UNEP

DIAGNOSTIC ANALYSIS OF THE LAKE XINGKAI/KHANKA BASIN (PEOPLE'S REPUBLIC OF CHINA AND RUSSIAN FEDERATION)

United Nations Environment Programme
Chinese Research Academy of Environmental Sciences
Pacific Geographical Institute,
Far-Eastern Branch of Russian Academy of Sciences

Financially supported by the Government of Japan

For bibliography purpose this document may be cited as:

UNEP/CRAES/PGI: Diagnostic Analysis of the Lake Xingkai/Khanka Basin. UNEP. 2001.

ISBN No: 92-807-2124-0

Cover photos by Takehiro Nakamura (UNEP)

UNEP

DIAGNOSTIC ANALYSIS OF THE LAKE XINGKAI/KHANKA BASIN (PEOPLE'S REPUBLIC OF CHINA AND RUSSIAN FEDERATION)

United Nations Environment Programme

Chinese Research Academy of Environmental Sciences

Pacific Geographical Institute
Far-Eastern Branch, Russian Academy of Sciences

Financially supported by:

The Government of Japan

List of Contributors

United Nations Environment Programme (UNEP)
Takehiro Nakamura (Division of Environmental Policy Implementation

People's Republic of China
Chinese Research Academy of Environmental Sciences
Jin Xiangcan (Team Leader), Xu, Nanni, Cao Hongfa, Hu Xiaozhen, Liu Wenxiang, Yan Changzhou

Heilongjiang Provincial Environmental Protection Agency
Su Fenxian

Heilongjinag Provincial Research Institute of Environmental Protection Sciences
Zhang Dajun, Zhao Yanbin, Zhao Zhe, Yin Yanhua, Zhang Pe

Mishan City Environmental Protection Bureau
Yan Tiezheng, Cui Baoshan

No. 81 Agriculture and Reclamation University, Heilongjiang
Li Wenfa, Zhu Wande

Russian Federation
Pacific Geographical Institute, Far Eastern Branch of the Russian Academy of Sciences
Anatoly N. Kachur (Team Leader), Ivan S. Arzamastsev, Peotr Ya. Baklanov, Vladimir N. Bocharnikov, Aleksandr V. Vlasov, Sergey S. Ganzei, Nedezhda K. Ignatova, Alexei N. Kiselyev, Matvey T. Romanov, Aleksei A. Stepanko, Valentina A. Chudaeva

Biology and Soil Institute, Far Eastern Branch of the Russian Academy of Sciences
Vladimir I. Oznobikhin, Larisa A. Prozorova

Institute of Marine Biology, Far Eastern Branch of the Russian Academy of Sciences
Evgeny Shornikov

Promorsky Territorial Board on Hydrometeorology and Environmental Monitoring of Federal Service on Hydrometeorology and Environmental Monitoring of the Russian Federation

Primorsky Centre for Monitoring Environmental Pollution
Galina I. Semykina

Primorsky Kray Duma
Yury I. Bersenev

Khankaisky State Natural Reserve
Yury Sushitsky

Ussurisky Pedagogical Institute
Yury Gluschenko

Primorsky Geological Committee
Evgeny I. Shornikov

TABLE OF CONTENTS

PREFACE

Lake Xingkai/Khanka is the largest freshwater lake in Northeast Asia, located on the border between the People's Republic of China and the Russian Federation. Its basin is a part of the Wusuli/Ussuri-Heilong/Amur basin. The lake provides a large amount of water resources, and serves as a critical habitat for important animal and plant species, such as red-crowned crane, *Grus japonensis*.

Two riparian countries respectively initiated specific measures to protect the significant species and their habitats, particularly, wetland areas around the lake. Two protected areas were established for this purpose. The Russian side of the lake shore wetlands have been designated as a Ramsar site. However, it was recognized by both of the riparian countries that more co-ordinated efforts between the riparian countries would enhance the efficiency and cost-effectiveness.

Stakeholders between the two riparian countries agreed on selected joint actions through various international forums and agreements, such as the Memorandum of Understanding (25 May 1998) on the Wusuli/Ussuli Basin among the Primorsky Kray, Khavarovsky Kray (both in the Russian Federation) and Heilongjiang Province (in the People's Republic of China) in which one of the foci is placed on "joint planning of the coordinated system of protected territories in the Lake Xingkai/Khanka area, including development of tourism and recreation facilities". Further, this MOU also set the goal of initiation of applied science exchange in hydrology, watershed management, and related fields to devise plans for enhancing and maintaining water quality and fishery resources in the Wusuli/Ussuri River and adjacent waterways. Through the MOU, it was proposed to the respective national governments that the International Ussuli Commission (IUC) be established. Also, both Lake Xingkai National Nature Reserve (China) and Khankaisky National Nature Reserve (Russia) agreed to take steps for negotiations for establishment of a joint international reserve for the Lake Xingkai/Khanka, and for exchange of scientific information and experiences.

Based on the existing framework for cooperative work between the two countries, UNEP assisted the development of a Diagnostic Analysis of the lake basin, partially funded by the Government of Japan. Through this project, two riparian countries identified issues for environmental management and sustainable development of the lake basin through regional cooperation. Two institutions have been designated by the respective national governments as focal institutions: Chinese Research Academy of Environmental Sciences (CRAES) in the People's Republic of China and Pacific Geographical Institute (PGI), Far-Eastern Branch, Russian Academy of Sciences in the Russian Federation.

The project was initiated by the inception meetings in September 1997, where representatives of the two countries visited the lake and had interviewed with relevant experts. Based on the findings at these inception meetings, national reports on the environmental and socio-economic status of the basin have been prepared, and further three reports were prepared by respective focal institutions: (i) general background and water resources in the basin, (ii) biodiversity in the basin, and (iii) socio-economic development of the basin. In December 1999, the final workshop was convened to present the national reports and the three thematic reports. After the final workshop, the Diagnostic Analysis has been compiled based on the three thematic reports. Editing of the national reports and compilation of the Diagnostic Analysis was carried out by Monitor International (U.S.A.).

The Government of Japan generously provided financial support to this project.

CHAPTER 1

INTRODUCTION TO LAKE XINGKAI/KHANKA AND ITS DRAINAGE BASIN

1.1 Purpose and Background for Diagnostic Analysis

Lake Xingkai/Khanka is located on the border of the People's Republic of China (China) and the Russian Federation (Russia). It is the largest lake in Northeast Asia, as well as a transboundary waterbody between China and Russia. The lake is called Lake Xingkai in China and Khanka Lake in Russia. For easy reference, and emphasizing its transboundary nature, the lake will be identified as Lake Xingkai/Khanka for the purposes of this report, with no national preference intended by the order of the listing of the names.

There are 23 inflowing rivers to the lake, 8 draining from China and 15 draining from Russia. The Song'acha River is the only outflow river from the lake, and is subsequently connected with the Wusuli/Ussuri River and the Heilong/Amur River system. The drainage basin of Lake Xingkai/Khanka is a habitat for important animal and plant species of both countries, particularly the wetlands surrounding the lake. To this end, the Russian Federation designated the lake area as a Ramsar Convention wetland site, on the basis of its importance for migratory bird species.

Because of its environmental and economic importance to both China and Russia, it was previously recommended that a cooperative environmental management programme be prepared between these two riparian countries. The programme would provide a means to address *inter alia*: (i) wetland conservation and management; (ii) water quality control (particularly nutrients and pesticides from agricultural runoff); (iii) groundwater protection; and (iv) water use for irrigation, drinking water and fishing. Subsequent to this recommendation, the United Nations Environment Programme (UNEP) began a cooperative effort with the two riparian countries, and prepared a proposal for development of a comprehensive environmental diagnostic analysis for Lake Xingkai/Khanka and its drainage basin. This analysis was to serve as a technical basis for future development of an environmental management programme for the Lake Xingkai/Khanka drainage basin. Other factors relevant to the environmental conditions and characteristics of the lake and its drainage basin also are reviewed in this Diagnostic Analysis report (e.g., land-use regulations, environmental laws, economic conditions, and existing institutions).

Cooperation between Russia and China regarding Lake Xingkai/Khanka has previously been demonstrated with joint research efforts conducted by the Chinese Institute of Applied Research and the Far Eastern Branch of the Russian Academy of Sciences. The two countries also previously completed a study report relevant to the proposed diagnostic analysis, entitled "A Sustainable Land Use and Allocation Program for the Ussuri/Wusuli River Watershed and Adjacent Territories (Northeastern China and Russian Far East)." The Mishan City People's Government in China, and the Primorsky Kray Administration in Russia also concluded an agreement to establish an international nature reserve in the Lake Xingkai/Khanka drainage basin.

This cooperative project embodied in this Diagnostic Analysis report was endorsed by the two riparian countries, specifically the Chinese State Environmental Protection Administration and the Russian State Committee for Environmental Protection. The two riparian countries also identified responsible national institutes for the preparation of this report. For China, it is the Chinese Research Academy of Environmental Sciences (CRAES). For Russia, it is the Pacific Geographical Institute (PGI), Far Eastern Branch, Russian Academy of Sciences. Both organizations had the mandate of preparing national reports and the subsequent Diagnostic Analysis report.

The first meeting for "Preparation of a Diagnostic Analysis for the Lake Xingkai/Khanka Drainage Basin" was held during 14-19 September 1998. The first session of this initial meeting was held in Spassk-Dalnii City on 14-16 September 1998 and in Kamen-Ribolov on 16-17 September 1998 (both in Russia), while the second session of the initial meeting was held in Mishan (China) on 17-19 September 1998. Participating experts at this meeting also visited the Khankaisky Nature Reserve and the Astrakhanka Hydrometeological Monitoring Station (Russia), and the Xingkai Nature Reserve (China).

National reports on Lake Xingkai/Khanka and its drainage basin were prepared by the responsible national institutions of the two riparian countries. Additional background reports on water resources and geographic conditions, biodiversity, and the socio-economic conditions in this region were prepared by experts, and served as major inputs for this Diagnostic Analysis report. The participation and work of the involved experts in the preparation of these various reports is gratefully acknowledged and appreciated. A regional workshop also was held in Mishan, China during 13-16 December 1999. The purpose of the workshop was (i) to present the results of the national reports, and (ii) to agree on the remaining work and procedures for completing the overall project. The regional workshop participants also visited the lake and the nature reserve on 16 December 1999.

The national reports of the two riparian countries provide detailed data and information regarding (i) the natural characteristics of the drainage basin, (ii) the environmental status and problems observed in the drainage basin, and (iii) recommendations for addressing these problems. In preparing this Diagnostic Analysis report, it is emphasized that available information and data on specific issues vary between the two countries, as well as within their national management and assessment systems. This varying availability of information and data is due primarily to the fact that the two riparian countries have understandably approached Lake Xingkai/Khanka and its drainage basin within the context of their national interests and goals. Nevertheless, this Diagnostic Analysis attempts to integrate the information and data from the two countries into an integrated report that addresses Lake Xingkai/Khanka and its entire drainage basin.

Building on the national reports, and the additional work of Chinese and Russian experts and officials, this Diagnostic Analysis report was designed to provide an initial evaluation of (i) the physical and environmental features characterizing Lake Xingkai/Khanka and its drainage basin, (ii) the major environmental problems confronting this transboundary water system, and (iii) the scientific/technical and socio-economic factors to be considered in developing a cooperative binational management plan for the sustainable use of this important transboundary water resource. Equally important is the goal of providing initial guidance on the important elements to be considered in developing the environmental management plan.

1.2 Overview of Physical, Environmental and Demographic Features of Lake Xingkai/Khanka and its Drainage Basin

1.2.1 Physical characteristics

The Lake Xingkai/Khanka drainage basin covers about 2,200 km^2, with about 97% of the drainage basin being in Russia. In the report, the Muling River basin in China is not included, although there is seasonal hydrologic linkage between the lake and the Muling River. The lake itself is located in the central part of the Prikhankaiskaya Lowland, in the western part of Primorsky Kray, with about 70% being situated in Russia and the remaining 30% located in China. As previously noted, Lake Xingkai/Khanka is a boundary lake between China and Russia (Figs. 1-1 to 1-3). The water plane of the lake varies between 4,000 – 4,400 km^2, depending on the water surface level. The lake consists of small Xingkai (Xiao-Xingkai) and large Xingkai/Khanka. The lake has an average length of 90 km and an average width of 45 km. The average lake depth and volume is 4.5 m and 18.3 km^3, respectively. The maximum lake depth and volume is 10.6 m and 22.6 km^3, respectively. At its average water depth, the length of the lake shoreline is approximately 308 km.

1.2.2 Climate

The Lake Xingkai/Khanka basin is located in the continental monsoon climatic zone, with the climatic characteristics of the region being affected by the monsoon character of the air mass circulation. The average air temperature and precipitation distribution in the drainage basin is illustrated in Figs. 1-4 to 1-12.

In the winter, the lake basin territory is predominantly influenced by very cold, dry air masses forming in the area of strong Asian anticyclones. During this period, the weather is primarily clear and frosty. The cold period (represented by the period of average daily air temperature below O° C in the Prikhankaiskaya Plain) is approximately 200 days in length, with the coldest month being January (with an average monthly air temperature being lower than -18° C).

The precipitation falls in solid (snow) and mixed form (snow, water) for 3-4 months during the winter period, comprising 8-20% of the total annual precipitation falling during this period. The average dates of onset of snow-free land cover are 9-13 April, although earlier dates (March) have been observed in the past at some individual meteorological stations. The snow cover at the end of December typically does not exceed 5-10 centimeters.

Western (30-60%) and northwestern winds (25-45%) predominate at the western part of the plain, and southern and southwestern winds (20-40%) predominate at the northern part. The average velocity of winter winds is 2-4 m/s. Heavy winds (lower than 15 m/s) occur about once per month, although its duration can increase to 5-7 days in February in the western part of the plain and in the Lake Xingkai/Khanka shoreline areas.

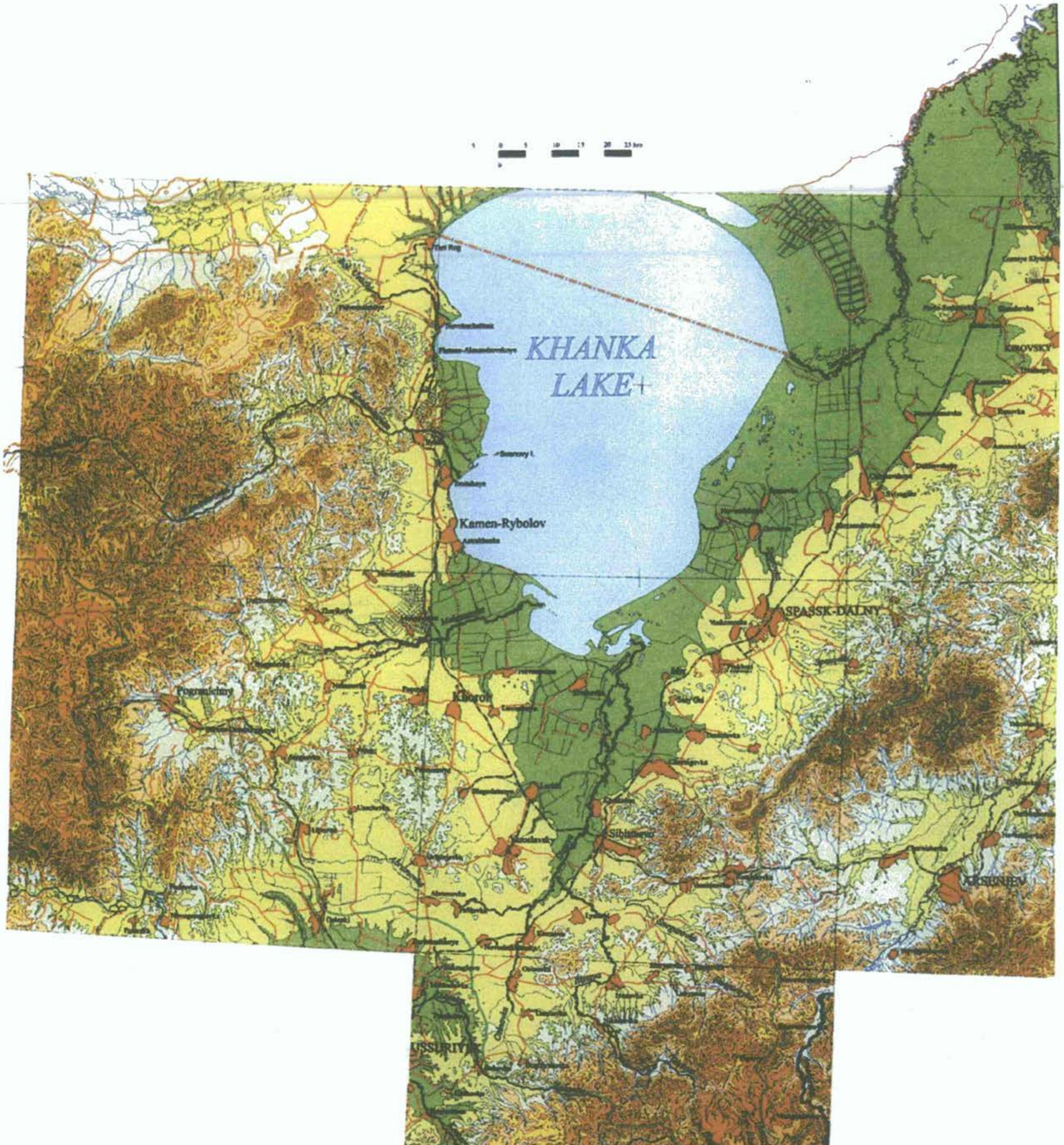


Fig. 1-1 Lake Xingkai/Khanka drainage basin (Russian portion)

Fig. 1-2 Lake Xingkai/Khanka Drainage basin (Chinese portion)

Fig. 1-3 Landsat Satellite Image

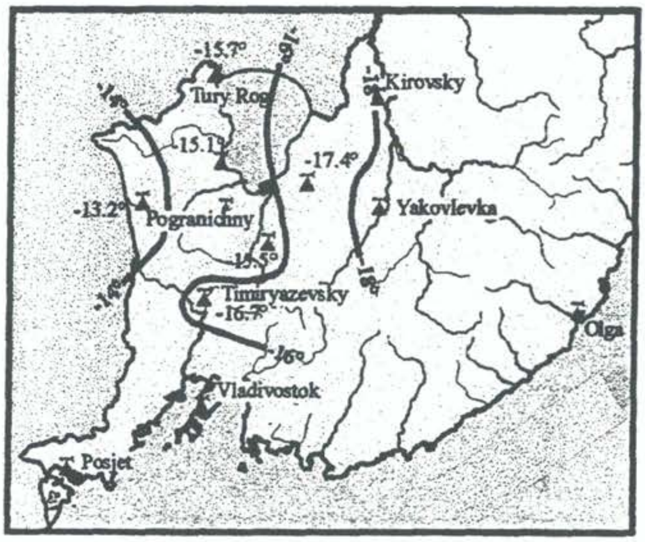


Fig. 1-4 Average air temperature (°c) in Winter (Dec. Jan. & Feb.)

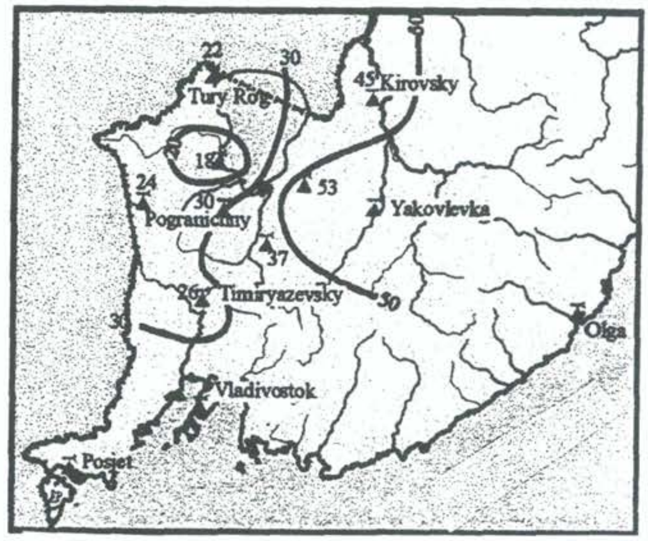


Fig. 1-5 Precipitation (mm) in winter (Dec. Jan. & Feb.)

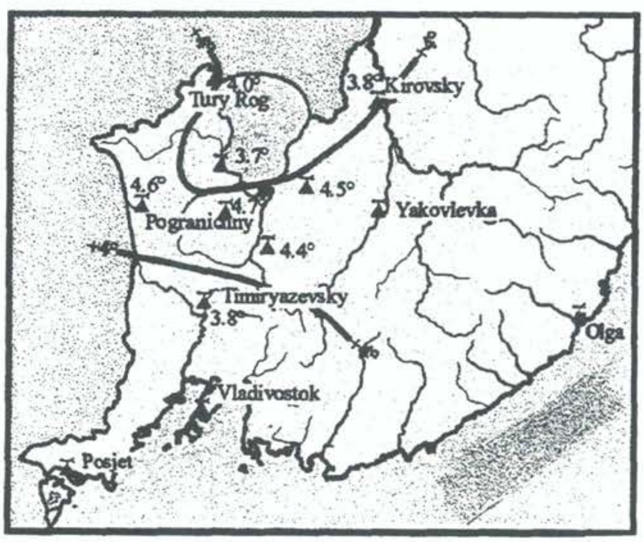


Fig. 1-6 Average air temperature (°c) in Spring (March – May)

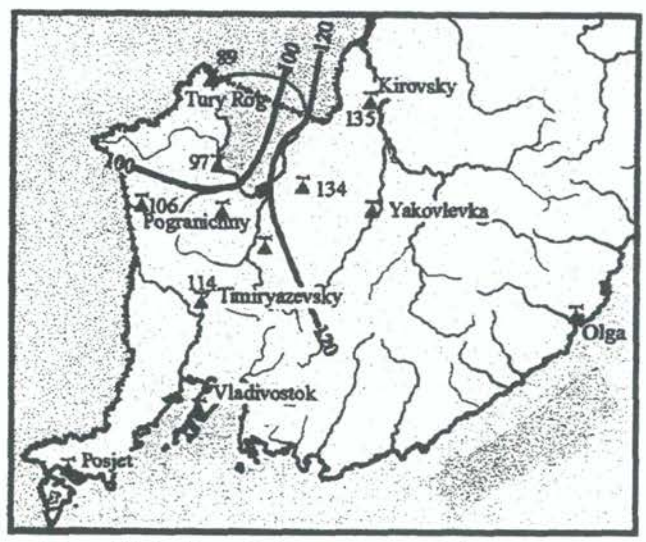


Fig. 1-7 Precipitation (mm) in Spring (March-May)

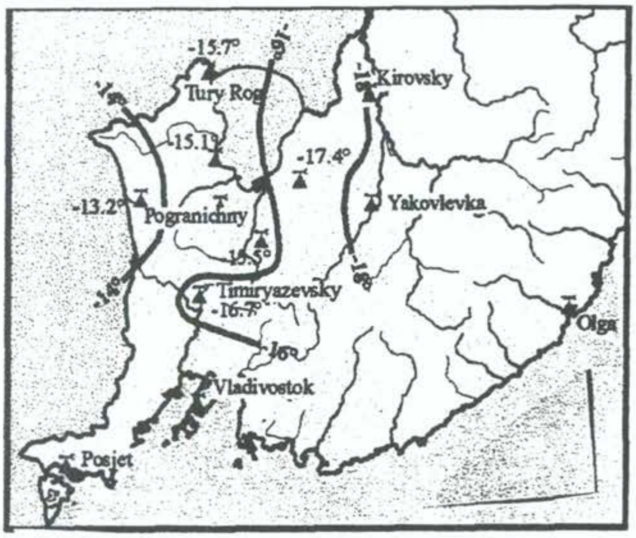


Fig. 1-8 Average air temperature (°c) in Summer (June – August)

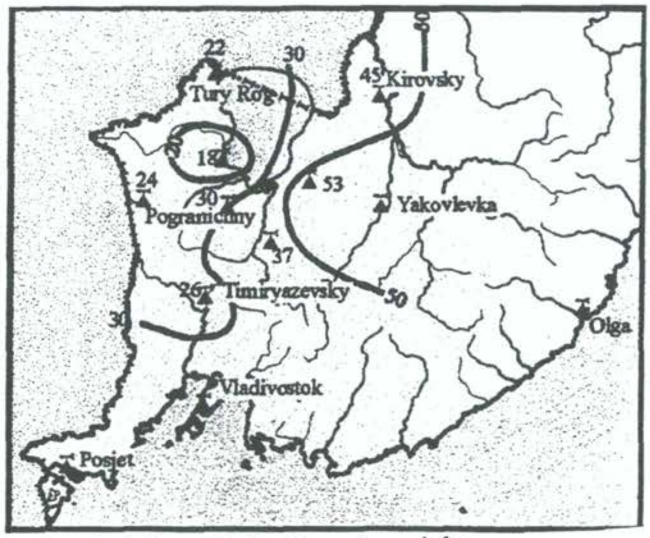


Fig. 1-9 Precipitation (mm) in Summer (June – August)

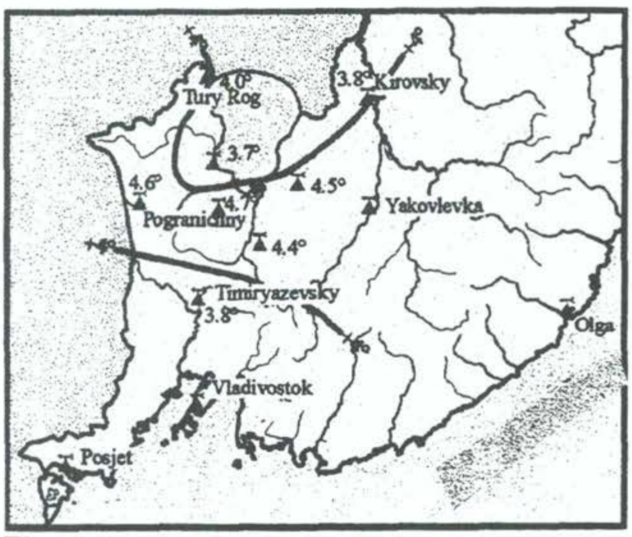


Fig. 1-10 Average air temperature (°c) in autumn (September - November)

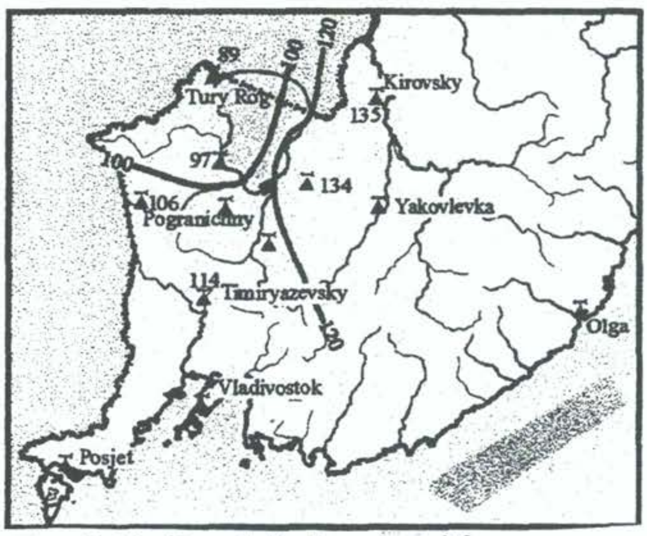


Fig. 1-11 Precipitation (mm) in Autumn (September – November)

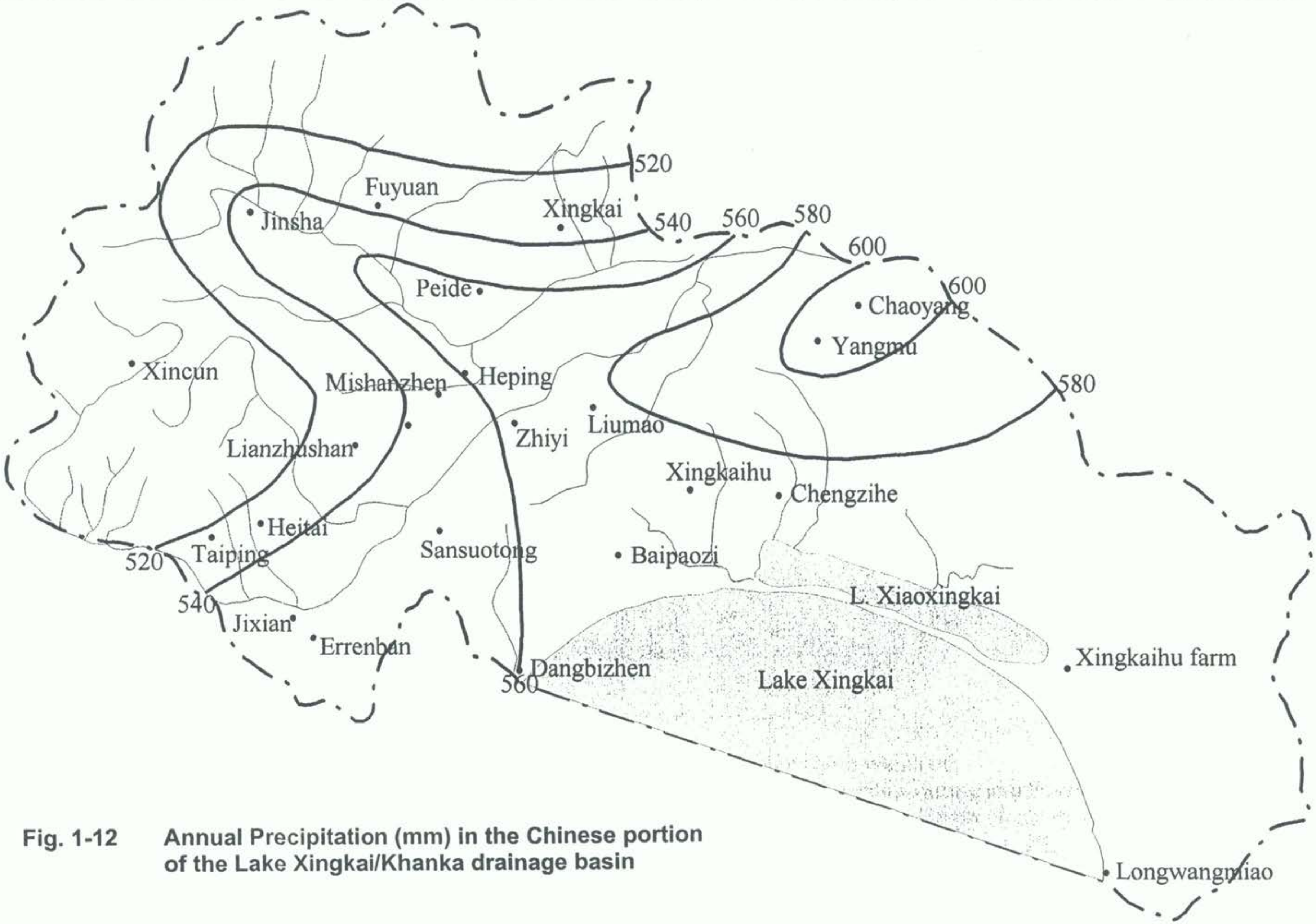


Fig. 1-12 **Annual Precipitation (mm) in the Chinese portion of the Lake Xingkai/Khanka drainage basin**

The spring is characterized as a transitional season, with the winter wind continuing into March. The transition of average air temperature through +5° C goes through the middle of April, and through +10° C to increasing temperatures in the first ten days of May. The average monthly precipitation increases notably during the spring term, being 8-26 mm in March, 23-36 mm in April and 52.4-68 mm in May.

The wind direction in the summer is southern in the Prikhankaiskana Plain (Russia). The average wind velocity is 2-5 m/s, with stronger winds (higher than 15 m/s) observed about 1-2 days each month. During the spring period of hot, dry winds, the wind speed is not less than 5 m/s, and can sometimes exceed 20 m/s, with durations of 4-6 days. The winds can cause considerable harm to agricultural lands, causing arable soil to dry up and blow away, and creating dust storms in the process.

In the first half of summer, monsoons bring drizzling rains, with air masses coming from the Sea surrounded by Japan, Korean Peninsula and Russia and the Sea of Okhotsk, and even sometimes from the Yellow Sea. Long, intense showers characterize the second half of summer and the early autumn. Strong typhoons sometimes come from tropical latitudes to the Lake Xingkai/Khanka region. The summer monsoon lasts throughout the whole summer period.

The average monthly air temperature fluctuates between 16.1-18.2° C in June and between 20.1-21.7° C in July and August. The air temperature can rise as high as 33-35° C in July and August, with the absolute maximum temperature for these two months being 37-39° C.

The autumn is typically dry, clear and calm, with a slowly decreasing air temperature. Low temperatures commence at the end of September, with cooler air masses coming at the beginning of October. A sharp temperature drop (daily air temperature below O° C) occurs at the beginning of November. The most intense temperature decrease over the annual cycle (19-21° C) occurs during October-November. A transition from average daily temperature from 15° C to lower temperatures occurs during around 10-20 September, over 10° C around 1-10 October, and over O° C to minus temperatures around 1-10 November. The duration of the frost-free period in the Lake Xingkai/Khanka drainage basin is 153-161 days over the annual cycle.

1.2.3 Annual Precipitation Pattern

The annual precipitation in the Lake Xingkai/Khanka drainage basin averages between 530-630 mm, decreasing progressively from the southeast to the northwest.

Precipitation is an especially prominent feature of the summer period (June to August). Approximately 50-60% of the total annual precipitation occurs during the summer. In dry years, the monthly precipitation can vary between 5-25 mm, although 2-3 months of precipitation can fall during individual precipitation events.

The precipitation in autumn is less than in the summer period, but is more than in spring. The eastern shore of the lake receives more precipitation than the western shore. Precipitation ranges between 95-100 mm and 65-90 mm in September, and between 45-60 mm and 35-45 mm in October.

In a given year, however, the autumn precipitation can be up to 2-2.5 times more than the normal volume, resulting in waterlogging in autumn. The monthly precipitation in spring averages 1-22 mm in March, 20-40 mm in April and 50-69 mm in May.

1.2.4 Geology

The orography of the Lake Xingkai/Khanka drainage basin is characterized by transition from mountainous ridges of middle mountainous and low mountainous relief, to zones of tumulus and hummocky relief, and subsequently to high and low accumulative plains. The Lake Xingkai/Khanka drainage basin comprises territory with absolute altitudes 600-700 m in the west, the Zapadny Sinii Ridge with absolute altitudes from 600-1,000 m, and the northern part of the Shkotovskoe plateau in the east. The south part of the basin includes Khorolskii hummock zones.

The high accumulative flatness of the region as a geomorphologic element is widespread throughout the drainage basin. In the western part, it is located on the watershed divide between Lake Xingkai/Khanka and the Muling River basins, stretching from Turii Rog settlement to the Bolshige Usachi River mouth.

A low accumulative lake-alluvial plain extends Kamen Cape to the south, and encircles the southern, eastern and northern shores of the lake. The origin of the flat regions is related to the Quaternary period of accumulation, when the lake's water level reached its maximum altitude.

The current distribution of bottom sediments is closely related to the geomorphologic formation of the drainage basin and its hydrodynamics. Most sand and gravel to Lake Xingkai/Khanka comes from the Komissarovka River, and rivers draining to the lake from the west and southwest also deliver some sandy and silt-sandy deposits. Approximately 63,000 tons of deposits are accumulated in the lake each year. This rate of sediment deposit is considered minimal for the central part of the lake. However, in the proximity of rivermouths and beach areas, the deposition rate is two or more times greater than in the central part.

Lake Xingkai/Khanka is shallow, with its greatest depth in the northern part, and shallower depths in the southern part. The western and southern shore are generally elevated, although they are lowered to the water depth in some places by steep scarps and rocky cliffs of altitudes from 6-15 to 30-40 m above average lake water level. The eastern and southeastern shores are low and often swampy.

The lake basin is generally considered to be of tectonic origin, with its underlay being related to the Pliocene Epoch, and the drainage basin's river network is considered to have developed at the beginning of the Pleistocene Era. The lake water basin arose in the Middle Pleistocene Era, with its proportions changing strongly after that time.

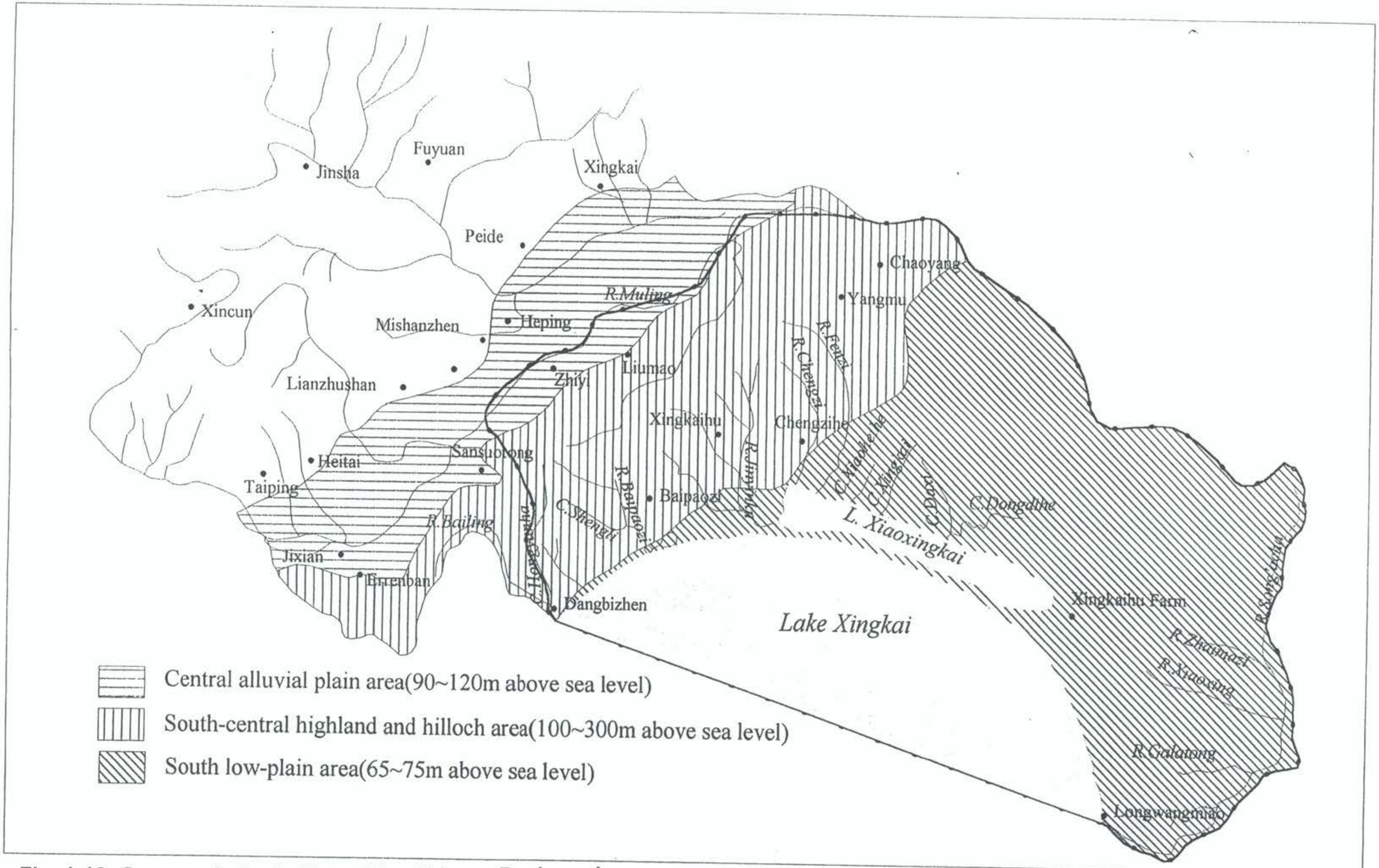


Fig. 1-13 Geomorphologic Map of the Chinese Basin and Main Rivers

1.2.5 Land Use

The Lake Xingkai/Khanka drainage basin represents a major Chinese and Russian agricultural zone. It has long been a productive agricultural area, due primarily to its suitable soils and climate. The main Russian agricultural district in Primorsky Kray consists of six administrative districts (Khankaisky, Spassky, Pogranichny, Khorolsky, Mikhailovsky and Chernigovsky). The agriculture in these districts occupies about 465,000 ha, comprising 47% of the arable lands and more than 60% of the irrigated lands of Primorsky Kray. The major Russian settlements are Dalnii City, Astrakhanka, Horol and Turii Rog. The Chinese portion of the drainage basin comprises most of the area of Mishan City, as well as 2 towns, 3 state farms and 6 villages. The Chinese farmland area is approximately 1,547 km^2.

On a drainage-basin scale, the main economic activities are agriculture, mining (fluorspar, rare earth elements, and coal), some industry, fish and cattle breeding, forestry and tourism. Both China and Russia also have established special nature protected areas in the drainage basin; namely, the Russian Federation Khankaisky State Natural Reserve, and the Xingkai Lake Nature Reserve of the People's Republic of China.

Information on overall land use within the Lake Xingkai/Khanka drainage basin is summarized in Table 1-1. The total land area comprises 21,766 km^2. Approximately 39.5% of the basin area is agricultural land, 32.7% is forest, 6.5% is inhabited land and factory areas, 7.5% is traffic areas, 1% is water area, and 6% is marshland.

The land area in the Russian side of the drainage basin totals 17,296 km^2. Thirty-eight percent of the total land is agricultural land, 36.9% is forest land, 8% is grass area, 8.8% is inhabited land and factory areas, 1% is traffic area, and 6% is marshland.

In the Chinese portion of the drainage basin, the land area is divided into three zones, on the basis of agricultural zonation (Fig. 1-13). Zone I is the partial pastoral area, Zone II is the farming and forest area, and Zone III is the farming, fishing and husbandry area. Of the total land area, 34.8% is farmland, 23.9% is woodland, 0.3% is grassland, 2.4% is residential area, 1.1% is traffic land use, 23.7% is water area and 13.7% is marshland.

Table 1-1 Land Use in the Lake Xingkai/Khanka basin

Districts		Total area (km^2)	Agriculture area (ha)	Forest area (ha)	Grass area (ha)	Inhabitant and factories (ha)	Traffic area (ha)	River and lake		Marsh (ha)	Arable (ha)
								Rivers and lake (ha)	Reservoir (ha)		
Russia portion of drainage basin	Mikhailovsky	2,741	121,036	127,777	27,568	41,695	6,384	2,189	-	1,368	-
	Paoaranichny	3,750	93,131	173,851	28,359	13,748	1,714	1,904	-	14,130	-
	Spassky	4,190	22,450	184,493	23,488	33,311	1,955	1,679	-	74,806	256
	Khankaisky	2,756	124,628	96,345	25,220	18,382	1,955	1,815	-	8,240	725
	Khorolsky	1,969	142,108	3,646	29,370	21,704	3,220	636	-	4,708	-
	Cherniaovsky	1,843	83,548	73,968	11,152	28,162	2,580	1,260	-	9,019	-
	Total	**17,249**	**687,101**	**660,080**	**145,157**	**157,002**	**17,808**	**9,483**	-	**112,271**	**981**
China portion of drainage basin	Zone I	1,430	83,100	22,500	800	6,300	2,200	1,700	-	14,300	-
	Zone II	621	26,100	27,200	500	1,800	700	300	80	3,800	-
	Zone III	2,466	86,900	21,900	500	3,800	3,100	122,800	300	7,300	-
	Total	**4,517**	**196,100**	**71,200**	**1,800**	**11,700**	**6,000**	**124,800**	**380**	25,400	-
Basin of Lake Xingkai/Khanka		**21,766**	**883,201**	**731,280**	**146,957**	**168,702**	**23,808**	**134,283**	**380**	**137,671**	**981**

1.2.6 *Agricultural, Fishery and Industrial Activities*

1.2.6.1 Agriculture

As previously noted, suitable climatic conditions and fertile lands favor the agricultural development of the Lake Xingkai/Khanka drainage basin. The agricultural area and crop yields for the drainage basin are given in Table 1-2. The agricultural crop area totals 409,957 ha, with rice-growing area totaling 4% and soybeans and grains totaling 44%.

