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LAND USE CHANGES IN THE TRANS-BOUNDARY AMUR RIVER BASIN IN THE 20TH CENTURY

ABSTRACT: All distinctions in the economic and nature protection policy of the neighboring states are well reflected and shown within trans-boundary river basins. The parts of trans-boundary geosystem of one country can experience an essential negative influence from rash decisions in the field of nature use and nature protection policy of the neighboring state. The Amur River Basin covers the territories of Russia, the Peoples Republic of China, Mongolia and Democratic People's Republic of Korea and occupies more than 2 million km^2. The most intensive development of the basin territory has started since the middle of the 19th century. We compiled two maps of land use in the Amur River basin in the 1930–1940s and in the early 21st century. Results showed that, negative dynamics is marked for forest lands, meadows, wetlands and mountain tundra. The basic features in the change of land use within national parts of the basin in Russia, China and Mongolia are analyzed. The comparative analysis of land use peculiarities of the countries for the last 70 years has been done.

KEY WORDS: land use and land cover changes, topographic maps, remote sensing, the Amur River Basin

INTRODUCTION

Any country, as a rule, aspires not only to strictly define and support its own sovereignty by means of its frontiers, but also to develop certain cooperation with other countries, especially with its neighbors. In this process, frontier territories can play a pioneer role. In case the aspiration to develop various means of cooperation, including economic and humanitarian, with neighboring countries is mutual, there begins an active interaction of adjacent frontier territories. Infrastructural links of frontier areas are formed and developed, specifically, transport transitions, communication lines and power grids, and some links of market infrastructure. As a result, a trans-boundary territory is formed from closely and steadily co-operating frontier territories. This trans-boundary territory often has a common uniform natural and geographical basis that strengthens coherence within trans-boundary territories, and simultaneously demands for the development of shared approaches to nature management to working out of joint programs of development.

Complete watersheds of large rivers, lakes, sea basins are integral geosystems of the highest rank. If the integral geosystem simultaneously enters two or more countries, it would be considered and assessed as a uniform geosystem at the top level. Within trans-boundary geosystems which are components of uniform river watersheds, all distinctions in the economic and nature conservation policies of the neighboring countries are appreciably shown. The negative impacts on the environment of pollution from various wastes of economic activities, and the use of natural resources, such as water, forest, ground and mineral resources, within one country can be manifested in another country. Catastrophic natural phenomena, such as floods, can also be manifested within basin geosystems as a whole. The international experience of development of trans-boundary territories and our studies show that, at first, sustainable nature management can be realized in different territorial patterns. Second, under conditions of inefficient nature management, one frontier territory can cause a negative impact on the nature management of a neighboring frontier territory as a rule. Therefore, comparative assessments of nature management patterns which are formed on the frontier territories of neighboring countries are necessary. At the same time, observing the long-term land use/cover changes in a certain region of the world is one of the more interesting and important tasks of LUCC (Land Use/Cover Change) studies.

The Amur River Basin is a good example of a trans-boundary trans-regional basin-type geographical structure. Its total area exceeds 2 million km^2. About 50% of its territory belongs to Russia, 42% to China, and 8% to Mongolia. Previous studies on the basin's territories of these three countries were significantly different. Investigations in the southern part of the Russian Far East in the end of the 19th–20th century were mostly oriented on the study of natural conditions – vegetation, soils, and geomorphology, among others. The works of Anuchin [1896] were the first, and they considered a complex of the natural features, population, and economy of Manchuria. A great volume of research works that are both scientific and applied in nature has been produced by the Amur Expedition, a research body organized at the beginning of the last century [Kryukov, 1911; Korotkii, 1912] to study opportunities for economic development in Amuro-Ussuriiski krai, further resettlement of peasants, and development of trade and industry. During the second part of the 20th century, works devoted to the economic and geographical characteristics of Manchuria were published [Anuchin, 1948; Glushakov, 1948].

An essential contribution to the accumulation of extensive material about differentiation in natural environments in the Amur River watershed has been made by the Russian-Chinese Joint Amur Expedition under the Council on Industrial Forces Organization of the USSR Academy of Science and by the Heilongjiang Expedition of the People's Republic of China. These studies were carried out as surveys in the 1956–1962 [Nikolskaya and Chichagov, 1957]. The results of these surveys became the basis for fulfilling a series of thematic works, in which the natural environment of the Amur River watershed was considered not only within separate countries but also as an integral geographical formation. These works included studies about the soil and geographical zoning of the Amur River by Liverovskii and Rubtsova [1962], a vegetation map of the Amur River watershed [Sochava, 1969], and a number of others. Modern interest in studies on the trans-boundary watershed of the Amur River is evidenced by the publication of papers devoted to the program of sustainable land use and rational distribution of lands in the Ussuri River watershed and the Khanka Lake [Kachur et al., 2001], issues on its economic development [Baklanov and Ganzei, 2008], land resource assessment [Karakin and Sheingauz, 2004], and trends of economic interaction between the Russian Far East of Russia and Northeastern China [Tattsenko, 2006]. The common feature of the works in the last few years is that the analysis of the situation within the watershed was made as a rule by large units of administrative and territorial divisions situated on their territories. The use of such data is complicated because information about the separate parts of the Amur River watershed is often incomplete, diverse, and dissimilar in details, methods of data collection, and processing. Land use was mostly characterized through statistical data without the mapping of wide territories. As a result, the works devoted to LUCC in the region are few in number, and their content is very heterogeneous. Data on land use changes in Eastern Mongolia are very rare and incomplete.

