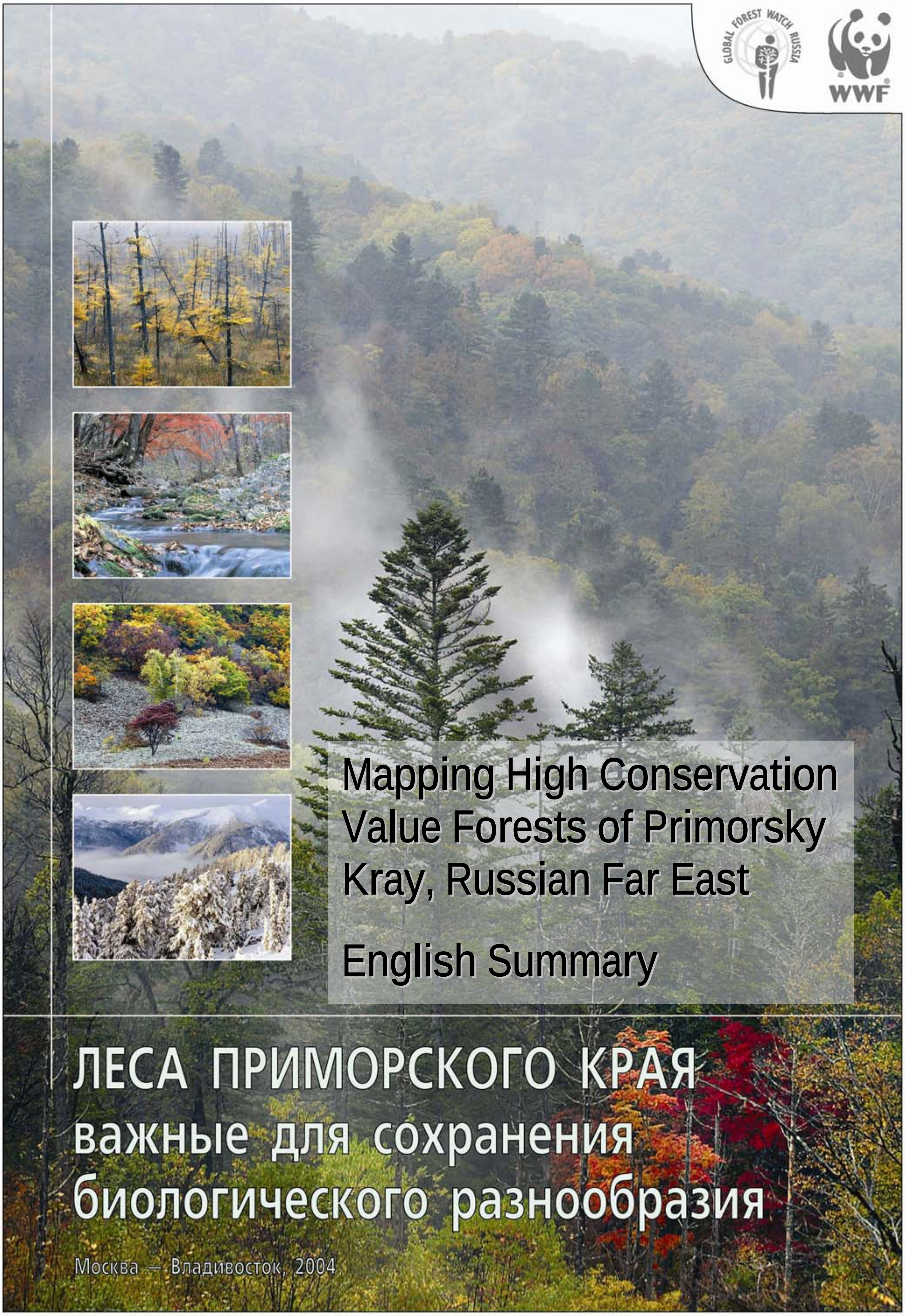


Mapping High Conservation Value Forests of Primorsky Kray, Russian Far East

English Summary

ЛЕСА ПРИМОРСКОГО КРАЯ важные для сохранения биологического разнообразия

Москва — Владивосток, 2004

D. E. Aksenov[a], M. Yu. Dubinin[b], M. L. Karpachevskiy[c], N. S. Liksakova[d],
V. E. Skvortsov[e], D. Yu. Smirnov[f], T. O. Yanitskaya[g]

Moscow—Vladivostok, 2006

English Summary: **D. E. Aksenov**[a]

Contributors to the English text: **L. Laestadius**[h], **V. Roshchanka**[i], **S. Minnemeyer**[j]

Edited by: **I. Munilla**[k]

[a] International Social Ecological Union, P.O. Box 211 119019 Moscow Russia, email: picea@online.ru
[b] International Social Ecological Union, P.O. Box 211 119019 Moscow Russia, email: m_a_x_d@mail.ru
[c] Biodiversity Conservation Center, Vavilova 41, 117312 Moscow Russia, email: forest@biodiversity.ru
[d] Komarov Botanical Institute, Prof. Potapova st., 2, 117312 Sankt Petersburg, Russia, email: nliks@mail.ru
[e] Biodiversity Conservation Center, Vavilova 41, 117312 Moscow Russia, email: vsturnus@yandex.ru
[f] WWF Russia, Far Eastern Branch, Verkhneportovaya 18a, 690003, Vladivostok, Russia, email: dsmirnov@wwfrfe.ru
[g] International Social Ecological Union, P.O. Box 211 119019; WWF Russia, Nikoloyamskaya st., 19, bld 3, 109240, Moscow, Russia, e-mail; tyanitskaya@wwf.ru
[h] World Resources Institute, 10 G Street NE Washington, DC 20002 USA, email: larsl@wri.org
[i] World Resources Institute, 10 G Street NE Washington, DC 20002 USA, email: volha@wri.org
[j] World Resources Institute, 10 G Street NE Washington, DC 20002 USA, email: susanm@wri.org
[k] World Resources Institute, 10 G Street NE Washington, DC 20002 USA, email: isabelm@wri.org

We welcome your feedback!
The authors are happy to explain or discuss the study methods or study findings.

Please do not hesitate to contact them.

ABSTRACT

Primorsky Kray, also known as Primorye, hosts one of the most diverse forest ecosystems in Russia that protects a significant portion of the region's biodiversity. Its mixed broadleaf coniferous forests are the last remaining habitat for the Far East leopard and the Amur tiger. Historic and current development rates in the region raise questions, however, about the future conservation value of these forest ecosystems. Thus, a project was initiated to map high conservation value forests (HCVF) to aid regional conservation strategies and to update protected area systems.

The highest conservation priority should be given to those ecosystems that are most endangered: the least disturbed forests whose total area is decreasing with each passing year. In formulating a research plan, we discussed the following forest ecosystem categories:

- Less disturbed forest tracts;
- Floodplain and bottomland ecosystems of intact river basins;
- Naturally rare and unique forest communities; and
- Rare and endangered plant species habitats.

In mapping HCVF in Primorsky Kray, we focused on identifying forests important for the preservation of natural vegetation and its biodiversity. To a large extent, animal biodiversity would also be represented within these forest communities. Although this assumption might not hold true in each case, especially for large, mobile animal species, the survival of many animals depends on preserving natural vegetation and vegetation habitats. We did not consider the importance of forests in watershed protection and erosion control as well as cultural and social values in this analysis, since the identification of these elements requires a different approach and extensive fieldwork. Moreover, forest areas with different high conservation values often overlap.

An important aspect of this project was mapping less-fragmented forest territories. It was carried out in several steps. Step 1 used topographic information to exclude infrastructures from the territory of interest. The next step used remote sensing to identify infrastructure not present on available topographic maps, such as logging roads, clear-cuts, high-graded areas, areas converted to agricultural lands, mining areas, and other anthropogenic disturbances. As a separate agent, burned areas were also delineated and excluded from less-fragmented areas. Image interpretation was carried out using Landsat-7 ETM+ data and Landsat-5 TM data.

Independent mapping of core areas of the least transformed forests was carried out by simultaneously using topographic maps, forest inventory data, and satellite images. Least transformed forests were identified in all main forest formations of the region.

To locate less disturbed forest tracts, we combined the areas found to be least transformed with areas that were found to be least fragmented, identified clusters of candidate core areas and eliminated fragmented areas. In addition, floodplain and bottomland ecosystems of intact river basins, some rare forest communities, and known occurrences of rare plant species were mapped. All these kinds of HCVF, if protected together, could support the flora and vegetation diversity of Primorsky Kray.

The total area of HCVF identified (without intact forest landscapes) comprised 2.94 million hectares, or 17.8% of the region's area. The total area of rare forest communities' was found to be almost 195 thousand hectares. Altogether, more than 1600 habitats of rare and endangered vascular plant species were identified.

The most endangered vegetation types, especially in comparison to the relatively small area they occupy, are Manchurian fir and mixed formations in the very south of the region. The next priority for protection is the largest identified less disturbed forest tracts.

Keywords: High Conservation Value Forest (HCVF), Intact Forest Landscapes, biodiversity, conservation, disturbance, fragmentation, Far East, Russia

1. INTRODUCTION

The term High Conservation Value Forest (HCVF) was proposed by the Forest Stewardship Council in 1999. Since then, identifying HCFV became one of the key requirements for "Criteria and Indicators for Sustainable Forest Management" (Forest Stewardship Council A.C., 2004a). One of the FSC indicators of sustainable forest management states that HCVF need to be identified and preserved. However, the concept of HCVF is now used widely outside of voluntary certification in, for example, functional zoning of the territory or to support the selection of priority regions for nature conservation.

As implied by the term, high conservation value forests are forest territories that should be preserved because of the special value of their ecosystems or natural characteristics contained within them. Currently, HCVF includes all forests having one or several characteristics described below:

a) Forest areas that have global, regional, or national significance due to:
    - concentrations of biodiversity values (e.g. endemism, endangered species, refuge) (**HCVF 1**); and/or
    - large, landscape level forests, contained within, or containing the management unit, where viable populations of most, if not all, naturally occurring species exist in natural patterns of distribution and abundance (**HCVF 2**).

b) Forest areas that are in, or contain, rare, threatened, or endangered ecosystems (**HCVF 3**).

c) Forest areas that provide basic services of nature in critical situations (e.g. watershed protection, erosion control) (**HCVF 4**).

d) Forest areas fundamental to meeting basic needs of local communities (e.g. subsistence, health) (**HCVF 5**) and/or critical to local communities' traditional cultural identity (areas of cultural, ecological, economic, or religious significance identified in cooperation with such local communities) (**HCVF 6**).

