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**Working Paper**

## Forestry Research: A Provisional Global Inventory

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CENTER DISCUSSION PAPER NO. 503

FORESTRY RESEARCH: A PROVISIONAL GLOBAL INVENTORY

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### **Abstract: Forestry Research: A Provisional Global Inventory**

Data on resources allocated to forestry research in either developing or developed countries are not widely available. This paper presents a first attempt to construct an international inventory of spending and scientist man-years devoted to forestry research. The problems inherent in collecting internationally comparable data are discussed. Country data for about 40 countries are presented and regional estimates for investment levels worldwide are given. The data show consistently low levels of research investment in the developing countries and regions of the world.

Measures of research spending and manpower intensities are also presented and compared with the same measures for agricultural research. These comparisons indicate that all countries, regardless of region or income group, have been investing more in agricultural research than in forestry research. The final data section of the paper explores some specific forestry research station characteristics obtained from approximately 140 completed survey questionnaire returns. These characteristics include the distribution of research expenditures by area of research, type of tree, and funding sources; and the distribution of personnel by administrators, scientists, and technicians.

The concluding section of the paper suggests both that the inventory needs to be improved and expanded and that the area of forestry research needs to be given more emphasis by individual countries and by international aid donors.

## Forestry Research: A Provisional Global Inventory

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At present no inventory of resources devoted world-wide to research on forest production exists. Reliable estimates of spending or scientist man-years (SMYs) directed toward forestry research in different regions have not been available. International aid agencies and national governments, therefore, have had little in the way of internationally comparable data to guide investment decisions. International aid agencies, for example, have not known how the developing nations compare with more developed countries in terms of research intensities (research spending relative to the value of harvested forest products). Many national forestry agencies do not know how much research is being undertaken in other countries with similar forest production problems or, in many cases, how much research is being undertaken by other organizations within their own country.

Until 1971, there was a similar lack of data for agricultural research and extension. A survey conducted by Evenson and Kislev in 1971 provided an international inventory of resources directed towards agricultural research and extension. This inventory was updated and expanded in 1974 by Boyce and Evenson and again in 1982 by Judd, Boyce, and Evenson.<sup>1/</sup> The experience gained in the compilation of these inventories has shown that the process is both difficult and valuable. It is difficult because few governments are in a position to provide inventories of national expenditures. In many cases no clear demarcation exists between research activities and other activities such as regulation and management. Such inventories are valuable, however, because

they can provide policy-makers with a basis for determining where severe under-investment in research or extension activities exists.

The present paper develops an inventory of resources devoted to forestry research. The inventory is based primarily on returns from a mail survey of forestry research institutions, supplemented wherever possible by secondary data sources such as annual reports from specific institutions or general governmental reports on research spending in a number of fields including forestry. Although the data at this stage are incomplete because they do not cover all research institutions, the coverage they provide is sufficient to be able to make reliable estimates of global forestry research investment.

The estimates of worldwide investment, while based on this preliminary inventory, do have important policy implications. They show, for example, that huge disparities exist between developed and developing countries in terms of research intensities. Developing countries have agricultural research intensities roughly one-third as high as those for developed countries. For forestry research, the intensities are less than one-tenth as high in the developing countries as they are in the developed countries. Overall, forestry research intensities are consistently lower than agricultural research intensities.

In Part I of this paper, the problems inherent in compiling forestry research data are discussed. In Part II, the results of the national investment survey are reported, and then a number of comparisons between forestry research and agricultural research investment patterns are made in Part III. Data on budgets, staffing, sources of funds and program emphasis for approximately 140 research institutions are presented in Part IV. In the final section, the major trends observed in the data are discussed and

suggestions are made for ways to improve the data base for forestry research resources.

## **I. DEFINITIONAL AND MEASUREMENT ISSUES**

One of the major definitional problems encountered in developing a global inventory of forestry research investment is defining what forestry research is. To some foresters and program administrators, forestry research relates only to activities surrounding the growing and harvesting of trees. Others include activities involving the manufacture and marketing of products derived from trees. The forestry research expenditures presented in the tables in Parts II and III of the paper are expenditures for both forest production and forest product research. The station data contained in Part IV provides some insight into the mix of production/product research for the major regions of the world.

Past experience with the development of agricultural research inventories (Kislev and Evenson, 1975; Boyce and Evenson, 1975; and Judd, Boyce, and Evenson, 1983) proved to be of value in the present endeavor because many of the definitional problems encountered were the same. The definition of what activities constitute research varies somewhat from country to country and from institution to institution. For example, depending on the sophistication of the organization, one group might classify its activities as research while another group might consider similar work to be demonstration or extension. Or, in some countries, biology teachers and professors carrying out botany research on woody species might have their work included under forestry research. While this type of work is interesting and necessary to the advancement of science, it may have little bearing on the advancement of professional forestry objectives.

The quality of research also varies from country to country and from

institution to institution. Some "research" may be poorly organized and devoid of imagination and hence not real research.

The nature of forest production itself often hinders the development of quality research projects. For some research objectives, the benefits from the research will not be experienced during the lifetime of the researcher. Research financed by international aid agencies is usually on a time span of 3 to 5 years. Compared to the life span of a tree, this is too short a period to become involved in studies that cover a significant portion of the life of a tree, even if one is dealing with fuelwood or short rotation trees in the tropics. As a consequence, many research studies are very short-term in outlook, and financing of research is often on a crash basis which does not allow adequate lead time to assemble the plant material and qualified researchers required to produce quality research.