Northeast China has considerably been studied better on the basis of LUCC methodology. At the same time, available data from publications in the 20th century are widely diversified regarding the studied areas and duration of analyzed periods. Generally, works estimating long-term changes are rare. One of the exceptions was a set of works by Professor Himiyama. Under his leadership, The Land Use Map of Northeastern China was compiled in 1995, which allowed the study of spatial land use and land cover structures from the 1930s and the assessment of land changes for a 70-year period [Himiyama et al., 1995; 2002]. Previously we have also provided data on LUCC in the Amur river basin [Ganzey et al, 2007, 2009, 2010].

MATERIALS AND METHODS

Land cover/land use map for1930–1940s

An inventory of different materials containing information on land cover/land use statements in the 1930–1940s in the Chinese, Russian, and Mongolian parts of the Amur Basin showed that topographical maps published during the same period were the main source of land use data, and that it was possible to compile the Land Cover Map of the Amur River Basin during the 1930–1940s on their bases [Ganzei and all, 2009].

The map was compiled through an analysis of the topographical sheets of the Amur River watershed printed mainly in the 1930s–1940s in different countries and in various scales (1:100,000; 1:200,000; 1:250,000; 1:300,000; 1:420,000, 1:1,000, 000). In all, the topographical sheets totaled more than 1500. The maps of land use in the Chinese part of the watershed were compiled through an analysis of topographical sheets (scale 1:100,000), and were compiled for Manchurian territory in 1930 by the General Staff of the Kwantung Army of Japan. It was checked by the General Staff of the Military/Air Forces of the USA using topographical maps in the scale of 1:250,000 made for the Manchurian territory between 1949 and 1952. Published in the former USSR in the 1930s–1940s, the maps (scale 1:100,000–1:1,000,000) were also used to draw the near-border forest areas of China. The Mongolian part of the watershed was characterized through an analysis of topographical maps in the scale of 1:100,000, 1:200,000, and 1:1,000,000 compiled in the USSR in the 1930s–1940s. The maps in the scales of 1:300,000 and 1:200,000 contained more detailed information about the land cover and land use in the territory. We could identify additional characteristics such as forest types (coniferous, mixed, and deciduous – partly divided), grasslands, sparse forests and bushes, bushes and grasslands, forest cutting area, burned-out forests, salt-marshes, sand ground, dry lands, and settlements. Maps in the scale of 1:100,000 showed the same types of land cover and land use as in the 1:300,000 and 1:200,000 maps. Additionally, these maps allowed us to define the boundaries between arable (dry) lands and paddy fields. The forest types (coniferous, mixed, and deciduous forests) had a presumptive character (for the whole watershed).

Land cover/land use map for 2000s

A set of satellite images from Landsat-7 (USA) in 2000–2001 provided the initial basic information for drawing the map "Modern Land-Use in the Amur River Watershed" [Ganzei and all, 2007]. Composite compilations of the average resolution from 30 m and more were used in the work. The satellite images from Landsat TM with a resolution of 15–30 m were used to specify some of the most disputed territories. Decoding was made via GIS ArcView 3,3 and ArcGIS software using a special extension Image Analysis to form shape files and their subsequent conversion to Arc/Info coverings. The next information was converted to electronic raster and then to vector format: a map of the vegetation of the Amur River watershed in the scale of 1:2,500,000 edited by Sochava [1969], a map of the vegetation of the Mongolian National Republic [1990], a map of the vegetation of China from the Atlas of Vegetation of PRC [2001], Raster topographical maps in the scale of 1:500,000. It was necessary to create a uniform classification of land use types since the classifications accepted and used in China, Russia, and Mongolia differed significantly.

The classification of forest lands has been corrected. In addition to the density of wood stands, their typological characteristics have been introduced. Coniferous, mixed, and deciduous forests, sparse forests, and other forests have been further defined in forest lands. Since the mapping scale is small enough, and the level of generalization is high, each type's concept includes various kinds of land use and natural states of lands. In these, the genesis of each type of land is not considered; they can be formed through very different ways. The "coniferous forest" type includes fir, abies, Korean pine, pine, larch forests, and their other species. The "mixed forest" type includes all transitive versions from coniferous to deciduous forests at approximately equal ratios. The "deciduous forest" type includes broad-leaved and small-leaved forests and their other species. The "sparse forests" type includes rare forests of various compositions, alternating with woods with bushes of density stands less than 30%. Again, as already mentioned above, the genesis of this type of lands is not considered; they can be formed after fires, loggings, and so on. The "other forests" type includes forest and industrial plantations. The category "meadows and bushes" describes meadows, bushes, and by-golets bushes with high-mountainous tundras. The "bushes" type includes bushes, meadows, and bush lands, partly, bush and sparse forested lands with a prevalence of bush vegetation. The "meadows" type is rather varied, and at any given stage in the study, it includes any grassy vegetation: usually meadows, steppes, and so on. The "golets bushes with high-mountainous tundras" type includes mountainous pine, dwarf forms of high-mountainous bushes, tundras, and goletses. The "agricultural lands" category describes reclaimed and unreclaimed agricultural lands. The "reclaimed lands" type includes paddy fields, and the type "unreclaimed lands" includes arable lands, fallow lands, haymaking sites, and pastures. The "water bodies" category embraces lakes, water reservoirs, swamps. The "wetland" type includes swamps, high bogs, and water-logged flooded meadows and marshes. Fire-sites and loggings at locations of former forests, residential areas (large settlements), and industrial and unused lands (quarries, slag-heaps, etc.) enter the category "other lands."