Unfortunately, even though these general definitions have been proposed and it can be said that all the HCVF categories aim to preserve biodiversity, there is no one single methodology to classify HCVF on a regional basis (Jennings et al., 2003). This study identifies HCVFs in the Russian Primorsky Kray that are important for preservation of biodiversity of the vegetation cover. By vegetation cover, we imply the total amount of flora and vegetation. Thus, we aimed to identify territories of Primorsky Kray that have retained most, if not all, of their natural biodiversity, both in plant species and vegetation communities. We excluded those types of communities that can be conserved without requiring any limits on human activities.

2. LESS DISTURBED FOREST TRACTS

To map *less disturbed forest tracts*, we combined the results of two separate analyses: one that identified the degree of human-caused transformation of different forest ecosystems; and, another that determined the degree of fragmentation of the natural forest landscapes (Figure 1).

Figure 1. Types of forest disturbances.
Left — transformation of a forest ecosystem. This narrow-leaved deciduous forest grew after clear-cut logging and the following fire. (Primorye, Partizanskiy mountain range. Photo N.S. Liksakova, V.E. Skvortsov).
Right — Fragmentation. This forest landscape is fragmented by anthropogenic infrastructure, logged sites, and recent fires. (Primorye, Krasnoarmeyskiy region, in the vicinity of the settlement Molodezhnyy and river Obilnaya, Landsat-7 ETM+ satellite image).

After analyzing transformation and fragmentation separately, we combined the results to identify areas that have little fragmentation and contain relatively undisturbed ecosystems.

We called such areas **less disturbed forest tracts**. (Figure 2).

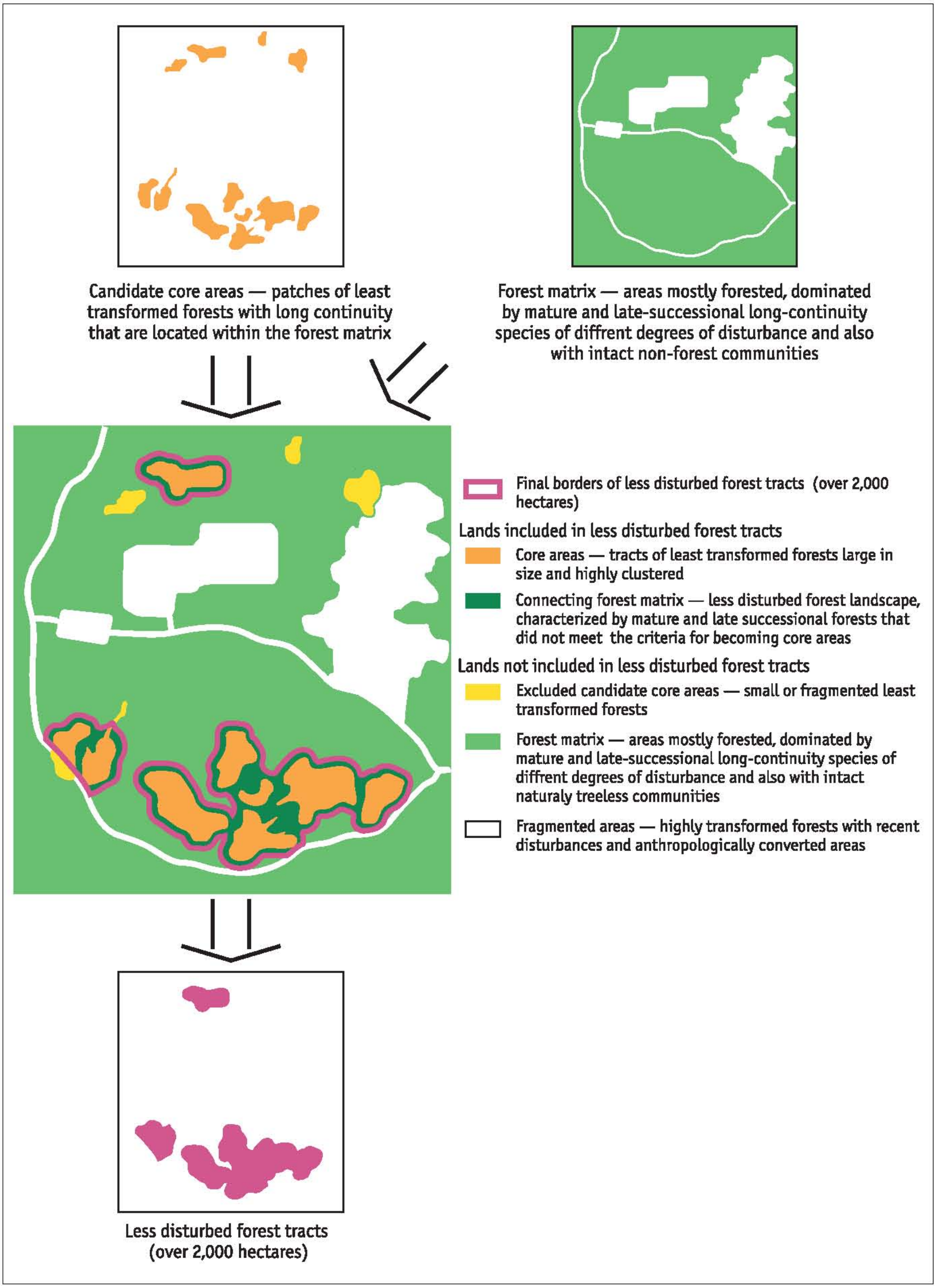


Figure 2. Steps in identifying less disturbed forest tracts.

Transformation analysis

In the **transformation analysis,** our approach was the opposite of the one we used to map intact forest landscapes (Intact forest landscapes are large mosaics of untouched ecosystems, 50,000 hectares or greater, located in the forest zone, that show no visible signs of human disturbance that can be detected in satellite imagery; Yaroshenko et al. 2001; Aksenov et al. 2002).

We identified intactness features, such as tree species composition and advanced age, and mapped the least anthropologically transformed forests areas without mapping disturbed areas. This approach is commonly used to map intactness and biodiversity values.

For example, we used it in 1995-1998 to map old-growth forest in Karelia Republic and Murmansk Oblast. Our Finnish colleagues used a similar approach to map old-growth forest in their country, although in association with extensive field verification. A group of Vladivostok scientists used a similar methodology in Primorsky Kray in 1999 but with different criteria (Dyukarev *et al.*, 1999[1]). However, we believe that in many cases this approach alone is insufficient to identify low-disturbance forests and was therefore was considered to be only one step in our research. The output of this step was the location of a set of *candidate core areas*, or, least transformed patches of vulnerable forest types.

We classified the forest landscape into forest types, using a common Russian forest classification system (Rozenberg and Vasiliev, 1969[2]). To facilitate the analysis, a few types of highland forest and alpine communities typically found in close proximity to each other were grouped into one category. From this list we selected those forest types that are native to the region and are vulnerable to human activities. Thus, we analyzed six forest types:

- Korean pine forest (Korean pine, *Pinus koraiensis*, in mixture with deciduous species or other coniferous, except forests with Manchurian fir, *Abies holophylla*, see below);
- Manchurian fir forest (forests with the Manchurian fir, *Abies holophylla*);
- Dark coniferous forest (mixed Yezo spruce, *Picea jezoensis,* also called *P. ajanensis*, and East Siberian fir, *Abies nephrolepis*);
- Highland complexes of vegetation (including dark coniferous forest, Stone birch, *Betula ermanii,* forests, Dwarf pine, *Pinus pumila*, and mountain tundra communities);
- Mixed noble hardwood forest (Japanese elm, *Ulmus japonica,* and Manchurian ash, *Fraxinus mandshurica,* dominated hardwoods); and
- Riparian poplar forest (a mixture of *Populus coreana, P. maximoviczii, P. suaveolens*, and *Chosenia arbutifolia* with presence of conifers).

We then attempted to locate the least anthropologically transformed parts of each sensitive forest type. In Primorye, different types of least transformed forests showed different degrees of human impact due to differences in their accessibility and economic value. While highland dark coniferous forests are well-preserved in northern Primorye, Manchurian fir forests have a limited area of distribution and are heavily affected by humans. Practically all patches of Manchurian fir forest show traces of recent human disturbance. Therefore, we used different criteria for each forest type, using less stringent criteria for more disturbed forest types, which nonetheless preserve their natural plant diversity. If a forest type had no relatively undisturbed patch, we selected areas with the greatest potential for restoration. An important consideration when constructing criteria was to take into account the full range of plant and vegetation diversity for any given forest type.

Transformation analysis - Technical description

Step 1. Using state forest inventory data, we located forest stands which fulfill our criteria for candidate least- transformed forests. Forest inventory data can be unreliable and must be used with precaution. We relied primarily on age data and dominant tree species as these usually correlate with forest condition and diversity and adequately represent the true state of the forest.

Our selection criteria relied on empirically established relationships between age and dominant tree species on the one hand, and the level of human impact on the community on the other. However, because available data did not include the most recent inventory data, we could only locate *candidate* areas of least-transformed forests in this step. (Figure 3).