The quality of research scientists can vary as much as the quality of the research itself. Scientific training varies by academic system so one cannot impose a single standard, e.g., completion of a doctorate, to define a scientist. Further, many scientists may be engaged in multiple activities and do little actual research. Some forestry professors may spend most of their time teaching while others devote a substantial proportion of their time to research.

One final problem encountered in developing both the present inventory as well as the agricultural research inventories is that of converting local currencies into U.S. dollars.

These problems defeated efforts to construct an inventory of agricultural research until 1971 and have defeated similar efforts in forestry research in the past. The first agricultural research inventory did not overcome all of these problems. Nor, for that matter, has the most recent

agricultural research inventory resolved them all. It is clear from experience, however, that most of these problems can be dealt with satisfactorily and that the development of improved data bases requires the production of an initial data base and a demonstration that such a data base is useful. Only then can progress be made toward more reliable data.

It is in this spirit that the current inventory is presented. The most reasonable adjustments and modifications possible were made in compiling it. The inventory should be useful and should stimulate further efforts to improve upon it. The data base shows clearly that much of the developing world invests practically nothing in forestry research and that research investment relative to the value of product is substantially lower in all regions for forestry than for agriculture. This broad comparative pattern emerges from the data even if one is highly skeptical of the quality of the data. No reasonable adjustment for errors could alter it.

## **II. FORESTRY RESEARCH: AN ESTIMATED GLOBAL INVENTORY**

We utilized two sources of data in constructing the global estimates of forestry research expenditures and Scientist Man-Years (SMYs) reported in this section. We utilized data from more than 140 survey questionnaires that were returned by forestry research institutions (more than 400 were sent). To facilitate the study and to obtain more accurate data, the questionnaires were translated into several languages. We also obtained estimates from as many secondary sources as possible.

We were able to obtain what we considered to be "hard" estimates of forestry research expenditures and SMYs for 46 countries for the years 1970, 1975, 1980 and 1981. We had questionnaires returned from over 90 countries, but in many cases we could not develop national estimates from these questionnaires because they covered only a single institution in the country.



The 46 countries, however, do conduct 75 percent of the world's forestry research, and if we consider the estimate for the USSR to be a reasonable estimate, the 46 countries plus the USSR conduct close to 90 percent of the world's forestry research.

Data for the 46 countries are reported in Table 1.2/ It shows that among the low-income developing countries for which data are available, India has been spending much more than any other country even though its spending in 1981 was only around \$9.5 million (in 1980 U.S. dollars). Indonesia was spending \$3 million in 1981 and Bangladesh around \$1.3 million. Spending levels in the other three countries in this group were very low. The same pattern holds for SMYs with India having many more scientists engaged in forestry research than any other country in the group, followed by Indonesia and Bangladesh.

Spending among the nine middle-income countries in this sample is dominated by Nigeria where spending levels were over \$10 million in 1981. Nigeria also had the most dramatic expansion in investment levels between 1970 and 1981 with spending increasing from \$.6 million to \$7.5 million between 1970 and 1975 and to slightly over \$10 million by 1981. Ghana and the Philippines were both spending almost \$3 million in 1981. However, Ghana's spending level doubled between 1970 and 1981 while spending in the Philippines was actually lower in 1975 and 1980 than in 1970, and was only about 15 percent higher in 1981 than it had been in 1970. In general, however, the 1970s was a period of expansion, in terms of expenditures, for the forestry research programs in these countries, although the rate of growth in expenditures was modest in many of the countries.

The interpretation of the SMY data for the middle-income countries is more problematic because these data are probably not as reliable as the

Table 1. Forestry Research Expenditures and SMY's by Country

Country	Total Expenditures (000 1980 U.S. Dollars)				SMY's (Ph.D and M.S.)			
	1970	1975	1980	1981	1970	1975	1980	1981
<u>Low-Income</u>								
<u>Developing Countries</u>								
<u>Africa</u>								
Kenya	236.6	254.0	281.8	574.7	3.5	6	6	7
Malawi	47.2	97.3	92.6	138.8	7	7	5	5
<u>Asia</u>								
Bangladesh	-	573.5	976.9	1,260.8	-	23	39	49
India	5,205.4	4,336.5	7,315.5	9,441.5	156	218	310	380
Indonesia	879.2	1,655.8	2,502.0	3,010.0	11	24	56	69
Nepal	156.2	140.3	216.7	283.3	2	2	3	3
<u>Middle-Income</u>								
<u>Developing Countries</u>								
<u>Oceania</u>								
Papua New Guinea*	981.7	1,106.1	1,336.5	1,360.4	4	6	4	4
<u>Latin America</u>								
Colombia*	580.9	759.6	990.7	1,124.4	1	1	11	7.5
Paraguay	-	55.1	44.6	89.3	-	2.5	2.5	2.5
<u>Africa</u>								
Congo	381.6	549.6	496.9	828.2	5	7	9	9
Ghana	1,452.9	2,092.7	2,184.9	2,942.9	17	25	30	31
Ivory Coast	636.7	917.1	1,350.5	1,537.7	13	9.5	12	13
Nigeria	644.4	7,477.0	7,490.3	10,207.8	13	38	45	45
<u>Asia</u>								
Philippines	2,520.6	2,061.7	2,177.3	2,951.6	11	33	38	60
Thailand	618.6	766.0	1,303.6	1,868.3	10	24	41	44
<u>Semi-Industrialized</u>								
<u>Countries</u>								
<u>Latin America</u>								
Brazil*	6,449.4	8,799.5	8,062.0	10,782.6	29	33	52	75
Mexico*	868.2	6,749.8	9,835.5	12,850.4	1	4	8	12
Suriname	630.9	458.6	840.4	840.4	2.5	2.5	4	9
<u>Africa</u>								
South Africa	2,657.5	5,046.4	5,228.5	7,488.0	36	53	62	64
<u>Asia</u>								
Cyprus	12.3	17.1	24.1	69.4	1	1	1	1
Iran*	3,513.6	3,405.6	1,200.0	500.0	10	10	6	0
Korea, South	1,793.7	1,904.6	3,664.9	4,112.9	13	24	24	29
Malaysia*	1,755.0	2,814.4	4,811.6	7,466.9	3	6	13	17

\*SMY figures for these countries are probably underestimated, but the questionnaire returns did not contain enough data to permit better estimates.