RESULTS

Land cover/land use status in the periods of 1930-1940 and 2000-2001

The thematic content of the topographical maps allows us to use 18 land use types for compiling the land cover map of the Amur River basin from 1930-1940 (Fig. 1, Table 1). According to these data, 53,1% of the basin were occupied by forests, 17,6 % by grassland, 13,2 % by wetlands, and 16 % of dry land. Over 63% of the Basin's forest land, 57,7% of wetlands, and about 72% of urban lands were situated in Russia in the1930–1940s, and 91,1% of dry lands and 55% of grassland were in China.

The map of modern land use in the Amur River basin is more detailed in thematic content and contours of different polygons (Fig. 2).

At present, forest areas occupy over half (54,3 %) of the watershed territory (Table 2). Over 30% of this area is occupied by mixed

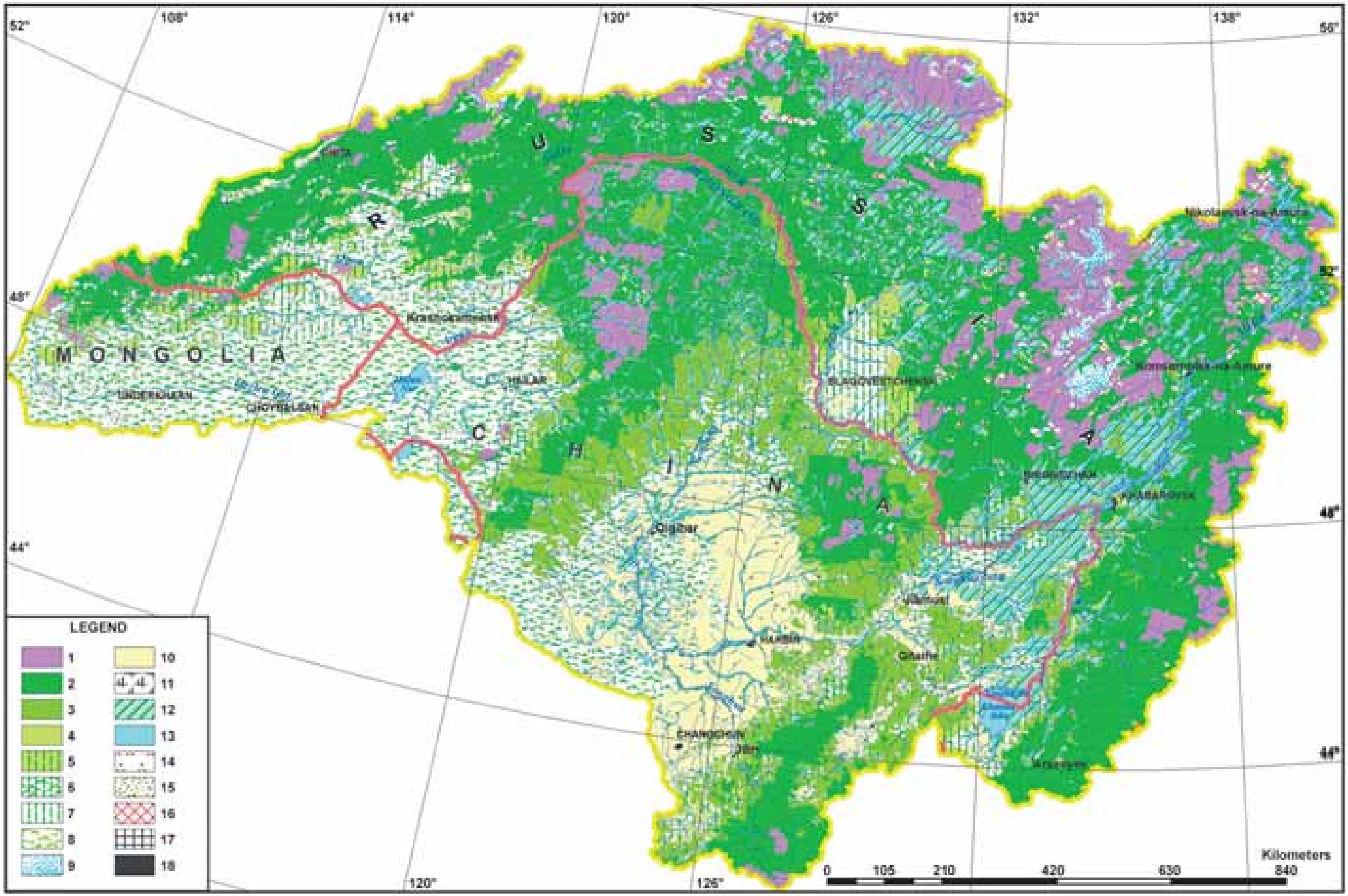

Fig. 1. Land-use in the Amur River basin in 1930–1940s.

