

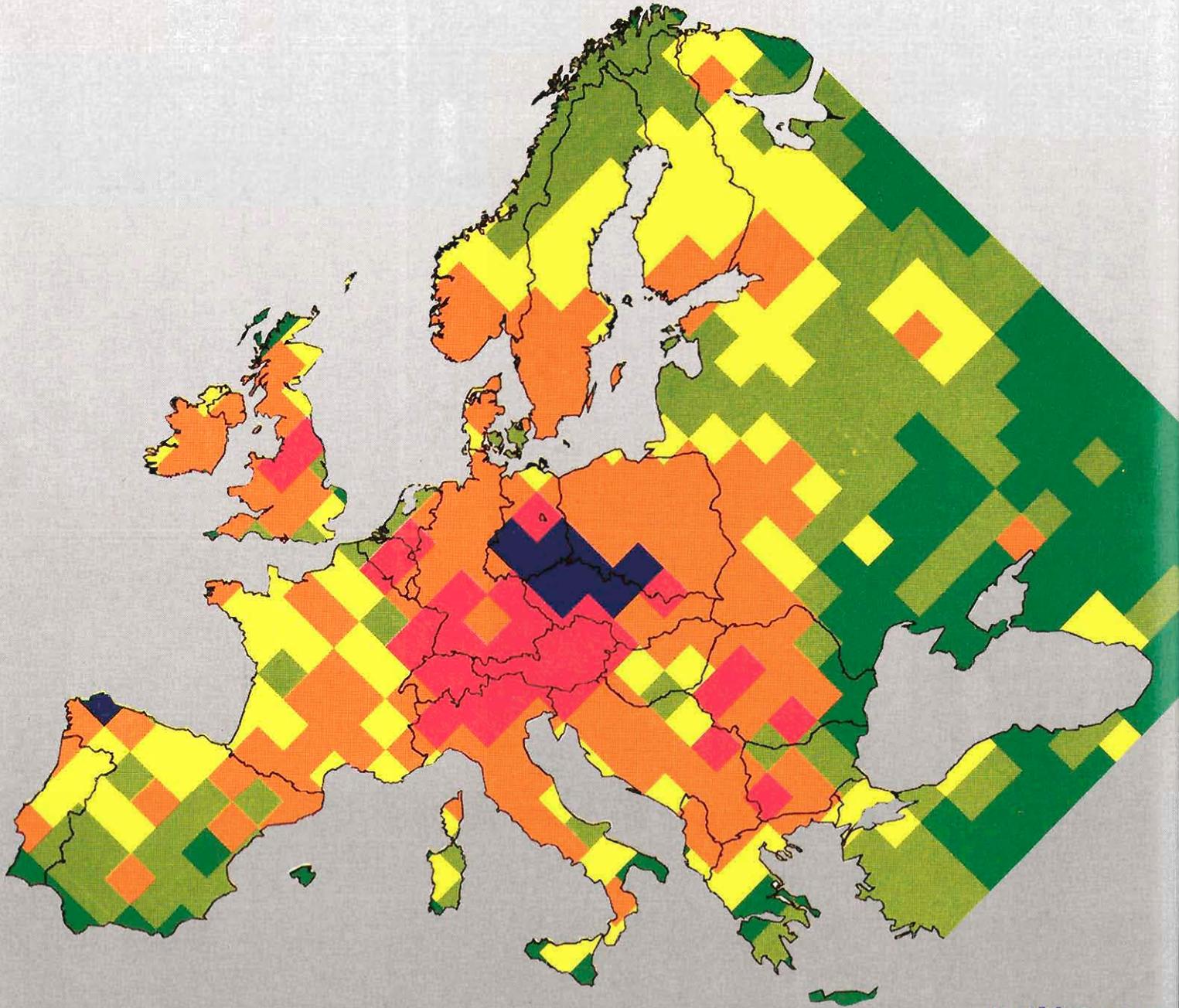


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In this Issue:

The Price of Pollution

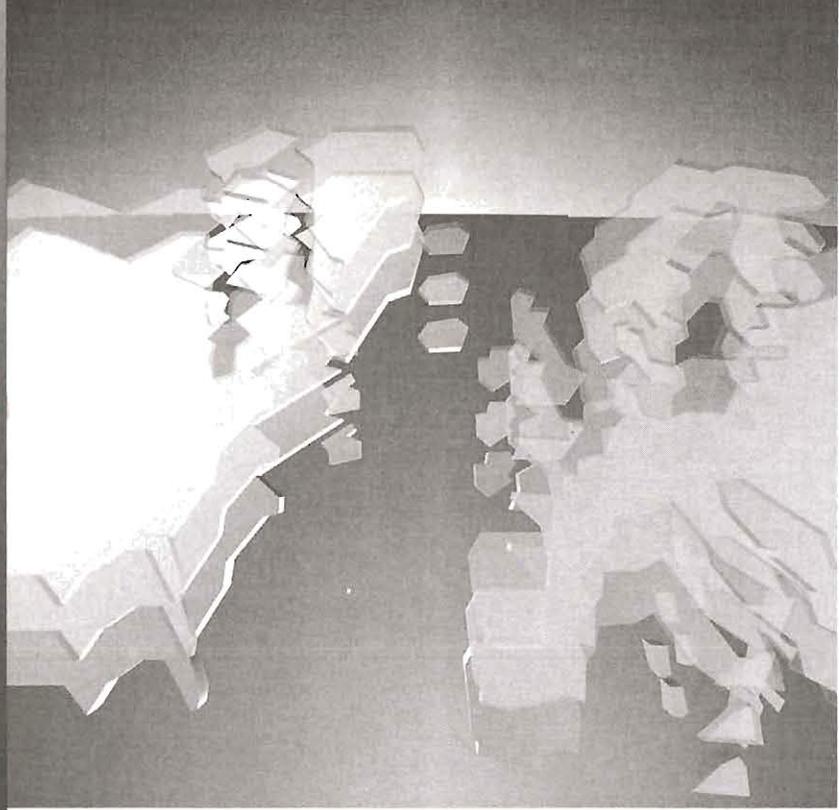
Acid and the Forests of Europe

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FUTURE DEMOGRAPHIC TRENDS IN EUROPE AND NORTH AMERICA

What Can We Assume Today?

EDITED BY WOLFGANG LUTZ



***Future Demographic
Trends in Europe and
North America
What Can We
Assume Today?***

Wolfgang Lutz, editor
Academic Press

A state-of-the-art report on what demographers and scientists in related disciplines assume today about the future of human reproduction, longevity, and migration. Alternative views are translated numerically into several scenarios on possible future population structures in Europe and North America.

options

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Used worldwide, IIASA's results and products have established IIASA as a front-runner in applying systems analysis to the resolution of international issues.

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EDITORIAL



The world's forests are one of humanity's most important resources. They provide materials for industry, shelter wildlife, and regulate ecological processes by taking up carbon dioxide and producing oxygen. Today we can identify a number of worrisome trends in development of these resources.

Various agencies estimate that global demand for industrial wood, currently 1.5 billion cubic meters per year, will increase 15 to 40 percent by 2005. Estimates of growth in Third World use of wood for fuel are even more dramatic: from 1.7 billion cubic meters this year to 2.7 billion in 2010.

In 1980 the rate of tropical deforestation was estimated to be 11 million hectares per year; recent estimates put the current rate at 17 to 20 million hectares per year.

Tropical deforestation is believed to account for 20 to 25 percent of the greenhouse effect. There is now a consensus (IPCC, August 1990) that we can expect an increase of global mean temperature of about 0.3 degrees centigrade per decade. Projections by IIASA's Biosphere Dynamics Project indicate that, given such a shift, half the world's forests would be unstable.

Pollution is a threat to many forests. IIASA's ongoing Forest Study has documented the alarming consequences of air pollution for European forests, and there are clear signs of pollution-induced forest decline elsewhere.

Forest management is another problem. The World Resources Institute estimates that only five percent of tropical timber forests are well managed. The Forest Study has confirmed the failure of many European countries to practice their avowed management policies, as well as the over-harvesting of the great boreal forests of Northern Russia and the Urals. And a new IIASA project dealing with Siberia has found that many of its forest resources may be depleted in 40 to 50 years.

Clearly forest resources are global resources, and they require global management. We scientists must refine our understanding of the ecological role of forests and the links between socioeconomic development, forest development, and forest conservation. And our political leaders must find an equitable way to share the burden and the costs of forest conservation and development around the world. Only then will we have long-term policies that can ensure wise use of this vital resource.

Sten Nilsson
Leader, IIASA Forest Study

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Cover: Map of Europe generated by RAINS using IIASA's Geoman environmental data display to depict acid depositions above critical loads.

F E A T U R E



Alpine forest: New continent-wide studies of forests and forest industries underline the staggering price that Europeans pay for fouling their air.

The Price of Pollution

Evidence is mounting that, for Europeans at least, it might cost less to clean up air pollution than to continue it. The total cost of acidic pollution is probably incalculable, given that it attacks everything from Norwegian trout stocks to the Acropolis. But an IIASA study to be published this winter indicates that pollution damage to forests alone costs Europe at least \$30 billion each year. That loss is about equal to the yearly output of West Germany's iron and steel industry, and about three times as much as Europe's

political leaders have committed to spend each year to control air pollution.

Europe's forest industries directly employ some five million people. Processing of wood accounts for more than 7 percent of value added by manufacturing in Western Europe and up to 25 percent in countries such as Finland. But purely economic measures understate the value of forests. It is no exaggeration to say that without forests, life as we know it would cease. Forests purify water and protect

soil, provide habitat to innumerable animals, plants, and insects, and take from the air vast amounts of carbon dioxide, the chief cause of increased global warming. For many people forests have become places of recreation and refuge, symbols of their commitment to nature, and benchmarks for gauging their political leaders' performance as stewards of the environment.