Table 1 (continued)

Country	Total Expenditures (000 1980 U.S. Dollars)				SMY's (Ph.D and M.S.)			
	1970	1975	1980	1981	1970	1975	1980	1981
<b><u>Semi-Industrialized Countries (cont'd.)</u></b>								
<b><u>Europe</u></b>								
Greece	2,225.3	2,674.8	3,979.0	3,462.5	20	35	60	50
Portugal	754.3	803.9	488.0	672.0	6	8	12	11
Spain	5,478.9	5,850.8	4,827.2	4,927.8	32	46	53	54
<b><u>Western Europe</u></b>								
Austria	1,062.5	3,011.5	3,477.9	3,915.7	103	112	113	116
Belgium	1,078.7	2,450.5	3,398.7	3,740.4	26	31	35	36
Denmark	2,296.9	3,583.4	3,970.2	4,358.9	46	44	47	44
Federal Republic of Germany	15,733.1	32,052.4	31,358.5	34,384.0	230	240	250	245
Finland	18,416.1	16,484.8	15,459.1	16,880.4	107	120	170	180
France	8,653.2	19,096.5	22,665.3	28,360.1	99	123	151	161
Ireland	1,255.7	1,850.4	1,878.7	1,778.8	5	10	15	12
Italy	8,250.7	8,505.1	10,651.2	15,471.5	59	79	103	96
Netherlands	6,877.4	15,196.6	15,488.9	17,605.0	118	127	147	150
Norway	6,217.9	12,143.2	12,458.9	13,988.3	126	120	122	124
Sweden	21,420.5	51,764.3	49,948.0	57,281.9	309	401	490	513
Switzerland	5,312.4	13,743.7	10,807.5	10,974.5	215	215	285	295
United Kingdom	23,386.1	25,246.0	31,297.1	32,562.9	286	310	312	297
<b><u>Other Developed Countries</u></b>								
Australia	20,983.0	27,237.0	27,519.0	30,823.5	102	156	200	200
Japan	23,649.1	34,598.6	65,961.6	66,155.1	649	858	953	962
Canada	109,489.2	95,493.0	115,168.7	133,042.7	1345	1277	1283	1264
United States	130,588.8	165,171.6	176,200.0	196,800.0	1527	1595	1640	1673
<b><u>Planned Economies</u></b>								
Hungary	753.7	1,025.7	1,289.9	1,347.5	19	24	33	33
Romania	2,168.7	1,379.7	1,203.7	1,777.7	100	120	127	130
Yugoslavia	4,216.3	7,100.7	11,200.0	13,367.5	60	105	105	95

expenditure data. As indicated in Table 1, there are a number of countries for which the SMY estimates appear to be too low, but the available questionnaire returns do not contain enough data to permit better estimates. The numbers of scientists engaged in forestry research were highest in the Philippines, followed by Nigeria, Thailand and Ghana. Judd, Boyce and Evenson (1983) found that costs per scientist in agricultural research were high in Africa relative to Asia. A comparison of these figures for the countries in this limited sample suggests this may be the case in forestry research as well. (Thousands of dollars per SMY in 1981 were \$92.0 for the Congo; \$94.9 for Ghana; \$118.3 for the Ivory Coast; \$226.8 for Nigeria; \$49.2 for the Philippines; and \$42.5 for Thailand).

Brazil and Mexico were investing the most in 1981 in forestry research among the semi-industrialized countries, \$10.8 million and \$12.9 million respectively. South Africa and Malaysia were both investing around \$7.5 million, Spain approximately \$5 million, South Korea \$4.1 million, and Greece \$3.5 million. The remaining countries in this group were investing less than \$1 million in 1981. Mexico, as was true for Nigeria, experienced a dramatic increase in expenditure levels between 1970 and 1975. Expenditures increased from \$.9 million to \$6.7 million. Between 1975 and 1981, Mexico's expenditures almost doubled, rising from \$6.7 million to \$12.9 million. With the exception of Iran, Portugal and Spain, the countries in this group all increased investments in forestry research between 1970 and 1981.

The developed countries of Western Europe and the rest of the world generally have had much higher investment levels than the countries of other income groups. Canada and the United States had the highest levels of expenditures in 1981, \$133.0 million and \$196.8 million respectively. Japan, with expenditures of \$66.2 million in 1981, and Sweden, whose expenditures

were \$57.3 million in 1981, also have substantial research programs. These four countries also have the highest number of SMYs. With a few exceptions, the period between 1970 and 1981 was one of program expansion for the developed countries. Japan's expenditures were 2.8 times higher in 1981 than they had been in 1970, France's were 3.3 times higher, Sweden's 2.7 times higher, and Norway's 2.2 times higher. Expenditures generally increased more slowly in the other developed countries.