Forest lands: 1 – coniferous forest, 2 – mixed forest, 3 – deciduous forest, 4 – sparse growth; Scrub and Grassland: 5 – scrub and sparse growth, 6 – scrub and grassland, 7 – scrub, 8 – grassland; 9 – mountain tundra; Agricultural lands: 10 – dry lands, 11 – paddy field; Waters: 12 – wetland, 13 – lakes; Other lands: 14 – salt-marsh, 15 – sands, 16 – burned out forest, 17 – forest cutting area, 18 – urban land

Table 1. Land Cover and Land Use in the Amur River Basin in 1930–1940

Land use type	Total (km^2)	Russia (km^2)	China (km^2)	Mongolia (km^2)
Coniferous forests	189 448	155 635	30 815	2997
Mixed forests	686 902	495 434	179 367	12 099
Deciduous forests	180 500	17 064	163 354	81
Sparse forests	25 745	14 794	7931	3018
Sparse forests and bushes	64 386	31 586	20 502	12 297
Bushes	40 032	27 968	106	11 957
Bushes and grasslands	28 835	5858	22 311	665
Grassland	358 445	46 022	195 201	117 221
Dry farmands	136 782	12 177	124 605	–
Wetlands	270 251	155 892	111 166	3192
Lakes and reservoirs	9086	5589	2858	639
Urban lands	308	221	87	–
Forest cutting area	2144	2144	–	–
Burned-out forests	17 864	17689	–	175
Mountain tundra	21 245	20980	–	265
Salt-marsh	5024	954	273	3796
Sand ground	2302	–	2014	288
Paddy fields	545	–	545	–

Table 2. Land Cover and Land Use in the Amur River Basin in 2000–2001

Land use type	Total (km^2)	Russia (km^2)	Mongolia (km^2)	China (km^2)
Coniferous forests	277 610	214 035	8411	55 163
Deciduous forests	315 971	118 255	3080	194 635
Mixed forests	347 253	231 010	6161	110 081
Sparse forests	145 396	106 318	4583	34 495
Burned-out forests	27 156	26 365	491	300
Other forest lands	4976	–	1811	3165
Grasslands	248 664	24 469	135 076	89 118
Paddy fields	25 982	2370	–	23612
Dry farming lands	346 695	81 053	2311	263 330
Lakes	10 619	5189	815	4614
Reservoirs	2493	2040	–	452
Wetlands	139 929	95 308	44	44 576
Urban lands	2666	991	–	1675
Unused lands	657	611	–	45
Mountain tundra	13 304	12 783	131	388
Waste ground	222	186	–	36
Bushes	121 597	82 303	5777	33 517
Forest cutting area	8655	6721	–	1933

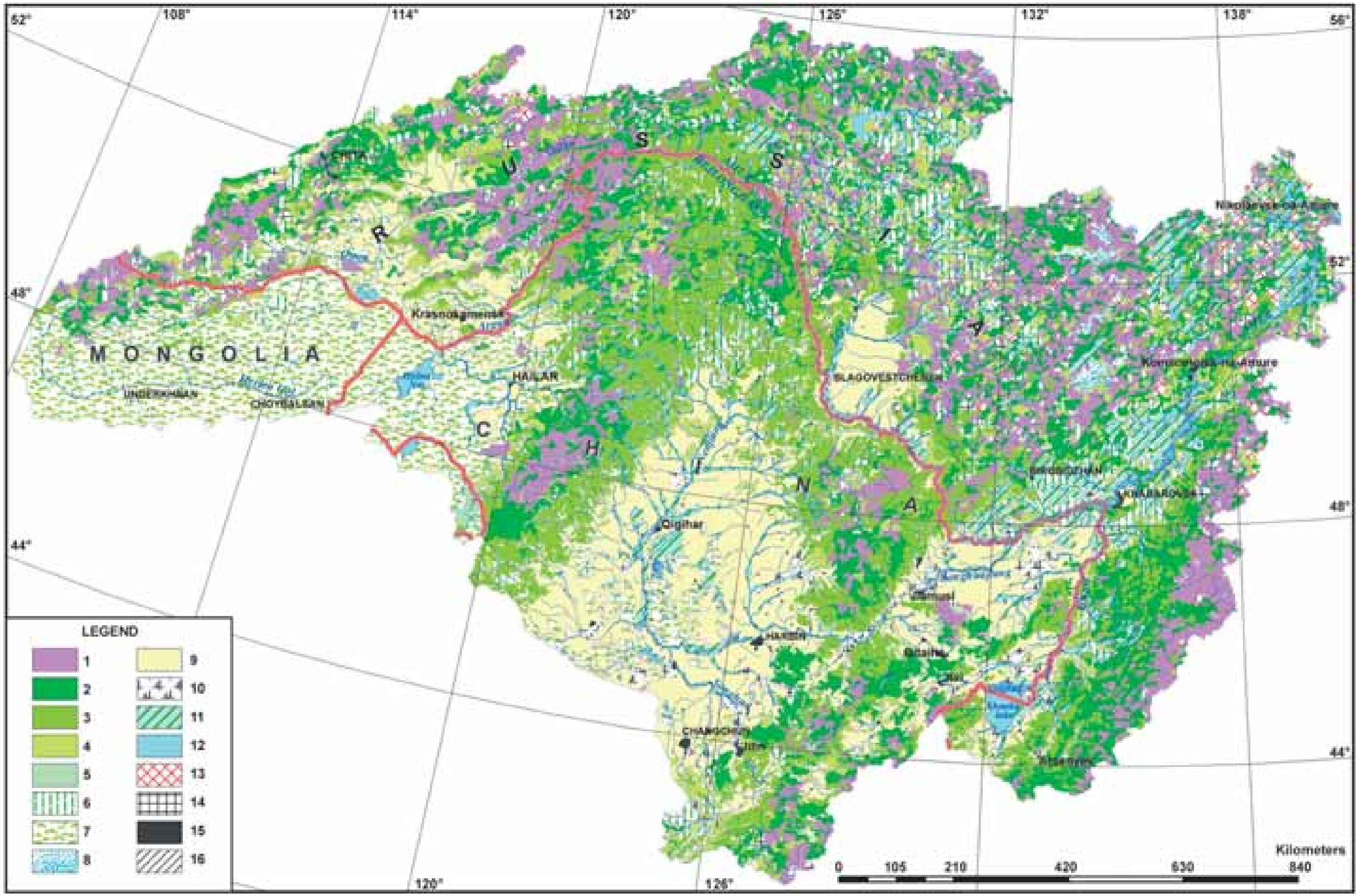

Fig. 2. Modern land-use in the Amur River basin (according to the materials of decoding satellite images).

