International Institute for
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options

autumn 2000

IIASA's Forestry Project

Seeing the Forest *and* the Trees

Options Autumn 2000

Contents

Options magazine features the activities of the International Institute for Applied Systems Analysis (IIASA), located in Laxenburg, Austria. IIASA is an interdisciplinary, nongovernmental research institution sponsored by a consortium of National Member Organizations in Asia, Europe, and North America. The Institute's research focuses on sustainability and the human dimensions of global change. IIASA's studies are international and interdisciplinary, providing timely and relevant insights for the scientific community, policymakers, and the public.

Options is prepared by the IIASA Publications Department.

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Printed by ***Rema***print, Vienna

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Cover photo courtesy of
Dr. Vladislav Vorobjev (Tomsk)

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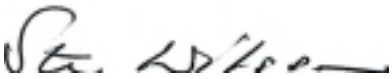
Research by well-respected national and multinational organizations shows that the world's forests have declined in both area and quality. Growing recognition of the economic and ecological importance of forests has prompted increased interest in finding and implementing strategies to ensure sustainable development of this vital resource. However, failures to establish a global forest convention in the early 1990s demonstrated the difficulty of mandating a single approach to the management of "forests," whose elements range from tropical mangroves to the boreal forests of the arctic slopes. In-depth understanding of the complex factors affecting the world's forests, of the divergent interests of stakeholders, and of ecological realities frames the efforts of IIASA's Forestry (FOR) project, whose activities are featured in this issue of *Options*.

Much of FOR's research has so far focused on the forests of Russia, although in all cases this work has wider applications. For example, the perceived dangers to the global forest sector illustrate the importance of IIASA's analysis of the institutional framework of the Russian forest sector, which clearly confirms that sustainable development of Russia's vast forests requires substantial changes in the country's economic and political structures. FOR's work has produced a methodology that other countries and regions of the world can employ to examine structural aspects of their own forest industries.

Implementation of the Kyoto Protocol (whatever its ultimate form) could have major implications for the global forest sector, including greatly expanded incentives to decrease atmospheric carbon through afforestation. Instead of the command-and-control approaches favored in the past, strategies to reduce greenhouse gas emissions must be built on the principle of locally driven activities backed up by market mechanisms, such as the carbon trading provisions proposed in the Protocol. The Forestry project's detailed studies of carbon accounting have produced troubling evidence that raises fundamental questions regarding the potential effectiveness of the Protocol, demonstrating that the current state of knowledge regarding carbon sources and sinks cannot determine the levels and flows of carbon with sufficient accuracy to form the basis for the Protocol and any viable trading scheme.

Improvements in wood utilization resulting from biotechnology and the continually increasing efficiency of mills that transform virgin wood into industrial products have already begun to relieve some pressure on forests. The rapidly expanding use of information technology, with its potential impacts on the demand for different types of forest products, may exert an even more profound impact on the forests. The Forestry project's innovative research in this area can make a significant contribution to future policy setting regarding sustainable development of the forest sector as well as the geographic location and structure of forest enterprises. This work also links to a new project activity: cluster analysis, which concentrates on the probable future consolidation of the European forest industry. FOR's activities concentrate on identifying policy options that will ensure the sustainability of the forests under the new conditions created by a more highly consolidated industry.

As the articles in this issue of *Options* show, the Forestry project exemplifies the integrated assessment approach typical of IIASA's research activities, and indeed carries out many of its initiatives in tandem with other projects. For example, FOR's analyses of carbon fluxes both draw on and contribute to related research by the Environmentally Compatible Energy Strategies and Transboundary Air Pollution projects; the project also conducts some of its remote-sensing activities and studies of forest inventories together with the Land-Use Change project. FOR's studies of the forests contribute vital input to the quest for sustainable development of the world's natural resources, an overriding goal of much of IIASA's research in the 21st century.

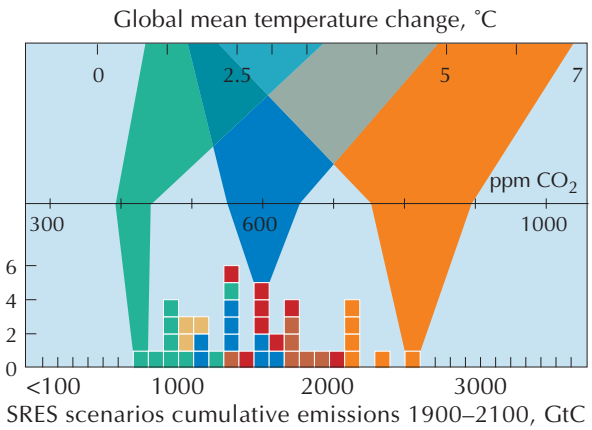


Sten Nilsson
Counselor to the Director
Leader, Forestry Project

The World in 2100: Richer and Warmer?

Over three years of work by an international writing team of some 50 scientists and experts, with lead authorship by members of IIASA's Environmentally Compatible Energy Strategies and Transitions to New Technologies projects, culminated in the acceptance of the Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES) at the IPCC May Plenary Meeting in Montreal. The report, published by Cambridge University Press, covers the full range of demographic, socioeconomic, and technological driving forces for future emissions of greenhouse gases (GHGs) and other radiatively active gases, such as SO_2. This work has placed IIASA scientists at the forefront of climate research, as emission scenarios are essential inputs that drive climate modeling and analyses of impacts and mitigation.

All four sets of SRES scenarios describe futures that are more affluent than today, and many of them assume a narrowing of relative income differences among world regions. Compared with the previous set of IPCC scenarios, developed in 1992, the SRES scenarios cover a wider range of driving forces and emissions consistent with the underlying literature. Many of the SRES scenarios also project somewhat lower emissions (compared with previous scenarios) of SO_2 and GHGs—primarily CO_2 and methane (CH_4)—as a result of new information on lower population growth and on the impacts of technological innovation. Estimates of global CO_2 emissions from energy range from 3.3 to 37 gigatons of carbon (GtC) by 2100; projected emissions from land-use changes range from a sink of 2.5 GtC to a source of about 1.5 GtC by 2100, compared with today's emissions of 6 GtC from energy and about 1 GtC from land use (the latter figure has a high associated uncertainty). The anthropogenic emissions of CH_4 and nitrous oxide projected for 2100 also span a very wide range that reflects high uncertainties concerning their future sources.



Major climate change uncertainties: socioeconomic (cumulative emissions), carbon cycle (resulting ppm CO_2) and climate sensitivity (resulting change in °C).

Some of the energy and many of the land-use emissions paths show trend reversals, where emissions initially increase, then peak, and gradually decline. For most scenarios, global forest area continues to decrease for some decades, primarily because of increasing population and economic growth, but this trend eventually reverses. Global SO_2 emissions peak within the next two to three decades and decrease by 2100, when the SRES estimates that they will range from 11 to 83 megatons of sulfur, compared with 76 megatons today.

As the scenarios show, these developments lead to generally higher levels of radiative forcing compared with the 1992 forecasts. Initial calculations of climate change indicate that in the SRES scenarios global mean surface temperature increases by about 1–5°C by 2100, in contrast to the IPCC Second Assessment Report projections of 1–3.5°C. These higher estimates result primarily from the lower expected SO_2 emissions, which tend to cool the climate, thereby offsetting the warming effect of increased GHG emissions.

The SRES concludes that technology is at least as important a driving force as demographic change and economic development, and that all of the driving forces influence not only CO_2 emissions but also the emissions of other GHGs. The scenarios illustrate that similar future GHG emissions can result from very different socioeconomic developments, and that similar developments in driving forces can nonetheless result in widely different future emissions. Thus, the SRES reveals many continuing uncertainties that climate research and policy analysis must take into account. In particular, the report cautions against the use of single "best guess" or "business as usual" scenarios and instead recommends the use of multiple baselines to reflect uncertainty. It also puts technology policy in the forefront of possible response strategies in a warming world, although the uncertainties imply that traditional cost/benefit and cost minimization approaches are no longer appropriate. Analyses must move toward contingency planning and optimal portfolio analysis under continued high uncertainty—domains in which IIASA has made, and continues to make, path-breaking methodological advances.

For further information on the SRES, or to access the Summary for Policymakers, visit the IPCC Web site at www.ipcc.ch. To purchase the SRES, contact Cambridge University Press at www.cup.org.

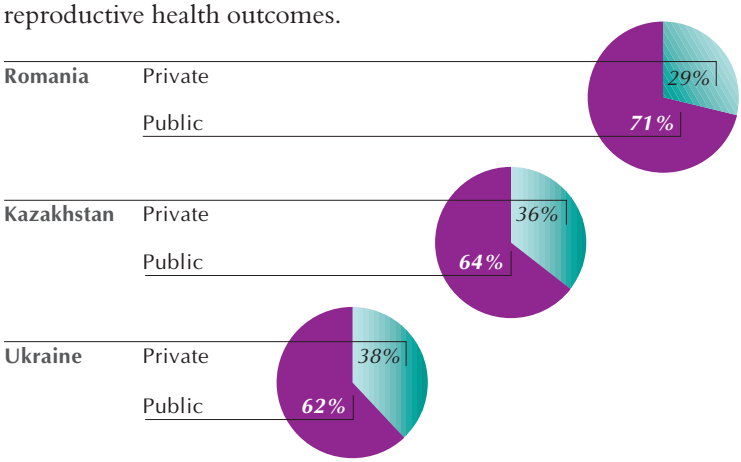
Financing Reproductive Health Care in Three Post-Socialist Countries

Although the 1994 United Nations International Conference on Population and Development called for "universal access to reproductive health care by the year 2015," many countries lack the resources to attain this goal. Even more fundamental, government leaders rarely engage in the straightforward dialogue necessary to define the challenges associated with financing reproductive health services or enter into the alliances needed to develop solutions. A conference on Financing Reproductive Health Care in the Europe and Eurasia Region, organized by IIASA's Social Security Reform project and The Futures Group International (TFGI), and held at IIASA from 24–27 June, was a critical first step in initiating and framing this dialogue. The meeting was financed by the US Agency for International Development under its POLICY Project.