Table 1-2. Agricultural area and crop yield in Lake Xingkai/Khanka drainage basin

Districts		Agriculture crop area (ha)					Crop yield (t/a)
		Total land area	Rice	Soybeans and grain	Potatoes	Vegetables	
Russia portion of drainage basin	Mikhailovsky	42,477	-	27,159	1,495	468.7	-
	Poaranichnv	27,017	-	17,486	1,103	171.9	-
	Spassky	41,763	910	26,444	2,130	536.6	-
	Khankaisky	48,340	2,580	29,807	1,714	314.0	-
	Khorolsky	48,747	3,250	37,111	987	179.8	-
	Cherniaovsky	31,713	800	21,443	2,013	714.5	-
	Total	240,057	7,540	159,450	9,442	2,385.5	-
China portion of drainage basin	Zone I	57,200	2,900	54,300	-	-	519,125
	Zone II	26,000	1,300	24,700	-	-	162,500
	Zone III	86,700	5,200	81,500	-	-	539,937
	Total	169,900	9,400	160,500	-	-	1,221,562
Drainage basin total		409,957	16,940	181,943	-	-	-

(ha, hectare; t/a; tons/year).

The agricultural land area in the six Russian lake districts totals 4,642 km^2. The estimated economic value of the agricultural output is 460 million rubles (1991 prices). The structure of the agriculture land in the Russian lake districts is 29.8% fodder area, 38.0% grain, 24.4% soybean, 0.2% potatoes, 0.2% vegetables, and 3.1% rice.

The total farmland area is approximately 1,699 km^2 in the Chinese portion of the drainage basin. Described as "a land of fish and rice", this area is an important base for commodity grain production for the Heilongjiang Province. It abounds in soybean, rice, corn and wheat, as well as industrial beet crops, etc. Mechanized agriculture is used in about 85% of the farmland area in the Chinese portion of the drainage basin.

1.2.6.2 Fisheries

Lake Xingkai/Khanka is the major water resource for the region, containing 65 species of fish. The major species include cyprinidae, such as *Cyprians carpio, Carassius, aurutus, Erythroculter erythropterus, Erythroculter erythropterus, Erythroculter mongolicus, Esox reicherii, Silurus soldatavi, Hypophthalmichthys moditrix, Channa argus, leiocassis Brachymystax lenok, Salmo taimen, Oncorhynchus keta, Huso dauricus*, etc.

Fisheries represent an important economic activity in the drainage basin. Fishing activities are conducted in the lake, and in rivers, channels and reservoirs in the drainage basin. The total annual catch of trade fish in Lake Xingkai/Khanka is given in Table 1-3.

Table 1-3. Annual catch of trade fish for Lake Xingkai/Khanka

Year	Total Catch (t/a)	Russian portion (t/a)	Chinese portion (t/a)		Year	Total catch (t/a)	Russia Portion (t/a)	Chinese portion (t/a)
1960	1,193.3	263.3	930		1993	-	122.3	-
1965	970	240	730		1994	979	104.8	875
1970	1,089	279	810		1995	1,129.4	87.4	1,042
1980	870.2	220.2	650		1996	-	-	1,327
1985	-	194.8	-		1997	-	-	936
1991	-	208.2	-		1998	-	-	706
1992	-	94.9	-					

(t/a, tons/year)

The Russian shoreline of the lake contains two fish-breeding enterprises and one fish-processing factory (i.e., Khankaisky fish-processing complex in Astrakhanka settlement, Khankaisky District). The total annual fish production on the Russian side since 1990 has not exceeded 150 tons, and the fish stocks in the lake are considered to be in a poor state. Based on a 1987 evaluation, the annual fish production was 3,700 tons, about 10 times less than the value of 50 years ago. The decreased fish production is attributed to a progressive pollution of the rivers in the drainage basin, resulting from industrial and agricultural activities.

A total of 570 employees are involved in fishing activities in the Chinese portion of the drainage basin, including 220 fish folk at the Xingkaihu Aquaculture Field, Heilongjiang Province. The Xingkaihu Aquaculture Field focuses on halieutics products, using 40 manual boats and 43 powerboats. The annual fish catch on the Chinese side averages 977 tons.

1.2.6.3 Minerals

Although there is not a wide range of natural resources in the Lake Xingkai/Khanka drainage basin, it does have considerable deposits of coal (Pavlovskoye and Lipovetskoge coalfields), cement raw materials (Spassky District), and fluorspar raw materials (Voznesenskoy Deposit).

There is comparatively little industry on a drainage-basin scale, and most of the existing industry is concentrated on the Russian side of the basin. The general characteristics of industrial development in the drainage basin are summarized in Tables 1-4 and 1-5 and in Fig. 1-14. The Voznesenskoye fluorspar deposit is the largest in Russia and development of the Pogranichny deposit also has begun. The estimated total stocks of the Voznesenskoe and Pogranichny will provide at least 20-30 years of fluorspar production, based on present levels of usage.

Table 1-4. Economic structure in the Russian portion of the Lake Xingkai/Khanka drainage basin (expressed in %)

Branch	District					
	Khankaisky	Pogranichny	Spassky	Mikhailovsky	Khorolsky	Chernigovsky
Total material production:	53.2	58.3	67.2	68.8	55.3	54.1
-Industry	1.1	2.6	26.9	15.3	16.9	11.3
-Construction	4.2	4.0	8.9	9.7	6.0	5.4
-Agriculture	30.6	22.0	15.3	25.7	17.7	15.9
-Forestry	0.2	0.8	0.3	0.5	-	0.1
-Transport	3.6	7.3	5.5	6.4	1.5	10.0
-Connection	1.6	2.3	1.6	1.7	1.9	1.6
-Trade	5.4	14.9	5.9	4.2	4.4	5.9
-Common catering	0.7	0.7	0.7	0.5	0.6	0.4
-Purchase, supply-sale	12	2.4	1.4	0.3	0.2	0.4
-Other material production	4.6	1.3	0.6	4.5	4.1	3.1
Total non-industrial branches:	46.8	41.7	32.8	31.2	44.7	45.9
-Education	11.9	11.0	11.0	7.6	12.0	1.6
-Culture and arts	1.1	2.3	1.4	1.4	3.2	1.0
-Science	0.6	-	0.2	-	-	-
-Sports	0.1	0.1	0.3	0.1	-	0.1
-Public health	5.2	9.8	5.1	4.4	5.9	5.0
-Social maintenance	0.4	0.8	0.6	0.1	0.5	0.5
-Housing and communal services	4.4	2.6	5.5	6.0	9.0	3.8
-Non-industrial repairs	0.3	0.8	0.2	0.7	1.0	0.6
-Transport of social spheres	0.7	1.0	0.9	1.4	1.5	0.8
-Credit financing, insurance and other spheres	20.2	9.1	5.8	4.2	5.1	2.8
-Other non-industrial branches	1.9	4.2	1.8	5.3	6.5	20.7
TOTAL	100	100	100	100	100	100

(%, percent)

Table 1-5. Industry center groups in the Russian portion of Lake Xingkai/Khanka drainage basin

Industrial center	Size of industrial center (number of people)					
	Large		Medium		Small	
	>10,000	10,000-5,000	5,000-1,000	1,000-500	500-100	<100
Spassk-Dalny	+					
Lesozavodsk		+				
Dalnerechensk			+			
Lipovtsy			+			
Luchegorsk			+			
Novoshakhtinsk			+			
Sibirtsevo			+			
Yaroslavsky			+			
Kirovsky				+		
Mikhailovka				+		
Chernigovka				+		
Kamen-Rybolov					+	
Pogranichny					+	
Rettikhovka					+	
Khorol					+	
Yakovlevka						+

(1992 data)

There are 5 known limestone stocks for cement manufacturing activities, as well as 4 uncalculated deposits. Two deposits are developed by "Spassk Cement" Combine. The calculated stocks of Dlinnogorskoe deposits will allow maximum production of Novospassk Cement Factory to the year 2030. Cement raw materials ensure 48% of the production of this valuable building material for the entire Russian Far East region. Local coalfields provide 35% of the total coal output in Primorsky Kray. It is estimated that existing industrial coalfield reserves will last for 96 years, based on the current usage.

The most developed industries are the manufacturing of building materials, such as cement, armored concrete, crushed stone and sanitary engineering (Spassk-Dalny, Yaroslasky, Sibirtsevo), coal-mining in quarries (Lipovtsy, Novoshakhtinsky) and metal work repair (Sibirtsevo, Spassk-Dalny, etc.).

1.2.7 Population Centers

The population of the Lake Xingkai/Khanka drainage basin is approximately 345,500 people (Table 1-6). The population is primarily rural, with about 68.7% of the total population living in rural areas. There is only one city in the drainage basin (Spassk-Dalnii in Russia), with a population of approximately 59,000 people.

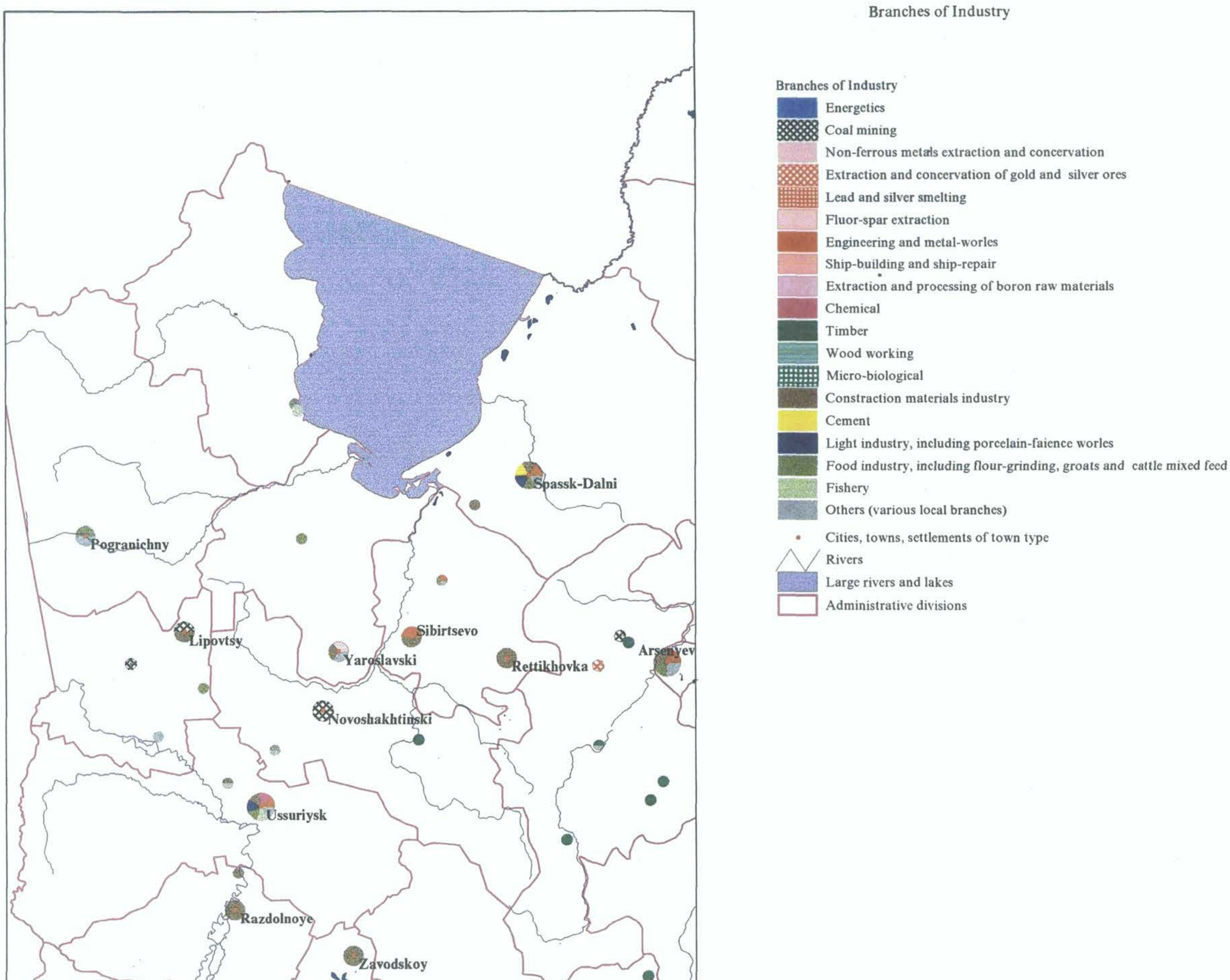


Fig. 1-14 Industrial development in the Russian portion of the Lake Xingkai/Khanka drainage basin

Table 1-6. Population distribution in the Lake Xingkai/Khanka drainage basin

Districts and largest settlements		Total population (thousand people)	Urban population (thousand people)	Rural population (thousand people)
Russian portion of drainage basin	Mikhailovsky District	42.4	10.1	32.3
	Novoshakhtinsky town	10.1	10.1	-
	Pogranichny District	24.8	11.6	13.2
	Pogranichny town	11.6	11.6	-
	Spassky District	89.6	58.7	30.9
	Dalnii City	58.7	58.7	-
	Khnankaisky District	27.8	-	27.8
	Khorolsky District	40.7	11.8	28.9
	Yaroslavsky town	11.8	11.8	-
	Chemigovsky District	46.9	15.4	31.5
	Rettikhovka town	3.7	3.7	-
Total of Russian portion		272.0	107.7	164.6
Chinese portion of drainage basin	Village Sansoutong	10.624	0.624	10.0
	Zhiyi Town	9.156	0.156	0.9
	Village Liumao	11.26	-	11.26
	Village Baipaozi	17.124	-	17.124
	Village Xingkaihu	10.99	-	10.99
	Village Chenzhihe	7.616	-	7.616
	Dangbizhen Town	0.3	-	0.3
	Farm No. 8510	2.45	-	2.45
	Farm No. Xingkaihu	15.0	-	15.0
Total of Chinese portion		73.5	0.78	72.72
Total drainage basin		345.5	108.08	237.32

The population in the Russian portion of the Lake Xingkai/Khanka drainage basin is relatively small, being approximately 272,000 residents, with 61% living in rural areas. The Russian population dynamics are illustrated in Table 1-7. As previously noted, because of its suitable soils and climate and the existing transportation network, the Russian portion of the drainage basin is the most developed territory (primarily agriculture) in Primorsky Kray.

Table 1-7. Population dynamics in settlements and districts of Russian portion of Lake Xingkai/Khanka drainage basin (expressed in thousands of people)

District	1959	1970	1979	1985	1990	1995	1998
-Spassky + Spassk Dalny	73.4	78.2	83.9	88.7	92.8	94.0	89.6
-Spassk	39.6	45.2	53.2	57.4	60.1	60.4	58.7
-Mikhailovsky	32.6	33.0	37.6	40.2	44.1	43.8	42.4
-Pogranichny	23.4	23.7	23.5	25.1	26.6	27.0	24.8
-Khankaisky	23.6	28.8	29.5	28.6	31.1	29.8	27.8
-Khorolsky	34.2	36.6	37.1	38.5	43.5	43.0	40.7
including urban area	6.2	7.1	9.3	10.3	11.7	12.3	11.8
-Chernigovsky	36.7	41.3	41.9	45.0	45.8	46.5	46.9
including urban area	9.0	12.8	12.9	14.6	15.4	15.5	15.4

The average population density in the Russian portion is about 15.3 persons/km^2 (Table 1-8), although it is not uniform throughout this region. The highest population density (25.4 persons/km^2) is in the Chernigovsky District, and the smallest density (6.6 persons/km^2) in Pogranichny. A reduction in the Russian population density has been noted since the 1980s, however, which is attributed both to a decreased birthrate and migration of people to other areas.

Table 1-8. Current population density in Russian Districts of Lake Xingkai/Khanka drainage basin

District	Area (km^2)	Population (thousand people)	Population density (persons/km^2)
Mikhailovsky	2,741	42.4	15.5
Pogranichny	3,750	24.8	6.6
Spassky	4,790	89.6	18.7
Khankaisky	2,756	27.8	10.1
Khorolsky	1,969	40.7	20.7
Chernigovsky	1,843	46.9	25.4
Total	17,849	272.2	15.3

(km^2, square kilometer)

The population in the Chinese portion of the Lake Xingkai/Khanka drainage basin is greater than in the Russian portion, with about 130,000 people living near the lake. The waterbodies in the Chinese portion include the Muling River, east dyke of Wuxing Canal, Song'acha River, Benin River and the lake itself. There also are 2 towns and 6 villages under the jurisdiction of Mishan City. Including the full catchment area of the Muling River, the Chinese population totals about 1.9 million people, with about 54% living in urban areas and 46% living in rural areas. There are approximately 420,000 residents in Mishan City, comprising a population density of 55 people/km^2.

The population distribution in the Chinese portion of the drainage basin is illustrated in Table 1-9. Most people in the region are engaged in agricultural activities, while the urban population is primarily engaged in business, manufacturing and agricultural management activities.

Table 1-9. Population distribution in Chinese portion of Lake Xingkai/Khanka drainage basin

City or settlement	Population (thousand persons)
Ziyi Town	9.2
Liumao Village	11.3
Yangmu Village	19.2
Xingkaaihu Village	11.0
Chenzihe Village	7.6
Baopozi Village	17.1
Shansuo Village	10.6
Dangbizi Town	0.3
Xingkaihu Farm	13.1
№ 857 Farm	14.3
№ 8510 Farm	2.5

1.2.8 Forests

The forest area of the Lake Xingkai/Khanka drainage basin comprises 1.73 million ha. This is approximately 33.6% of the total drainage basin area. The proportion of forested areas in the drainage basin, listed by dominant species, is given in Table 1-10.

Table 1-10. Distribution of dominant species in the forested areas of Lake Xingkai/Khanka drainage basin (expressed in km^2)

District	Forest types		Total
Russia portion of drainage basin	Coniferous species	Deciduous species	526.2
	108.1	418.1	
Chinese portion of drainage basin	Natural	Non-natural	132.2
	123.6	8.6	
Total drainage basin			658.4

CHAPTER 2
FRESHWATER RESOURCES AND DEMANDS IN LAKE XINGKAI/KHANKA DRAINAGE BASIN

This chapter focuses on the freshwater resources of the Lake Xingkai/Khanka drainage basin. In addition to discussing the water balance in the drainage basin (i.e., water supply versus water demands), this chapter highlights major water pollution problems and sources in the drainage basin, as well as their impacts on the water quality of the lake and its inflowing rivers. The economic consequences resulting from the present and anticipated water pollution problems are also highlighted.

2.1 Precipitation and Runoff

The hydrometerology of the Lake Xingkai/Khanka drainage basin has several distinguishing hydrologic characteristics. It receives less precipitation than surrounding areas, the natural drainage network is not extensive, it is very arid at some times and experiences significant flooding events at other times, and the local water runoff is polluted with anthropogenic contaminants.

The annual atmospheric precipitation onto the surface of Lake Xingkai/Khanka varies between 412-768 mm, averaging 567 mm. The precipitation volume decreases from the southeast to the northwest. The summer is the period of greatest precipitation, typically comprising up to 50-60% of the total annual precipitation. As previously noted, this results in waterlogging conditions during the subsequent autumn season.

Lake Xingkai/Khanka has 23 tributary inputs, with 8 coming from China and 15 coming from Russia. It has only one outflow river (Song'acha River), which ultimately connects the lake to the Wusuli/Ussuri River. Table 2-1 provides an overview of the characteristics and annual runoff of the rivers in the Lake Xingkai/Khanka drainage basin, with a total annual runoff volume of approximately 4.1 billion m^3.

A major hydrologic feature is the non-uniform nature of the annual runoff in the drainage basin, related primarily to the regional precipitation patterns. The period of winter–beginning of spring experiences the least water runoff. In contrast, riverine-driven floods can occur during the warm period of the year. The summer-autumn flood period, for example, extends from approximately June 15-October 10, and can exhibit between 3-15 floods in a given year, with relatively frequent and long floods.

Disastrous floods related to tropical typhoons can occur an average of twice per year during the summer autumn period, particularly in the Primorsky Kray territory. During this period, the precipitation can average 200-300 mm, flooding hundreds of thousand square kilometers, and causing significant economic damage (Table 2-2).

Table 2-1. Characteristics and annual runoff of rivers in the Lake Xingkai/Khanka drainage basin

River		Runoff area (km^2)	Length (km)	Average flow (m^3/s)	Runoff module ($1/sec.km^2$)	Annual runoff volume (million m^3)
Russian portion of drainage basin	Spasovka	1,200	83	6.72	5.6	212
	Llistaya	4,030	220	21.2	5.25	784
	Chemigovka	322	67	2.06	6.40	
	Melgunovka	3,450	111	9.95	2.83	321
	Komissarovka	2,080	46	10.4	5.00	340
	Bolshiye sachi	237	-	0.78	3.29	27.1
	Small Rivers *	15,370	-	54.5		1,715.6
	Russian Total	11,319		51.1	4.51	3,399.7
Chinese portion of drainage basin	R. Bailing	60	21	0.15	-	6.88
	C. Hongyanha	85	24	0.12	-	3.84
	C. Baipaozi	85	15	0.07	-	3.63
	R. Jinyinku	95	26.2	0.12	-	7.60
	R. Chengzi	54	24.5	0.06	-	4.33
	C. Daxi			1.9	-	9.92
	R. Kanzi	72	22	0.15	-	4.73
	C. Dihe			20.8	-	655.95
	Chinese Total	444	-	-	-	696.88
Total for Drainage Basin		11,763				4,096.58

*Volume of runoff of small rivers, including the Chernigovka River.
(km^2; square kilometers; km, kilometers; m^3/s, cubic meters/second; $l/sec.km^2$, liters per second per square kilometer; m^3, cubic meters)

Table 2-2. Estimated damages in the Russian portion of the Lake Xingkai/Khanka drainage basin from large typhoons (millions of rubles; 1991 prices)

Cities and districts	Typhoon "Juddy" (1989)	Typhoon "Polly" (1991)	Typhoon "Robin" (1993)
Mikhailovsky	2.4	177.3	2,857.9
Pogranichny	0.9	-	-
Spassky and Spassk-Dalny	0.9	62	1,919.8
Khankaisky	1.4	12.1	-
Khorolsky	1.8	31.7	1,904
Chernigovsky	4.4	33	419.9

2.2 Morphometric Characteristics of Lake Xingkai/Khanka

The main morphometric characteristics of Lake Xingkai/Khanka and its drainage basin are summarized in Table 2-3. Anthropogenically-related changes in river runoff to the lake have resulted from the associated economic development, with water diversion for irrigation of agricultural lands being a major cause. In the Russian portion of the drainage basin, for example, reductions in river inputs, including the Melgunovka and Komissarovka Rivers, commenced in approximately 1975. The water withdrawals by the six Russian Districts are summarized in Table 2-4.

Table 2-3. Main morphometric characteristics of Lake Xingkai/Khanka water basin

Water plane (highest level without wind denivellation (390 cm) above zero of graph	501 km^2
Water plane (average long-term water level 290 cm)	4,070 km^2
Water plane (lowest water level (150 cm)	3,940 km^2
Volume of water (highest level)	22.6 km^3
Volume of water (average long-tern water level)	18.3 km^3
Volume of water (lowest water level)	12.7 km^3
Length of longitudinal (large) axes (average long-tern water level)	90 km
Average breadth of lake	45 km
Average depth (highest level) without a wind denivellation	4.51 m
Average depth (average long-tern water level)	4.50 m
Average depth (lowest water level)	3.22 m
Greatest lake depth (average long-tern water level)	6.50 m*
Ratio of the length of the lake to its average breadth	2.00
Length of a coastal line (average long-tern water level)	308 km
Basin area (without water plane)	16,890 km^2
Ratio of basin area to basin area not considering small basin	25.7%
Ratio of lake volume (average long-tern water level) to annual inflow of water	9.4
Ratio of lake volume (average long-tern water level) to annual water drainage	9.9

*Maximum depth, based on 1998 data = 10.6 m

(km^2, square kilometers; km^3, cubic kilometers; %, percent; km, kilometers; m, meters)

Table 2-4. River runoff and water withdrawals in the Russian portion of the Lake Xingkai/Khanka drainage basin

District	Annual runoff volume, (km^3; local/total)	Provision of water resources	
		(thousand m^3 /km^2)	(thousand m^3/ person)
Khankaisky	0.192/ 0.645	71.1/239	6.60/22.2
Spassky	0.619/ 1.212	151/ 296	7.36/14.4
Pogranichny	0.477/ 0.477	126/ 126	20.5/20.5
Khorolsky	0.165/ 0.708	82.5/354	4.60/19.7
Chernigovsky	0.200/ 0.529	111/ 294	4.1/13.0
Mikhailovsky	0.457/ 0.486	163/ 174	12.3/13.1

(km^3, cubic kilometers; km^2, square kilometers)

The Lake Xingkai/Khanka drainage basin currently receives a high anthropogenic pollutant load. In the Russian portion of the drainage basin, it receives approximately 100 times the allowable limit. In the Chinese portion of the drainage basin, industrial, agricultural, and domestic sewage from Muling, Jixi, Jidong and Mishan City are discharged into the Muling River, which is also the major Chinese pollution source to the lake. Approximately 0.6 billion m^3 of polluted wastewater enters the small basin of the lake via discharge of the Muling River through the Dihe Canal, subsequently entering the full lake through the flood-diversion sluice gate.

Significant groundwater resources underlay both the Chinese and Russian portions of the drainage basin, being particularly concentrated in the Prikhankaisky artesian basin (Table 2-5). This artesian basin flows in a northern direction, with a groundwater table between 0-30 meters below the land surface. The scheme of aquifers of the Khankaiskaya depression is illustrated in Fig. 2-1. Based on data of the Primorsky Board for Geological Survey, the groundwater in the Prikhankaiskaya depression is mainly of the hydrocarbonate-calcium type, with calcium being the predominant cation.

Table 2-5. Groundwater reserves in Prikhankaiskaya hydro-geological complex

Artesian basin	Reserves (thousand m^3/d)	Area (km^2)
Tury Rog	73	350
Sintuhe	57	220
Ussuriisky	64	150
Shmakovsky	21	225
Krasnorechensky	28	410
Santakhezsky	180	510
Spassky	90	850
Zharikovsky	226	1050
Grodekovsky	50	180
Vadimovsky	66	900
Vishnevsky	12	90
Merkushevsky)	6	50
Ilistaya River	59	75
Manzovsky	6	50
Lyalichinsky	77	450
Poiskovy	16	100
Osinovsky-Danilovsky	17	90
Ivanovsky	105	260
Prikhankaiskaya hydro-geological province	1153	

(m^3, cubic meters; d, day; km^2, square kilometers)

2.3 River Inputs and Overall Water Balance

2.3.1 River Inputs

As previously noted, the total water volume flowing into Lake Xingkai/Khanka from its drainage basin is approximately 4.1 billion m^3 (see Table 2-1). In the lower portion of its watercourse, the average water velocity is 0.5-1.0 m/s.

In the south, the Melgunovka River flows parallel to the Komissarovka River. It is formed by the confluence of the Sfudyonnaya and Nesterovka Rivers, and flows into Lake Xingkai/Khanka. The Melgunovka River is about 105 km long, with an average water velocity of 0.1-0.5 m/s.

The eastern confluent of Lake Xingkai/Khanka is the Spasovoka River, which is formed by the confluence of the Kuleshovka, Odarka and Slavyanka Rivers. Their sources are in the western slope of the Sinii Ridge. The length of the Spasovoka River, as measured by its main confluent (Kuleshovka) is 66 km, its basin area is 1,260 m^2, and its average water velocity is 0.3-0.5 m/s.

The annual inflow water volume of the rivers from the Chinese portion of the Lake Xingkai/Khanka drainage basin is approximately 0.7 billion m^3. The water of the Dihe Canal comes from the Muling River, and represents a major inflow to the lake.

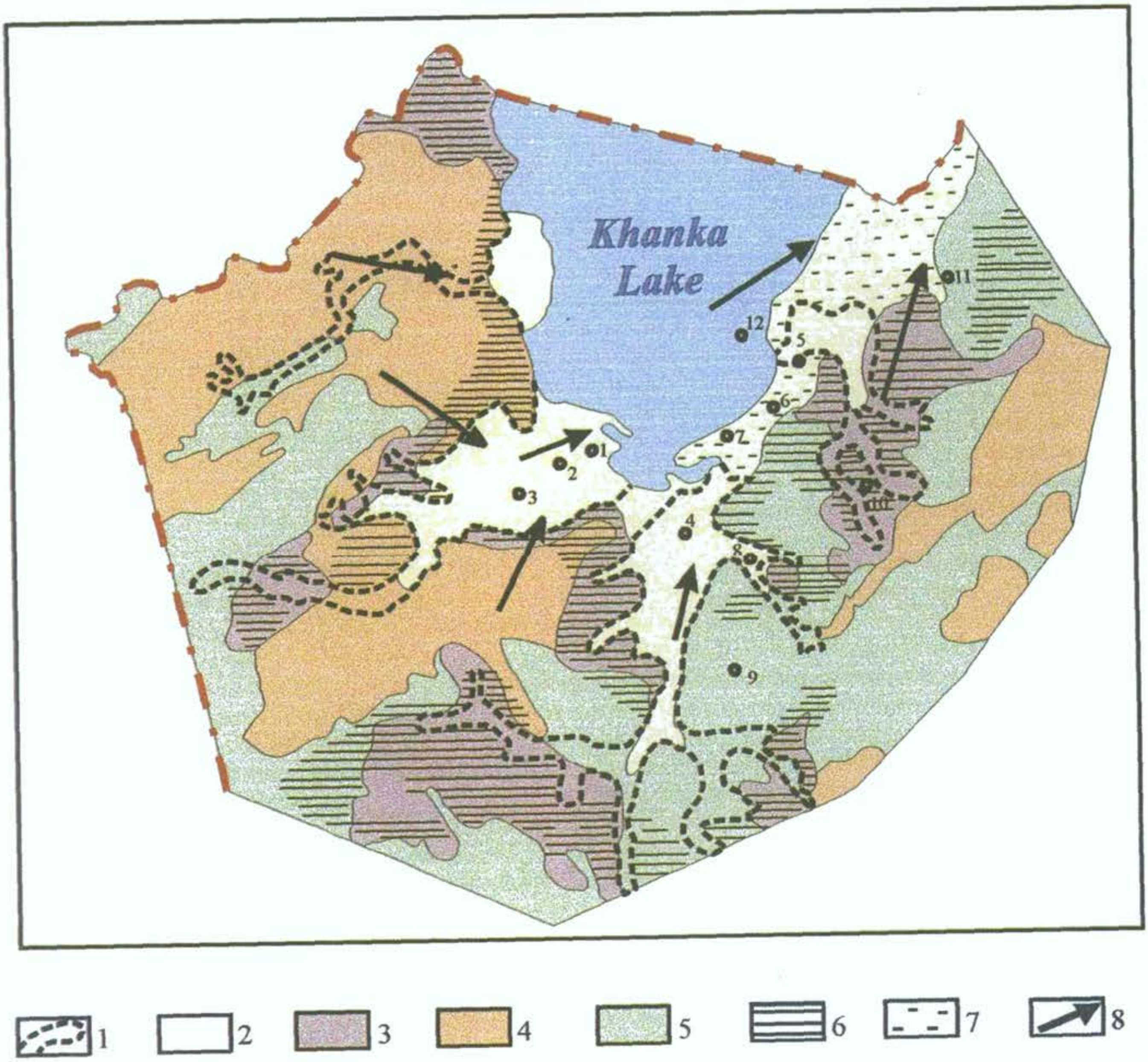


Fig. 2-1 Aquifer scheme of the Khankaiskaya depression

1 - aquifer of present deposits

2 - aquifer of middle-low-quaternary deposits (Q_{1-11}),

3 - aquifer of neogenic deposits (N),

4 - waters of fissure zone of intrusive rocks,

5 - waters of fissure zone of sediments and effusive-sediment rocks (D-P-PR-PZ),

6 - regional waters overlaying impermeable sediments,

7 - aquifer of lake sediments,

8 - main directions of groundwater movements.

2.3.2 Water Balance

The hydrological regime of Lake Xingkai/Khanka is based on the atmospheric precipitation onto the lake surface, surface inflows, evaporation minus condensation, surface outflow through the Song'acha River, and underground inflows into and from the lake. The groundwater regime, including water inflows and outflows from the lake, has not yet been investigated. The data on the surface water inflows to the lake are summarized in Table 2-6.

Table 2-6. Annual water inflow into Lake Xingkai/Khanka

River		Watershed area (km^2)	Length (km)	Annual water inflow (m^3)
Russian portion of drainage basin	Spasovka	1260		212×10^6
	Llistaya	5470	220	784×10^6
	Melgunovka	3510	105	321×10^6
	Coastal interflave	1666	145	
	Komissarovka	2310		34.0×10^6
	Bolshiye Usachi	304		27.1×10^6
	Small Rivers *	15370		1715×10^6
	Russia side			3399.7×10^6
Chinese portion of drainage basin	R. Bailing	86		6.88×10^6
	C. Hongyanha	85		3.84×10^6
	C. Baipaozi	52		6.63×10^6
	R. Jinyinku	95		7.6×10^6
	R, Chengzi	54		4.33×10^6
	C. Daxi	72		4.73×10^6
	R. Kanzi			9.92×10^6
	C. Dihe			655.95×10^6
	China side			696.88×10^6
	Total			4096.58×10^6

*Including the Chernigovka River
(km^2, square kilometers; km, kilometer; m^3, cubic meters).

As previously noted, the annual atmospheric precipitation onto the lake surface varies between 412-768 mm, averaging 567 mm. The annual water evaporation from the lake surface (584 mm) is comparable to atmospheric precipitation. Thus, Lake Xingkai/Khanka is an evaporation-neutral reservoir, and essentially exchanges its water volume about every 10 years.

Although the surface water outflow from the lake through the Song'acha River has not been studied as extensively, it is estimated to be between 35.4-64.7 m^3/s.

2.4 Water Quality of Lake Xingkai/Khanka and its River Inputs

Based on its background hydrochemical composition, the waters of Lake Xingkai/Khanka and its inflowing rivers from Russia are characterized by small temporary amplitudes of quantity fluctuations of dissolved salts, and by the absence of an obvious relation between debits (levels) and mineralization (Table 2-7).

Table 2-7 Average monthly concentration of dissolved substances in Lake Xingkai/Khanka

Month	HCO_3^-	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	Mineral-ization
Jan.	82.1/107.0	15.1/5.0	2.6/13.5	17.9/24.4	7.3/6.4	5.7/10.3	29.4/16.0	158.7/183.0
Feb.	115.9/111.0	22.0/5.1	6.0/14.0	24.2/25.1	7.7/6.9	13.1/11.3	15.4/16.4	204.3/190.0
Mar.	65.9/57.6	12.2/2.7	4.2/7.8	13.5/13.3	5.2/3.7	8.5/4.3	11.8/9.1	121.3/100.4
Apr.	53.7/31.1	8.8/1.8	2.8/3.5	11.0/7.8	6.8/1.7	4.6/3.9	12.0/3.5	99.7/53.3
May	59.5/68.9	13.2/4.0	2.0/8.0	12.0/15.8	3.9/4.6	6.8/8.9	10.3/10.0	107.2/120.0
Jun.	62.4/64.0	5.4/3.8	2.6/6.9	12.9/14.0	4.1/4.0	6.4/7.4	13.5/11.3	107.3/111.5
Jul.	65.2/68.9	11.1/3.1	2.9/9.5	13.0/15.8	4.3/3.6	6.9/7.4	12.7/6.8	114.3/115.0
Aug.	60.0/73.4	10.4/3.2	2.5/8.8	9.9/15.3	4.3/4.0	4.6/7.6	8.2/6.9	93.9/120.0
Oct.	64.2/70.2	12.0/3.7	2.6/9.8	13.0/15.4	4.1/4.6	5.6/6.7	22.1/10.0	123.6/120.6

(HCO_3^-, bicarbonate; Na^+, sodium; K^+, potassium; Ca^{2+}, calcium; Mg^{2+}, magnesium; Cl^-, chloride; SO_4^{2-}, sulfate).

The waters of the lake and its rivers are of the carbonate-calcium type. The pH of the lake water varies within a small interval, being 7.4-7.6 in the summer, and decreasing slightly to 7.0-7.2 in the winter.

A significant feature of Lake Xingkai//Khanka is its turbidity, which results from a considerable content of suspended substances from the end of March to the end of October. When the water begins freezing, the content of suspended substances typically decreases to 5-11 mg/L.

The average annual concentrations of suspended substances in the lake water varied between 24.7-225.6 mg/L during the observation period in 1992-1998. Maximum concentrations can exceed 300 mg/L in the summer, although the content of suspended substances does not exceed 5-7 mg/L before the ice begins breaking up.

2.4.1 Lake Water Quality

Table 2-8 summarizes the average annual concentrations of dissolved oxygen (DO), chemical oxygen demand (COD) and biochemical oxygen demand (BOD_5). The data indicate that only the COD value seriously exceeds the accepted standard, and that the DO and BOD_5 values are relatively low, and only the COD values seriously exceed the accepted standard. Although the upward tendency for COD concentrations is a cause for concern, the overall water quality is generally suitable for agricultural irrigation, tourism and fishing.

Table 2-8 Water quality of Lake Xingkai/Khanka (1992-1998)
(expressed in mg/L, unless other noted)

Location		Year	pH	Water trans-parency (cm)	Total hardness (German degree)	SS	DO	BOD_5	TP	COD	Phenol
Russia portion of drainage basin		1992	7.60	7	-	53.3	12.1	2.83	0.039	31.5	0.005
		1993	7.30	9	-	40.9	12.3	3.09	0.009	23.1	0.005
		1994	7.25	15	-	36.0	13.1	2.03	0.013	24.3	0.005
		1995	7.10	13	-	27.5	13.0	1.93	0.009	22.1	0.004
		1996	7.20	11	-	24.7	12.8	1.48	0.022	14.5	0.005
		1997	7.60	15	-	46.2	12.1	2.24	0.021	21.3	0.002
China portion of drain-age basin	large lake basin	1993	7.23	-	3.78	112.4	9.73	1.52	0.042	4.04	0.001
		1994	7.08		3.79	163.4	11.15	1.72	0.049	4.81	0.001
		1995	7.37	-	3.64	146.4	11.13	1.59	0.045	6.43	0.001
		1996	7.46		3.45	225.6	10.56	2.40	0.040	6.19	0.001
		1997	7.62		4.05	83.6	8.20	1.92	0.026	3.47	0.001
		1998	7.00		3.81	63.8	10.83	2.91	0.013	6.18	0.001
	small lake basin	1993	7.20		4.16	55.43	11.11	2.62	0.004	5.68	0.001
		1994	7.10		3.69	183.0	10.40	1.76	0.054	7.07	0.001
		1995	7.39		3.59	140.1	10.40	2.11	0.071	7.25	0.001
		1996	7.38		3.57	212.1	10.81	2.46	0.036	6.49	0.001
		1997	7.39		3.95	94.06	8.62	3.10	0.027	5.58	0.001
		1998	7.53		3.65	56.67	10.69	3.20	0.013	6.85	0.001

(mg/L, milligrams/liter; cm, centimeter; SS, suspended solids; DO, dissolved oxygen; BOD_5, biochemical oxygen demand; TP, total phosphorus; COD, chemical oxygen demand [COD_{Mn} for Russian data; COD_{Cr} for Chinese data])

In the Russian portion of the Lake Xingkai/Khanka drainage basin, copper is the heavy metal of most concern. The maximum allowable concentration (MAC) for copper in the Russian portion of the drainage basin, based on fishery concerns is 1 mg/L. However, the maximum copper concentrations sometimes exceed 30 times the MAC, with an extremely high level (100 MAC) noted in Lake Xingkai/Khanka near the Kamen-Rybolov Settlement. Increased contents of copper also were noted in the southern part of the lake in September 1991, although the source is unknown.

Overall, the contents of dissolved copper in Lake Xingkai/Khanka and the rivers of its drainage basin are close to the regional magnitudes. The same characteristic generally applies to other heavy metals in the drainage basin waters. The distribution of various heavy metals in the Russian waters of Lake Xingkai/Khanka and its tributaries is summarized in Figs. 2-2 and 2-3.

An intensive assimilation of rice cultivation zone in the immediate proximity of the lake was begun in the 1960s-1970s in the Russian portion of the drainage basin. Pesticides subsequently became the major pollutant in the basin, with this problem first becoming significant in Primorsky Kray.

By the middle of the 1980s, rice irrigation systems surrounded the lake for about 160 km. Because of the large volumes of irrigation water subsequently draining back into the lake, agrochemicals and fertilizer compounds have become a major environmental threat to the lake ecosystem.

The high anthropogenic load also coincided with a phase of a natural decrease in the lake water level from the late-1980s to the early-1990s, resulting in high pollutant concentrations in the lake water. Fig. 2-4 provides an overview, for example, of the distribution of organochlorine pesticides in the lake waters for the period 1985-1997.

The maximum concentrations of agrochemicals appeared to occur between 1987-1989. The decrease in pesticides in the lake waters in the 1990s is a consequence of a reduction in their application volumes, a reduction in the sowing areas devoted to rice, and a natural rise in the lake water level.

During 1985-1992, the overall quality of Lake Xingkai/Khanka waters, based on hydrochemical parameters, was evaluated as being "very dirty", "dirty" or "polluted". By 1996-1997, the quality of the lake waters became "temperately polluted" at the Astrakhanka and Sivakovka observation stations in Russia, and "clean" at the Troitskoe and Novoselskoe settlements (Russia).

The distribution of polluted substances in the lake is non-uniform. The increase in petroleum products content is most significant at the northern part of the aquatory (Fig. 2-5), while pesticides and phenols are most noticeable at the southern end (Fig. 2-6). The area of maximum pollution by biogenic substances is at the mouth of the Spasovka River. Fig. 2-7 highlights the content of organochloride pesticides in the Russian portion of the Lake Xingkai/Khanka drainage basin.

The saprobility index is a criterion for evaluating water quality on the basis of hydrobiological parameters. Using this index, the lake water in all the inspected areas is classified as being in the "temperately polluted" class.

Based on evaluation of various environmental components, the overall pollution state of Lake Xingkai/Khanka does not exceed the "weak" status. At the same time, however, specific regions of the lake basin exhibit elevated levels of pollution.

2.4.2 Inflow River Water Quality

Analysis of water quality of the inflow rivers to Lake Xingkai/Khanka is based on monitoring efforts. The water quality of the Bailing River, Baipaozi River, Jinyingku River and Chengi Rivers in China is summarized in Table 2-9. The data indicates that the water quality of these four rivers meets national demands of fishery water quality without exceeding any Chinese standards. The monitoring results for the four rivers indicate a Grade III (GB3838-88) standard of surface water. The exceptions are that the chemical oxygen demand (COD_{Mn}) of the Jinyingku River and Chengzi River exceed the Grade III surface water standard of 6.0 mg/L, suggesting that these rivers suffer from organic pollution.