Although hard data were not achieved for more than these 46 countries, these hard data can be "expanded" to global estimates in a reasonable way. This is done in Table 2. The procedure used was to first obtain data on the total number of publications in forest science in the Commonwealth Agricultural Bureau (CAB) data base for the period 1972-82. This number was available for all countries (see the Appendix). Next, for each region (see Table 2) the average ratio of expenditures to publications for those countries with "hard" expenditure data was computed. A common ratio was used for all African regions, another for all Latin American regions and another for West, South and Southeast Asia. These ratios were then used to "predict" expenditures from the publications data for the missing countries. For consistency, ratios for expenditures/publication for forestry were compared with similar ratios for agricultural research. The resultant ratios of expenditures to the value of product for each country are also checked to be sure that there were not any unusual numbers. The SMY data for many regions was not sufficiently reliable to attempt to estimate a global SMY inventory.

The resultant global forestry research expenditure inventory (and partial SMY inventory) is summarized by region in Table 2. In 1981, world-wide expenditures on forestry research were estimated to be just over one billion dollars. This represents almost double the amount spent in 1970.

Table 2. Forestry Research Expenditures and SMY's  
by Major Geographical Region

Region	Total Expenditures (000 1980 U.S. Dollars)				SMY's (Ph.D. and M.S.)			
	1970	1975	1980	1981	1970	1975	1980	1981
Northern Europe	72,993.2	111,072.1	115,012.0	126,851.2	879	1005	1156	1170
Central Europe	38,717.3	85,551.2	87,196.8	98,979.7	791	848	981	1003
Southern Europe	16,709.2	17,834.6	19,945.4	24,553.8	117	168	228	211
Total Western Europe	128,419.7	214,457.9	222,154.2	250,364.7	1787	2021	2365	2384
Eastern Europe	36,783.2	48,794.5	70,287.3	84,656.5	n.a.	n.a.	n.a.	n.a.
USSR	52,550.9	69,711.1	100,417.1	120,945.9	n.a.	n.a.	n.a.	n.a.
Total Eastern Europe/USSR	89,334.2	111,505.6	170,704.4	205,602.5	n.a.	n.a.	n.a.	n.a.
North America	240,078.0	260,664.6	291,368.7	329,842.7	2872	2872	2923	2937
Oceania	36,233.1	46,864.3	47,568.4	53,143.8	175	268	340	340
Total North America and Oceania	276,311.1	307,528.9	338,937.1	382,986.5	2112	2292	2409	2456
Temperate South America	2,346.5	4,608.6	5,416.5	7,025.4	n.a.	n.a.	n.a.	n.a.
Tropical South America	7,987.2	10,444.0	10,314.1	13,289.9	n.a.	n.a.	n.a.	n.a.
Caribbean and Central America	969.1	7,533.8	10,977.9	14,343.0	n.a.	n.a.	n.a.	n.a.
Total Latin America	11,302.8	22,586.4	26,708.5	34,658.4	n.a.	n.a.	n.a.	n.a.
North Africa	1,356.8	1,679.5	1,790.0	3,411.2	n.a.	n.a.	n.a.	n.a.
West Africa	3,575.4	12,663.1	13,223.4	17,806.0	n.a.	n.a.	n.a.	n.a.
East Africa	2,840.9	3,516.6	3,747.8	7,142.3	n.a.	n.a.	n.a.	n.a.
Southern Africa	3,635.3	6,903.2	7,152.3	10,243.2	n.a.	n.a.	n.a.	n.a.
Total Africa	11,408.4	24,762.4	25,913.5	38,599.7	n.a.	n.a.	n.a.	n.a.
West Asia	6,786.8	6,494.9	6,399.3	7,250.8	n.a.	n.a.	n.a.	n.a.
South Asia	8,273.1	7,792.8	13,129.8	16,951.1	n.a.	n.a.	n.a.	n.a.
Southeast Asia	5,773.4	7,297.9	10,794.5	15,296.8	35	87	148	190
East Asia	26,570.2	37,700.3	71,929.9	72,853.1	n.a.	n.a.	n.a.	n.a.
Total Asia	47,403.5	59,285.9	102,253.5	112,351.8	n.a.	n.a.	n.a.	n.a.
Total All Regions	564,179.4	740,127.1	886,671.2	1,024,563.6	n.a.	n.a.	n.a.	n.a.

North America and Oceania accounted for 37 percent of world expenditures in 1981, down from 49 percent in 1970. Western Europe's share did not change significantly between 1981 and 1970 (24% vs. 23%). The other major region, Eastern Europe--USSR, expanded its share from 16 percent to 20 percent over this period.

The low-income regions of the world account for relatively small shares of global forestry research spending. Latin America increased its share from 2 to 3 percent from 1970 to 1981. Africa increased its share from 2 to 4 percent, and Asia (excluding Japan) increased its share from 4 to 5 percent. It is clear that the developed countries of the world dominate investment in forestry research.

### **III. COMPARATIVE INDICATORS: FORESTRY AND AGRICULTURAL RESEARCH**

Tables 1 and 2 provided a broad overview of the forestry research system. Tables 3 - 5 report three comparative indicators of research systems that allow comparisons between forestry and agricultural research and between forestry research and economic variables. These are: (1) expenditures as a percent of the value of production; (2) SMYs per 10 million dollars of product; and (3) expenditures per SMY. These indicators are computed for 42 countries for which there was "hard" data for both forestry and agricultural research. (Nepal, The Congo, Suriname and Papua New Guinea were included in the forestry research data set, but there were no comparable agricultural research data available for these countries).