Among the countries represented at the conference were IIASA members Ukraine and Kazakhstan; Romania, also attempting to reform a post-Soviet health system, participated as well. In all three countries, despite dwindling financial resources policymakers have been reluctant to back away from the socialist-era promise of universal state-financed medical care. Prior to the conference, each country formed a study team to estimate the sources and uses of reproductive health funds. The teams were forced to rely primarily on indirect approaches, aggregating published and unpublished data from government sources. IIASA and TFGI provided technical support in these efforts.

The work of the teams revealed that, despite the constitutional guarantee of state-provided medical care, even the current (and largely inadequate) levels of reproductive health care in the three countries are made possible only by substantial private spending (see figure). Women secure much of their reproductive health care through out-of-pocket payments, and for some types of care, particularly family planning, virtually all expenditure is private.

The conference represented the first attempt by any post-socialist country to come to terms with the difficult issues of financing reproductive health, including acknowledging that consumers will have to pay for much of their own reproductive health care. It provided an opportunity for researchers to collect and extend their national data, and to share data, findings, and strategic approaches with their colleagues from other nations. The IIASA–TFGI conference also provided a forum where the government officials (mostly from ministries of health) who propose and implement reproductive health programs could discuss issues and interact with the authorities (mostly from ministries of finance) responsible for making budgetary decisions. The expected results include better decision making concerning reproductive health, more efficient and equitable matching of resources with needs, and, ultimately, improved reproductive health outcomes.



Public–private split in total reproductive health care expenditure.

Second EuroConference on Earthquake Risk

Increasing concentrations of population and capital in exposed areas have dramatically increased losses from natural disasters, raising complex policy issues regarding the best ways to decrease both human losses and economic damages, and to spread the financial burdens following a disaster. To address these issues, IIASA's Risk, Modeling and Society (RMS) project organized a conference on Global Change and Catastrophe Risk Management: Earthquake Risks in Europe, the second of two EuroConferences sponsored by the European Commission within the Training and Mobility of Researchers (TMR) Programme.

The conference, held at IIASA from 6–8 July, attracted 100 participants from 25 countries, primarily experts in the fields of risk management, insurance, and natural disasters. Building on case studies of the recent severe earthquakes in Asia, Eurasia, and North America, speakers presented analyses of topics related to earthquake risk assessment, vulnerability to earthquakes and mitigation of human and economic losses, the

long-term economic and social effects of earthquakes, and financial management, including risk transfer and loss sharing. The program also addressed temporal and geographic dependencies between earthquakes; one speaker noted that a possible link between the Turkish earthquake and a future event in Greece was discussed with civil protection authorities some days before the Athens earthquake, and that this information proved helpful in coordinating the actual response. Many presentations stressed that human and economic losses could be reduced by improving the built environment; one promising strategy would be to link private risk management tools, such as insurance, with public regulations, such as enforcement of existing building codes. The greatest need is to induce more households and businesses to purchase insurance, and thereby decrease the burden on government budgets.

The conference ended with a panel discussion on the potential global consequences of future earthquakes. The panelists concluded that while economic impacts could be very serious at the regional level, they would probably not have a catastrophic effect at the global level. RMS has posted a summary of the conference discussions on its Web page at www.iiasa.ac.at/Research/RMP/july2000/summary.html; full text of selected papers can be viewed at www.iiasa.ac.at/Research/RMP/july2000/papers.html.

A workshop held on 9 July gave students and young researchers an opportunity to present their findings and receive feedback from experienced scientists, industry representatives, and policymakers. Most of the speakers represented the TMR Programme, IIASA's Young Scientists Summer Program, and the young scientists program of Japan's Institute for Disaster Prevention at Kyoto University. The three sessions addressed hazard assessment; risk, vulnerability, and mitigation; and long-term effects, financing, and resource allocation.

IIASA Expands Contacts with Chinese Policymakers

Professor Siwei Cheng, vice chairman of the Standing Committee of the National People's Congress of China and director general of the Department of Management Sciences at China's National Natural Science Foundation, returned to IIASA on 17 July 2000 to discuss IIASA's research and explore possible collaborative activities, and to hold informal discussions with Chinese scholars and participants in IIASA's Young Scientists Summer Program.

Cheng also spoke on "Economic Reform and Development of China" to IIASA staff and representatives of the Chinese diplomatic community. His talk reviewed China's achievements and some major remaining challenges, many of which stem from the country's "dual-layer" economy. The income disparity between the industrialized coastal areas and poorer farming areas in the west underlies China's drive to balance social equality and economic efficiency through the creation of a socialist market economy. Key to achieving this goal are improved agricultural productivity and expanded markets and distribution channels in farming areas. China must also increase the efficiency of state-owned enterprises, institute a pension system with both a national social security program and private retirement accounts, develop its capital markets, and revitalize the country through science, technology, and education. Finally, Cheng noted that isolationist policies in the past had caused China to miss opportunities to benefit from advances in world knowledge; China will not miss the opportunities presented in the 21st century.

Gordon J. MacDonald with Professor Siwei Cheng during Cheng's recent visit to IIASA.

Professor Jikun Huang, director of the Center for Chinese Agricultural Policy, Chinese Academy of Agricultural Sciences, accompanied Professor Cheng. He held discussions with researchers in IIASA's Land-Use Change project and spoke on "Trade Liberalization and China's Agriculture in the 21st Century" to IIASA staff and students. His talk analyzed the probable impacts of China's accession to the World Trade Organization on domestic production, prices and markets, and farm incomes, and concluded that China's current trends toward increased imports of grain and increased exports of livestock will continue.

IIASA's Forestry Project: Seeing the Forest and the Trees

The Policy Setting

For most of human history, people have viewed the forests primarily as sources of fuel and other products to be exploited at will for human benefit, as obstacles to human settlements, and as a source of pests, predators, and diseases. Thus, economic incentives or simply human comfort drove the use of forest resources. Only recently have scientists come to recognize the crucial role that forests play in protecting soil and water, providing habitat for indigenous peoples and for 75% of the world's animal and plant species (including some that are potential sources of medicinal drugs), and regulating the chemistry of the atmosphere. At the same time, governments and industry continue to focus on the potential economic benefits to be realized from forest resources. Confronted by the evidence of heedless and wasteful exploitation of forests and their resources, decision makers now acknowledge the need for a much more careful approach to protection and economically wise management of the globe's forest resources.

Although the concept was introduced by the US National Environmental Protection Act of 1969, it was the Brundtland Commission report of 1987 that gave worldwide currency to the term *sustainable development*—which implies both needs and limits. The needs of present and future generations must be met through the full support of human ingenuity, but within the limits of a stable biosphere. In the context of forestry, sustainable development mandates that the human population utilize the material goods and services provided by the forests in a way that does not jeopardize their ecological functions.

Sustainable management of the global forest resource is a highly politicized, controversial, and multidisciplinary issue, involving governments, international organizations, industry, scientists, and private citizens. Moreover, there is widespread consensus that most of the bottlenecks that prevent sustainable forest management occur outside the traditional forest sector. They include disputes over national sovereignty, the lack of overall institutional reforms, incorrect price setting for forest products, misguided approaches to international trade and cooperation, and lack of active partnerships between private and public sectors regarding forest resources. This internationalized environment has resulted in some 30 treaties, agreements, and conventions that affect forest protection and management directly or indirectly. While the political will that led to these instruments is probably a positive sign, the agreements themselves often reflect only the interests of particular stakeholders, many of them contradict each other, and few have been implemented.

Meaningful government policies concerning the forest sector must reach beyond the private interests of individuals and groups to achieve an enlightened interpretation of both the public interest and long-term forest health. IIASA's Forestry (FOR) project supplies precisely the scientific underpinnings and the comprehensive data on which such policies depend.

Science can only support forest protection and management if scientists constantly interact with the government authorities and managers who actually make and implement the relevant decisions. This principle has guided FOR since the early 1970s, when the Ecology and Environment project developed IIASA's first forest application: the now classic spruce budworm study that linked nonlinear population dynamics with policy formulation and real-world forest management in Canada and Russia. Over the years, IIASA's research on forests has dealt with forestry and regional development (late 1970s); a model of global supply, demand, and trade of industrial forest products (early 1980s); assessment of European forest resources and impacts of air pollution (mid-1980s); climate change and vegetation dynamics (late 1980s); and environmental impacts of paper recycling (early 1990s).

The current global forest sector	
Forest land	3.5 billion ha (27% of the world's total land area)
Fast-growing plantations[1]	125 million ha
Productive, closed, non-reserved (PCNR) forests[2]	2.0 billion ha
Forests undisturbed by human actions (area)	40%
Protected world forests (area)	8%
Population living in forest ecosystems	450 million people
World's poorest people depending entirely on forest ecosystems	350 million people
Forest provision of habitats	75% of all species on Earth
Forest carbon stocks (vegetation and soils)	1,000 PgC (40% of all terrestrial carbon)
Loss of forest land (1958–1997)	700 million ha
Losses of tree species due to deforestation	10%
Losses of total global species due to deforestation	5–10%
Sustainable growth and possible supply of wood from PCNR forests	3.3 billion m^3/year
Probable supply of wood available for industrial purposes	2.5 billion m^3/year
Consumption of industrial wood	1.7 billion m^3/year
Global roundwood consumption	0.58 m^3/capita/year
Consumption of fuelwood and charcoal	1.9 billion m^3/year
Extent of fuelwood as the primary energy supply in developing countries	15%
People employed in the industrial forest cluster	50 million/year
Global consumption of paper and paperboard	50 kg/capita/year
Recovery of waste paper	120 million tons/year
Global Ecosystem Services Value of forests[3]	US$1,000 billion/year
World market economy of industrial forest products	US$425 billion/year (2% of total GDP)
Internationally traded industrial forest products	• Import US$140 billion/year • Export US$150 billion/year (3% of all trade)
Non-wood forest products value	US$120–150 billion/year

Note: GDP= gross domestic product; ha = hectares; kg = kilograms; m^3= cubic meters; PCNR = productive, closed, non-reserved; PgC = petagrams of carbon
[1]Plantations with expected lifetimes of 10–20 years.
[2]"Closed" refers to the forest canopy; a closed canopy blocks a view of the forest floor from above.
[3]The Global Ecosystem Services Value is a widely accepted economic assessment of the value of the world's forests. [Adapted from Constanza, R., et al., 1997, The value of the world's ecosystem services and natural capital, Nature, *287:253–260.]*

The Russian Forest Resource

In the 1990s, the Forestry project concentrated much of its research on Russia, whose vast forested areas represent 23% of the world's total forested area, contain 55% of the world's coniferous stock, and stretch over 11 time zones. The Siberian Forest Study, conducted from 1993–1998, was the most extensive international project ever undertaken on Russia's forests; subsequently, the scope of FOR's studies expanded to include all of Russia. With the overall goal of increasing the forest sector's contribution to the welfare of Russian society, the study conducted assessments focused on greenhouse gases, biodiversity, environmental status, and non-wood products and functions that directly restrict wood supply. In addition, quantitative analyses were carried out with respect to infrastructure, industrial development, markets, and socioeconomic impacts of the forest sector. These applied studies led to policy analyses on institutional aspects, sector responses, and priority setting that balanced immediate needs and long-term sustainable development.