Swedish Forestry and Agriculture Minister Mats Hellstrom, in his opening remarks last July to the European Forum for Forest Protection, spoke not only of forestry's "fundamental importance" to the Swedish economy, but of "the living essence of the forest." The forest, he said, "is the home of saga and myth ... a significant part of life." Hellstrom also hailed the conclusions of the new IIASA report as "early warnings about forest conditions in Europe for coming decades" and "a base for counter-measures."

The report is one of the first comprehensive attempts to quantify the effects of acid air pollution on Europe's forests. A product of the IIASA Forest Study headed by Sten Nilsson, it joins a growing list of IIASA contributions to understanding the acid-emission problem. Nilsson and his colleagues have also completed a preliminary study of the extent of air pollution in European parts of the USSR (page 10). And IIASA colleagues studying heavy metal contamination in Europe have considered the role of acid pollutants in leaching heavy metals from soils (these studies will be the subject of articles in a future Options). But perhaps the institute's greatest contribution to acid-rain research has been the creation and ongoing refinement of the RAINS (Regional Acidification INformation and Simulation) model. RAINS was developed by IIASA's Transboundary Air Pollution Project, currently headed by Roderick Shaw, for the simulation and analysis of European

air pollution. It has proven to be a powerful research tool in the hands of IIASA's Shaw, Nilsson, Markus Amann, and others and is expected to be the technical cornerstone for negotiation of future treaties to limit air pollution in Europe (page 9).

Nilsson's latest analyses are the culmination of four years of work. The Forest Study was set up in 1986 to examine the social, economic, and ecological consequences of global forest decline, beginning with Europe. The backbone of Nilsson's work is an unparalleled database assembled with the help of more than 125 collaborators in every country in Europe. Analyses of that data by Nilsson and colleagues in his native Sweden and in Canada have yielded the first consistent, continent-wide assessment of Europe's forests. They expect to publish their findings early in 1991 in two volumes; a subsequent volume will deal specifically with Soviet forests. Nilsson's current studies include preliminary data on the value of pollution damage. Taken together, what emerges is a startling picture of forests crippled by air pollutants, at immense cost to European industry and society.

About 75 percent of Europe's commercial forests endure damaging levels of sulfur deposition; about 60 percent suffer from depositions of nitrogen above critical loads. To make matters worse, many timber stands are badly managed and in poor health — too old, too dense, and with species unsuited to site conditions — rendering them needlessly vulnerable to the stresses of acid pollution. The only solution, says Nilsson, is quick action on several fronts. First, timberland owners and managers must adopt sound silvicultural practices to improve the health and vitality of forests; second, European policymakers must commit themselves to massive, continent-wide cuts in emissions of sulfur and nitrogen — cuts at least three

ACID FACTS

Airborne acids can be traced to three primary sources: sulfur dioxide (SO_2), nitrogen oxides (NO and NO_2 , collectively referred to as NO_x), and ammonia (NH_3). The main sources of sulfur dioxide are coal- and oil-burning power plants; nitrogen oxides come largely from the exhausts of cars and trucks; and atmospheric ammonia is almost entirely a by-product of animal waste on farms. Sulfur dioxide is the biggest problem, accounting for 60 percent of the acidification in Europe; nitrogen oxides account for 21 percent, and ammonia 19 percent. But the situation varies widely from country to country.

In Ireland, a country with more farm animals than people, ammonia from waste accounts for 57 percent of acidifying emissions, while SO_2 contributes 30 percent. In East Germany, where little has been done to limit sulfur emissions by industry, SO_2 accounts for 84 percent and ammonia just 6 percent. Generally SO_2 is more of a problem in Eastern Europe than in Western Europe because in the 1980s many Western countries halved their SO_2 emissions. At the same time, however, some European nations, especially in eastern and southern Europe, increased their SO_2 emissions. The result was that from 1980 to 1986 overall emissions of SO_2 in Europe fell just 15 percent. In any event, the relative mix of sulfurous or nitrogenous acids is less important than the total acid deposition.

Acidic emissions are spread liberally by the atmosphere. Nitrogen oxides and sulfur typically stay aloft for one to three days and travel hundreds of kilometers before returning to earth. Oxides of nitrogen travel farthest, often 1,000 kilometers or more. Ammonia tends to settle closer to home. In 1985 Europeans pumped into their skies 55 million tons of sulfur dioxide; 28 million tons of nitrogen oxides; and 76 million tons of ammonia. About 30 percent of Europe's SO_2 emissions return in precipitation, hence the phrase acid rain. Some 50 percent to 60 percent is deposited in dry form as gaseous SO_2 or sulfur ions (SO_2 , SO_3 , SO_4). The remainder, about 15 percent, is transported out of Europe.

Precisely how airborne acids damage trees is unknown, but theories abound. Several theories relate to the acidification of forest soils; in the last 50 years forest soils in much of Europe have experienced a five- to ten-fold increase in acidity. Acids leach heavy metals and aluminum from the soil, and dissolved aluminum damages the fine root hairs that take up water and nutrients. Acids could also cause a deficiency of magnesium by leaching too much of it from leaves and soil. Another theory is that airborne acids erode the waxy, protective layer on leaves, leach out nutrients, and leave them vulnerable to pests and disease. Excess nitrogen also disrupts plant functions. Nitrogen is essential for plant growth, but forests typically need only 0.5 to 0.8 grams per square meter per year; current deposition rates in Central Europe are 3.0 to 4.0 grams per square meter per year. There is a consensus that, whatever the mechanism of acid damage, its impact is compounded by an accumulation of stresses, including severe climatic episodes or outbreaks of disease. In the end, says forest economist Sten Nilsson, head of IIASA's Forest Study, an exact understanding of the process is unnecessary. "We know enough to be sure of the links between acid emissions and forest decline," says Nilsson. "If we wait until we have a detailed understanding of the process before taking action, it will be too late."

FEATURE

or four times deeper than those scheduled under current reduction plans – by reducing the amount of fossil fuels burned and by installing the best possible control equipment as widely as possible, from the smokestacks of large power plants to the exhaust pipes of small cars. Even if policymakers embraced these measures tomorrow, said Nilsson, it is probably too late to save some areas of forest in East Germany and Czechoslovakia; over the next decade he expects that they will simply die.

Studies by Nilsson, Shaw, and

Amann indicate that current efforts to curtail air pollution achieve almost nothing. In the year 2000 most European forests would continue to suffer acid depositions far above tolerable limits. Of the three main contributors to acid pollution – sulfur dioxide (SO₂), nitrogen oxides (NO and NO₂, collectively known as NO_x), and ammonia (NH₃) – most of the efforts to cut emissions have been aimed at sulfur dioxide. In theory, current commitments would by the year 2000 lower European SO₂ emissions by 28 percent from

1980 levels. In fact, some countries are increasing their emissions while others are going beyond their international commitments. Calculations with RAINS indicate that the net result will likely be a reduction of SO₂ emissions of 18 percent.

But current sulfur deposition levels are so high – more than 30 times the damage threshold in parts of Czechoslovakia – that an 18 percent cut would have little effect. Nilsson calculated that in 1980 about 75 percent or 17 billion cubic meters of the commercial wood in Europe suffered annual

Estimated losses attributable to air pollution, by volume and value. For data on the European USSR see page 10.

Region Country	Potential harvests (million m ³ /yr)			Value of harvest reduction ^b (million 1987 \$US/yr)			
	Without air pollution	With air pollution as per current reduction plans	Losses attributable to air pollution	Roundwood	Industrial products	Non-wood benefits	Total
Finland	59.1	54.6	4.5	234.9	317.7	635.0	1187.6
Norway	20.6	19.8	0.8	42.0	54.9	113.5	210.4
Sweden	75.6	69.8	5.8	302.8	406.0	818.3	1527.1
NORDIC	155.3	144.2	11.1	579.7	778.6	1566.8	2925.1
Belg & Lux	4.0	3.3	0.7	52.0	60.1	140.5	252.6
Denmark	3.3	2.9	0.4	22.6	33.6	60.9	117.1
France	56.7	53.2	3.5	232.1	314.0	627.5	1173.6
Germany (West)	49.4	37.5	11.9	700.9	1018.6	1894.5	3614.0
Germany (East)	14.6	9.7	4.9	250.4	233.2	677.2	1160.8
Italy	20.3	17.2	3.1	333.5	595.1	901.9	1830.5
Netherlands	0.9	0.7	0.2	13.3	18.1	36.0	67.4
UK & Ireland	15.3	11.4	3.7	234.0	306.5	632.6	1173.1
EEC-9	164.5	135.9	28.6	1838.8	2579.2	4971.1	9389.1
Austria	17.1	13.7	3.4	191.8	206.1	515.5	913.4
Switzerland	7.5	5.1	2.4	140.4	140.2	379.6	660.2
CENTRAL	24.6	18.8	5.8	332.2	346.3	895.1	1573.6
Greece	2.8	2.7	0.1	4.1	8.1	11.2	23.4
Portugal	7.4	5.9	1.5	64.5	95.1	174.5	334.1
Spain ^a	17.8	17.8	n.a.	n.a.	n.a.	n.a.	n.a.
Turkey	27.0	24.2	2.8	125.4	206.9	339.1	671.4
Yugoslavia	23.2	20.4	2.8	175.3	119.3	474.0	768.6
SOUTHERN	78.2	71.0	7.2	369.3	429.4	998.8	1797.5
Bulgaria	8.6	6.4	2.2	107.6	122.5	290.8	520.9
CSFR	23.7	14.2	9.5	540.6	369.5	1461.1	2371.2
Hungary	8.5	5.5	3.0	171.0	156.6	462.3	789.9
Poland	30.5	19.4	11.1	585.0	491.8	1581.7	2658.5
Romania	40.2	36.4	3.8	219.3	185.0	592.8	997.1
EASTERN	111.5	81.9	29.6	1623.5	1325.4	4388.7	7337.6
EUROPE	534.2	451.9	82.3	4743.5	5458.9	12820.5	23022.9

^aSpanish data insufficient to allow calculation of pollution effects.