Tables 3 and 3A report expenditures as a percent of the value of production and as a percent of the value of production plus imports, by major geographic region and by income group.<sup>3/</sup> The countries in all regions and income groups are consistently spending a larger share of the value of production on agricultural research than on forestry research. This

**Table 3. Research Expenditures as a Percent of the Value of Production,  
by Region and Income Group  
for Forestry Research and Agricultural Research**

Region/Income Group	Forestry Research Expenditures as a % of Production			Agricultural Research Expenditures as a % of Production		
	1970	1975	1980	1970	1975	1980
Africa (6)	.071	.119	.122	.765	.764	1.272
Asia (10)	.056	.079	.075	.983	.998	1.117
Latin America (4)	.060	.068	.053	.510	.648	.887
Europe (19)	.272	.299	.246	1.036	1.010	1.214
North America/Oceania (3)	.316	.291	.269	1.491	1.352	1.234
Low-Income Developing (5)	.019	.023	.019	.222	.230	.451
Middle-Income Developing (7)	.046	.077	.059	.553	.508	.863
Semi-Industrialized (10)	.096	.100	.070	.612	.652	.816
Western Europe (13)	.281	.329	.267	1.106	1.128	1.456
Other Developed (4)	.272	.266	.253	1.723	1.614	1.515
Planned (3)	.166	.133	.148	.853	.795	.690

**Table 3a. Research Expenditures as a Percent of the  
Value of Production Plus Imports**

Region/Income Group	Forestry Research Expenditures as a % of Total Production Plus Imports			Agricultural Research Expenditures as a % of Total Production Plus Imports		
	1970	1975	1980	1970	1975	1980
Africa (6)	.068	.114	.118	.695	.680	1.106
Asia (10)	.052	.072	.068	.813	.751	1.117
Latin America (4)	.058	.067	.052	.477	.584	.773
Europe (19)	.213	.235	.188	.635	.553	.645
North America/Oceania (3)	.297	.271	.250	1.264	1.126	1.034
Low-Income Developing (5)	.019	.023	.019	.206	.209	.419
Middle-Income Developing (7)	.045	.075	.058	.512	.462	.754
Semi-Industrialized (10)	.091	.093	.066	.523	.524	.630
Western Europe (13)	.217	.255	.199	.622	.545	.672
Other Developed (4)	.250	.241	.226	1.398	1.239	1.177
Planned (3)	.146	.116	.135	.747	.691	.600

Note: Number of countries in parentheses.



**Table 4. SMY's per 10 Million (Constant 1980) Dollars of Production, by Region and Income Group for Forestry Research and Agricultural Research**

Region/Income Group	SMY's per 10 Million Dollars of Forestry Production			SMY's per 10 Million Dollars of Agricultural Production		
	1970	1975	1980	1970	1975	1980
Africa (6)	.112	.103	.117	1.135	1.395	1.985
Asia (10)	.126	.192	.127	2.548	2.547	2.744
Latin America (4)	.067	.077	.059	1.324	1.377	1.556
Europe (19)	.394	.303	.274	1.735	1.732	1.920
North America/Oceania (3)	.359	.306	.263	1.123	1.068	.969
Low-Income Developing (5)	.053	.092	.073	.685	.831	1.251
Middle-Income Developing (7)	.050	.070	.069	1.340	1.410	1.758
Semi-Industrialized (10)	.093	.108	.080	1.391	1.323	1.468
Western Europe (13)	.405	.310	.281	1.441	1.516	1.833
Other Developed (4)	.346	.320	.267	2.049	1.960	1.861
Planned (3)	.415	.348	.286	3.152	2.850	2.500

**Table 4a. SMY's per 10 Million (Constant 1980) Dollars of Production Plus Imports**

Region/Income Group	SMY's per 10 Million Dollars of Forestry Production Plus Imports			SMY's per 10 Million Dollars of Agricultural Production Plus Imports		
	1970	1975	1980	1970	1975	1980
Africa (6)	.107	.099	.114	1.030	1.241	1.648
Asia (10)	.119	.175	.115	2.107	1.916	2.067
Latin America (4)	.065	.075	.058	1.239	1.240	1.356
Europe (19)	.308	.238	.209	1.063	.948	1.020
North America/Oceania (3)	.338	.286	.245	.952	.889	.812
Low-Income Developing (5)	.053	.091	.072	.637	.758	1.164
Middle-Income Developing (7)	.049	.075	.067	1.238	1.281	1.536
Semi-Industrialized (10)	.088	.100	.075	1.190	1.062	1.134
Western Europe (13)	.312	.240	.209	.811	.733	.846
Other Developed (4)	.319	.291	.238	1.662	1.504	1.445
Planned (3)	.366	.304	.261	2.759	2.479	2.172

**Note:** Number of countries in parentheses

Table 5. Expenditures per SMY (000 1980 U.S. Dollars),  
by Region and Income Group for Forestry Research and Agricultural Research

Region/Income Group	Forestry			Agriculture		
	1970	1975	1980	1970	1975	1980
Africa (6)	63.411	114.690	103.648	67.418	54.796	67.102
Asia (10)	43.921	40.919	58.829	38.588	39.179	40.729
Latin America (4)	90.000	89.075	89.151	38.539	47.071	56.984
Europe (19)	68.953	98.663	89.676	59.712	58.306	63.234
North America/Oceania (3)	87.781	95.080	102.109	132.756	126.626	127.329
Low-Income Developing (5)	35.878	24.882	26.848	32.401	27.631	36.008
Middle-Income Developing (7)	91.607	100.607	86.330	41.412	36.066	49.088
Semi-Industrialized (10)	102.919	93.102	88.182	43.988	49.330	55.508
Western Europe (13)	69.384	106.174	95.027	76.768	74.413	79.477
Other Developed (4)	78.584	82.990	94.418	84.087	82.329	81.430
Planned (3)	39.881	38.177	51.674	27.077	27.885	27.617

Note: Number of countries in parentheses.

percentage for forestry research was lower for almost all regions and income groups in 1980 than it had been in 1970 (Africa, Asia, and the middle-income countries showed slight increases while the percentage was unchanged for the low-income developing countries.) Several regions and groups -- Latin America, Europe, Asia, low and middle-income developing countries, semi-industrialized countries, and Western Europe -- had an increase in this percentage for forestry research between 1970 and 1975, followed by a decline in 1980. In contrast, the percentage for agricultural research was higher in 1980 than in 1970 with few exceptions (North America/Oceania, other developed countries, and planned economies). The addition of imports to the value of production has a somewhat greater effect in agriculture than in forestry and has a much greater effect among the developed countries and regions than among the developing countries and regions.