Through these and other activities, FOR has built an unparalleled set of information resources to serve

as a platform for new policy implementations in the Russian forest sector and, by extension, in the boreal forest sector worldwide. FOR's land resources databases are the most comprehensive ever assembled—inside or outside of Russia—on Russia's environment, forest resources, and related factors. FOR is the first project to bring together the rich data sets held by individual institutions in Russia and link them in a modern geographic information system (GIS).

FOR has not confined its efforts to Russia: it has also conducted well publicized—and controversial—analyses of the sustainability of forestry practices in Canada and the United States, leading to special commissions in both countries to extend these studies.

Policymaking for Sustainable Development

At the beginning of the 21st century, FOR's multiple activities are converging toward one overriding goal: to contribute to improved international policy setting regarding sustainable development of the world's forests. Within that framework, the project places special emphasis on expanding knowledge about the carbon balance of Russia and other countries, and identifying sustainable mechanisms to ensure that forests can continue to provide goods and services to the human population, animal and plant species, and the global climate. These activities depend upon new means of mapping, with satellite remote sensing providing an especially powerful mechanism. It is also essential to examine the impact of the knowledge society on demand for paper and paper-based products, and to apply modern information technology in sustainable management of the forest sector. To reach its objectives, FOR carries out case studies and analyses of various aspects of the world's forest resources, and extends the results to the policy dimension.

Because Russia's forests represent such a large proportion of the world total, FOR continues to perform research in and about Russia. However, responding to new international initiatives and changing client priorities, the project is currently phasing out efforts that target specific problems in the Russian forest sector, replacing them with activities that use Russia as a case study to analyze issues of more general interest. For example, FOR conducted its in-depth study of the Russian carbon balance (see article, page FOR-4) not simply to expand knowledge about the Russian forest resource, but to illustrate the methodological difficulties in accounting for carbon emissions under the Kyoto Protocol. The studies of the institutional framework of the Russian forest sector illuminate issues that could plague other countries making the transition from a planned economy to a free market system. Policymakers and scholars already disseminate many of FOR's preliminary results in this area and recognize them as the best research in this field to date; both the World Bank and the European Union (EU) have begun efforts in this field.

At the same time, FOR is introducing new activities into its research program (see Figure 1). Current efforts center on three blocks: (1) institutional analysis of the forest sector in Russia (and to some extent that in North America); (2) carbon accounting and the Kyoto Protocol, with case studies of Russia and Austria, and supporting activities in remote sensing and land resources analysis; and (3) information technology and the global forest sector, as well as forest cluster analysis of Central and East European countries. While FOR has almost completed the institutional analysis activities, certain aspects of this work will necessarily continue, as there are strong links between this activity and the research supporting carbon accounting. Given the world policy climate, FOR currently allocates most of its effort and resources to studies related to verification of carbon budgets under the Kyoto Protocol.

FOR's exploration of the interrelationships between information technology and the global forest sector, and the cluster analysis activities (right-hand part of the figure) have just begun, but will probably expand to become the central focus of the project's future activities. Again, these research areas have strong linkages to FOR's other work. For example, advanced information technologies make it more feasible and less costly to process remotely sensed data and create the networked GISs needed for accurate understanding of the forests.

Cluster analysis will focus on the challenges presented by the eastward expansion of the EU in relation to the forest-based and -related industries of Eastern Europe and Russia. Clearly, this issue will become a critical policy area as the EU admits new members; FOR is currently positioning itself to take the lead in such studies.

The following articles illustrate some of FOR's ongoing activities within the framework of the project's overall objectives. Additional information on project activities and publications is available on the FOR Web page at www.iiasa.ac.at/Research/FOR.

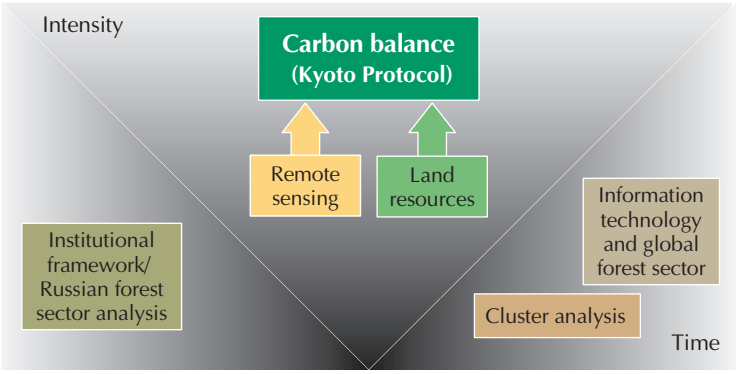


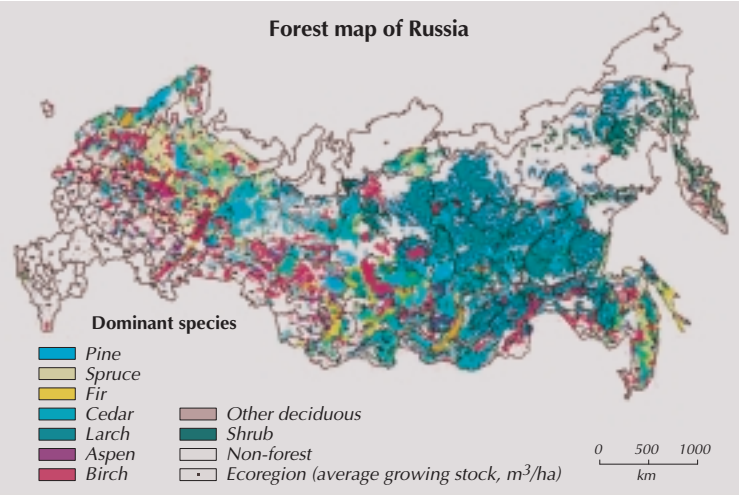
Figure 1. An overview of IIASA's Forestry project research program.

Carbon Accounting and the Kyoto Protocol

Before the industrial revolution, the atmosphere contained some 580 billion tons of carbon (tC) in the form of CO_2. Today the content is about 750 billion tC, with 3.3 billion tC being added each year. The main causes of this higher CO_2 concentration are the burning of fossil fuels and the destruction of vegetation. Many scientists, including those serving on the Intergovernmental Panel on Climate Change (IPCC), believe the increased atmospheric CO_2 concentrations may change the global climate, resulting in higher temperatures; greater frequency and intensity of storms, droughts, and floods; altered monsoons; more frequent pest and disease infestations; and dramatic rises in sea levels as the result of melting arctic ice.

To counteract these potentially devastating effects, the 1997 Kyoto Protocol commits the industrialized countries—so-called Annex 1 nations—to reducing their net emissions of greenhouse gases in 2008–2012 by 225 million tC from the 1990 level of 4,350 million tC. Many environmental interest groups have long claimed that these commitments are ridiculously small. More recently, other stakeholders have argued that the Kyoto targets neither can nor will be met; that they are "too much, too soon."

To make target reductions more feasible and cost-effective, the Kyoto Protocol allows Annex 1 countries to offset their fossil fuel emissions by deducting the presumed savings that would result from creating biological sinks for carbon. The eligible approaches (termed "Kyoto activities") may include planting new forests, reforesting clear-cut areas, cutting down unhealthy forests, and other agreed land-use, land-use change, and forestry activities, as well as so-called joint implementation projects, clean development mechanisms, and international trading schemes. Countries are required to verify the savings that result before trying to balance them against emissions. To make the necessary calculations, the IPCC has recommended partial carbon accounting (PCA), a system that covers only the Kyoto activities. Yet these results cannot depict the actual savings, because activities obviously affect carbon sources and sinks in parts of the biosphere not eligible under the Kyoto Protocol.



Articles 3.3 and 3.4 of the Kyoto Protocol state that a Kyoto activity must take place within a "Kyoto project area" that has strict physical boundaries and is fully under the control of the forest carbon owner. Together, these activities and areas constitute the "Kyoto biosphere." Only the savings within this biosphere may be included in calculations under the Protocol. PCA leaves aside factors such as the leakage effects of Kyoto activities into the non-Kyoto biosphere, destructive activities in the non-Kyoto biosphere, unpredictable fires, and insect infestations and diseases caused by Kyoto activities taking place in the non-Kyoto biosphere.

In fact, any workable emissions trading scheme must be supported by a comprehensive, verifiable accounting system. Based on extensive research over the past three years, FOR has concluded that only full carbon accounting (FCA), covering all carbon-related components of terrestrial ecosystems, can provide the necessary accuracy. FCA consists of a "snapshot" taken at a specific point in time of the amounts of carbon stored in or released from soils, terrestrial biota, agricultural and forest products, animal husbandry, and the energy sector. FCA uses the concepts of pools (reservoirs that can accumulate or release carbon) and fluxes (transfers of carbon from one pool to another) to capture how these components interact. The FCA approach has the additional advantage that it identifies possible biases often ignored under PCA, such as the need to capture changes in CO_2 emissions outside the accounting system of the existing Kyoto Protocol.

To evaluate the usefulness of current carbon accounting and how it might influence implementation of the Kyoto Protocol at the national level—the reporting unit requested—FOR used FCA to conduct an in-depth analysis of Russia's carbon balance. An important feature of the FCA is that it analyzed the functioning of all the ecosystems making up Russia's biosphere as well as the energy and industry emissions. Russia was an ideal case study for several reasons. FOR

already possessed an outstanding network of Russian collaborators and unique databases of its terrestrial ecosystems. Moreover, Russia accounts for some 15% of the global net releases of carbon to the atmosphere. Therefore, a better understanding of the Russian carbon balance is both important in itself and critical to a better understanding of the global carbon balance.