Forest lands: 1 – coniferous forest, 2 – mixed forest, 3 – deciduous forest, 4 – sparse growth, 5 – other forest land; Scrub and Grassland lands: 6 – scrub, 7 – grassland; 8 – mountain tundra; Agricultural lands: 9 – dry lands, 10 – paddy fields; Waters: 11 – wetlands, 12 – lakes and reservoirs; Other lands: 13 – burned out forest, 14 – forest cutting area, 15 – urban land, 16 – unused lands and waste ground and coniferous woods situated mainly in the Russian territory. It is necessary to note that the majority of fire-sites, loggings, and sparse forests are also located in the Russian territory, which reflects adverse trends in forest management, developed on our territory in the 1990s. Deciduous forests occupy about 15 % of all forest lands.

Agricultural lands occupying nearly 20% of its territory are the second type of lands in the area of the watershed. The dominant share of cultivated lands including irrigated land is located in the Chinese part of the watershed. Prompt reduction of wetlands is one of the consequences of its active agricultural development. According to Chinese researchers [Liu et al., 2004], a share of wetlands on the Sanjiang Plain for the period from 1950 to 2000 was reduced by 52,5%, from 32,4 thousand km^2 to 9,2 thousand km^2. At the same time, the share of agricultural lands increased from 10,2% to 55,1%. Most of the wetlands are located still on Russian territory.

Meadows and bushes also make up about 20% of the area of the Amur River watershed. The territorial distribution of the types of modern land use reflects both the natural and climatic conditions of the territory, as well as the national features of nature management, and the historical and modern trends in development of the economy of the countries involved.

In the Chinese territory, coniferous forests occupy the largest area within the Great Khingan Ridge in Inner Mongolia Autonomous Region, measured at 25,3 thousand km^2. Mixed forests prevail in Heilongjiang Province, measuring 59,7 thousand km^2 or about 54,2% of the area of the forests in the Chinese territory. Decoded satellite images allowed us to reveal other features of the modern state of forests in Chinese territory. It was observed that there existed a considerable divergence between the data of the Atlas of Vegetation of the PRC (2001) and the decoded data. For example, the northern portion of the Great Khingan Ridge is shown in the Atlas of Vegetation as a zone with a practically continuous distribution of coniferous forests. However, the decoded data show that at present, deciduous forests dominate the area, and that coniferous and mixed forests are typical in the central and southern portions of the Great Khingan Ridge. A high share of timber cuttings in Jilin Province, about 36,3% of the logging area in the Chinese part of the watershed, also appeared to be unexpected. Besides, it is necessary to take into account that used data may not reflect the present situation in full because objects in areas less than 50 km^2 have not been displayed on the final map.

Wide spectrum of land use is characteristic of Dornod Aimak of Mongolia. Deciduous forests dominate the forested lands, with a share of up to 24,7% of the forests in the Mongolian portion of the watershed. The share of coniferous and mixed forests is much less, about 5,6% and 2,3%, respectively. Sparse forests and bushes are widely distributed, reaching 21% and 43,5%, respectively. Approximately half of the meadows of the Mongolian portion of the watershed is concentrated in this aimak. About 86,5% of its agricultural lands are also located in this area.

Long-term dynamics of land cover/land use in the basin

For the estimation of the dynamics of spatial distribution of various types of land cover/ land use in the basin, it was necessary to compare the different legends and to create the common legend.

Table 3 provides the scheme of generalization of land use types. All subtypes of forest land were grouped in land use type Forest. Sparse forests and Scrub and Sparse forests were combined into the type sparse forests. The Scrub and Scrub and grassland subtype were combined into the type Bush. Salt-marsh, sand lands, unused land, and waste ground are presented by a common legend and one land use type, Unused land. The analyses of this two maps have allowed us from unified positions and on a uniform scale, to assess the character, structure, and national features of land use of the territories

Table 3. Integrated Legend for the Comparison of Land Cover/Land Use in the Amur River Basin

1930-1940	2000-2001	Joint legend
Conifer forest Mixed forest Deciduous forest	Conifer forest Mixed forest Deciduous forest Other forest land	Forest
Sparse growth Scrub & sparse growth	Sparse growth	Sparse growth
Scrub Scrub & Grassland	Scrub	Bush
Grassland	Grassland	Grassland
Dry farming lands	Dry farm lands	Dry farm lands
Paddy field	Paddy field	Paddy field
Wetland	Wetland	Wetland
Lake	Lake & Reservoir	Lake & Reservoir
Urban land	Urban land	Urban land
Forest cutting area	Forest cutting area	Forest cutting area
Burned out forest	Burned out forest	Burned out forest
Mountain tundra	Mountain tundra	Mountain tundra
Salt-marsh Sands	Unused land Waste ground	Unused land

of Mongolia, China, and Russia included in the Amur River watershed.