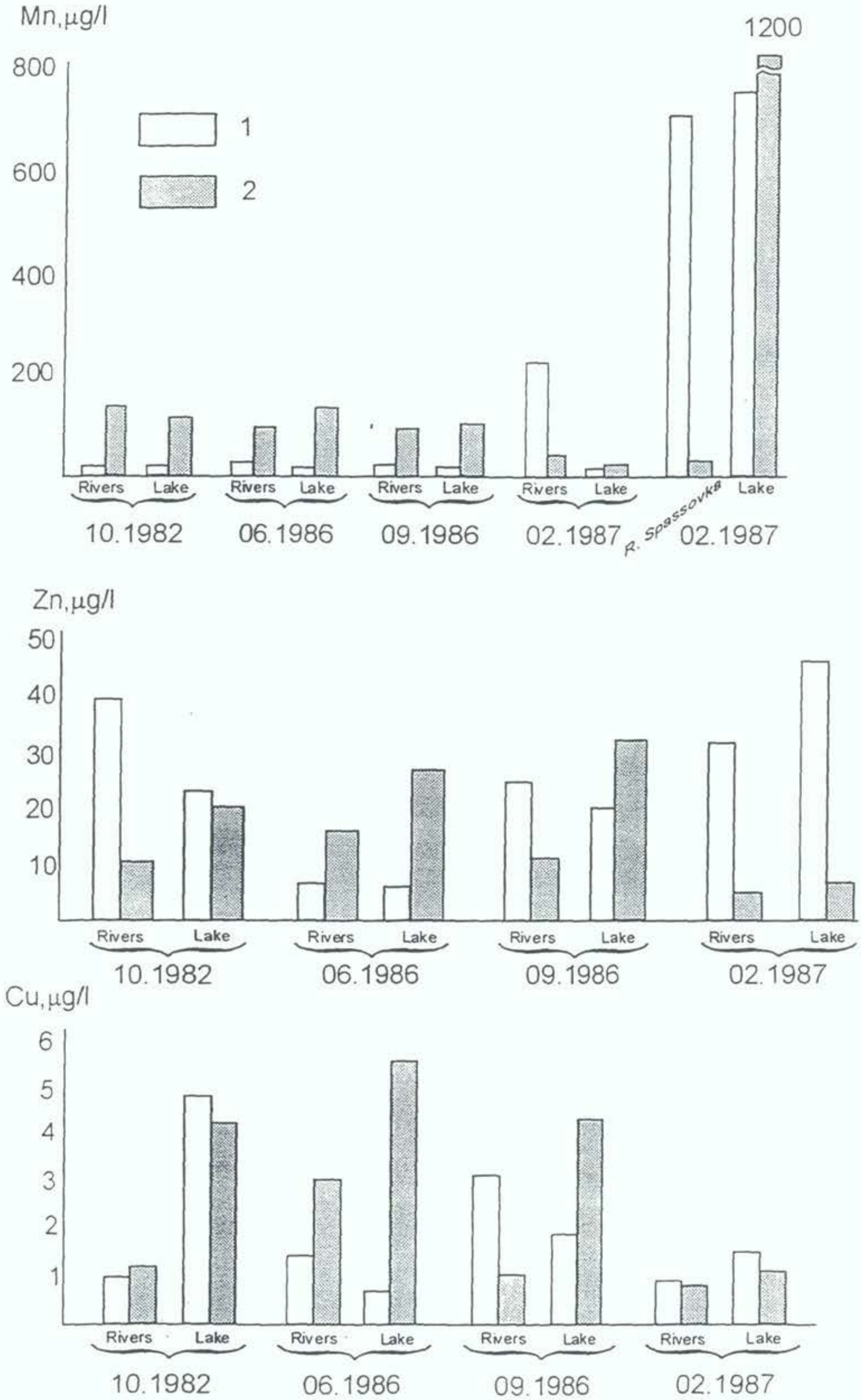


Fig. 2-2 Dissolved (1) and suspended (2) Manganese, Zinc and Copper Concentrations in the Russian portion of the Lake Xingkai/Khanka Drainage basin and its tributaries

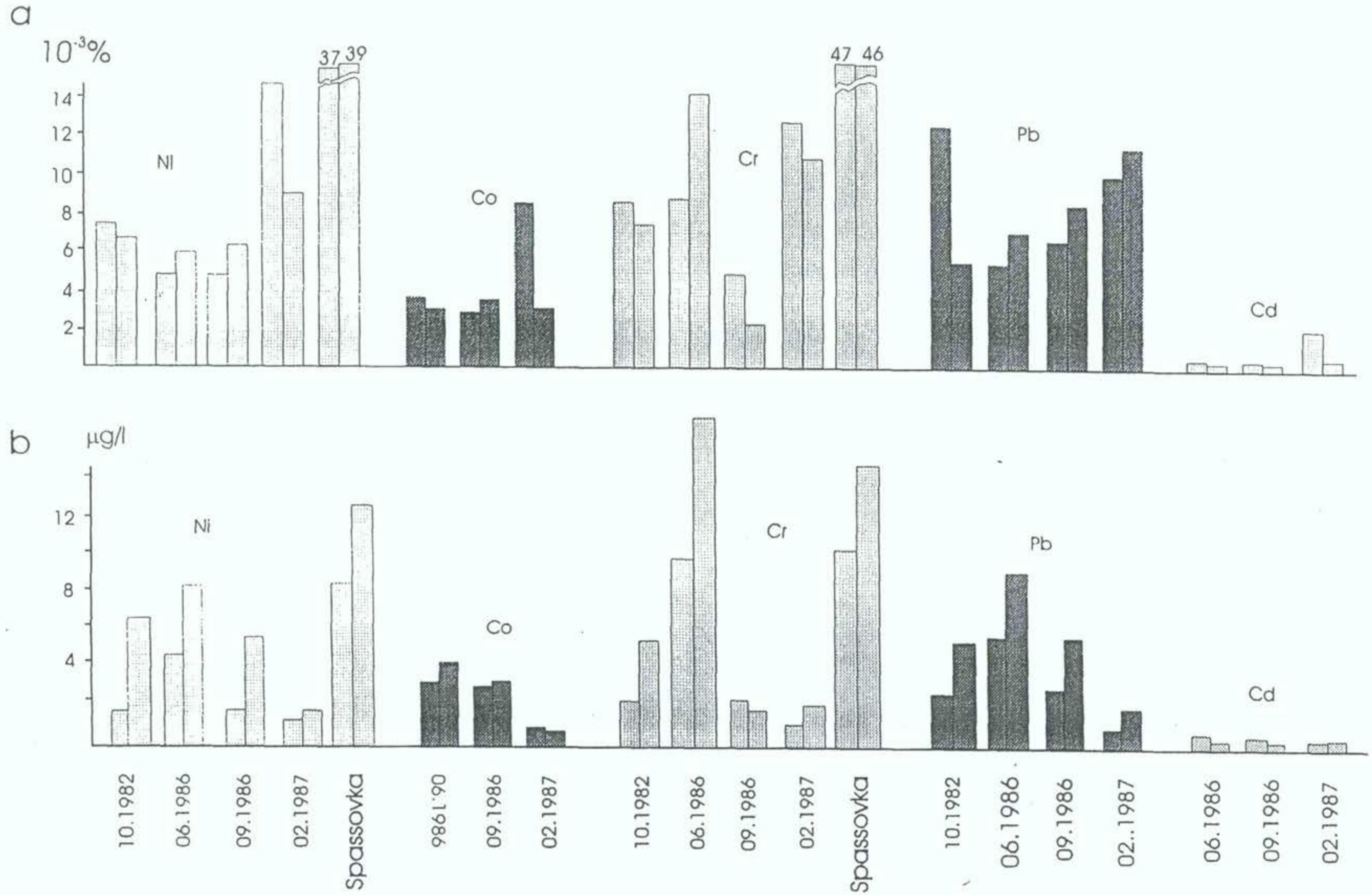
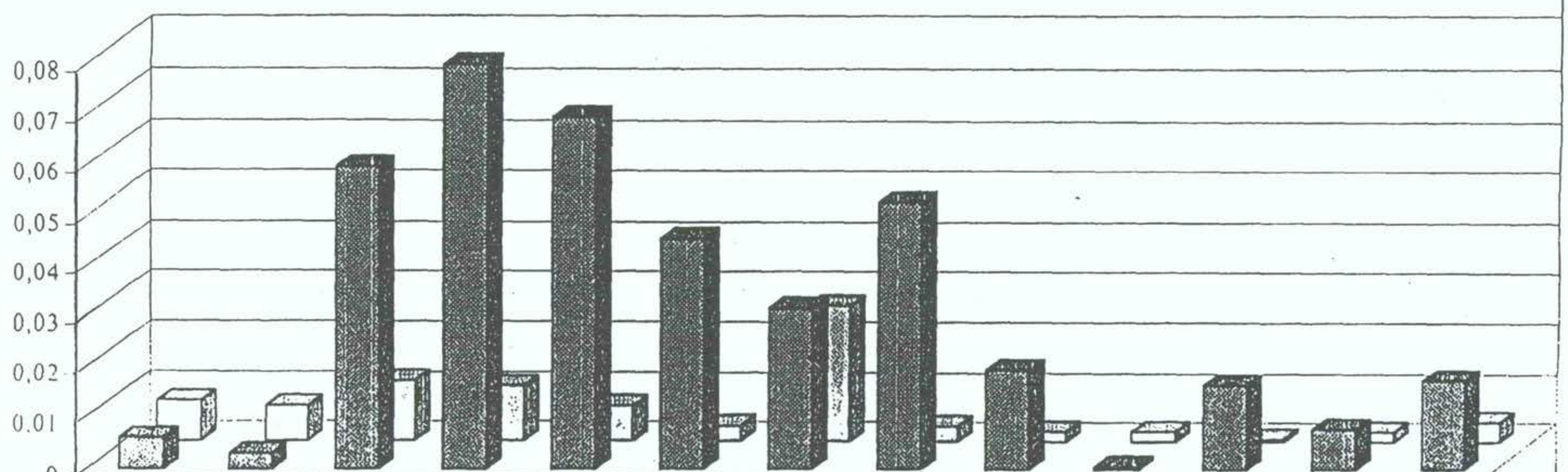


Fig. 2-3 Nickel, cobalt, chromium, lead and cadmium concentrations in the Russian portion of the Lake Xingkai/Khanka drainage basin and its Tributaries



	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
DDT	0,006	0,003	0,06	0,08	0,07	0,046	0,032	0,053	0,02	0,0005	0,017	0,008	0,018
GHCG	0,008	0,007	0,012	0,011	0,007	0,003	0,027	0,003	0,002	0,002	0,0005	0,002	0,004

Years

Fig. 2-4 DOT and GH CG concentration in the Russian portion of Lake Xingkai/Khanka

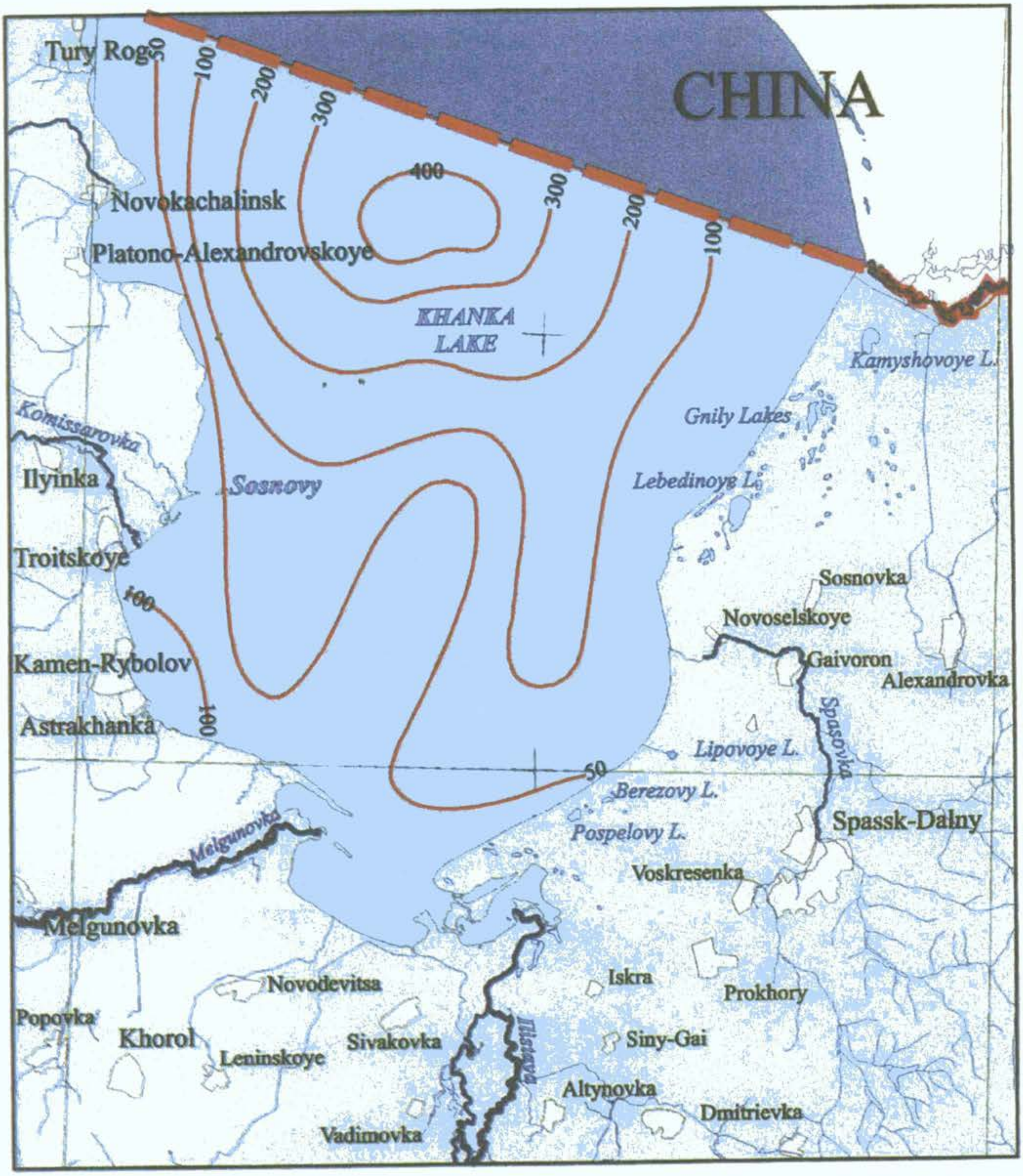


Fig. 2-5 Distribution of oil production in the Russian portion of Lake Xingkai/Khanka (expressed µg/L)

Fig. 2-6 Distribution of phenol in the Russian portion of the Lake Xingkai/Khanka (expressed µg/L)

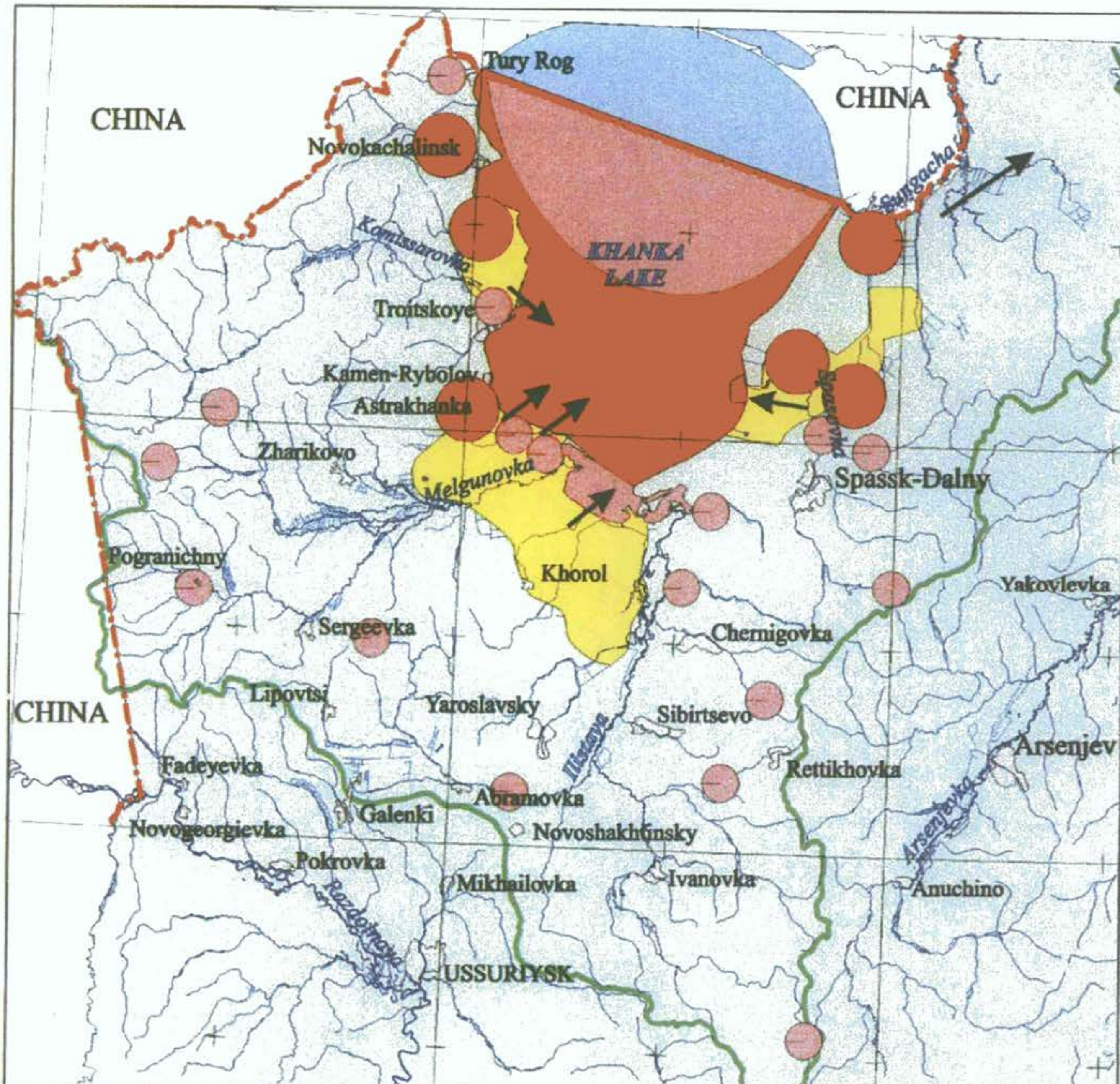


Fig. 2-7 Schematic of organo – chlorine distribution in the Russian portion of Lake Xingkai/Khanka drainage basin

Rice areas

Points of sampling and summary composition of chlorine-organic pesticides.

Less. Than 0,05 μg/L

0,5-1 μg/L

More than 1 μg/L

Main ways of pesticides entrance

Table 2-9 Water quality of Chinese inflow rivers to Lake Xingkai/Khanka
(expressed in mg/L, unless otherwise indicated)

Item / River	pH	Conductivity	DO	COD_{Mn}	BOD_5	SS	K	Na (μg/L)	Ca (μg/L)	Mg (μg/L)
Bailing	7.4	1006.06	6.70	5.12	5.12	44.00	8.19	6.37	12.40	4.50
Baipaozi	7.2	1371.89	7.15	3.60	3.60	189.50	5.06	8.37	18.30	5.26
Jinyingku	7.3	1257.57	6.85	10.30	10.30	190.00	1.64	1.00	1.40	0.02
Chengi	7.3	1167.08	6.98	8.60	8.60	40.00	2.60	9.92	15.80	4.82

Item / River	Hardness (Germany degree)	Mn	Fe	V	Co (μg/L)	Cu (μg/L)	Pb (μg/L)	Zn (μg/L)	Cd (μg/L)
Bailing	2.87	0.034	0.962	0.32	0.02	2.32	3.57	18.9	1.24
Baipaozi	4.54	1.009	6.582	0.30	0.047	14.43	13.21	11.9	1.42
Jinyingku	0.42	0.153	2.021	0.01	No	11.40	24.07	22.1	0.21
Chengi	3.46	0.073	1.298	0.36	0.042	14.95	10.04	13.4	0.23

(DO, dissolved oxygen; COD_{Mn}, chemical oxygen demand; BOD_5, biochemical oxygen demand; SS, suspended solids; K, potassium; Na, sodium; Ca, calcium; Mg, magnesium; Mn, manganese; Fe, iron; V, vanadium; Co, cobalt; Cu, copper; Pb, lead; Zn, zinc; Cd, cadmium; mg/L, milligram/liter; μg/L, microgram/liter).

The Muling River flows through the Hubei sluice gate, the Muxing flood-diversion course, wetlands of the east Dihe Canal, and moorland, ultimately flowing into the small basin of Lake Xingkai/Khanka. Self-purification and dilution functions of wetlands and moorlands may improve the quality of the river water in the wet season. However, the overall water quality of the river is thought to be identical to the water quality of the inflow waters to the small basin of Lake Xingkai/Khanka.

The monitoring results for the Muling River input are summarized in Table 2-10. The COD value (11.85 mg/L) exceeds Grade III of the surface water standards by approximately 80%. The maximum COD value is 11.85 mg/L, significantly exceeding the standard of 5.85 mg/L. The BOD_5 value exceeds the standard by approximately 9%. The maximum BOD_5 is 5.6 mg/L, also significantly exceeding the standard of 1.6 mg/L. These monitoring results suggest the Muling River is suffering from serious pollution from organic matter.

In the Russian portion of the drainage basin, the water mineralization of the Spasovka River ranges between 20.4-52.5 mg/L during the winter low-water period. During the vernal high water period, it ranges between 26.1-68 mg/L, and during the summer-autumn floods from 8.5-10.6 mg/L. Bicarbonate (HCO_3^-) is the predominant cation (26.1-68.4 mg/L), and calcium (Ca^{2+}) is the predominant anion (10.6-15.7 mg/L). The magnesium (Mg^{2+}) concentration ranges between 2.0-7.5 mg/L, the sodium (Na^+) and potassium (K^+) between 2.5-12.2 mg/L, the sulfate (SO_4^{2-}) between 3.1-9.5 mg/L, and the chloride (Cl^-) between 1.0-4.3 mg/L.

Table 2-10. Water quality of the Muling River (Yanggang section; expressed in mg/L, unless otherwise indicated)

Year	Month	Conduc-Tance	Hard-ness	SS	DO	COD	BOD	NO_3-N	NO_2-N	NH_4-N	pH
1993	Jan.	40.9	7.06	-	4.60	6.44	3.60	0.113	0.024	0.126	
	Feb.	41.5	7.18	-	5.00	3.21	1.60	0.179	0.021	0.368	
	May	226.1	-	-	11.4	8.38	3.6	0.179	0.021	0.368	
	June	-	-	-	7.40	4.94	2.3	0.191	0.021	0.406	7.92
	July	178.07	5.29	-	8.2	3.60	0.8	0.275	0.032	0.352	
	Sept.	225	9.42	52	8.0	8.07	0.6	0.272	0.030	0.303	7.60
	Oct.	178.1	8.08	290	10.6	9.13	3.35	0.251	-	0.285	7.14
1994	Jan.	44.9	5.39	-	6.80	2.82	1.00	0.247	0.016	0.232	6.74
	Sept.	40.9	5.38	187	9.00	8.22	1.98	0.186	0.037	0.313	6.90
1995	Jan.	44.90	5.38	148	7.00	8.78	-	0.158	0.037	0.231	6.0
	Feb.	45.49	5.83	150	7.40	6.58	2.20	0.179	0.041	1.531	6.83
	May	44.90	-	-	9.30	6.58	1.50	0.191	0.022	0.406	6.80
	July	43.55	5.39	194	7.20	9.72	1.80	0.116	-	0.380	-
	Aug.	49.45	5.38	210	7.0	8.78	1.90	0.111	-	0.375	7.0
	Sept.	49.44	5.39	181	9.20	6.58	2.2	0.121	-	0.386	6.20
	Oct.	41.90	5.06	200	8.70	5.17	2.3	0.131	0.051	0.398	7.16
1996	Jan.	57.12	3.40	74	6.30	7.63	2.15	0.008	0.016	0.179	6.90
	Feb.	57.12	3.42	82	6.40	7.56	2.10	0.010	0.015	0.175	6.92
	May	22.61	3.61	140	9.10	8.23	2.70	0.005	0.016	0.059	6.20
	June	30.46	4.65	144	6.60	7.60	2.20	0.013	0.016	0.092	6.12
	July	21.55	4.28	291	7.20	9.35	1.40	0.032	0.024	0.152	6.80
	Aug.	18.60	4.47	100	7.40	7.07	2.20	0.014	0.022	0.105	7.18
	Oct.	42.26	4.24	464	10.20	6.43	2.10	0.030	0.019	0.085	6.20
1998	Jan.	-	5.61	-	10	6.00	3.50	0.073	0.003	0.133	6.71
	Feb.	-	6.17	-	10.5	6.40	4.5	0.045	0.038	0.169	7.17
	June	-	3.89	65	8.20	5.93	4.0	0.054	0.044	0.068	5.60
	July	-	3.37	75	7.80	6.10	5.4	0.020	0.003	0.027	6.20

(mg/L, milligram/liter; SS, suspended solids; DO, dissolved oxygen; COD, chemical oxygen demand; BOD, biochemical oxygen demand; NO_3-N, nitrate-nitrogen; NO_2-N, nitrite-nitrogen; NH_4-N, ammonia-nitrogen)

In the Ilistaya River (Khalkidon Settlement), the water mineralization in the winter low-water period changed from 54.8 to 8.88 mg/L. During the spring high water period, it varied between 41.4-68.2 mg/L, and during the summer-autumn flood period it decreased up to 6.2-22.7 mg/L. Bicarbonate is the predominate cation, with concentration varying between 22.7-68 mg/L, while calcium is the predominate anion, with a concentration varying between 4.8-16.6 mg/L). Other major ions are magnesium (2.8-5.3 mg/L), sodium and potassium (5.9-9.2 mg/L), sulfate (4.8-10.3 mg/L) and chloride (2.7-4.5 mg/L).

For the Melgunovka River (Staro-Devitsa Settlement), the water mineralization in the winter low-water period varies between 42.1-63.8 mg/L, during the spring high water period it ranges between 34.3-54.6 mg/L, and during the summer-autumn flood period, it ranges between 10.5-38.8 mg/L. Bicarbonate is the predominate cation (24.4-63.4 mg/L), and calcium is the predominate anion (12-18.8 mg/L). The magnesium concentration varied between 1.5-4.7 mg/L, sodium and calcium between 8.2-13.5 mg/L, sulfate between 5.1-23.4 mg/L, and chloride between 0.7-5.1 mg/L.

Water mineralization in the Komissarovka River during the winter low-water period was 11.3-54 mg/L, in the spring high-water period it was 36.5-48.4 mg/L, and in the summer-autumn flood period it was 29.2-42.3 mg/L. The predominant cation is bicarbonate (29-54 mg/L), while calcium is the predominate anion (6.0-11.3 mg/L). The magnesium concentration varied between 1.5-6.8mg/L, sodium and potassium between 5.0-9.5 mg/L, sulfate between 2.1-4.6 mg/L, and chloride between 4.1-6.8 mg/L.

In regard to hardness, the Russian river waters are generally of the very soft class. The hardness is least in the spring high water and summer-autumn flood periods, varying between 0.30-0.55 mmol/L. The greatest hardness (1.2 mmol/L) occurred during the winter low-water period.

The greatest quantity of dissolved substances is carried by the Ilistaya River (531,700 tons/year), while the smaller quantity is carried by the Melgunovka River (210,410 tons/years). Figs 2-8 and 2-9 illustrate the inter-annual and 20-year (1960-1980) carryover of suspended substance by the llistaya River, which is the main supply to Lake Xingkai/Khanka.

The large quantity of organic substances in the Russian portion of the drainage basin is carried by the llistaya River (176,600 tons/year) and the smallest quantity by the Melgunovka River (75,700 tons/year). These values correspond well with the distribution of organic substances in Lake Xingkai/Khanka sediments (Fig. 2-10).

Of the Russian inflow rivers to Lake Xingkai/Khanka, the Spasovka River carries the largest quantity of nitrogen. The average annual concentrations of ammonium nitrogen in river water below Spassk-Dalny City during the observation period exceeded the MAC by 3-11 times, with the maximum concentrations being 10-15 times greater than the MAC. The average annual concentrations of nitrate-nitrogen in the river water varied between 0.12-0.46 mg/L, while the nitrite-nitrogen varied between 0.031-0.090 mg/L.

The DDT and HCCH group of pesticides are found in considerable quantities in cross-sections in rivers in the Lake Xingkai/Khanka drainage basin. The concentrations of organic substances, phenols, petroleum products and copper are typically elevated (compared to existing standards) in the Russian side of the drainage basin. Further, the carryover of heavy metals determines their distribution in the lake's bottom sediments (Fig. 2-11).

During 1990-1992, high concentrations of phenols were observed in the Spasovka, Melgunovka, Komissarovka and Sungachu Rivers. Petroleum products were observed in the lake and the rivers throughout the survey period, with the average annual concentration varying between 0.05-0.15 mg/L. The maximum concentrations (0.96-1.92 mg/L) were observed during the end of the 1980s-beginning of the 1990s.

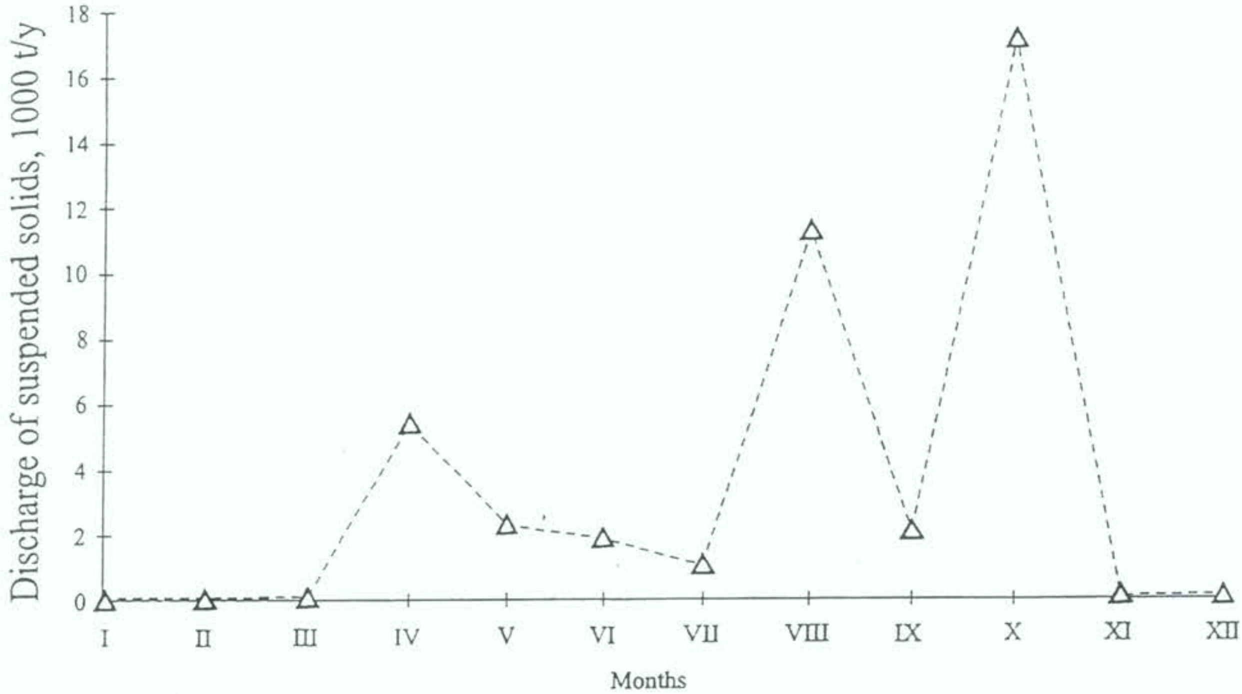


Fig. 2-8 Average (1060-1980) annual discharge of suspended sediments in Ilistaya River

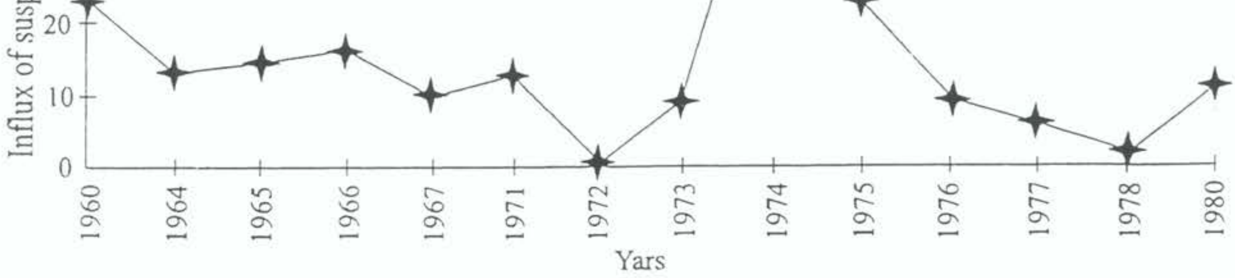


Fig. 2-9 Suspended solids load in Ilistaya River, 1960-1980

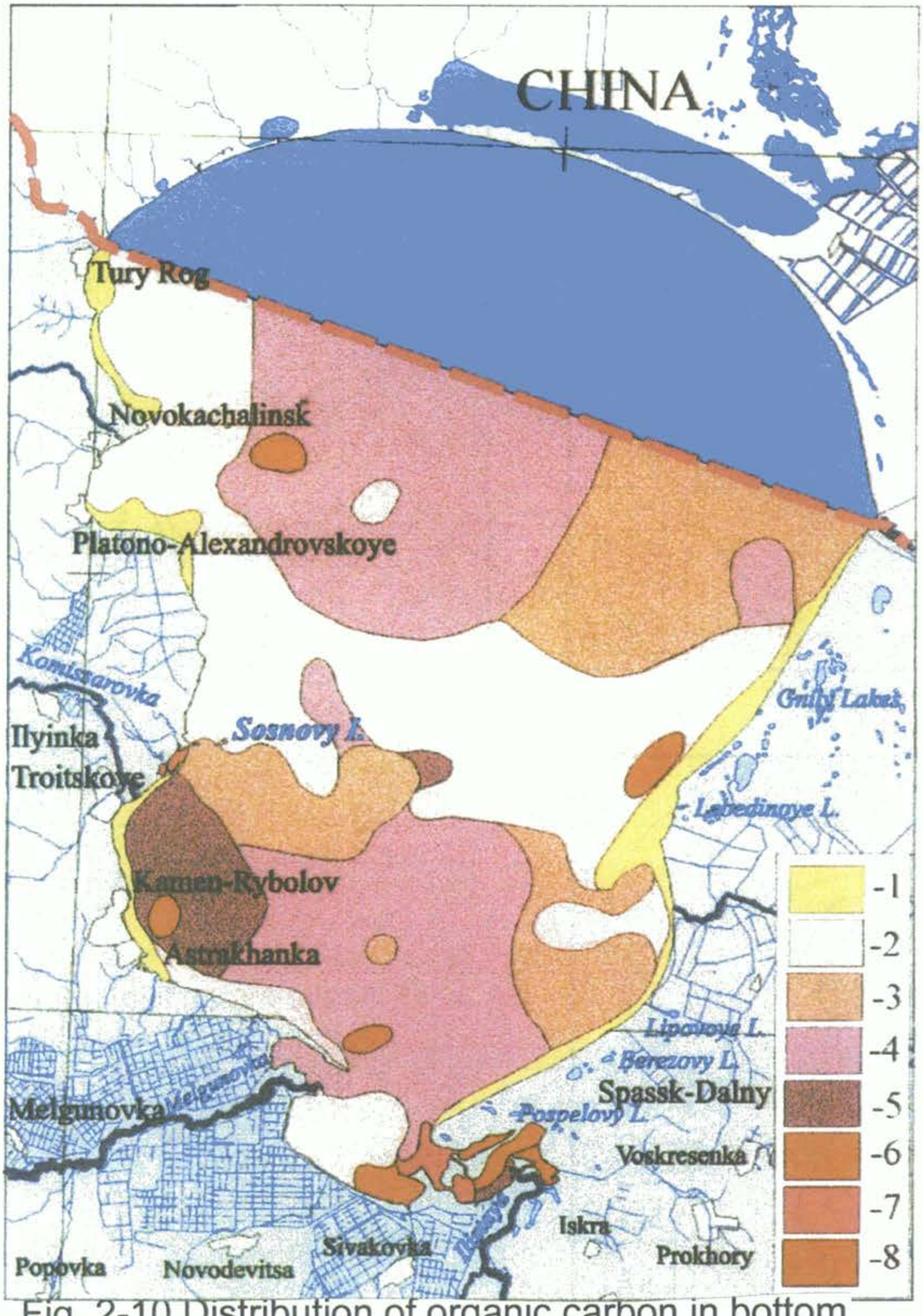
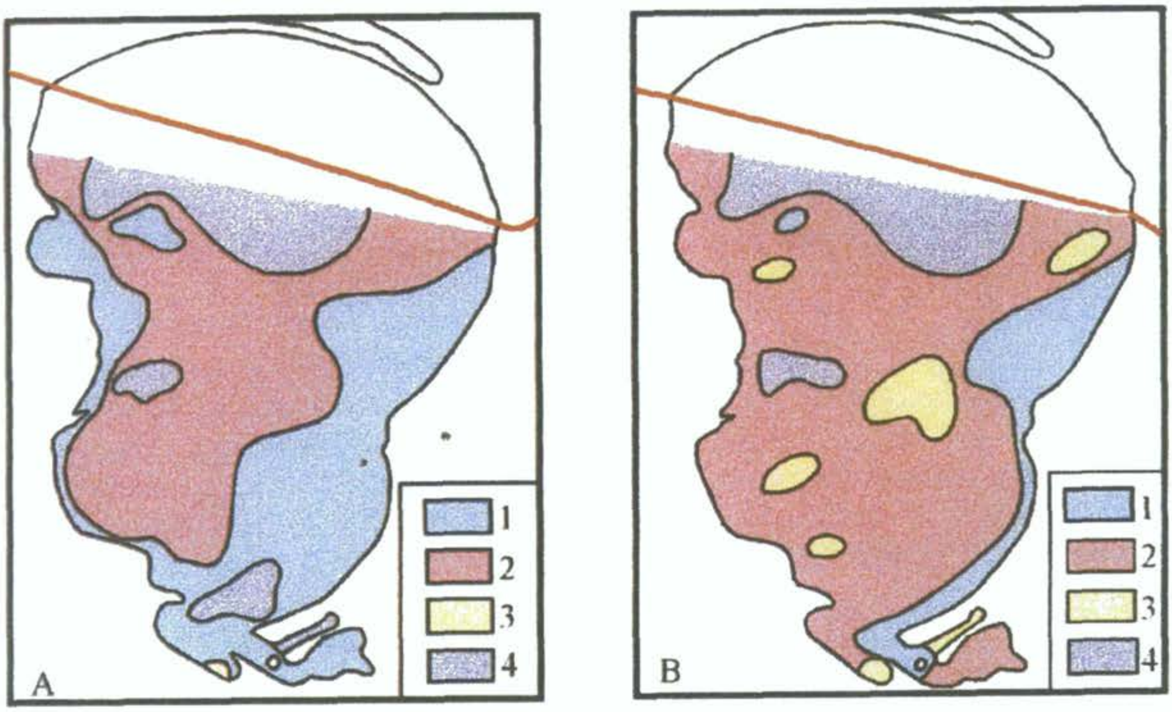


Fig. 2-10 Distribution of organic carbon in bottom sediments of Russian portion of Lake Xingkai/Khanka

Concentrations C:

1- <0,10; 2-0,10÷0,20; 3- 0,20÷0,30; 4-0,30÷0,40; 5- 0,40÷0,50; 6- 0,50÷0,75; 7- 0,75÷1,5; 8 -> 1,5



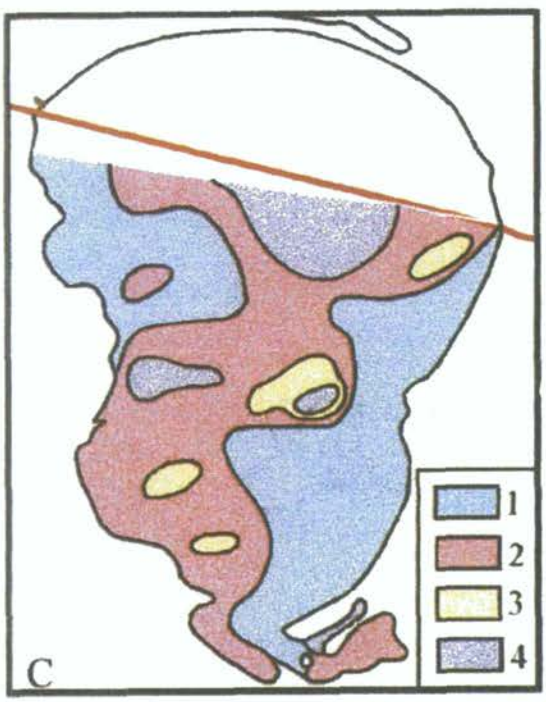


Fig. 2-11 Heavy metal distribution (copper, nickel and cobalt) in bottom sediments (g/t)

A - Cu: 1 - <5,0; 2 - 5,0-10; 3 - 10-20; 4 - 20.

B - Ni: 1 - 10; 2 - 10-50; 3 - 50-100; 4 - >100.

C - Co: 1 - <10; 2 - 10-20; 3 - 20-30; 4 - >30.

On the basis of hydrochemical parameters, the Melgunocka, Komissarovka, llistaya and Sungachu Rivers are considered "temperately polluted", while the Spasovka River (lower Spassk-Dalnii) has been designated as "dirty", "very dirty" or "extremely dirty" for a considerable period of time. The water in all the inspected aquatories of Lake Xingkai/Khanka is considered to be in the "temperately polluted" class.

Based on hydrobiological parameters (i.e., saprobility index), the Melgunovka and Llistaya Rivers are considered "temperately polluted", while the Spasovka River ecosystem below Spassk-Dalnii city is in a continuing degraded condition.

2.5 Trophic Status

Both the nutrient content of water and sediments, as well as the types and quantities of aquatic organisms present, provide an indication of the trophic state of a lake. To this end, it is typically agreed that a lake has a eutrophic status when the nitrogen concentration exceeds 0.2-0.3 mg/L, and the phosphorus concentration exceeds 0.01-0.02 mg/L.

The main form of nitrogen in Lake Xingkai/Khanka is ammonia (NH_3-N). The nitrate content (NO_3-N) is also elevated, although the nitrite content (NO_2-N) is relatively low. The average annual concentrations of ammonia, nitrate and phosphorus are given in Table 2-11.

Table 2-11. Average annual concentrations and ranges of nitrate (NO_3-N), ammonia (NH_4-N) and phosphorus in Lake Xingkai/Khanka (1985-1997)

Year	Concentration (mg/L)					
	NO_3-N		NH_4-N		Phosphorus	
	Range	Average	Range	Average	Range	Average
1985	0.04-0.39	0.15	0.05-1.01	0.23	0.000-0.038	0.012
1986	0.00-0.26	0.03	0.00-3.44	2.43	0.000-0.091	0.025
1987	0.00-0.26	0.03	0.00-4.44	2.43	0.000-0.091	0.025
1988	0.01-0.49	0.03	0.78-3.00	1.54	0.017-0.059	0.031
1989	0.00-0.65	0.06	0.12-4.92	1.28	0.000-0.190	0.049
1990	0.00-0.43	0.06	0.00-0.92	0.20	0.000-0.175	0.040
1991	0.00-0.60	0.07	0.00-3.82	1.34	0.000-0.154	0.015
1992	0.00-0.81	0.07	0.00-4.31	0.10	0.000-0.088	0.039
1993	0.01-0.40	0.04	0.00-0.98	0.14	0.000-0.052	0.009
1994	0.00-0.18	0.04	0.00-1.21	0.32	0.000-0.073	0.013
1995	0.01-0.32	0.06	0.00-0.49	0.10	0.000-0.063	0.009
1996	0.00-0.10	0.04	0.00-0.68	0.22	0.000-0.061	0.022
1997	0.00-0.22	0.03	0.00-0.38	0.04	0.000-0.043	0.024

(mg/L, milligram/liter)

The data in Table 2-11 and Figs. 2-12 and 2-13 indicate that, although the average nitrogen and phosphorus concentrations have decreased during the 1990s, they still indicate a eutrophic status. The ratio of the average annual ammonia and nitrate concentrations (Table 2-12) confirm the observation that a decreased anthropogenic load, as well as a rising lake water level, have slowed the pace of eutrophication of the lake.

Table 2-12. Ratio of average annual ammonia (NH_4-N) and nitrate (NO_3-N) concentrations

Year	Average annual concentration (mg/L)		Ammonia:nitrate ratio
	NH_4-N	NO_3-N	
1985	0.23	0.15	1.5
1986	2.43	0.03	81.0
1987	2.43	0.03	81.0
1988	1.54	0.03	51.0
1989	1.28	0.06	21.3
1990	0.20	0.06	3.3
1991	1.34	0.07	19.1
1992	0.10	0.07	1.4
1993	0.14	0.04	3.5
1994	0.32	0.04	8.0
1995	0.10	0.06	1.4
1996	0.22	0.04	5.5
1997	0.04	0.03	1.3

(mg/L, milligram/liter)

2.6 Major Pollutant Sources in the Lake Xingkai/Khanka Drainage Basin

2.6.1 *Agriculture*

Agriculture pollution is comprised mainly of chemical fertilizers and pesticides used around the lake. Nitrogen, phosphorus and potassium are applied as mineral fertilizers in agricultural production within the Lake Xingkai/Khanka drainage basin.

The total quantity of applied mineral fertilizers for over a five-year period (1981-1985) are 116,869 tons of nitrogen, 65,112 tons of phosphorus, and 43,909 tons of potassium .(Table 2-13). Based on these applications, it is estimated that 8,100 tons of nitrogen, 0.42 thousand tons of phosphorus and 4.82 tons of potassium drain into the waters of Lake Xingkai/Khanka.

A broad spectrum of pesticides is used to combat weeds and other agricultural pests (Table 2-14). Over the last decade, for example, 12,300 tons of pesticides (approximately 33 kg/ha) have been applied in the Russian portion of the LakeXingkai/Khanka drainage basin over the last decade.

Soil erosion also is a very serious problem in the Lake Xingkai/Khanka drainage basin, due primarily to irrational exploitation of the land resources. The annual volume of soil erosion in the Mishan region, for example, is approximately 2.35 million m^3. Nutrients and nonpoint-source pollutants also enter the Muling River, and can ultimately be drained into Lake Xingkai/Khanka.