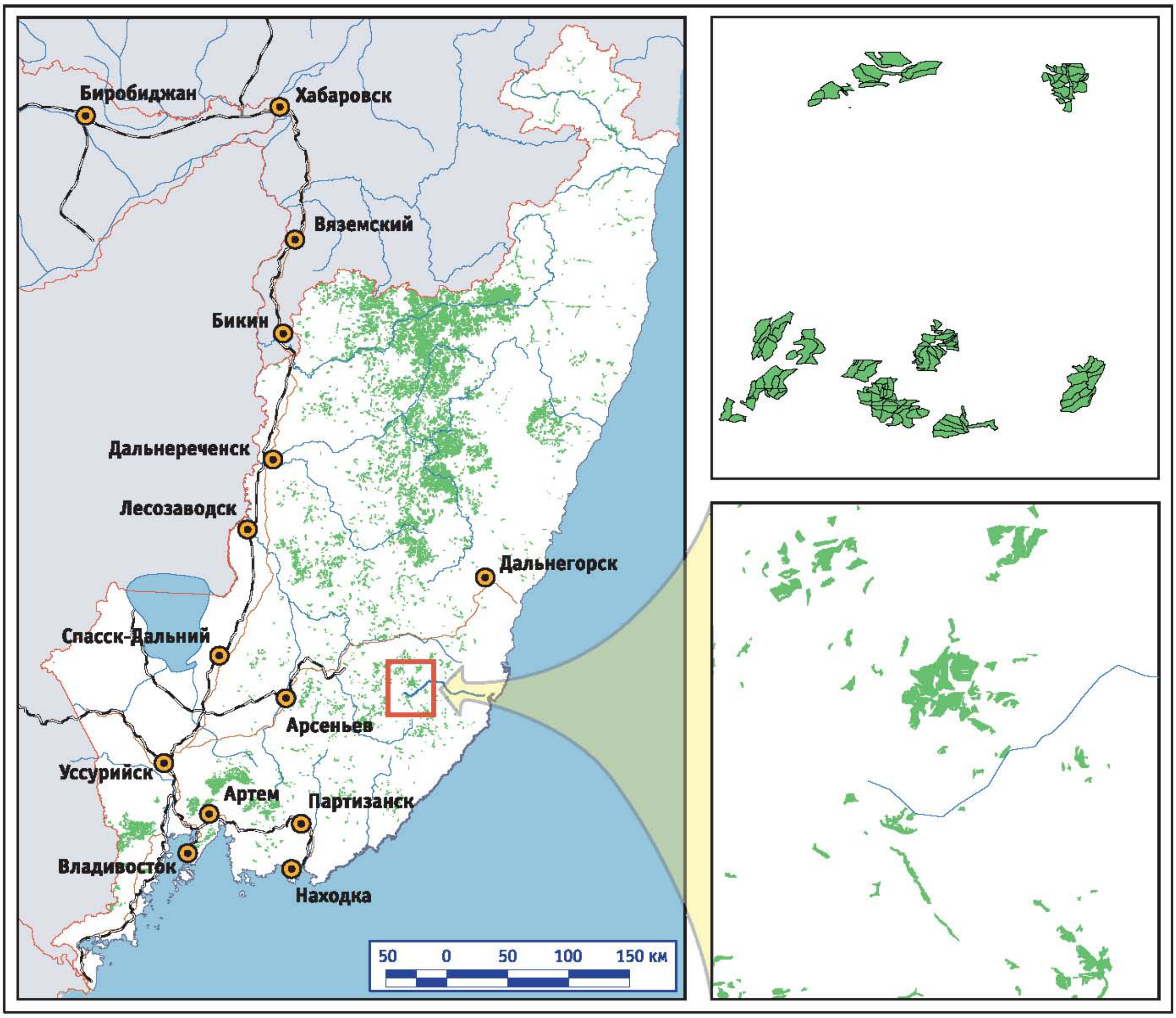


Figure 3. Transformation analysis. Step 1 — locating least transformed forest using state forest inventory data (shown in green). Left — a map of the region. Bottom right — an enlarged detail map. Top right — a schematic map.

Step 2. Next, we located high-altitude vegetation types, located higher than 1000 meters above sea level, and bottomland dark coniferous forests located in the floodplains of river valleys. For this step, we used a digital elevation model that we derived from topographic maps. We overlaid these with data on forest type distribution data to locate high-elevation vegetation complexes, as well as riparian forests, which both tend to have the specific biodiversity associated with them. (Figure 4).

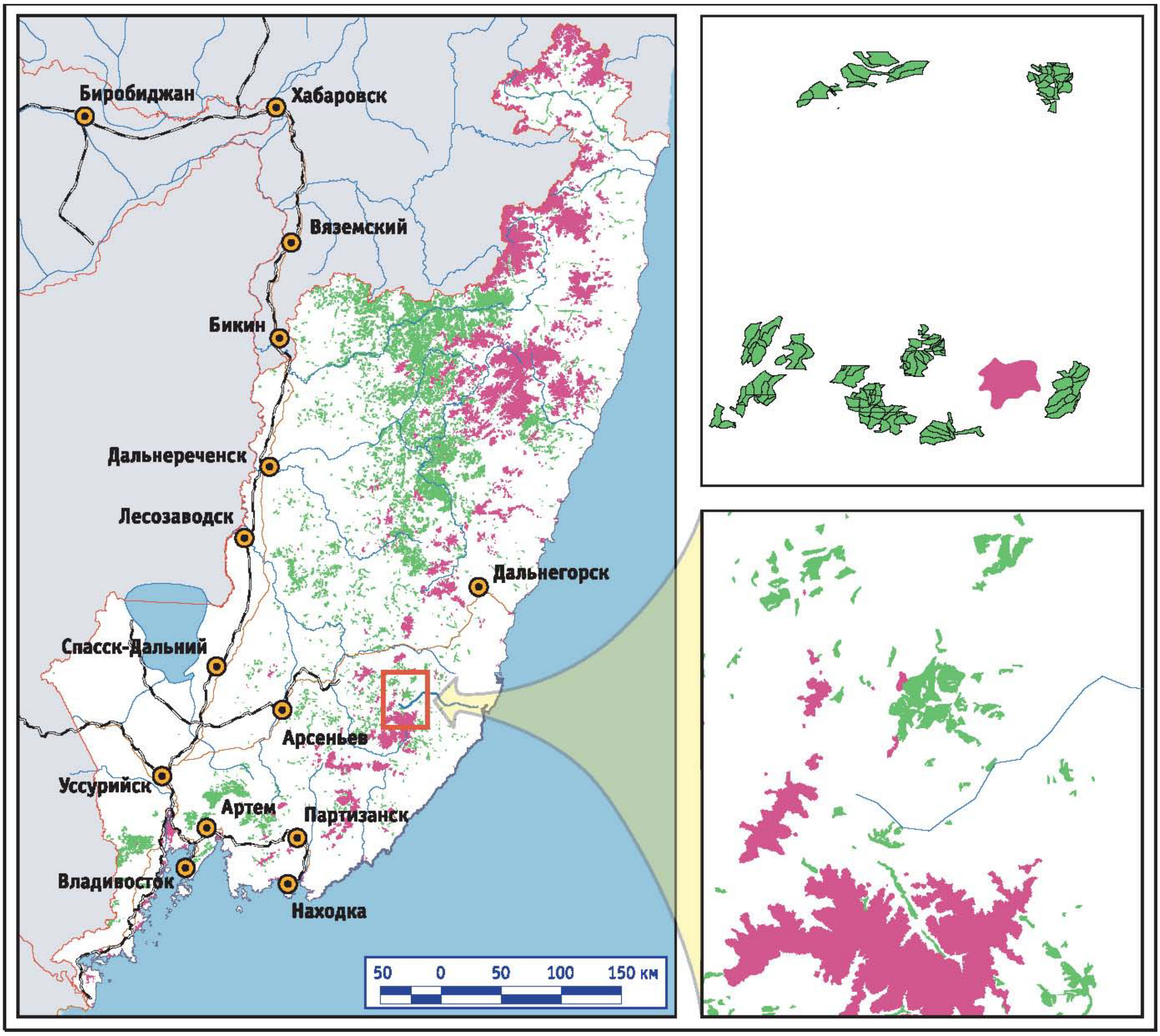


Figure 4. Transformation analysis. Step 2 — locating high elevation and riparian spruce-fir forest (shown in magenta) using a digital elevation model. Left — a map of the region. Bottom right — an enlarged detail map. Top right — a generalized map.

Step 3. Using satellite images, we corrected and updated the boundaries of the forest stands located in the previous steps. If an adjacent area had the same spectral and textural characteristics on the satellite images as the ones identified through the forest statistics, this area was included in the core. We also made sure that our boundaries reflected the most recent changes in the forest by excluding areas recently disturbed. Spruce-fir forests on slopes, which connect highland and riparian ecosystems were also included. (Figure 5).

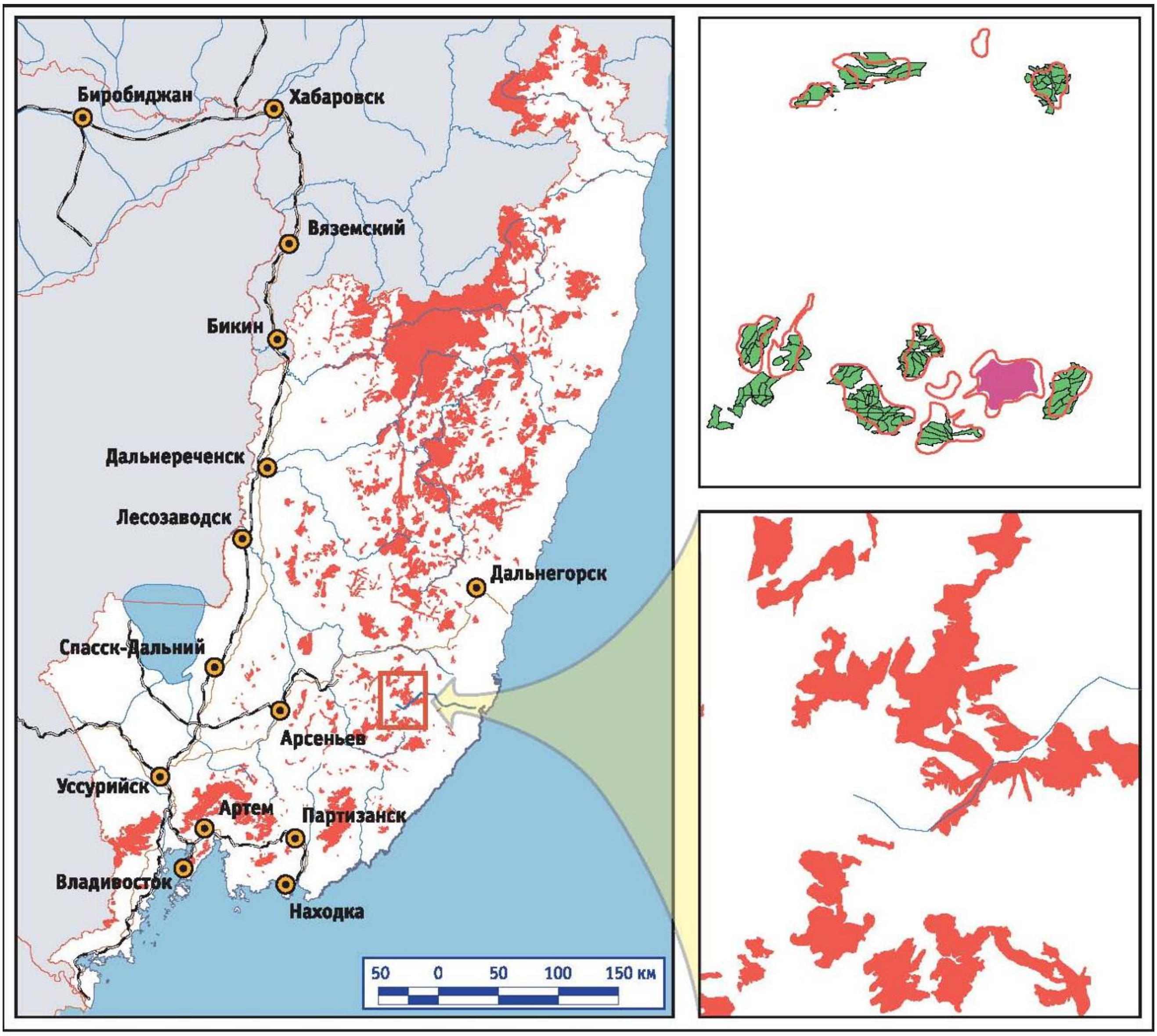


Figure 5. Transformation analysis. Step 3 — correcting boundaries of the forest stands located in previous steps (in red). Left — a map of the region. Bottom right — an enlarged detail map. Top right — a generalized map.