^bPreliminary data.

depositions of sulfur above critical loads; the projected reduction of emissions by the year 2000 would reduce that figure by just 9 percent. In the case of nitrogen, where fewer commitments to control have been made, current trends would result in a paltry 2 percent cut in the 60 percent of timber subjected to damaging nitrogen depositions.

Indeed, simulations by Shaw and Nilsson indicate that only radical cuts in emissions will bring radical cuts in the volume of timber at risk. Adoption of state-of-the-art control technologies throughout Europe would cut sulfur emissions by 82 percent and NO_x emissions by 60 percent from 1980 values and reduce the volume of timber at risk from sulfur deposition by two-thirds. The effect would not be nearly so dramatic for nitrogen, reflecting the fact that NO_x accounts for only half of all nitrogen depositions (the other half is from ammonia, NH₃, mainly from farm animal waste). Across-the-board adoption of the best available control technology for SO₂ and NO_x would leave half of all forests still suffering nitrogen depositions above target levels, compared with a quarter receiving damaging depositions of sulfur. Clearly efforts to lessen emissions of sulfur and nitrogen oxides will be wasted unless Europeans adopt equally aggressive programs to cut emissions of ammonia, the third leg of the acidification triad. From 4–6 February 1991, Markus Amann and Ger Klaassen, both members of IIASA's Transboundary Air Pollution Project, will host an international workshop at IIASA to discuss questions of ammonia emissions and control in Europe, with the intention of incorporating calculations of NH₃ emissions within RAINS. The model already incorporates SO₂ and NO_x.

The RAINS simulations underscore another important point: even if the best available control technology were applied to all emission sources on the con-

tinental – clearly an unattainable goal – Europe would still have an acidification problem. A balanced program to control acidification must include efforts to conserve energy and reduce the use of fossil fuels, as well as stringent controls on emissions.

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 ”

By any measure the costs of control will be enormous. Amann has calculated that the maximum feasible 82 percent reduction of sulfur emissions would require installation of flue-gas desulfurization equipment in large boilers in power plants, refineries, and factories, plus the use of low-sulfur coal in small boilers. The estimated cost: \$50 billion per year. It would cost an additional \$40 billion per year to achieve a 60 percent reduction of NO_x emissions by installing three-way catalytic converters on all gasoline-powered cars, modifying the engines and exhaust gas circulation of diesel-powered vehicles, and installing catalytic reduction equipment and low-NO_x burners on some power plants and industrial boilers. Amann and Klaassen have not yet calculated detailed costs for control of NH₃ emissions, but control systems – essentially improved manure-handling methods – are available at roughly comparable costs, relative to efficiency.

The other side of the balance sheet, the cost of acid pollution, is probably impossible to calculate. A complete tally would include, among many other things: the cost of adverse effects on human health resulting from the leaching of heavy metals from soils into groundwater; widespread damage to buildings, ranging from the breakdown of mortar in modern brick buildings to the corrosion of the stained-glass windows in the medieval Cathedral of Cologne; and, of course, the damage to forests. Clearly, some of these costs are incalculable.

Within the category of costs to forests there is considerable room for debate. The basic value of reduced timber harvests is relatively easy to calculate; prices of timber are knowable. But there is no price list for forests' other contributions to human comfort and survival, including: protection of soil and water; recreation; wildlife habitat; microclimate amelioration; and sequestration of atmospheric carbon, the major cause of increased global warming. There is a consensus that these “non-wood” benefits are of immense value, but only recently have researchers begun trying to assign those values.

Nilsson based his assessment of the cost of forest damage on his study of the long-term impact of airborne acids on potential timber harvests. He linked the timber database and its detailed information on timber stocks and site conditions throughout Europe, including regional sensitivities to acid deposition, with the RAINS model, which generated information on future deposition patterns. Estimates of the impact of depositions on forests were calculated using PEMU, an elaborate East German model developed from data based on field observations since the 1960s at a series of test sites along emission gradients. Nilsson also made two highly conservative assumptions: first, he calculated only the negative effects of sulfur

FEATURE

Outlook for European wood supply/demand balances. Projections of potential harvests assume air pollution based on current plans for emission reductions.

	In million m ³ roundwood equivalent		
	Mid-1980s	2000	2010
Nordic			
Domestic demand	31.2	41.2	43.4
Surplus/deficit	+89.5 ^a	+88.9	+91.5
EEC-9			
Domestic demand	202.5	279.0	326.5
Surplus/deficit	-93.2 ^a	-160.1	-200.0
Central			
Domestic demand	13.8	18.3	22.8
Surplus/deficit	+8.5 ^a	-0.2	-3.9
Southern			
Domestic demand	49.3	67.2	77.2
Surplus/deficit	+22.8 ^a	-1.9	-9.3
Eastern			
Domestic demand	69.4	91.3	105.6
Surplus/deficit	+30.1 ^a	-5.4	-17.6
Total Europe			
Domestic demand	352.4	497.0	575.5
Surplus/deficit	+71.5 ^a	-75.4	-139.3

^a1987 actual harvest.

pollution, assuming no ill effects from NO_x, NH₃, or other pollutants; second, he assumed that by the year 2000 SO₂ pollution will decline 18 percent from 1980 levels, then suddenly stop altogether. Even so, his calculations indicated that sulfur emissions alone to the year 2000 will reduce potential timber harvests in Western and Eastern Europe by an average 85 million cubic meters, or 16 percent, each year for the next century. And they will cut potential harvests in European parts of the USSR by an additional 35 million cubic meters.

By comparing the data with current values of roundwood at the mill site, Nilsson calculated that the yearly potential loss of unprocessed wood is equivalent to \$2.9 billion for Western Europe; \$1.9 billion for Eastern Europe; and \$1.5 billion for the European USSR. The total loss attributable to sulfur dioxide pollution would be \$6.3 billion per year, or just \$0.5 billion less than the \$6.8 billion European governments have agreed to spend each year to reduce SO₂ emissions.

But that comparison ignores the value of industrial wood processing and of social, non-wood benefits. Nilsson estimated both. His estimate of lost industrial processing value took into account basic products such as softwood and hardwood lumber, pulp, and wood for energy; values for lumber and pulp were based primarily on export price data from the UN Food and Agriculture Organization. The estimate of loss is almost certainly conservative, given that it excludes the potential value normally added by joinery and furniture making, paper production, and the manufacture of plywood and particle board. The results indicated potential average yearly losses from sulfur pollution of \$3.9 billion in Western Europe; \$1.6 billion in Eastern Europe; and \$1.7 billion in the European portions of the USSR. The total: \$7.2 billion.

Finally, Nilsson estimated the additional costs of lost non-timber and social benefits. In West Germany, such benefits are valued 4.0 to 4.5 times higher than

the country's industrialized timber production, which is by far the largest in Europe. Nilsson settled on an average multiplier of 2.7 times the local value of unprocessed timber delivered to the mill site. His estimates for average yearly value lost to sulfur pollution were: Western Europe, \$8.4 billion; Eastern Europe, \$4.4 billion; and the European USSR, \$4.1 billion. The total: \$16.9 billion.

Adding up the three categories – the values of unprocessed wood, basic industrial value, and non-wood benefits – Nilsson estimated that the final cost to Europe, including the European USSR, of sulfur damage to forests would be \$30.4 billion each year for the next 100 years. Given the conservative nature of his assumptions, the true cost may be considerably higher. Even so, \$30 billion is about two and a half times as much as European governments have agreed to spend annually to control air pollution. And, as noted earlier, damage to forests is just a fraction of the total damage inflicted by acidic pollutants.

Clearly the onus to address the problem rests with political leaders, not scientists. But the work of Shaw, Nilsson, and their colleagues underscores several points that could guide their efforts. First, existing efforts to limit air pollution are grossly inadequate. Second, state-of-the-art scrubbers, catalytic converters, and other clean-up equipment must be installed as widely as possible, but that alone will not solve the problem; parts of Europe will continue to suffer damaging levels of acid deposition unless steps are taken to reduce overall consumption of fossil fuels and emissions of ammonia. Third, the cost of controlling pollution will be high, but the cost of not controlling it would probably be higher. Further research by IIASA and other research organizations will develop additional insights into these environmental problems. ●

FEATURE

RAINS: A Model for Negotiations

Negotiations currently underway among 20 European countries on a new protocol to limit emissions of sulfur dioxide (SO_2) are placing an extraordinary reliance on a computer model, IIASA's Regional Acidification INformation and Simulation model, or RAINS, for scientific support. RAINS models the entire sequence of air-pollution events in Europe, from the generation and emission of pollutants in 27 countries, to their transport in the atmosphere, to their deposition and effects on the environment. By doing so, it allows negotiators to test different abatement strategies.