FOR built its carbon account on an integrated system of georeferenced descriptions of Russia's land and environment comprising GIS products and databases on individual components of Russia's environment (Figure 1). The analysis covered all 1,710 million ha of land in Russia and all industrial sectors; IIASA's Environmentally Compatible Energy Strategies project supplied energy sector emissions data. To mimic the Kyoto Protocol, FOR set 1990 as the base year and developed projections for 2010, the midpoint of the Kyoto commitment period.

The findings showed that in 1990 Russia discharged 4,957 million tC to the atmosphere, compared with global human-induced net releases of 7,900 million tC, and that fluxes out of the atmosphere amounted to 4,430 million tC. Thus, if emissions from the energy and industrial sectors and the fluxes from the ecosystems are included in the calculations—the only realistic way to view the carbon balance—Russia was a net emitter of 527 million tC. If only the ecosystems are considered, Russia served as a net sink of 149 million tC.

FOR then created three main scenarios for 2010 around possible economic trends. In all three scenarios, Russia sequesters more carbon than in 1990, a result of higher carbon storage in forests and pastures. However, the high-growth scenario (assuming 7% annual economic expansion) calculated that total emissions to the atmosphere would increase compared with 1990 levels. The low- and medium-growth scenarios (annual growth rates of 2% and 5%, respectively) show lower emissions than in 1990, but discharges still exceed sequestration. Thus, even though the carbon balance will improve by 2010, Russia will continue to be a net emitter of some 156–385 million tC if the total system of energy, industry, and ecosystems is taken into account. If fossil fuel emissions are excluded from the calculations, FOR estimates that Russia's net sink of carbon will increase to about 277 million tC.

Thus, in theory Russia could try to bring an improvement of between 142 million and 372 million tC into a trading scheme permitted by the Kyoto Protocol. But this is only one side of the coin. The other side is the issue of uncertainty. FOR devoted substantial effort to estimating the uncertainties in the carbon account and linking them with the length of time needed to establish the atmospheric effects of carbon emissions. For example, for 1990 FOR found an uncertainty range of ±579 million tC around the average net

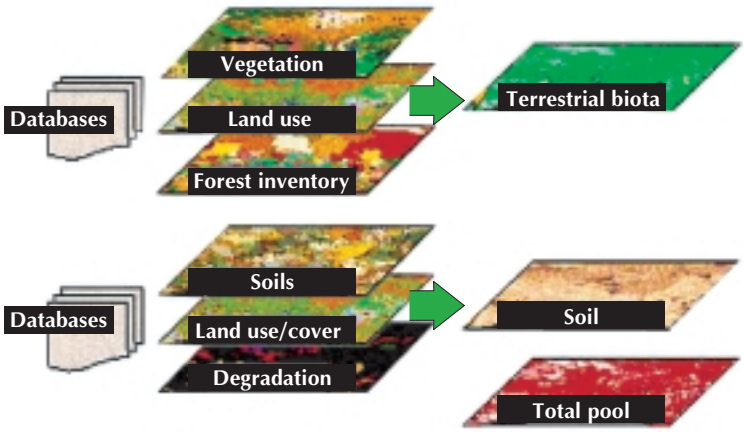


Figure 1. The integrated information system used in analyses of Russian FCA.

emissions—a figure that exceeds the estimated total emissions. This relationship holds over the three development scenarios, and any changes between 1990 and 2010 fall completely within the uncertainty range for the total carbon account (see Figure 2).

To demonstrate the universal relevance of FCA, FOR conducted a related study of Austria and found similar results: large uncertainties underlying its carbon account. The persistent uncertainties confirm that any verification of changes in a country's carbon budget will require time extending far beyond the Kyoto commitment period.

While FOR's research shows that FCA is the best possible approach for tracking national-level changes in carbon budgets, the uncertainties in the carbon accounting remain high. These findings lead to several inescapable policy conclusions:

- Currently, Annex 1 countries cannot verify that they have achieved the targets to which they committed themselves under the Protocol.

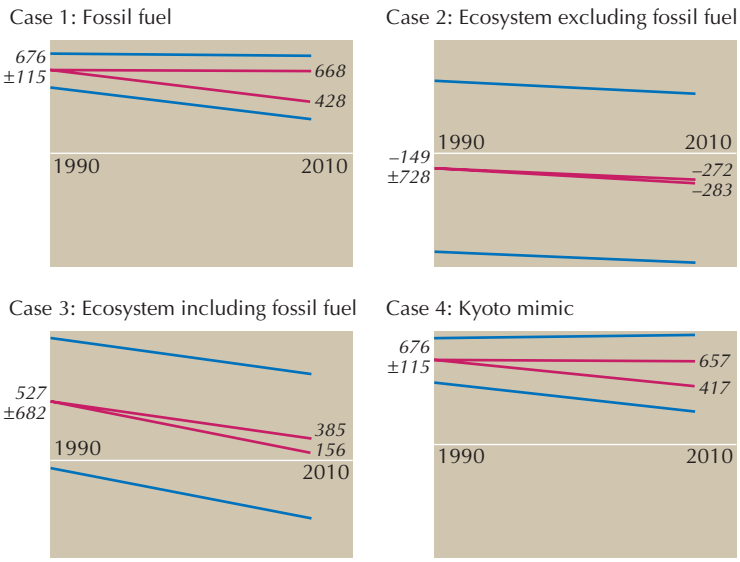


Figure 2. Changes in total flux balances (red) and uncertainty ranges (blue) from 1990 to midpoint of Kyoto Protocol commitment period (2010), in teragrams of carbon.

- Given the Protocol's wording and the current knowledge base, countries can therefore circumvent their Kyoto targets.
- Only FCA including uncertainty assessments can begin to approach the transparent, consistent, accurate, and verifiable accounting system required by the Protocol. Without uncertainty assessments, no verification can occur.
- With no reliable verification tool, it is impossible to assess the impact of Kyoto activities on atmospheric CO_2 levels.

The Forestry project's research has therefore added new dimensions to earlier statements about the current Kyoto targets: "impossible to prove" or "a cheater's charter" (Fred Pearce, "Smokescreen Exposed," *New Scientist*, 26 August 2000).

The Russian case study, titled *Full Carbon Account for Russia,* is available on IIASA's Web site at www.iiasa.ac.at/Admin/PUB/Documents/IR-00-021.pdf. Other reports on carbon accounting by IIASA's Forestry project can be found at www.iiasa.ac.at/Publications/Catalog/PUB_PROJECT_FOR.html.

The Big Picture: Remote Sensing of Forests

In its *Contribution to the Global Forest Resources Assessment 2000*, the United Nations stressed the urgent need for "a set of recent, reliable and internationally comparable data on the extent, location, nature, condition and productivity of, and changes to, the forest resource, at the global and regional level, as vital input to any serious discussion of policy and decision-making relating to wood supply, industry location, protection of biodiversity, climate change and a whole host of other topics linked in one way or another to the forest resource" (United Nations, 2000, *Forest Resources of Europe, CIS, North America, Australia, Japan and New Zealand, UN-ECE-FAO Contribution to the Global Forest Resources Assessment 2000*, United Nations, New York and Geneva).

Currently there are some 30 political and legally and non-legally binding instruments that deal with various aspects of the forests (see article, page FOR-1). For some time, FOR has questioned the effectiveness of these instruments because the lack of relevant data often makes it impossible to verify their impact. Although a few countries have gathered recent forest inventory data of outstanding quality, most of the world's inventory information is poor or very old. There is also a serious lack of data—especially consistent data—relevant to the issues on the current international forest agenda and to existing international agreements. At the heart of the current forest policy debate are changes over time in the forest resource, and even developed countries often lack adequate inventories at the national scale to reflect the dynamics of sustainable forest management. The statistics needed for analysis of wood supply, trees outside "forests," disturbances (fires, insects, windfalls, etc.), official harvest, unreported (illegal) harvests , so-called non-wood benefits, and other issues simply do not exist in most nations.

Figure 1. Area of interest captured by the SIBERIA project.

Thus, most countries face formidable challenges in developing new national forest inventories. Governments, nongovernmental organizations, industry, scientific institutions, and international agencies would benefit from a vastly improved process for sharing information on forests and their related resources. The answer to all these challenges is efficiently applied remote sensing.

The overall objectives of FOR's remote-sensing activities are to contribute to the much-needed development of new forest inventories and to support FOR's own work on carbon accounting and the Kyoto Protocol. To reach these objectives, FOR obtains data from different sensors, develops multisensor approaches, validates the different sensors and multisensor approaches against field data, and creates new data sets relevant to carbon accounting.

The SIBERIA Project

Radar remote sensing has become an increasingly important tool for observing forest ecosystems. Several programs use currently available spaceborne synthetic aperture radar (SAR) data, and in recent years the use of multitemporal images gathered in repeat cycles has led to significant advances in the field.

Most of FOR's remote-sensing activities have so far focused on Russia through participation in the SAR Imaging for Boreal Ecology and Radar Interferometry Applications (SIBERIA) project, funded by the European Commission (DG-XII) and carried out by a European/Russian consortium of 16 institutions. The professional breadth, coupled with the project's vast geographic scope—the application area covers an area of almost 120 million ha (Figure 1), roughly equal to the total size of the forests in the EU—make SIBERIA unique among current remote-sensing activities.

The primary source of information about all Russian forests currently is the State Forest Account (SFA), an inventory based on field observations, aerial photographs, and satellite remote sensing of the forest areas. Although Russia has a better inventory system than many other countries, the SFA cannot monitor the indicators established for the sustainable development of the Russian forests and does not support the information needed for reliable estimations of economic, ecological, and social roles of Russian forests under transition conditions. Until now, radar data could not be recorded over Eastern Russia because there was no receiving station within range. The deployment of a mobile receiving station in Mongolia has made it possible to close the radar acquisition gap for central Siberia and receive data from three radar satellites: Earth Resources Satellites (ERS) 1 and 2 and Japanese ERS-1 (JERS). Given its economic situation, Russia cannot fund a domestic satellite program sufficient for collecting the data required until at least 2004.