These identified territories were termed *candidate core areas* —patches of a certain forest type that are the least transformed by humans and are the most biologically diverse. We did not include "secondary" forest — post-fire or post-cleaning forest — in the candidate core areas, nor did we include forest with clear evidence of multiple ground fires, often indicated by an abundance of Mongolian oak, *Quercus mongolica*. Such forests usually do not have long continuity are not threatened by modern human impact, and do not represent any flora, which has a strong association with them.

Fragmentation analysis

In the **fragmentation analysis,** like the approach we used to map intact forest landscapes, we assumed at the outset that the entire research area was intact unless otherwise proven by adequate information. This information included basic infrastructure maps, satellite images, and official forest inventory data, showing evident human disturbances. Such disturbed areas were mapped and excluded from further study, while the remaining areas were classified by size and configuration of its constituent forest fragments.

Fragmentation analysis – Technical description

Step 1. We eliminated major elements of human infrastructure using topographic maps. Built-up areas, croplands, railroads, paved roads, gravel roads, and smaller roads, if they connected two populated areas, were assigned a buffer with a width of 50100 meters (500 meters for urban settlements). In comparison with the analysis of intact forest landscapes, these criteria were "softer". For example, dirt roads, including most small logging roads, small (local) power lines, and selective logging were not regarded as sufficient fragmentation and were not excluded. Also, the buffer assigned to linear features like pipelines, power lines, quarries, and other types of mining activity was smaller. (Figure 6).

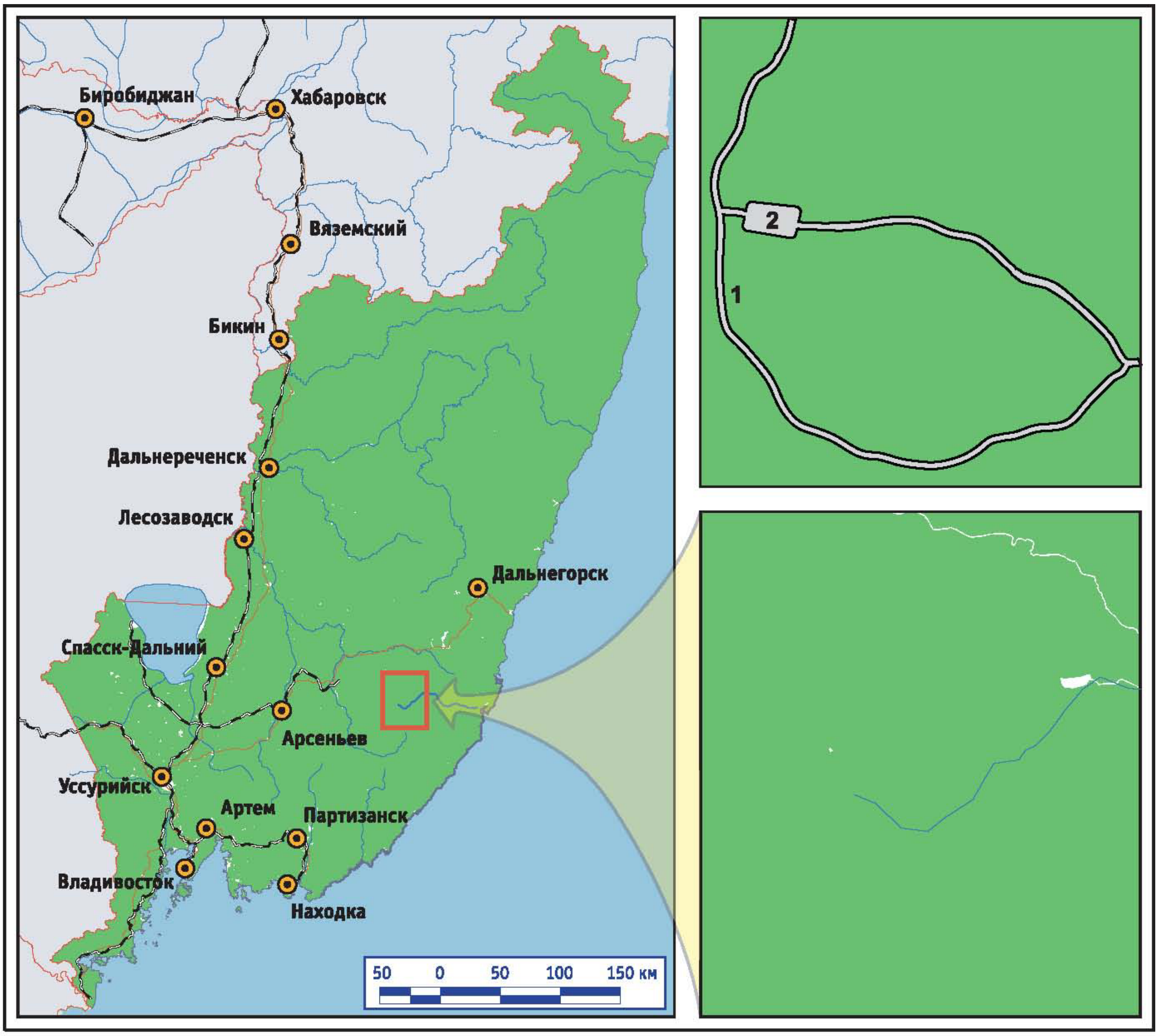


Figure 6. Fragmentation analysis used in compiling the map. Step 1 — eliminating major elements of human infrastructure that fragment natural forest cover, using topographic maps (residual areas — in green). Left — a map of the region. Bottom right — an enlarged detail map. Top right — a schematic map. In numbers: 1 — roads with buffer zones; 2 — built-up areas with buffer zones.

Step 2. We eliminated areas that have been completely transformed by humans, identifying them through satellite images. These areas included built-up areas, croplands, and quarries that had not been eliminated in the previous step, and wide roads that were not indicated on topographic maps (mainly big logging roads). These areas were buffered and eliminated from further analysis. (Figure 7).

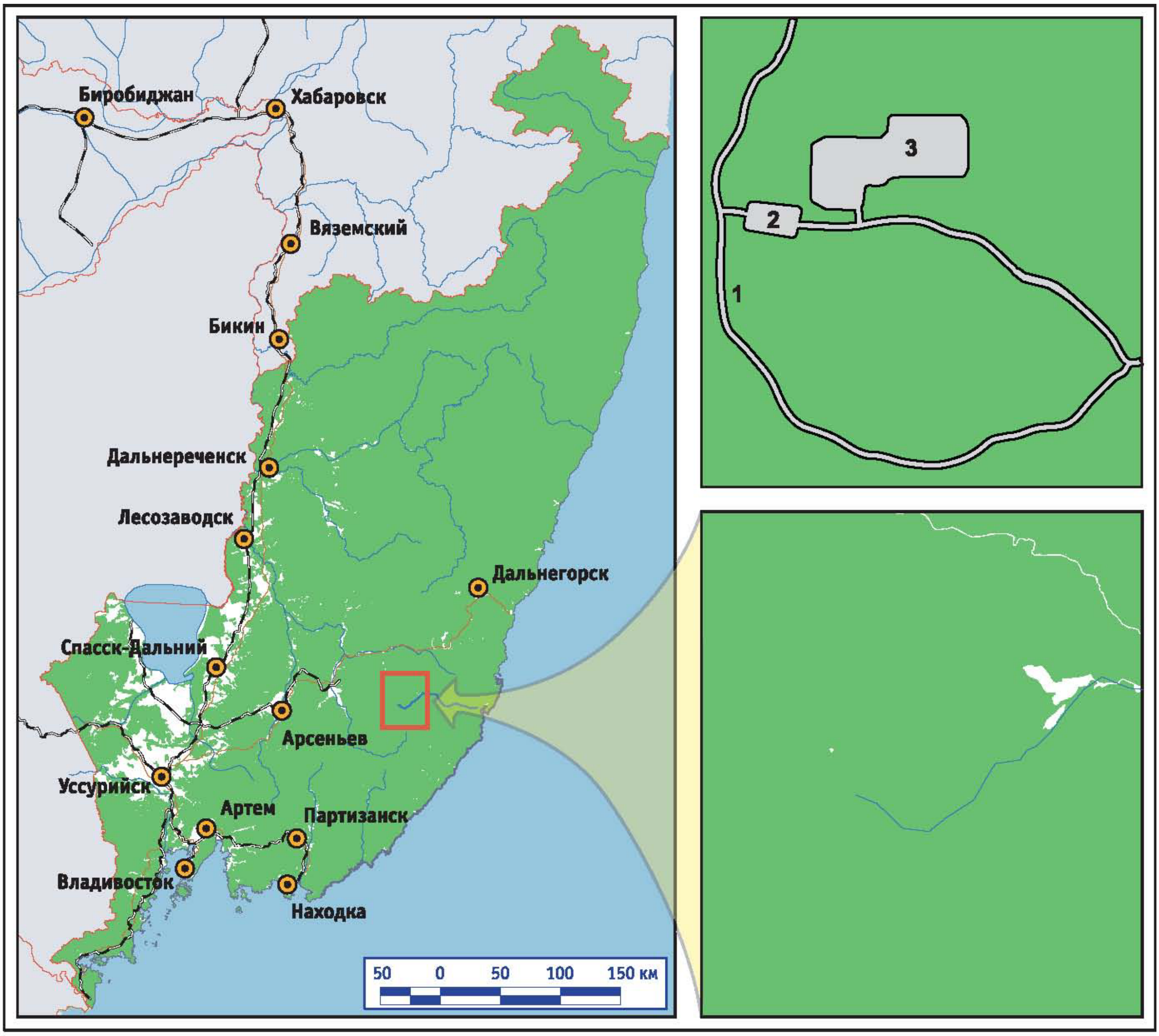


Figure 7. Fragmentation analysis, used in compiling the map. Step 2 — eliminating areas that have been completely transformed by humans using satellite images (residual areas — in green). Left — a map of the region. Bottom right — an enlarged detail map. Top right — a generalized map. In numbers: 1 — roads with buffer zones; 2 — built-up areas with buffer zones. 3 — croplands.