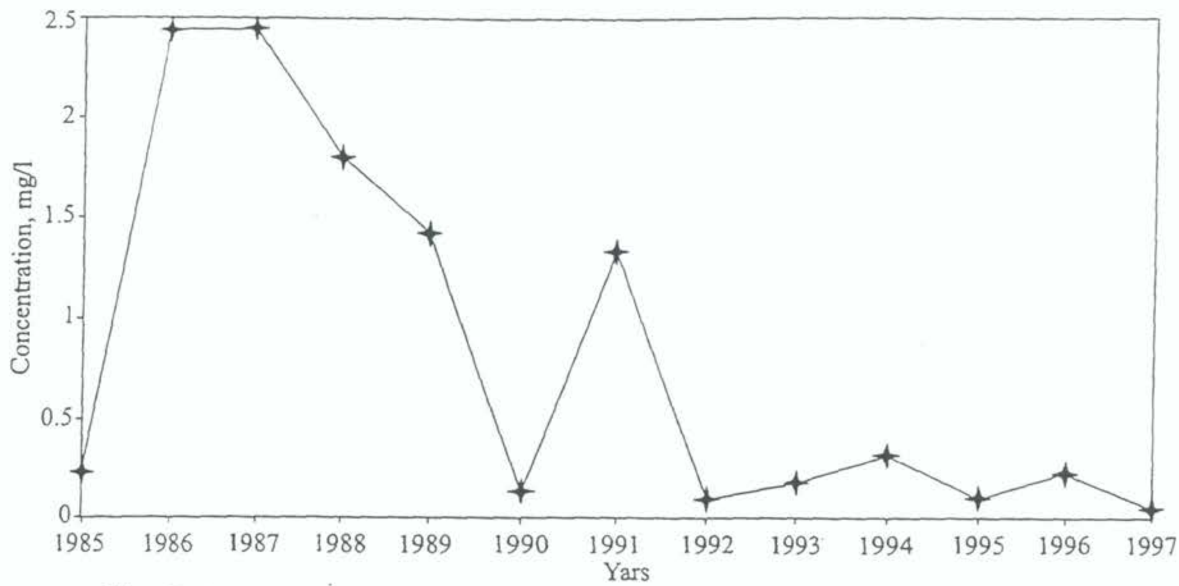


Fig. 2-12 Average annual ammonium concentration in the Russian portion of Lake Xingkai/Khanka, 1985-1997

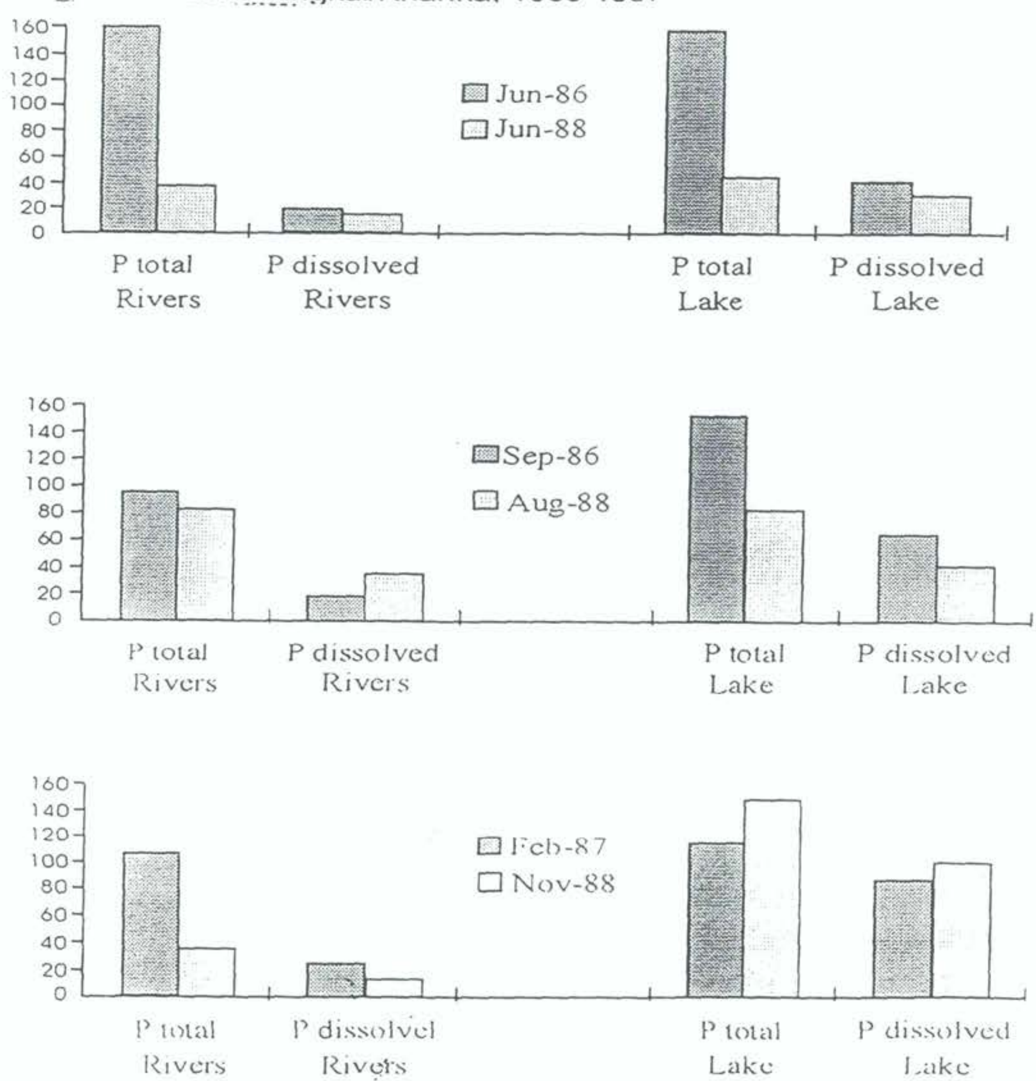


Fig. 2-13 Seasonal total and dissolved phosphorus concentrations in the Russian portion of Lake Xingkai/Khanka and its tributaries

Table 2-13. Mineral fertilizer application in the Lake Xingkai/Khanka drainage basin
(expressed in tons)

District	Year					Total for 5 years
	1981	1982	1983	1984	1985	
Nitrogen fertilizer						
Russian portion of drainage basin	10,676	20,177	26,471	25,702	21,004	104,100
Chinese portion of drainage basin	1,360	1,081	2,311	3,632	4,385	12,769
Basin total	12,036	21,258	28,782	29,334	25,389	116,869
Phosphorus fertilizer						
Russian portion of drainage basin	8,064	12,275	12,851	12,570	8,912	54,700
Chinese portion of drainage basin	1,488	2,823	1,971	2,092	2,038	10,412
Basin total	9,552	15,098	14,822	14,662	10,950	65,112
Potassium fertilizer						
Russian portion of drainage basin	7,086	6,219	9,205	9,898	10,655	43,100
Chinese portion of drainage basin	80	51	201	266	211	809
Basin total	7,166	6,270	9,406	10,164	10,866	43,909

Table 2-14 Major agrochemicals applied in Primorsky Kray.

Insecticides and acaricides
M-Parathion
Phozanol
Chlorophos (dipterex)
Chlorophos (20%)
Fungicides and nematocides
Benlat (fundozol)
Cuprozan (Homecin) (80%)
Policarbocin (80%)
Cineb (80%)
Herbicides
2-4D, Ammonium
Butanol (43%)
Trichloracetate sodium (90%)
Sitrin (50%)
Mayozin (zeapos-10)
Ronstar (40%)

2.6.2 Cities and Coastal Pollution

A continuing major source of pollution to Lake Xingkai/Khanka is untreated municipal sewage from a number of settlements in the drainage basin. The volumes of sewage discharges are given in Table 2-15.

Table 2-15. Domestic sewage volumes in the Lake Xingkai/Khanka drainage basin

District		Year	Sewage volume (million m^3/yr)	Sewage volume discharged into natural waters	Treatment rate (%)	Volume of fresh water required to neutralize sewage (million m^3/yr)
Russian Portion Of Drainage Basin	Pogranichny	1990	0.92	0	0	
		1995	1.70	0.97	0	90.9
	Khankaisky	1990	51.6	51.1	0	
		1995	67.5	67.0	0	44.5
	Khorolsky	1990	65.6	64.5	0	
		1995	13.1	10.5	0	66.2
	Chernigovsky	1990	12.0	11.6	0	
		1995	9.98	9.71	0	41.7
	Mikhailovsky	1990	17.6	14.2	0	
		1995	13.7	12.4	0	224
	Spassky	1990	31.2	30.7	0	
		1995	6.40	6.10	0	5.79
	Spassk	1990	9.43	9.0	0	
		1995	8.60	8.59	0	188
	Russian Total	1990	188.35	181.10	0	
		1995	120.98	114.87	0	661.09
Chinese portion of drainage basin		1995	3.62	3.62	0	
TOTAL DRAINAGE BASIN		1995	124.6	118.49	0	

(million m^3/yr, million cubic meters/year; %, percent)

The input of toxic substances to Lake Xingkai/Khanka from the Melgunovka River originate from rice fields, and in industrial-household sewage from Khorol, Chernigovka, Kamen-Rybolov and other settlements. Neither the industrial enterprises nor municipal sources have efficient treatment plants. Accordingly, untreated household sewage and industrial wastewaters ultimately drain into Lake Xingkai/Khanka. As an example, two settlements along the Melgunovka River (Dukhovskoye and Boguslavka) discharge untreated sewage into the river. The household and industrial sewage from other settlements (Table 2-16) is not discharged directly to the river.

Table 2-16. Household and industrial sewage discharges into the Melgunovka River Basin

Settlement	Sewage volume (m^3/d)
Novoselische	240
Luchki	188
Petrovichi	100
Oktyabrskoye	246
Vadimovka	400
Rubinovka	352
Popovka	266
Vladimiro-Petrovka	350
Khorol	860

(m^3/d, cubic meters/day)

A schematic of the pollution of the coastal waters of Lake Xingkai/Khanka by domestic sewage from the Astrakhanka settlement area is provided in Fig. 2-14. The information is based on biomonitoring of the composition and distribution of Ostracods in the waterbody. Most of the local sewage receives insufficient treatment.

2.6.3 Industrial Pollution Sources

Industrial activities in the Lake Xingkai/Khanka drainage basin are concentrated in the Russian portion of the basin. These include coal mining, non-ferrous metallurgy, metalworking, and production of cement and other building materials. The industrial discharges of wastewater and solid wastes are summarized in Table 2-17.

Table 2-17. Wastewater and solid waste discharges from industrial activities in the Lake Xingkai/Khanka drainage basin

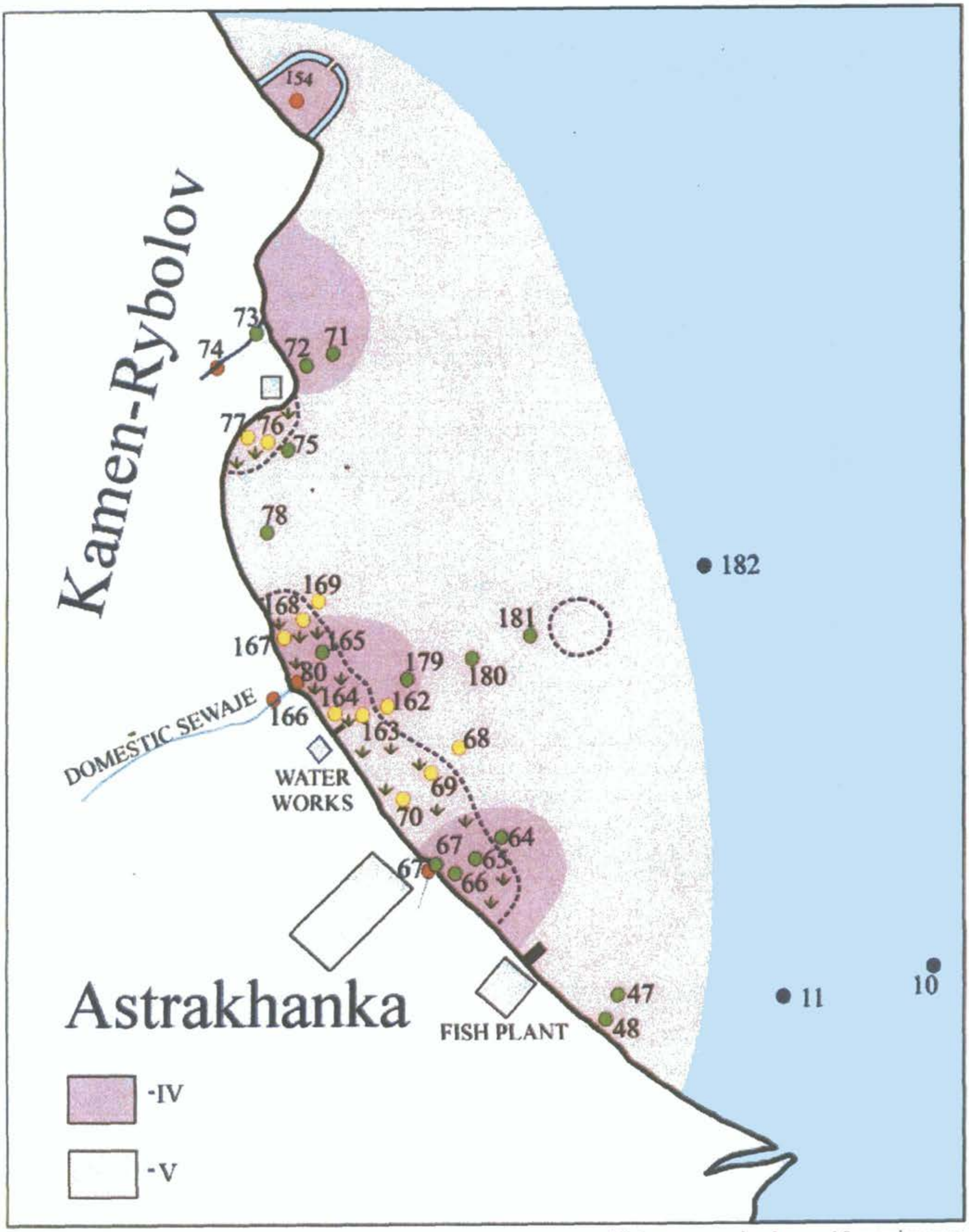
Industrial sectors		Wastewater (million ton/yr	Treated amount (thousand tons/yr	Solid waste (million ton)
Russian Portion Of Drainage Basin	coal mining	15.8	44.9	5.6
	non-ferrous metallurgy	0.5	53.4	0.5
	metal working	0.1	36.9	0.00005
	construction industry	5.5	93.1	2.1
	woodworking	0.006	36.3	0.003
	Food industry	25.9	63.8	8.203
	Total for industries	47.81		16.41
Chinese Portion of drainage basin	Paper mill	2.23		
Drainage basin total		50.04		

(million ton/yr, million tons/year; thousand tons/a, thousand tons/year).

The main mining enterprises in the Lake Xingkai/Khanka drainage basin are coal mining enterprises and the Yaroslavkii Mining and Concentrating Combine, which focuses on fluorspar production. The greatest environmental impacts are related to coal digging in quarries, while the second most serious environmental impact is related to the extraction of various kinds of building materials.

Mining and primary processing of minerals are causes of degradation and loss of land, water and forest resources, aggravation of some nature protection problems, and a general worsening of human habitat in these areas. Coal mining results in the changing of the land surface relief, and in negative exogenic processes. Coal digging in quarries is characterized by a large quantity of waste per unit of production.

Erosion processes also are intensified in dump areas. Erosion carryover can be as high as 18 t/ha, and extended tails 500 m long have been formed during rainfall periods.



Histogram scale: 1mm=10 speciments

- -absence of Ostracoda
- -marked ostracoda of the bankphytal
- -marked Ostracoda-indicators of severe pollution
- -marked Ostracoda of Lake variety

Fig. 2-14 Schematic of pollution of coastal waters of Lake Xingkai/Khanka near Kamen Rybolov

Digging activities can significantly impact land resources (Table 2-18). Main reasons for decommissioning lands with underground mining include the formation of cavities and deflections, surface watering and waterlogging or drying. Environmentally-negative impacts associated with coal quarries include a lowering of the groundwater table, shrinking of surface watercourses, and occasional watering and waterlogging as a result of surface deflections. The pumping out of mine water also can change the hydrologic connection between groundwaters and surface waters.

Table 2-18. Lands allocated and used for digging mining (1 January 1989)

Composition of land resources (ha)	Quarries			
	Lipovetsky	Pavlovsky-1	Pavlovsky-11	Total
Total allotted lands:	1317.9	1176	4026.1	6520
Including agricultural lands	387	898.9	4026.1	5312
and plowlands	198	342.6	2712.2	3252.8
Allotted lands for digging mining:	401.2	650	1500	2551.2
Including agricultural lands	387	650	1500	3537
and plowlands	198	300	1000	1498
Disturbed agricultural lands:	251	812.1	1093	2156.1
Including plowlands	179	342.6	1000	1521.6
Agricultural lands disturbed by mining activities	238	494	745	1477

(ha, hectares)

The main freshwater stores are concentrated in non-coal formations in the Rettikhovka and Pavlovka depressions. Development of these coal deposits typically leads to an almost complete drainage of aquifers lying above the coal deposits. For example, for a six-year period beginning in 1972, approximately 43.1 million cubic meters of water were pumped from the Pavlovka quarry. The resulting depression crater had a radius of 10-20 km and a depth of 15 m. The quarry aquifer also was depleted, and some local settlements (Abramovka, Pavlovka and others) lost their water sources as a result.

Over 50% of all discharged waters in the Lake Xingkai/Khanka drainage basin are polluted, resulting in material, chemical and bacteriological contamination of watercourses in the basin. As noted above, the most contaminated waters are drainage waters from mining activities. Based on administrative data from the Lipovetsky Mine, for example, the annual discharge of such waters exceeds 11.6 million m^3. In spite of treatment efforts, these waters contain approximately 11,000 tons of suspended substances, 22 tons of petroleum products, 130 tons of detergents, and 0.06 tons of phenols. The Pavlovsky quarry discharges about 160 thousand cubic meters of wastewater per year, with only 135,000 m^3 being treated.

The rivers into which the mine wastewaters are discharged contain elevated contents of copper, zinc, phenols, nitrate, ammonia, chloride, petroleum products and suspended substances.

2.6.4 Tourism

The Lake Xingkai/Khanka region attracts thousands of tourists each year because of its unique natural landscape. Tourism in the region has developed rapidly in recent years, and an estimated 160,000 man days of tourists from Russia, China and other locations visit the region each year.

This increased tourism has resulted in both positive economic benefits and negative pollution impacts. The estimated 160,000 man-days of tourists annually produce approximately 60,000 tons of domestic sewage. Based on a water consumption of 0.5 m^3/person, this is equivalent to 6 tons of biochemical oxygen demand (BOD_5) and 18 tons of chemical oxygen demand (COD).

2.6.5 Solid Wastes

Solid materials discharged in the Lake Xingkai/Khanka drainage basin consist primarily of slag and ash, with an annual production of 10,600 tons. Of this total, about 3,600 tons is used to fill moorlands. The other major solid waste sources are domestic garbage and organic fertilizer (with about 0.4 million tons of organic fertilizer being non-utilized).

2.6.6 Other Sources of Pollution

The remaining important pollution sources in the Lake Xingkai/Khanka drainage basin are automobiles and the Muling River (as a conveyance for pollution to the lake).

The pollutant load from automobile transport in the drainage basin was evaluated indirectly by consideration of the highway network. Based on this approach, the atmospheric discharge of automobile emissions has increased dramatically during the 1990s, including both local and transit automobiles. The total atmospheric emission in Spassk-Dalny has increased from 7.8% in 1987 to 10.1% in 1993 and 23.1% in 1996.

About 0.6 billion m^3 of wastewater discharged by Muling, Jixi, Jidong and Mishan Cities into the Muling River ultimately drain into Lake Xingkai/Khanka Lake through the Dongdihe canal, as well as through the flood-diversion sluice gate during flood periods.

(A) *Calculation of pollutant input into the large basin of Lake Xingkai/Khanka through the flood-diversion sluice gate*

Table 2-19 indicates that the annual water flow from the small basin of Lake Xingkai/Khanka to the large basin of the lake through the flood-diversion sluice gate is approximately 0.33 billion tons. The maximum value during 1991-1998 was 1.051 billion m^3 and the minimum value was 0.08 billion m^3. The annual average discharge of chemical oxygen demand (COD) was 1,752 tons, ranging between 753-2,472 tons. The annual average discharge of biochemical oxygen demand (BOD_5) was 686 tons, ranging between 352-713 tons. The annual average total phosphorus (TP) discharge was 10.8 tons, ranging between 1.4-18.9 tons. The annual average suspended solids

(SS) discharge was 30,000 tons, ranging between 2.0-6.4 tons. The discharge of these pollutants decreased to a minimum level during 1997 and 1998.

Table 2-19. Pollutant discharge to Lake Xingkai/Khanka via the flood-diversion sluice gate

Year	Water volume ($10^8 m^3$)	COD		BOD_5		TP		SS	
		Concen-tration (mg/L)	Load (t)	Concen-tration (mg/L)	Load (t)	Concen-tration (mg/L)	Load (t)	Concen-tration (mg/L)	Load (t)
1991	10.51								
1992	0.8								
1993	2.4	5.68	1,363	2.62	6,288	0.04	9.6	55.43	1.3
1994	3.5	7.07	2,474	1.76	616	0.054	18.9	183.0	6.4
1995	1.6	7.25	1,160	2.11	338	0.071	11.4	140.1	2.2
1996	2.9	6.49	1,882	2.46	713	0.036	10.4	212.1	6.2
1997	2.1	5.58	1,172	3.06	643	0.027	5.7	94.06	2.0
1998	1.1	6.85	753	3.20	352	0.013	1.43	56.67	0.6
Average	3.11	6.49	1,752	2.54	686	0.04	10.8	123.4	33

(m^3, cubic meters; mg/L, milligrams/liter; t, tons, COD, chemical oxygen demand; BOD_5, biochemical oxygen demand; TP, total phosphorus; SS, suspended solids)

(B) Calculation of pollutant input into the small basin of Lake Xingkai/Khanka via the Dongdihe Canal

A portion of water discharges into the Dongdihe Canal through the north sluice gate of the Muling River ultimately flows into the small basin of Lake Xingkai/Khanka. Based on an annual water inflow of 0.65 billion m^3, the annual discharges of chemical oxygen demand (COD_{Mn}), biochemical oxygen demand (BOD_5), suspended solids (SS), and nitrate-nitrogen (NO_3-N) are 5,119 tons, 1,570 tons, 144,000 tons and 123 tons, respectively (Table 2-20).

Table 2-20. Pollutant discharge from the Muling River to the small basin of Lake Xingkai/Khanka

Year	SS		BOD		COD		NO_3-N	
	Concentra-tion (mg/L)	Discharge (thousand tons)	Concentra-tion (mg/L)	Discharge (thousand tons)	Concentra-tion (mg/L)	Discharge (thousand tons)	Concentra-tion (mg/L)	Discharge (thousand tons)
1993	-		3.1	2,015	7.7	5,005	0.211	137
1994	192	12.5	2.1	1,365	7.4	4,810	0.229	149
1995	176	11.4	2.4	1,560	8.3	5,395	0.129	83
1996	295	19.2	2.06	1,339	8.1	5,265		
Average	14.4		1,570		5,119		123	

(SS, suspended solids; BOD, biochemical oxygen demand; COD, chemical oxygen demand; NO_3-N, nitrate-nitrogen; mg/L, milligram/liter)

2.7 Water Demand and Use in the Lake Xingkai/Khanka Drainage Basin

Data on water use for various needs in the Lake Xingkai/Khanka drainage basin is summarized in Table 2-21. The data indicate that irrigation water consumption is the most significant water use in the basin, comprising 93% of the total water use.

Table 2-21. Water use and demand in the Lake Xingkai/Khanka drainage basin

District		Water consumption (million m^3/yr)					
		Year	Sectors				Total
			Communal and domestic	Industrial	Irrigation	Agriculture	
Russian portion of drainage basin	Pogranichny	1985	0.73	0.18	0.07	1.28	2.26
		1990	0.85	0.06	0	1.25	2.16
		1995	1.54	0.39	0	0.86	2.79
	Khankaisky	1985	1.09	47.1	252.3	1.47	301.9
		1990	0.08	6.79	166.6	1.55	181.4
		1995	1.17	8.36	61.5	1.04	78.0
	Khoroisky	1985	1.34	2.49	116.0	2.90	122.7
		1990	2.45	7.15	107.4	3.01	120.0
		1995	2.39	1.69	36.0	0.95	41.0
	Chernigovsky	1985	1.20	1.19	63.0	0.92	66.3
		1990	1.85	0.53	49.5	1.27	53.1
		1995	1.62	0.54	18.3	0.68	21.2
	Mikhailovsky	1985	1.34	0.54	0.42	2.25	48.1
		1990	2.06	0.77	0.06	2.68	5.81
		1995	1.97	0.44	0.06	1.74	4.22
	Spassky and Spassk-Dalnii City	1985	10.2	3.77	86.1	1.69	105.4
		1990	7.18	9.37	55.9	1.89	74.3
		1995	3.99	4.78	27.1	0.96	39.0
	Russian Total	1985	15.9	54.9	517.9	10.5	603.5
		1990	14.5	24.7	379.5	11.6	436.8
		1995	12.7	16.2	143.0	6.23	178.23
Chinese Portion Of Drainage Basin	Alluvial plain zone	1996			200		200
	Hilly overflow mound zone	1996					
	Riparian plain zone	1996			350		350
	Chinese Total	1996	8.5	2.3	550		560.8
Total drainage basin		1995-1996	21.3	18.5	693.0	6.23	738.93

(m^3/yr, cubic meters/year)

In the Russian portion of the Lake Xingkai/Khanka drainage basin, decreasing water consumption in recent years corresponds to recent economic declines in all economic branches, especially water-intensive production. For the most water-intensive district (Khankaisky), the volume of water consumption for irrigation over the last ten years has decreased by 80%.

2.8 Socio-Economic Costs and Environmental Damage Related to Water Issues in the Lake Xingkai/Khanka Drainage Basin

The estimated economic loss caused by pollutant discharges in the Lake Xingkai/Khanka drainage basin is given in Tables 2-22 and 2-23.

Table 2-22. Estimated economic losses from pollutant discharges in the Lake Xingkai/Khanka drainage basin

Economic branch	Type of waste	Volume of non-utilized valuable resources	Total cost of non-utilized resources (million rubles)
Wood processing	Edging, knots, sawdust, etc.	0.344 thousand m^3	0.2
Municipal economy	Slag, ashes	90.3 thousand tons	2.7
Agriculture	Organic fertilizer	0.4 million tons	8

(m^3, cubic meters)

Table 2-23. Estimated economic losses resulting from the discharge of valuable, non-utilized resources from Spassk-Dalny City

Types of pollutants Discharged from Spassk	Discharge volume (tons)	Normative payments for discharge (rubles)	Estimated damage (rubles)
Petroleum products	1.5	44,250	44,351.5
Ammonium nitrogen	46.5	5,545	257,842.5
Phosphates	11.6	11,090	128,644.0
Copper combinations	0.06	2,217,500	133,050.0
Zinc combinations	0.01	221,750	2,217.5
Ferrous combinations	0.5	22,175	11,087.5
TOTAL			1,008,031

It is obvious that discharged pollutants degrade and destroy both the natural environment and human habitats. The economic damage of discharged pollutants can be assessed as summary expenses directed to their treatment, and to the achievement of appropriate environmental standards. It also is possible to estimate the economic losses resulting from increased human health impacts resulting from environmental pollution.

Based on such estimations, the economic loss in 1997 was approximately 5.1 million denominated rubles. The estimated economic loss from non-utilization of valuable resources and substances also is high, totaling tens of millions of rubles.

Due to the incomplete utilization of organic fertilizers, the estimated economic loss associated with agriculture is approximately 8 million rubles, while the estimated loss to the municipal economy is 2.5-3 million rubles. Even in the wood processing industry, which has a high level of waste utilization, the estimated cost of non-utilization of valuable resources is 0.2 million rubles.

2.8.1 Decreasing Quality of Russian Agricultural Production, including Fisheries

Agricultural activities are a significant source of water pollutants in the Lake Xingkai/Khanka drainage basin. For example, based on a special 1986 study, the concentration of organochlorine pesticides in 14 fish (from a total sample of 45 fish) from the Khanka fish-processing factory exceeded the MAC for food products. Five samples contained DDT, and notable quantities of DDE were found in 27 of the samples. Nine of the DDE samples exceeded the MAC for food (fish) products, and four were close to the maximum standards stated in 1983.

Overall, the highest concentrations of organochlorine pesticides were found in *Hypophthalmichthys molitrix, Erythroculter erythropterus* and *Culter alburnus*. It is also noted that the average content of organochlorine pesticides in the flesh, liver and fat in these fish exceeded the MAC.

Further, two-year-old *Cyprinus caprios* from the Khanka fish-breeding factory contained 0.04 mg/kg of DDE in liver and 0.05 mg/L in fat. Neither value exceeds the MAC. It also is noted that, among all the organochloride pesticides considered, mollusks from the mouth of the Melgunovka River contained 0.074 mg/kg of DDE, which does not exceed the MAC.

There are some data on concentrations of the herbicide Saturn in the fish in Lake Xingkai/Khanka. Forty percent of the 250 samples of the examined fish contained Saturn in their organs and tissues. The highest herbicide concentrations were found in tissues of predatory fishes. It is noted that benthic invertebrates, shrimps and mollusks can accumulate Saturn in their tissues.

A large fish kill was noted in 1987 in the water intakes and canals of the State Farm "50th Anniversary of the USSR". Signs of the pesticide ordram were seen for the fish. Pesticide analysis was not carried out for the subsequent mass fish kill in 1988.

Notable contents of ordram and Saturn were found in 3 large fish from the Khanka fish-processing factory, with the contents being 2.4 and 8 times, respectively, higher than the MAC for food products. Further, mercury levels in fish at the Khanka fish-processing factory sometimes exceeded the MAC value. The data suggest that larger fish accumulate mercury over long periods of time. In 1986, for example, the mercury concentration in *Pseudaspius leptocephalus* was 4 times the MAC value.

Pesticides also were found in bird flesh. DDE (up to 5-mg/kg) was found in the liver of wild ducks nesting in the drainage basin, and the pesticide Saturn was found in gray heron. Pesticides also were found in the flesh and livers of ducks at the State poultry-farm, "Pioneer". Mercury concentrations in the flesh of some wild ducks were higher than the MAC, and the MAC for mercury was exceeded for the liver of one of the duck samples.

A biochemical analysis of heavy metals and organochlorine pesticides for 6 fish species (including *Esox Lucius, Erythroculter erythropterus, Culter alburnus* and *Erythroculter mongolicus*) was carried out by Hydromet Survey in Russia in 1991. The content of the heavy metal nickel exceeded the MAC in the majority of the samples, and the cadmium concentrations exceeded the MAC in *Erythroculter mongolicus* and *Culter alburnus* samples.

2.8.2 Decreasing Environmental Quality in Russia, including Natural Waters

The overall economic damage resulting from a decrease quality of the environment within the Lake Xingkai/Khanka drainage basin has not been accurately calculated. There is no doubt, however, that it is significant. As an example, focusing attention solely on the industrial territory of Spassk-Dalny City, the estimated economic damage related to the discharge of valuable, non-utilized materials and resources exceeds one million rubles (1991 prices).

CHAPTER 3

BIOLOGICAL RESOURCES AND ECOLOGICAL STATUS OF LAKE XINGKAI/KHANKA AND ITS DRAINAGE BASIN

This chapter discusses the biological resources and biodiversity characteristics unique to the Lake Xingkai/Khanka drainage basin. In addition to providing an overview of the flora and fauna of the lake and its drainage basin, this chapter also identifies the environmental problems linked to the region's biodiversity, as well as the associated economic consequences of these problems. It also reviews the natural reserve protected areas established in both the Chinese and Russian portions of the drainage basin.

3.1 Overview of Biological Resources

Lake Xingkai/Khanka is the largest freshwater lake in Northeast Asia, connecting distant regions of China and Russia. The single most important economic activity in the Lake Xingkai/Khanka drainage basin is agricultural production. At the same time, however, the lake and its adjacent territory differ essentially from other regions of both countries in their landscapes (Fig. 3-1) and the unique biodiversity of the lake and its drainage basin has attracted international attention.

The lake's drainage basin contains widespread meadow vegetative communities and grassy bogs. Based on their unique vegetation and fauna, the wetlands at the eastern end of the lake have no analogs in the region (Fig. 3-2). The drainage basin is characterized by a substantial biodiversity, including a concentration of waterfowl. There also are many fish species and other aquatic organisms in the lake. The adjacent territory contains a significant number of rare and endangered plant species. The highly-productive ecosystems in the drainage basin have produced a large number of species and genetic diversity, and the area contains many valuable plant and animal species.

The Russian portion of the drainage basin is one of the largest agricultural zones in the Russian Far East, containing about half (47%) of the arable lands, and more than 60% of the irrigated lands of Primorsky Kray. The Chinese portion of the drainage basin is also one of the main agricultural zones in Northeastern China, and contains most of the area of Mishan City, 2 towns, 3 state farms and 6 villages, with approximately 1,547 km^2 of the area being farmland. It also contains some industry and coal mining, as well as agricultural activities (fish-breeding, cattle-breeding, forestry, etc.). Because of its favorable agricultural production conditions, suitable climate and fertile land, the drainage basin of Lake Xingkai/Khanka has long been described as a "land of fish and rice".

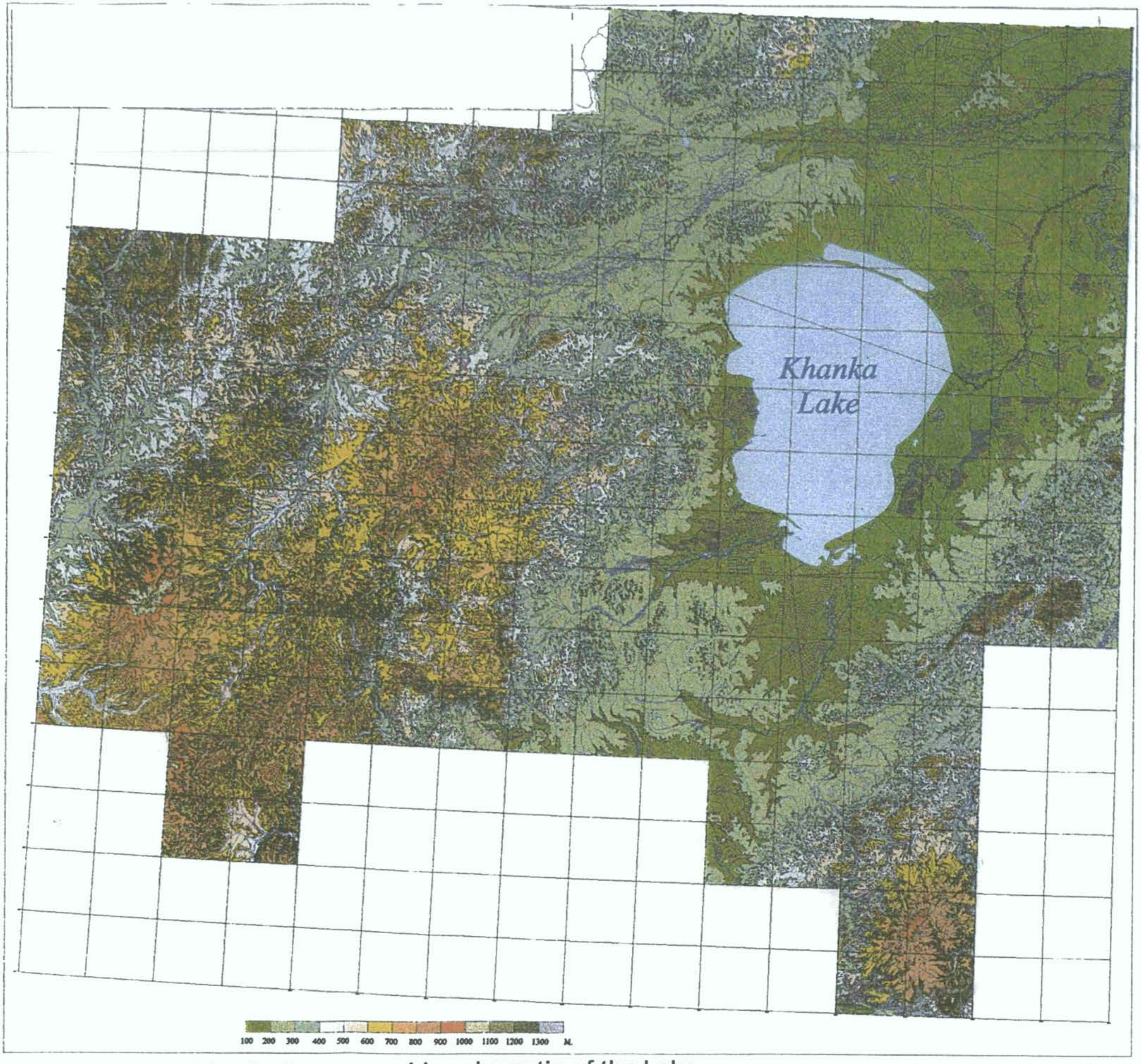


Fig. 3-1 Physical – goegraphic schematic of the Lake Xingkai/Khanka drainage basin

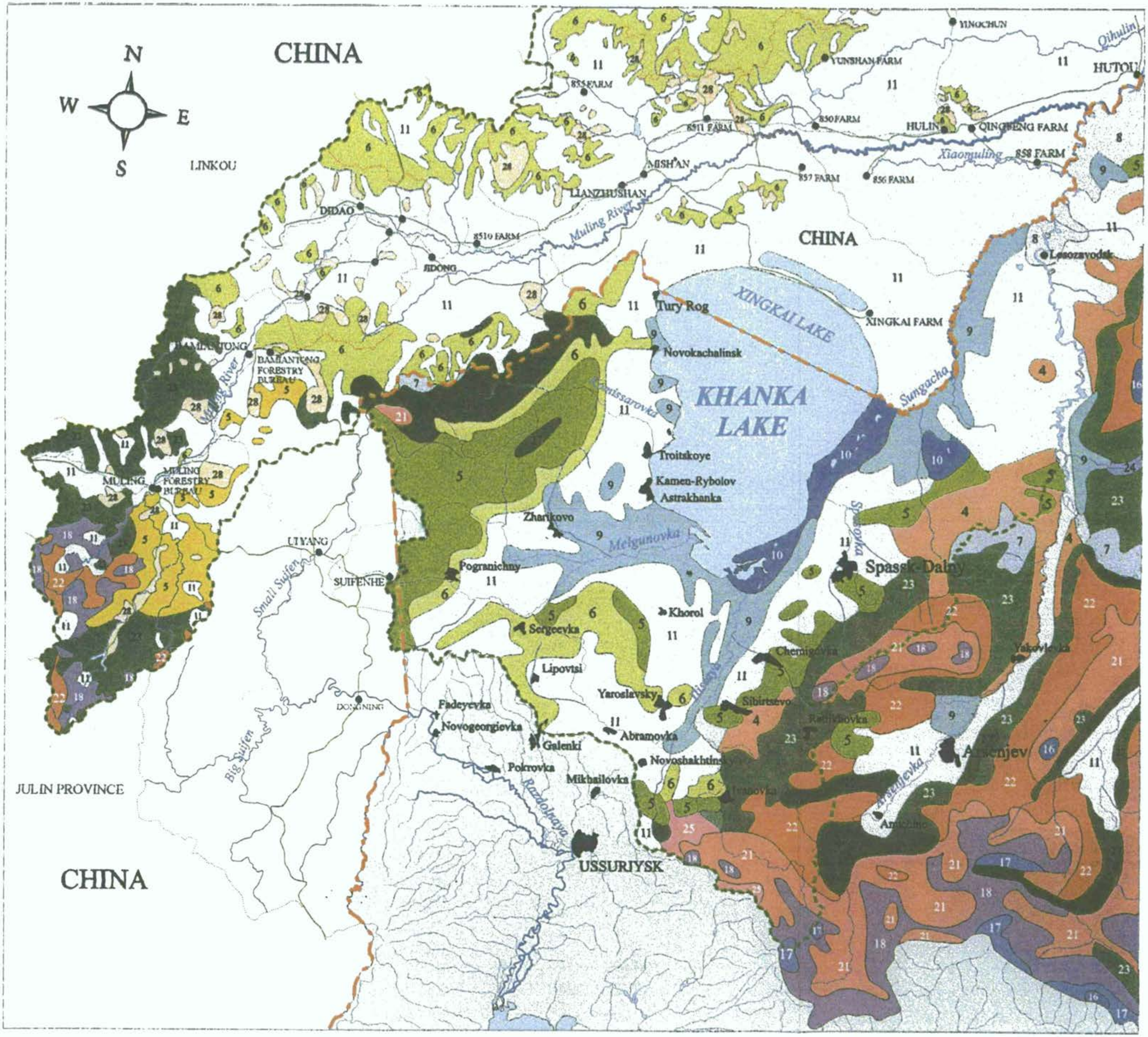


Fig. 3.2 Vegetation and vegetation cover of the Lake Xingkai/Khanka drainage basin

BOREAL VEGETATION

1 *Larix gmelinii* subtaiga forests mixed with nonmoral elements and Larixg melinigrass and sphagnum mari

2 *Betula manchurica B. platyphylla* productive forests in combination with *B.fruticosa* rose willow brushwoods and meadows in situ of south-taiga and subtaiga forests.

3 Rose willow- chosenia- poplar *(Larix gmelinii)* durk coniferous *(Picea ajanensis, Abies nephrolepis, P. obolata)* number of associations of flood plains vegetation

NONMORAL VEGETATION

4 Cegar-broad-leaved with fir mixed broad leaved with cedar ***(Pinus koraiensis, Quercus mongolica , Tilia amurensis, Betula dahurica)*** tall + grassy forests. their rate and brishwoods in situ of cedar broad-leaved forests.

5 Oak low trunk grassy and oak with participation of lime and other broad-leaved roks of forest: their sparse growth of trees and brushwoods in some places with combination of meadlows *B. Fruticosal* brushwoods and bogs.

6 Oak-birch (*B. Dahurica)* forests and rare forests with steppe grassy cover in combination with brushwoods.

7 *B. manchurica. B. dahurica* and aspen grass forests in combination with oak-birch sparse growth of trees. *B. fruticosa* brushwoods and various grassy. Woodreed meadows in situ of oak and cedar-broad-leaved forests.

8 Willow *(Salix raddeana, S. caprea, S feoderi, S mixta), Betula ovalifolia, B. fruticosa and S. brachypoda* brushwoods in combination with meadows and lawland bogs.

9 Ling woodreed and various grassy woodreed meadows (peridically and constantly wet)

10 Reed *(Phragmites communicsi)* and ling *(Carex lasyocarpa, C. megeriana)* bogs.

11 Agricultural lands in combination with meadows and brushwoods in situ of nonmoral vegetation.

Vegetation of lowlands, plants and low plateau

GOLETS AND SUBGOLETS VEGETATION OF MAINTAINS

12 Brushwoods of dwarf pine *(P. pumila)*, somewhere in combination with mountain tundras.

13 Fir *(Picea ajanensis, Abies nephrolepis)* sparse growth of trees with participation of draft pine, in combination with *B. emanil* groves.

BOREAL VEGETATION

14 Larch moss shrabs forests with combination of Larch sphagnum mari anol *B. Fruticisa* brushwoods

15 Larch grass shrabs forests with participation of cedar and broad-leaved species.

16 Fir green moss forests

17 Fir forests with nonmoral elements in the cover and in underbrush.

18 Fir forests with participation of cedar and broad-leaved species of forests.

19 Larch herbal-shrubs productive forests in situ of fir and native larch and fir forests.

20 *Betula manchzurica* and aspen *Betula manchzurica* grassy forests in situ of fir forests.

NONMORAL VEGETATION

21 Cedar broad leaved mixture of dark coniferous species. grassy forests with participation of boreal elements in the cover.

22 Cedar broad leaved tall grassy forests.

23 Mixed (polidominant) broad leaved productive forests in situ of cedar- broad leaved forests

24 Birch *(B. manchzurica, B. costata)* grassy shrabs productive forests. here and there with the plots of mixed broad-leaved forests. rare forests and brushwoods in situ of cedar- broad leaved forests.

25 Coniferous broad leaved *(Pinus karaiensis, Abies holophylla, Kalapanax septembolum, Aser pseudosiboldov)* tall grassy forests.

