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Carbon in the Former Soviet Union: The Current Balance
Grant # NAGW- 3856 Final Report

to the

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Washington, D. C.

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Introduction

1. What we have learned.

This work has been carried out in a period of great changes in Russia that have brought extreme hardships to the scientific community. We have been fortunate in establishing excellent relationships with the Russian scientific community and believe we have helped to retain coherence in circumstances where the continuation of research was in doubt. We have learned much and have been effective in advancing, even establishing, scholars and programs in Russia that might not otherwise have survived the transition. The vigor of the International Boreal Forest Research Association (IBFRA) is one sign of the value and success of these activities.

Largely due to the current political and economic transitions in the former Soviet Union, the forests of much of the FSU are under reduced logging pressure. In addition, there is a decline in air pollution as heavy industry has waned, at least for now. Russian forestry statistics and our personal experience indicate a decline, perhaps as high as 60%, in forest harvesting over the last few years. But, new international market pressures on the forests exist in European Russia and in the Far East.

The central government, still the "owner" of Russian forests, is having difficulty maintaining control over forest use and management particularly in the Far East and among the southern territories that have large, non-Russian ethnic populations.

Extraordinarily large areas of mixed forest and grasslands, sparse or open forests, and mixed forests and tundra must be considered when calculating forest area. It is insufficient to think of Russia as simply forest and non-forest.

Forest productivity, measured as growth of timber, appears to be in decline in all areas of Russia except in European Russia.

Most information and publications on the recent history of these forests is heavily dependent on statistical data from the Soviet era. The interpretation of these data is very much open to debate. Anatoly Shwidenko, a long term collaborator and former senior scientist (mensuration) for the Soviet Committee on Forests, now a scholar at the International Institute of Applied Systems Analysis (IIASA), Vienna, has provided abundant contributions from the data available to him and from his experience.

Forest stand carbon is concentrated in the Russian Far East (i.e. Primorski Kray), Central-Southern Siberia and European Russia. But, soil carbon can be 10 times forest stand C.

Our efforts in mapping the area and changes in area (as well as the internal structure) of forests have made major contributions to our joint understanding of the scale and status of these forests. To realize the importance of this contribution one needs only to recognize that any large scale Soviet-era maps of the area did not include latitude and longitude. Even today, there is great reluctance to provide these data, the basis of any GIS.

2. What are the current and significant uncertainties?

Forest fire statistics. These values can change by an order of magnitude from one year to the next and, historically, have been systematically underestimated. Although an effort here would seem tailor-made for satellite analysis, basic information on forest composition and depth of burn is required to accompany the forest areal estimates. Up to 14 million ha of forests can burn in an exceptional year (Stocks, 1991) and 2.5 million ha yr^{-1} burns on average (Krankina, 1993). Current estimates (Korovin 1995) are that fires burn 2 to 5 million ha yr^{-1} of forests in Russia, about the same magnitude as the rates of forest harvest.

Carbon. All estimates of the carbon content of Russian forests published to date are dependent on aggregated Soviet-era forest stand tables. These include estimates by the three leading Russian researchers on this topic, V. Alexeyev, A. Isaev, and A. Shwidenko. Generally, these estimates do not include information on dead biomass, which can be significant component of the forested zone.

Forest harvest rates. There are great uncertainties as to the extent of forest cover, its rate of change and its carbon content. Some of these uncertainties are definitional, but some are due to the size and difficulty of access of Russian forests especially in the east and Far East.

Soils. The soils of Russia hold a large pool of C, large enough to affect the global carbon cycle significantly. The total carbon available for mobilization into the atmosphere is on the order of 300 Pg (Rozhkov et al. 1996).

Forest Regrowth. Estimates of forest regrowth after harvest and forests are very weak.

Forest Productivity. Why is the productivity of the forests of much of Russia in decline? Shwidenko and Nilsson (1996) have stated that it is not due to harvesting.

Climate Change. How will the forests and soil of Russia respond to projected climate change?

Forests and Markets. How and when will the forests of central Siberia re-enter the market place? How much illegal vs. legal clearing is occurring now in the Russian Far East?

3. In what direction should future research on the Russian forests proceed?

The largest uncertainties are in rates of forest cover change in Russia and in the changes in the productivity of the forests. Low-resolution satellite estimates of the land cover of Russian and the FSU are now just beginning. We have made a 15 km resolution map and will soon complete a 1 km resolution map. These are the first steps in appraising forest cover. But, neither of these products will describe forest change. Similarly, the IGBP 1-km map, now close to completion, will not describe forest change. There are now no estimates of the forest or land cover and changes in the forest or land cover of Russia based on high-resolution satellite data. A necessary next step is to provide these rates from a time series of high-resolution (e.g. Landsat) satellite imagery. These would allow an unbiased estimate of the location, area, and rates of change of these forests over that 20 to 30 year period.

The scale of the forests of Russia is such that changes there are of global consequence. Maintaining and improving the capacity for appraising the status, and changes in the status of these forests seems an essential component of any effort at protecting the normal functioning of the biosphere.

Research Results

"*The general purpose of this research is an appraisal based on satellite imagery of the area (and standing stock of carbon) of forests of the former Soviet Union (FSU). The purpose extends to measurements of changes in the standing stock and the development of a potential for monitoring those forests. There is still considerable uncertainty and discrepancy among estimates of forest area in Russia, whether the area is expanding or contracting, and whether carbon is being accumulated in, or lost from, Russian forests. The research carried out with this grant is collecting satellite and ground data and developing methods to be used for a clarification of these uncertainties and discrepancies.*" (WHRC 1995 Annual Report for NAGW-3856)

The three questions have been addressed as follows:

1. What is the area of forest in the former Soviet Union?

We have used a 10-year data set of the GVI (15-km resolution) to create a land-cover map with 60 classes (Figure 1). This work partitions some 21 million km^2 of the FSU. Of this total we have found 2.8% to be mixed coniferous – deciduous forest, 23.8 % to be the main boreal coniferous forest, 17.2 % to be northern or maritime taiga and 6.1% to be non-boreal conifers. The total forest area was about 10.6 million km^2 but of this 3.7 million km^2 is very low productivity and sparse montane, and very high latitude forests. This work was presented at the 1996 Ecological Society of America (ESA) annual meeting and at the 1997 IBFRA conference and will be published in the IBFRA symposium's proceedings (Stone et al 1997a).

We are currently generating a 1-km map of Russia with AVHRR LAC data (see below). We are using as guides for labeling (but not for area calculations) the Vegetation Map of the USSR (1990, Figure 2) and Forest Cover Map of the USSR (1990, Figure 3a) that will help provide us with a "point in time" estimate of Russian forest cover that is independent of Russian sources.

2. Has that area of forest changed over the last two decades?

We have digitized Krasnoyarsk Kray from the USSR Forest Atlas (1973) and from the Forest Cover Map of the USSR (1990, Figure 3a, 3b) to appraise the differences as one approach to answering the question. The 1990 map provides little additional information over the earlier map despite the fact that the 1990 map is more recent and is of higher resolution (larger scale). This experience appears to confirm comments by Anatoly Shwidenko (pers. comm. 1997) that the 1990 map is not a new map but rather a hasty revision of the 1973 map.