Step 3. Using satellite images, we excluded areas with visibly transformed vegetation caused by clear-cutting, catastrophic fires, and recurring forest ground fires over the last several decades. We also eliminated abandoned agricultural areas, which we identified by such characteristics as shape, drainage system, and proximity to a road network. In this step, we applied criteria that were more rigid than in the analysis of intact forest landscapes. All areas affected by forest fires, whether of natural or anthropogenic origin, were excluded along with all forest regarded as "secondary" (i.e., all early stages of post-fire and post-logging succession). (Figure 8).

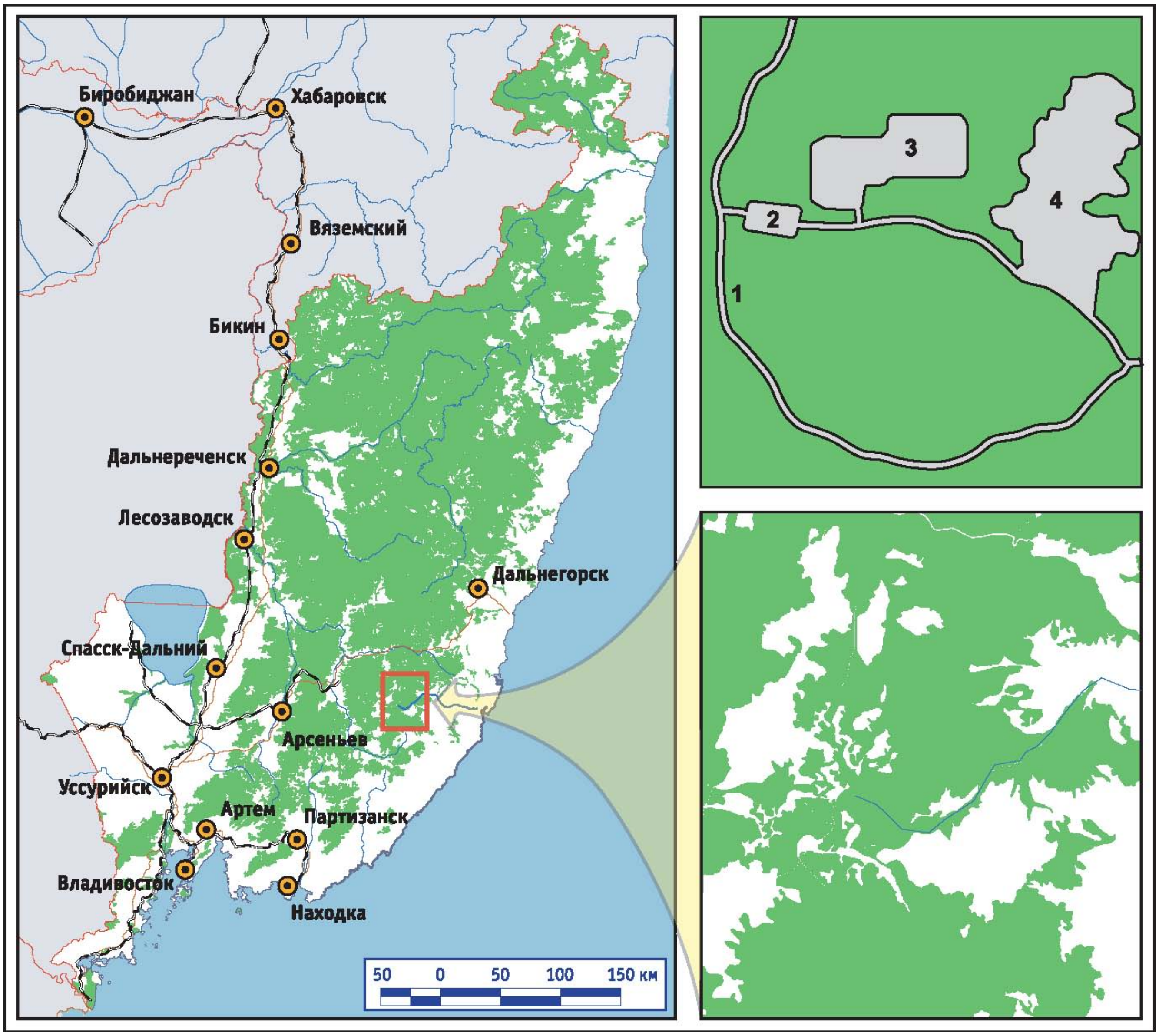


Figure 8. Fragmentation analysis used in compiling the map. Step 3 — eliminating areas with visibly transformed vegetation, caused by clear-cutting and fires (residual forest matrix in green). Left — a map of the region. Bottom right — an enlarged detail map. Top right — a generalized map. In numbers: 1 — roads with buffer zones; 2 — build up areas with buffer zones; 3 — croplands; 4 — significantly transformed forest ecosystems (clear-cuts, fires, post fire successions).

Our objective in the fragmentation analysis was to eliminate areas not capable of maintaining the ecological connection between the least transformed forest patches. The remaining area was called the *forest matrix* — defined as a less disturbed forest landscape, characterized by mature and late-successional forests — and was used as a point of departure for the further analysis.

Areas over 10,000 hectares of the forest matrix make up a separate HCVF category — *non-fragmented forest landscapes*. The conservation value of these landscapes is limited in Primorsky Kray, because of the abundance of intact forest landscapes. In other regions, where land use has caused more extensive transformation of the forest landscape, such areas may play an important role in protecting key biodiversity values. Special regulations for forest management and a protection from mining, drilling, and infrastructure development may be needed in order to maintain the full range of their ecological functions.

Locating less disturbed forest tracts

To locate less disturbed forest tracts, we **combined the results of the transformation and fragmentation analyses,** identifying clusters of candidate core areas and eliminating fragmented areas.

Locating less disturbed forest tracts – Technical description

Step 1. The region was divided into small rectangular blocks, 30x30 meters. A circular area with a radius of 2,000 meters was investigated around each block. Blocks that had more than half of their surrounding area as candidate core areas were joined into plots, representing a high-density zone of candidate core areas. In this way, clusters of small candidate core areas were unified into larger plots, and candidate core areas, whether clustered or individually large enough, were provided with a surrounding buffer zone. Isolated small candidate core areas, as well as very narrow ones, were eliminated. (Figure 9).

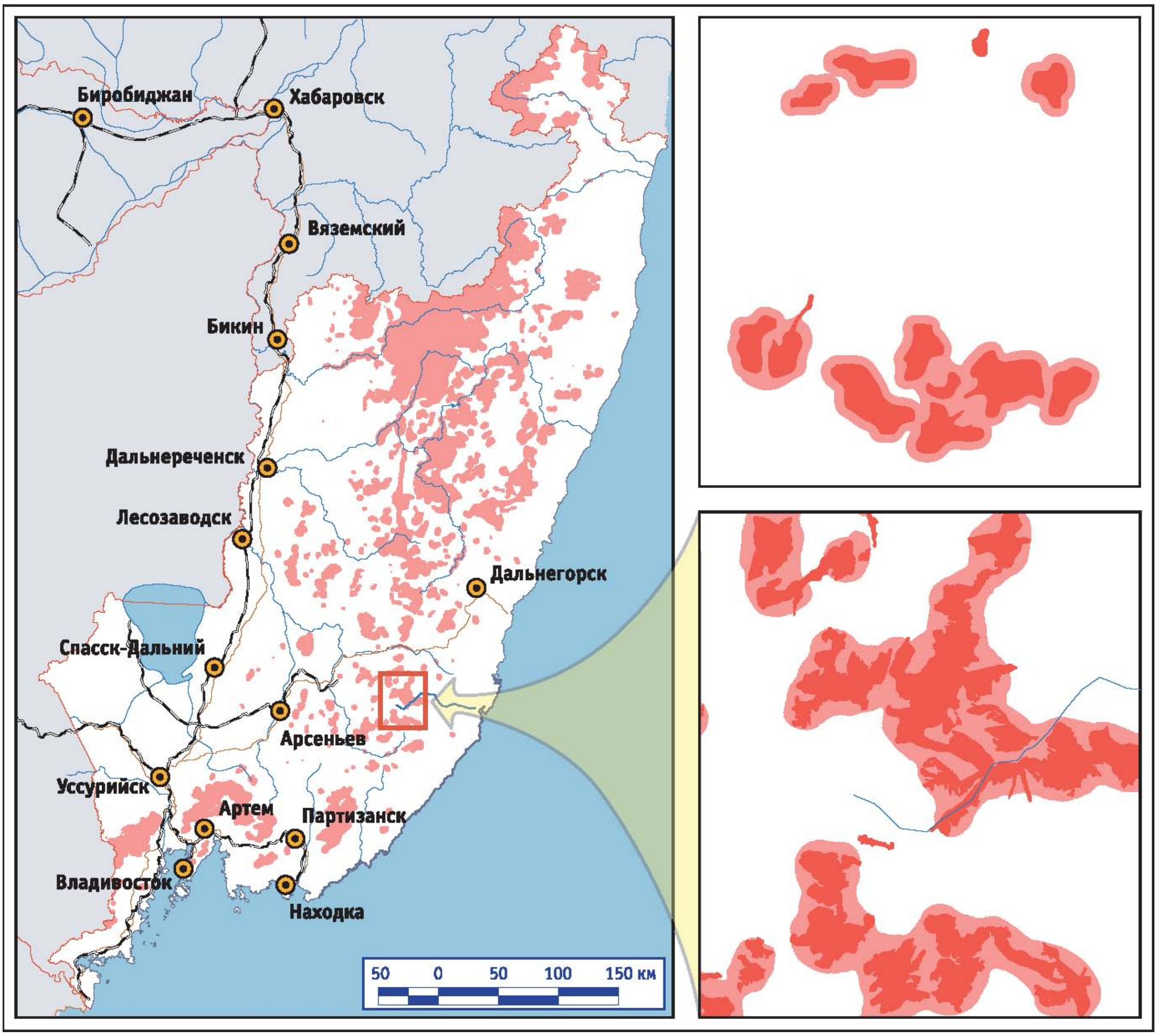


Figure 9. Locating less disturbed forest tracts. Step 1 — compiling a map of high density zones of candidate cores areas (candidate core areas in red, zones of their high density in pink). Left — a map of the region. Bottom right — enlarged map fragment. Top right — generalized map.

Step 2. Areas with high density of candidate core areas were overlaid with the result of the fragmentation analysis — with the forest matrix. Thus, we eliminated lands located close to candidate core areas but occupied by clear cuts, post-fire forests, or croplands. We also eliminated smaller candidate core areas located close to each other if they were divided by significantly transformed land. In such case, candidate core areas would not have ecological connectivity between them. (Figure 10).