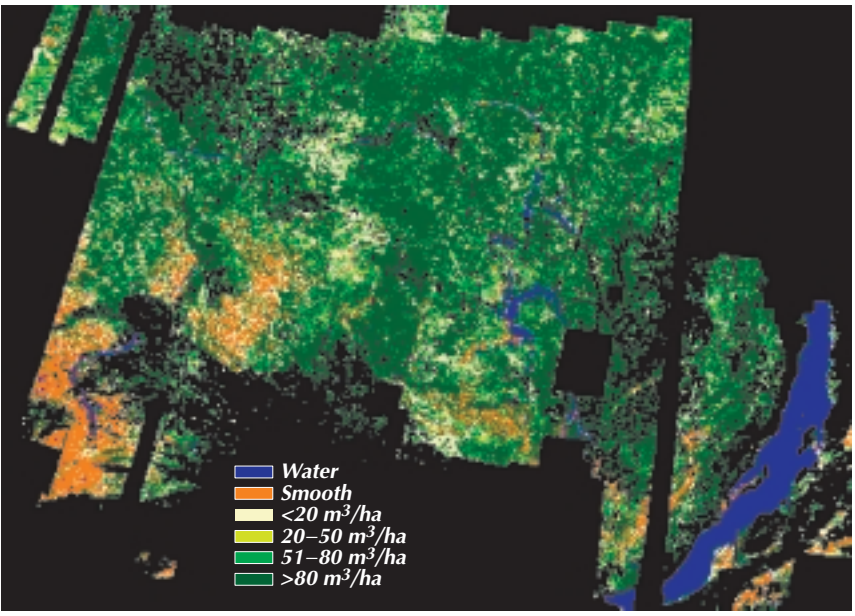


Figure 2. The forest stem volume and land-cover classification mosaic for the entire SIBERIA project.

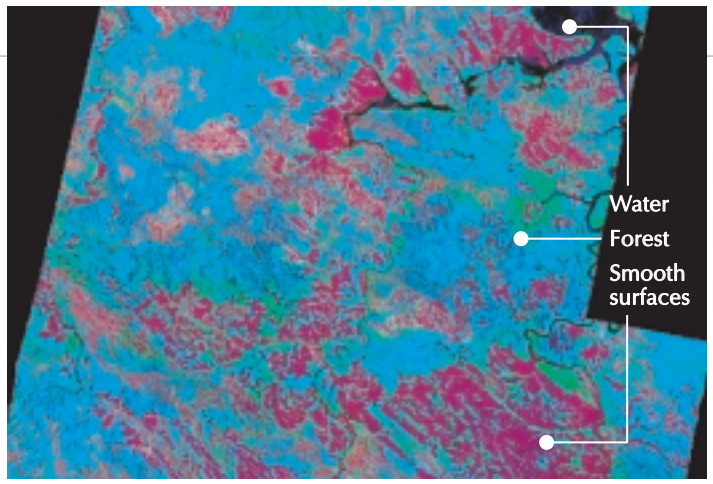


Figure 3. A portion of the radar image mosaic produced for the entire SIBERIA area.

After two years of intensive work, the SIBERIA project has produced an extensive data set and a new forest-cover map of a geographic region for which detailed information is limited. This map, developed in close cooperation with different users in the Siberian forest sector, will be an important component in the creation of a new inventory system in Russia. Created at a scale of 1:200,000 (Figure 2), it identifies six land classes (water, agricultural land, and forest growing stock <20 m^3/ha, 20–50 m^3/ha, 51–80 m^3/ha, and >80 m^3/ha). The result is a 7.5m × 5.5m wall map (also available in digital form) of the central Siberian forests. In addition, SIBERIA produces color-composite images (Figure 3) that aggregate the information contained in the radar data and digital elevation maps (Figure 4) that can be used for forest planning.

FOR identified suitable Russian collaborators for the SIBERIA effort and negotiated contracts with them, and then selected and established 50 so-called test areas, covering about 2.5 million ha, where detailed information was measured in the field. FOR then produced detailed GIS maps for the test sites and guided SIBERIA's methodology team on the characteristics of the boreal forests and the key parameters to look for in the data. SIBERIA applied the ground-truth information and the maps from 38 of the areas in the methodological development and classification of the radar signals, and FOR used the information from the other test areas to evaluate the final forest cover map

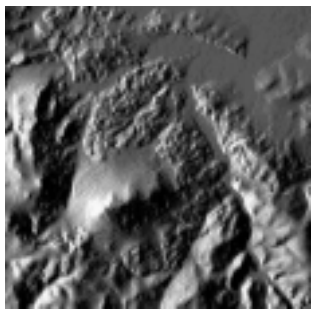


Figure 4. Digital elevation model generated from radar data.

in cooperation with local Russian experts. The evaluation proved that, beyond direct benefits to users in Russia, radar data have significant value for larger-scale forest mapping, can make an important contribution to the development of relevant new inventory systems, and can generate data adequate for carbon accounting.

FOR contributed to the development of improved remote-sensing techniques by supplying detailed ground-truth information about the Russian forests to the SIBERIA team. FOR will use this information set as a platform for validation of other optical sensors, such as SPOT VEG and LANDSAT 7, and various multisensor approaches. FOR has also provided a direct link between Russian users and the remote-sensing community through the SIBERIA project.

Remote Sensing for Full Carbon Accounting

FOR has also used data obtained by remote sensing to create a set of tools to assist it and other organizations in carbon analysis and in promoting sustainable forest management activities. Specifically, these tools help to reduce uncertainties by providing input to national- and regional-level databases that are spatially and thematically suitable for conducting FCA. The data describe topics such as land use, land cover, biomass, disturbances, and changes in these components.

FOR's work on the Full Carbon Account for Russia (see article, page FOR-4) clearly illustrates that many of the uncertainties connected with the Russian account stem from a lack of data and from insufficient methods for analyzing the data available. Moreover, the data currently gathered are not very well suited for carbon accounting, making verification of Kyoto targets difficult, if not impossible. In December 1999, the project organized a workshop on "Harnessing Remote Sensing to Accomplish Full Carbon Accounting," where members of the remote-sensing community met with carbon researchers to identify the linkages between these two disciplines and create joint research opportunities. FOR subsequently entered into several partnerships with external collaborators to develop innovative ways of using remote sensing to provide relevant data.

While a national land-cover database can support FCA at the national scale, managing the landscape in a way that considers carbon requires information at finer spatial and thematic scales. FOR scientists are participating in a consortium of remote-sensing experts who will seek to achieve this finer scale by developing methodologies for integrated, multisensor information from high- and low-resolution scanners and radar for regional carbon accounting and other forestry applications. FOR has established partnerships with the Centre for Aerospace Research of the Earth in Ukraine, and a new center will be established in Kiruna, Sweden (funded by the Kempe Foundations of Sweden and Swedish governmental funds), whose sole objective will be to support IIASA's remote-sensing activities.

The technology to perform remote sensing and process the resulting data is advancing rapidly, becoming both more accessible and more affordable. IIASA's involvement in remote sensing has positioned FOR to play an increasing role as more countries and international projects apply remote-sensing techniques for analysis of the world's forests.

The Russian Forest Sector: Creating the Future

Following the breakup of the Soviet Union, many experts expected that Russia's huge forest resources would contribute significantly to national wealth and welfare as the country moved toward a market-based economy. However, after nearly 10 years of transition, the figures are discouraging (see Figure 1). Why did this happen? What can be done to improve the situation?

Over the past three years, IIASA's FOR project has sought answers to these questions through case studies on the institutional framework of the forest sector in eight Russian regions—from Khabarovsk in the Far East to Murmansk in the Northwest. The studies included structured interviews with 221 forest enterprises in Russia; for comparison, IIASA carried out a parallel study of 24 Swedish firms. The findings for Russia revealed the following:

- In a country with 23% of the world's forests, almost half the firms perceive a shortage of wood.
- Most do not invest in physical capital.
- Most do not export their products.
- The vast majority have no banking contacts.
- At least half engage in barter. Some of the large firms interviewed by FOR sell as little as 10% of their production for real money. Typically, regional and local authorities are heavily involved in this practice.
- Payment procedures are built on mistrust; for example, some 96% of firms demand payment before delivery.
- Violations of agreements are the rule rather than the exception.

FOR has identified various structural characteristics of the Russian economy as primary contributors to this counterproductive business climate. One key problem is that property rights in Russia remain unclear. Although Russia has privatized almost all industrial enterprises in the forest sector, many companies were privatized in name only. In this area, Russia's forest code and other subsidiary rules conflict with the national constitution: Russia's constitution allows all types of ownership, whereas the forest code forbids private ownership of forests. Even among government entities, property rights are ambiguous. Who are the real owners of the forests, the Russian Federation, the so-called "subjects" (administrative units) of the Federation, or both? What happens when the interests of the two deviate; for example, who is responsible for cleaning up polluted areas, the region or the state?

Russia has enacted rules and regulations to prevent devastation of forest land, but authorities lack the means to monitor and enforce them. The same goes for laws governing fire protection, forest regeneration, and other activities essential to preserving healthy forest land. In many places the pricing of timber is a farce. There is no real competition, and the very ideas of leasing or timber auctions fall altogether flat. The artificially low prices that result should make Russian timber strongly competitive in international markets; in fact, exports are low and bring too few financial resources into the forest sector. Moreover, in the absence of effective bankruptcy and arbitrage procedures, vulnerable firms often "trade" company shares for tax credits and other public rebates to avoid total collapse, creating unhealthy collusion between government authorities and private actors.

Finally, Russia has a low level of investment—a further indication of a poor market economy. This probably results from a lack of confidence in adequate returns, especially among foreign investors.

Problems are Institutional

In essence, all these problems are institutional, involving the formal and informal rules used by a given set of actors. For example, well-defined systems of property rights and institutions not only help to make the world predictable, but they also make transactions cheaper. Barter, negotiations for privileges, bribes, and the like take time and consume significant amounts of resources that might have an alternative use.

More important, however, is that a poorly defined institutional framework promotes what political theorist Robert Axelrod terms "short shadows of the future"—precisely the opposite of what businesses need to function efficiently. For example, if a manager is certain that his company will continue to trade with a particular firm and that the terms of trade are well defined and agreed upon, he will behave accordingly, knowing that his behavior today will affect future interactions. But if he expects that his trading partner will break agreements, that trade rules might suddenly change, or that his company may not survive economically, he might be wiser to act as if today were his last day in business and grab all he can. Unfortunately, this is the reality confronting Russian forest firms.