How much the forests of the FSU have changed over the last two decades has only been determined to date from Russian source materials. It is clear that forest harvest rates in Russia have declined over the last 5 or 6 years from 350 to 450 million m^3 in 1989 to 100 to 150 million m^3 in 1996 (Shwidenko and Nilsson, 1997). Shwidenko and Nilsson (1997) show an increase in the forested area of Russia from 1960 to 1986 and then a more recent decline. More puzzling however, is an apparent decline in growing stock (Figure 4) that began in Asian Russia about 1983 and is now large enough to offset the increase in growing stock in European Russia (Shwidenko and Nilsson 1997).

The only alternative to using Russian source materials to answer the forest change questions would be a very large sampling of forested Russia based on high resolution remote sensing data.

3. What is the total carbon content of these forests and its distribution spatially?

We have used the satellite-derived and other maps of land and forest cover, supplemented by mean monthly precipitation and temperature data and estimates of forest C stocks from Alexeyev and Birdsey (1994), to map the distribution of forest stand carbon (see below and Figure 5). From this, it is clear that C density in forests is highest in south central Siberia, in pockets in European Russia and in the southern part of the Russian Far East. The mapped C represents 96% of the total of 26.1 Pg forest tree stand C described by Alexeyev and Birdsey (1994) and Alexeyev et al. (1995). We now have data on forest cover and composition data at the level of forest management units (approximately county-scale), carbon and other characteristics at the administrative district (state or territory scale) level, and biomass estimates of 2,000 sites via N.I. Bazilevich. This work was also presented at the 1997 IBFRA conference and will be published in the IBFRA symposium's proceedings.

Year 3 Accomplishments

A. Creating a 1 km Resolution Forest Map of the FSU

We have compiled the best AVHRR LAC image resources available of Russia and the FSU to make a land cover map of the FSU. For this effort, we have identified, acquired, and concatenated about 110 satellite images from 1990 to 1994 to develop a 1-km surface for subsequent classification. Imagery data include 25 dates from 1990, 23 from 1991, 27 from 1992, 31 from 1993 and 4 from 1994. All data have been projected to a Lambert azimuthal equal area and have been radiometrically corrected. All data have been clustered and signature files have been created. We estimate that we have summer (mid-growing season), cloud free coverage for 95% of the region of the FSU. We will label the clusters based on a decision tree and two newly digitized maps of Russia (The 1990 Soviet Vegetation and Potential Agriculture Map, Inst. of Geography, 1990 and The 1990 Forest cover map of USSR, GUGK, 1990) as guides (Figs. 2 and 3a).

Earlier, we tried retrieving 1-km data sets via the Internet from the USGS/EROS Data Center but retrieval was not feasible despite months of effort. We were also unsuccessful in acquiring the data directly from the DAAC via mail. We have made several suggestions for improvement in the operations of the DAAC regarding 1-km AVHRR data distribution.

We also evaluated the global 1-km NDVI composite images that were collected as a part of the IGBP effort at the EROS Data Center. We downloaded six months of data (April to September 1992) via the Internet. From close inspection of these time series and via principal component analyses we determined that the methods used to collect these data would compromise their utility for land surface classification at 1-km resolution. Specifically, inter-image and inter-orbital seams were visible throughout, making it quite difficult to tell whether a numerical boundary is a processing flaw or a land cover boundary.

B. A 60 class, 15 km Resolution Land Cover Map of the FSU

A 15-km resolution land cover map of the region of the FSU has been created that shows 60 distinct phenological classes for the region of the FSU. This map was built on 10 years of satellite data and is independent of any Russian or Soviet bias. Its purpose is to provide a basis for stratification of Russia suitable for high-resolution sampling.

This map was presented at the annual ESA meeting in Providence, RI. (Stone et al. 1996). In addition, this map and associated paper (Stone et al. 1997a, submitted) were presented at the 1997 IBFRA meetings in Duluth, and have been submitted for the symposium proceedings. See Figure 1.

C. Digitizing the 1973, 1:2M scale Forest Cover Map of Krasnoyarsk Kray

We have digitized the 1973, 1:2M scale Forest Cover Map of Krasnoyarsk Kray from the Forest Atlas for a comparison with the same region of the 1990 Forest Map (1:2.5M) of the USSR. A comparison in the southern part of the Kray (approx. 215,000 km^2 or 10% of the total area of the Kray) showed increases in the categories of Non-Forest, Birch, Fir, Scots Pine and Aspen [Table 1]. The comparison also showed decreases in Undefined Forest (literally, forests without species indicated), Burned Forest, Cut Forest, Outcrops/Stones and Sparse Arctic Birch. Although these changes were particularly evident near agricultural areas, it is unclear whether these differences are real or are simply re-classifications. It is clear, however, that large amounts of Undefined Forest in the older map were called Non-Forest in the 1990 map, and that increases in Birch, Scots Pine, and Aspen were in areas formerly called Non-Forest [Table 1]. This effort is made more difficult by map distortions and projections, lack of good control points, lack of map pedigree, and differences in map scale.

Table 1. A comparison of the disagreements between the 1973 and 1990 maps of a subset of Krasnoyarsk Kray. The three categories on the right show the composition of the single landcover category on the left from the other date. For example, the 6.7% increase in the area defined as Non-Forest in the 1990 map were from areas defined in the 1973 map as either Undefined Forest, Birch, or Fir.

1990 Cover Type	'73 to '90 Largest Increases	Land cover in 1973 Map (in order of importance)		
Non-Forest	+ 6.7 %	Undefined Forest	Birch	Fir
Birch	+ 3.7 %	Non-Forest	Other Wooded Lands	Fir
Fir	+ 3.2 %	Sib. Pine	Birch	Aspen
Scots Pine	+ 1.2 %	Non-Forest	Other Wooded Lands	----
Aspen	+ 0.7 %	Non-forest	Other Wooded Lands	Fir
1973 Cover Type	**'73 to 90 largest decreases**	**Land cover in 1990 Map (in order of importance)**		
Sparse Arctic Birch	- 0.5 %	Non-Forest	Birch	Fir
Outcrops & Stones	- 1.5 %	Sib. Pine	Non-forest	--
Cut or Cleared Forest	- 1.5 %	Fir	Scots Pine	Larch
Burned Forest	- 2.6 %	Non-Forest	Birch	Larch
Undefined Forest	- 10.2 %	Non-Forest	Birch	Fir

D. Mapping Forest Stand Carbon

To learn more about the geographic distribution of carbon across the landscape of the FSU, we have constructed an area-weighted map of aboveground forest stand carbon (Figure 5). We used data from Dr. Vladislav Alexeyev (Alexeyev and Birdsey 1994) and a forest map of the Soviet Union digitized from the 1973 Forest Atlas. The 1973 map (1:15,000,000 scale) is comprised of 22 different cover types: Pine, Spruce, Fir, Spruce/Fir, Larch, Siberian Pine, Juniper, Creeping Cedar, Oak, Beech/Hornbeam, Stone Birch, Sand/Haloxylon, Birch, Aspen, Nonforest, Water, Tilia, other woody and sparse categories. It was digitized here as a part of this research.