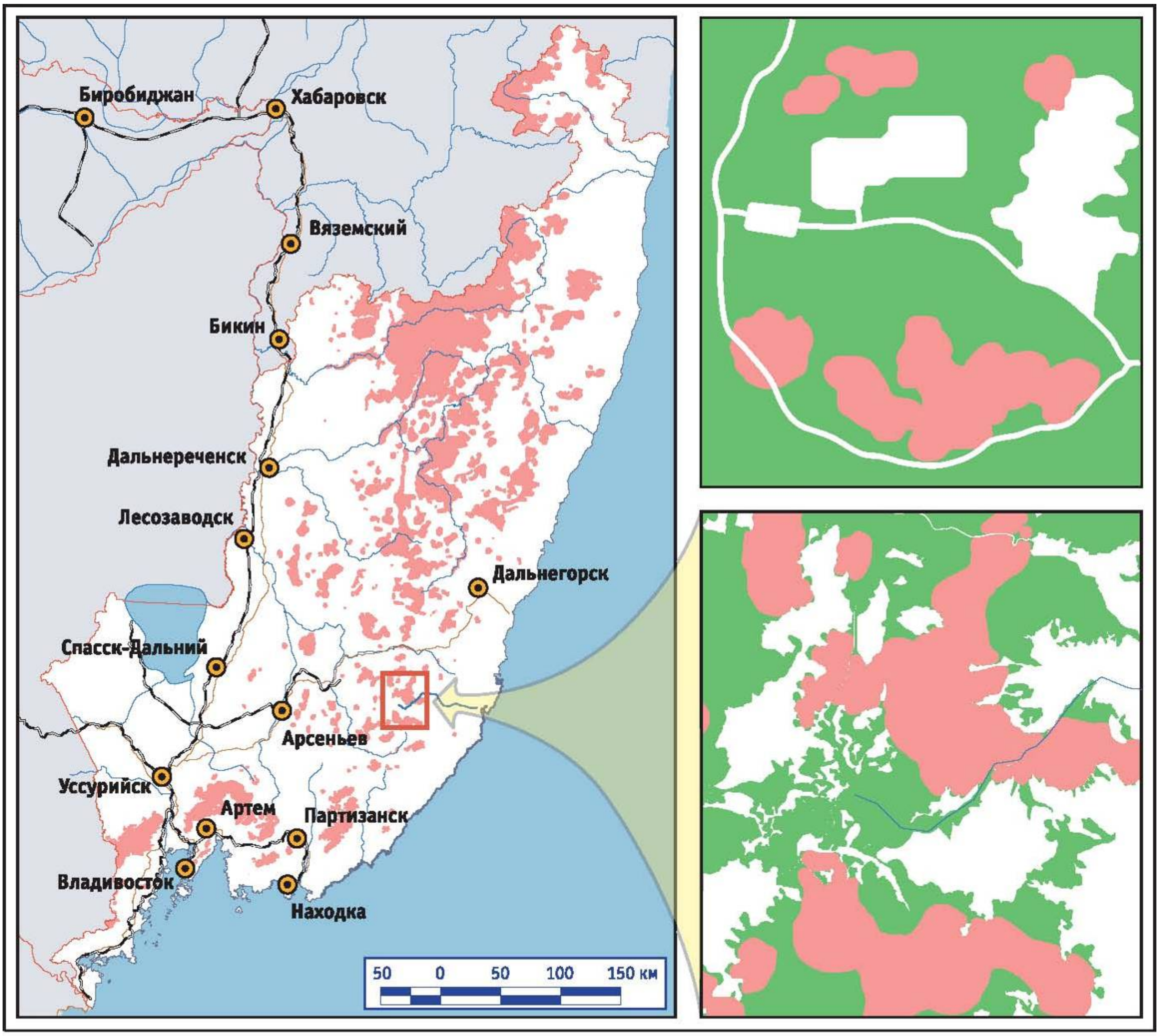


Figure 10. Locating less disturbed forest tracts. Step 2 — reduction of the high-density zone of candidate core areas that are outside the forest matrix (zones of high density of candidate core areas in pink, forest matrix is in green, territories not included in the forest matrix are in white). Left — a map of the region. Bottom right — an enlarged detail map. Top right — a generalized map.

Step 3. We checked the geometrical shape of the remaining areas and eliminated parts (“appendices”) if less than 1 kilometer wide.

Step 4. The remaining areas with a high density of core areas were classified by size. Areas smaller than 2,000 hectares were eliminated. The rest were called less disturbed forest tracts. (Figure 11).

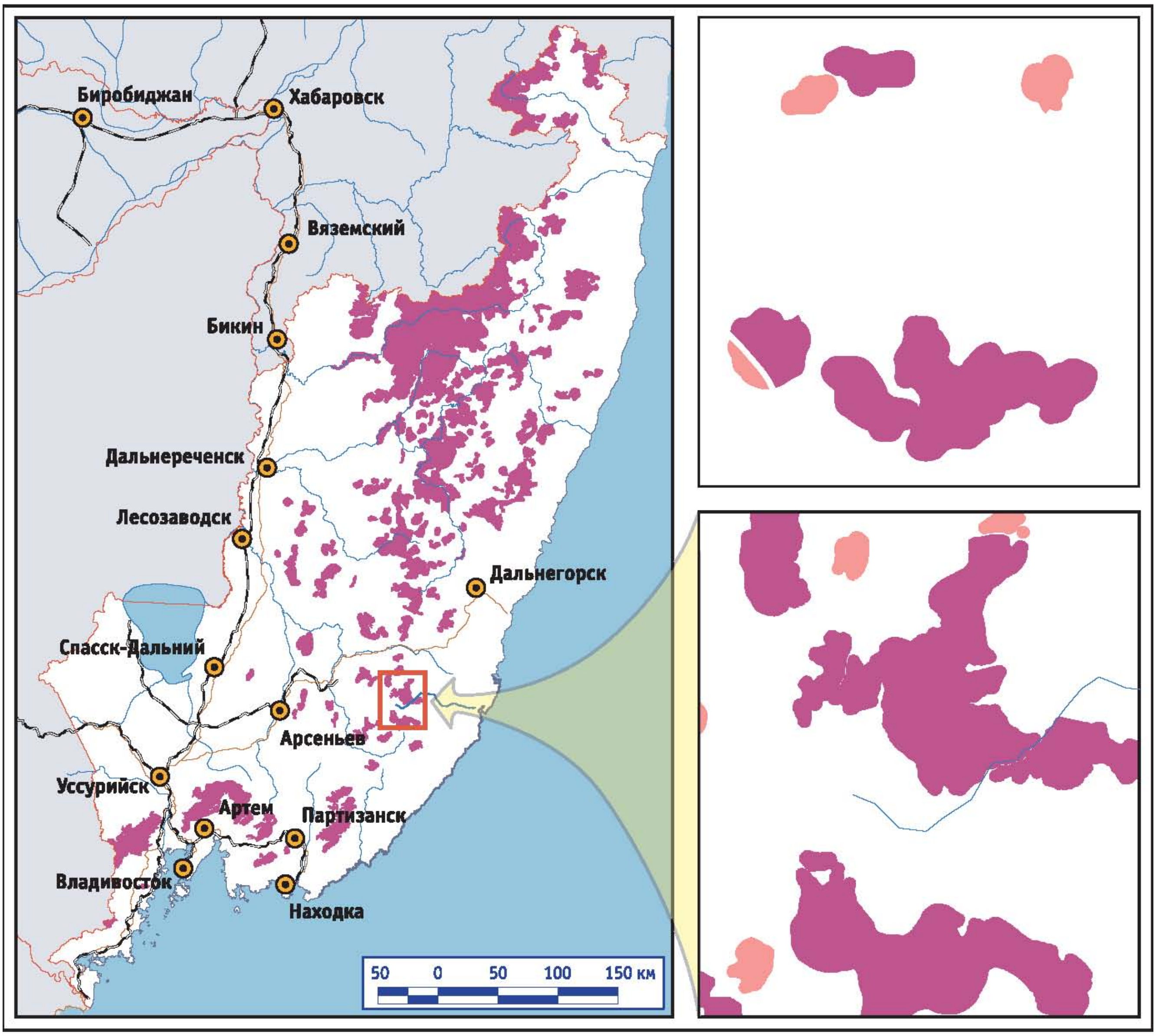


Figure 11. Locating less disturbed forest tracts. Steps 3-4 — final location of the contours of the less disturbed forest tracts (in magenta). In pink are zones of high density of candidate core areas that are located in the forest matrix and that were not included in the less disturbed forest tracts. Left — a map of the region. Bottom right — an enlarged detail map fragment. Top right — a generalized map.

Step 5. For some of the most threatened forest types, such as Manchurian fir forests, mixed noble hardwood forests, and riparian dark coniferous forests, we used another algorithm — just buffered core areas — and a smaller threshold — 500 hectares.

3. NATURALLY RARE AND UNIQUE FOREST COMMUNITIES

We used the publication by Krestov and Verkholat (2003)[3] to identify a list of naturally rare communities. However, we excluded several communities, whose biodiversity value is in doubt, relative to other forest types, according to our research. For example, we excluded mono-dominant Korean stone pine forests, which many authors regard to be post-fire communities and which anyway are very poor floristically and lack strongly associated plant species.

There are also some forest communities that have become rare due to human impact. Examples include forests with Manchurian fir and some types of noble hardwood forests with Korean pine. Some of them are globally rare and/or endemic to the region. However, those forests were not analyzed separately as they make up a part of the category called less disturbed forest tracts (see previous section).

The naturally rare communities we analyzed can be grouped as follows:

1. Forests with the rare or endemic tree species.
   - Forests with Japanese yew (*Taxus cuspidata*)
   - Forests with iron birch (*Betula schmidtii*)
   - Forests with castor aralia (white nut, *Kalopanax septemlobus*)
   - Japanese red pine forests (beauty pine, *Pinus funebris, Pinus densiflora*)
   - Forests with Daimio oak (dentate oak, *Quercus dentata*)
   - Manchurian apricot forests

2. Forests with the rare or endemic dominant species in undergrowth or grass.
   - Mountain dark coniferous forests (Yezo spruce, *Picea jezoensis* and East Siberian fir, *Abies nephrolepis*) with bergenia (*Bergenia pacifica*)
   - Mountain dark coniferous forests (Yezo spruce, *Picea jezoensis* and East Siberian fir, *Abies nephrolepis*) with Asian devil's club (wolfberry, *Oplopanax elatus*)
   - Siberian Cypress communities (*Microbiota decussata*)

3. Forest communities with an unusual combination of species which are not individually rare.
   - Dark coniferous (Yezo spruce, *Picea jezoensis* and East Siberian fir, *Abies nephrolepis*) — hornbeam (*Carpinus cordata*) forests
   - Dark coniferous (Yezo spruce, *Picea jezoensis* and East Siberian fir, *Abies nephrolepis*) — dwarf Siberian pine (*Pinus pumila*) forests
   - Coastal larch forests, or larch (*Larix* spp.) — dwarf Siberian pine (*Pinus pumila*) forests
   - Mongolian oak (*Quercus mongolica*) — dwarf Siberian pine (*Pinus pumila*) forests
   - Mongolian oak (*Quercus mongolica*) — stone birch (*Betula ermanii*) forests
   - Lime (*Tilia spp.*) — stone birch (*Betula ermanii*) forests

We selected the communities from the list for which we had sufficient data. Forests with Daimio oak and Manchurian apricot forests from the first group could not be located — neither by the state forest inventory data nor by remote sensing methods.