A comparison of the two compiled maps shows an essential decrease in the area and simplification of the structure of forests towards a prevalence of invaluable woods (Table 4). This especially concerns the northern and eastern parts of the Great Khingan Ridge, Less Khingan (both in the Russian and Chinese portions), northern portion of Sikhote-Alin Ridge, and Chitinskaya

Table 4. Land Cover and Land Use Changes in the Basin

Land use type	1930–1940 (km^2)	2000–2001 (km^2)	Change (km^2)	1930–1940 (%)	2000–2001 (%)	Change (%)
Forest land	105 7016	945 812	–111 204	51.8	46.4	–5.5
Sparse forest	97 306	145 397	48 090	4.8	7.1	2.4
Bush	68 703	121 598	52 894	3.4	6.0	2.6
Grassland	351 270	248 664	–102 606	17.2	12.2	–5.0
Dry farming lands	136 783	346 696	209 913	6.7	17.0	10.3
Paddy field	546	25 982	25 437	0.0	1.3	1.2
Wetland	270 251	139 929	–130 322	13.2	6.9	–6.4
Lake & reservoir	9087	13 112	4026	0.4	0.6	0.2
Urban land	309	2666	2358	0.0	0.1	0.1
Forest cutting area	2689	8655	5967	0.1	0.4	0.3
Burned-out forest	17 423	27 365	9943	0.9	1.3	0.5
Mountain tundra	21 144	13 177	–7967	1.0	0.6	–0.4

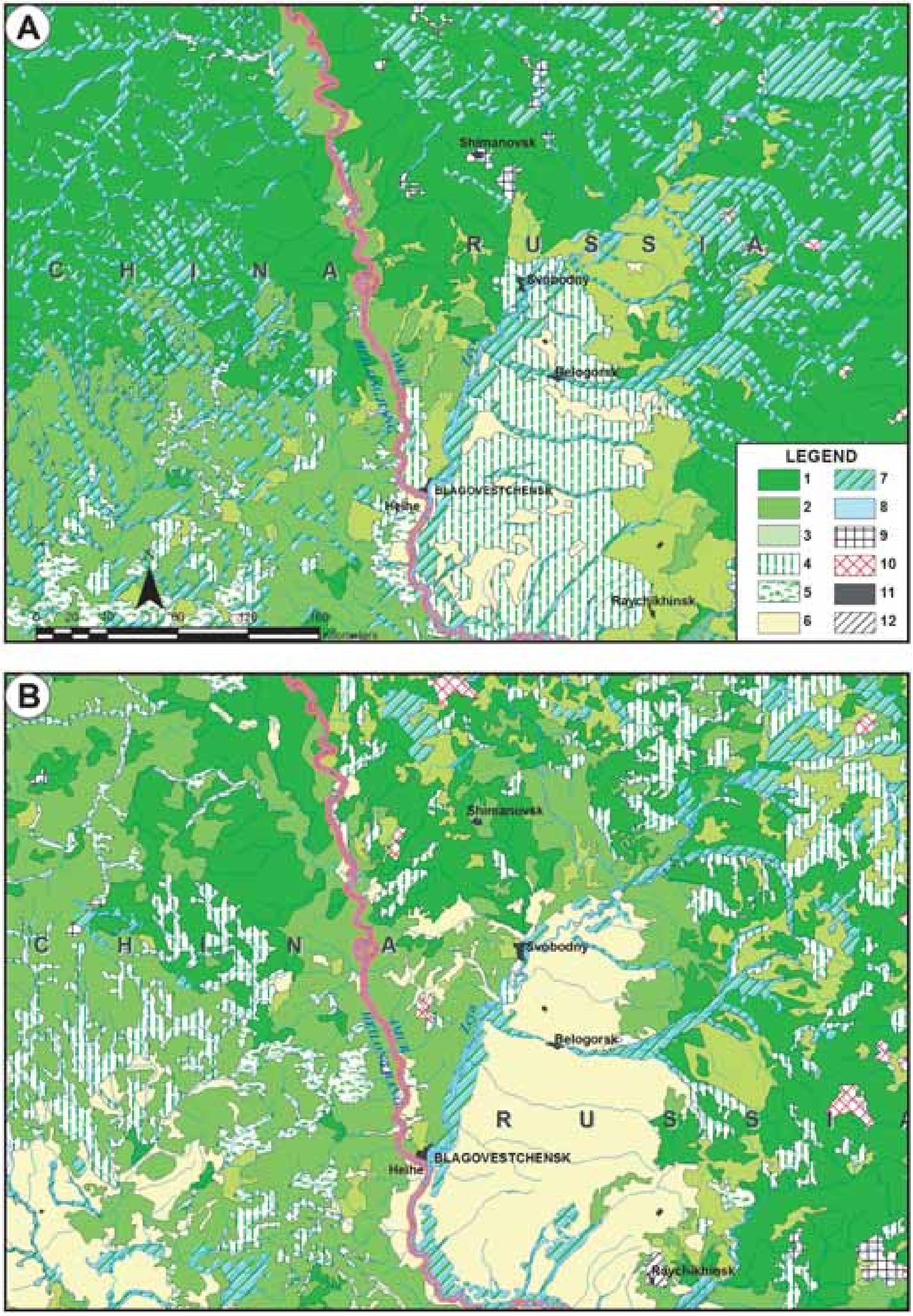

Fig. 3. The Xioxing Anling and Zeya-Burea plain. Forest and Scrub lands:
A – in 1930–1940s, B – at the beginning of the XXI century.

1 – coniferous and mixed forests; 2 – deciduous forests; 3 – sparse growth; 4 - bushes; 5 – grassland; 6 – dry land; 7 – wetlands, 8 – lakes and reservoirs; 9 – forest cutting area; 10 – slash fire; 11 – urban land; 12 – unused lands

Oblast. About 78% of the cut down forests in the Amur River watershed and 97% of the forests burned in 2000–2001 are on the Russian territory. In total, forests have lost about 111.2 thousand km^2 of their area since 1930.