The SO_2 negotiations also mark the first acceptance of critical loads—scientific assessments of the acidic deposition that each area of Europe can stand without damage—as a starting point for talks. Previous pollution-abatement negotiations have generally aimed

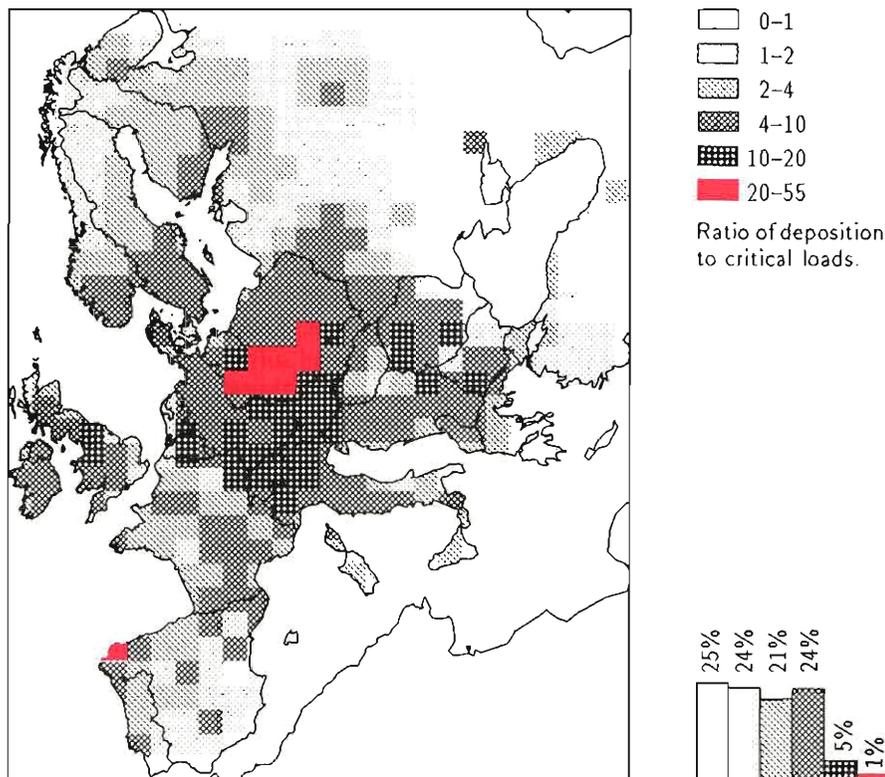
for uniform, across-the-board cuts in emissions. But emissions are not generated uniformly or spread evenly by the atmosphere. Moreover, some areas of Europe are highly sensitive to acid depositions, while others can tolerate higher levels of abuse. National research groups across Europe are currently producing critical-load maps for their own countries. The goal is to develop a map for Europe as a whole in 1991 and to conclude an updated SO_2 protocol in 1992.

Critical-load maps, however, only give an idea of the environment's susceptibility to acidic deposition and its potential impact. To take advantage of such information negotiators need equally detailed knowledge of the entire pollution chain. In 1989 a UN-ECE task force reported that "an integrated model that can assist in

cost-effectiveness analysis is now available"—RAINS—and recommended it be adopted by all parties as the central technical support for the negotiations.

With a few hours of training bureaucrats, politicians, and other nontechnical people can put a broad range of what-if questions to RAINS: What would happen to Norway's lakes and forests if the United Kingdom cut SO_2 emissions from power plants by 30 percent? How much would it cost? What is the cheapest way to halt the acidification of forest soils in Czechoslovakia? In all of Europe? RAINS answers these and other questions, usually within minutes, using only a personal computer. IIASA researcher Markus Amann, a member of a UN-ECE task force supporting negotiations, has already generated several scenarios using RAINS and preliminary critical-load maps to give negotiators a feel for the process and an idea of RAINS's potential.

About a hundred copies of RAINS have been distributed to government agencies, universities, research institutions, and private organizations. RAINS comprises a series of submodels that organize information into three categories: pollution generation and control, including costs; atmospheric transport and deposition; and environmental impact. The model covers all of Europe, including the European USSR. As conceived in 1983, RAINS dealt with SO_2 , the source of three-fifths of Europe's acid air-pollution problem, but not NO_x and NH_3 , which are responsible for the rest. NO_x was incorporated into RAINS last summer, and ammonia (NH_3) will be incorporated in 1991 following an international workshop at IIASA, February 4–6, to discuss emissions and control of NH_3 .



RAINS map of Europe after implementation of planned emission reductions showing acid deposition above critical loads proposed by Chadwick and Kuylenstierna.

F E A T U R E



Parts of the European USSR suffer depositions of SO_2 and NO_x two and five times as high as any country in Europe.

Assessing Soviet Pollution

Parts of the European USSR suffer acidic air pollution far worse than any country of Western or Eastern Europe, although the Soviets' air-pollution problems as a whole are not as severe, according to preliminary data from recent studies by IIASA's Sten Nilsson and Roderick Shaw. Deposition rates of sulfur and nitrogen in the European USSR are generally lower than in Europe, but around some Soviet industrial areas and near the border with Eastern Europe the pollution problems rank with the world's worst. Nilsson's preliminary estimates indicate that damage to forests from sulfur emissions alone will cut potential timber harvests in the European USSR by about 35 million cubic meters, or about one-sixth, each year for the next century. The loss will cost Soviet industry and society an estimated \$7.4 billion each year, or three times what the Soviet government has said it will spend annually to curb air pollution.

Unlike the situation in the smaller nations of Europe, where pollutants are distributed liberally by the atmosphere from country to country, most of the air pollution in the Soviet Union is homegrown. About two-thirds of all sulfur depositions from human sources and more than half of the nitrogen depositions in the European USSR are generated within the country. Depositions of sulfur and nitrogen average, respectively, 1.0 and 0.6 grams per square meter per year, less than half typical values in Europe. But those averages mask a wide range. Some regions, notably on the Baltic coast near Poland, in the Carpathians and Moldavia, and near the Czech-Polish border, suffer depositions of SO_2 and NO_x as high as 14 and 6 grams per square meter, respectively. These deposition levels, two to five times higher than in any country in Europe, result largely from a spillover of pollutants from their European neighbors.

Not surprisingly, the worst affected forests are in these areas. But Nilsson's analysis, conducted with Swedish colleagues Ola Sallnäs and Märten Hugosson, was not completely without surprises. The study indicates that deposition of nitrogen is a much greater problem for Soviet forests than deposition of sulfur, a reversal of the situation in the rest of Europe. There, three-quarters of forest land suffers deposition of sulfur above target loads, compared with one-quarter above the limits for nitrogen oxides. But in the European USSR the proportions are more balanced: about a third of forests are above target loads for sulfur, and a quarter above limits for nitrogen oxides.

Even that comparison may understate the problem. Most nitrogen acidification in the Soviet Union appears to be due to emissions of ammonia (NH_3) whereas in other parts of Europe NH_3 and NO_x contribute about equally to the

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Key forests in northern regions of the USSR are being harvested far beyond sustainable levels

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problem. Nilsson estimates that if ammonia emissions are considered about 80 percent of forests in the European USSR will suffer nitrogen depositions above target levels in the year 2000, unless emissions are cut drastically.

Forests in European regions of the USSR share one unfortunate characteristic with forests in the rest of Europe: many are the victims of poor silvicultural practices, too old and too dense to be productive and susceptible to attack from pests, disease, and airborne acids. But the vast commercial forests of the European USSR – 130 million hectares in total, equal to all the forests in the rest of Europe – are in “much worse shape” than others in Europe, Nilsson said. “There is a strong need for better silvicultural practices in the Soviet Union.”

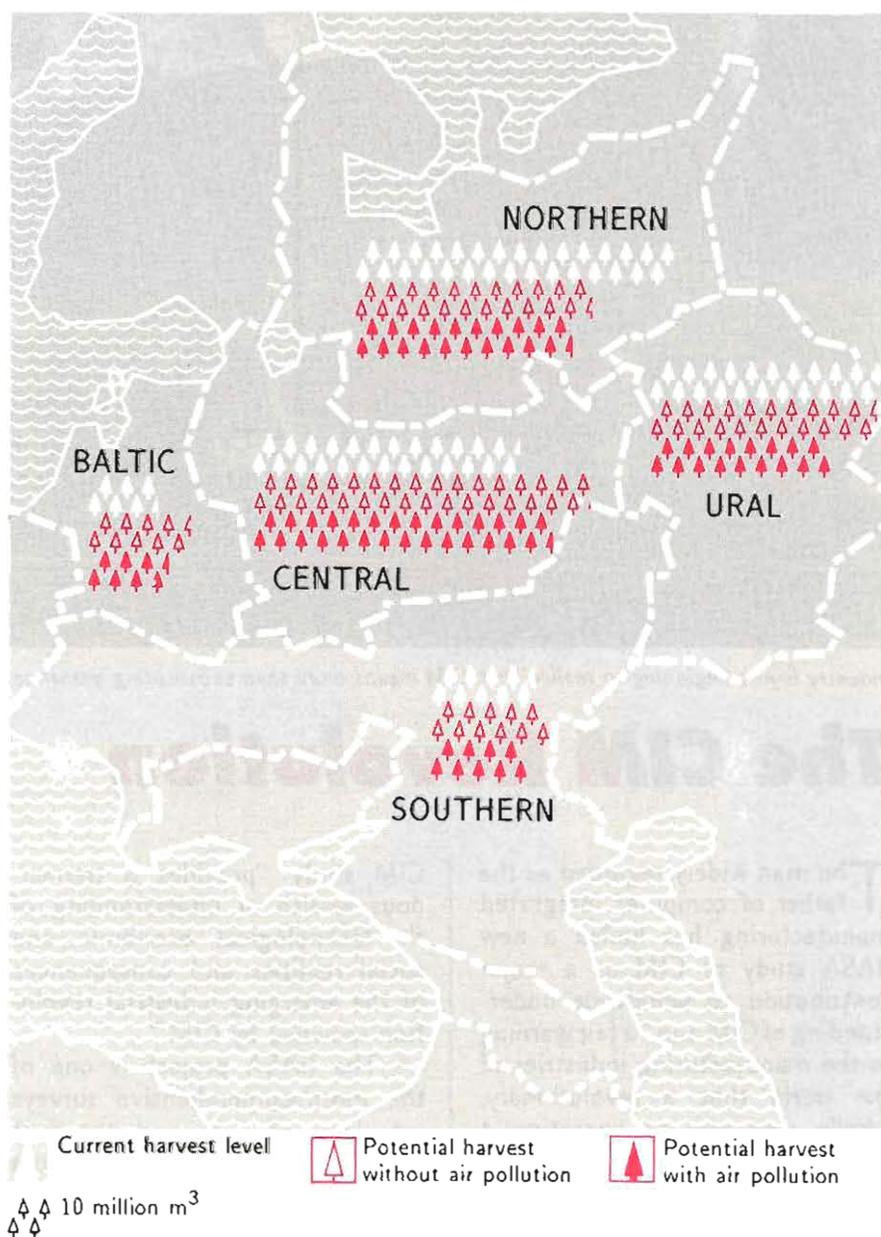
Nilsson and his colleagues also concluded that the Soviets are simply harvesting too much timber. Even without considering the effects of air pollution, he said, “they are over-harvesting in a number of key regions. They will have to reduce their harvest dramatically in some regions to achieve sustainable levels.”