Locating communities from the second group presented similar obstacles — grass is poorly reflected in both forest inventory data and remote sensing materials. However, most of these forests are intact highland communities. Thus, they make up a part of the core areas of the less disturbed forest tracts (see the previous section). Also, we identified some of these forests while looking for rare and endangered species habitats (see the next section).

To identify other communities (group 3 and the most of group 1), we used the official forest survey data. We filtered the data by present tree species. Some rare forest ecosystems could have been described inaccurately in the forest survey data. So, we buffered all forest stands (*vydels*) selected from the database by 200 meters to ensure that no part of a rare ecosystem is lost because of possible inaccuracies.

4. KNOWN HABITATS OF RARE AND ENDANGERED PLANT SPECIES

Since the Red Data Book of the Primorsky Kray has not been published yet, we used the Russian Federal Red Data Book (1988)[4] as a resource for the list of rare and endangered plant species for our work. From the red listed species we selected only forest species. We did not map habitats of aquatic and grasslands plant species. We also examined the remainder of the list and eliminated species, which do not need any additional special protection measures due to their abundance in the region and/or absence of threats to their typical habitats. These species are listed in Table 6 of the Russian report. Species that require protection from any logging operation (including any selective logging) in their habitats to survive are marked in bold.

Data on the selected species were gathered from all possible sources. Thus, we processed about 2,000 herbarium samples from different research institutes in Moscow, St. Petersburg, and Vladivostok. These samples likely comprise all the herbarium data available for the region on those species. We then added our own field findings. However, it is certain that these data do not represent all or even the majority of the habitats of rare and endangered forest species. We also understand that the final picture may give a better picture of the most popular places for scientific study rather than the densest populations of the rare species. However, producing a more representative picture will require an enormous amount of planned and systematic field studies, and therefore might not be feasible.

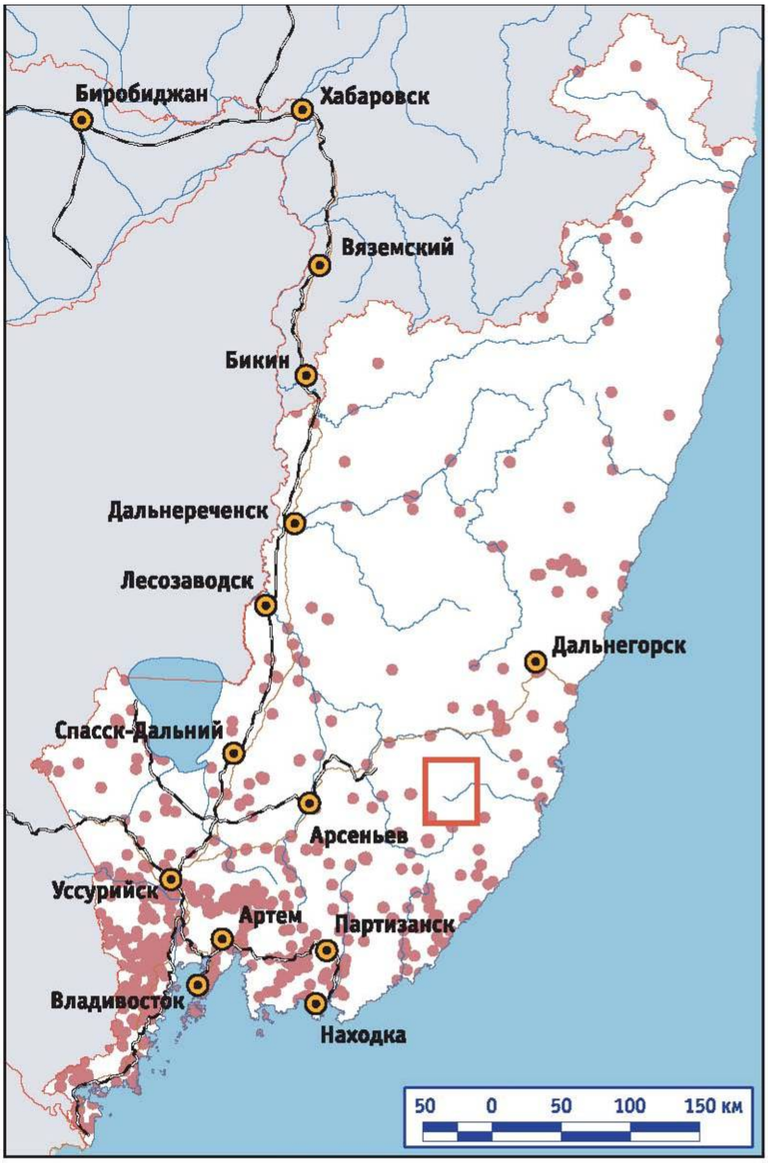


Figure 12 shows a map of sites of rare and endangered species of vascular plants.

Known locations of rare and endangered plant species were plotted on the maps. For our own field observations this was a simple task due to the availability of GPS measurements identifying these areas. However, for herbarium and publication data it has often been a challenge to determine the precise location. The location of herbarium species is usually described rather approximately — often just down to vicinity of a certain settlement. In such cases we tried to use our expert knowledge about species biology to find the most likely location of the species. (For example, coastal species can be assumed to belong in a riparian area, etc.) However, in some cases it was impossible to determine the location with sufficient accuracy. In those cases, the observation was simply omitted.

A buffer zone of 200 meters has been added around the locations of observed rare and endangered species. The area within the buffer zone is regarded as a probable habitat for those species.

5. FLOODPLAIN AND BOTTOMLAND ECOSYSTEMS OF INTACT RIVER BASINS

The analysis so far has left out major portions of the floodplain and bottomland (riparian) ecosystems that can be found in the intact river basins that are located in flood-lands and low-lying, gently sloped terraces. Floodplain and bottomland ecosystems, if they are not affected by industrial activities, are very important for maintaining the natural biodiversity of river basins.

There are several reasons for why they have high conservation value. Firstly, because of their natural diversity and dynamics, they are high in biodiversity. Secondly, they provide habitat for many rare plant species. Thirdly, because of their moisture and mosaic characteristic, riparian ecosystems provide refuge for many types of fauna on the occasion of catastrophic forest fires.

Floodplain and bottomland ecosystems also contain key habitats for many animal species, including those that are rare. Finally, these areas are of key importance for the hydrological regime of rivers, the maintenance of which is necessary for preservation of water-dependent flora and fauna, especially the unique fish fauna of the salmon rivers. Thus, according to the FSC classification of HCVF, these territories can simultaneously fit into several categories.

At the same time, riparian areas are often the first to come under the influence of industrial activities, such as road construction along rivers, and selective logging of flood-land forests. For this reason, we decided to introduce and identify large areas of floodplain and bottomland ecosystems, undisturbed by industrial activities, as a special HCVF category.

For this analysis, we chose relatively long river sections (at least 30 km from the source, measuring along the river course, including within intact forest landscapes) in watersheds without infrastructure or signs of industrial logging, such as settlements, roads (including logging roads), or disturbances clearly emanating from logging. We did not consider fire scars to be a sign of disturbance unless it directly affected the vegetation of the flood-lands and low-lying terraces.

Floodplain and bottomland forests were separately identified only outside of intact forest landscapes and only in relatively wide riparian zones (at least 200 m wide, except for some local narrower parts). The first delineation was made using topographic maps to include floodplains and other low-lying terraces (which would usually include communities of similar composition), using as preliminary boundaries the line where the flat valley bottom meets the hillside. This boundary was subsequently adjusted with the help of satellite imagery to include only communities with a composition close to what is natural. We excluded valley communities, if they had traces of disturbances from catastrophic fires over the last several decades. The contour was delineated along the course of the river until reaching an area showing signs of anthropologic disturbance.

Since the contours included low-lying terraces, no buffer zone was added. Parts found to be especially narrow were not excluded, as a stretched and narrow form is a natural characteristic of these ecosystems. No criterion for smallest size was used; and, all of the delineated areas turned out to be in excess of 500 ha.

CONCLUSIONS

Key findings:

- The total area of HCVF identified here, including all analyzed categories, is 2.94 million hectares. This area comprises 17.8% of Primorsky Kray (a.k.a. Primorye). This is generally enough to sustain the plant biodiversity of the region, but may not be sufficient to preserve biodiversity in its entirety, especially large mammals. Additional measures should therefore be taken to preserve high value habitats of organisms not covered within this study.

- The area of Less Disturbed Forest Tracts (HCVF 1 and 2) in Primorye is 2.67 million ha, or 16.2% of the total area. Within these, core areas make up 1.94 million ha.

- Floodplain and bottomland ecosystems of intact watersheds make up 307.5 thousand hectares, or 1.9% of the area of Primorye.

- Rare forest communities were found on 195.1 thousand hectares, or 1.2% of the area of Primorye. These were identified on the basis of forest inventory data, and may in reality occupy a significantly greater area.

- Sites of rare and endangered species composed 16.6 thousand hectares, or 0.1% of the area of Primorye.

Limitations of this study:
Accuracy: The accuracy of the results is generally greater in the south than in the north, and at lower altitudes rather than higher. Field expeditions might reduce the size of intact forest landscapes found in this study, but also find additional areas of high conservation value.

Species data: Not all locations of rare plant species have been identified and the list of rare species used is not exhaustive. For example, we have not included non-vascular plants, lichens, and mushrooms. Additional studies are required to identify these.

Species location mapping: To identify locations of rare species, we mapped their habitats based on reference books and put a buffer zone around them. (Thus, it is important that the list of rare species is updated and completed). If references for rare and endangered species give inaccurate information on their location, it is impossible to avoid inaccuracy in mapping them. For this reason, differentiating methods should ideally be used when mapping.

Comprehensiveness: The work on identifying HCVF in the region is not yet conclusive. This study is limited to HCVFs that can be identified in satellite images and forest inventory information. It is important that those areas that cannot be identified by those means are not forgotten. Areas of high conservation value may also exist undiscovered within trivial areas. Foresters and specialists alike need to engage in additional work.