A significant expansion of the area of agricultural lands that occurred in the People Republic of China from the 1930s and in 2000–2001 has been observed. These changes concern the Xioxing Anling and Zeya-Bureya plain (Fig. 3) and the Sanjiang Plain (Fig. 4). In many cases, these changes are associated with a reduction in the area of wetlands and forests. Wetlands lost an area of about 130,3 thousand km^2 in the basin. Most parts of wetlands are still concentrated on the Russian part of the watershed.

DISCUSSION

Data accuracy

It is necessary to notice that the legends of the topographic maps published in Japan and in the USSR are essentially different. The legends of the Japanese maps are more detailed especially for the developed agricultural areas, these types of land use were practically not shown on the maps in the scale of 1:100 000 published in the USSR. The Japanese maps for flat territories that were economically developed are distinguished for their accuracy and are compiled with a high degree of reliability. Topographical maps of mountain forest territories contain a lot of errors: in hydronetwork drawing, in the width of river valleys, in the border position of forest territory, and in the characteristics of forests. For the Russian and Mongolian parts of the watershed, the borders of forested territories, wetlands, burnt-out areas, felling areas, meadows, sparse forests, shrubs and sparse forests, shrubs, mountain tundra, steppes, salt marshes, sand lands, and water objects and large settlements are defined with a high degree of reliability. In most cases, the borders are of the type forest. One of the key questions in this study is concerned with the reliability of comparisons obtained. In our opinion, one can determine with a high level of confidence only the general tendencies in the spatial dynamics of land distribution within the Amur River basin.

Forest lands

Sheingauz A.S. [2006] identified several periods in the economical use of Far-Eastern forests, noting meanwhile the complex spatial-temporal dynamics of volumes and heaviness of felling. From 1900 to 2000, he revealed two peaks of felling which coincided with the periods of 1930s–1940s and 1980s. During the first of these periods, the most intense felling was noted in the Zeya-Burea plain and the Amur-Zeya Plateau in Amurskaya Oblast (Fig. 3), and on the western macroslope and foothills of the central and southern Sikhote-Alin in Primorskii Krai. By 2000, a zone of intense felling had shifted to the northern part of Sikhote-Alin. Felling had also remained quite high within Little Khingan. A.S. Sheingauz notes that the Amur zone of intense felling had disappeared by 2000. This fact was also confirmed in our cartographic estimates of the spatial dynamics of forests and their felling within the Amur River basin.

In the Chinese portion of the basin, the basic felling in the 1930–1940s was concentrated around the mountain massif of Changbaishan and Little Khingan ridge [Zhang, 2000; He et al., 2008], which was partly related to the construction and subsequent operation of the railway between Harbin and Jiamusi. From 1931 to 1945, the forest area within Little Khingan and the Sungari River basin decreased by more than 10,1 million hectares [Glushakov, 1948]. From 1949 to 1998, the area of forest land in the Autonomous Area of Inner Mongolia decreased by 5%, while it increased by 5–10% in Heilongjiang and Jilin Provinces [He et al., 2008]. North-eastern PRC has remained in the 20th century to be one of the main suppliers and consumers of timber [Yamane, 2007]. The area of forests has, to the largest extent, decreased on the western and eastern spurs of the Great Khingan mountains, in western and northern Sikhote-Alin Ridge, within Little Khingan ridge (Russian and Chinese parts), and in the Amurskaya and Chitinskaya Oblasts. Although this process was characterized by a stable negative trend, there are regions where the forest areas have increased owing