The analyses also underscored weaknesses in IIASA’s RAINS model as it pertains to the Soviet Union. RAINS has proven to be a highly efficient tool for simulating acid depositions and abatement strategies for Western and Eastern Europe (page 9). One characteristic of

the model is that, to simplify calculations, it treats each country as a single emission area: any increase or decrease of emissions is allocated proportionally to every emission source within the country. With the small countries of Europe, this introduces an acceptable error of 5 to 16 percent. But in a country the size of the Soviet Union, the system breaks down.

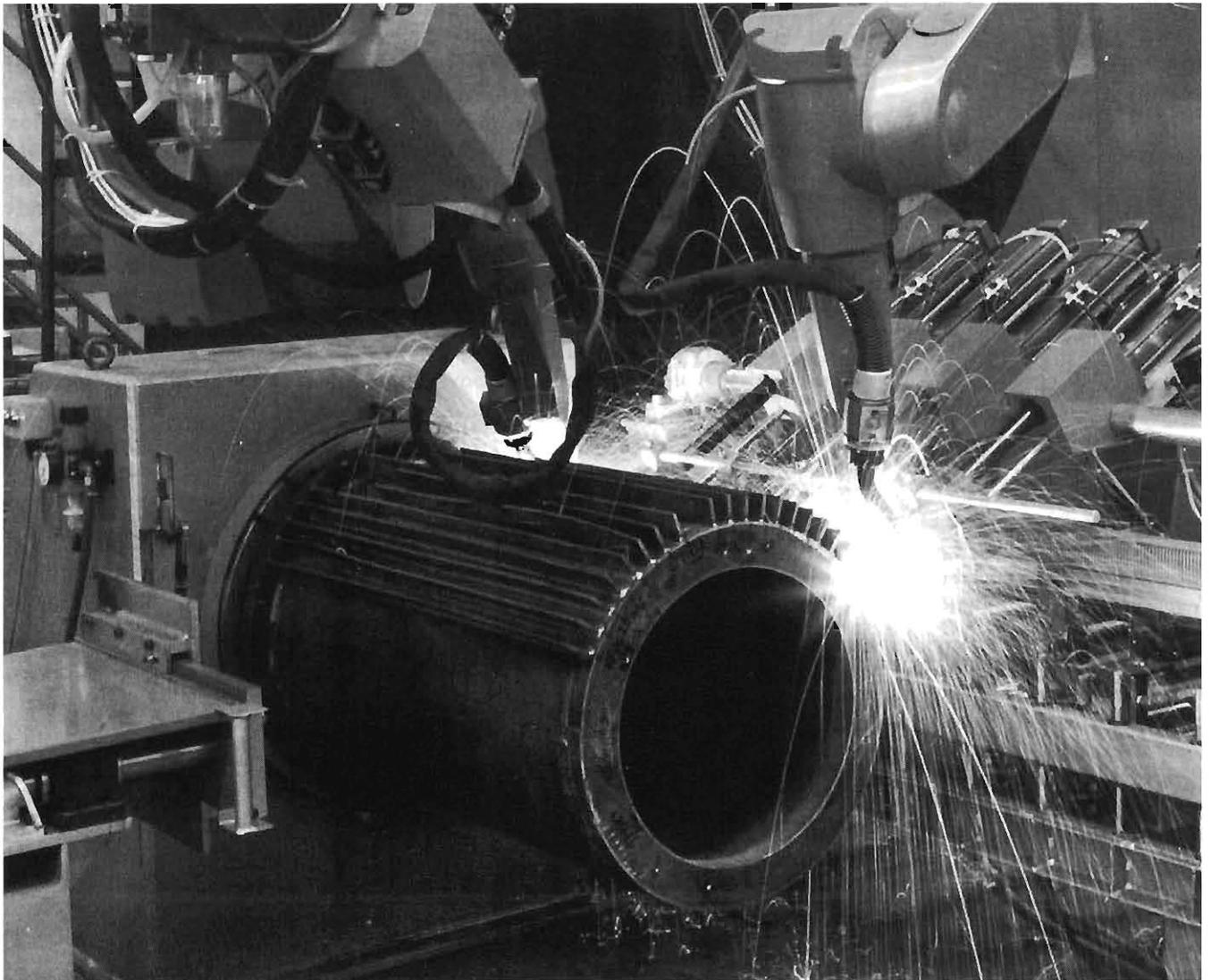
Shaw, leader of IIASA’s Transboundary Air Pollution Project, said that the answer is for Soviet

researchers to work with colleagues at IIASA to divide the USSR into emission regions about the size of smaller European countries. Nilsson added that such an adaptation of RAINS is essential if he is to conduct an analysis of Soviet forests comparable to his studies of forests and forest industries in the rest of Europe. Until the model is suitably adapted, RAINS will not be as useful to Soviet scientists and policymakers as it has been for their counterparts in Europe. ●



Map of the European USSR indicating current annual harvests by region in millions of cubic meters, and preliminary estimates of potential annual harvests for the next century without air pollution and with pollution at current levels.

F E A T U R E



Industry is just beginning to realize that CIM means more than substituting unmanned robots for machine operators.

The CIM Revolution

The man widely regarded as the father of computer integrated manufacturing has hailed a new IIASA study of CIM as a major contribution to worldwide understanding of CIM and "a fair warning to the manufacturing industries of the world that a revolutionary, wholly new way of operating a manufacturing enterprise, be it large or small, is now coming into being." Eugene Merchant, formerly chief scientist at Cincinatti Milacron, told 105 participants in a CIM conference held last July in Laxenburg, Austria, that IIASA's

CIM study "provides a tremendous wealth of understanding of the technological, economic, and social realities and consequences of the emerging industrial revolution spawned by CIM."

The IIASA project is one of the most comprehensive surveys yet done of CIM and the first to include extensive data from Eastern Europe. Project leaders Robert Ayres and Jukka Ranta worked with experts from 16 countries and five international organizations for four years to produce the study. Results will be published in

five volumes and as a database on diskette outlining the use of flexible manufacturing systems (FMS) in 28 countries. The first four volumes—a summary volume; a survey of CIM technologies, present and future; a description and analysis of diffusion of CIM technology; and a study of its economic and social impacts—are to be published in 1991 by Chapman & Hall, London. A fifth volume dealing with CIM organizational and managerial issues will be published late in 1991 as a monograph by the Harvard Business Review Press. A diskette

with the FMS database is available from IIASA, as is a volume of proceedings of the July conference.

The database contains detailed information on 880 FMS systems in 28 countries. For each system it provides data on up to 35 parameters, including name of user, country, and year of installation; the system's technical features, including numbers of robots, numerically controlled (NC) machines, and types of transport and storage systems; and its economic outcomes and operating benefits, such as labor and lead-time reductions. In addition, the database comes with an interface that allows users to compute statistics across the database or for particular countries – the interface uses Lotus spreadsheet software – or to produce scatter diagrams that give an impression of the relationships between different parameters. The database and interface package was widely praised at the July conference.

Discussions and presentations at the conference underscored the revolutionary implications of CIM. Merchant, among others, said that manufacturers are only now beginning to appreciate that CIM will entail completely new corporate structures and thinking, rather than the creation of islands of automation through the piecemeal application of computers to manufacturing. Truly integrated manufacturing, he said, entails a "wholly new approach" dependent on "a culture of cooperative relationships" among generalists and systems integrators. Ranta added that it is misleading to equate the use of robots with automation. Mature, stand-alone applications of robots, he said, are "a harbinger rather than a cornerstone of truly modern automation."

Ayres presented data indicating that a switch to CIM would allow a typical firm to maintain output with half as many machines in a plant half as large. Direct labor costs, now typically 20 percent

of value-added, would fall some 75 percent, inventory of work-in-progress would decline close to zero, and lead time for deliveries would fall to a matter of days. Moreover, reprogrammable production machines can be switched to a different product in the time it takes to load a new program, eliminating costly retooling. As a result competitiveness will be based more and more on the quality of a firm's computer software, its organizational structure, and its responsiveness to the market – getting out new products quickly. For consumers the upshot will be a wider selection of higher-quality, lower-priced products.