26 Broad leaved productive forests of complex composition their sparse growth of trees verdure rushwoods of coniferous- broad leaved (with cedar, black abies , hornbea)m) forests.

27 Oak *(Quercus mongolica)* grassy-shrabs *(Corylus heterophylla, Lespedeca bicolor)* forests. their rare forests and brushwoods.

28 Artificial forests.

The importance of the unique natural-territorial unit of the Lake Xingkai/Khanka drainage basin has long been recognized. An example is the biological uniqueness of the wetlands and their waterfowl. These wetlands in the Russian Federation were first recognized under the Ramsar Convention (1971) as having an important role in supporting the normal course of seasonal migration and reproduction of many important waterfowl species. Based on such characteristics, the biodiversity of the region is considered to be rich in species and taxonomic diversity. Examination of the taxonomic diversity clearly highlighted its importance to the two riparian countries. The cenotic, population and functional diversity are only some demonstrations of the general ecological diversity characterizing the region, including almost endless mutual relations between the organisms and their environment.

3.2 Overview of Major Biodiversity-related Problems

The Lake Xingkai/Khanka drainage basin is one of the most important agricultural and industrial regions of Primorsky Kray in Russia. The most important features fundamentally influencing the ecological uniqueness of the region include (i) the territory's relief characters and geological structure, (ii) the distinctive monsoon climate with its constant possibility for catastrophic sequences of different natural phenomena (floods, typhoons, soil erosion), (iii) the uneven nature of its economic development, and (iv) the concentration of anthropogenic pressures in the region conducive to zones of ecological distress.

Nevertheless, the Lake Xingkai/Khanka drainage basin is recognized by the international scientific community as one of the world's most important regions in regard to its biodiversity characteristics. It was included in the list of the Ramsar Convention for Russia as one of the largest wetlands in Nrtheast Asia, and as a nesting center for rare and endangered bird species.

The drainage basin has a striking diversitiy of plant and animal species. The Chinese portion of the drainage basin, for example, contains 1,460 species of plants and 282 species of wild animals. Based on preliminary data, the Russia portion of the drainage basin contains at least 620 speces of vascular plants, 61 species of mammals and 342 species of birds. Fifty-eight of the bird species have a status of being rare species in the territory. Forty-four species are included in the Red Book of Russia, and 12 species are included in the International Red Book.

Eight species of amphibians and 10 species of reptiles also have been identified in the drainage basin. Further, the Ichthyofauna is highly diversified in Lake Xingkai/Khanka, and 73 species of fish and one specie of *Cyclostomata* have been registered here. Considering the biodiversity of its freshwater fish fauna, the lake has no analogs in the whole Palaeoarctic region.

The area contains grassy swamps (reed-sedge swamps, sedge bogs, and large-grass swamps) and meadow vegetative communities. Their importance to the bird communities is fundamental. No comparable-sized areas in Russia contains as large a number of bird species included in the Red Book of Russia and the International Red Book. Of the 48 endangered bird species of the Far Eastern territory in Russia, 10 species are unique to the Prikhankaiskaya Lowland. Further, 225 species of the 287 species under protection of Soviet-Japanese (1973) and Soviet-Korean (1987) conventions dwell in the Lake Xingkai/Khanka drainage basin.

The Chinese portion of the drainage basin contains 4 animal species that belong in the Chinese 1st class of the national system of conservations, 34 species that belong in the 2nd class and about 100 species of birds protected under the Agreement between China and Japan on the protection of migratory birds. Six species of waterbirds also have been newly registered in Changbaishan sub-region of Heilongjiang Province. Two of the species were first registered in the Province. There also are rare plant species in the drainage basin that belong in the 3rd class of conservation in China.

Economic development of the coastal zone, and water pollution related primarily to agrochemicals, have resulted in major biota changes. For example, 7 species of birds that previously bred in the Russian portion of the drainage basin have subsequently disappeared, including three listed in the Russian Red Book. Four other species also are on the verge of extinction.

Over the years, the total number of waterfowl has been reduced by a factor of ten, and one-third of the unique wetlands have been destroyed. Further, the relict grove of *Pinus Funebris* on Sosnovy Island was completely cut. Lake Xingkai/Khanka also is experiencing a rapid decline in fish stocks. Over the past decades, the fish biomass in the lake has been reduced 8-10 times. Further, Chinese perch, Khankayskii bream, Far Eastern turtles and some species of endemic mollusks also are under threat of extinction in the region.

Other areas associated with degradation of biodiversity in the drainage basin are the upper portions of the Llistaya, Komissarovka and Melgunovka River basins in Russia. Intensive forest-cutting activities commenced in the early-1960s, and accompanying forest fires have accelerated undesirable changes in the forest structure. The more productive cedar wide-leaved forests have been reduced and/or replaced by lesser-productive oakwoods. All the region's forests have been subjected to woodcutting activities, repeatedly in some cases.

Another negative situation has arisen in regard to some isolated animal populations in the upper portions of the Melgunovka, Komissarovka and Usachi River basins. The present State border regime, and the presence of continuous Control Trace Lines (CTL), have totally eliminated some wild animal populations that previously inhabited the Russian portion of the drainage basin and the northeastern region of China. These include such animals as *sable*, *Ursus arctor* and *U. Thibetanus, Cervus nippon, C. Elaphus, Sus scrofa* and *Capreolus capreolus*. Species initially included in the International Red Book, but which no longer live in the region, include *Cuon alpinus, Panthera pardus orientalis* and *Nemorhaedus caudatus*.

The Lake Xingkai/Khanka drainage basin has undergone significant economic development over the past 130 years. This development, including agricultural activities throughout the drainage basin, has resulted in negative ecological impacts, including (i) contamination of surface waters and (partly) groundwater, (ii) soil cover erosion, and (iii) reduced communities of rushes in wetlands and related degradation of biodiversity. The occurrence of natural calamities in the region exacerbates such negative impacts as well.

Overall, the primary reasons for biodiversity degradation in the Lake Xingkai/Khanka drainage basin include (i) the draining of swamps, (ii) lowering of the lake's water level, (iii) agricultural development (particularly affecting bird nesting areas), (iv) stress due to the noise and other impacts of technical facilities, (v) large-scale environmental contamination, (vi) cutting of forests, and (vii) reduction and/or elimination of ecological corridors.

3.3 Status and Changes in Flora and Vegetative Cover in the Drainage Basin

The biodiversity in the Lake Xingkai/Khanka drainage basin is connected historically with intensive geological processes, resulting in a unique mixture of flora and fauna.

3.3.1 Vegetation Cover in the Chinese Portion of the Drainage Basin

According to Chinese experts, the flora in the Chinese portion of the Lake Xingkai/Khanka drainage basin comprises plants of 53 orders, 104 families, 477 genera and more than 1,060 species.

Deciduous forests of poplar, birch, oak, linden, elm, walnut on typical brown soils once existed in the foothills of the Eastern-Manchurian Mountains. Many of these forests, however, have subsequently been clear-cut and transformed into agricultural fields (see Fig. 3-2).

Mixed forests, including lianas and epiphytic ferns, grow on slopes of 500 m altitude and higher, with acid or typical brown soils. Woodlands are found on higher alpine patches, including tiagi thickets (compounded from Korean cedar *Pinus Koreansis*, Ayan spruce *Picea ajanensis*, white-bark fir *Abies nephrolepis* and leafy *Abies holophylla*, Gmelina larch *Larix gmelinii* and birches).

The forests in the drainage basin belong to the temperate-cold forestal sub-zone. Broadleaf forests of *Quercus mongolica, Tilia amurensis, Fraxinus mandshurica, Phellodendron amurensis, Populus davidiana, Betula platyphylla. Ulmus propinkua*, Mongolian Scotch Pine, Manchurian Walnut, Maple and Indigobush Amorpha occupy the largest area. The bush and liana include Filbert, Shrub Lespedeza, Prikly Rose, Mongolian Willow, Amur Grape, Marlyprickle Acanthoparlax, Fimbriate Orostachys, Mongolian Ephedra, Chinese magnoliavine, Fourleaf Ginseng and Lilyofthevalley, as well as more than 20 healing plants.

The grass cover is dominated by herbs, such as Brooklet Anemone, Lilyofthevalley, Fragrant Solomonseal, Hastate Cacalia, Scabrous Doellingeria, Cottonsedge, Stolonbearing, Upright Ladybell, Wilson Iris, Common Parthenium and Cliff parthenium.

The marshy vegetation resources in wetlands include *meytriana, Caret schmidtii, Carex tato, Utricularia vrlyris, Spargraminm stenophylla, Eguisetum helocharis, Carex Lasiocarpa, Comarum pulustre, Carex psendocuraica,* Meyer sedge, Narrowleaf Burreed, Marsh Cinquefoil, Japanese St. John's wort, Rabbitear Iris, Thyrse Loosesrtife, and Oriental Waternplantain. The primary submerged aquatic plants are Common Bladderwort, Hormvort and Waterplantain Ottelia.

Industrial forests in the Chinese portion of the drainage basin, as well as water protection zones or forest belts, comprise Korean cedar, Chinese juniper, various species of spruce, larch, fir, tree-like willow, poplar, pine (*Pinus silvestris*), Manchurian nut, chozenia (*Chosenia macrolepis)* and David aspen (*Populus davidiana*).

3.3.2 Vegetation Cover in the Russian Portion of the Drainage Basin

The Russian portion of the drainage basin, including the Komissarovka, Melgunovka, Ilistaya, Spasovka and Sungacha Rivers and their tributaries, is approximately equal to the Chinese portion of the basin (including the Muling River basin). The land involved in intensive agricultural activities is about 45% of the total area, with forests and sparse forests being about 35%. The remaining land area is covered by sedge (*Carex lasyocarpa, C.megeriana*) and reed (*Phragmites communis*) bogs, sedge-forb and multi grasses-forb meadows that are continuously or periodically saturated (see Fig. 3-2).

Most widely-spread forested areas consist of black birch and oak sparse forests (*Quercus mongolica, Betula dahurica*), with steppe-like grass cover and nut-lespedetsa thickets (*Corylus heterophylla, Lespedeca bicolor*). Oak grass and grass-bushy forests with an admixture of broadleaf species (linden, maple, ash, etc.) exist at altitudes of 500 m and higher above sea level. Cedar-deciduous forests exist on the northwestern and northern slopes of the Vostochny Siny Ridge, and on the higher patches of the East-Manchurian mountains, often with an admixture of significant number of dark-coniferous species (Ayan spruce, white-bark fir). At altitudes above 800 m (e.g., Vostochny Siny Ridge), spruce-fir forests are found, with an admixture of cedar and broadleaf species, as well as boreal taiga plants.

Japanese Alder (*Alnus japonica*) is a floral species of great botanical-geographical interest. Along with oak, the alder is found in the western part of the Prikhankaiskaya Plain. The preference of Japanese Alder for water plain and lakeshores suggests that Lake Xingkai/Khanka occupied a greater land area in former geological periods. The alders generally form small mono-dominant thickets on near-lake and riparian terraces, and are surrounded by Calamagrostis-carexes meadows and oak-bushy shoot thickets.

Most of the Prikhankaiskaya Plain steppe floral species are presently on the verge of extinction, as a result of the cultivation of these areas. In the 1950's, however, the steppe floral communities represented the typical vegetative cover in the Lake Xingkai/Khanka drainage basin. The feather-grass baikalskaya (*Stipa baicalensis*) and *Filifolium sibiricum* are the most typical representatives of the steppe flora in East Asia. The steppe vegetation is grouped on high terraces with loam or loamy sand soils, as well as on the stony dry slopes of low-mountain relief.

Some rigged oak groupings are found at the western shore of the lake. In the past, high riparian and laky terraces were covered by dry grassy vegetation, including many steppe species and their phytocenoses. Wet and damp Calamagrostis meadows, carex-calamagrostis meadows and grassy swamps occupy flood plains and low terraces. The numerous water plant colonies are characteristic of those typically found in meandering lakes and river channels. The aquatic and shore vegetation of Lake Xingkai/Khanka also includes plants of old species, with the lotus and euriala being of most interest.

3.4 Fauna Biodiversity of the Lake Xinkai/Khanka Lowlands

3.4.1 Overview of Fauna Biodiversity

Further efforts are needed in order to obtain an accurate picture of the non-flordal biodiversity of the Lake Xingkai/Khanka drainage basin. Nevertheless, it is estimated that the drainage basin contains from one-third to one-half of the species known in Russia. Focusing on the Russian Far East, the drainage basin contains 61.5% of the mammal species, 65% of the bird species, 80% of the amphibian species, and 45.4% of the reptile species. These totals include 498 species of *Vertebrata* of *Chordata,* comprising 6 classes, 37 orders, 104 families, and 291 genera (Table 3-1). Considering only mammals, there are 61 registered species of 44 genera of 18 families of 6 orders.

Table 3-1. Taxonomic variety of animals in the Russian portion of the Lake Xingkai/Khanka drainage basin

Taxonomic group	Lake drainage basin	Russian Far East total	Russia total
Mammals	61	104	320
Bird	342	526	732
Amphibians	8	10	27
Reptiles	10	22	75
Lepidopterous	-	-	12000
Pisces	89	-	269
Mollusks	67	700	2000
Vascular plants	620	4500	11400

The current ornitho-fauna in the Lake Xingkai/Khanka drainage basin comprises 342 species. Of this number, 185 have been determined as authentically nesting in the basin, with an additional 7 species thought to nest there. During the winter period, 93 species were observed, with 28 other species being occasional visitors, and the remaining species appearing only during the seasonal migrations. The nesting habits of bird species in the Russian portion of the drainage basin is highlighted in Table 3.2. Fig 3-3 illustrates the waterfowl distribution in the Lake Xingkai-Khanka lowlands during the summer molting period.

Approximately 53% of all registered birds for this region have been observed to nest in the drainage basin. Further, the number comprises 69% of all nesting ornitho-fauna in Primorye. Among the waterfowl birds in the Prikhankaiskaya Lowland, *Anas platyrhynchos* 41.7% of total), *Anas querquedula* (30.2% of total) and *Aythya filigula* (15.8% of total) predominate.

To the present time, 333 species of birds have been recorded at the Khanka Nature Reserve. Forty-four of these species are included in the Red Book of Russia and 12 in the Red Book of International Union for Nature Conservation, which is a record for Russia.

The Chinese portion of the Lake Xingkai/Khanka drainage basin has relatively fewer groups of animals, related primarily to the degraded remaining natural biotopes, as well as an apparently high degree of anthropogenic transformation and fragmentation of sites.

Table 3-2. Biological variety of birds in the Russian portion of the Lake Xingkai/Khanka drainage basin

ORDER	Total number of species				Including nesting birds				Nesting Is presumed	Have nested in the past	New nests	Wintering birds	Visiting birds
	Total	Including rare for:			Total	Including rare for:							
		World	Russia	Far East		World	Russia	Far East					
Gaviiformes	2	-	-	-	-	-	-	-	-	-	1	-	-
Podicipediformes	5	-	-	3	4	-	-	3	-	-	1	-	-
Pelecaniformes	2	-	-	1	1	-	-	1	-	1	2	-	-
Ciconiidae	16	2	6	7	12	2	5	7	1	1	-	1	4
Anseriformes	36	1	9	15	15	-	3	7	1	1	-	3	2
Falconidae	27	1	11	15	16	1	5	10	-	1	-	15	2
Galliformes	5	-	-	2	5	-	-	2	1	1	-	5	-
Gruiformes	14	4	7	9	9	2	3	4	-	-	4	1	2
Charadriidae	65	1	8	14	17	-	2	5	-	-	-	1	10
Columbiformes	4	-	1	2	2	-	-	1	1	-	-	2	2
Cuculiformes	5	-	-	-	4	-	-	-	-	-	-	-	-
Strigiformes	10	-	1	2	8	-	1	1	-	-	-	8	-
Apodidae	2	-	-	-	-	-	-	-	-	-	-	-	-
Coraciae	2	-	-	1	2	-	-	1	-	-	-	-	-
Upupae	1	-	-	-	1	-	-	-	-	-	-	-	-
Picariae	10	-	-	-	9	-	-	-		-	-	8	-
Passeriformes	136	1	5	8	80	1	2	6	3	-	2	49	6
Total	**342**	**9**	**48**	**79**	**185**	**6**	**21**	**48**	**7**	**5**	**10**	**93**	**28**

Fig. 3-3 **Distribution of waterfowl during summer molting period in the Russian portion of the Lake/Khanka basin**

1. **Main places of concentration of molting ducks;**
2. **Main places of duck feeding during the period before and after molting;**
3. **Directions of daily feeding displacements; and**
4. **Main places of concentration of molting gray geese.**

The Lake Xingkai/Khanka drainage basin has 8 permanent species of amphibians (Table 3-3), representing two orders: *Caudata (Salamandrella keyserlingi)* and *Anura* (representatives of 4 families). Ten species of reptiles from two orders, 2 species of lizards and 7 species of snakes also have been recorded.

Table 3-3. Amphibians and reptiles in the Lake Xingkai/Khanka drainage basin

Latin name	Abundance of species
AMPHIBIANS	
Salamandrella keyserlingi	U
Bombina orientalis	S
Bufo raddei.	S
B. gargarizans	S
Hyla japonica	U
Rana nigromaculata	U
R. amurensis.	U
R. semiplicata	U
REPTILES	
Trionyx sinensis	S
Tachydromus amurensis	S
T. wolteri	C
Rhabdophis tigrina	R
Amphiesma vibakari	R
Elaphe rufodorsata	S
E. schrencki	U
E. dione	U
Agkiastrodon saxatilis	U
A. biomoffi	S

(U, usual; S, sparse; R, rare; C, casual)

Lake Xingkai/Khanka also contains a diversified ichthyofauna, determined primarily by the shallow depth of the lake and its hydrological regime. The ichthyofauna include 1 species of *Petromyzonidae* and 73 species of fishes incorporated in 58 genera, 18 families and 8 orders

The Lake Xinkai/Khanka drainage basin contains about one-quarter of all representatives of freshwater fish fauna in Russia. Based on its diversity, the freshwater fish fauna in the lake's basin has no analogs either in Russia or in the entire Paleoarctic region. The autochthonous species of Lake Xingkai/Khanka can be grouped as follows:

- Euroasian species, for which the Amur/Heilong River Basin represents their marginal, extreme southeastern extent;
- Endemic species of the Amur/Heilong River Basin (Amur Province, without Sakhalin);
- Species spread only in the Amur (Manchurian) transition region, or visiting Northern China through the Yellow (Huanghe) River; and
- Sine-Indian species, for which the Amur/Heilong River Basin is the border of their northern extent.

The first group consists of 14 fish species (20% of the total), including *Hucho taimen, Brachymystax lenok, Brachymystax savinovi, Thymallus arcficus, Phoxinus czekanowskii, Phoxinus perenurus, Phoxinus phoxinus, Rhodeus sericeus, Gobio gobia, Carassius aurutus, Nemacheilus toni, Cobitis granoei, Lota lota* and *Pungitius sinensis.*

The second group consists of 12 species (17% of the total), including *Acipenser schrenckii, Huso dauricus, Coregonus ussuriensis, Pseudaspius leptocephalus, Acanthorhodeus chankaensis, Squalidus chankaensis, Leptobotia mantschurica, Cobitis lutheri, Leiocassis brushnikawi, Leiocassis herzensteini, Mystus mica* and *Silurus soldatovi.*

The third group consists of 15 species (21% of the total), including *Lampetra reissneri. Esox reichertii, Leuciscus walecka, Phoxinw lagowska, Acanthorhodeus asmussa, Gnathopogon strigutus, Gobio soldatovi, Ladislavia taczanowska, Romanogobia tenuicorpus, Sarcocheilichthys czerska, Sarcocheilichthys soldatovi, Lefua costata, Leiocassis ussuriensis, Perccottus glenii* and *Rhinogobius similis.*

The fourth group consists of 30 species (42% of the total), including *Elopichthys bambusa, Hypophthalmichthys molitrix, Cutter alburnus, Chanodichthys mongolicus, Chanodichthys erythropterus, Chanodichthys dabryi, Hemiculter leucisculus, Hemiculter lucidus, Megillobrama terminalis, Parabramis pekinensis, Xenocypris argentea, Plagiognathops microlepis, Opsanichthys uncirostris, Rhodeus lighti, Abbottina rivularis, Gobiobotia pappenheimi, Hemibarbus maculatus, Hemibarbus tabes, Microphysogobia tungtingensis, Pseudorasbora parva, Sarcocheilichthys sinensis, Saurogohio dabryi, Ctenopharyngodon ideas, Mylopharyngodon piceus, Cyprians carpio, Misgurnus anguillicaudatus, Pelteobagrusfulvidraco, Parasilurus asotus, Siniperca chuatsi* and *Chasa argus.*

Three species of fish (*Hypophthalmichthys*, *Aristichthys nobilis* and pike-perch) were introduced to the lake. Table 3-4 summarizes the freshwater ichthyofauna of Lake Xingkai/Khanka, and Fig. 3-4 identifies the main spawning grounds for trade fish in the Russian portion of its basin.

Table 3-4. Composition of freshwater ichthyofauna of Lake Xingkai/Khanka (expressed as percent of total)

Northern forms	Endemics of Amu/Heilongr River	Endemics of Manchuria	Southern forms
20	17	21	42

Some of the fish species comprise important fisheries, including *Erythroculter erythropterus, Erythroculter mongolicus, Erythroculter oxycephalus, Hypophthalmichthys molitrix*, and Chinese perch, accounting for about 70% of the total fish catch.

The mollusks in Lake Xingkai/Khanka include 84 species of 28 genera and 15 families. *Gastropoda* comprise 55 species of 28 genera and 15 families, large bivalves comprise 21 species of 7 genera and 2 families, and small bivalves comprise 8 species of 4 genera and 3 families.

Fig. 3-4 **Location of major commercial fish spawning grounds in the Russian portion of the Lake Xingkai/Khanka drainage basin**

The most important benthic organisms are the mollusks, including the large bivalves *Nodularia*, *Sinanodonta,* and *Cristaria* and the gastropods *Hua,* and *Amuropaludina*, which also are common in the rivers of the drainage basin. Waterbodies in the basin's floodplain abound in various pulmonates, pectinibranchs (*Cipangopaludina, Boreoelona, Cincinna)* and large bivalves (*Anemina, Sinanodonta).* The greatest mollusk population density (ostracods) is observed on the silty bottom in the lower reaches of the rivers and in the southwestern section of the lake (Fig. 3-5). Other invertebrates, including various insects, worms and crustacea also are abundant among the benthos of Lake Xingkai/Khanka.

Based on botanical survey data, there also are 620 vascular plants of 345 genera of 108 families on the territory of the Khankaisky Nature Reserve. The distribution includes 30 species of trees, 40 species of bushes, 3 species of lianas, 9 species of half-bushes, 1 specie of semi-parasite, and 383 species of grass. Fig. 3-6 illustrates the biodiversity of wood ecosystems in the Russian portion of the Lake Xingkai/Khanka drainage basin.

The vegetation of the lake and the adjacent areas of the Prikhankaiskaya Lowland comprises a number of communities particular to eutrophic waterbodies. Comparative species of sedge (*Carex*), ranunculi, buckwheat, and water and wetland floral complexes also have been observed.

The lake phytoplankton is characterized by the relatively-constant presence of diatoms, which are most abundant in autumn. The most abundant phytoplanktons in summer are *Cyanophyta* of the genera *Microcystis, Gloeocapsa, Aphanothece* and especially *Anabaena*, whose growth usually continues until late-autumn. Algal blooms attributed to the mass development of *Cyanophyta* and colonial filamentous algae, coupled with diatoms, also have been observed.

Based on 1995 data, the Lake Xingkai/Khanka basin contained 180 species and intra-species of algae, including *Cyanophyta* (26 species), *Euglenophyta* (9 species), *Dinophyta* (1 specie), *Cryptophyta* (4 species), *Chrysophyta* (12 species), *Bacillariophyta* (64 species), *Xanlhophyta* (1 specie) and *Chlorophyta* (62 species).

In winter and spring, diatoms comprise the main phytoplankton biomass and species varies in the lake. In summer and autumn, the number of *Chlorophyta* species increases and their biomass becomes comparable to that of diatoms. In July and October, the phytoplankton biomass consists of approximately equal biomasses of the following species: *Snowella rosea,* species of diatom genera *Synechocystis, Gloeocapsa, Synechococcus, Merismopedia of Cyanophyta; Stephanodiscus, Cyclotella, Nitzschia, Navicula, Aulacoseira, Schroederia setigera Lemm., Ulothrix tenerrima Kutz.*, species of *Chlorophyta* and *Chrysophyta* from *Ankistrodesmus, Monoraphidium, Scenedesmus Dinobryon divergens lmh* and *Mallomonas tonsurata Teil* genera.

3.4.2 Biological Diversity of Birds in the Lake Xingkai/Khanka Drainage Basin

The characteristics of the bird populations were used to provide an estimation of the species biodiversity in the drainage basin. To this end, the drainage basin was sub-divided into three sites, including (i) the Prikhankaiskaya Lowland, (ii) foothills, and (iii) mountainous areas within the river basins draining into Lake Xingkai/Khanka.

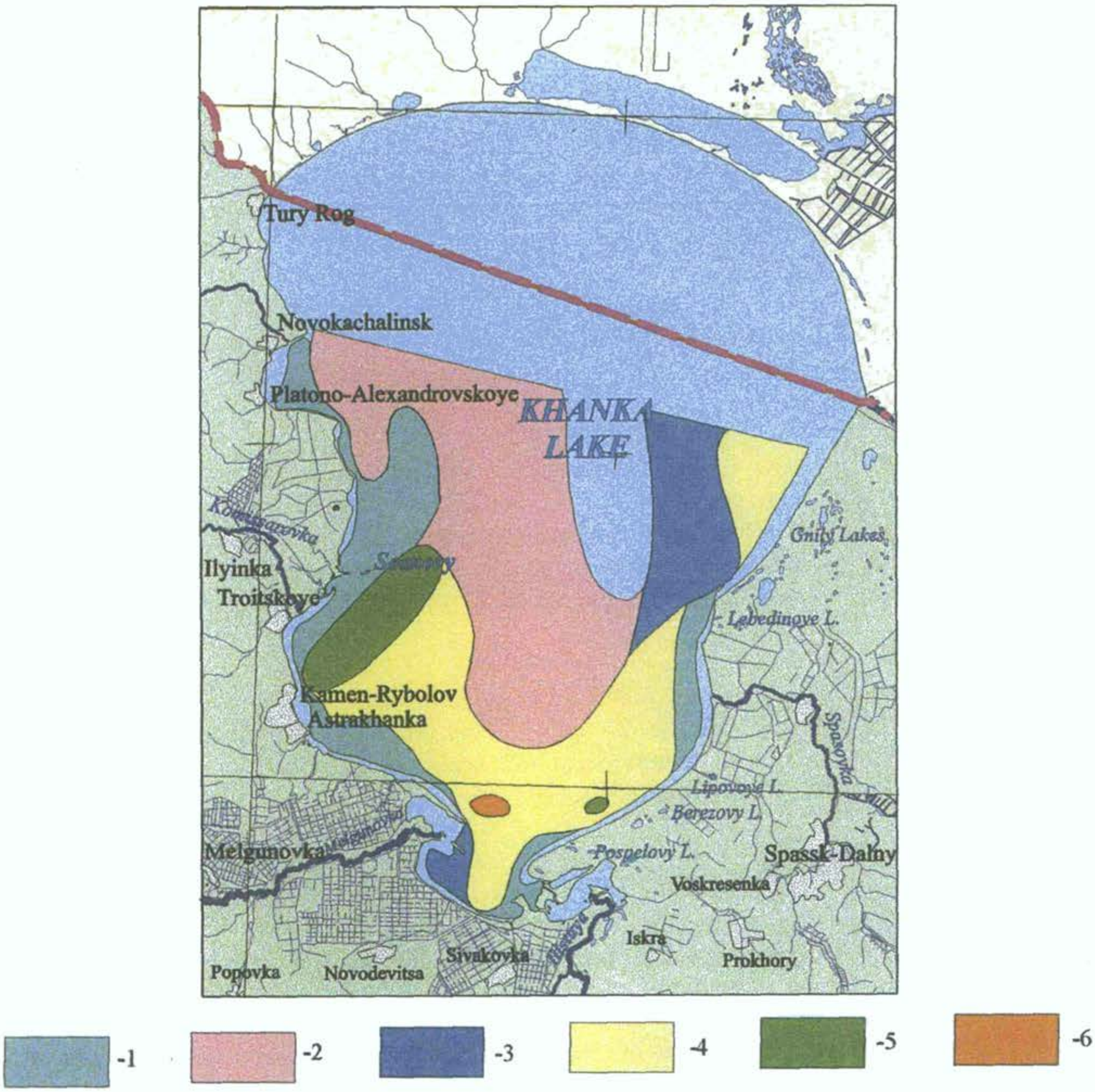


Fig. 3-5 Distribution of ostracods in Lake Xingkai/Khanka

I - 1-20 in a sample, 2 - 21-50, 3 - 51-100, 4 - 101-500, 5 - 501-1000, 6 - 1200 and more.

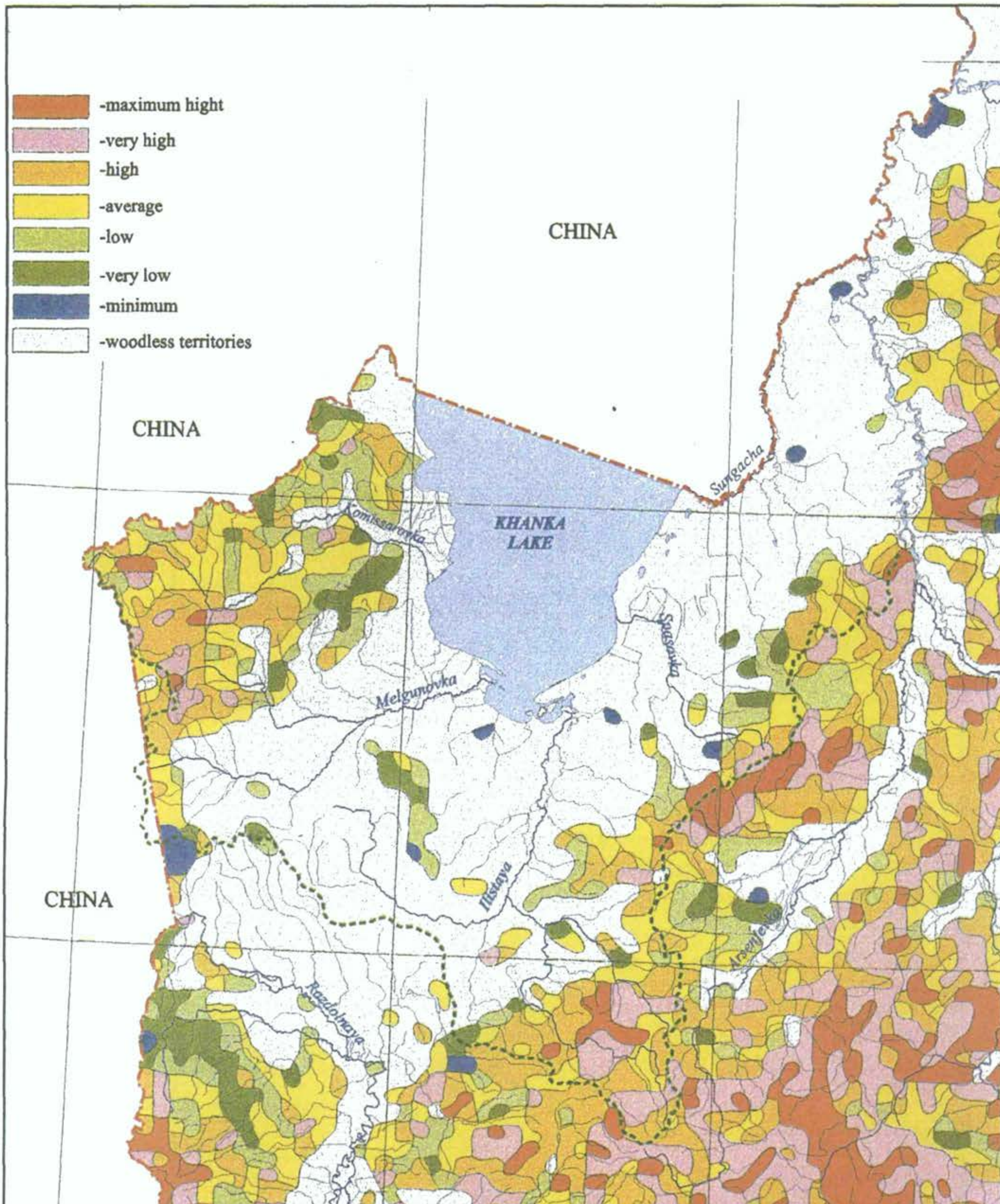


Fig. 3-6 Forest biodiversity of the Russian portion of the Lake Xingkai/Khanka drainage basin

Based on the composition of the bird populations, the greatest species diversity occurs in the Prikhankaiskaya Lowland (133 nesting species, representing 72.3% of the total species in this region). More than one-third of this number exists only in this region, not being found in either the middle or upper courses of the rivers. Ducks are numerous in the Lowland during seasonal migrations. Nesting colonies of seagulls, terns and herons also have been observed in the Khanka Nature Reservoir for a long period.

In the middle courses of the rivers, 115 species have been identified (63% of the total species in this region). Only five of these species (*Surnia ulula, Columba rupestris, Lyrurus tetrix, Pandion haliaetus* and *Falco peregrinus*) are considered relatively permanent residents of this region. Seventy-six nesting species of birds (41.3% of the total species in this region) have been recorded in the mountainous upper course of the rivers. However, the information for this region is incomplete, and it is possible that an additional 8-10 nesting species may exist here in this region, including *Regulus regulus, Tarsiger cyanurus, Pyrrhula cineracea, Ficedula mugimaki, Sitta villosa* and *Buteo buteo*.

The Chinese portion of the drainage basin also contains significant and spectacular bird populations. It is estimated that more than 10,000 birds rest and feed in spring and autumn each year. Based on the available information, the observed bird populations comprise 16 orders, 39 families and 180 species. Among the endangered species included among the Chinese national first-class protected birds are the Red-crowned Crane (*Grus japonensis*), Oriental White Stork (*Ciconia boyciana*), White-tailed Sea Eagle (*Haliaeetus albicilla*), Gold Eagle (*Aquila chrysaetos*), Spoonbill (*Platalea leucorodia*), White-fronted Goose (*Anseu albifrons*), Whooper Swan (*Cygnus Cygnus*), Mandarin Duck (*Aix gaoericuoata*) and White-naped crame (*Grus vipio*). Both the Red-crowned Crane and White-naped Crane are important protected birds. There also are 8 bird species included on the Chinese national second-class protected birds.

3.4.3 Bird Population Dynamics as Indicators of Biodiversity Losses

The dynamics of the former and existing bird populations in the Russian portion of the drainage basin provide a model for estimating biodiversity loss. This is due to the fact that birds (i) have a high ecological integrity, (ii) have unlimited mobility, and (iii) respond to changes in habitat enviroment. Based on the available data, several bird species were examined, as follows:

- *Nipponia nippn* -- This ibis species previously nested in small numbers along the Song'acha River, and in the middle course of the Llistaya River. At the present time, however, the species appears to have disappeared, and no nesting birds can be found anywhere in the Lake Xingkai/Khanka drainage basin. Its disappearance is attributed to anthropogenic transformations of its habitats (drainage, tillage, destruction of forest vegetation, etc.) as well as hunting activities.

- *Cygnus olor* -- Early in this century, this species nested both around Lake Xingkai/Khanka and near lakes in southern Primorsky Kray. However, only one sighting of this bird has occurred in the second half of this century (April, 1966), changing its status from a resident to a visiting bird species.

- *Lyrurus tetrix* -- In the early part of this century, this species nested in small numbers on the Prikhankaiskaya Lowlands and in adjacent foothills. Its non-breeding visitations also were numerous. Currently, however, representatives of this species have only occasionally been seen in the Song'acha River valley. The data suggest that the eastern border of the areal extent of this bird species has been displaced to the northwest, possibly as a result of complex anthropogenic impacts.

- *Otis tarda* – Data regarding the nesting habits of this species are only available for the last century, and it is presumed that it nested in the drainage basin. This species is now only irregularly seen in the region, however, being attributed to anthropogenic factors, including cultivation of Lowland steppe sites.

Overall, the disappearance of these and other species in the Prikhankaiskaya Lowland is attributed to anthropogenic factors. Other species also appear to be under significant threat in the drainage basin, including *Platalea leucorodia, Ciconia ciconia, Cygnopsis cygnoid, Grus vipio Pall, Limosa limosa, Suthora webbiana, Haliaeetus albicilla* and *Perdix daurica.* Distribution of Grus japanesis and Ciconiaboyciana is indicated in Figs. 3-7 to 3-9. A number of natural and anthropogenic factors, including grassy fires, habitat disruption and landscape transformation, have been cited as causative factors of this situation.

3.5 Primary Anthropogenic Impacts on Biodiversity in the Russian Prikhankaiskaya Lowlands During the 20th Century

A number of anthropogenic changes have affected the biodiversity of the Prikhankaiskaya Lowlands in Russia during the 20th Century. These changes include (i) cultivation, transformation and land drainage, (ii) alteration of vegetation and vegetative cover, (iii) fires in grassy and tree-bush environments, (iv) pasturing of cattle and other forms of agriculture, as well as pollution resulting from such activities, (v) hunting and fishing, including illegal shooting and catching of fish, and (vi) spontaneous and organized recreation in natural locations, as discussed below:

3.5.1 Cultivation, Transformation and Drainage of Land

The area used for growing of rice covered approximately 65,400 ha in 1985, with the most suitable sites being the leveled lands of the Russian Prikhankaiskaya Lowlands. These sites were previously crude meadows and low bogs, and their area has been reduced by a factor of 10 over the years. The reduction in these habitats, due to transformation of land for rice growing, has caused a significant decrease in the number of waterfowl and water birds in these areas. For example, the meadow and bog areas in the Lowlands suitable for nesting of *Anas platyrhynchos, Anas cressa* and *Anas akuta* were reduced, and the protective function of moulting sites decreased. At the same time, however, a plentiful and constant source of forage subsequently appeared, providing an accumulation of energy stocks of migrating birds in the spring and autumn seasonal cycles.

Fig. 3-7 Distribution of *Grus japonensis* on the Prikhankaiskaya Lowland in 1978-1987

1. Borders of nesting areas;
2. Best places for nesting; and
3. Main places of concentration of birds not nesting.

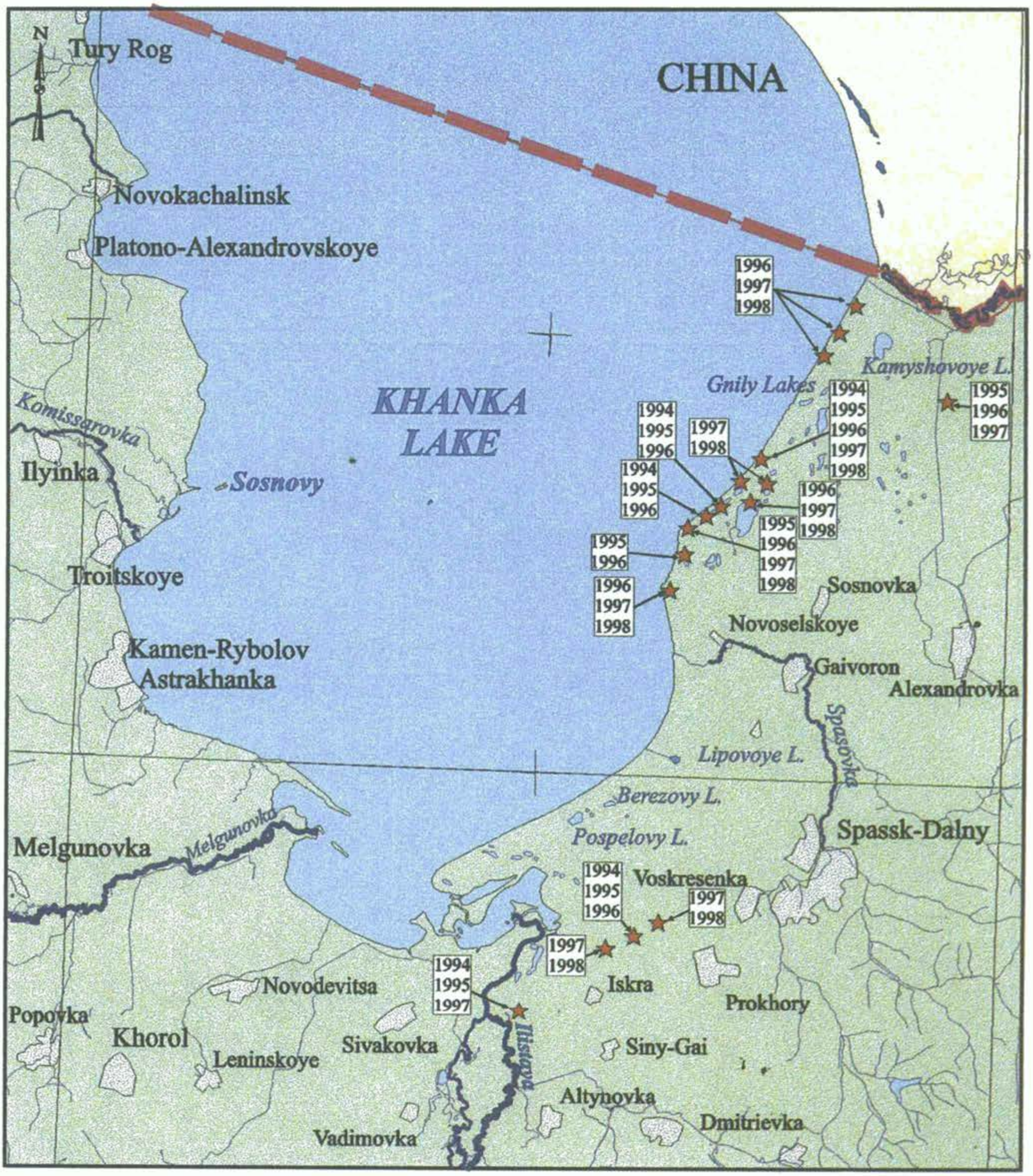
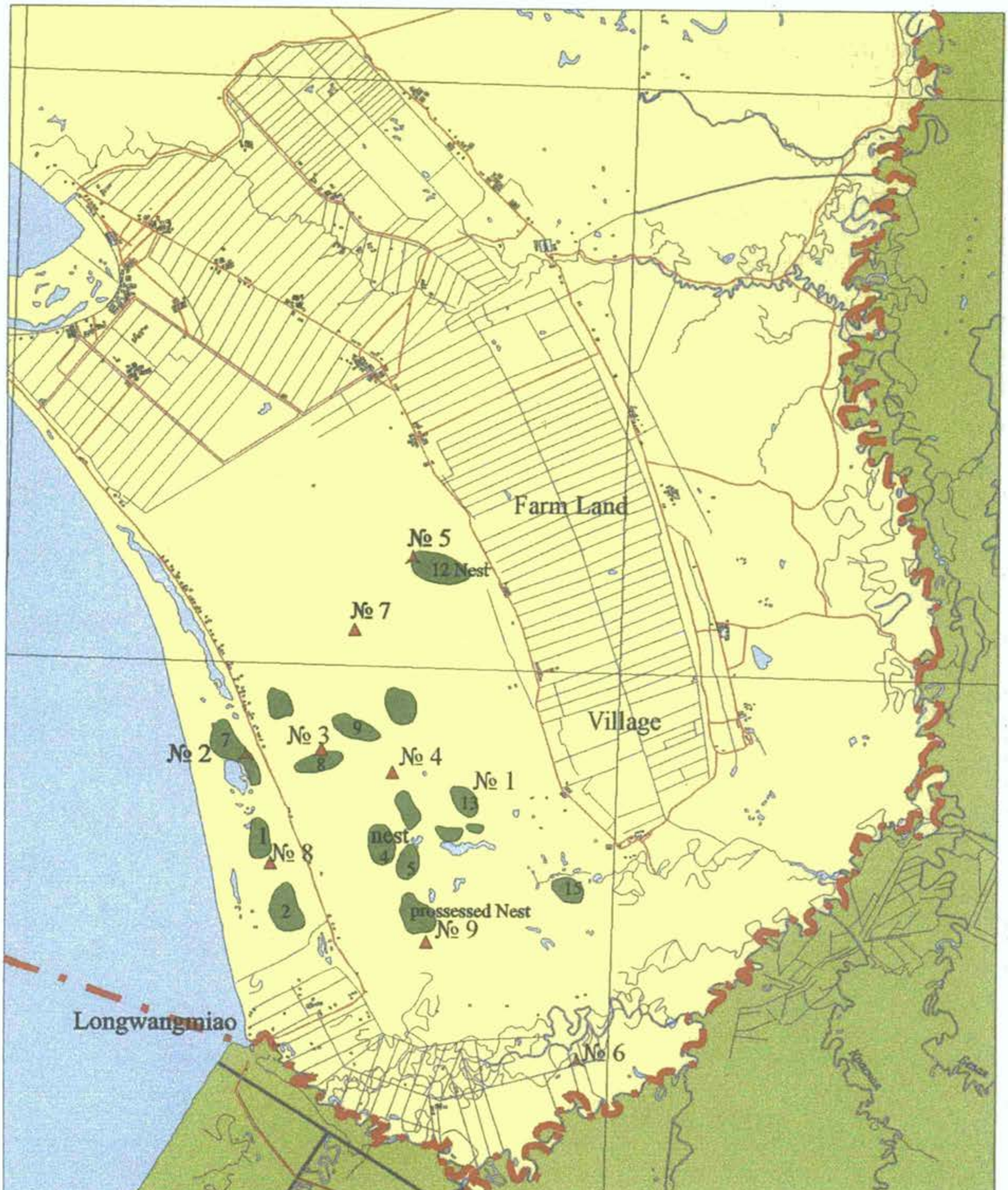


Fig. 3-8 **Distribution of Oriental White Storks (Ciconia boyciana) in Prikhankaiskaya Lowland in 1994, 1995, 1997 and 1998**

★ -occupied nests



▲ Artifical nest of oriental White Stork

⅄ Naturall nest of Oriental White Stork

Fig. 3-9 **Distribution of Red Crowned cranes (*Grus japonensis*) and Oriental White Stork (Ciconia boyciana) in the Chinese portion of the Lake Xingkai/Khanka drainage**

A significant decrease in the rice-growing areas in the 1990s has affected the distribution of birds in the Russian Prikhankaiskaya Lowlands, including a significant migration of birds to fields in China, a reduction in the length of time that migrating birds remain in the drainage basin, and a reduction in the total number of flying ducks and geese. It is expected that this trend will continue in the future.