Does the recent production increase (see Figure 1) indicate a brighter future? Possibly, but most observers seem to agree with IIASA that the upturn instead reflects the devaluation of the ruble. No significant restructuring of the forest sector has taken place, and though production is up, the real value of salaries has gone down. Thus, most people depending on the forest sector have become poorer, not richer.

A Virtual Economy

Russia's forest sector, like many others, exhibits few qualities normally associated with efficient market economies. But socialism is gone, and the Soviet state has been dismantled. Or has it? If Russia is neither capitalist nor socialist, what is it?

IIASA's study is the first to verify empirically the so-called virtual economy theory suggested to explain Russia's poor development toward a market economy. Such an economy "functions" through the extensive use of barter and other informal transactions, which effectively breaks market-based signals and creates prices for goods and services unrelated to their actual market values. This practice makes the economy seem larger than it is and maintains the pretence of value creation even in failing industries.

To take an example, why don't Russian forest firms invest, or restructure, to reduce their "distance" from the competitive wood market? Ultimately, this distance reflects the extent to which a company's physical and

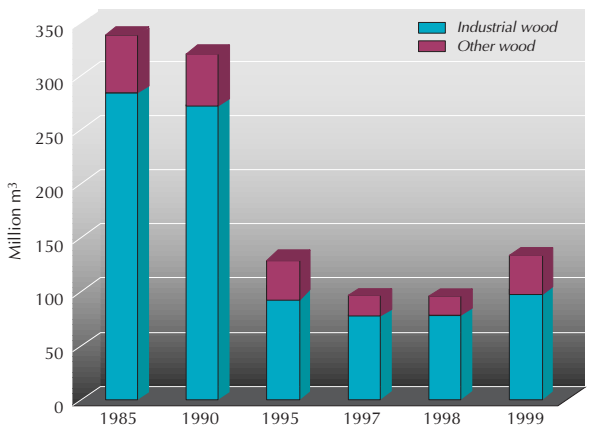


Figure 1. Wood harvest in Russia, 1985–1999. *Source*: World Bank and IIASA.

human capital is obsolete or malfunctioning relative to the demands of a modern market economy. The best option for most firms would be to invest in making production more efficient, thereby cutting their transaction costs. Unfortunately, in the framework of Russia's current economy, that solution may carry more penalties than rewards. The other option is to invest in "relational capital," for instance, by performing services for the local authorities, negotiating for privileges, and the like. Whether forest firms choose to invest in relational or physical capital depends on their initial (inherited) stock of capital. The virtual economy theory assumes that managers of Russian enterprises are rational and that their behavior therefore results from strong incentives to continue running their firms, whether they are profitable or not. Quite logically, managers prefer the most profitable type of investment, and the integrated forest industry system inherited from the former Soviet Union obviously provides a rich fund of relational capital from which to profit.

IIASA found that only 12 of 203 forest firms behave as "normal" market actors, trying to maximize efficiency and profit (Figure 2). About 60–70% of the firms are still deeply rooted in the virtual economy, behaving like anything but commercial players. The two groups have diametrically opposed views of business problems and their solutions (Figure 3). This research has led FOR to conclude that the logic of the old Soviet system still serves as the dominant institutional framework determining enterprise behavior. If nothing changes, new generations of entrepreneurs and business leaders will adopt the predominant behavior and Russia's road to a sound market economy might become an endless detour.

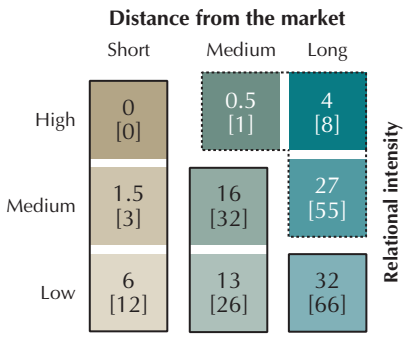


Figure 2. Distribution of Russian forest firms according to their distance from the market and their investment in relational capital, in percent [*N*=203].

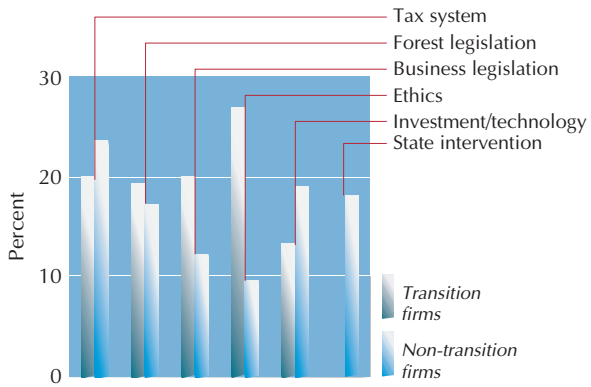


Figure 3. Important changes in the forest sector, based on a recent survey of forest enterprise managers.

Can IIASA Help to Solve the Problems?

FOR's studies of the forest sector reveal an institutional deadlock in all regions of Russia and a type of negative equilibrium in the national economy. The most promising strategies for breaking out of this system are again institutional. They include higher payoffs for producing tangible goods rather than "soft goods," tax rewards rather than punishments for enterprises moving toward market behavior, establishment of law and order, discontinued government support for the virtual economy, and public support for the transition to a market economy. In the current economic climate, however, the implementation of such strategies is highly problematic and unlikely to take place.

After discussions with Russian executives about the best way to promote this transition, FOR initiated a series of so-called policy exercises in the case study regions. At these events, FOR researchers present their results to Russian stakeholders, raise important questions, and initiate open discussion of the central issues. The exercises encourage participants to develop short- and long-term strategies and policy recommendations and concrete decisions, and promote interaction and mutual understanding among different stakeholders, interest groups, and scientific disciplines involved in the forest sector.

The first exercise, held in Tomsk Oblast in June 2000, not surprisingly revealed no easy or universal solutions. Instead, the results indicated that reforms must take place at different levels, against the backdrop of increased participatory democracy. For example, at the national level, Russia should resolve all constitutional ambiguities and contradictions concerning property rights, align federal and regional policies with market economic principles, and enact a thorough reform of the tax system to make it simpler, more transparent, and thus more enforceable. The country must also make its bankruptcy system and arbitration courts more efficient. Politicians and bureaucrats should withdraw from direct involvement in individual enterprises. At the same time, forest enterprises should create their own independent branch organizations to draft and conclude binding agreements concerning rules of conduct and standards, and to govern corporate operations. The firms must also develop programs to train people to perform new tasks and to use modern technologies. As these exercises continue through 2000 and 2001, FOR will disseminate the results to Russian policymakers as well as to international organizations supporting Russia's development efforts.

FOR recognizes that any institutional framework suitable for the development of the forest sector must be created from within Russia by enterprise managers, politicians, forest managers, and other stakeholders.

Taking advantage of the opportunities offered by *perestroika* requires participants in the virtual economy to recognize their own contribution to Russia's overall economic problems. The managers of Russian transition enterprises—those who actively seek to move their firms toward efficient functioning in the market economy—can provide the most appropriate suggestions and strategies for effecting positive change. Through its institutional framework studies, IIASA's Forestry project can contribute to putting these ideas into practice, and thereby help to improve economic opportunities for the Russian population.

The IIASA Report "Why is the Russian Bear Still Asleep After Ten Years of Transition?" (IR-00-19), as well as reports on FOR's individual case studies, are available through the FOR Web page at www.iiasa.ac.at/Research/FOR. In addition, *The Forestry Chronicle* has published an article titled "If money only grew on trees—The Russian forest sector in transition," by Lars Carlsson, Mats-Olov Olsson, and Nils-Gustav Lundgren, in its July/August 2000 issue.

The Impact of New Information Technology on the Forest Sector

When you read a newspaper online, you conduct what is known as a paperless B2C (business-to-consumer) transaction. The transaction is paperless, however, only as long as you read from the screen. Once you hit the "print" button you replace (no-)newsprint with printing paper grades. How often do you and other readers choose print media over electrons, and will your choices change in the future? How will the increasing use of information technology (IT) affect the forest sector?

Few can doubt that new IT in general, and the Internet in particular, have changed the way we live. The gale-force winds of change propel not only the fiberglass racing yachts of the new economy—the high-technology firms, the dot.coms—but also the traditional wooden-hulled boats of the old economy, such as the forest sector. FOR's research initiative on New Information Technology and the Forest Sector endeavors to develop a compass that can point stakeholders in the global forest sector in the right direction by applying rigorous analysis and course correction to strategic aspects of sector development.

Forecasting Future Demand

Understanding how the Internet will affect paper consumption is key to determining IT's likely impact on the forest sector. Currently, various types of paper and paperboard account for about 30% of the forest industry's end products. Many experts believe that paper consumption will decrease dramatically as online information delivery replaces print products, including newspapers, journals, and books, and as online shopping increases the need for packaging paper grades. However, the total impact is far from clear. While some experts envision a decline of 30–90% in the proportion of printed to electronic information over the next 10–20 years, others expect that the number of printed documents will double over the same period. Future paper consumption in the e-commerce environment will also depend on the paper industry's ability to develop and increase the relevance of its products as supplements to IT.

FOR's current work focuses on building theories that describe the positive and negative feedback economies crucial to understanding the role of information and innovation in the new economy in general. These theories provide the necessary system insight to design model scenarios that forecast the possible futures of paper-based information, and therefore the demand for paper products. Because the impact of IT will differ in different parts of the world, the scenarios draw on forecasts by IIASA's Population project that trace various possible trajectories of population growth, economic growth, education, changes in life and work styles, substitution behavior, and technological change for individual population cohorts.

FOR tests its scenarios by conducting so-called future exercises with groups of stakeholders in the paper and IT industries. These exercises subject FOR's hypotheses to rigorous examination by industry representatives with differing backgrounds and interests. The exercises systematically explore alternative social and technical developments, taking the range of uncertainties into account, and thereby increase stakeholders' ability to identify opportunities as early as possible and avoid or at least minimize the impact of undesirable situations. The exercises include scenario plots visualized in the form of *paperscapes*—detailed maps of paper consumption

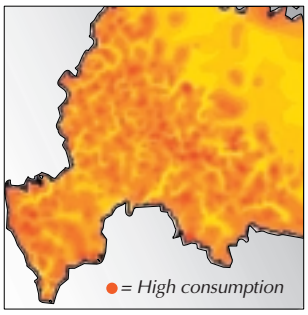


Figure 1. Paperscapes: Paper consumption levels across European Russia.

levels in real geographic space (see Figure 1)—that allow improved calibration of the model parameters, and therefore continued improvements in FOR's scenarios.