“
Studies of CIM repeatedly stress the need for governments to adopt vigorous labor policies including provisions for training and retraining of adult workers”

Some analysts, particularly in the USA, have expressed concern about the potential social impact of CIM, especially the prospects of a squeeze on middle-income groups and consequent polarization of society resulting from the elimination of relatively well-paid, semiskilled jobs in manufacturing. Indeed, Ayres estimates that employment in manufacturing, currently about a quarter of all jobs in OECD countries, will drop to 10 percent by the middle of the next century as CIM elimi-

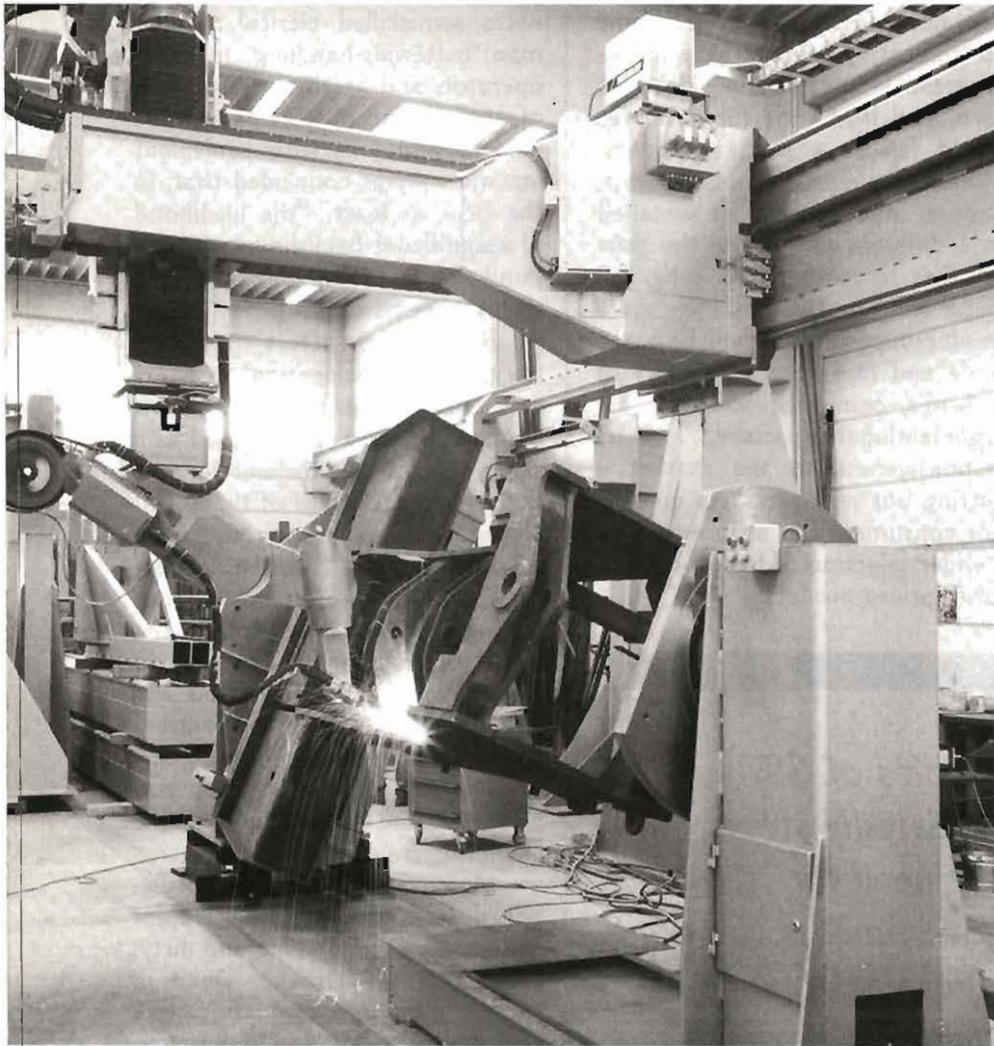
nates semiskilled clerical, draftsman, materials-handling, machine operator, and assembly jobs. Few of the displaced workers will be able to find jobs with equivalent incomes. Ayres concluded that, in the USA at least, "the likelihood of a significant backsliding of some families from the middle class into poverty seems clear."

But several factors may limit the degree of dislocation. In many developed countries, employment in manufacturing has declined as a share of total employment for several decades. A third of those employed in manufacturing now have no direct contact with the production process; Ayres estimates that no more than 12 percent of the US labor force and 20 percent of the Japanese labor force now has any hands-on role in production. CIM's capacity to produce higher-quality goods at lower prices may also stimulate other sectors of the economy, creating new jobs.

Moreover, the jobs that will disappear from manufacturing are, for the most part, mundane and dirty; those that will emerge, albeit in smaller numbers, will be more skilled positions. And if employers and governments accept the need for more training and retraining of workers – something stressed by virtually every study of CIM – at least some of the displaced workers will assume those new jobs.

The advent of CIM may also prompt the repatriation of many manufacturing plants that had been shifted offshore in recent decades. Those moves were made to take advantage of low-cost labor available in developing countries, especially on the Pacific Rim. But "as the direct manufacturing component of total cost declines, large firms will be increasingly disinclined to fragment their operations in this way, with the accompanying penalties in terms of more complicated logistics, inventory controls, and so on," Ayres said. "The logic of the situation would seem to indicate a trend back toward the collocation

FEATURE



Welding robot (above) and control device (below) for reprogramming on the shop floor. A new IIASA database includes detailed information on 880 flexible manufacturing systems in 28 countries.



of production with major markets."

For the many developing nations that based their industrial development strategies on low-wage labor, such a trend could be devastating. The impact on Eastern European countries currently in transition could be equally significant. There was a consensus at the conference that this area needs further study.

Near the end of the conference Harvey Brooks of Harvard University summarized some of the areas in which governments and policymakers can help their societies exploit CIM. Governments can help spread advanced technologies by promoting technical standards and by supporting diffusion directly. Brooks cited the example in the USA of NASA, which he said has a technology extension program budgeted at 0.1 percent of its research and development program – "a ridiculous extension policy." Brooks also called for incentives to encourage long-term planning for investment in production technology. And he called on governments to support social and organizational research related to new technologies, as well as high-risk generic research related to the technologies.

Above all, said Brooks, governments should adopt vigorous labor market policies to promote the mobility and versatility of their work force. Regular retraining of adult workers will be essential, as well as a public education system that gives new workers the basic skills to handle later retraining. In addition, he said, governments should adopt social policies that reduce the risk of job changes and moving, including portable pensions and national health-care schemes. Such combinations of policies have allowed some countries, notably Sweden, to phase out obsolete industries with a minimum of disruption. The emphasis, said Brooks, should be not on job preservation but on employment preservation in an age of rapid change.

F E A T U R E

Advising Soviet Reformers

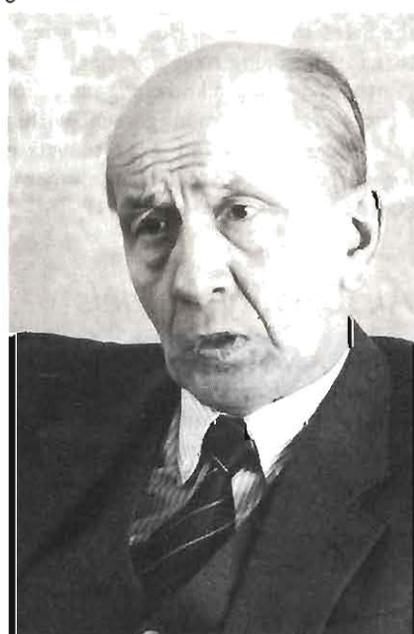
IIASA's Economic Reform and Integration (ERI) Project continues to provide a useful sounding board for Soviet reformers trying to shift the USSR to a market economy. Prominent Soviet officials have said ERI meetings and seminars had considerable impact on the shaping of the economic reform proposal generally known as the 500-Day Plan or the Shatalin Plan after economist Stanislav Shatalin, a leading Soviet reformer and a member of the USSR Presidential Council. The plan has been adopted by the Russian Republic and is currently under debate in the USSR Supreme Soviet. Soviet President Mikhail Gorbachev has expressed support for the plan.

Shatalin is the inspiration for IIASA's ERI Project. In 1989, recognizing the lack of Soviet experience with market economies, he asked IIASA to establish a mechanism to allow Soviet reformers to exchange ideas with outside experts. The project quickly took shape under the leadership of Merton Peck, a highly regarded US economist associated with Yale University, as a series of small working groups comprising eminent economists from the United States, Western and Eastern Europe, and Japan. The five groups focus on capital market and privatization; labor market and employment; opening of the economy; economic stabilization; and prices and competition.

The first full ERI meeting was held in July in Sopron, Hungary. Participants included three of the eleven members of the group that drafted the Shatalin Plan, including Eugeny Yasin, department chief in the USSR State Commission on Economic Reform. Written reports were dispatched to the State Commission, which in turn passed them to senior officials in the offices of President Gorbachev and Boris



Soviet market: A select team of economists from Europe, the USA, and Japan are working closely with leading reformers in the Russian Republic and the central government.



Stanislav Shatalin

Yeltsin, President of the Russian Republic. In a speech to the All Union Parliament in September, Yasin mentioned IIASA's help in formulating the 500-Day Plan. Deputy Prime Minister Grigory Yavlinsky of the Russian Republic also noted IIASA's contribution in a speech on Soviet television.