The carbon values for forests (millions of tons, MT, of C), taken with the assistance of Dr. V. Alexeyev from Table C-1 of Alexeyev and Birdsey (1994), are the sums of total growing stock of various forest age classes (young, middle-aged, maturing, mature and over-mature). These values were listed by administrative or political district and by forest type.

Forested polygons from the digitized 1973 forest map were assigned carbon values according to the percentage of their area in different tree species. Carbon was assigned to each of the 71 administrative districts of Russia:

Area-weighted Carbon = (Area of forest polygon / Area of forest species) x Tot. MT C per species

Estimating carbon in this manner has certain weaknesses. For instance, we found some disagreement in 68 of 71 administrative districts between the forest tree species described in the 1973 map and those listed by Alexeyev. These disagreements accounted for 4.18% of a published total of 26.1 x 10^9 T C of carbon in tree stands and shrubs. Likely causes for the disagreement are the different scales between the forest map we digitized (1:15M) and administrative district boundary file data (1:8M), the (unknown) scale of the original data used to create the published values of carbon, and the differences between the map classifications that were used. In all, these differences accounted for less than 1 % of the total carbon mapped.

The newly calculated map is the only map of forest stand carbon for the Russian territory of which we are aware. To improve our map, we require a reliable administrative boundary layer map. This work could be repeated relatively easily with the 1990 Forest Map of the USSR at 1:2.5 million scale. Also, this work could be repeated relatively easily with future maps (e.g. the IGBP 1 km mapping effort) of the forests of Russia. To do this, we could use all of the same administrative datasets and instructional macros used in the current effort.

Data for forest types, stand volume, and increment exists for all Russia at the local forest administrative unit (*leshoz*) level (county-scale). Given that there are more than 2,500 of these units across Russia, the map could be further refined if the boundary files for these management units were available. Using these units in a similar manner would result in a 30-fold increase in resolution for forest stand carbon mapping. However, this would be a significant effort because of the large number of forestry management units across Russia.

We are planning to merge this map with digital soil carbon maps of Russia available through two Russian collaborators. This work will be beyond the goals of this grant. We expect to complete this within the next six months.

The forest stand carbon map (Figure 5) was presented as a poster for the 1997 IBFRA meeting, has been submitted to the Symposium proceedings and is attached to this report (Stone et al. 1997b, submitted). A reduced version of the map can be seen at our WWW site (http://www.whrc.org/gislab/gislab.htm).

E. New Maps of the FSU

In collaboration with NASA Graduate Fellow Dmitry Valyguin we have acquired a 1:4,000,000 scale map of the agricultural regions of the FSU (Rakitnikov and Yanvariova 1989) and a 1:4,000,000 scale map of the Land Cover and Land Use of the FSU (Yanvariova et al. 1991). With our support, Valyguin has translated the legends into English. These are now in digital format.

F. Related meetings attended

NASA STAC review, Moscow, September 1995
NASA-Russia Environ. Working Group, Alexandria, June 1996

Ecological Soc. of America, Annual meeting, August 1996
NASA-Russia Environ. Working Group, Washington, December 1996
NASA-Russia Environ. Working Group, Washington, April 1997
IBFRA, Duluth, Minn., August 1997.
NASA-Russia Environ. Working Group, Moscow, August 1997

G. Visits by Russian Ecologists to WHRC (see Appendix B)

Vladislav Alexeyev, Sukachev Inst., Krasnoyarsk, February, 1996, January 1997, September 1997
Alexander Bondarev, Sukachev Inst., Dec. to March 1996,
Alexander Lioubimov, St. Petersburg Forest Tech. Acad., March to June 1996
Andrei Laletin, Sukachev Inst., Nov. 1996
Boris Romanyuk, Research Inst. for Forest Mgmt., St. Petersburg, Jan. 1997
Kira Kobuk of the State Hydrological Inst., St. Petersburg, May 1996
Marina Botch of the Komarov Botanical Inst., St. Petersburg, May 1996
Dmitry Varlyguin, NASA Graduate Fellow, Clark Univ., several visits
Michael Tarasov, Research Inst. for Forest Mgmt., St. Petersburg, Sept. to Dec. 1997

Although support for most of these visitors came from private foundations, they bring, nonetheless, great strength to the effort for NASA by the WHRC.

H. Papers submitted, published, or in preparation

Stone, T. A., and P. Schlesinger, 1994. Building a Spatially Referenced Database of Landcover for the Region of the Former Soviet Union. Pecora 12 Symposium Proceedings, Land Information from Space-Based Systems. Sioux Falls, August 1993. pp. 555-558.

Stone, T. A. and P. Schlesinger, 1994 [abs.]. A Comparison of Satellite-Based and Russian Map-Based Estimates of the Forest Cover of Krasnoyarsk Territory, Siberia. Boreal Forest and Global Change Conference Papers Advance Abstracts, International Boreal Forest Research Assoc., Saskatoon. Sept. 25-28, 1994. p. 83.

Stone T. A. and V. A. Alexeyev, 1995. Joint US Russian Environmental / Ecological Seminar, Washington, DC, May 15-19, 1995. Invited Poster Presentation "Collaborative Mapping Of the Forest Cover of Russia Using Satellite Data".

Stone, T. A., R. A. Houghton and P. Schlesinger, 1996. [abs.]. Developing a 15 km resolution land cover map of the region of the Former Soviet Union based on low resolution NOAA AVHRR time series data. ESA Annual Meeting 1996, Providence, Supplement to the Bulletin of the ESA 77(3):426.

Bondarev, A. 1997. Age Distribution Patterns in Open Boreal Dahurican Larch Forests of Central Siberia Forest Ecology and Management 93(3):205-214

Woodwell, G. and R. A. Houghton, 1997. The Mystery of the Great Northern Forest. Proceedings of the 7th Annual Conference of the IBFRA, Sustainable Development of Boreal Forests, August 1996, St. Petersburg, Federal Forest Service of Russia, Moscow, pp.37-44.

Houghton, R.A. in press. Historic role of forests in the global carbon cycle. G.H. Kohlmaier, M. Weber, and R.A. Houghton (eds.). Carbon Mitigation Potentials of Forestry and Wood Industry. Springer-Verlag.

Stone, T. A., R. A. Houghton and P. Schlesinger, submitted 1997a. A Digital Land Cover Map of the Former Soviet Union Based Upon a Time Series of 15 km Resolution NOAA AVHRR Data. International Boreal Forest Research Association 1997, Duluth, Symposium Proceedings.

Stone, T.A, P. Schlesinger, and V. A. Alexeyev, submitted 1997b. A Spatially Explicit Map of Forest Stand Carbon for Russia: A First Approximation. International Boreal Forest Research Association, 1997, Duluth, Symposium Proceedings.

Lioubimov, A., R. Paivinen and T. Stone, in prep. Forest resources and forest inventory of the St. Petersburg (Leningrad) region of Russia.