FOR also seeks to establish regional expert networks throughout the world that will use case studies and "consensus conferences" to produce regional estimates of preferred reading formats and paper consumption over time. FOR plans to combine the resulting information with the population projections to compile data and create innovative techniques for deriving long-term regional predictions of the demand for different paper grades. Use of these approaches will generate essential input to the validation of existing industrial policies and to the process for formulating new policies.

Structural Reform of the Forest Industry

FOR will use its analysis of changes in demand to assess potential impacts on the world's forests and the structure of the global forest industry, and to advise stakeholders on adaptation strategies. As forest companies improve their understanding of shifting market demands and their ability to respond to them, their planting and harvesting decisions could have major implications for global ecology by affecting the amount and type of forests maintained for commercial purposes.

New IT not only changes the landscape of demand for paper products, but through e-commerce also exerts pressure to restructure at both the industry and individual business levels in order to take advantage of new capabilities, such as B2B (business-to-business) transactions. For example, more and more customers will order their paper through a specialized office supplies dot.com or directly from the producer. In a first cut analysis, FOR has concluded that at the e-industry level, forest firms must improve their performance by increasingly making use of economies of scale within a more networked industry structure. Globally organized e-commerce platforms will lead to improved planning and coordination of the industry, resulting in the elimination of redundant capacities and less volatile markets. Other new ITs, such as networked geographical information systems in combination with remotely sensed data, will increasingly lead to improved planning, decision making, and automation along the entire fiber supply chain—from the forests all the way to the end consumer—at significantly lower costs and with less human input. However, forest enterprises should avoid an overly horizontal market structure that might trap them in a pattern characterized by low innovation and organizational inertia (Figure 2). Improved openness, connectivity, and strategic integration will be especially important in helping the mature and consolidated forest industry to garner the greatest possible benefit from networking and integration effects along the entire value chain.

The first two IIASA Interim Reports on FOR's study of New Information Technology and the Forest Sector, "Strategic Implications of eCommerce for Papermakers" and "Pressimistic Futures?—Science-Based Concepts and Models to Assess the Long-Term Competitiveness of Paper Products in the Information Age," as well as a related report titled *Innovation and the Market Process,* are available through the Forestry project's Web page at www.iiasa.ac.at/Research/FOR.

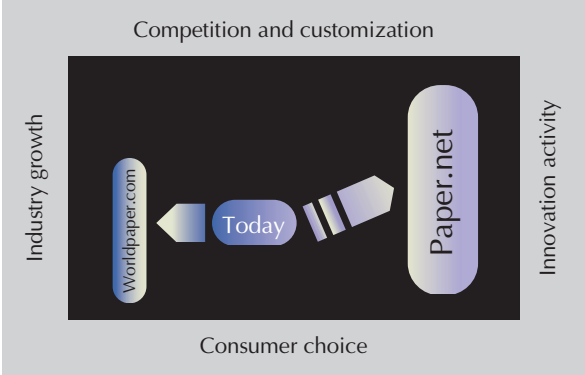
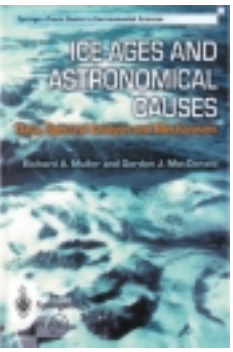


Figure 2. The implications of e-commerce on the forest industry structure.

IIASA's Forestry project will continue to build theories on information and innovation by applying and extending methodologies developed by IIASA's Adaptive Dynamics Network project to the economic sphere and extending Institute Scholar Yuri Ermoliev's work on growth theory. Eventually, the project will expand its demand simulation models to a full-fledged market model by using a geographically explicit micro-simulation model that is capable of incorporating various types of commercial behavior among individual buyers and sellers of forest products. FOR developed and tested this model in the context of the transition of the Russian forest sector. These simulations will not only help the forest industry to adjust to the new economic climate, but will also constitute valuable input to discussions of whether new IT will benefit or harm the world's forest resources.

Recent Publications

Ice Ages and Astronomical Causes—Data, Spectral Analysis and Mechanisms



Many of IIASA's projects study topics directly related to global climate and its effects on the human and natural environments. *Ice Ages and Astronomical Causes—Data, Spectral Analysis and Mechanisms*, by Richard A. Muller (University of California, Berkeley) and former IIASA Director Gordon J. MacDonald, contributes to an understanding of climate and its determinants by examining newly available data on paleoclimate and presenting an original—and controversial—theory of why and how the glacial cycles occur. The authors explain how changes in the Earth's orbit drive the formation of glaciers and the timing of the ice ages, focusing on aspects critical to trying to deduce the origin of these climate events. Spectral analysis of climate data from deep-sea cores enabled the authors to link the cycles to changes in the inclination of the Earth's orbital plane relative to the invariable plane of the solar system, rather than to orbital eccentricity, as the conventional theory assumes. The book is available from Springer-Praxis Publishing, Ltd., for £80; for more information, see www.springer.co.uk.

Three PDE Studies from IIASA's Population Project

Population and Climate Change, by Brian O'Neill, Landis MacKellar (leader of IIASA's Social Security Reform project), and Wolfgang Lutz (leader of IIASA's Population project), provides the first systematic, in-depth treatment of links between two major themes of the 21st century: population growth and associated demographic trends such as aging, and climate change. The book examines the causes of climate change and its impacts on human population, and how each would be affected by policies that reduce the rate of population growth. The multidisciplinary team of authors integrates natural science and social science perspectives to make the discussion understandable to members of both communities. Part I explores the climate outlook, demographic prospects, and economic perspectives on population, development, and environment (PDE). Part II analyzes the role of population growth in greenhouse gas emissions (not taking into account the structure of the population), the effect of population growth and structure on social resilience to the expected impacts of global warming, and the implications of global warming for population-related policies. The authors address the key question of whether climate change strengthens the case for population policies, especially those directly or indirectly related to fertility. *Population and Climate Change* is available from Cambridge University Press for US$49.95. To order the book, contact the publisher at www.cup.cam.ac.uk.

IIASA's Population (POP) project has also issued the third and fourth volumes in its series of case studies of PDE interactions in specific settings. *Population, Development, and Environment on the Yucatán Peninsula: From Ancient Maya to 2030* (RR-00-14), edited by Wolfgang Lutz, Leonel Prieto, and Warren Sanderson, offers historical and sectoral analyses of the area and defines and calibrates intersectoral models on specific relevant issues. Part one consists of a set of studies of the history, culture, environment, and economy of the Yucatán peninsula. The second part constructs a set of computer simulation models of PDE interactions.

Since 1997, POP has been conducting a study on Evaluating Alternative Paths for Sustainable Development in Botswana, Mozambique and Namibia. *Population–Development–Environment in Namibia: Background Readings* (IR-00-31), edited by Ben Fuller and Isolde Prommer, includes papers resulting from workshops held at IIASA in 1997 and 1998, augmented by meetings in Namibia and close collaboration with the University of Namibia's Multidisciplinary Research and Consultancy Centre (MRCC). For further information, see www.iiasa.ac.at/Research/POP.

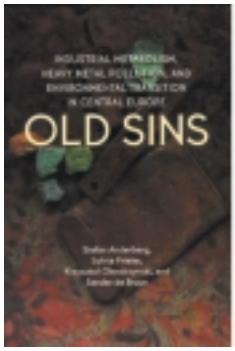
Model-Based Decision Support Methodology with Environmental Applications

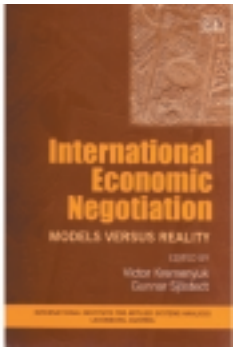
The modeling components of IIASA's Risk, Modeling and Society (RMS) project and the former Methodology of Decision Analysis (MDA) project have long concerned themselves with providing better support for institutional decision making through the application of advanced information technology. *Model-Based Decision Support Methodology with Environmental*

Applications, edited by Andrzej P. Wierzbicki, Marek Makowski, and Jaap Wessels, presents a state-of-the-art decision support methodology specifically targeted at strategic environmental decision problems, illustrated using complex applications. Part one provides methods for building and analyzing mathematical models that represent the underlying physical and economic processes needed at various stages of decision making. Part two reviews tools for development of model-based decision-making support systems. The final part discusses environmental applications developed at IIASA to address issues of water quality management in river basins, land-use planning, cost-effective policies for improving air quality, and energy planning. More information on the book is available at www.iiasa.ac.at/~marek/pubs/dss00.html.

Old Sins: Industrial Metabolism, Heavy Metal Pollution, and Environmental Transition in Central Europe

Sustainable development requires the ability to foresee and prevent future pollution, which, in turn, depends on understanding the links among societal activities, resource use, and environmental damage. *Old Sins: Industrial Metabolism, Heavy Metal Pollution, and Environmental Transition in Central Europe*, by Stefan Anderberg, Sylvia Prieler, Krzysztof Olendrzynski, and Sander de Bruyn, applies the concept of industrial metabolism to examine environmental issues in two regions of Europe and discusses ways to combine economic restructuring with environmental cleanup. Both the Rhine Basin and the Black Triangle–Upper Silesia (BTUS) regions have hosted significant heavy industry and coal-mining operations, relied on coal for energy, and suffered severe environmental damage. *Old Sins* maps the cumulative effects of industrial development, shows how the scales and patterns of pollution have changed, and compares the social and institutional developments accompanying the cleanup in the Rhine Basin with current institutional preconditions in the BTUS region. *Old Sins* is available for US$19.95 from the United Nations University Press at www.unu.edu.





International Economic Negotiation: Models versus Reality

A recurrent theme in the work of IIASA's Processes of International Negotiation (PIN) Network is assessing the extent to which the subject matter of a particular negotiation influences the bargaining process. *International Economic Negotiation: Models versus Reality* seeks to identify both the typical and unique features of negotiation on economic issues and to weigh the value of economic theory versus negotiation theory in explaining the outcome of these negotiations. The book includes 11 comparative case studies that examine negotiations in four major areas: direct investment, macroeconomic affairs, financial and monetary issues, and international trade. An introductory section provides a theoretical framework for the case studies, and a concluding analytical section contains lessons for both theory and practice. The book, edited by Victor Kremenyuk and Gunnar Sjöstedt, is available from Edward Elgar Publishing for £55; see www.e-elgar.co.uk.