Yavlinsky and Nikolai Petrakov, an economic adviser to President Gorbachev, are expected to be among 14 participants at an ERI meeting in November in New Haven, Connecticut, USA, to discuss further refinement of the 500-Day Plan and future projects involving IIASA.

The ERI Project will be the principal focus of a future issue of *Options*. ●

RESEARCH

Climate Strategies

The Dutch National Institute of Public Health and Environmental Protection (RIVM) and IIASA's Transboundary Air Pollution Project have agreed to modify RIVM's Integrated Model for Assessing the Greenhouse Effect (IMAGE) to produce regionalized scenarios of temperature and precipitation change. These scenarios will be linked to IIASA's Global Vegetation Model. Parameters for assessing the effect of climatic change on food crops will be obtained from the UN Food and Agriculture Organization, then incorporated into the Global Vegetation Model by IIASA's Biosphere Dynamics Project and RIVM. IIASA's Environmentally Compatible Energy Strategies Project and Collection and Evaluation of Energy/CO₂ Data Project will provide scenarios of greenhouse gas emissions. The modified model will be used by IIASA's Environment and Development Project to examine interactions among population, consumption, pollution generation, and environmental change in preparation for the 1992 UN Conference on Environment and Development in Brazil. (Contact: *Roderick Shaw, IIASA*)

Pollutant Inventories

The Italian Environment Ministry has contracted with the Transboundary Air Pollution Project to coordinate development of a common emission inventory for sulfur dioxide (SO₂), nitrogen oxides (NO_x), ammonia (NH₃), and volatile organic compounds (VOCs) for the member nations of the Pentagonale (Austria, Czechoslovakia, Hungary, Italy, and Yugoslavia). (Contact: *Markus Amann, IIASA*)

Emission Models

The Swedish Environmental Protection Agency of Solna, IIASA's Transboundary Air Pollution Project, and the Institute of Industrial Protection (IIP) of the University of Karlsruhe, Federal Republic of Germany, began a five-month project to link the

IIP energy flow optimization models (EFOM-ENV) with IIASA's RAINS model. (Contact: *Markus Amann, IIASA*)

Soviet Reforms

IIASA's Economic Reform and Integration Project has been awarded one-year research contracts from the Soviet Academy of Sciences, the Ford Foundation of New York (USA), the Pew Charitable Trusts of Philadelphia (USA), and the Japan Foundation of Tokyo. See story page 15. (Contact: *Merton Peck, IIASA*)

Impacts Assessment

Within the framework of the WEUREKA Project and in collaboration with research institutions in Italy, IIASA's Advanced Computer Applications Project is working on components of an environmental information and decision support system for river basin planning and management. (Contact: *Dr. Kurt Fedra, IIASA*)

Water Management

The Advanced Computer Applications Project and the Water Resources Management Division of the Swedish National Board of Agriculture in Jönköping have agreed to work jointly to develop a knowledge base for agricultural water management within the framework of an expert system for environmental impact assessment. (Contact: *Kurt Fedra, IIASA*)

Air Quality Models

The Advanced Computer Applications Project signed an eight-month agreement with the Entrepreneurship Institute and the Systems Research Institute of the Polish Academy of Sciences to develop existing single and multilayer mesoscale models; apply dispersion models for optimal planning of emission reduction; and optimize problem statement and solving. (Contact: *Kurt Fedra, IIASA*)

Water Resources

With support from several Japanese organizations, members of IIASA's Water Resources Project, Japanese researchers, and the Indonesian Ministry of Public Works will develop a regional planning support system based on the Interactive River System Simulation (IRIS) software program developed at IIASA. (Contact: *Kazimierz Salewicz, IIASA*)

Climate Change

IIASA's Climate and Ecology Related Energy Program signed a two-year agreement with the Economic Research Center of the Central Research Institute of Electric Power (CRIEPI) of Tokyo to evaluate policies designed to mitigate global warming. The study will identify ways of reducing environmental impacts of energy consumption, and will also relate the institutional aspects of economic and social development to their impact on the environment. (Contact: *Yuri Sinyak, IIASA*)

YOUNG SUMMER SCIENTISTS' PROGRAM

Each year, from June to August, IIASA holds the Young Scientists' Summer Program (YSSP). This work-study program offers an opportunity for a small group of exceptional students, mainly from countries with IIASA member organizations, to take part in an international exchange of experience and ideas on the development and application of systems analysis. The 1991 program duration is 3 June until 30 August. Applicants should be graduate students expecting to gain Ph.D.'s or equivalent degrees within the next two years. A good knowledge of English is essential. Applications should be made before 17 January 1991. For further information contact *Margaret Traber*, YSSP Coordinator, IIASA.

CONFERENCES

Recent Conferences

International Energy Workshop, Honolulu, Hawaii, USA, 7-8 June.

The workshop included discussions of energy supply, demand, and prices as well as presentations on climate change and developments in Eastern Europe. Among the observations: the potential for energy saving in Eastern Europe will at least compensate for the growth in demand due to new investments, yielding a net demand growth comparable to Western Europe; and the major share of global energy consumption growth will occur in developing nations. (Contact: Leo Schrattenholzer, IIASA)

9th International Conference on Analysis and Optimization of Systems, Antibes, France, 12-15 June.

Some 100 specialists discussed numerical algorithms for a range of control and optimization problems; deterministic optimal control; stochastic and adaptive control; algebraic and geometric systems theory; distributed parameter systems; linear and nonlinear filtering; games; and signal processing.

The plenary focused on optimization in financial economics, combinatorial optimization, and chaos in dynamical systems. (Contact: INRIA, Domaine de Voluceau, B.P. 105, F-78153 Le Chesnay, Cedex, France)

Statistical Measures in the Transformation of Economic Systems, Laxenburg, Austria, 27-29 June.

Eighteen experts discussed research on nontraditional socioeconomic indicators undertaken by IIASA's Economic Reform and Integration Project and other institutions. They also agreed on five topics for a seminar to be held in Sochi, USSR, 15-17 October 1990: output and growth rates; output structure and evaluation of capital and labor; income consumption and savings; productivity; and monetary statistics. (Contact: Peter Aven, IIASA)

International Environmental Negotiations, Laxenburg, Austria, 7-8 July.

This meeting was part of a study by IIASA's Processes of International Negotiations (PIN) Project of international environmental negotiations.

The object was to identify, assess, and suggest ways to overcome the unique difficulties of such negotiations. (Contact: Gunnar Sjöstedt, IIASA)

Boreal Forests, Arkhangelsk, USSR, 16-26 July.

Some 90 scientists discussed the decline of boreal forests and the threat posed by CO₂-induced warming of the climate. A working group was set up to discuss the possibility of establishing joint projects and an international organization focused on boreal forests. (Contact: Allen Solomon, School of Forestry and Wood Products, Michigan Technological University, Houghton, MI 49931, USA, or Nadejda Tchebakova, IIASA)

Soviet Economic Reform, Sopron, Hungary, 23 July-3 August.

Sixty economists and Sovietologists involved with IIASA's Economic Reform and Integration Project discussed background papers and draft legislation provided by Soviet officials. See story page 15. (Contact: Merton Peck, IIASA) ▷



1990 YSSP candidates: IIASA is now accepting applications for the 1991 Young Scientists' Summer Program.

CONFERENCES



IIASA Deputy Director Alexander Kurzhanski (left) with Igor Makarov, chief learned secretary of the Academy of Sciences of the USSR, during a recent visit to IIASA.

Advances in Decision Support Systems, Laxenburg, Austria, 20–24 August.

This workshop was organized by IIASA's Methodology of Decision Analysis Project to discuss applications of DSS in management. Scientists and managers from leading Japanese industrial enterprises reviewed the background and applications of DSS in Japan. Participants also reviewed the international comparative study on design and implementation of DSS for resource-constrained project scheduling. (Contact: *Marek Makowski, IIASA*)

Computationally Intensive Methods in Simulation and Stochastic Optimization, Laxenburg and Vienna, Austria, 23–26 August.

Participants discussed new methods for combining system simulation and system optimization in an efficient way. The 40 papers presented dealt with optimization of discrete event systems; speedup for stochastic approximation; algorithms for parallel hardware; simulated annealing and neural networks; and random number generation. The proceedings will be published by Springer-Verlag early in 1991. (Contact: *Georg Pflug, IIASA*)

Operations Research 1990, Vienna, Austria, 28–31 August.