I. Related WHRC Staff activities

In June 1996, as a follow-up to the May 1995 Chantilly meeting described earlier, T. A. Stone attended a NASA/NOAA/DOD Russian American Environmental Working Group, Forestry Subgroup meeting in Washington, DC. Mr. Stone has been asked to consult with this group and to provide data from our joint research with our Russian colleagues. Several forest test sites have been chosen by this group in the US (Alaska) and Russia.

In August 1996, Stone attended the Ecological Society of America Annual Meeting, Providence, where he presented a paper based, in part, on the work with Russian colleagues who have come to the Woods Hole Research Center.

In late April 1997, Stone traveled to Washington to participate in meetings for the Gore Chernomyrdin Forestry EWG.

In August 1997, Stone attended the 1997 IBFRA meeting in Duluth, Minnesota. He made an oral presentation and presented a poster on different topics. Bot papers have been submitted for the proceedings.

In August and September 1997, Stone traveled to Moscow to participate in the Forestry Subgroup of the Environmental Working Group of the Gore Chernomyrdin Commission. This trip included a visit to the Yevgoryevsk forest about 2 hours from Moscow. It appears that the Gore Chernomyrdin Commission will increase it support into research on the current and historic carbon balance of the region of the former Soviet Union. Data on all sites will be shared and reports on the results on the collaboration to date will be reported at the Gore Chernomyrdin Commission Meeting in Washington in March 1997.

In September 1997, Drs. George Woodwell and Ramakrishna Kilaparti attended a meeting of the World Commission on Forest and Sustainable Development in St. Petersburg, Russia which included a public hearing on the future of the Russian forests and other forests in the boreal zone.

J. References

Alexeyev, V. and R. Birdsey, 1994 (eds.). Carbon In: Ecosystems of Forests and Peatlands of Russia, Sukachev Inst. for Forest Research and USDA Forest Service, Krasnoyarsk, 224 pp., in Russian.

Inst. of Geography, 1990. Vegetation and Potential Agriculture of USSR (1:4,000,000), in Russian.

GUGK, 1990. Forest Cover of USSR Russia. (1:2,500,000 scale), in Russian.

Rakitnikov, A. N., and Yanvariova, L. F. 1989. Agricultural Regionalization Map (Scale: 1:4,000,000). Moscow State University, Moscow, USSR. Moscow: GUGK (General Management of Geodesy and Cartography), in Russian.

Rozhkov, V., V. Wagner, B. Kogut, D. Konyushkov, S. Nilsson, V. Sheremet, and A. Shwidenko, 1996. Soil Carbon Estimates and Soil Carbon Map for Russia. IIASA WP 96-60.

Shwidenko, A. 1997. Personal communication.

Shvidenko, A, and S. Nilsson, 1996. Expanding Forests but Declining Mature Coniferous Forests in Russia. IIASA WP 96-59.

Shwidenko, A. and S. Nilsson, 1997, The Russian Forest Sector, A Position Paper for the World Commission on Forest and Sustainable Development. St. Petersburg, Russia, Sept. 1997.

Yanvariova, L.F., Martynuk, K.N., and Kiseleva, N.M. 1991. Land Use / Land Cover Map (Scale: 1:4,000,000). Cartography Lab, Geography Department, Moscow State University. Moscow: GUGK (General Management of Geodesy and Cartography), in Russian.

Appendix A.

Maps digitized

The 1990 Soviet Vegetation and Potential Agriculture Map at 1:4,000,000 scale. The original version of this map (Inst. of Geography, 1990) had 374 classes of vegetation. This digital map has been provided to the EWG Forestry Subgroup of the Gore Chernomyrdin Commission and is available via FTP at our web site at http://www.whrc.org/gislab/gislab.htm.

A 1:15,000,000 scale forest cover map of FSU from 1973 Russian Forest Atlas (Soviet Min. of Geodesy and Cartography, 1973).

A 1:2,000,000 scale forest cover map of Krasnoyarsk Kray from the 1973 Russian Forest Atlas (in progress).

A 1:2,500,000 scale forest cover map of Russia. (GUGK, 1990) Sections covering central Siberia and the Russian Far East have been digitized including the territories of Krasnoyarsk, Chita, Amur, Khabarovsk, Primorski, Sakhalin Island, Irkutsk, Buryat and portions of Yakutia. The rest of the map was digitized through the auspices of the World Conservation Monitoring Center. We have provided the digital map to the EWG Forestry Subgroup of the Gore Chernomyrdin Commission who has provided to the IFI in Moscow.

The S. F. Kurnayev Vegetation Zones Map. This map is provided as a subset to the 1990 Forest cover map. It is a reprint of the 1973 effort by S. F. Kurnayev that attempted a comprehensive forest vegetation classification based on floristics. Scale: 1:10,000,000.

A Geobotanical Map of the Komarov Botanical Institute, 1954. Scale: 1:4,000,000. 252 classes in total. Krasnoyarsk portion digitized. Originally in Conic Projection, but re-projected to a Latitude / Longitude projection.

Other maps generated with satellite imagery

Krasnoyarsk Territory
Primorski Kray and Southern Khabarovsk Kray (with World Wildlife Fund support)

Other data

System of Landscapes for the USSR: Zones, Sectors and Altitude Divisions, 1:4,000,000. 1988. Chief Admin. of Surveying and Cartography for the Soviet Ministries, USSR, 1988. Origin: Digitized by A. L. Halpin, Univ. of Virginia.

Matthews Vegetation Map (32 classes), Origin: NOAA/EPA Global Ecosystems Database CDROM. Projection: Geographic Latitude/Longitude. Resolution: 1 degree

Olson World Ecosystems (30 classes), Origin: NOAA/EPA Global Ecosystems Database CDROM. Projection: Geographic Latitude/Longitude. Resolution: 1 degree

Henderson-Sellers Vegetation (81 classes), Origin: NOAA/EPA Global Ecosystems Database CDROM. Projection: Geographic Latitude/Longitude. Resolution: 1 degree

Holdridge Standard (40 classes), Origin: NOAA/EPA Global Ecosystems Database CDROM. Projection: Geographic Latitude/Longitude. Resolution: 1/2 degree

Holdridge Combined (15 classes), Origin: NOAA/EPA Global Ecosystems Database CDROM. Projection: Geographic Latitude/Longitude. Resolution: 1/2 degree

Appendix B. Visiting Russian Forest Scholars supported by the MacArthur Foundation

Dr. Vladislav Alexeyev

Dr. Alexeyev also worked in our Remote Sensing and Geographic Information Systems (RS/GIS) lab extensively while here to help convert his data on Russian forest area, forest stature, and forest growth rates into a spatially explicit form suitable for use in a GIS. In September 1995, Dr. Alexeyev returned here to continue his research with us.

In February 1996, Dr. Alexeyev traveled with T. A. Stone to the University of New Hampshire to write a joint proposal with a UNH forest ecologist and colleagues at the U.S. Forest Service office in Durham that was submitted to NSF. The proposal was to examine with satellite data and field work an extensive area of forest decline that is likely due to air pollution in the Kemerovo region of central Siberia. During June and July 1996, Dr. Alexeyev did preliminary fieldwork in the Kemerovo to evaluate the causes and extent of the decline in Siberian Fir forests.