For both forestry and agricultural research, there is a positive correlation between level of development and the proportion of production devoted to research. In both cases, Western Europe and the other developed countries are spending a much larger percentage of the value of production on research than are the low and middle-income developing or semi-industrialized countries. The differences between the developing and the developed countries are greater in the case of forestry research than for agricultural research. In addition, the percentages themselves are very low for forestry, e.g., in 1981 Western Europe was spending not quite three-tenths of one percent of production on forestry research while the proportion was close to one and one-half percent for agricultural research. By comparison, in 1981, the low-income developing countries were spending approximately two one-hundredths of a percent of the value of production on forestry research and close to one-half of one percent on agricultural research.

SMYs per \$10 million of production and of production plus imports are given in Tables 4 and 4A. As was the case for expenditure intensities, manpower intensities are consistently and significantly higher for agricultural research than for forestry research. Among the regions, Europe and North America/Oceania had the highest manpower intensities for forestry research in 1981; Latin America had the lowest.

Over time, manpower intensities in agricultural research have tended to increase for most regions and income groups, with the exception of North America/Oceania, other developed countries, and planned economies. In forestry research, on the other hand, manpower intensities have either declined or increased only slightly. SMYs per \$10 million of forestry production decreased between 1970 and 1980 for all regions except Africa and Asia and for all income groups except low and middle-income developing countries. As was true in the case of expenditure intensities, forestry manpower intensities often increased between 1970 and 1975, only to decline between 1975 and 1980.

The final table in this section presents expenditures per SMY for forestry and agricultural research. The forestry data for Table 5 were taken directly from Table 1, with modifications. In the case of those countries where SMYs were possibly underestimated, an upper limit of \$90,000 per SMY was established before averages were calculated. This adjustment was applied to Colombia, Brazil, Mexico, Iran, and Malaysia.

The data in Table 5 show that expenditures per SMY have generally been higher for forestry research than for agricultural research. North America/Oceania is the major exception to this. In 1980, expenditures per SMY in both forestry and agricultural research were lowest for Asia. In forestry research, they were highest for Africa; in agricultural research, they were

highest for North America/Oceania. The breakdown by income group shows that, in forestry research, expenditures per SMY have consistently been the lowest for the low-income developing countries. By 1980, the other income groups (with the exception of the planned economies) were all spending close to the same amount per SMY. The pattern shown by the figures for agricultural research is one in which expenditures per SMY consistently increase with income level.

#### **IV. EXPERIMENT STATION CHARACTERISTICS**

The 140-plus completed questionnaire returns provided station characteristic data that are informative. They are summarized by region and by level of development in Tables 6 - 9. The reader should note that the "sample" of returned questionnaires for a region or group is not necessarily "representative." Some selectivity bias is likely in terms of the willingness to return questionnaires. Nonetheless, given the absence of any prior data on these characteristics, they deserve discussion.

Table 6 reports the distribution of research expenditures by three broad categories of research. The first is traditional forestry research directed to the production of management and biological research of trees. The second is research directed to the conversion of primary forest products into processed forest products. The third is a more general category covering ecological studies, wildlife, recreation, marketing and other studies. The table shows that the proportion of spending on research directed to products has tended to fall in most regions (except North America where it has a low proportion) over time. This has been offset by rises in the proportion of spending on traditional forestry research in the developing countries and by rises in the other research in the semi-industrialized and developed countries. This trend for the developing countries is probably related to the

**Table 6. Percentage Distribution of Research Expenditures  
for Individual Forestry Research Facilities,  
by Region and Income Group**

Region/Income Group	Forestry				Products				Other			
	1970	1975	1980	1981	1970	1975	1980	1981	1970	1975	1980	1981
Africa	42.5	45.2	42.2	44.6	38.6	35.2	41.3	39.0	18.8	19.6	16.5	16.4
Asia	48.6	58.3	48.1	50.3	27.2	21.2	19.4	20.0	24.2	20.5	32.5	29.7
Latin America	89.3	75.0	72.9	71.2	.33	2.6	3.1	2.2	10.3	22.4	24.0	26.6
Europe	54.5	54.3	53.3	54.9	36.0	35.1	29.2	28.7	9.5	10.6	17.6	16.4
North America/Oceania	70.9	68.9	74.4	73.0	8.0	12.1	11.3	9.2	21.1	19.0	14.3	17.8
Low-Income Developing	37.8	52.4	41.4	49.3	53.4	35.3	48.9	42.8	8.9	12.3	9.8	7.9
Middle-Income Developing	16.0	44.7	48.0	53.8	70.6	43.2	40.3	35.1	13.4	12.0	11.7	11.1
Semi-Industrialized	61.0	64.8	64.0	64.2	14.7	12.5	11.1	9.9	24.3	22.7	24.9	25.9
Western Europe	54.6	54.1	53.0	54.7	36.1	35.6	29.6	29.0	9.4	10.4	17.5	16.3
Other Developed	71.3	68.9	69.5	68.8	7.4	11.3	9.7	8.5	21.3	19.8	20.8	22.8
Planned	53.0	61.6	61.7	60.9	35.4	21.8	18.2	19.4	11.6	16.6	20.1	19.7