Some 1000 participants from 40 countries exchanged information on operations research with particular emphasis on applications and on the interaction between operations research and computer science. (Contact: *Gustav Feichtinger, Department of Operations Research and Systems Theory, Institute of Econometrics, Technical University of Vienna, Argentinierstrasse 8, A-1040 Vienna, Austria*)

Forthcoming IIASA Conferences

November 19–23, 1990: The Environment in East Europe. Laxenburg, Austria (Contact: *Joseph Alcamo, IIASA*)

November 21–23, 1990: Economically Efficient and Environmentally Sound Energy Strategies for Sustainable Food Production, Dresden, Federal Republic of Germany (Contact: *Tibor Vasko, IIASA*)

December 9–14, 1990: Global Optimization, Sopron, Hungary (Contact: *Yuri M. Kaniovski, IIASA*)

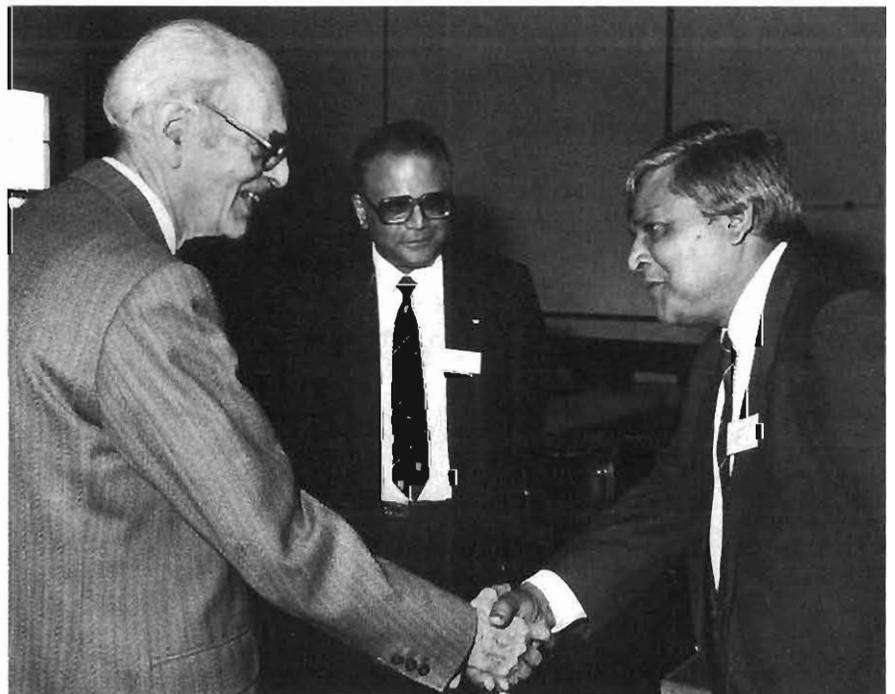
February 4–6, 1991: Ammonia Emissions in Europe – Emission Factors and Abatement Costs, Laxenburg, Austria (Contact: *Ger Klaassen or Markus Amann, IIASA*)

May 13–17, 1991: Electricity and the Environment, Helsinki, Finland (Contact: *Joint Secretariat, c/o IAEA, P.O. Box 100, A-1400 Vienna, Austria*)

June 18–20, 1991: International Energy Workshop, Laxenburg, Austria (Contact: *Leo Schrattenholzer, IIASA*)

August 5–23, 1991: Summer School in Applied General Equilibrium Modeling, Laxenburg, Austria (Contact: *Lars Bergman, Stockholm School of Economics, P.O. Box 6501, S-113 83 Stockholm, Sweden*)

August 27–29, 1991: Workshop on Applied General Equilibrium Modeling, Laxenburg, Austria (Contact: *Lars Bergman, Stockholm School of Economics, P.O. Box 6501, S-113 83 Stockholm, Sweden*)



Nathan Keyfitz, leader of IIASA's Population Program (left), greeting Jagdish Manrakhan, vice-chancellor of the University of Mauritius (center), and Jawaharlal Baguant, head of the university's School of Engineering. The two men were at IIASA to discuss a project aimed at modeling interactions among population, technology, economy, and environment on Mauritius.

NEWS

Positions Available

The Regional Environment Center for Central and Eastern Europe, which opened 6 September 1990 in Budapest, has asked that we notify readers of several positions available. The center is currently seeking associate program managers for:

- information resources
- institutional development
- clearinghouse
- education and training

The center is an independent, non-advocacy, nonprofit organization whose mission is to preserve, improve, and protect environmental quality and public health in the region; and to support nature conservancy by utilizing worldwide experience and resources.

Information on job applications can be obtained from Price Waterhouse: in Budapest (Alagut utca 5., 1013 Budapest, Hungary; telephone 36 1 155 9801, fax 36 1 155 9256) or in London (East European Services Group, 14 Chapel Yard, Union Street, London, SE1 1SZ; telephone 44 71 939 3000).

For information on the Regional Environment Center for Central and Eastern Europe, contact the center itself at Miklos ter 1., 1035 Budapest, Hungary; telephone 36 1 168 6284, fax 36 1 168 7851.

In Memoriam

The deaths of two US IIASA alumni have recently been announced: Dr. Miles Lee Merians, a researcher with IIASA's Management and Technology Program (1981-1982), in Sausalito, California, 5 September 1990; and Dr. William Orchard-Hays, with IIASA's System and Decision Sciences and Food and Agriculture Programs (1975-1979), in Silver Spring, Maryland, 2 November 1989.

Awards and Appointments

Gerd Esser (FRG) of the Biology Department of the University of Osnabrück has been named Leader of

IIASA's Biosphere Dynamics Project. Bertram Spector (USA) Principal and Manager, Decision Support Systems Practice, Booz, Allen, and Hamilton Inc. of Washington, DC, has been appointed Leader of IIASA's Processes of International Negotiations Project.

Nathan Keyfitz, Leader of IIASA's Population Program, has been awarded the Paul Lazarsfeld Award of the American Sociological Association in recognition of his contributions to empirical work in social science. Keyfitz also received an honorary degree from the Institute of Statistics of the University of Siena, Italy.

Visitors to IIASA

Among those recently visiting IIASA were Igor M. Makarov, Chief Learned Secretary of the Academy of Sciences of the USSR; Georgy Arbatov, Director of the Institute of the USA and Canada Studies of the Academy of Sciences; a Chinese delegation consisting of Jingyuan Yu, Deputy Director of the Beijing Institute of Information and Control as well as Secretary General of China Social Economic System Analysis and Research Society, Yuxian Gao, Deputy General Manager of China Statistical Information and Consultancy Service Center, Zhongfan Li, General Secretary of CSESARS, Xichun Wang, Project Coordinator at BIIC, and Xianying Jiao, Division Director of BIIC; a group of researchers from the National Science Council in Taipei, Taiwan, headed by Chairman Han Min Hsia; Gerald Dinneen, Foreign Secretary of the US National Academy of Engineering in Washington, DC; Jean-Michel Chassériaux, from the French Ministry of Research and Technology in Paris; a US National Science Foundation delegation consisting of Richard Ries, Executive Officer at the Directorate for Scientific, Technological, and International Affairs, William Blanpied, Senior International Analyst at the Division of International Programs, both in Washington, DC, and Charles Owens, Head, European NSF Office in Paris; Harald Uhl, Head of the Division of Social Sciences and Scientific Research at the Ministry for Research and Technology in Bonn, Federal Republic of Germany.

PUBLICATIONS



IIASA Books

Two new IIASA books, now off press, are available from your regular book supplier or direct from the publisher.

Climate Change and World Agriculture. M. Parry. Earthscan Publications: London. ISBN 1-85383-065-8.

Future Demographic Trends in Europe and North America: What Can We Assume? W. Lutz, editor. Academic Press: London, New York, San Diego, Boston, Sydney, Tokyo. ISBN 0-12460-445-5.

IIASA Reports

In addition, the following IIASA reports are now available from the Publications Department at the price indicated:

Toward Ecological Sustainability in Europe: Climate, Water Resources, Soils, and Biota. A. M. Solomon and L. Kauppi, editors. August 1990. RR-90-6. US \$15.

Towards the Fifth Kondratiev Upswing: Elements of an Emerging New Growth Phase and Possible Development Trajectories. A. Grübler and H. Nowotny. November 1990. Reprinted from *International Journal of Technology Management*, Vol. 5, No. 4. RR-90-7. US \$5.

Forest-Pest Interaction Dynamics: The Simplest Mathematical Models. M. Ya. Antonovsky *et al.* November 1990. Reprinted from *Theoretical Population Biology*, Vol. 32, No. 2. RR-90-8. US \$5.

For further details contact Robert McInnes.



◆ Capital Cities of NMO Countries

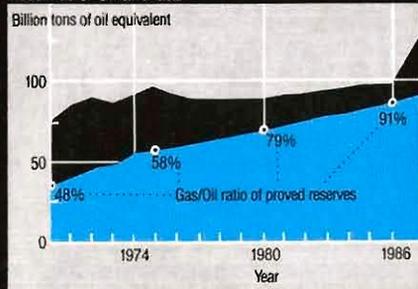
IIASA

International Institute for Applied Systems Analysis

IIASA's ROLE

The International Institute for Applied Systems Analysis is a non-governmental research institute sponsored by scientific organizations from East and West. It brings together scientists from more than 20 nations and a variety of disciplines. Its purpose is to develop practical options to deal with issues of international importance through the application of system sciences. The Institute's effectiveness is rooted in its international sponsorship and focus, its nonpolitical status, its freedom to choose its research agenda from a variety of pressing international issues, its interdisciplinary base, and its worldwide network of collaborating organizations.

Reserves of Oil and Gas



RESEARCH

Recent projects have included studies on global climate changes, world agricultural potential, energy resources, acid rain, computer integrated manufacturing, the social and economic impacts of demographic changes, and the theory and methods of systems analysis. The basis of IIASA's scientific

Risk Analysis in the Netherlands



research is the development and use of computer models to help define how global issues and problems may evolve in the future. The objective is to develop viable policy options that can be implemented through international cooperation.

Global Mean Temperature



MEMBERSHIP

IIASA was founded in 1972, on the initiative of the USA and the USSR, with the eventual participation of another 14 countries in the East and West. IIASA has member organizations in the following countries: Austria, Bulgaria, Canada, Czechoslovakia, Finland, France, the German Democratic Republic, the Federal Republic of Germany, Hungary, Italy, Japan, the Netherlands, Poland, Sweden, the Union of Soviet Socialist Republics and the United States of America.

FURTHER INFORMATION

Further information about IIASA and its work is available from: The Office of Communications, International Institute for Applied Systems Analysis, A-2361 Laxenburg, Austria. Telephone: (0 22 36) 715 21-0.