3.5.2 *Cutting of Trees and Bushes, and Changing Vegetation Status*

Even though the natural forest cover in the Lake Xingkai/Khanka drainage basin has changed over time, there are still original types of vegetation in the basin in various stages of succession. Before a period of relatively intensive development in the 1960s and 1970s, the Prikhankaiskaya Lowland in Russia was characterized by a prevalence of forestless spaces above forest-covered area. The western parts of the Lowlands were dominated by oak forests, stepped sparse trees and oak-lespedeza-nutwood forests, while the eastern parts were dominated by mezofil marple-lime forests, and çomplexes of stepped grass and calamagrosris meadows and grassy bogs. The vegetation characteristics of these regions, however, have experienced major alterations with their subsequent economic development. The stability of the vegetative cover to anthropogenic impacts is illustrated in Fig. 3-10.

3.5.3 *Fires*

The burning of grassy vegetation is a major factor affecting the Lowland bird populations. The specific impacts of the fires, however, have varied in different years, however, depending on such factors as the precipitation patterns and the water level of Lake Xingkai/Khanka. During the periods of autumn 1977- spring 1978 and autumn 1979 - spring 1980, for example, the burned areas comprised 90% of the wetland areas and 55% of the crude meadow areas. In the subsequent periods of major fires (spring 1986 and May 1987), the burned areas extended to the mouth of the Melgunovka River and Maly Khankaichik Bay, from the mouth of the Spasovka River to the Song'acha River, and to the Llistaya River delta.

After creation of the nature reserve (see the following section), the degree of burning decreased considerably. Nevertheless, the longer-term impacts of major fires include the destruction of animals and birds and their habitats, decreased protective conditions, and decreased biodiversity.

3.5.4 *Pasturing of Cattle*

A noteworthy negative influence affecting bird reproduction is the sensitivity of birds to the pasturing of cattle in their habitat areas. Unfortunately, cattle pasturing is typically carried out in many areas that are important for bird nesting and reproduction, including wet meadows, swamps and lakes. Cattle densities of over 1,600 cows/50 km^2 have been observed in the drainage basin. Although the total number of pastured cattle has decreased in recent years, the pasturing of cattle has become uncoordinated and poorly controlled, and the negative impacts of this practice may persist into the future.

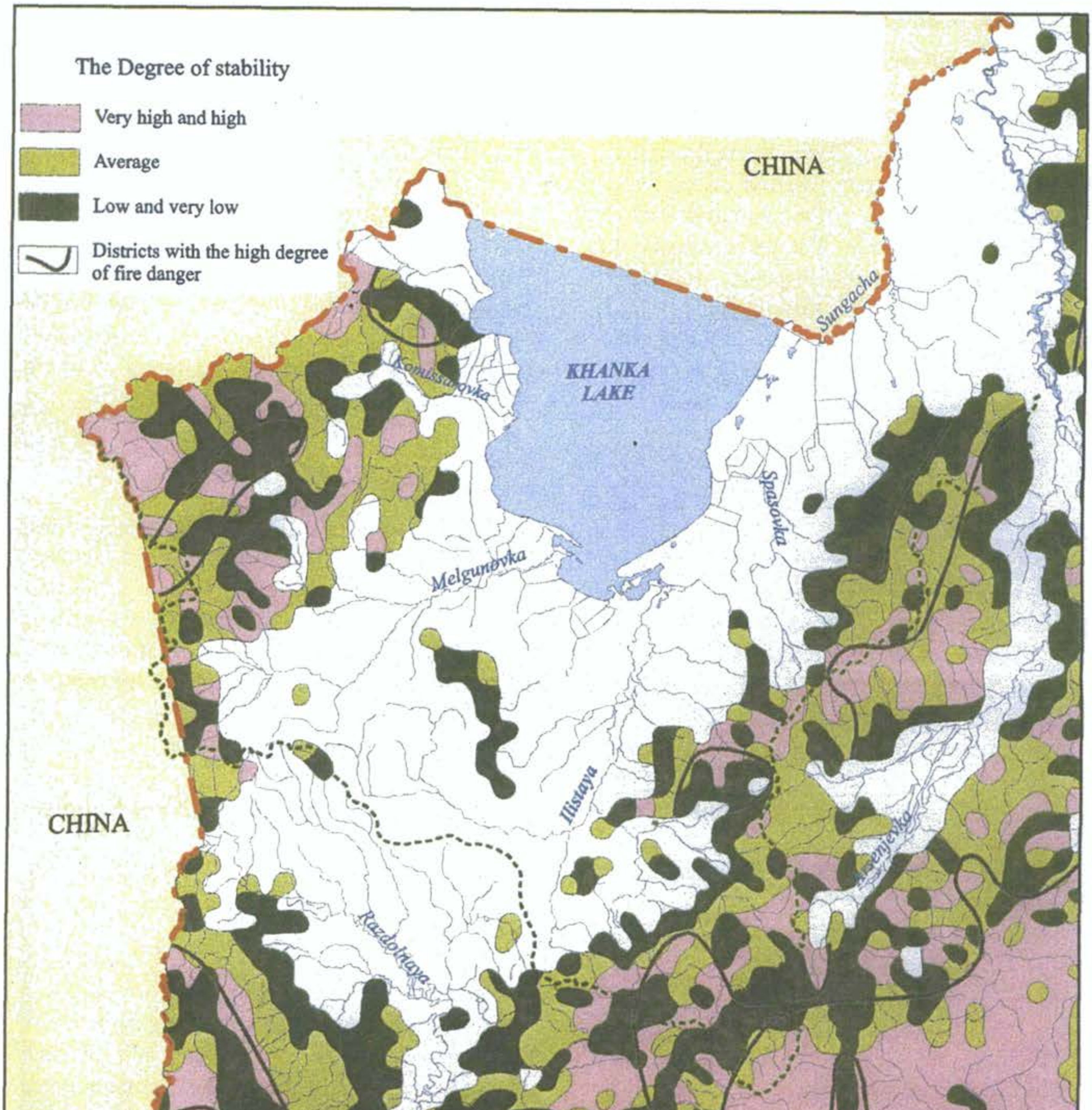


Fig. 3-10 Forest stability of vegetation in the Russian portion of the Lake Xingkai/Khanka drainage basin

3.5.5 Hunting

Sports and professional hunting is allowed on the greater part of both the Prikhankaiskaya Lowlands and the entire Lake Xingkai/Khanka drainage basin. The primary hunting activities are directed to mammal and bird species. There also are hunting farms, with the main hunting targets being hoofed animals (roe, wild-boar), furred animals (ondatra, kolinsky, mink, fox, wolf, and waterfowl birds) and bog and field game. The hunting intensity, expressed in terms of numbers of animals caught, is as follows: waterfowl - tens of thousands; pheasant - thousands; snipe - thousands; mink, fox and roe - hundreds; wild boar and wolf – tens.

There appears to be no threat of extinction or loss of biodiversity for any of the above-noted hunting targets. However, the number of hoofed animals appears to be showing a decreasing tendency, and there is some concern about similar patterns for pheasant. Overall, however, the hunting population appears to be maintained at a relatively safe level.

Spring hunting for waterfowl takes place primarily in the Prikhankaiskaya Lowland area of Russia. Data for the last ten years suggest that between 7,000-13,000 ducks and up to a thousand geese have been caught. However, counting the illegal shooting, it is estimated that the actual total is approximately 21,000-28,000 ducks, and up to 2,000 geese. This is of some concern primarily because of the tendency of a decreasing aggregate number of migrating river ducks and geese observed in the spring (due possibly to reduced fodder stocks). Additional studies are necessary to confirm this observation.

3.5.6 Fishing

Fishing is one of the important economic branches in the drainage basin, being conducted in Lake Xingkai/Khanka and in rivers, meliorate channels and other reservoirs in the basin. Based primarily on Russian data, the total volume of fish caught in the lake during 1932-35 was about 3,000 tons. For the last ten years, however, the fish catch has not exceeded 150 tons.

There are both direct and indirect impacts on fish biodiversity in the Lake Xingkai/Khanka drainage basin. The direct impact is related to the significantly increased volume of fish caught in Lake Xingkai/Khanka and other nearby lakes, which has reduced the fish stocks. This is exacerbated by the uncoordinated regulation of fishing in the Russian and Chinese portions of the drainage basin, as well as a progressive contamination of rivers by industrial and agricultural pollution.

Data on the volumes of main trade fish species caught in Lake Xingkai/Khanka during 1960-1989 and during 1991-1995 are summarized in Tables 3-5 and 3-6, respectively, and illustrate the notable reduction in the total catch over time. Up to approximately 1954, *Erythroculter oxycephalus* was the main trade fish in the lake, making up about 57-65% of the total fish caught. During 1977-88, small-sized fish comprised 56% of the total catch, including *Erythroculter oxycephalus* and others.

Such species *as Cyprians carpio, Carassius aurutus* and *Erythroculter erythropterus* currently make up about 98% of the catch of Russian fisherman. The changed catch structure for the lake during recent years suggests that valuable trade fish have already been decreased to critical levels.

A complicating factor is that amateur fishing typically increases significantly during periods of economc uncertainty or instability. In 1995, for example, the total fish catch of amateur fisherman was approximately 16 tons. It is estimated that Russian amateur fisherman catch about 15% of the total volume of fish caught in Lake Xingkai/Khanka.

Table 3.5 Annual catch of Russian trade fish in Lake Xingkai/Khanka during 1960-1989 (expressed in tons)

Fish	Year						
	1960	1965	1970	1975	1980	1985	1989
Cyprians carpio	83.3	65.5	28.5	42.8	24.2	27.9	15
Carassius aurutus	26.3	39	15	27.4	1.6	3.7	1.4
Erythroculter erythropterus	25,.	32.2	15.9	16.9	14.2	29.1	36.8
Erythroculter mongolicus	15,4	0	0	13.2	30.7	12.5	17.3
Esox reichertii	20.5	0	82.5	20.1	0	8.6	1.1
Silurus soldatovi	15.7	18.6	9.7	16.2	4.9	7.7	3.3
Hypophthalmich thys molitrix	0	0	0	0	0	0	0.1
Chasa argus	0	0	0	19	0	0	0.2
Leiocassis	0	0	0	0	0	0	6.7
Erythroculter oxycephalus	0	0	0	94.5	144.6	56	0
Small-size fish	76.3	84.7	127.4	1.1	0	49.3	126.3
Total	263.3	240	279	251.2	220.2	194.8	208.2

Table 3.6 Annual catch of Russian trade fish in Lake Xingkai/Khanka during 1991-1995 (expressed in tons)

Fish	Years				
	1991	1992	1993	1994	1995
Cyprians carpio	10,765	21,355	37.77	34.16	27.15
Carassius aurutus	1,093	9,418	11.57	12.75	7.84
Erythroculter erythropterus	18,606	19,91	21.45	16.52	12.35
Erythroculter mongolicus	4,613	5,479	4.21	4.17	4.67
Silurus soldatovi	4,203	6,298	7.91	8.14	4.54
Hypophthalmic hthys molitrix	0	0	0	3.13	0
Erythroculter oxycephalus	15,024	29,540	12.63	5.77	11.79
Others	40,587	56,573	26.76	3.15	2.38
Total	94,891	148,573	122.30	104.85	87.43

The number of valuable fish species (e.g., *Cyprians carpio*) has been reduced by at least one-half over time. On the other hand, fish breeding activities have increased significantly in the Chinese portion of the drainage basin. It is expected that the reduction in agricultural activities in the drainage basin, including the associated reduction in water pollution from herbicides and fertilizers, as well as a reduction in water withdrawal from the lake, should have a positive impact on the ichtyofauna status of the Prikhankaiskaya Lowlands.

3.5.7 Recreation and other anthropogenic impacts

There are no accurate estimates of the pollutant loading to Lake Xingkai/Khanka from recreational activites in its drainage basin. The primary recreational activities include the previously-mentioned sports fishing, as well as general rest and relaxation. Most of the impacts are manifested near large settlements (Spassk-Dalny, Kamen-Rybolov, Chernigovka, etc.). It is noted, however, that there is a considerable increase in recreational activities occurring at the same time (April – May) that there is a major influx of nesting birds, including waterfowl. The presence of large numbers of humans in the proximity of their sensitive nesting areas doubtlessly further increases the stress to resident and migratory bird populations.

In addition to the previously-noted impacts related to forest fires in the drainage basin, the intensive cutting of trees and bushes on the shoreline of Lake Xingkai/Khanka and other basin rivers that are related to tourism also have negative ecosystem impacts. Noting that a large part of the forest vegetation is already deteriorated, such additional impacts are of environmental concern. Accordingly, a rationale scheme for the safe utilization of the recreational resources in the Lake Xingkai/Khanka drainage basin is a worthy goal for consideration by the two riparian countries.

3.6 Protected Nature Territories in the Lake Xingkai/Khanka Drainage Basin

3.6.1 Khankaisky State Nature Reserve in Russia

The Russian portion of the Lake Xingkai/Khanka drainage basin currently has three categories of protected nature territories, including nature monuments, wetlands of international significance and the Khankaisky State Nature Reserve (Fig. 3-11).

Of particular interest to the environmental integrity of the Russian portion of the drainage basin is the Khankaisky State Nature Reserve. The Reserve was developed to fulfill obligations under the the Ramsar Convention. Although the melioration of wetlands had not begun during the signing of the Ramsar Convention, the Union of Soviet Socialit Republics (USSR) nevertheless declared a 310,000 ha area in the Lake Xingkai/Khanka drainage basin being within the provisions of the convention.

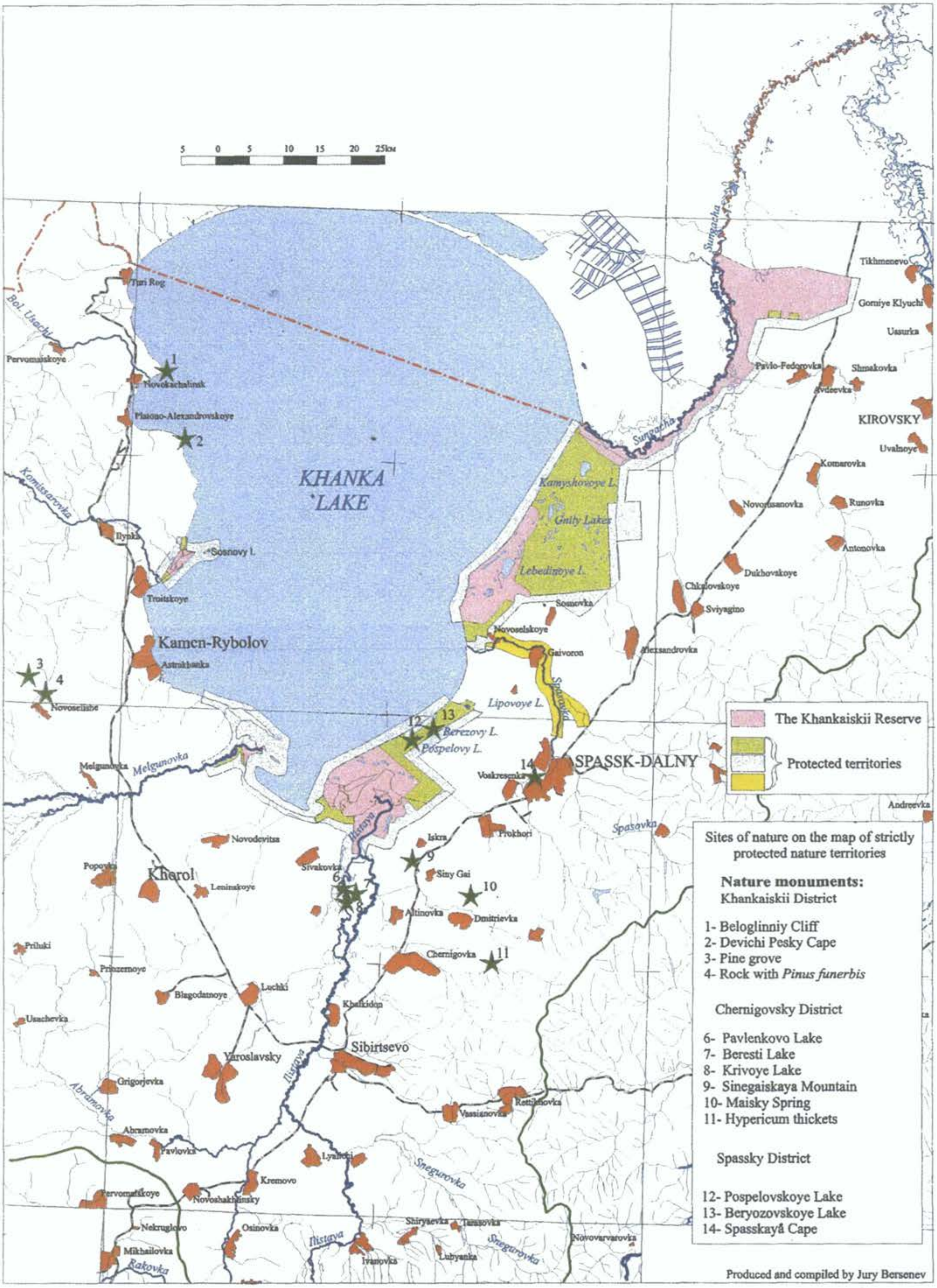


Fig. 3-11 Present system of specially protected natural territories in the Russian Portion of the Lake Xingkai/Khanka drainage basin

The Khankaisky State Nature Reserve was created by Enactment of the RSFSR Council of Ministers No. 616 (28 December 1990). Enactment of Primorskii Kray Governor No.185 (29 April 1999) increased the size of the Reserve area in the Khorolsky District by another 1,300 ha. The present area in the various Russian districts of the Lake Xingkai/Khanka drainage basin is as follows: Kirovsky District - 16,641 ha; Spassky District - 19,707 ha (the Republican Khankaisky Zakaznik is completely included in the Reserve); Chernigovsky District - 966 ha; Khorolsky District - 300 ha, and Khankaisky District - 377 ha. The total Reserve area covers 37,989 ha, with the lake covering 5,690 ha.

The nature protection complex in the Russian portion of the Lake Xingkai/Khanka drainage basin comprises four gradations; namely (i) sites of the Khankaisky State Nature Reserve, (ii) specific protected zone, (iii) protected zone of special assignment, and (iv) protected zone of common assignment, with each zone having its specific protection regime. The protected zones of the Reserve were allocated by enactment of Primorsky Kray Administration No. 243 (19 July 1990), with a total area of 73,743 ha, including the the specific protected zone (34,803 ha), the protected zone of special assignment (2,600 ha), and the protected zone of common assignment (36,340 ha). Enactment of Primorsky Kray's Governor No.185 expanded the area of the protected zone of common assignment by 780 ha.

The territories in the Reserve are not protected from human activities. Rather, any economic activity deemed environmentally harmless to the nature complexes in the State Reserve can be conducted, provided that appropriate regulations are followed. In the territory of the protected zone of common assignment, for example, activities such as the cutting of trees and bushes, burning of vegetation, hunting, storage or use of fertilizers and agrochemicals, fishing, harvesting of plants, berries, mushrooms and medicinal raw materials, and certain construction activities are forbidden. Similarly, such activities as warehousing of fertilizers, agrochemicals, agricultural aviation, cutting of trees and bushes, waste discharges, machine washing and the collection of insects are forbidden in the protection zone of special assignment. The management and coordination of maintenance of the nature protection regime in the protected zones is the responsibility of the State Nature Reserve, with monitoring carried out by the Reserve's security service.

Unfortunately, the relatively small size of the Reserve territory (only 14% of the total land area declared by the USSR during the signing of the Ramsar Convention) does not allow for proper protection of the regional biodiversity. A number of marshlands of significance under the provisions of the Convention also were not included in the Reserve. Further, there are numerous urban settlements in the Reserve area, whose inhabitants have used the natural resources of the region (hunting, fishing) for their own needs for many generations. The lack of sufficient Reserve area boundary markings also complicates the situation.

The Reserve territory presently contains 616 species of vascular plants from 343 genera of 107 families, including 49 rare and endangered species, as well as 523 species of algae. It also contains 48 species of mammals, including 4 species listed in the Red Books of the USSR and Russia, 7 species of reptiles (including *Trionyx sinensis Strauch*, listed in the Red Book), 6 species of amphibians, 60 species of fishes (2 species listed in the Red Book), and 12 rare and endangered species of insects. Also documented have been 333 species of birds. There are no other territories in Russia containing as many species of birds (44) listed in the Red Books of IUCN and Russia.

As an overall observation, the system of specially-protected nature territories in the Russian portion of the Lake Xingkai/Khanka drainage basin requires further attention, including solutions to conflict problems in the protected zones, maintenance of a special protection regime, and protection of existing (and building of new) nature monuments, all of which will require additional finances.

3.6.2 *Lake Xingkai Nature Reserve in China*

The Lake Xingkai Nature Reserve in China comprises the lake's littoral zone and the south part of Mishan City, Heilongjiang Province (Fig. 3-12). The Nature Reserve was established in 1986, and subsequently renamed as the National Nature Protection District in 1994. It includes the aquatory, wetlands and partial forests, as well as some settlements, agricultural lands, and aquaculture sites. There are about 15,000 people living in the Nature Reserve, which also contains about 870 km^2 of farmland.

The Nature Reserve is 90 km in length, and covers a total area of 3,460 km^2. It is composed of a core area (758 km^2), buffer area (1,467 km^2) and an experimental area. The buffer area was established in the surroundings of the core area, and includes parts of primeval ecosystems and semi-developed regions in a period of transition. Various protection areas for plants and animals have been established in different portions of the Nature Reserve (Table 3.7).

Table 3.7 Distribution of land in the Lake Xingkai Nature Reserve in China

Type	Total	Water	Swamp	Woods	Sandy areas	Deserted lands	Agricultural land	Residual land	Traffic roads
Area	3,460	1,565	523	225	0.07	208	870	39	30

The Nature Reserve contains a variety of plant and animal species. The available data indicate the plant resources comprise 53 orders, 104 families, 477 genera, and 1,060 species, including a variety of major species of trees, bush and liana, herbs, marshy wetland vegetation, aquatic plants, float-leaved plants and standing plants. The wild animal resources include vertebrates comprising 6 classes, 33 orders, 73 families, 176 genera, and 281 species. Four of the wild animal species are listed in the Chinese first national class of protected animals, and 34 species are listed in the second class of protected animals.

Birds are the main protected animals in the Lake Xingkai/Khanka Nature Reserve, which is a main breeding place for rare birds in Heilongjiang Province. The lake area is characterized by a unique diversity of birds, either breeding species or species that migrate through the area. It is estimated that more than ten thousand birds rest and forage for food in spring and autumn each year in the Nature Reserve. This total comprises 16 orders, 39 families and 180 species.

The Chinese first national class of protected birds includes *Grus japonensis, Grus leucogeranus, Haliaeetus albicilla*, and *Aquila chrysaetos*, while *Platalea leucorodia, Anseu albifrons, Cygnus cygnus, Aix gaoericuoata* and *Grus vipio* belong to the second national class of protected birds.

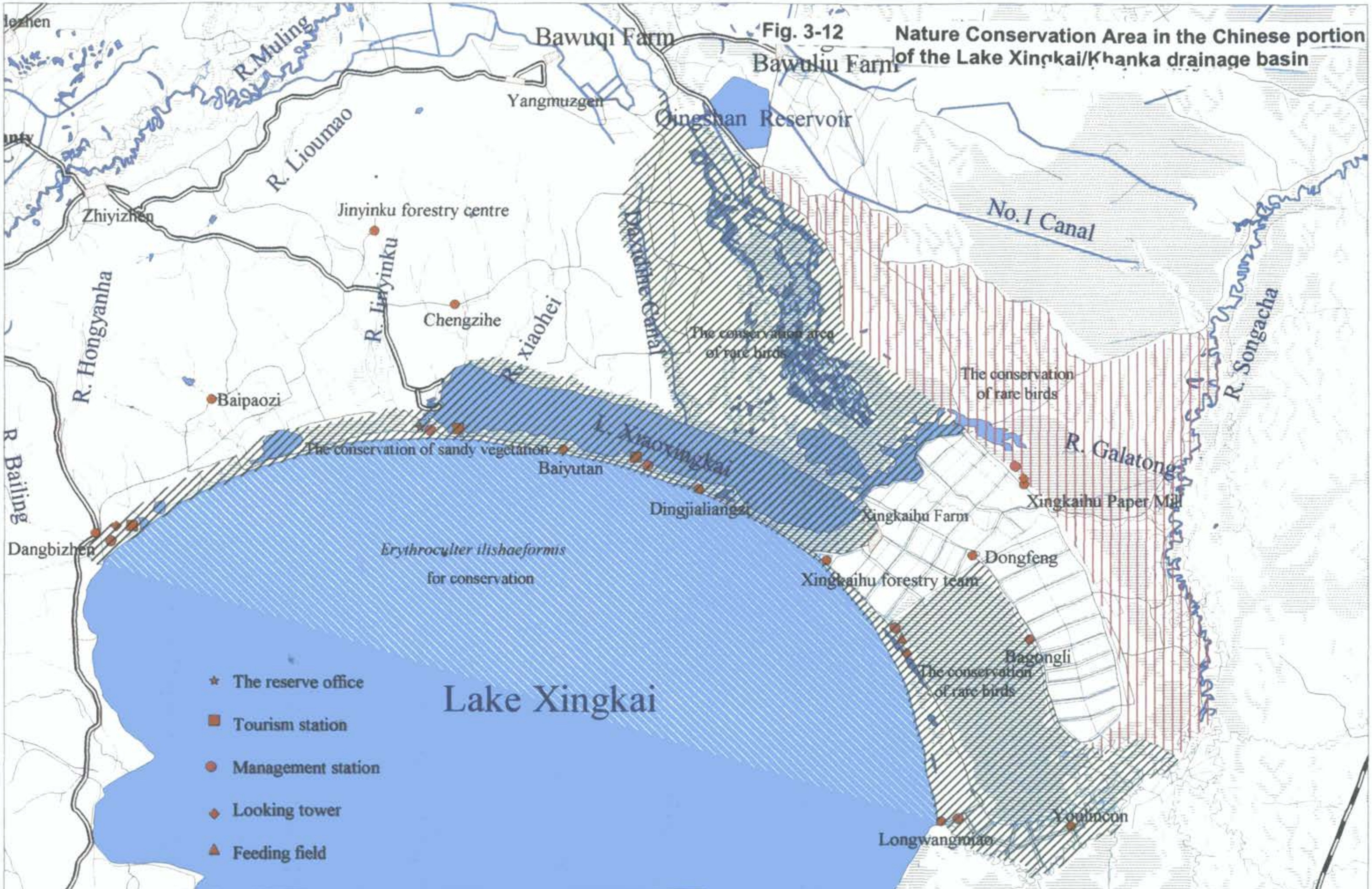


Fig. 3-12 Nature Conservation Area in the Chinese portion of the Lake Xingkai/Khanka drainage basin

In regard to protected animals, there are 6 orders, 14 families and 39 species in the Nature Reserve, with *Selenarctos thibctanus, Lutra lulra lepus timidus* and *Cervus elaphus* listed in the second national class of the protected animals. There also are 6 species of amphibians in 4 orders residing in the Nature Reserve, particularly in the grass marshland or hill forest areas surrounding the lake. There also are 7 species of 2 orders and 3 families of reptiles in the Nature Reserve.

Focusing on rare and endangered species, there are 53 species of priority-protected animals in the Nature Reserve, including some listed in the Chinese first national class of protected species. Major endangered animal species include *Grus japonensis, Grus leucogeranus, Haliaeetus albicilla, Aquila chrysaetos* and *Selenarctos thibctanus*. There also are a number of wild plant species, including medicinal plants and the endangered Xingkai pine, in the Nature Reserve.

3.7 Continuing Negative Habitat and Ecosystem Modifications Affecting the Biological Diversity of the Lake Xingkai/Khanka Drainage Basin

Prior to around 1950, the area surrounding Lake Xingkai/Khanka was relatively undeveloped, with abundant wildlife and sparse human population. Subsequently, however, both natural and anthropogenic activities have begun to have significant impacts on the habitats and biological diversity of the lake's drainage basin, as follows:

- *Agricultural development activities are directly encroaching on many wetland areas* – Between the 1950's to the present time, the total area of cultivated wetlands has been about 260 km^2. However, agricultural development activities are resulting in a slow, continuing conversion of wetlands into agricultural lands, with the encroachment area comprising about one-fourth of all the wetland areas in the Lake Xingkai/Khanka drainage basin. Over time, the ecological landscape in these areas is being transformed into a mixed ecosystem of wetlands and agricultural landscapes. The rate of conversion of wetlands is about 1 km^2 per year. This continuing reduction of wetland area directly threatens the survival of wild plants animals and plants (Fig. 3-13 for wetland conversion in the Chinese portion of the Lake Xingkai/Khanka drainage basin). It also has negatively impacted the biodiversity in the area, influencing both the quantity and types of species present. Some rare species, in fact, have since become extinct, or else are on the verge of disappearing.

- *Agricultural development activities have lowered the groundwater table* – Because of the water needs of agricultural activities, the agricultural development occurring in the drainage basin is also the primary factor affecting the level of the groundwater in some areas. This phenomenon has resulted in changes in the ecological environment of wetlands, including degradation of marshy vegetation and the destruction of wetland wildlife habitats. With continuing agricultural development, this trend is likely to continue into the future.

- *Increasing human population in the Nature Reserve areas* – There are about 15,000 residents in the Nature Reserve areas. However, the population from tourism development can reach 150,000 persons/year. This trend has developed rather rapidly, and it is estimated that the annual tourist population will increase to 180,000 by the year 2000. The range of anthropogenic activities associated with this increased tourist population (increased need for natural resources, increased waste production, increased pollution, etc.) has, and will continue to have, a negative impact on the biological diversity in the Lake Xingkai/Khanka drainage basin.

- *Impacts of natural disasters on the status of ecosystems* – Natural disasters in the drainage basin (fires, floods, etc.) also can seriously impact the status of habitats in the Nature Reserve areas. Two fires in protected areas in 1992 an 1993, for example, destroyed a sufficiently large area that birds and other animals were forced to move closer to human-inhabited areas, affecting their nesting habits and their reproduction potential.

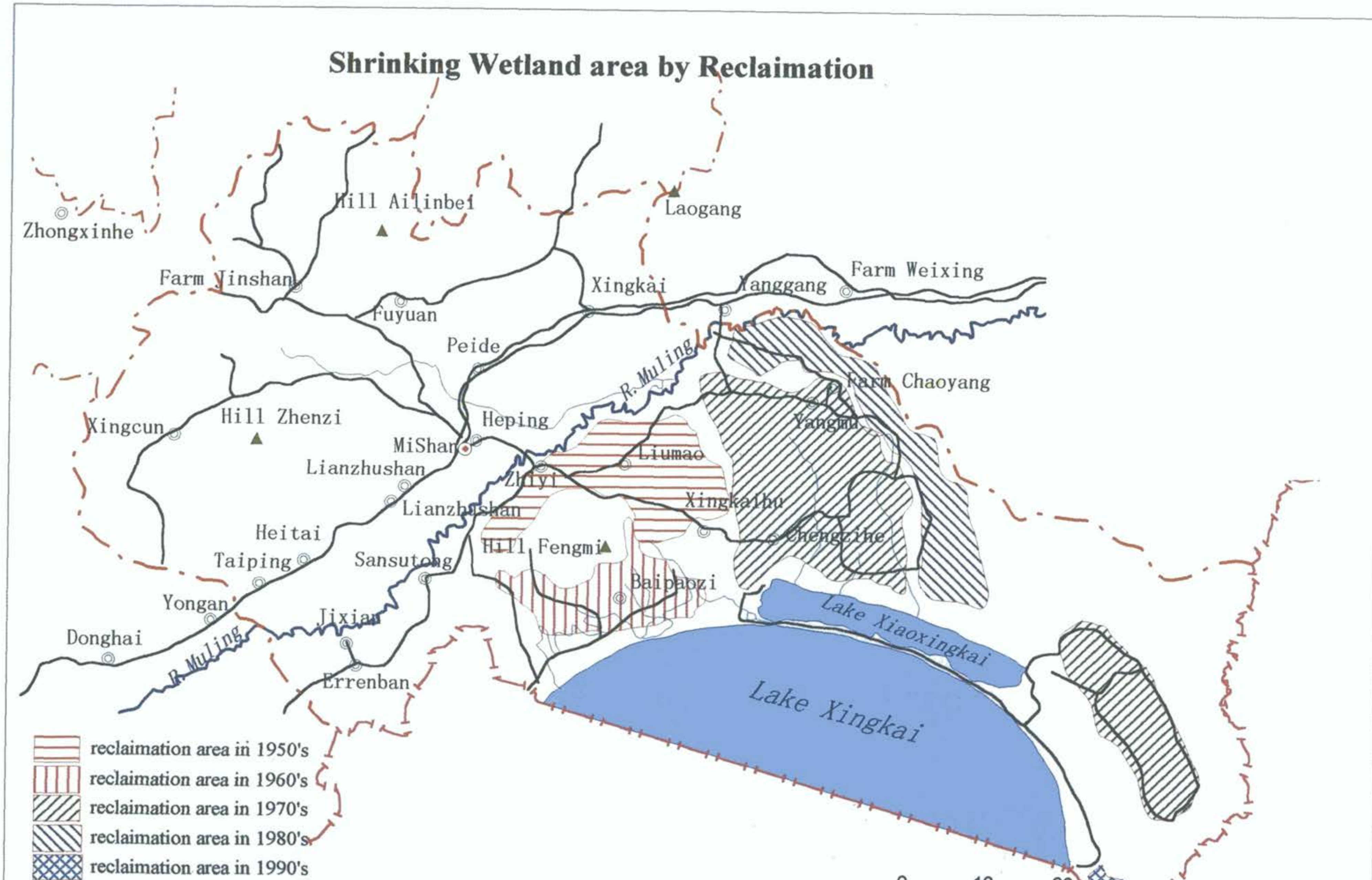


Fig. 3-13 Shrinking wetland area by reclamation in the Chinese portion of the Lake Xingkai/Khanka drainage basin

CHAPTER 4

SOCIO-ECONOMIC DEVELOPMENT OF THE LAKE XINGKAI/KHANKA DRAINAGE BASIN

This chapter discusses the socio-economic characteristics of the Lake Xingkai/Khanka drainage basin. Different components of the natural environment of the drainage basin (water resources, biodiversity, mineral resources, etc.) were discussed in previous chapters. The emphasis in this chapter is shifted to the linkages between socio-economic development and a healthy environment. It includes discussion of the economic consequences of unsustainable utilization and/or environmental degradation, both of which have significant implications for the social and economic development of the drainage basin and the well-being of its inhabitants. As with previous chapters, similar information and data is not necessarily available for both Russia and China. However, the characteristics and trends are believed to be relatively similar in most cases.

4.1 The Natural Resource Base for Supporting Socio-economic Development (Excluding Water Resources)

The Russian portion of the Lake Xingkai/Khanka drainage basin is the most developed area of Primorsky Kray. By comparison, the Chinese portion is considered by some to be a sparsely-populated area of China. Although the region does not have an extensive range of natural resources, there are significant coal deposits (Jixi deposit in China; Pavlovskoe and Lipovetskoe deposits in Russia), cement raw materials (near Mishan City, China; Spassk-Dalny, Russia), and fluorspar raw materials (Voznesenskoe deposit in Russia). There also are major agricultural lands in this region, capitalizing on its relatively flat terrain and the suitable soils and climatic conditions that characterize it.

The quantity and quality of the surface water and groundwater resources of the drainage basin were previously discussed, and reference is made to Chapter 2 for further information on this topic. The remainder of this section focuses on the non-water components of the natural resource base and their economic implications.

4.1.1 Forest Resources

Although the Lake Xingkai/Khanka drainage basin has a diverse composition of vegetation and ground cover, the basin's forest resources are not as significant as its agricultural or mineral resources. The drainage basin's forest resources are represented by primary and secondary broad-leaved woods engaging relatively small and flat areas, river valleys and foothills (Fig 4-1). The forests belong to the temperate-cold forestal sub-zone.

Broad-leaved forests are composed of oaks, white poplar, Maximovich poplar, birch, yellow birch, Manchurian ash, maples, maakia, Manchurian walnut, linden and elm. In contrast, oak forests are represented by a rather sparse collection of trees, primarily Mongolian oak, as well as abundant bushes and lianas.

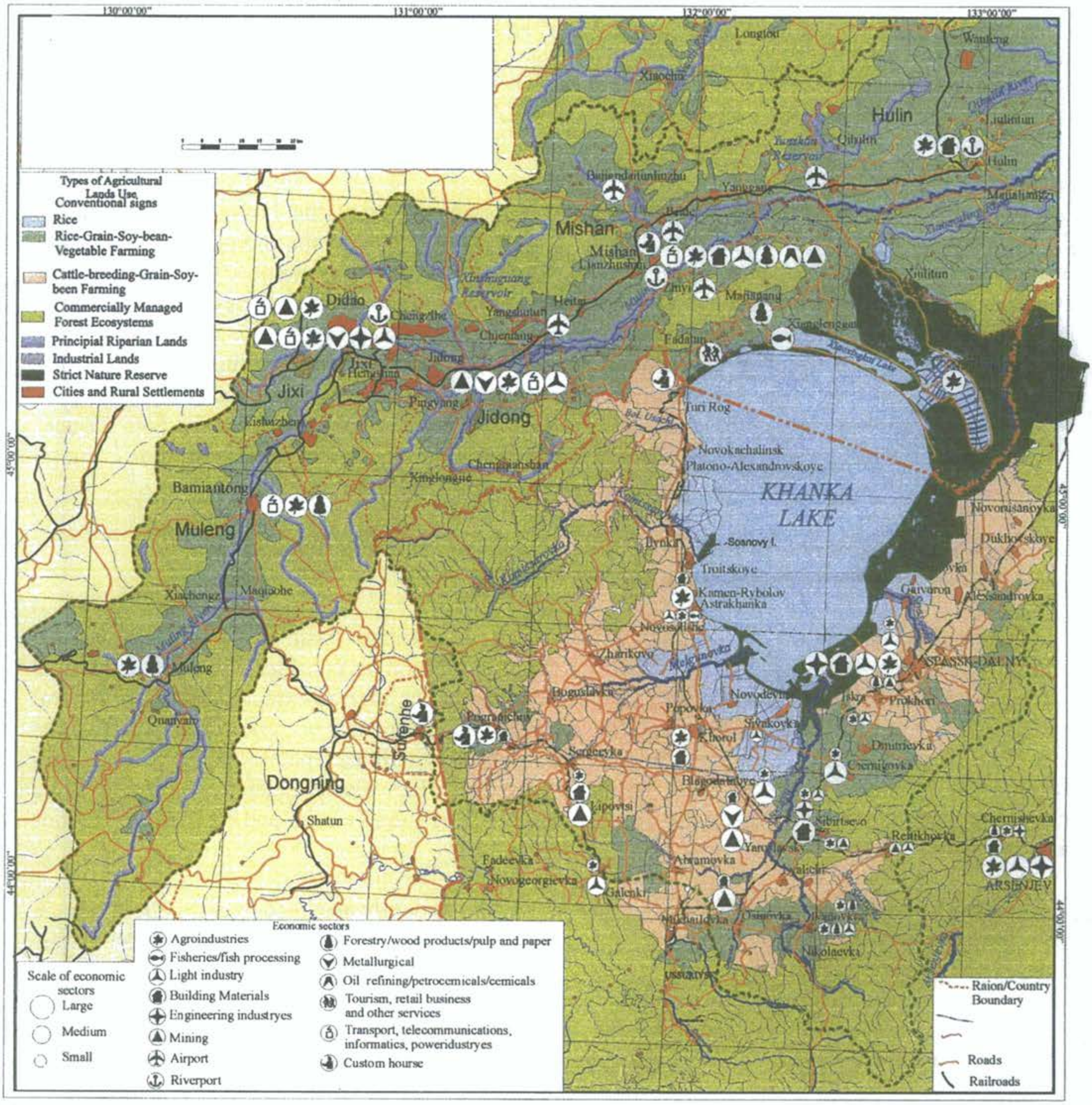


Fig. 4-1 Economic activities in the Lake Xingkai/Khanka Region

The overall distribution of the forest areas and their wood stocks in the Russian portion of the drainage basin are summarized in Table 4-1.

Table 4-1. Distribution of forest areas and wood stocks in the Russian portion of Lake Xingkai/Khanka drainage basin

Type	Species	Area (thousand ha)	Wood stocks	
			Total (million. m^3)	m^3/ha
Coniferous	Korean pine	61.9	12.6	204
	Fur-tree	39.4	7.1	180
	Abies	4.9	1.0	204
	Larch	0.1	-	0
	Pine	1.9	0.1	56
	Total	108.1	20.8	192
Hard deciduous	Ash	31.4	3.9	124
	Oak	258.6	17.4	67
	Linden	72.4	11.4	157
	Other	13.4	1.1	82
	Total	375.8	33.	90
Soft deciduous	Birch white	15.0	1.4	93
	Poplar	0.5	-	0
	Other	26.8	2.3	86
	Total	43.3	3.7	87
Only		526.2	58.	111

(ha, hectares; m^3, cubic meters)

The percentage of original forests in the Chinese portion of the drainage basin is less than in the Russian portion. However, industrial forests, as well as water-protection belts and agroclimatic forests belts, have been developed in the Chinese portion of the basin. A number of different tree species have been used in this effort, including Korean pine, Chinese juniper, various spruce species, larch, fir, tree-like willow, poplar, pine, Manchurian nut and David aspen.

4.1.2 Hunting Resources

The fauna of the Lake Xingkai/Khanka drainage basin are as diversified as the basin's flora. The main animals species are represented by carnivores, rodents, and predatory and hoofed animals.

The bird populations are very significant fauna in the drainage basin, exhibiting considerable diversity, as well as being a main hunting resource. To this end, the drainage basin is an important habitat for many rare bird species, as well as being a major migratory corridor for many rare and game birds wintering in Southern China and Southeastern Asia.

The Prikhankaiskaya plain is a major area for waterfowl, and 333 bird species have already been identified within the territory of the Khankaisky Nature Reserve. The number of birds noted in the spring in the Prikhankaiskaya Lowland is especially noteworthy, and can number 100,000-130,000 geese in favorable years. Even in unfavorable years, the geese can number 30,000-40,000. Further, during the vernal passage of ducks (miid-March to mid-May), one can observe between 70,000-130,000 ducks on the lake. The predominant waterfowl birds are ducks.