Dr. Alexeyev also visited here in January, and September 1997.

Dr. Alexander Bondarev

In November 1995, Dr. Alexander Bondarev arrived in Woods Hole. Dr. Bondarev is an expert on the northern-most forests in the world in the Taimyr Peninsula. These forests, at 72° N latitude, may be unusually susceptible to the earliest effects of climate change. The majority of his efforts while here, November to February 1996, was to write up his research results and to plan more field work to the Taimyr and to write proposals for continued support. His efforts resulted in a paper "Age Distribution Patterns In Open Boreal Dahurican Larch Forests Of Central Siberia" published recently in Forest Ecology and Management. To assist Dr. Bondarev with his ongoing research, we purchased GIS software and several dates of Landsat MSS satellite data of his research region. Dr. Bondarev returned from his last fieldwork in the Taimyr at the end of August 1996. Also while here, Dr. Bondarev traveled to University of Toronto to discuss future collaboration with the forestry faculty.

Dr. Alexander Lioubimov

In April 1996, Dr. Alexander Lioubimov of St. Petersburg Forest Technical Academy arrived in Woods Hole. Most of his work was to evaluate the forest inventory system of the Russian Federation as the basis for spatial accuracy assessment of forest resources. Dr. Lioubimov arrived with an extensive collection of forest maps, many of which he digitized in our laboratory. We purchased for him, with foundation support, two LANDSAT TM images of the St. Petersburg region and GIS software.

Also while here Dr. Lioubimov traveled to Ft. Collins, Colorado where he presented a paper jointly authored with T. A. Stone, entitled "A Forest Inventory System of the Russian Federation as the Basis for Spatial Accuracy Assessments of Forest Resources" at the 2nd International Symposium on Spatial Accuracy in Natural Resources and Environmental Sciences. Later, he visited forest researchers at Michigan Technical University where. he discussed joint programs of research that will likely involve graduate students from Russia traveling to Michigan and graduate students from Michigan going to Russia.

Dr. Lioubimov is using the satellite data as a tool to update forest resource maps as well as teaching graduate students in St. Petersburg about GIS and map digitization. Much of this work is part of an on-going collaboration with the European Forestry Institute (EFI) in Joensuu, Finland

Dr. Boris Romanyuk

Dr. Boris Romanyuk, a Sr. Researcher at the Research Institute for Forestry Management in St. Petersburg, came for an extended stay here during early 1997. Dr. Romanyuk continued his research here on landscape approaches to forest management, planning, and protection. In August 1997, Dr. Romanyuk presented his work at the IBFRA symposium in Duluth, MN.

Mr. Michael Tarasov

Mr. Tarasov arrived here from St. Petersburg on Sept 12th. 1997 and will stay until December. Mr. Tarasov, a student of Dr. Alexeyev, is constructing a field portable system for measuring CO_2 respiration from soils. Researchers at WHRC have made two of these systems for use in New England forests This will allow Mr. Tarasov to continue his research and will significantly improve his and his colleagues ability to measure soil CO_2. In addition, he will continue his research into the decomposition of coarse wood y debris. To date Mr. Tarasov and his colleagues have only been able to use wet chemical techniques and have been limited to bringing soil and wood samples into the laboratory for analysis. Mr. Tarsov will return to Russia and will begin a field program in the spring of 1998 designed to understand below-ground respiration in the St Petersburg region and in the Karelian Isthmus.

Figure Captions

Figure 1. A digital land cover map of the former Soviet Union based upon a ten year time series of NOAA AVHRR GVI data produced here as a part of this work. (See also Stone et al., 1997a).

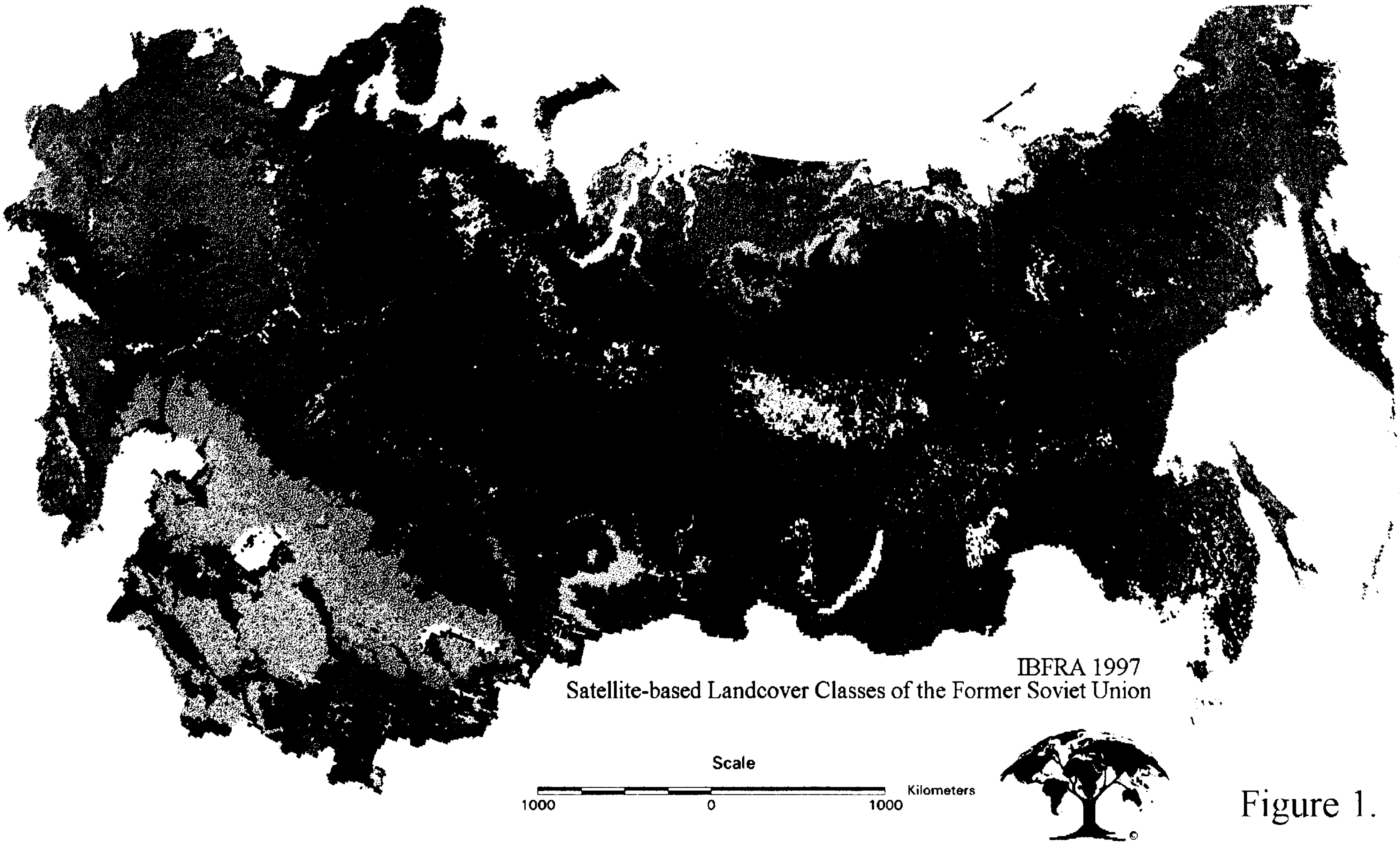
Figure 2. FSU Landcover and potential agricultural vegetation map, originally at 1:4,000,00 scale, digitized here. The digital map and associated database are available at our World Wide Web site at http://www.whrc.org.