Table 7. Percentage Distribution of Personnel for Individual Forestry Research Institutes,  
by Region and Income Group

Region/Income Group	Administrators				Ph.D.				M.S.				B.S.				Technicians			
	1970	1975	1980	1981	1970	1975	1980	1981	1970	1975	1980	1981	1970	1975	1980	1981	1970	1975	1980	1981
Africa	18.5	21.4	28.8	25.5	8.3	5.5	4.7	5.2	9.6	8.9	9.2	9.1	19.1	14.6	9.5	10.6	44.6	49.6	47.9	49.6
Asia	27.2	22.9	21.4	22.5	7.7	9.6	10.3	10.2	4.2	7.2	10.3	10.1	21.5	20.7	18.5	19.1	39.4	39.6	39.5	38.2
Latin America	18.0	20.0	16.3	34.4	12.0	10.5	14.9	3.4	22.0	14.7	16.8	4.9	42.0	38.9	34.2	38.4	6.0	15.8	17.8	18.7
Europe	10.4	11.1	10.6	11.3	17.6	17.6	17.9	18.7	15.0	15.4	17.6	17.6	14.0	14.3	15.0	13.9	43.0	41.5	39.0	38.5
North America/Oceania	13.4	15.9	15.7	14.7	11.6	11.5	13.3	13.6	11.2	10.1	10.6	9.6	20.3	16.4	16.9	18.2	43.5	46.1	43.5	44.0
Low-Income Developing	18.8	19.2	23.0	22.5	.36	1.4	3.5	3.9	2.4	4.8	8.4	9.8	10.4	12.5	15.5	14.6	68.1	62.1	49.5	49.2
Middle-Income Developing	34.4	20.0	37.0	28.4	3.3	3.7	5.5	5.7	6.1	11.9	10.4	11.5	42.0	27.0	14.5	16.1	14.2	37.3	32.6	38.3
Semi-Industrialized	12.4	11.3	11.1	24.2	8.1	8.7	8.5	4.6	7.8	7.5	9.2	6.1	27.2	24.6	26.4	30.7	44.6	47.9	44.9	34.4
Western Europe	11.1	11.4	10.7	11.5	19.1	19.1	19.0	19.7	14.7	15.0	17.5	17.6	10.4	11.4	13.0	12.2	44.6	43.2	39.7	39.0
Other Developed	24.5	23.7	16.3	21.9	12.3	13.7	17.1	15.2	7.3	8.3	10.9	8.8	19.3	16.7	15.5	18.0	36.6	37.6	40.2	36.2
Planned	7.0	9.9	9.5	9.6	9.9	10.1	14.8	14.9	16.3	17.8	20.9	21.2	31.5	29.7	23.6	23.4	35.2	32.6	31.3	30.9

Table 8. Percentage Breakdown of 1981 Research Budget by Mission for Individual Forestry Research Facilities, by Region and Income Group

	Region					Income Group					
	Africa	Asia	Latin America	Europe	North America/Oceania	Low-Income Developing	Middle-Income Developing	Semi-Industrialized	Western Europe	Other Developed	Planned
Ecosystems	13.7	3.0	9.5	7.5	6.0	3.2	2.4	10.0	7.6	6.0	7.0
Land Classification	1.9	4.0	.05	2.7	8.1	1.6	.33	2.5	2.7	8.2	4.2
General Silviculture	15.7	10.7	7.8	12.8	14.8	12.2	13.7	10.0	12.9	15.0	9.6
Tropical Silviculture	9.4	4.2	7.0	.16	.99	7.7	24.1	2.2	.17	.57	.09
Other Silviculture	.18	2.9	.59	2.3	.62	3.1	4.6	1.7	2.3	.11	2.8
Total Silviculture	40.9	24.8	25.0	25.6	30.6	27.7	45.2	26.4	25.6	29.9	23.6
Physiology	1.4	1.1	1.6	3.1	5.5	.42	1.1	.88	3.2	5.6	1.6
Breeding	12.1	11.3	10.5	11.4	11.3	4.7	21.3	8.6	11.5	11.6	7.8
Pathology	1.7	15.1	3.2	3.8	9.6	1.3	4.7	12.0	3.7	9.1	4.5
Entomology	1.6	1.7	3.2	3.3	7.3	1.6	4.5	1.8	3.3	6.8	3.8
Other Protection	.13	2.8	0	1.5	3.4	.37	0	1.7	1.6	3.4	.14
Total Protection	17.0	32.0	18.6	23.1	37.0	8.5	31.6	24.9	23.3	36.6	17.9
Operations	.59	3.4	10.9	7.7	3.0	1.6	.01	5.0	7.3	3.5	19.7
Mensuration	5.2	5.6	15.6	5.9	4.4	3.7	5.6	8.8	5.8	4.7	9.2
Inventory	.28	1.9	.04	2.9	1.2	5.2	.50	.48	3.0	1.2	1.8
Economics	.38	1.9	1.0	3.3	1.1	.53	1.1	.35	3.3	1.5	4.6
Other Planning	0	.43	0	.62	.07	0	0	.07	.59	.16	1.7
Total Planning	5.8	9.9	16.7	12.8	6.7	9.4	7.3	9.7	12.6	7.5	17.3
Wood Quality	10.7	10.0	4.4	5.4	14.5	18.6	5.0	8.5	5.5	14.3	3.7
Wood Processing	11.6	9.8	1.8	7.4	2.3	15.9	3.9	9.9	7.4	2.1	8.8
Paper	6.8	2.6	3.2	10.1	0	2.2	.02	5.6	10.4	.11	.60
Other Products	3.8	4.9	.30	4.6	1.3	15.8	4.5	1.7	4.6	1.2	3.7
Total Products	32.9	27.4	9.7	27.5	18.1	52.4	13.4	25.8	27.9	17.7	16.8
Remote Sensing	2.7	.60	2.0	3.1	14.6	0	.26	6.5	2.0	3.1	1.5
Research	.18	.42	.49	0	4.5	.32	.12	1.7	.51	.07	.14
Other General	0	1.5	.82	1.5	0	0	2.1	.06	.75	1.6	3.1
Total General	2.8	2.6	3.3	4.5	19.1	.32	2.5	8.2	3.3	4.8	4.6