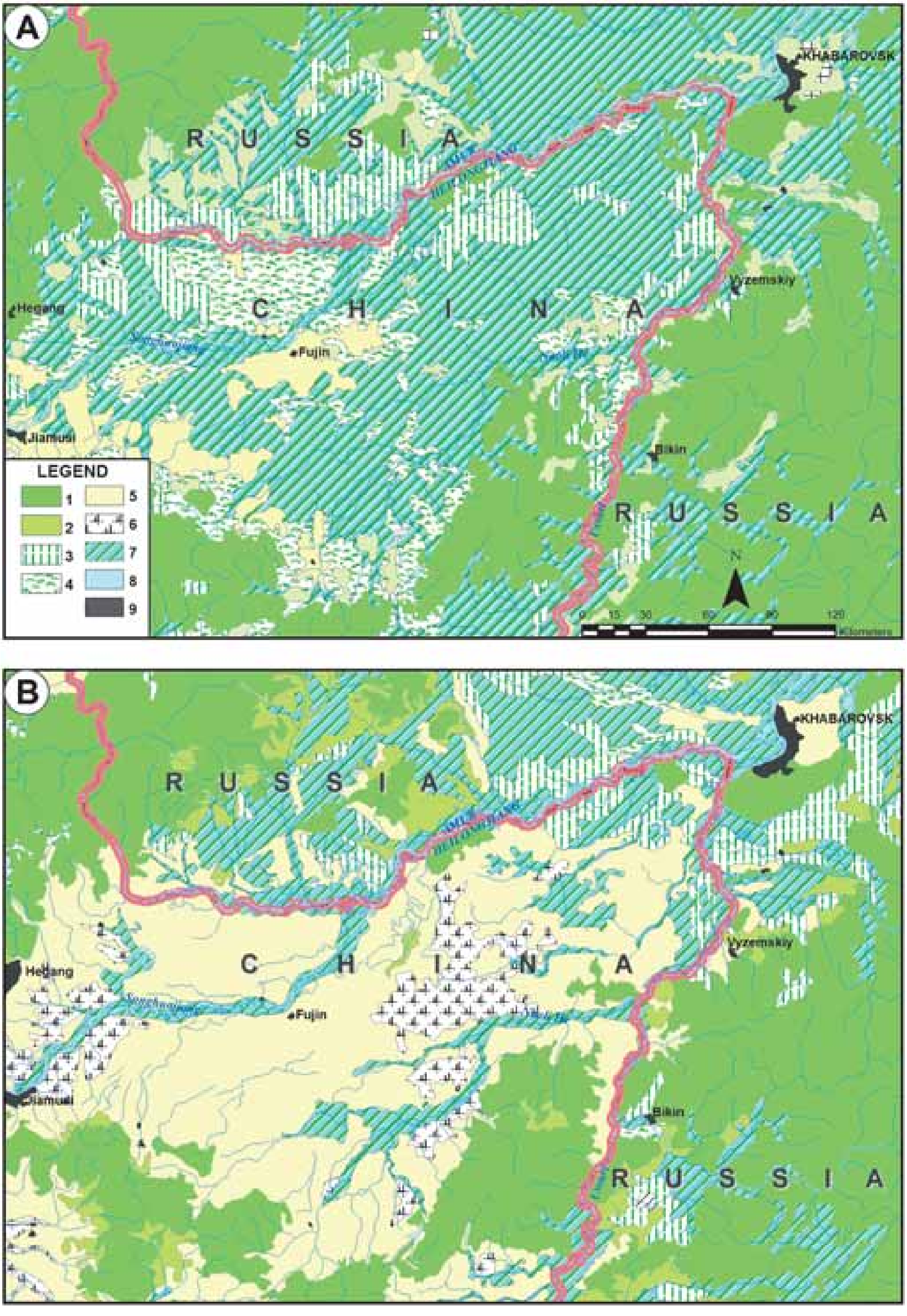

Fig. 4. The Sanjiang plain. Agricultural lands and wetlands:
A – in 1930–1940s, B – at the beginning of the XXI century.

1 – forests; 2 – sparse growth; 3 – bushes; 4 – grassland; 5 – dry land; 6 – paddy field; 7 – wetlands; 8 – lakes and reservoirs; 9 – urban land to active reforestation police, especially in the southern part of the Great Khingan ridge.

Agricultural lands

The cleared forest areas were often used for farm production. According to data of K. Nakagane [1982], the area occupied by crops in three north-eastern provinces of China increased between the period 1932–1942 by 17,7%. This figure agrees with the estimates of Russian geographers [Glushakov, 1948]. The lands sown with rice increased on the average by 2% [Nakagane, 1982]. The expansion of the area under cultivation was, to a large extent, related to the continuing development of the Nongjiang-Sungari lowland and the southern, most suitable for agriculture portions of the North Khanka plain.

According to the data of Tibekin A.R. [1989], crop areas between the period of 1930–1940 increased by 57,3 % in Amurskaya Oblast and by 66,7% in Khabarovskii Krai (Russian territory). In Primorskii Krai they decreased by 13,3% in connection with the resettlement of Koreans to various locations in Central Asia and Kazakhstan. The Zeya-Bureya plain and Khanka and Middle-Amur lowlands were subjected to the most development.

In the Russian part of the basin, there was a decrease in crop areas as compared to the pre-crisis period [Baklanov and Ganzei, 2008]. In the Chinese part of the basin, meanwhile, new territories were developed. On frequent occasions, this development was related to the conversion of water-marshes and meadow lands to agricultural land use. This process was characterized as intense development in the Sangjiang plain [Liu et al., 2004; Wang et al., 2006]. From 1980 to 2000, areas of meadows and water-marsh lands in the Nongjang-Sungari lowland were reduced by more than 25% and 8.5%, respectively. The changes on the Sangjiang plain were more significant. From 1950 to 2000, the area of water-marsh lands decreased by 52,5%, while that of arable land increased by 45% (Fig. 4). Overall, the stable tendency of increasing areas for agricultural lands was observed in all parts of the basin.

Cartographic analysis of the patterns of land distribution within the Amur River basin over the last 70–80 years, numerous investigations of Russian and foreign authors, and statistical data allowed us to confirm and quantitatively characterize the basic tendencies of spatial variations of land use within a great subregional trans-boundary geosystem. The general tendency in land distribution change is characterized by a reduction in areas of natural lands (forests, water-marsh lands, and meadows) and a swift increase in anthropogenically transformed landscapes (agricultural landscapes, burnt-outs, and coupes).

CONCLUSIONS

Cartographic analysis of the distribution of land use in the basin of the Amur River over the past 70–80 years, numerous studies of native and foreign authors, statistical materials made it possible to identify the main trends in the use of land in major subregional cross-border geosystems.

The compiled electronic maps are, in first, an information basis for carrying out of the further analysis of system of land-use in Amur River watershed, and, in second, as an electronic layer it is a component of forming geo-information space of the whole Amur River watershed.

Therefore studying of all complex of the problems influencing on efficiency of land use and an ecological condition in the trans-boundary river basins, and also the factors breaking their structural organization and functioning, is one of the primary goals for development of the program of sustainable land use which should be created for all basin.

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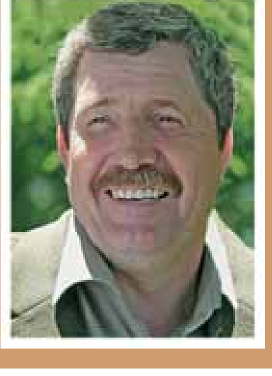

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