Compared to the 1950s-1960s, the total number of migratory birds has decreased markedly. For example, one duck species (*Anas querquedula*) has decreased so much in numbers that its status has changed from a background species to a rare species. Further, Manchurian pheasant and some species of hoofed animals are the primary field game species.

4.1.3 Fishery Resources

The fishery resources (ichthyofauna) of Lake Xingkai/Khanka are influenced primarily by the lake's shallow depth and hydrological regime. The freshwater ichthyofauna of the lake comprises 74 species (including introduced species) of 58 genuses from 18 families of 8 orders. This number represents 72% of all species inhabiting the Amur/Heilong River basin and about one-quarter of all the freshwater species found in Russia. Of this total, 44 species constantly dwell in the lake, while the remaining species come to the lake via inflow rivers from the Prikhankaiskaya Lowland.

The main spawning grounds for commercial fish in Lake Xingkai/Khanka were previously identified in Fig. 3-4, and some data on commercial fish catch between 1960-1990 presented in Table 4-2. It is noted that, based on the observed diversity of the freshwater fish in the drainage basin, this area has no analogs either in Russia or in the entire Paleoarctic area.

Table 4.2 Catch of trade fish in Lake Xingkai/Khanka (tons)

Fish	Year						
	1960	1965	1970	1975	1980	1985	1989
Cyprians carpio	83.3	65.5	28.5	42.8	24.2	27.9	15
Carassius aurutus	26.3	39	15	27.4	1.6	3.7	1.4
Erythroculter erythropterus	25.1	32.2	15.9	16.9	14.2	29.1	36.8
Erythroculter mongolicus	15.4	0	0	13.2	30.7	12.5	17.3
Esox reichertii	20.5	0	82.5	20.1	0	8.6	1.1
Silurus soldatovi	15.7	18.6	9.7	16.2	4.9	7.7	3.3
Hypophthalmichthys molitrix	0	0	0	0	0	0	0.1
Channa argus	0	0	0	19	0	0	0.2
Leiocassis	0	0	0	0	0	0	6.7
Erythroculter oxycephalus	0	0	0	94.5	144.6	56	0
Small-size fish	76.3	84.7	127.4	1.1	0	49.3	126.3
Total	263.3	240	279	251.2	220.2	194.8	208.2

Accordingly, fishing in the lake, as well as in rivers, channels and other reservoirs in the drainage basin, represents one of the most important economic branches in this region. Species such as *Erythroculter erythropterus, Erythroculter mongolicus, Erythroculter oxycephalus, Hypophthalmichthys molitrix* and Chinese perch comprise about 70% of the total catch. Nevertheless, the current state of the lake's fisheries are described as being in a "pitiable state". The catch of fish in 1987, for example, was only about one-tenth of the catch of 50 years ago. The primary reason for this dramatic decrease in fish catch was attributed to progressive and continuing contamination of the rivers from industrial and agricultural activities in the drainage basin.

As previously noted, the intensity of amateur fishing tends to increase during times of economic instability. In 1995, for example, the fish catch attributable to Russian amateur fishermen was estimated to be about 16 tons, with the overall catch attributable to amateurs being estimated to be about 15% of the total fish catch. Significant fish breeding activities also occur in the Chinese portion of the drainage basin.

4.1.4 Agro-industrial Resources

4.1.4.1 Soil and Agricultural Crops

The Russian portion of the drainage basin comprises the Prikhankaiskaya-Ussuriiskaya Plain, wide valleys and low mountainous areas, and enjoys favorable climatic conditions, all of which make the area well-suited for agricultural activities. The composition of the soil cover in the arable lands in the six Russian Districts surrounding the lake is summarized in Table 4.3.

Table 4-3. Soil composition of arable lands in the Russian portion of the Lake Xingkai/Khanka drainage basin

Administrative District	Total area, (ha)	Soil type (%)					
		cambisols	luvisols	phaeozem	planosols	Fluvisols	histosols
Khankaisky	83.1	9.1	17.5	43.1	28.4	1.9	0.01
Spassky	75.8	4.0	26.6	40.2	23.9	0.1	5.2
Pogranichny	42.3	25.1	8.0	41.0	22.6	3.1	0.2
Khorolsky	89.3	6.0	17.0	72.6	4.4	-	-
Chernigovsky	45.7	15.2	28.1	31.4	23.5	1.2	0.5

(%, percent; ha, hectares)

The primary agricultural crops grown in this region include grains (rice, wheat, barley, buckwheat), industrial crops (soybeans, sugar beets, sunflowers), vegetables (tomatoes, cucumbers, cabbages, beets, carrots, radishes, pepper, vegetable marrows, egg-plants) and gourds (melons, watermelons)

In the Chinese portion of the drainage basin, the main soil types are grassy soil, white thick soil, bog soil, sandy-silt soil and sandy soil. All are fertile soils, with humus contents above 5%. The primary crops grown in the Chinese portion of the drainage basin include soybeans, rice and wheat, as well as commercial beets and tobacco. Mechanized agriculture is common in this region, comprising approximately 85% of the total farmlands in this portion of the drainage basin.

4.1.4.2 Land Use

Arable lands comprise the dominant land usage in the Russian portion of the drainage basin (Table 4-4). In the Chinese portion, farmlands comprise about 34.8% of the total land area, with the other land uses being forest (23.9%), meadows (0.3%), settlements (2.4%), transportation corridors (1.1%), water (23.7%) and undeveloped land (13.7%). As noted in Table 4-5, some of the urban areas in the drainage basin have increased notably over the last half century.

Table 4-4. Distribution of land resources in the Russian portion of the Lake Xingkai/Khanka drainage basin (expressed in % of total area)

District	Developed areas	Arable lands	Forest lands	Marshlands	Disturbed lands
Khankaisky	45	67	45	3	0.05
Spassky	28	66	47	18	0.007
Spassk-Dalny	14	-	-	-	-
Pogranichny	24	48	64	4	0.04
Khorolsky	71	64	17	2	1
Chernigovsky	43	59	44	5	0.7
Total	39	62	47	7	0.3

(developed areas, forest lands, marshes and disturbed lands are given in percent of the total district area; arable lands are given in percent of plowed fields in total agricultural area; %, percent)

Table 4-5. Changes in urban areas and districts in the Chinese portion of the Lake Xingkai/Khanka drainage basin (expressed in ha)

District or City	1949	1959	1975	1983	1993
Hulin	17,769	121,061	151,358	240,281	238,783
Mishan	64,348	174,044	156,519	187,350	184,000
Jidong	-	-	52,231	53,790	69,200
Jixi	22,326	22,683	27,021	26,328	25,000
Muling	29,479	28,072	33,065	38,889	38,467

(ha, hectares)

4.1.5 Mineral Resources

The mineral resources are considered to be relatively sparse in both the Russian and Chinese portions of the Lake Xingkai/Khanka drainage basin. Nevertheless, the Russian portion contains considerable reserves of coal deposits (Pavlovskoya and Lipovetskove deposits), cement raw materials (near Spassk-Dalny City) and fluorspar raw materials (Voznesenskoye deposit). Some of these deposits are substantial. The region provides 48%, for example, of the industrial output of cement raw materials in the whole Far East, while the coalfield deposits (Table 4-6) provide about 35% of the solid fuel output in Primorsky Kray (sufficient for 96 years, at present extraction rates). The Voznesenskoye fluorspar deposit is the largest in Russia. The region also contains deposits of some other building materials, including brick-earth and porcelain clays, sand, building stones and marble.

Table 4-6. Coal deposits in Russian portion of Lake Xingkai/Khanka drainage basin

Coalfield	Type	Scale of resource	Method of mining	Degree of development
TuriiRogskoye	1-2	S	Underground, in quarry	Not developed
Ilinskoye	1-2	S	Underground	Not developed
Zharikovskoye	1-2	S	Underground	Not developed
Pogranichnoye	1-2	S	Underground	Not developed
Rettikhovskoye	1	S	In quarry	Exhausted
Pavlovskoye	1	M	In quarry	Developed
Lipovetskoye	L	S	Underground, in quarry	Developed

(Type refers to moisture content in brown coals: 1= more than 40%; 2 =30-40%; L=longflared black coal; Scale of resource: M=middle (200-1,000 million tons); S=small (less than 200 million tons); %, percent)

The Chinese portion of the drainage basin also contains considerable quantities of some mineral resources, including deposits of coal, marble, limestone, granite, aluminum, zinc and uranium. As an overall observation, these resources have not yet been extensively exploited. The coal reserves total 0.4-0.5 billion tons, with industrial reserves of 0.31 billion tons. The reserves of graphite, marble, limestone, peat and granite are estimated to be 0.25, 0.54 billion tons, and 0.08, 0.836 and 8.0 million tons, respectively.

Chinese coal reserves are most abundant near Mishan City. Compared to the one million ton output of raw coal in 1997, the expected output in 2000 will be 1.6 million tons. Plans also are underway to mine 300 thousand tons of marble and 1.2 million tons of cement production in 2000.

4.1.6 Recreational Resources

Major economic activities that most require a natural environment of good quality are recreation and tourism. Such activities are obviously facilitated by the presence of picturesque landscapes.

The Lake Xingkai/Khanka drainage basin does not belong to the major recreational zones in either Primorsky Kray in Russia or the Heilongjiang Province in China. Nevertheless, the lake itself and the Prikhankaiskaya Plain are of significant recreational interest for regional and foreign tourists. The Russian portion of the drainage basin contains some unique natural complexes of world-wide significance, including numerous wetlands as habitats and resting places for migratory birds, many of which are listed in the IUCN and Russian Red Books. Vast areas adjacent to the southern and eastern shores of the lake also have unique plants and animals with no analogs either in the Far East or elsewhere in the world. As previously noted, as a means of attempting to conserve habitat for waterfowl birds, the two countries established natural reserves in the drainage basin (Lake Xingkai Reserve in China; Khanka Nature State Reserve in Russia), which contain some of the largest unique wetlands in the world.

The steppe oak forests and sparse forests in the Prikhankaiskaya Plain in the Russian portion of the drainage basin are of recreational interest, containing the remaining sites of Ussuri Korean pine and broadleaved deciduous forests in the southeastern part of the basin. There also are many nature, history and cultural monuments in the Prikhankaiskaya Lowlands. An example is the great cultural-historical zone of Primorye, a territory with a high concentration of archeological and ancient cultural monuments, located in the vicinity of the Chernigovka settlement. The territory also contains mineral springs and healing muds, spurring development of sanatorium-health-resort services.

The Prikhankaiskaya Plain abounds with lakes. The Wusuli/Ussuri River basin alone, for example, contains 2,800 small lakes. Tourism related to hunting and fishing is facilitating development of a recreation-tourism complex in the Prikhankaiskaya Plain, which is of obvious economic benefit to the region.

Ecological tourism is also gaining a foothold, with bird watching being particularly significant in the Prikhankaiskaya Plain. As well, the wetlands, low flat hills and uplands appeal to many tourists interested in natural environmental complexes. In the rivermouth areas of the Komissarovka, Melgunovka and Ilistaya Rivers, large gulfs filled with sandy sediments have formed excellent sandy beaches. The northern, western and southwestern shores of the lake from the Tur River to the Ilistaya River contain picturesque landscapes and beautiful river valleys, and the numerous sandy beaches are favorite relaxation areas for both the local population and visitors.

The Chinese portion of the drainage basin has equally beautiful natural scenes and suitable climatic conditions for recreation and tourism. These include splendid views of the small basin of Lake Xingkai/Khanka in the autumn and its surging waves. The delicious fish and shrimp, and the presence of rare animals and birds attract large numbers of tourists.

Relics of ancient people (estimated to be 6,080 years old) were discovered in 1972 about 1.5 km from the lake. The site is now listed as a protected historic site by the Provincial Government of China.

A factor facilitating the development of the recreational potential of the drainage basin is the good transport accessibility from both China and Russia. The region contains a network of railroads and highways, as well as local airlines. Primorsky Kray – Vladivostok city and Heilongjiang – Harbin city are major hubs in this regard. There also are two transborder passages (Pogranichny/Suifenhe and Tury Rog) in the region.

There are some concerns, however, related to the development of the region's recreational potential, including (i) increased environmental impacts, (ii) lack of adequate infrastructure for tourism, and (iii) the presence of diseases in the region with natural vectors. The Spassky District in the Prikhankaiskaya Plain, for example, exhibits a high rate of tick encephalitis and hemorrhagic fever. There also are concerns about the possibility of rabies for wolves, fox and raccoons. There are no significant health concerns, however, in other portions of the Prikhankaiskaya Plain.

In spite of such potential problems, however, the area continues to exhibit an increasing level of tourism and outdoor recreational activities. The recreational resources of this area are significant, and there is considerable potential for such activities as ecological tourism, bird watching, photography, sports hunting and fishing, as well as relaxation in the forms of swimming and mineral and mud baths.

4.2 Present Socio-economic Status of the Drainage Basin

4.2.1 General employment

The average monthly wages of people employed in economic enterprises in the Russian portion of the Lake Xingkai/Khanka drainage basin is illustrated in Table 4-7. In evaluating these figures, the effects of currency fluctuations must be noted. Between 1992-1996, for example, the average monthly wages in the region continued to increase. Further, during 1998, average accrued monthly wages increased 11%, compared to previous years. At the same time, however, the ruble exchange rate fell four times in August 1998. Relatively speaking, therefore, the post-August wage actually decreased many times. The picture is particularly dramatic when the 1998 post-August wages are compared to the pre-reform 1990 wages.

Table 4-7. Average monthly wages of employees in Russian enterprises in Lake Xingkai/Khanka drainage basin (expressed in US$, calculated on basis of official currency exchange rate)

Cities and districts	1990	1992	1993	1994	1995	1996
Spassk-Dalny city	566.0	30.0	77.0	108.8	107.0	140.7
Mikhailovsky District	568.1	29.6	89.0	123.0	130.3	168.6
Pogranichny District	620.1	26.0	65.0	105.1	98.8	128.6
Spassky District	581.2	25.2	53.3	75.4	70.3	94.1
Khankaisky District	618.8	25.2	56.1	92.7	87.3	118.6
Khorolsky District	539.5	27.2	75.8	95.1	101.2	113.8
Chernigovsky District	569.2	27.8	73.	129.9	103.8	113.6
Average value in Primorsky Kray	620.2	32.3	90.5	144.7	145.6	197.9

The situation in the Russian rural areas is worse, however, in that the level of wages paid in agricultural activities is less than half that paid in other economic branches. Further, accrued wages are typically only paid after the agricultural output (grain, meat, etc.) has been produced and delivered.

It is unfortunate that the negative repercussions to the financial-economic situation in the Russian portion of the drainage basin began in the years of reform. Because of these repercussions, some regional enterprises do not operate, and most do not use their industrial capacities to the full extent. A summary of the unemployment situation in the Russian portion of the drainage basin is presented in Table 4-8.

Table 4-8. Registered and hidden unemployment in Russian settlements in Lake Xingkai/Khanka drainage basin (as of 1 January 1997)

Cities and districts	Able-bodied population		Number of registered unemployed persons	Ratio of registered unemployed persons to able-bodied population (%)	Hidden unemployment	
	Number of people	number of working persons			Number of people	Comparison to able-bodied population (%)
Spassk-Dalny	36,825	20,015	4,437	12.0	12,373	33.6
Spassky	18,200	7,595	1,491	8.2	9,114	50.1
Pogranichny	15,800	6,180	104	0.7	9,516	60.2
Khankaisky	14,100	9,545	1,082	7.7	3,473	24.6
Khorolsky	21,000	13,501	1,490	7.1	6,009	28.6
Chernigovsky	25,031	10,215	2,351	9.4	12,465	49.8

(%, percent)

4.2.2 Industrial Economy

The character of the economic development of the Lake Xingkai/Khanka drainage basin has largely been determined by the character of the basin's natural resource base. Table 4-9 provides an overview of the natural resource base, and its use and impacts on production in the Russian portion of the drainage basin.

The overall industrial output in the Russian portion of the basin was reduced 6 times between 1989-1997, and continues to decrease to the present time, although at a slower rate. The output of both industrial commodities and consumer goods also has decreased (Table 4-10). Based on output volume, coal mining is the most important industry for the Russian portion of the drainage basin (Table 4-11), as discussed further in section 4.2.4.

Table 4-9. Branch economic structure of districts in the Russian portion of Lake Xingkai/Khanka drainage basin (expressed as % of people involved in individual branches)

Branch	District					
	Khankaisky	Pogranichny	Spassky	Mikhailovsky	Khorolsky	Chernigovsky
Branches of material production, including:	53.2	58.3	67.2	68.8	55.3	54.1
-Industry	1.1	2.6	26.9	15.3	16.9	11.3
-Construction	4.2	4.0	8.9	9.7	6.0	5.4
-Agriculture	30.6	22.0	15.3	25.7	17.7	15.9
-Forestry	0.2	0.8	0.3	0.5	-	0.1
-Transport	3.6	7.3	5.5	6.4	1.5	10.0
-Connection	1.6	2.3	1.6	1.7	1.9	1.6
-Trade	5.4	14.9	5.9	4.2	4.4	5.9
-Common catering	0.7	0.7	0.7	0.5	0.6	0.4
-Purchase, supply-sale	1.2	2.4	1.4	0.3	0.2	0.4
-Other branches of material production	4.6	1.3	0.6	4.5	4.1	3.1
Non-industrial branches:	46.8	41.7	32.8	31.2	44.7	45.9
-Education	11.9	11.0	11.0	7.6	12.0	1.6
-Culture and arts	1.1	2.3	1.4	1.4	3.2	1.0
-Sciences	0.6	-	0.2	-	-	-
-Sports	0.1	0.1	0.3	0.1	-	0.1
-Public health	5.2	9.8	5.1	4.4	5.9	5.0
-Social maintenance	0.4	0.8	0.6	0.1	0.5	0.5
-Housing and communal services	4.4	2.6	5.5	6.0	9.0	3.8
-Non-industrial everyday repairs	0.3	0.8	0.2	0.7	1.0	0.6
-Transport of social spheres	0.7	1.0	0.9	1.4	1.5	0.8
-Administration body juridical, credit-financing, insurance and other spheres	10.2	9.1	5.8	4.2	5.1	2.8
-Other branches of non-industrial sphere	11.9	4.2	1.8	5.3	6.5	20.7
TOTAL	100	100	100	100	100	100

Table 4-10. Volume of industrial output from cities and districts in Russian portion of Lake Xingkai/Khanka drainage basin (expressed in millions of rubles)

Cities and Districts	Volume of output (works, services) in 1997 (million rubles)	As % of 1996 output (in actual prices)	Index of 1997 physical volume (in % of 1996 volume)
Spassk-Dalny City	277,592	85.3	69.9
Spassky District	19,010	87.2	82.5
Mikhailovsky District	535,698	160.0	107.6
Pogranichny District	3,935	97.1	87.9
Khankaisky District	7,172	72.5	56.0
Khorolsky District	30,414	55.6	49.3
Chernigovsky District	95,955	112.9	79.5

(%, percent)

Table 4-11. Output volumes by economic branch in 1997 in Russian portion of Lake Xingkai/Khanka drainage basin

Branch of economy	Volume of output (actual prices in millions of rubles)
Coal mining	536,549
Building industry	284,750
Agriculture	157,622
Food industry	74,618
Machine-building and metallurgy	55,239
Non-ferrous metallurgy	19,714

4.2.3 Agriculture (including Fisheries)

4.2.3.1 Agricultural activities in drainage basin

The favorable soil, climatic and orographic conditions for agricultural development were previously highlighted. To this end, the greatest extent of agricultural development in the Russian portion of the drainage basin has taken place in the Khorolsky, Khankaisky and Chernigovsky Districts. The value of the Russian agricultural output in this region is estimated to be 460 million rubles (in 1991 prices). Many agricultural crops are grown in this region, including rice, wheat, barley, soybeans, sugar beets, sunflower, tomatoes, cucumbers, cabbage, beet, carrot and watermelons. Nearly all the rice-growing areas in the Russian Far East (85%) are located in the Lake Xingkai/Khanka drainage basin. The major area of irrigated lands (60% of total) are represented by the rice-growing systems in the Khankaisky, Khorolsky, Chernigovsky and Spassky Districts.

There major types of Russian agricultural lands are designated in these areas, as follows:

- *Rice-growing* areas – Sown grain crops are predominant (70% or more) in these areas. Rice fields occupy more than half of the arable lands. The production costs are approximately US$ 500-650/ha of arable land.

- *Grain, soybean and vegetable-growing areas* – Grain crops predominate in these areas, with soybeans and forage crops representing 40% and 30%, respectively, of the crop area. Forage crops are concentrated on about 25% of the plowed lands. The production costs are US$ 250-300/ha of arable land.

- *Cattle-breeding and grain/soybean-growing* areas – Forage and grain crops predominate in these areas, which represent about 80% of the arable lands. The production costs are about US$ 170-220/ha of arable land.

The total area of irrigated lands in the Russian portion of the Lake Xingkai/Khanka drainage basin was about 109,400 ha, as of 1 January 1997, with plowed lands comprising about 100,400 ha of this total. Due to inadequate irrigation reconstruction and repair efforts, approximately 103,700 hectares of reclamation lands have been lost.

A reduction in rice-growing efforts in the Russian portion of the Lake Xingkai/Khanka drainage basin during 1970-1996 coincides with a decrease in the agricultural pollutant loads in the drainage basin, including a reduction in the rice-growing areas (by 5-10 times), implementation of forage crop rotation in water-protection zones, elimination of aerial chemical spraying, and a reduction in agrochemical fertilizer application. This situation was due in part to a "recession" in the Russian agriculture and livestock output during this period, as illustrated in Tables 4-12 and 4-13.

Table 4-12. Reduction in livestock output in Russian portion of Lake Xingkai/Khanka drainage basin between 1989 and 1996

Livestock output	Production		Reduction in 1996 production, compared to 1989 production (times)
	1989	1996	
Milk (tons)	122,935	25,167	4.9
Beef (living weight, tons)	22,538	2,606	8.6
Pork (living weight, tons	9,174	592	15.5
Eggs (million pieces)	114.8	19.7	5.8

Grain production in the Heilongjiang Province is an important agricultural activity in the Chinese portion of the drainage basin, comprising soybeans, rice, grain and wheat, as well as industrial ouputs of beets and tobacco. The distribution of cultivated lands in the Chinese portion of the drainage basin is illustrated in Table 4-14. As previously noted, approximately 85% of the farmlands in the Chinese portion are subjected to mechanized agriculture.

Table 4-13. Reductions in economic values of agricultural activities in Russian portion of Lake Xingkai/Khanka drainage basin between 1989 and 1996

District	Gross product (thousand US$)		Financial result: profit (- loss) (thousand US$)		Average monthly wage (US$)	
	1989	1996	1989	1996	1989	1996
Mikhailovsky	60,622	16,799	43,305	-5,332	505	100
Pogranichny	46,760	9,389	17,682	-1,257	565	84
Spassky	78,574	12,531	45,822	-4,112	552	63
Khorolsky	77,248	20,268	42,332	-5,482	536	81
Khankaisky	64,484	21,834	39,427	-2,197	564	105
Chernigovsky	52,077	9,091	35,460	-2,225	636	97
	Area of agricultural lands (thousand ha)		Plowed fields (thousand ha)		Grains (thousand ha)	
	1989	1996	1989	1996	1989	1996
Mikhailovsky	112.8	77.8	70.0	55.5	20.6	16.1
Pogranichny	79.8	62.5	42.2	39.2	12.5	9.4
Spassky	115.1	89.4	74.0	63.3	27.5	14.1
Khorolsky	121.9	105.4	82.4	76.3	36.4	18.7
Khankaisky	112.6	82.2	78.6	62.6	32.9	23.1
Chernigovsky	77.8	46.8	47.0	33.9	17.4	9.8
	Rice (thousand ha)		Soybeans (thousand ha)		Potatoes (thousand ha)	
	1989	1996	1989	1996	1989	1996
Mikhailovsky	-	-	14.3	10.1	0.9	0.2
Pogranichny	-	-	8.3	7.8	0.7	0.1
Spassky	6.9	0.9	13.4	9.8	0.7	0.1
Khorolsky	13.3	2.58	12.8	9.7	0.6	0.05
Khankaisky	13.8	3.25	13.6	12.6	0.5	0.03
Chernigovsky	3.2	0.8	8.1	8.5	0.7	0.02
	Vegetables (thousand ha)		Corn on green forage (thousand ha)		Cow (number)	
	1989	1996	1989	1996	1989	1996
Mikhailovsky	0.6	0.2	8.6	1.7	9,366	3,335
Pogranichny	0.1	0.1	5.6	2.9	5,671	2,583
Spassky	0.4	0.1	5.4	1.9	10,044	3,892
Khorolsky	0.2	0.1	6.4	2.6	8,252	3,247
Khankaisky	0.2	0.1	7.9	4.1	7,861	3,774
Chernigovsky	0.4	0.02	3.7	0.9	6,171	1,093
	Horned cattle (number)		Pig (number)		Bird (thousand)	
	1989	1996	1989	1996	1989	1996
Mikhailovsky	26,094	6,718	30,624	1,176	207	34.9
Pogranichny	18,589	5,197	17,223	1,456	315.2	33.7
Spassky	30,242	5,688	25,871	2,138	-	-
Khorolsky	27,417	6,488	17,336	1,846	104.7	63.8
Khankaisky	27,956	7,318	11,932	1,304	1.0	-
Chernigovsky	19,396	4,125	1,129	204	8.9	-

(ha, hectares; US$, U.S. dollars)

Table 4-14. Agricultural lands in the Chinese portion of Lake Xingkai/Khanka drainage basin

Settlement	Cultivated land (km^2)
Ziyi town	3.3
Liumao village	5.67
Yangmu village	9.9
Xingkaaihu village	5.8
Chenzihe village	4.0
Baopozi village	8.9
Shansuo village	7.1
Dangbizi village	0.2
Xingkaihu farm	98
857 Farm	153
8510 Farm	

(km^2, square kilometers)

The Chinese portion is characterized by three major types of agricultural lands (see Fig. 1-13), as follows:

- *Zone 1* – This type comprises the partial pastoral areas of the alluvial area along the Muling River. It is 1,429 km^2 in area, comprising about 18.6% of Mishan City, and 830 km^2 of farmland area (58.1% of total zone area). It is a major grain-production areas of Mishan City, comprising about 286 km^2 of paddy lands (69.1% of total paddy fields of Mishan City). It is an area of intensive farming activities. The presence of the Muling River and the Qingnian Reservoir allows irrigation of over 133.3 km^2 of paddy fields and dry land.

The zone also has a relatively high population density and relatively more villages and markets. Its negative characteristics are (i) a long history of cultivation, leading to poor soil structure and permeability, (ii) uneven seasonal surface water supplies, and (iii) an inappropriate mix of land use between agriculture, forestry and animal husbandry.

- *Zone 2* – This zone is located in the northern offsets of the Laoyuan and Changbai Mountains, and comprises the farming and forest zone in the middle southern hilly area outside the lake mound (between the Small and Large Lakes). It has an area of 620.6 km^2 (8.1% of the total area of Mishan City)

This zone has more forests than the other two zones, comprising 43.8% of its areas. The farmland soils are relatively poor, although the zone does have rich deposits of good quality limestone. A negative problem is serious soil erosion.

- *Zone 3* – This is the farming, husbandry and fishery zone in the southeastern lowlands, located in the eastern part of the Sanjiang Plain. With an area of 5,423 km^2, it occupies alluvial river and lake plains. It contains many waterbodies (occupying 16,000 km^2, approximately 30% of its total area), and is well-suited for growing rice. Land use in the Chinese agricultural zones is summarized in Table 4-15.

Table 4-15. Land use in the agricultural zones in the Chinese portion of Lake Xingkai/Khanka drainage basin (expressed in km^2)

one	Total area	Cultivated land			Forest land		rass land	Settlements nd factories	rans port	Rivers and lakes			Used land
		total	Paddy	land	total	forest				rivers	lakes	reserves	
1	1,430	831	29	543	225	193	8	63	22	17	0	0	143
2	621	261	13	247	272	222	5	16	7	3	0	0.8	38
3	34,611	869	52	815	219	154	5	38	31	26	1,202	3	73

(km^2, square kilometers)

The large sites between Lake Xingkai/Khanka and the Dongdi and Song'acha Rivers serve as habitats for many rare birds and animals (e.g., swans, white crane, red-crowned crane), as well as 44 fish species in the lake. A negative characteristic of this zone is its low terrains, which make it very sensitive to floods and waterlogging.

Water from Lake Xingkai/Khanka is used to irrigate 233 km^2 of land in the Chinese portion of the drainage basin. To this end, a large flood-diversion sluice gate was constructed in 1976 between the Large and Small Lakes, making it possible to direct the Muling River flow into the Small Lake. This provides a water supply for irrigating 66.78 km^2 of paddy land.

4.2.3.2 Environmental concerns related to agricultural activities

Because of the economic importance of agricultural activities in the Lake Xingkai/Khanka drainage basin, a brief overview of the related environmental problems illustrates the linkages between these two issues. In fact, the available data suggest that agricultural activities in both the Russian and Chinese portions of the drainage basin have resulted in environmental problems. Based primarily on Russian data, the primary problems can be described as follows:

- *Dehumification* – One major problem arising from agricultural activities in the Russian portion of the drainage basin is the loss of soil humus content. A productive soil requires 2.5-3% of humus in its plow horizon. However, on average about 35% of the arable soils in the adjacent territory, particularly in the Khankaisky District, contain less than 3% humus. It is therefore necessary to add approximately 6 tons of organic fertilizers per hectare in these areas (approximately 4 times that needed in other areas).

- *Soil erosion* – This is a serious problem in both riparian countries. In the Russian portion of the drainage basin, for example, a considerable portion of the arable lands are situated on slopes of more than 3°, thereby increasing soil erosion. The allocation of agricultural areas in the Russian part of the basin determines that a considerable part of arable lands is situated on slopes of more than 3° and is endangered by erosion (Table 4-16).

Table 4-16. Erosion status of agricultural lands in the Russian portion of Lake Xingkai/Khanka drainage basin (expressed in thousand ha)

District	Erosion dangerous lands		Eroded plowed fields
	All farmland	Plowed fields	
Khankaisky	13.1	0	23.0
Spassky	46.0	37.6	4.9
Pogranichny	20.0	9.7	21.7
Khorolsky	51.8	0	4.5
Chernigovsky	18.9	11.8	20.0

(ha, hectare)

Both water and wind cause soil erosion in these areas. Intensive washout and scour, and wind erosion occur on sloped lands growing dry-land crops. Arable lands are subject to the most serious agricultural erosion, comprising 80% of the eroded agricultural lands. The erosion also causes silting of small riverbeds, degradation of hay fields, pastures and other lands.

Soil erosion also is a serious problem in the Chinese portion of the drainage basin. The total area in the Chinese agricultural zones subjected to serious erosion in the northern part of Mishan City, for example, was estimated to be 1,114.7 km^2. The estimated annual erosion rate in farmland areas was 30,000 t/km^2. Soil erosion in Mishan City totaled about 2.35 million m^3/year, including nitrogen, phosphorus and potassium losses of 5,000, 5,000 and 40,000 tons/year.

- *Soil pollution* – Due partly to the above-noted problems, soil pollution from fertilizers and agrochemicals is another serious environmental problem related to agricultural activities in the drainage basin. Large pesticide usage, for example, impacts areas containing rice, vegetables and potatoes. To this end, the areas adjacent to the shoreline of Lake Xingkai/Khanka receive the largest volumes and doses of pesticides in the drainage basin.

A wide range of biocides is used to protect agricultural crops. It is estimated that about 12,300 tons of biocides (33 kg/ha of arable land) have been applied in the Russian portion of the drainage basin over the last 10 years.

During the period between 1981-1985, dosage rates of about 250-310 kg nitrogen/ha, 100-150 kg of phosphorus/ha and 40-70 kg of potassium/ha of arable land also were recorded in the Russian portion of the Lake Xingkai/Khanka drainage basin. The total volumes of these three fertilizers applied to arable lands are 104,100 tons, 54,700 tons and 43,100 tons, respectively. Of these applied volumes, it is estimated that approximately 7,300 tons of nitrogen, 350 tons of phosphorus and 4,740 tons of potassium fertilizers ultimately were carried into receiving waters in the drainage basin. An estimate of the annual average estimated environmental damage associated with agricultural production in the Russian portion of the drainage basin is provided in Table 4-17.

Table 4-17. Estimated average annual damage from agricultural activities in the Russian portion of Lake Xingkai/Khanka drainage basin

District	Plant growing						Livestock breeding		Cumulative damage (thousand US$)
	Fertilizers (tons)				Agrochemicals		Wastes (thousand tons)	Damage (thousand US$)	
	N	P	K	Damage (thousand US$)	Tons	Wastes (thousand US$)			
Spassky	310	18	155	2423	25.1	176.7	91.3	371.1	2970.6
Chernigovsky	205	17	118	1666	23.8	167.4	49.4	197.4	2030.8
Khorolsky	360	18	218	2776	18.5	130.1	88.5	352.6	3258.7
Khankaisky	364	28	244	2934	9.5	66.8	83.3	302.8	3303.6
Pogranichny	155	14	78	1278	9.5	66.8	55.8	277.8	1622.6
Mikhailovsky	314	21	97	2487	5.9	41.5	83.0	389.3	2917.8

(N, nitrogen; P, phosphorus; K, potassium; US$, U.S. dollars)

It is noted that the overall quantities of fertilizers used in the Russian portion of the drainage basin for all crops has been reduced from 103 kg/ha in 1989 to 4.2 kg/ha in 1996, due primarily to the decreased agricultural activity that generally characterized the 1990s. The quantity of agrochemicals also decreased markedly. In 1985, 9.6 tons of agrochemicals were used in the Russian portion of the drainage basin, compared to only 0.037 tons in 1996. The areal extent of usage also decreased. Only 70% of the arable lands was used to grow crops in 1996. Ironically, the economic downturn characterizing agricultural activities reduced the level of environmental contamination in some cases; many producers did not have the necessary funds to buy fertilizers and pesticides during the past decade.

The agricultural contamination situation in the Chinese portion of the drainage basin has been characterized as being more serious, due mainly to fertilizer and pesticide application. The annual quantity of fertilizer usage may reach 23,000 tons, equivalent to about 15,000 kg/km^2. It is estimated that approximately 12,500 tons of chemical fertilizers are lost each year, including 5,300 tons of nitrogen and 3,800 tons of phosphorus.

Wastes from cattle-breeding operations also are a serious problem in the Chinese portion of the drainage basin. The farming complexes discharge about 1.5-2.0 million tons of sewage each year, characterized by high concentrations of biogenic elements (Table 4-18). Although these wastes could be used to sprinkle forage crops, most farms do not have the necessary treatment facilities.

Table 4-18. Average chemical composition of livestock wastes (expressed in mg/L)

Animal	Suspended particles	N	P	K	Ca	Mg	Cl
Cattle	5,000	1400	190	750	300	350	370
Pig	2,000	1000	200	250	280	130	180

(mg/L, milligram/liter; N, nitrogen, P, phosphorus; K, potassium; Ca, calcium; Mg, magnesium; Cl, chloride)

There also are offsprings associated with fish breeding and commercial fishing in the Russian portion of the drainage basin. Two fish-breeding enterprises ("Khanka", Ltd.) and one fish-processing factory ("Khankaisky" Fish-processing Complex in Astrakhanka settlement, Khankaisky district) are located on the shore of Lake Xingkai/Khanka, with the enterprises being better developed in the Chinese portion of the drainage basin. Because of the availability of fish scraps, fur farms (breeding mink in China and ondatra in Russia) were established around the lake.

It is noted that large and multi-branch agricultural enterprises were usually established initially in the Russian portion of the Lake Xingkai/Khanka drainage basin, followed by a network of ancillary food enterprises using them as a base (diaryfarms, meat-packing plants, poultry farms, vegetable preserving plants, large mill factories for production of flour, cereals and mixed fodder, etc.). However, since about 1990, the economic situation has resulted in only about 15-20% of such enterprises being operated at capacity.

4.2.4 Industry

The most developed industries in the Russian portion of the drainage basin are the manufacture of building materials (cement, asbestos-cement and armored concrete, crushed stone, etc., in Spassk-Dalnii, Yaroslavskii and Sibirtsevo), coal mining in quarries (in Lipovtsy and Novoshakhtinskii), and metal work repair (in Sibirtsevo and Spassk-Dalnii, etc).

The output of cement raw materials has decreased by about 25%, and fluorspar mining has been reduced by a factor of four, over the last 10 years. Although economically distressing, the environmental impacts of these activities also have been reduced during the same period.

In the Chinese portion of the drainage basin, the main centers of industrial production are Mishan, Jixi, Dido, Hulin, Chengzihe, Mullein, Bamiantun and several other settlements. Major industries in Mishan City include breweries, cement plants, tanneries, paper mills, oil refining factory, cooking plant, pharmaceutical factory and dairy plant, with the total value of this output being approximately 0.97 billion Yuan.

4.2.5 Transportation

The main transport artery in the Russian portion of the drainage basin is the Trans-Siberian Mainline Railway, which stretches for 150 km over the lake districts. Two lateral lines across the districts also are connected with Trans-Siberian Railway. As a result, even the most remote areas in the drainage basin are located within 30-40 km of a railway connection. The region also contains a wide automobile road network (Table 4-19). The region also contains some local airports and helicopter sites.

Table 4-19. Automobile road network in the Russian portion of Lake Xingkai/Khanka drainage basin (excluding roads in settlements)

District	Length (km)		Density of roads (km/100 km^2)
	Total	Hard cover roads	
Khankaisky	289.3	233.3	6.9
Mikhailovsky	329.9	119.3	11.8
Khorolsky	302.0	181.0	15.3
Chernigovsky	254.0	254.0	13.8
Pogranichny	412.0	12.0	11.0
Spassky	268.0	268.0	6.4
Total	1,855.5	1,467.6	10.8

(km, kilometer)

The Chinese portion of the drainage basin also contains a dense highway network, as well as the Mudanjiang-Harbin Railway. Mishan City is the vital communications hub to the east of Mudanjian, and is linked directly by rail and road to Harbin, Mudanjiang, Jixi, Baoqing, and Qitaihe. The annual transport capacity is 1.27 million passengers and 310,000 tons of goods. A first-grade port (Mishan Port) was built in 1988, about 38 km from Mishan City. The port is a trading medium for trade with Japan, Korea and five continents, handling 0.3-0.5 million tons of goods each year.

4.2.6 Tourism

The situation with regard to tourism and recreational resources is somewhat different in the Russian and Chinese portions of the drainage basin. The Russian portion contains 6 health resorts (located in Gornye Khruchi Town/Kirorsky District, Astrakhanka Village/Khankaisky District, Novoshakhtinskii Town/Mikhailovsky District, Gribnoye Village/Chernigovsky District; Table 4-20). Most adult vacationers spend their time at the "Shmakovka" Resort in the Kirovsky District.

Table 4-20. Overview of sanatoriums, health resorts and rest institutions in Russian portion of Lake Xingkai/Khanka drainage basin

District	Year	Total number	Bed capacity		Number of people served	Including children
			Throughout year	During period of maximum use		
Khankaisky	1998	1	100	128	351	351
	1997	1	100	130	319	319
Mikhailovsky	1998	1	100	100	593	-
	1997	1	100	100	796	-
Chernigovsky	1998	1	75	75	834	652
	1997	1	75	75	830	-
Kirovsky	1998	3	920	1,120	16,790	1840
	1997	4	1,445	1,645	16,131	-

There also are over 100 sanative summer camps for school children in the Russian portion of the drainage basin. Some districts also contains labor and rest camps, specialized camps and sport-sanative camps. About 13,121 school children visited the camps in 1998, and 9,850 school children in 1999.

In spite of the availability of these recreational resources, the tourist and excursion network in the Russian portion of the drainage basin is relatively poorly developed. The density of both organized and non-organized tourist routes is low, with only 5 existing routes (mainly for automobiles) per 1,000 km^2. Tourism agencies only exist Spassk-Dalny City and Kamen-Rybolov Town, and are generally oriented towards Chinese visitors.

The tourism situation is strikingly different in the Chinese portion of the drainage basin. The splendid view of the lake's small basin, availability of delicious fish and shrimp, and the presence of rare animals and birds has attracted large numbers of tourists. In 1987, there were 170 staff members serving approximately 0.13 million man-days of tourists. Tourism is continuing to be rapidly developed in this area. In fact, the region has experienced about 160,000 man-days of tourists each year from Japan, Canada, United States of America, Sweden, Russia, Hong Kong, Singapore and the Republic of Korea over the past few years.

4.3 Possibilities for Socio-economic Development of Drainage Basin

In addition to examining the past and present economic situation, including the economic downturn during the 1990s in the Russian portion of the drainage basin, it also is informative to consider the future possibilities for socioeconomic development in the Lake Xingkai/Khanka drainage basin, including the relation of this development to the drainage basin's environmental resources.

4.3.1 Socio-economic Development Potential of Russian Portion of Drainage Basin

The potential for socioeconomic development of the Russian portion of the drainage basin is related primarily to (i) the basin's natural resource base, and (ii) economic-geographical location relative to neighboring China and the Trans-Siberian Railway, as follows:

- *Natural resource base* – this component includes agricultural land resources and favorable climatic conditions, deposits of different types of raw building materials, and recreational resources in the vicinity of the lake.

- *Economic-geographic location* – this component includes the close proximity of the region to the Trans-Siberian Railway, to transport passages through the state boundary, and to the federal highway ("Vladivostok-Khabarovsk").

- *Accumulated socioeconomic and demographic potential* – this component includes the relatively high local population density, the developed multi-branch economic, and developed transportation network.

At the same time, there are certain ecological limitations on the economic use of the land areas adjacent to the lake, related primarily to the need to preserve the biodiversity of the full drainage basin, the Khankaisky State Natural Reserve, and the lake and its inflowing rivers.

Some efforts to consider both the favorable and the limiting factors of socio-economic development in the Russian portion of the drainage basin have been undertaken in recent years, a prominent example being the "Federal purpose-oriented program of economic and social development of the Far East and Trans-Baikalia for 1996-2005".

It is assumed that future socio-economic development in the drainage basin will include modernization and new construction of many existing enterprises and economic spheres, including the mining and extraction industry (coal, building materials and fluorite), the processing industry (processing of timber and agricultural raw materials), and energy and infrastructure (including social infrastructure).

Taking into account the present financial-economic situation in the Russian lake districts, their resource base, and their favorable economic-geographical location, the following directions of economic development seem likely:

- *Agriculture and food industry* -- based on processing of local agricultural raw materials;
- *Coal mining, and creation of Mikhailovsky (Novoshakhninsky) or Vladivostok fuel-energy complex* -- analogous to the Luchegorsky fuel energy complex);
- *Building industry* -- based on use of different kinds of local natural raw materials (cement, marble, brick, clay, etc.);
- *Extraction and processing of raw materials* – such as fluorite; and
- *Organization of recreation and tourism* – focusing on the lake area itself.

The drainage basin's favorable economic-geographical location also is important, and should facilitate:

- *Large-scale cross-border tra*de -- based on creation of the Center for External Economical Cooperation in Pogranichny and Tury Rog settlements (analogous to that of Suifenhe), as well as possible free-trade zones; and
- *International tourism* – including involvement of other districts of Primorsky Kray.

The economic possibilities suggest that joint organization of a trans-border tourist route around the lake is in the interests of both China and Russia. Another possibility is the development of a Free-Economic Zone (FEZ) or Customs Zone for Free Trade (CZFT), thereby facilitating creation of comparable transport, customs, trade-service, tourist and other infrastructure facilities.

The economic structure of a CZFT development at Pogranichny would initially focus on transport-loading complexes, customs complexes, wholesale store houses, tourist complexes, trade markets, supermarkets and small retail-trade shops and service offices. The industrial enterprises should be food industry and other consumer and souvenir-producing enterprises.

The industrial structure of a CZFT or FEZ also must take into account the vast economic and market space of adjacent China, as well as the internal areas of the Russian Far East. The perspective industrial structure under such conditions would comprise at least four blocks of enterprises, as follows;

- *Export industries oriented to the Chinese market* – including processing of sea products and timber from the other districts of Primorsky Kray and the whole Far East, as well as food and forest medicinal resources;

- *Import-replaceable consumer industries* – using Russian and Chinese raw materials including food (e.g., preserving Chinese fruits oriented to the Russian Far East and Siberian markets);

- *Deep processing of local agricultural raw materials* – including preservation of milk and meat, cheese production, partially-finished soup products and other transportable products), based on Russian and Chinese technologies; and

- *New types of regional agricultural production* – including greenhouses, pig-breeding complexes, as well as existing agricultural enterprises, oriented to both Russian and Chinese markets.