Global Agro-Ecological Zones (GAEZ) 2000 CD-ROM

"Global Agro-Ecological Zones (GAEZ) 2000," by Günther Fischer and Harrij van Velthuizen from IIASA's Land-Use Change (LUC) project and Freddy Nachtergaele of the FAO, is the third CD-ROM issued by the FAO in collaboration with LUC. The FAO and LUC developed the Agro-Ecological Zones (AEZ) system for formulating and testing rational land-use planning options on the basis of land resources inventories and evaluation of biophysical limitations and potentials. The AEZ methodology provides a standardized framework for characterizing climate, soil, and terrain conditions relevant to agricultural production, and employs crop modeling and environmental matching procedures to identify crop-specific limitations of the land under different levels of inputs and management conditions. Recent availability of digital global databases of climatic parameters, topography, soil and terrain, vegetation, and population distribution has allowed the expansion of assessments of AEZ crop suitability and land productivity potentials to temperate and boreal environments. GAEZ 2000 includes examples of land productivity quantifications, estimations of extents of land with rain-fed or irrigated cultivation potential, occurrences of environmental constraints to agricultural production, indications of potential "hot spots" of agricultural conversion, and likely geographical shifts of agricultural land potentials as a result of changing climate. GAEZ 2000 provides numerous downloadable maps and tables in graphic, GIS, and spreadsheet formats. The information on the CD-ROM is also available at www.iiasa.ac.at/Research/LUC/GAEZ/index.htm.

Awards and Recognitions

Nebojša Nakićenović, leader of IIASA's Transitions to New Technologies project, received an honorary doctorate in engineering from the Russian Academy of Sciences on 22 September 2000.

New Staff at IIASA

Staff Member	Project	Country
Tsunetaka Bamba	Radiation Safety of the Biosphere (RAD)	Japan
Sebastien Barot	Adaptive Dynamics Network (ADN)	France
Hafiz Khan	Population (POP)	Bangladesh
Ian McCallum	Forestry (FOR)	Canada
Pertti Saariluoma	Population (POP)	Finland
Warren Sanderson*	Population (POP)	USA
Riku Suutari	Transboundary Air Pollution (TAP)	Finland
Harry van Velthuizen*	Land-Use Change (LUC)	Netherlands
Esa Viitamo	Forestry (FOR)	Finland
Ahmede Yahaya	Population (POP)	Niger

*Returning staff member

In Memoriam

Claire Doblin, who worked as a researcher in IIASA's Energy Program from 1975 to 1980, died on 24 May 2000. She maintained contact with the Institute and continued to contribute to our research activities from June 1981 to August 1991. Before joining IIASA, Dr. Doblin was on the staff of the Research Analysis Branch of the US Department of State and the Economic and Social Affairs Department of the United Nations in New York. Her scientific interests included the economic, financial, and technical aspects of energy demand.

IIASA Global Networking

Once again, IIASA researchers—both past and present—are involved in IPCC activities, this time working toward IPCC's Third Assessment Report. As in Assessment Reports I and II (see "The World in 2100," page 2), IIASA alumni and researchers are playing important roles as convening and lead authors. Shown below are IIASA alumni and researchers at the August 2000 meetings in Lisbon and Cape Town. These international groups, comprising individuals from diverse fields of research, reflect IIASA's main strengths: its strong international network of collaborators and the multidisciplinary nature of its research.

IIASA alumni and scholars at the Cape Town meeting: (standing, left to right) Ferenc Toth, Eva Toth, Susie Riley, Martin Parry, Cynthia Rosenzweig, Michael Apps, Sujata Gupta, Timothy Carter, Nebojša Nakićenović; (foreground) Rik Leemans, Kirit Parikh. Present at the meeting but missing from photo: Jan Kaczmarek.

IIASA alumni and scholars at the Lisbon meeting: (left to right) Shunsuke Mori, Hans-Holger Rogner, Kenji Yamaji, Michael Apps, Nebojša Nakićenović, Roger Sedjo, Jyoti Parikh, Pekka Kauppi, Kirit Parikh. Present at the meeting but missing from photo: Keywan Riahi, Ferenc Toth, Elena Nikitina.

Research Grants and Contracts

Project	Sponsor	Study
Adaptive Dynamics Network (ADN)	Austrian Federal Ministry of Education, Science and Culture	Adaptive Dynamics in Context: Facing the Challenges of Modern Evolutionary Theory
	European Commission, Research DG	Research Training Network: Modern Life-History Theory and Its Application to the Management of Natural Resources
Dynamic Systems (DYN)	Fujitsu Research Institute	Information Technologies and Global Technology Spillover
Environmentally Compatible Energy Strategies (ECS)	Central Research Institute of Electric Power Industry (CRIEPI)	New Energy Technologies for Eurasia
	Electric Power Research Institute (EPRI)	Joint Meeting of the Energy Modeling Forum and the International Energy Workshop (20–22 June 2000)
	European Commission, Research DG	Systems Analysis for Progress and Innovation in Energy Technology (SAPIENT)
	Nomura Research Institute (NRI)	Technological Change, Renewing Energy Resources and Sustainable Development
	Research Institute of Innovative Technology for the Earth (RITE)	Survey on Technology Development
	Tokyo Electric Power Company (TEPCO)	Medium- and Long-Term Demand and Supply Prospects for Fuel Cells
Forestry (FOR)	European Commission, Joint Research Centre, Space Applications Institute	Soil Digital Database for Russia and the European NIS at the Scale 1:2.5M
	Swedish Council for Planning and Coordination of Research (FRN)	Institutional Analysis of the Russian Forest Sector; Policy Exercises in Murmansk and Karelia; Tomsk Conference
General Research (GEN)	New Energy and Industrial Technology Development Organization (NEDO)	Survey on the Feasibility of Global Environmental Technology Transfer and Joint Implementation in Central Europe and Central Asia
	EVIDENZE S.r.l	Intelligent Transportation Systems: Economic and Strategic Implications for the Car Maker
	University of Studies, Florence	Medium-Long Term Prediction of the Evolution of Traffic Generated and Induced by the Construction of an Underground Transport System in Florence Called "Micrometropolitana"
Modeling Land-Use and Land-Cover Changes in Europe and Northern Asia (LUC)	GeoVille Informationssysteme und Datenverarbeitung GmbH	Monitoring Urban Growth in the Shanghai Region with Earth Observation Data
	Netherlands Organization for Scientific Research (NWO)	Support for scientist from the Netherlands
	Potsdam Institute for Climate Impact Research	Climate Impact Response Functions (CIRFs) Derived by the Agro-Ecological Zone Methodology
	Sinclair Knight Merz Pty Ltd.	European Rural Development
	UN Food and Agriculture Organization	Global Agro-Ecological Zoning: CD-ROM and Internet site

Project	Sponsor	Study
LUC (*continued*)	World Bank	GAEZ Indicators for the World Bank's "Vision to Action" Strategy
Natural Catastrophes and Developing Countries (CAT)	Bank Austria	Workshop: Environmental Insurance Policy Issues in Poland
	Cook Street Holdings Inc.	Natural Disaster Loss
Population (POP)	National Labour Institute of Greece	Ageing Population and Knowledge Based Society—Conference Paper
Processes of International Negotiation (PIN)	Austrian Federal Ministry for Science and Transport	Winfried Lang Memorial Conference
	Swedish Council for Planning and Coordination of Research (FRN)	General support
Radiation Safety of the Biosphere (RAD)	Japan Atomic Energy Research Institute	Radioactive Pollution in the Far Eastern Russian Coastal Region
	US Department of Energy	Assessment of the Impact of Russian Nuclear Fleet Operations on Russian Far Eastern Coastal Regions
Risk, Modeling and Society (RMS)	Austrian Federal Ministry of Education, Science and Culture; European Commission, Research DG	Public Participation and the Pension Policy Process: The Citizen and Pension Reform (PEN-REF)
	Österreichische Forschungsgemeinschaft; Swedish Council for Planning and Coordination of Research (FRN)	Global Change and Catastrophe Risk Management: Earthquake Risks in Europe (6–9 July 2000)
	Swedish Council for Planning and Coordination of Research (FRN)	Flood Risk Management Policy in the Upper Tisza Basin: A System Analytical Approach
Social Security Reform (SSR)	Nomura Research Institute (NRI)	Socioeconomic Impacts of Population Aging
Transboundary Air Pollution (TAP)	Central Research Institute of Electric Power Industry (CRIEPI)	Comprehensive Assessment of Large-Scale Environmental Problems in East Asia
	European Commission, Research DG	Predicting Recovery in Acidified Freshwaters by the Year 2010 and Beyond
	European Environment Agency (EEA)	Review and Development of Scenarios and Projections (European Union: Turn of the Century)
	German Federal Environment Agency	Particulate Emissions: Technology Cost Module for Integrated Assessment Modeling
Transitions to New Technologies (TNT)	International Gas Union (IGU)	Presentations in Japan on Global Natural Gas Perspectives—2000
Young Scientists Summer Program (YSSP)	Swedish Council for Planning and Coordination of Research (FRN)	Support for students from Bulgaria, Kazakhstan, and Ukraine
	Netherlands Organization for Scientific Research (NWO)	Support for student from South Africa

IIASA National Member Organizations

Austria The Austrian Academy of Sciences

Bulgaria* The Ministry of Environment and Waters

Finland The Finnish Committee for IIASA

Germany** The Association for the Advancement of IIASA

Hungary The Hungarian Committee for Applied Systems Analysis

Japan The Japan Committee for IIASA

Kazakhstan* The Ministry of Science—The Academy of Sciences

Netherlands The Netherlands Organization for Scientific Research (NWO)

Norway The Research Council of Norway

Poland The Polish Academy of Sciences

Russian Federation The Russian Academy of Sciences

Slovak Republic* The Executive Slovak National Committee for IIASA

Sweden The Swedish Council for Planning and Coordination of Research (FRN)

Ukraine* The Ukrainian Academy of Sciences

United States of America The American Academy of Arts and Sciences

*Associate member
**Affiliate

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