Figure 3a. The 1990 Forest Cover Map of the USSR. A digital version of this map was used in this research. The map was digitized here and at the World Conservation Monitoring Center.

Figure 3b. Estimates of the land cover of the FSU based on the digital version of the Forest Cover map of Russia (Garsia 1990).

Figure 4. Estimates of forest area and reconstructed growing stock for Russia from Shwidenko and Nilsson (1997). After a long period of increase, forest area now appears to be in modest decline. Forest growing stock appears to be in decline as well, largely due to loses in Asian Russia.

Figure 5. The distribution of forest stand carbon map, produced here as a part of this work. (See also Stone et al., 1997b, in press).



IBFRA 1997
Satellite-based Landcover Classes of the Former Soviet Union
Scale
1000
0
1000
Kilometers

Figure 1.

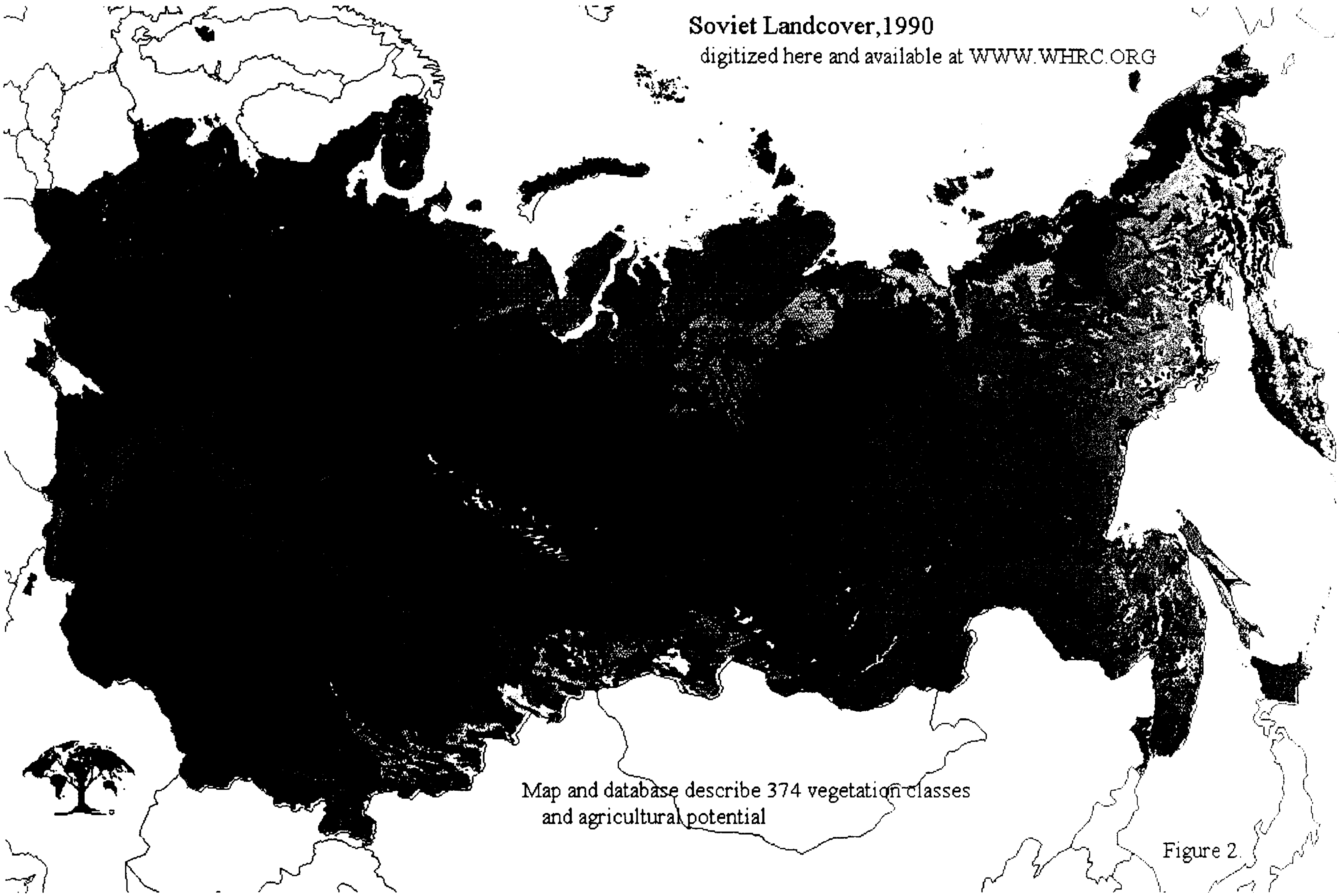

Soviet Landcover,1990
digitized here and available at WWW.WHRC.ORG
Map and database describe 374 vegetation classes
and agricultural potential