Conclusions:
The results of this analysis are suitable to guide policy decisions, such as compiling logging plans, planning fire prevention activities, allocating areas for protection, etc. While some of the areas identified here are already protected, others require additional measures to limit industrial activity on them, and this work can serve as a basis for developing a regional network of protected areas. The location of individual areas of high conservation value should therefore be integrated into the forest inventory and planning materials.

High Conservation Value Forests. Legend

Intact Forest Landscapes:
- forest ecosystems
- non-forest ecosystems

Native Forest Tracts:
- forest ecosystems
- non-forest ecosystems

Other HCVF categories:
- rare plant communities identified by official forest survey data
- rare plant communities identified by satellite images - Manchurian Fir forests, noble wood mixed forests and riparian dark coniferous forests
- rare vascular plant species habitats

Other areas:
- forests outside the above-listed HCVF categories
- non-forest areas

- Protected areas boundaries
- Boundaries of the buffer zones of zapovedniks (the federal strict scientific nature reserves)

Water features:
- seas, lakes and broad rivers
- other rivers

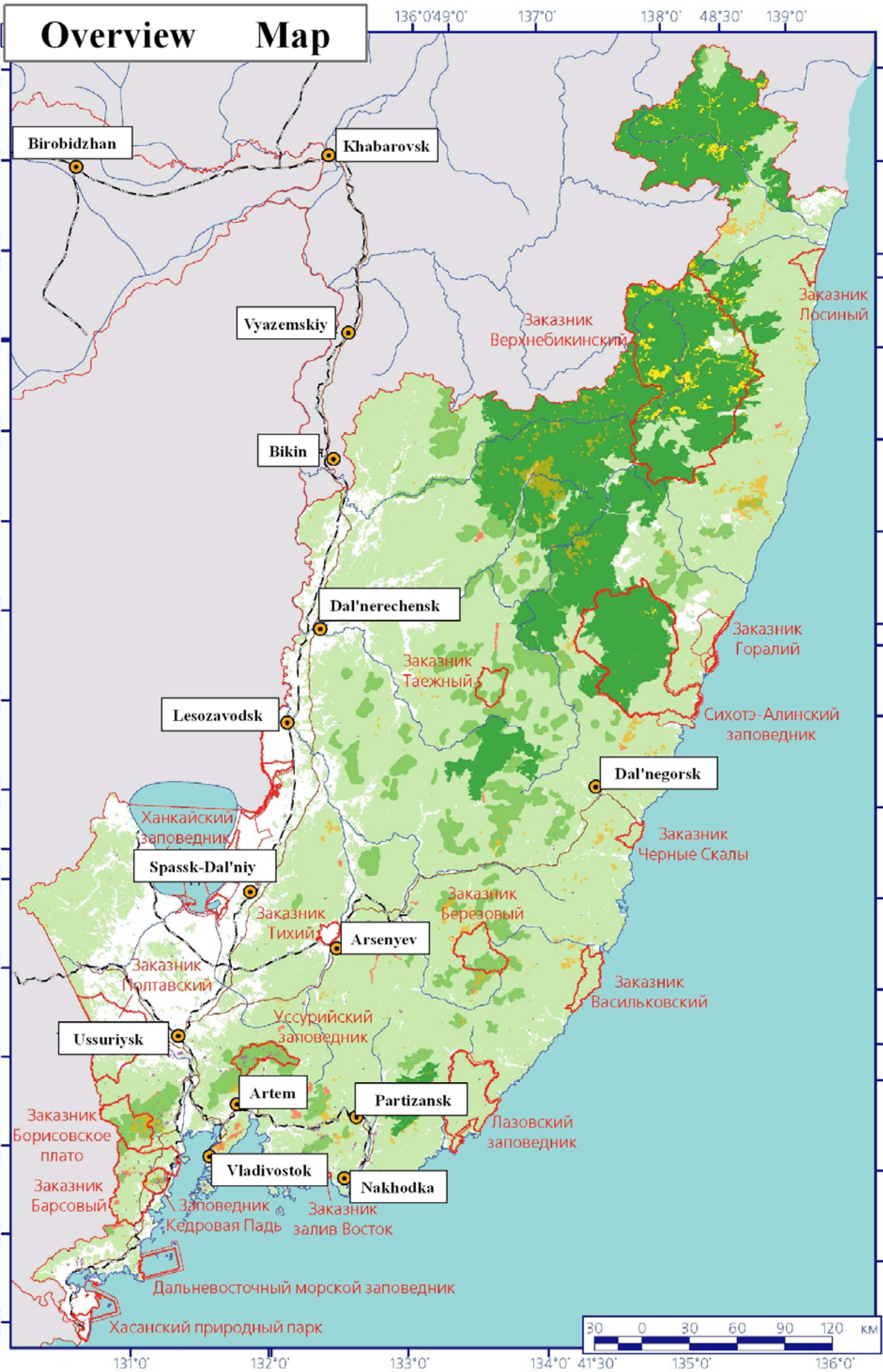
Road network:
- Railroads
- Narrow-gauge railroads
- Paved roads
- Earth roads
- Field and forest roads

Administrative boundaries:
- National boundary of the Russian Federation in detailed maps
- Regional boundaries inside the Russian Federation in detailed maps
- National and regional boundaries in overview maps

Forestry boundaries:
- Boundaries of Leskhoses - local forest management units under the Federal Forest Agency
- Boundaries of Lesnichestvos - subdivisions of Leskhozes
- Boundaries of forest kvartals - forest blocks, small forest management units

Populated areas:
- Populated areas in detailed maps
- Selected populated areas in overview maps

- Territories outside the Primorsky Kray


Overview Map
Birobidzhan
Khabarovsk
Vyazemskiy
Bikin
Dal'nerechensk
Lesozavodsk
Spassk-Dal'niy
Arsenyev
Ussuriysk
Artem
Partizansk
Vladivostok
Nakhodka
Dal'negorsk
Заказник Верхнебикинский
Заказник Лосиный
Заказник Горалий
Заказник Таежный
Сихотэ-Алинский заповедник
Ханкайский заповедник
Заказник Черные Скалы
Заказник Березовый
Заказник Тихий
Заказник Полтавский
Заказник Васильковский
Уссурийский заповедник
Лазовский заповедник
Заказник Борисовское плато
Заказник Барсовый
Заповедник Кедровая Падь
Заказник залив Восток
Дальневосточный морской заповедник
Хасанский природный парк
30 0 30 60 90 120 км
136°0' 49°0' 137°0' 138°0' 48°30' 139°0'
131°0' 132°0' 133°0' 134°0' 41°30' 135°0' 136°0'

Карта 73
131°25'0"
131°30'0"
131°35'0"
131°40'0"
131°45'0"
131°15'
131°20'0"
131°25'0"
131°30'0"
131°35'0"
43°12'0"
43°8'0"
43°4'0"
43°0'
42°56'0"
42°52'0"
42°48'0"
43°8'0"
43°4'0"
43°0'
42°56'0"
42°52'0"
42°48'0"
42°44'0"
131°45'0"
Овчинниково
Барабаш
Попова Горка
Береговое
Барсовый
Барабашский лесхоз
Барабашское лесничество
Кордон 4-й
ПРИМОРСКИЙ
заповедник
"Кедровая Падь"
Кедровая Падь
лесничество
Заповедник Кедровая Падь
Запов. Кедровая Падь
Сухая Речка
Кедровый
Перевозная
Нарва
Нижняя Нарва
Безверхово
Заказник Барсовый
Островной мастерский участок
Владивостокский лесхоз
Бамбурово
Маяк Бюссе
Пойма
База Круглая
СЛАВЯНКА
Рязановка
Дальневосточный
морской заповедник
(охранная зона)
2 0 2 4 6 8 км

ACKNOWLEDGEMENTS

We would like to thank the following institutions and people for their contributions:

- Staff at the Institute of Biology and Soil Science (Vladivostok, Russia), especially Dr. A. E. Kozhevnikov,
- Dr. N. S. Probatova, P. A. Krestov, T. A. Bezdeleva, V. V. Yakubov, and V. N. Dyukarev;
- Staff at the Nature Reserve "Kedrovaya Pad" (Primorsky Kray, Russia), especially its director, R. I. Korkishko and senior researcher V. G. Korkishko;
- Staff at the Ussuriyskiy Nature Reserve (Primorsky Kray, Russia), especially chief inspector V. A. Kovalev, science consultant A. I. Kudinov, and ornithologist V. A. Kharchenko;
- Staff at the Sikhote -Alinskiy Nature Reserve (Primorsky Kray, Russia), especially chief inspector V. A. Podlubnyi, and researcher M. N. Gromyko;
- Mr. E. G. Egidarev at the WWF Russia, Far Eastern Branch;
- Mrs. M. A. Podvezennaya at the Lomonosov Moscow State University;
- Mr. M. Jones at Pacific Institute of Geography of the Russian Academy of Sciences (Vladivostok);
- Mrs. Y. Uryu at the WWF Japan;
- Mr. M. Hashimoto at the WWF Japan;
- Mrs. A. Yan at the WWF China.

The Landsat satellite images used in this work were donated, in part, by the Global Land Cover Facility at the University of Maryland (USA), the WWF Russia, Far Eastern Branch (Vladivostok), the Pacific Institute of Geography of the Russian Academy of Sciences (Vladivostok), and the Research and Development Center ScanEx (Moscow, Russia).

The work and publication were supported by the WWF Netherlands, the WWF Germany, and by the Swedish International Development Agency (SIDA), and the World Resources Institute (WRI).

The work benefited from the use of software donated by Environmental Systems Research Institute Inc. (ESRI), and from Leica Geosystems (ERDAS).

REFERENCES

1 Dyukarev, V. N., Ermoshin, V. V., Murzin, A. A., Karakin, V. P., Prikhod'ko, A. I. *SikhoteAlin': Korennye lesa u poslednei cherty.* [SikhoteAlin' Range: Virgin forests at the edge of extinction.] Vladivostok: 1999. In Russian.

2 Rozenberg, V. A., Vasiliev, N. G. *Lesa Primorskogo Kraya // Lesa SSSR* [Forests of Primorsky Kray // Forests of the USSR.], Vol. 4. Moscow: Nauka, 1969, pp. 621667. In Russian.

3 Krestov, P. V., Verkholat, V. P. *Redkie rastitelnye soobshchestva Primoriya i Priamuriya.* [Rare plant communities of Primorsky Kray and the Amur River area.] Vladivostok, 2003. 200 pages. In Russian.

4 *Krasnaya Kniga RSFSR.* [Red Data Book of the Russian Soviet Federal Socialist Republic.] Moscow: Lesnaya Promyshlennost', 1988. 598 pages. In Russian.