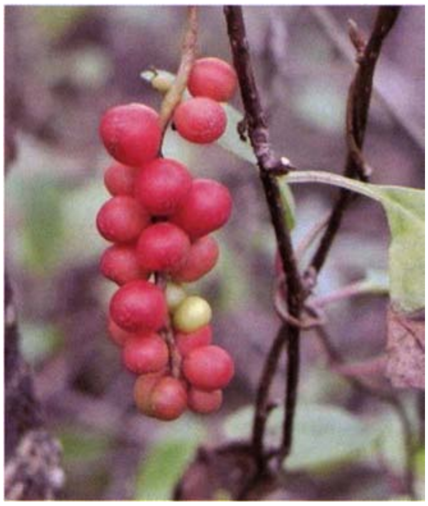
Photo 1. Larch forests of *Larix gmelinii* dominate in the forest cover of Priamurye. (Photo by V.T. Yaborov)

Photo 2. Scots pine forest in winter. (Photo by V.T. Yaborov)

Photo 3. *Pinus koraiensis* forest growing in the protective area. (Photo by V.T. Yaborov)

Photo 4. Secondary birch forest of *Betula platyphylla* with the fern as the main component of the herb layer. (Photo by V.T. Yaborov)



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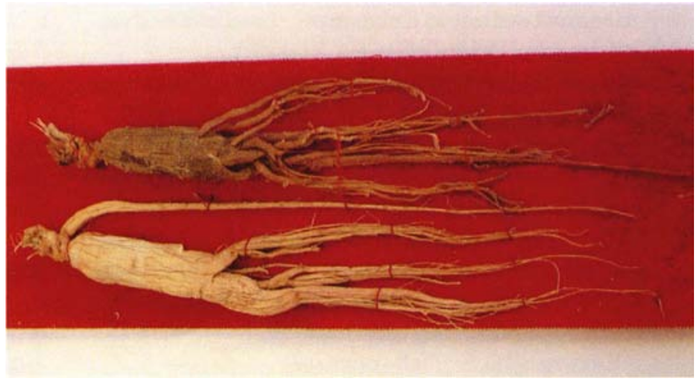

b

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Photo 5. *Schisandra chinensis* (a), *Panax ginseng* (b), *Gastrodia elata* (c) belong to the group of the most important medicinal plants.
(Photos by: (a) HP free photo, (b) H. Mamiya, (c) M. Yamanouchi)

Photo 6. Industrial wood harvesting in the southeast of Priamurye.
(Photo by V.T. Yaborov)

Photo 7. Losses of the wood during the harvesting: the wood, logged and left on the cutting area (a), and the wood, lost during the transportation (b).

Adopted from Yaborov (2000)