Figure 2

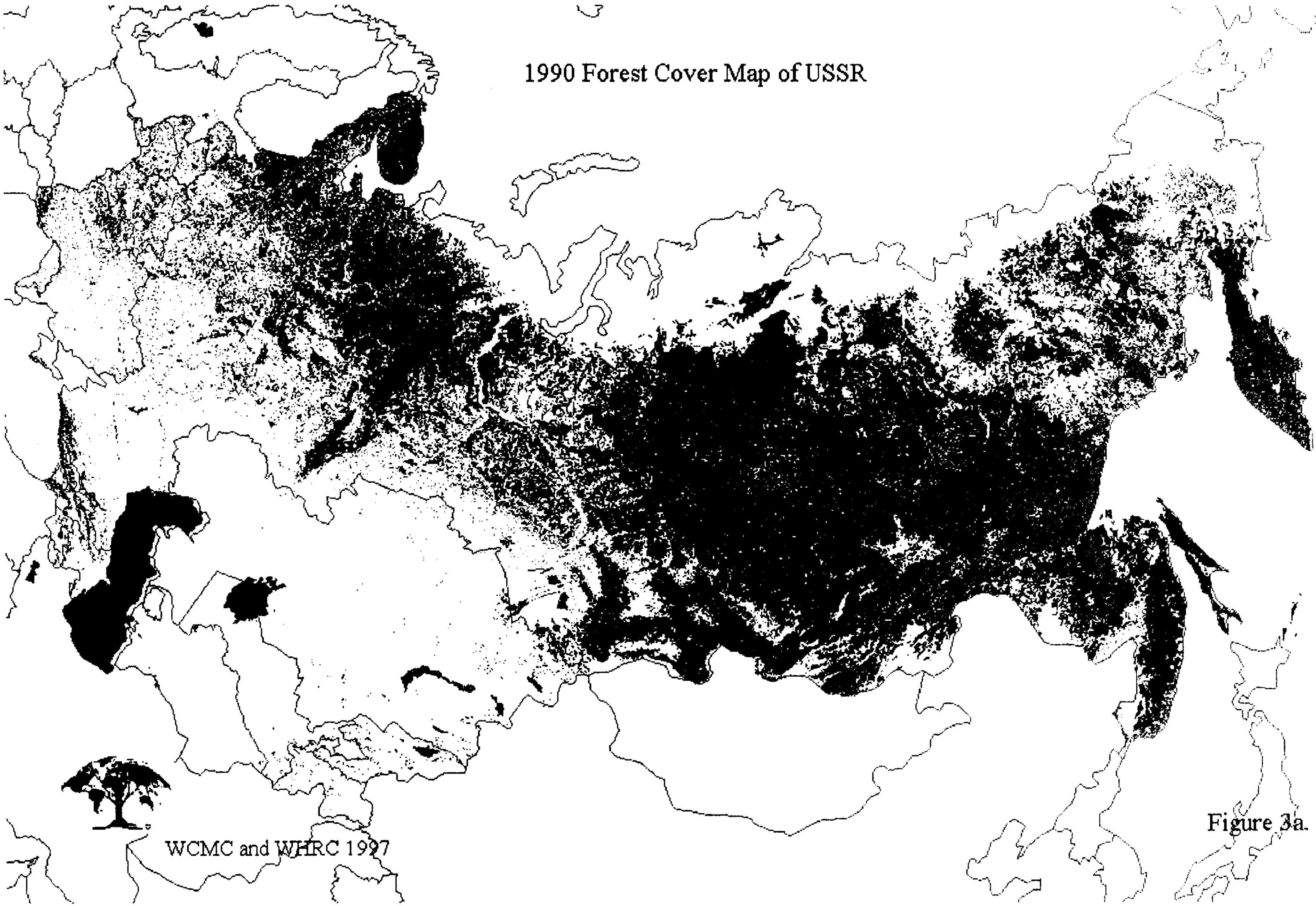
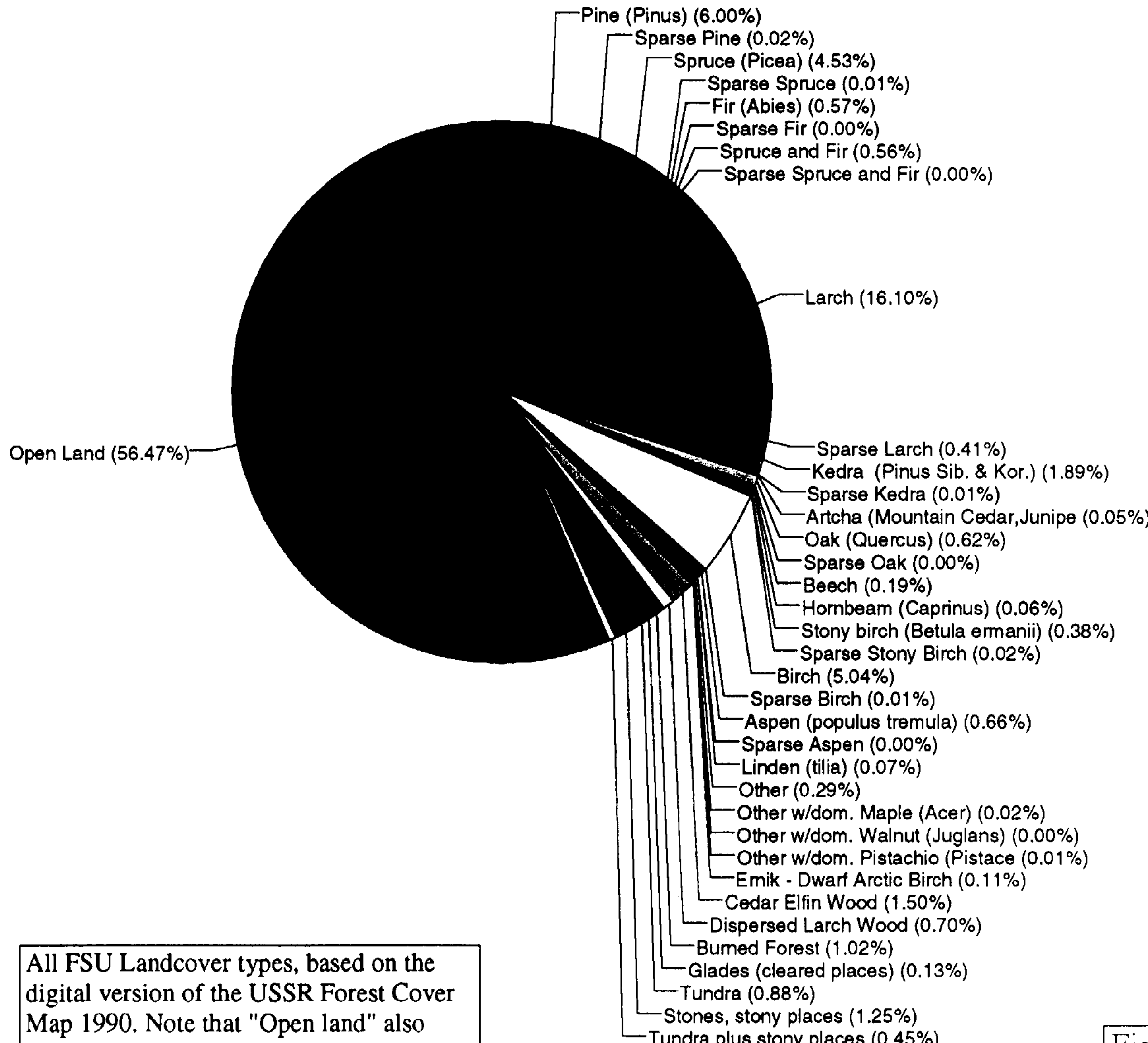


Figure 3a.