A major task for CZFT is to attract investments for development of the region, as well as advanced technologies for different industrial spheres. Accordingly, creation of advanced industries would be a major advancement and profitable undertaking for the many districts of Primorsky Kray. Japanese, Republic of Korea and Chinese investments are particularly important in this regard.

Further development of the transportation infrastructure also will be required for an assumed CZFT, including prior development of transportation modes facilitating external economic cooperation. Focusing on the international possibilities in regard to optimizing the railway and highway network, construction of approximately 50 km of united railway and parallel highway from the node station Sibirtsevo on the Trans-Siberian Mainline to Grodekovo Station near the Chinese border will be necessary to provide direct transportation between the mainline of the Trans-Siberian Railway and the eastern and northern districts of Primorsky Kray. This would also facilitate economic ties between Russia and China, as well as transit conveyances of goods to Japan and North America. An appropriate railway shifting complex and helicopter site also will be necessary

The Russian "Khorol Cosmodrome Project" is of relevance within this context as well. Considering the possible use of decommissioned military bases, the use of take-off runways (particularly for large airplanes), as a trans-shipping base for the air transportation of cargoes of large size from Southeastern Asia and Northeastern China to Europe and North America, also must be considered.

As ancillary benefits, realization of this transportation project would create new jobs and also provide food transportation to the Russian North (including local agricultural production), thereby benefiting all the Russian lake districts. Nevertheless, its realization will be very difficult, and demand large federal and private investments (including foreign).

In 1999, the Governor of Primorsky Kray approved a program for development of a highway network, including construction of two-leveled roads near Mikhailovka, Terekhovka and Sibirtsevo settlements and Spassk-Dalny City. Development of an industrial base is contemplated with this program, including new asphalt-concrete plants, bitumen bases and quarries, as well as re-equipment of existing plants. A practical reality to be considered, however, in regard to developing the building-materials branch of the economy is that large increases in demands for building materials will likely only be possible with the overall improvement of the Russian economy.

Under such conditions, it is most prudent to facilitate creation of separate small and technically-equipped enterprises, which produce products that might be demanded within main Russian and Chinese consumer markets in the Russian Far Eastern region (e.g., local marble, high-quality phosphorus clay). Accordingly, a study of consumer markets in Chinese and Russia, focusing on the building sphere of the economy, would be useful.

To facilitate future economic development, it also will be important to preserve the existing industrial potential of the leading building material enterprises in the Russian districts (Spassk Cement Association, Spassk Combine of asbestos-cement wares, Khorol Rural Building Combine, Sibirtsevo Combine of building industry, etc.). Ideally, such preservation would be based on increased consumer demand for their products.

Farming, as a major form of small business in the region, has considerable continuing development potential. As previously noted, the region is characterized by relatively high-quality land resources, suitable soil-climatic conditions, and adequate qualified personnel. Nevertheless, because of the decreased purchasing capacity of citizens, much of the locally-produced crops were not purchased in recent years.

Possible ways to improve the economic situation related to farming activities include (i) farmer cooperation in creating procuring and processing links and (ii) creating a joint- ancillary enterprise to realize cooperative production of farm crops.

4.3.2 Socio-economic Development Potential of Chinese Portion of Drainage Basin

It is the goal in the Chinese portion of the drainage basin, as well as in the Russian portion, to implement programs of sustainable economic development. To this end, coordinated economic development and environmental protection will require substantial finances. At the same time, societal stability must also be ensured, as a means of facilitating society's economic advancement and well-being.

The financial income of Mishan City, as a main territorial and economic complex in the Chinese portion of the basin, was 110 million Yuan in 1996. The annual average growth rate was 9.4%. The goal is to reach 434 million Yuan by the year 2000, with an average annual growth rate of 10.6%. Further, the estimated investment during the ninth Five-year Plan will increased by 158% over that of the eighth Five-year Plan.

Total investments in social fixed funds are 1,560 million Yuan. This includes a one hundred million Yuan (6.4% of investments) State investment. Banks and other financial institutions have provided loans of 700 million Yuan (44.9%), while the governments of two levels have invested 560 million Yuan (35.9%). Two hundred million Yuan from foreign investors is equivalent to 12.8%. Nevertheless, the external investments are only equivalent to 0.7% of the Chinese GNP. Thus, the goal is to increase the investing in a step-by-step manner, to reach a total of 1.5% of the GNP.

Building on the environmental advantages of the Lake Xingkai/Khanka area, the economic complex of Mishan City should give priority to using its natural resources to build a new economic picture, in which ecological tourism, green agriculture and industrial processing of organic foods become core industries.

To this end, the main indices in the national economic development plan for Mishan City are as follows:

(I) A GNP of 1.8 billion Yuan by 2000, with an annual increase of 10%. The anticipated GNP by the year 2010 is 3.6 billion Yuan, with an annual increase of 7.2%;

(II) A gross industrial output valued at 1.6 billion Yuan in 2000, with an annual increase of 15%. The anticipated output by the year 2010 is 4.2 billion Yuan, with an annual increase of 10%;

(III) A total output of output of grain crops, beans and potato of 600 million kg in 2000, with an annual increase of 3.7%. The anticipated total output by the year 2010 is 700 million kg, with an annual increase of 1.7%;

(IV) A per capita income in villages of 3,056 Yuan in 2000, with an annual increase of 8%. The anticipated per capita income by the year 2010 is 5,122 Yuan, with an annual increase of 5.3%; and

(V) A total turnover of social consumer goods of 9.73 million Yuan in 2000, with an annual increase of 12.5%. The anticipated turnover by the year 2010 is 3.3 billion Yuan, with an annual increase of 13%.

As previously noted, water resources are abundant, and fisheries flourish within the Chinese portion of the drainage basin. Accordingly, Mishan City plans to enlarge the fish-breeding area to 94,000 mu[1] (approximately 6,267 ha), increasing the fishery output to 180 million Yuan, the output value and profit to 150 million Yuan and 53 million Yuan, respectively.

[1] The "mu" is a unit used for measuring an area. 1 ha equals to 15 mu.

These values correspond to increases of 8, 33.3, 36.4 and 43.2%, respectively, over the 1997 values. It is anticipated that by the year 2010, the fish-breeding area will comprise 115,000 mu (approximately 7,667 ha), the fishery output will comprise 300 million Yuan, and the output value will be 400 million Yuan, corresponding to increases of 22.3, 66.7 and 166.7%, respectively, over the year 2000 values. The profit is expected to be 1.4 billion Yuan, an increase of 164.2% over the year 2000 value.

In regard to the protection of fisheries and other aquatic species, as well as the conservation of rare and endangered species, it is believed that fishing boats in Lake Xingkai/Khanka should be non-motorized. This would prevent oil pollution and allow for better control of the annual fish catches in the lake. Aquaculture activities in small water reservoirs in the drainage basin also will be steadily developed.

The direction of agricultural activities of Mishan City should be shifted to development of green-organic agriculture. As far as possible, the area of lands returned to wetlands and marshy lands should be increased annually. Villages also will develop into intensive mini-towns. Thus, public sewerage systems should be built in villages near the lake, and wastewaters should only be discharged after treatment.

The main agricultural goal is to grow 600 million kg in 2000, an increase of 16.5% over the 1997 value. It is anticipated that the total economic output of agricultural crops will be 700 million kg in the year 2010, a 16.7% increase over the year 2000 value.

Regarding livestock, the number of pigs and poultry will be 411,000 and 4.34 million, respectively, in the year 2000, increases of 44.3 and 24%, respectively, over the 1997 values. It is anticipated that the economic value of livestock husbandry output in 2000 will be increased approximately 180% over the 1997 value. It is further anticipated that the number of pigs and poultry will be 672,000 and 77.22 million, respectively by the year 2010, corresponding to increases of 63.5 and 66.4%, respectively.

The area devoted to fruit trees will comprise 80,000 mu (approximately 533 ha) in 2000, with an output of 50 million kg. The income from fruit trees will be 6.0 million Yuan, a 1,200% increase over the 1997 value. It is anticipated that the area devoted to fruit trees will comprise 100,000 mu (approximately 6,667 ha), with an output of 6262.5 million kg, by the year 2010.

Forest coverage also must be increased if socioeconomic development is to be conducted in a sustainable manner. The current rate of forest cover is 23.9% in Mishan City, with anticipated increases of 30% in the year 2000 and 35% in the year 2010. To this end, afforestation must be given the first priority. The development of the timber industry must be the second priority, and plans to reduce the areas subject to tree-cutting must be reduced. Activities to enhance the hillock's forest belt are of special importance.

Because coal reserves are abundant in Mishan city, the mining and processing of raw coal should be promoted. The output of raw coal should be increased to 1.6 billion kg in the year 2000, compared to 1.1 billion kg in 1997. The total economic value of the coal industry in 2000 will be 110 million Yuan more than the 1995 value. There also is a large marble deposit in Mishan City, and cement production also can be developed. To this end, mining of 300 million kg of marble and the production of 1.2 billion kg of cement are anticipated for the year 2000. At the same time, attention must be given to ensuring that mine drainage and waste discharges do not damage the surrounding environment, and also that the noise associated with the mining industry does not affect wildlife in the nature protected areas.

There is increasing interest in the tourism industry, with particularly focus on the natural amenities of the region. The good environmental characteristics of the Lake Xingkai/Khanka drainage basin support this goal as an appropriate economic activity. At the same time, tourism development must be done in a manner that protected the environment, for it is the environment that is the attraction in the first place. The main tourism development goals include the following:

- *Number of tourists* – The plan is to have 180,000 tourists in the year 2000. Included in this number is 160,000 domestic tourists, an annual increase of 8.5%. The number of Russian tourists will be 20,000, an annual increase of 12%.

- *Income from tourism* – By the year 2000, foreign exchange tourists will provide an economic value of US$ 18,390, an annual increase of 13%. The income from domestic tourists will be 93,460 Yuan, an annual increase of 9.75%.

- *Construction of touring projects* – Lake Xingkai/Khanka and its adjacent territory represent a scenic location, with abundant touring resources, and a minimum development of natural resources. Accordingly, the plan is to build nine scenic spots and four special scenic sites. These include the scenic spots of Mifeng Mountain, Dangbi Town, Longwangmiao, Xingkailiu, the Lianhua touring area, the hillock sightseeing spot, and breeding farms for wild animals and plants. These scenic spots will involve a comprehensive touring and vacationing area, with first priority given to their use as summer resorts for holidays, and alternatively as winter resorts.

4.4 Conclusions Regarding Socio-economic Development Potential of Drainage Basin

Analysis of the socio-economic status and potential of the Lake Xingkai/Khanka drainage basin indicates serious environmentally-related problems in both the Russian and Chinese portions of the basin. These problems arise because of the inadequate appreciation of the natural conditions, particularly in regard to imperfect forms of economic policy in the agricultural-production and the raw materials mineral complex spheres, as well as irrational use of water resources, and inadequate cleaning and treatment facilities associated with the industrial and municipal services spheres in both portions of the drainage basin.

Fortunately, the analysis also has highlighted the possibilities for the creation of economically-profitable and ecologically-adaptable variants for development of the drainage basin. To this end, considering the drainage basin as a united geographical object, it must be developed within the context of a united plan. Indeed, the most important component to consider at this stage is the development of a large-scale, concerted program of nature use transfer into the concept of sustainable development in the drainage basin. The ultimate goal is the development of joint programs of ecologically-sustainable economic progress in the drainage basin and some adjacent territories. This program should include sound recommendations in regard to land use and natural resource policy, recommended standards, allowable and first priority types and scales of economic activities, and proposals for organization of the system of specially-protected areas.

CHAPTER 5

ENVIRONMENTALLY-SUSTAINABLE DEVELOPMENT OF LAKE XINGKAI/KHANKA AND ITS DRAINAGE BASIN

Previous chapters of this report discussed the water and other natural resources, land use, biodiversity and socio-economic characteristics and potential of the Lake Xingkai/Khanka drainage basin, and the associated environmental concerns. The intention was to provide the reader with an analysis of the current conditions, and both the positive and negative environmental features, that characterize the lake and its drainage basin and inhabitants. The primary purpose of this final chapter is to (1) highlight environment-economic linkages in the drainage basin and (2) identify possible means of facilitating the socio-economic development of the drainage basin in an environmentally-sustainable manner.

5.1 Important Economic-Environmental Linkages and Protection Possibilities in Lake Xingkai/Khanka Drainage Basin

There are a number of actions that the two riparian countries can consider, either individually or collectively, as a means of facilitating the protection and conservation of the natural environment of Lake Xingkai/Khanka and its drainage basin, while at the same time continuing the socio-economic development of the drainage basin in a sustainable manner. Such actions will doubtlessly work to the positive short- and long-term benefit of the region and its inhabitants.

5.1.1 Land and Mineral Resources

Various areas of the drainage basin have undergone deforestation and/or land use transformation in recent decades. For example, the forest cover in Mishan City, China, decreased from 81% to 34% between 1963 and 1976. Considerable wetland areas also have been converted to agricultural use in different parts of the drainage basin. Such situations have caused serious destruction of the local and regional eco-environment, especially wetlands and marshy land areas. It also had negative impacts on biodiversity, water quality and other environmental features of the drainage basin.

Thus, every effort should be made to control activities that will reduce the wetlands, marshy lands and other natural areas in the drainage basin. The environmental benefits of re-converting the maximum quantity of land area each year that previously was converted from wetland and marshy lands to irrigated agricultural fields also should be seriously considered.

It has been suggested that the direction of future agricultural development in the drainage basin should be shifted from traditional agricultural crops to green-organic agriculture. This would promote industries focusing on the processing of organic foods and high-grade wood products. Properly managed, such industries can generate both low pollutant loads and high profits. Consideration also should be given to establishing an agriculture-ecological demonstration area, as a means of highlighting the efficacy of such activities for environmental protection and for improving the economic well-being of the basin inhabitants.

Forest restoration also should receive priority as a means of restoring and protecting the original forest ecosystems. To this end, the forest industry should limit its tree-cutting activities in sensitive drainage basin areas. A scientific forestry system also should be established, with the goal of promoting a balanced forest ecosystem.

Although there is no substantial manufacturing activity in the lake's drainage basin, certain portions of the basin do contain substantial deposits of several economically-viable mineral resources, including coal, fluorspar and raw building materials (cement, marble, etc.). Some currently known, but not yet exploited, mineral deposits also will likely be developed and utilized in the future. The extraction and processing of such materials can cause both physical landscape impacts and water pollution.

Although not presently a major environmental problem, concerns have been raised about the uncoordinated development and utilization of these mineral resources, as well as the generation of pollutants associated with mining and extraction activities. Thus, such efforts should be conducted in a manner insuring environmental protection, with particular attention given to reducing the generation of wastewaters associated with mining activities, as well as reducing air and noise pollution in local mining areas. The environmentally-sustainable exploitation of the limited natural resource base in the Lake Xingkai/Khanka drainage basin also is encouraged.

In regard to industrial activities, the region has not yet experienced extensive industrial development. The existing industrial activity is concentrated in the Russian portion of the drainage basin, and consists primarily of raw building materials, and some light processing industries.

The primary environmental concern related to industrial activities is water pollution of the lake and the other water systems in the drainage basin, due to inadequate or no treatment of industrial effluents and domestic wastewater. The Muling River, for example, is a primary water pollutant source to Lake Xingkai/Khanka, including both point source effluents and nonpoint source runoff, requiring concerted attention to address the problem.

It is clear that ecological problems in the Lake Xingkai/Khanka drainage basin have resulted from a mixture of inadequate management of agro-industrial and raw mineral complexes, irrational use of water resources, environmental pollution by chemical substances, and the direct destruction of natural objects. Nevertheless, based on its natural resource base and environmental characteristics, as well as such factors as land surface morphology, basic ecological restrictions, and composed territorial – economic specialization, one can identify different portions of the drainage basin best suited to supporting specific economic activities and enterprises. Obvious examples are agriculture, industry-transport, recreation and tourism.

5.1.2 Biodiversity Resources

Natural amenities, such as scenic landscapes and picturesque vistas, delicious fish and shrimp, recreational fishing and hunting, and opportunities to observe interesting and rare biodiversity strongly favor the development of the drainage basin's tourism industry. These amenities appear both to drainage basin inhabitants and foreign visitors from a number of countries.

The rich, and in some cases unique, biodiversity is a major natural environmental feature of both the Chinese and Russian portions of the Lake Xingkai/Khanka drainage basin. It includes many globally-recognized rare, endangered and/or unique species of plants and animals. The biodiversity of the bird and fish populations also are highlighted as important indicators of the drainage basin's biological diversity. Various habitats for different animal and plant species exist throughout the drainage basin, containing or home to many rare and endangered species of both scientific and recreational/tourism interest. Under the Ramsar Convention, in fact, the Russian portion of the drainage basin is designated as a major bird nesting areas, as well as resting areas for important migratory bird species, many of which are identified in the Red Books of Russia or the IUCN. The lake's fish populations also are a significant economic resource for the basin inhabitants, as well as being a biodiversity resource. Accordingly, every effort must be made to protect and conserve the drainage basin's plant and animal biological diversity, as well as to enhance the conditions for its stability into the future.

The biological resources of the drainage basin are under major threat from ongoing and anticipated economic development activities. Wetland reclamation and tourism development, for example, has already caused significant damage to some local ecosystems. The agricultural and industrial development taking place in the drainage basin is often at the expense of wetlands and forested areas being converted to agricultural, industrial and urban lands. These activities have also increased pollutant loads in the drainage basin. Loss of wetlands, marshy lands and forested areas has been translated into the loss of significant habitat areas. Of particular concern is the loss of habitat for nesting waterfowl, as well as resting areas for birds and waterfowl that seasonally migrate through the region. Rare and endangered species are especially susceptible to their habitat loss.

Recreational pursuits within the tourism industry, such as hunting and fishing, are also impacting the biological resources. Increasing numbers of tourists in sensitive areas also is causing significant noise and other disturbances of the resident and migratory animal populations. The resource needs for tourism also are increasing as this industry continues to expand, accompanied also by an increasing production of wastes and potential for water pollution and other ecosystem impacts.

Ironically, increasing ecological and recreational tourism was originally meant to facilitate appreciation of the natural wonders of the region. Good environmental quality is a fundamental requirement for a strong tourism industry. Unfortunately, the existence of the above-noted natural amenities has been its own worst enemy in some ways. It has resulted in significant negative environmental impacts, for example, in the form of land transformation for establishment of tourist facilities, increasing water and other natural resource demands, increased waste production and water pollution, etc. Development of hotels and other tourist housing facilities is occurring at the expense of native habitats. Increasing numbers of tourists require increasing quantities of resources (food, water, etc.), and produce increasing pollutant loads. Increasing hunting activities are negatively impacting the viability of some native animal species. The mere presence and/or noise of humans in some natural areas is disturbing sensitive species, causing the migration of some of them to other areas. Increasing tourism activities also is reducing the populations of desirable and rare fish species.

Accordingly, future tourism development must be undertaken in a manner that both highlights and protects the drainage basin's natural amenities. Positive actions can include restricting or prohibiting the entrance of tourists in regions that are habitats for rare or endangered species, and to other environmentally-sensitive regions in the drainage basin. The hunting or trapping of rare and endangered species should obviously be prohibited as well.

The fisheries of Lake Xingkai/Khanka are also a significant sports and commercial enterprise in the region, as well as being an important biodiversity resource. However, the fisheries also are undergoing being affected by human activities. Major environmental problems related to the fisheries include (i) excessive exploitation of existing fisheries, particularly high-quality and economically-important fish, (ii) low fish production in the lake, due partly to lack of scientific methods for estimating sustainable fish catch levels, and (iii) deteriorated water quality in the lake and its inflowing rivers. Further, the two riparian countries currently do not employ any joint fish production and conservation methods for protecting this valuable and sensitive resource.

Thus, there is an obvious and urgent need for the two riparian countries to develop and implement a joint plan for protecting the drainage basin's biological diversity, as well as its existing natural areas. A joint plan will facilitate a viable relationship between the demands of socioeconomic development and the protection and conservation of the drainage basin's natural resources, including its rich and important plant and animal communities.

5.1.3 Agriculture

Agriculture is a major economic activity in both the Russian and Chinese portions of the Lake Xingkai/Khanka drainage basin. This is due to a combination of suitable soils, climatic conditions and available land resources. A large number of some grains and other crops, and livestock, already are produced in significant quantities in different portions of the drainage basin. Agricultural development will continue to increase in importance over time, concurrent with increasing population growth and industrialization in various portions of the drainage basin.

Agricultural development in the drainage basin is also the underlying cause of many of its environmental problems, including (i) increased soil erosion and degradation; (ii) loss of wetlands, marshy lands and forests because of their conversion to agricultural land; (ii) increased water demands; and (iv) increased use of agricultural fertilizers and pesticides, and associated water pollution of the lake and the rivers draining into it.

As one way of reclaiming some forested areas, it has been suggested by some that farmlands with slopes greater than about 15° from the horizontal should gradually be converted from farmland to forestland, and that land with slopes greater than 25° should be totally converted to forestland. This practice would increase forestland areas, reduce agricultural nonpoint runoff and facilitate water conservation. Accordingly, the two riparian countries should seriously explore the environmental implications of such a suggestion for specific areas of the drainage basin.

Environmentally-sustainable farming practices also should be employed in the drainage basin to the maximum extent. Particular attention should be given to reducing the quantity of fertilizer and pesticide usage in agricultural areas. Soil tests, for example, would help identify accurate soil fertilizer requirements and optimal fertilizer application rates. Changing single fertilizer use to combined fertilizers would work to decrease fertilizer losses and increase the utilization ratio. Efforts also should be made to introduce and popularize the appropriate use of farm manure as a fertilizer.

Integrated pest management procedures should be employed to the maximum extent, as a means of reducing pesticide applications in agricultural areas. Further, ecologically-damaging practices such as aerial spraying of pesticides on rice fields should be prohibited.

Activities that facilitate efficient water use also should be encouraged, including changing from more water-intensive flood irrigation to less-water-intensive spray and/or drip irrigation techniques. More attention also must be given to reducing agricultural nonpoint-source runoff, with the utilization of such measures as buffer strips, detention ponds, etc.

5.1.4 *Tourism Development*

Unfortunately, further development of the tourism industry in the drainage basin will necessarily be accompanied by the building of hotels, guesthouses and sanitariums, as well as increasing environmental degradation. It will also increase the production of effluents garbage, fecal-contaminated sewage, etc., draining to the lake and its inflowing tributaries, with subsequent environmental deterioration. Therefore, although it will reduce the short-term economic benefits to drainage basin inhabitants, protecting the region's natural amenities for the long-term benefits of its inhabitants can include limiting the construction of new hotels and other tourist facilities in the drainage basin. Further, the sewage and other wastes from existing hotels, restaurants and other establishments along the lakeshore must be treated to appropriate discharge standards for protecting water quality and other environmental standards. Simple practices, such as prohibiting fishing and engine-powered recreation boats in the area, will reduce water pollution from oil and engine fuel.

The importance of protecting and conserving biological diversity as a fundamental requirement for enhancing the potential for recreational and ecological tourism as a significant economic activity in the Lake Xingkai/Khanka drainage basin also is reiterated.

5.1.5 *Freshwater Resources*

There presently are no significant concerns regarding water scarcity in the Lake Xingkai/Khanka drainage basin. The existing water resources appear to be adequate to address current and foreseeable water needs for population growth and related agricultural and industrial development.

The issue of water pollution, however, is a different matter, requiring immediate and concerted attention. There is a substantial input of water pollutants into Lake Xingkai/Khanka via the Muling River, for example, from domestic wastewaters and industrial effluents from towns and cities in the Muling River catchment area. Nonpoint-source runoff in the drainage basin also contains water pollutants such as agricultural fertilizers and pesticides.

Despite the relatively sparse population and industrial development in the drainage basin, a range of water pollutants from existing industrial enterprises in different parts of the drainage basin are finding their way into Lake Xingkai/Khanka from both riparian countries. The relevant sources include the mineral-processing industry, coal industry, metallurgical industry, electrical industry, food processing industry, chemical industry and wood-processing industry. Typical industrial water pollutants being discharged in the drainage basin from such industries include oxygen-depleting substances, suspended solids, phenol, chromium, mercury and others.

A number of steps have been proposed for addressing various aspects of water quality problems. These include such measures as (ii) establishing a unified administration for the environmentally-sustainable utilization of the lake's water and related natural resources; (ii) strengthening public awareness and education activities regarding the need for environmental conservation and protection; (iii) building treatment plants for domestic and industrial wastewaters; (iv) reducing industrial water usage, including encouraging effluent reuse and recycling; (v) increasing forest areas and land vegetative cover to conserve water; (vi) using fertilizers and farm chemicals in a wise manner, and (vii) increasing water use efficiency (e.g., drip and spray irrigation).

Sediments also are a potential pollutant source, in that many of the pollutants discharged in the Lake Xingkai/Khanka drainage basin ultimately end up in the bottom sediments of the lake. Accordingly, proper dredging of the bottom sediments in polluted portions of the lake should reduce the potential for remobilization of sediment-bound pollutants back into the overlying lake waters. Dredged sediments that do not contain elevated levels of heavy metals or persistent organic pollutants also may be useful as an agricultural fertilizer.

It is clear that domestic sewage from the towns located along the lake's shoreline must be collected and treated prior to discharge, as a means of protecting Lake Xingkai/Khanka from water pollution problems. Domestic wastewater that meets appropriate discharge standards also can be used in farm irrigation or fish production activities.

5.2 Environmental Monitoring

Implementation of effective actions directed to environmental protection is difficult without accurate data and information on existing environmental conditions. To obtain the necessary data for protecting and conserving the water and other natural resources of Lake Xingkai/Khanka and its drainage basin, therefore, proper monitoring efforts are essential. It is noted, for example, that the existing monitoring stations for both water quantity and quality are only monitored infrequently over the annual cycle.

Accordingly, a comprehensive programme for monitoring the status of surface and groundwater in the drainage basin should be established, with an initial focus on major hydrochemical and hydrological parameters. Monitoring the status of reservoirs in the drainage basin on the basis of their biological parameters, including studies of zoobenthos and algaflora usually used for saprobility indices, also can provide valuable information for evaluating the drainage basin's ecological situation. The training of technical and management personnel to staff and administer an appropriate monitoring programme also is fundamental.

A monitoring mechanism for developing a biodiversity conservation database for the drainage basin's flora and fauna, including its sensitive, rare and/or endangered plant and animal species, also should be expeditiously established. Such data and information would facilitate the capabilities of the two riparian countries to identify and analyze the complex relationships between the life cycles, habits and characteristics of resident plants and animal species and their natural surroundings, as well as their environmental inter-linkages. A biodiversity conservation base also will facilitate the protection of the natural environment, facilitate ecological balance, and progressively allow formation of a relatively permanent biological gene pool. It will also facilitate the dissemination of scientific research and knowledge.

5.3 Binational Cooperative Programme for the Environmentally-SustainableDevelopment of the Lake Xingkai/Khanka Drainage Basin

It is relatively easy to identify the environmental problems and their underlying causes facing Lake Xingkai/Khanka, consistent with the continuing socio-economic development of its drainage basin. It is a much more difficult matter, however, to address these problems in a satisfactory manner. Many of the problems are complex in nature and will require concerted, long-term efforts by many individuals and agencies to satisfactorily address them. The fact that Lake Xingkai/Khanka is a boundary lake between Russia and China adds an international dimension to be considered in addressing the long-term sustainability of this important binational water resource, as well as the common interests and concerns of the two countries.

In recognition of this reality, a regional workshop on the Lake Xingkai/Khanka project was held during 13-16 December 1999 in Mishan City. During the course of their discussions and deliberations, the Chinese and Russian representatives and experts identified issues of mutual concern to be addressed collaboratively by the two countries, based on the information on the environmental problems in the lake basin. They also identified proposed actions for addressing them. These items and conclusions are summarized in Table 5-1.

The major environmental priorities identified in Table 5-1 include (i) water resources and environmental monitoring, (ii) environmental management and protected areas, (iii) socio-economic development impacts, (iv) biodiversity and (v) information exchange. The proposed solutions to the problems include (i) joint monitoring, study and research, (ii) implementation of pollution control measures, (iii) information and scientific exchange, (iv) development of drainage basin-scale sustainable development plans, (v) comprehensive biodiversity assessment and inventories, (vi) development of joint fisheries plan, and (vi) establishment of joint databases.

Table 5-1. Summary of major issues and proposed actions for the environmentally-sustainable management of Lake Xingkai/Khanka and its drainage basin

Topic	Issues	Proposed actions
Water-related issues and environmental monitoring	• Elevated chemical oxygen demand levels; • Mesotrophic lake trophic status, necessitating careful observation of future trends; • Levels of some pollutants (e.g., heavy metals, pesticides) in water may become higher, necessitating future actions; • Specific control measures will be necessary to address pollutants and flooding of Muling River; • Water monitoring data in two countries have different format and sampling and analysis procedures; and • Pollutant sources should be more clearly identified.	• Joint monitoring (including joint sampling, inter-calibration and information exchange on monitoring points); • Updating and exchange of recent monitoring results; • Further analysis on lake water quality which has impacts on wetlands surrounding the lake; • Further study and survey on groundwaters and their interactions with lake water quality and hydrology; • Agricultural and industrial pollution control measures in China (specially Muling River basin and state farms); and • Possible measures for addressing future pollution in Russia after its economy improves.
Environmental management and protected areas	• Lack of information on management efforts and structure, in spite of ongoing efforts of the two riparian countries; • Two official agreements, including (i) Mishan and Primorie on the lake nature-protected areas; and (ii) Heilongjiang, Primorie and Khabarovsk on Ussuri/Wusuli, which should serve as a good basis for regional cooperation; and • Different management regulations and structure in the two riparian countries.	• Exchange of information on management regulations and enforcement; • More solid establishment of an international reserve; • Development of a map showing functional zones, based on land use plans and using GIS systems; and • Joint development of sustainable development plans for the drainage basin.

Impacts of socioeconomic development	• Although Russia's current economic situation is environmentally-favourable, it is anticipated that the negative environmental impacts of economic activities will increase with an upturn in Russian economic development.	• Development of national and regional sustainable develop plans and their incorporation into environmental management plans; • Joint eco-trourism development; • Development of a joint transportation development plan, taking into account joint environmental management efforts; • Development of a joint fishery development plan, taking into account its impacts on biodiversity and ecosystems.
Biodiversity and habitat degradation	• Lack of information exchange on plant and animal species, which should be promoted; • Primary causes of current habitat changes are reclamation/fire in China and fire in Russia, as well as some pollution; • Different regulations for protected areas in the two riparian countries.	• A comprehensive biodiversity assessment (species, population dynamics, and genetics); • An inventory of main habitats; • Study on migratory species (fish, birds, etc.); • Joint development of bio-indicators for monitoring purposes; • Strengthening of existing management measures in the two riparian countries; and • Exchange of scientists and experts.
Information exchange	• Insufficient exchange of information; • Inadequate coverage of information on management activities; and • Inadequate public awareness activities.	• Establishment of a joint GIS system; • Establishment of a joint database; • Development of a regional and/or basin map; • Information exchange via Internet; and • Publication of the results of this project into a popularized version, as a means of enhancing public awareness.

Effectively addressing these issues and priorities will require concerted and collaborative efforts on the part of Russia and China, including involvement of their relevant institutions and agencies, and the provision of necessary financial and human resources. First and foremost, however, is the requirement for development and implementation of a binational cooperative programme between the two riparian countries, as the basis for their continuing efforts to address the environmental problems associated with the socio-economic development of Lake Xingkai/Khanka and its drainage basin. Although the environmentally-sustainable socio-economic development of the drainage basin is a long-term goal, the preparation of this joint Diagnostic Analysis report provides convincing evidence of the desire of the two riparian countries to continue along this path. To this end, the comprehensive approach for the "Environmentally-Sustainable Management of Inland Waters" (EMINWA), previously developed by the United Nations Environment Programme, provides a useful model for a binational cooperative programme for the lake and its drainage basin.

Based on Table 5-1, a binational cooperative programme for the environmentally-sustainable economic development of the Lake Xingkai/Khanka drainage basin will comprise both scientific/technical and institutional elements.

5.3.1 Scientific and Technical Elements

The national reports of the two riparian countries provide substantial information and data on the relevant environmental issues identified in Table 5-1, as well as possibilities for addressing these issues. Nevertheless, in regard to the scientific and technical elements of an effective binational cooperative programme, it is suggested that primary attention for the lake initially focus on the following environmental elements:

- *Conservation and rational management of wetland, marshy lands and forests;*
- *Evaluation and control of water quality degradation of both surface water and groundwater, with initial emphasis on agricultural pesticides and nutrients;*
- *Evaluation, protection and conservation of rare and endangered species;*
- *Rational water use for drinking, irrigation and maintenance of fisheries;*
- *Facilitating environmentally-compatible agricultural activities; and*
- *Development of eco-tourism, consistent with the sensitive environmental characteristics of the lake and its drainage basin.*

Substantial scientific and technical expertise for addressing these issues already exists within the two riparian countries. What remains is the development of the appropriate scientific and technical studies, projects and activities to address these issues within the context of a binational cooperative programme, capitalizing on this expertise. A logical first step is to convene experts to (i) identify and further elaborate the elements requiring further study and a timetable for completing the studies, (ii) the logical individuals and agencies to carry out the studies, and (iii) the financial and human resources necessary to undertake and complete them.

5.3.2 Institutional Elements

A significant number of institutional and social elements also must be addressed within the context of an effective binational cooperative programme for the environmentally-sustainable socio-economic development of Lake Xingkai/Khanka and its drainage basin. To this end, the following elements are deemed especially important:

5.3.2.1 A Unified Plan and identification of Authoritative Agencies for Addressing Identified Problems

Lack of coordination among multiple agencies responsible for overseeing or managing different elements of the same basic components has long been recognized as a major impediment to the development of an effective environmental management plan for the lake and its drainage basin. As one example (among many) in the case of Lake Xingkai/Khanka, the Lake Xingkai Natural Reserve is simultaneously managed by the People's Government of Mishan, the Xingkaihu State Farm No. 8510, the Xingkaihu Aquaculture Factory of Helongjiang Province, and the Army. This "shared responsibility" has resulted in management confusion, due both to lack of a unified plan for addressing the problems and an authoritative organization for implementing it. In this example, this multiple ownership has led to reclamation efforts on the one hand, and industrial development on the other hand, both taking place in nature protected zones.

To avoid such confusing, and sometimes conflicting, goals, considerable attention must be given to developing environmental management plans that simultaneously incorporate the environmental and development interests of both riparian countries. The identification of responsible agencies and lines of authority for the various tasks to be undertaken within the drainage basin is also a fundamental requirement for its success. Otherwise, in addition to the needless confusion, there also is significant potential for uncoordinated activities, duplicative efforts, and the wasteful expenditure of human and financial resources.

It is especially important also to identify and critically evaluate the existing institutional framework in both riparian countries. This will provide the two riparian countries with a basis for determining their adequacy, both individually and collectively, for identifying and incorporating the important environmental and economic linkages inherent in sustainable socio-economic development in an appropriate manner. This critical assessment must include consideration of the international dimensions and implications of this goal as it applies to Lake Xingkai/Khanka and its drainage basin.

5.3.2.2 Enhanced Public Awareness and Understanding

In the Lake Xingkai/Khanka drainage basin, as elsewhere in the world, people and organizations alike often engage in environmentally-unsustainable socio-economic development activities simply because they are not aware of the potential environmental damage likely to result from these activities. This happens on both the local and drainage basin-scale. Accordingly, the two riparian countries must undertake public education and awareness activities directed to both (i) identifying how people and organization can cause environmental problems, and (ii) identifying their potential role in helping to solve these problems.

There are many avenues for public awareness and education activities, including the written and electronic media, extension programmes, school instruction, work-related training, etc. Such efforts can be especially helpful in fostering a sense of ownership and commitment on the part of the drainage basin inhabitants in regard to the identification and implementation of programmes directed to environmentally-sustainable socio-economic development. It will also highlight the importance of environmental protection and conservation in general.

5.4 Development of Joint Scientific Cooperative Research Programme

Because Lake Xingkai/Khanka is an international boundary lake between Russia and China, it is important that the two countries undertake a joint scientific/technical cooperation research programme to further investigate and study the eco-environmental characteristics and problems of the lake and its drainage basin. Relevant elements of such a joint programme include the following:

5.4.1 Drainage Basin Investigations

Fundamental investigations to be undertaken at the drainage basin scale should include (i) quantitative assessment of the water quality of the lake and its major inflow rivers, (ii) quantity and quality of the drainage basin's groundwater resources, and (iii) more accurate quantification of the pollutant loads entering the lake and its drainage basin tributaries, particularly from nonpoint pollutant sources.

5.4.2 Fundamental Research Components

Fundamental research efforts should include (i) identification and efficacy of appropriate technologies for preventing and controlling water pollution from existing and future pollutant sources; (ii) identification and evaluation of protection and conservation possibilities for rare and sensitive animal and plant communities in the lake and its drainage basin; (iii) identification and evaluation of protection and conservation possibilities for wetlands, marshy lands and forests in the drainage basin; (iv) identification of the environmental problems associated with tourism and the environmental capacity of the affected regions; and (v) data and statistics on optimization of fish catches and aquaculture possibilities.

5.5 Joint Sustainable Development Plan

To effectively incorporate environmental concerns at an early stage of economic development, the two riparian countries can develop a joint sustainable development plan for exploitation of the natural resources of the Lake Xingkai/Khanka drainage basin. Indeed, this recommendation can be viewed as an underlying goal of the entire Lake Xingkai/Khanka project. To this end, basic elements of a sustainable development plan should include:

5.5.1 Mineral Resource Exploitation Control Plan

Significant deposits of some raw building materials in the drainage basin have been identified. China and Russia are already exploiting these resources in different parts of the drainage basin, and there are plans to expand these activities in the future. As a means of ensuring the environmentally-sustainable exploitation of these mineral resources, therefore, the two riparian countries should jointly formulate a realistic plan for ensuring that the present and future exploitation of these resources continue in a sustainable manner. The plan should also include the goal of limiting the scale of the environmental damage that may result from such exploitative activities in the drainage basin.

5.5.2 Plan for Sustainable Aquatic Resources

The two riparian countries are also exploiting the aquatic resources of Lake Xingkai/Khanka and the water systems in its drainage basin, including sports and commercial fisheries. Due to excessive fish catches in recent years, the lake's aquatic resources are decreasingly at an alarming rate, with some species even approaching extinction. In order to conserve rare fishery resources and to protect the aquatic environment in general, Russia and China should also formulate a joint cooperative plan for the protection and rational utilization of the aquatic resources in Lake Xingkai/Khanka and its drainage basin.

5.5.3 Regional Eco-Environment Protection Plan

This component of a binational cooperative programme should give priority to identifying and implementing projects that would incorporate environmental concerns into socio-economic development plans at the earliest possible stage. To this end, possible environmentally-related projects to be considered include:

5.5.3.1 Joint Environmental Monitoring Project

The two riparian governments should develop and implement a joint and scientifically-rigorous water quality and biological monitoring programme within Lake Xingkai/Khanka and its drainage basin. The goal is to obtain the necessary information and data on existing water quality, sediment and related environmental parameters, as well as the future trends for these parameters. A joint monitoring programme would also provide a basis for assessing the effectiveness of future activities directed to preventing and controlling environmental degradation.

5.5.3.2 Enhancement of Nature Reserves

To protect the rich biological diversity resources in Lake Xingkai/Khanka and its drainage basin, the two riparian countries should implement a range of scientific research projects within the nature reserves in both countries. A primary goal of such projects would be to gain a better understanding of the linkages between the environmental elements within the lake and its drainage basin, as well as acquiring fundamental data on their biological resources and their sensitivity to anthropogenically-related environmental degradation.

5.5.3.3 Development of Joint Biodiversity Conservation Database

The two riparian countries also should initiate the development of a biodiversity conservation database for Lake Xingkai/Khanka and its drainage basin. The goal would be to identify and compile fundamental information and data on its terrestrial and aquatic components and their interactions and critical habitats. It would also assist in identifying the anthropogenic threats to these important biodiversity resources.

5.5.3.4 Development of Joint Eco-Environmental Monitoring Network

Establishment of a joint eco-environmental monitoring and control network is also fundamental for obtaining comparable data in the Chinese and Russian portions of the lake and its drainage basin. This will require (i) identification and agreement of appropriate biological indicators, and (ii) adoption of similar sampling methods, frequencies and analysis procedures, and (iii) consideration of their relevance to sustainable socio-economic development within the drainage basin.

5.5.3.5 Development of Common Ecosystem Management Rules

Because it is a transboundary lake, the natural resource base of Lake Xingkai/Khanka and its drainage basin is exploited in different ways and intensities by Russia and China. The means of incorporating environmental concerns into the socio-economic development plans for Lake Xingkai/Khanka and its drainage basin also differ between the two countries. As a result, it is difficult to insure the living and non-living natural resources of the drainage basin are being exploited in a sustainable manner. Accordingly, the two riparian countries should pursue the formulation of common rules and regulations for the joint utilization and management of the lake and its natural resources.

5.5.3.6 Development of Legal Framework

Consideration of a common legal framework for the Lake Xingkai/Khanka drainage basin should also be given consideration by the two riparian countries. In making this suggestion, it is recognized that this is not a simple matter. China and Russia already use their existing legal system within their national borders. Nevertheless, some type of compatible legal framework to be used throughout the binational Lake Xingkai/Khanka drainage basin would obviously facilitate monitoring, management and regulation efforts directed to ensuring its socio-economic development was occurring in a manner that (i) promoted protection and conservation of its natural resource base, and for (ii) enhanced the economic well-being of its inhabitants. It would also provide the two riparian countries with a legal framework for addressing issues of common interest within the drainage basin.

5.6 Conclusions

The above-noted components represent some, but not necessarily all, of the fundamental components to be considered by Russia and China if they wish to facilitate the (i) environmentally-sustainable socio-economic development of Lake Xingkai/Khanka and its drainage basin, and (ii) the protection and conservation of the rich biodiversity, freshwater and mineral resources of its drainage basin. The convening of this international cooperative effort between the two riparian countries represents a significant step.

Nevertheless, much remains to be done to protect this important transboundary freshwater resource. There is no doubt that the population and socio-economic development of the lake and its drainage basin will continue to increase in both countries, along with the accompanying increased demands on its freshwater and mineral resources, as well as its rich biodiversity resources. Thus, continuation of the spirit of cooperation between Russia and China regarding Lake Xingkai/Khanka and its drainage basin, as evidenced with the completion of this Diagnostic Analysis report, is fundamental. Indeed, the above-noted binational cooperative programme provides a realistic and rational means of identifying and addressing the important environmental and economic issues particular to this sensitive region. To be successful, it must ultimately develop realistic guidelines and recommendations on such complex topics as (i) the exploitation of freshwater and other natural resource needs compatible with the ability of nature to supply these resources in a sustainable manner, (ii) rational land-use policy, (iii) implementation of binational standards for environmental conservation, (iv) agreement on appropriate types and scales of economic activities and enterprises consistent with the environmental characteristics of the drainage basin, and (vi) establishment of additional nature protected areas.

As previously noted, an effective binational cooperative programme must also build on the good will of the drainage basin inhabitants. This will require (i) open exchange of relevant information and data, (ii) education and public awareness activities, and (iii) research and administration cooperation and collaboration regarding issues of mutual interest. Frank and open discussions on how to best achieve the dual goal of protecting and conserving the natural environment of this important boundary waterbody, while simultaneously enhancing the economic and social well-being of its drainage basin inhabitants will go far in this direction. Indeed, the two riparian countries may have to consider that some of these goals may even be conflicting, thereby requiring their best efforts to reconcile them in an appropriate manner.

Nevertheless, the cooperative and collaborative spirit already demonstrated by the two riparian countries in these initial activities highlights their willingness to consider this and other possibilities. As previously noted, the continued cooperation of the United Nations Environment Programme (UNEP) and its sister agencies within the United Nations system also can facilitate this goal, building on the excellent cooperative work already completed between Russia, China and UNEP.

Whatever approach ultimately proves to be most useful, the environmentally-sustainable socio-economic development of Lake Xingkai/Khanka and its drainage basin should remain the primary goal for the two riparian countries. To do less would be to undermine the substantial efforts already undertaken to address the environmental and economic problems of this important transboundary freshwater resource.

Issued and Printed by:

Division of Environmental Policy Implementation
United Nations Environment Programme
P.O. Box 30552
Nairobi
Kenya
Tel. +254-2-623886
Fax. +254-2-624249
e-mail. takehiro.nakamura@unep.org

www.unep.org

United Nations Environment Programme
P.O. Box 30552 Nairobi, Kenya
Tel: (254 2) 621234
Fax: (254 2) 623927

UNEP