All FSU Landcover types, based on the digital version of the USSR Forest Cover Map 1990. Note that "Open land" also includes tundra. WHRC 1997

Figure 3b

Russia's Forested Area & Growing Stock
after Shwidenko and Nilsson 1997

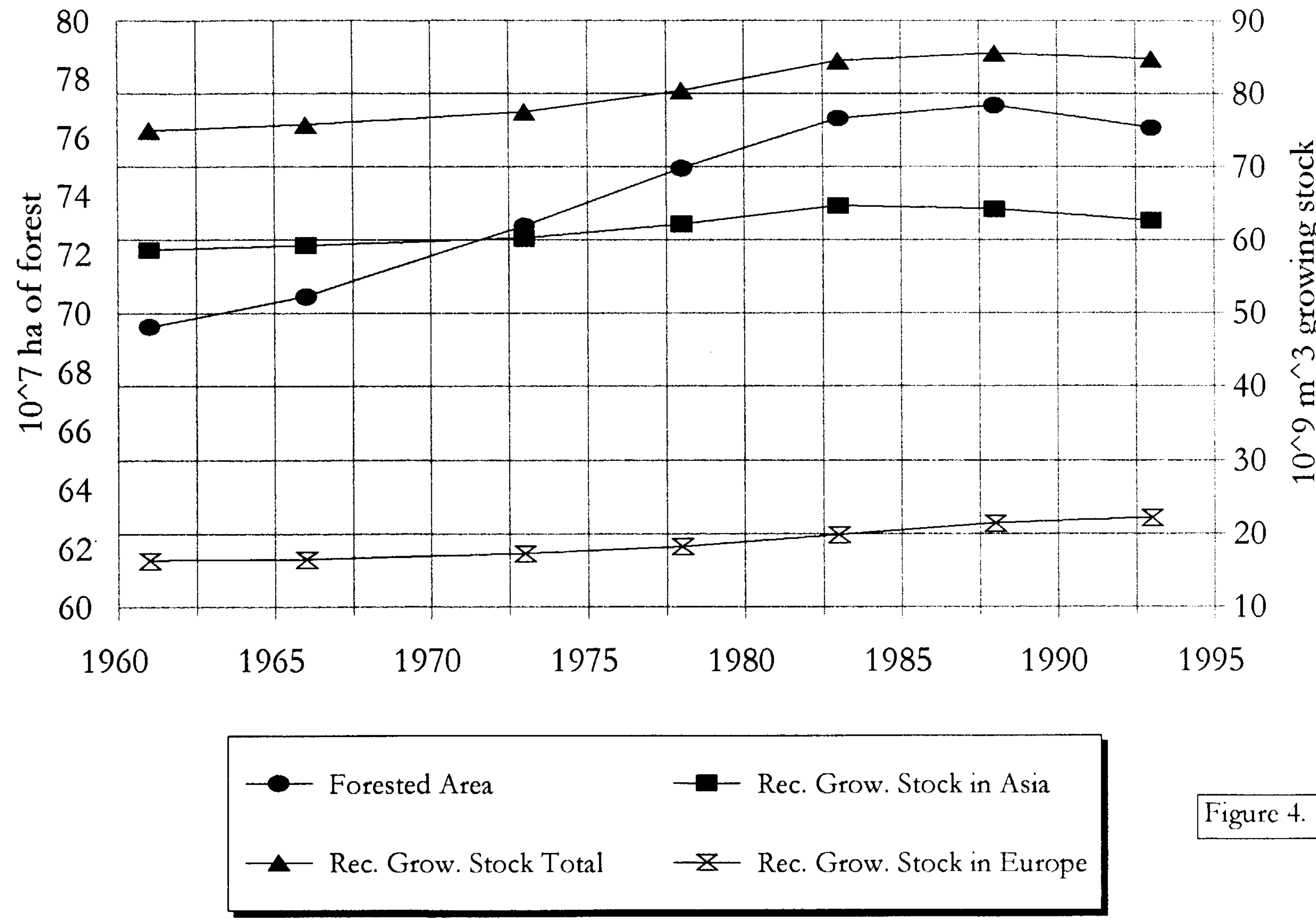


Figure 4.

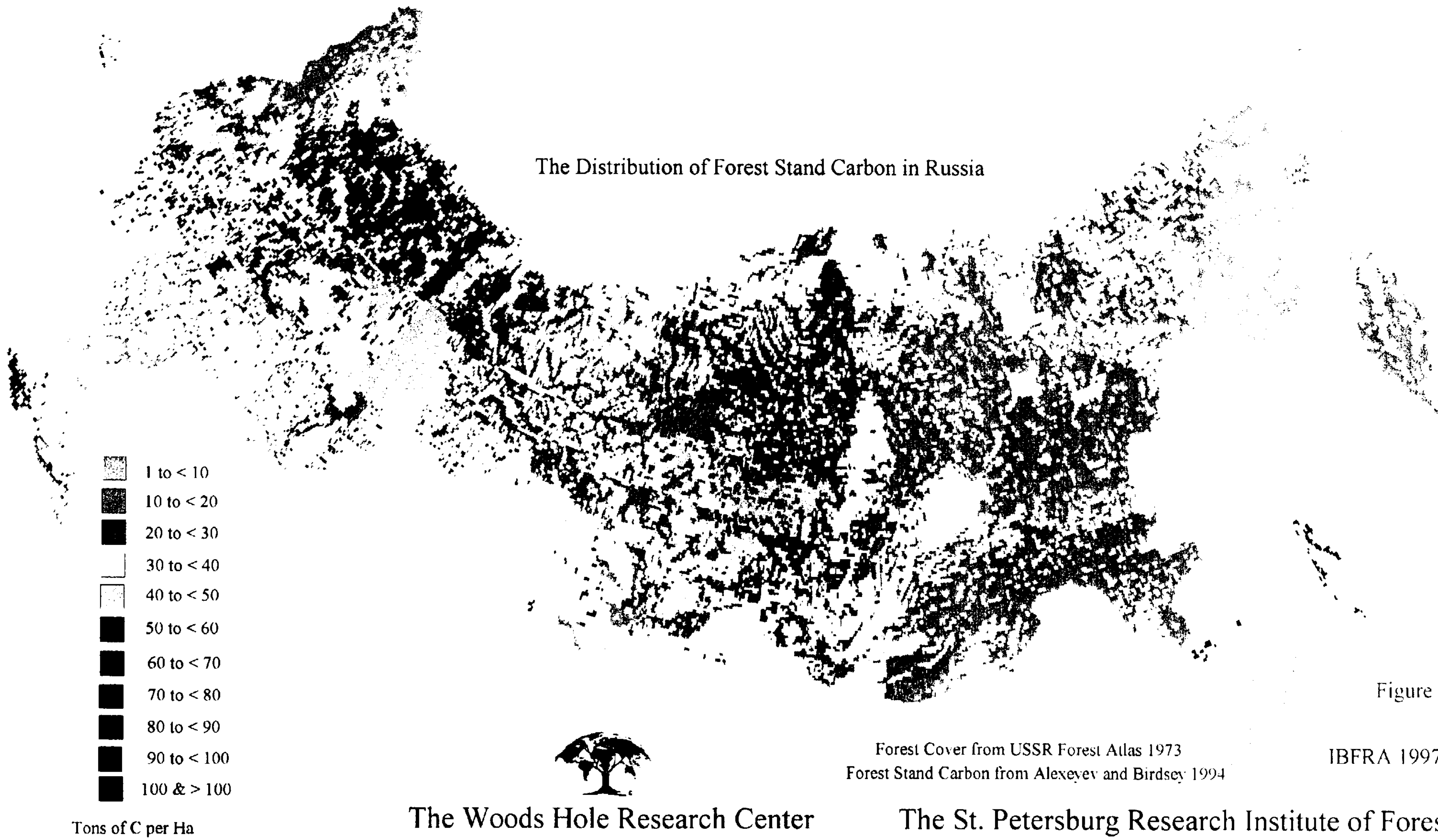


Figure 5.

IBFRA 1997

The Woods Hole Research Center

The St. Petersburg Research Institute of Forests