**Table 9. Percentage Breakdown of 1981 Budget by Type of Tree and by Funding Source for Individual Forestry Research Facilities, by Region and Income Group**

	Region					Income Group					
	Africa	Asia	Latin America	Europe	North America/Oceania	Low-Income Developing	Middle-Income Developing	Semi-Industrialized	Western Europe	Other Developed	Planned
<b>Type of Tree</b>											
Broadleaf	37.9	42.6	38.2	28.8	29.3	54.4	63.1	44.9	28.1	25.0	53.5
Coniferous	57.4	52.5	45.9	62.8	70.1	37.9	27.9	43.9	63.8	73.6	25.9
Palm	1.0	.20	.10	.57	0	.95	1.7	.10	.58	.10	.20
Other Species	.06	1.1	15.8	.63	0	.35	.11	10.9	.62	.004	1.7
Non-Specific	3.6	3.6	.002	7.2	.62	6.4	7.2	.20	6.9	1.3	18.7
<b>Funding Source</b>											
Government	68.4	94.6	84.4	73.5	95.3	95.9	83.6	84.8	74.1	94.7	56.4
Industry	27.7	3.3	5.8	23.6	4.6	0	13.7	7.5	23.0	5.2	42.4
Other Private	2.7	1.9	.87	2.3	.09	0	1.3	2.1	2.4	.10	0
International Organizations	1.1	.12	8.9	.60	.03	4.1	1.4	5.6	.58	0	1.2

fact that many of these countries are reaching the end of the period of harvesting existing stands and are beginning to be more concerned about long-run production issues. In developed countries, the ecology, wildlife and recreation issues have demanded more attention in recent years.

Table 7 reports the distribution of research staff by administrators, scientists with Ph.D., M.S., and B.S. degrees, and technicians. The table shows that developing countries have relatively high proportions of administrative personnel and that in low-income and semi-industrialized countries this proportion has risen somewhat. The proportion of scientists with Ph.D. degrees has risen in the developing countries since 1970 (as expenditures in developing countries tripled). This proportion fell in the semi-industrialized countries largely because of an apparent increase in administrative personnel in 1981. The proportion of scientists with M.S. degrees fell. It appears that developing countries have been achieving an upgrading of staff skills while expanding their small systems. Low-income developing countries appear to place the highest reliance on technicians but are moving toward other countries in this regard.

Table 8 reports the distribution of the research budget by the mission orientation of the research in 1981. (This is not available for earlier years.) A number of differences in mission emerge by group. It was noted earlier that the low-income developing countries are highly oriented toward forest products research. That is shown to be the case here as well. Accordingly, they have less emphasis on silviculture, entomology and pathology. The relative absence of work on tropical silviculture by the countries of Europe, North America, and Oceania, and by the planned economies is notable indicating that little of the work on silviculture in these countries is relevant to the low-income tropical countries. Work on

physiology, economics, land classification and remote sensing tends to be concentrated in higher-income countries. Work on the pulp and paper industry is also concentrated in a few European and semi-industrialized countries. Low-income countries are engaged in some work in this field, but even though all of these countries import paper, they are not emphasizing research on paper products. In general, work in the area of pulp and paper requires expensive, sophisticated equipment and needs the support of industries. These industries are non-existent in virtually all of the developing countries.

Table 9 reports distributions of research work according to type of tree and funding source. Most developing countries in general have few native conifers that are used commercially and, therefore, do less work on coniferous trees and more on palm trees than is the case for developed countries. Funding sources show, rather interestingly, that international agencies tend to provide more support for semi-industrialized country research and neglect the middle-income developing countries. The private sector is not supporting research in the low-income developing countries, but does support some work in middle-income developing countries (especially in Africa) and is quite important for support of research in Europe.

## **V. IMPLICATIONS FOR POLICY-MAKING AND SUGGESTIONS FOR FURTHER DATA COLLECTION**

This inventory is incomplete. For many countries there are no hard data. Some of our data are also subject to problems of definition. There are problems of currency conversion. Nonetheless, the hard data coverage is sufficiently complete that we believe our estimates of regional aggregates are quite reasonable. The broad patterns shown by our data are very likely to be revealed in better data. These patterns have substantial relevance for policy-making.

The major pattern shown by our data is that there is a low level of

investment in forestry research in low-income developing countries and in the tropics generally. The World Bank and other international agencies concerned with forest productivity can hardly be complacent about the state of forestry research in the developing world. Research spending is low and institutional development is poor in most low-income countries. When we compare the development of research institutions in forestry with the development of agricultural research institutions in developing countries we find great contrast. Many countries with significant forestry sectors appear not to have begun the complex process of building research institutions to address problems of production management, harvesting, and marketing of forest products. Some of these countries, on the other hand, have made progress in building agricultural research institutions. Indeed many developing countries have not only built agricultural research institutions but have realized significant benefits from this investment.<sup>4/</sup>

We do not suggest that the same institutional, social, and economic mechanisms that have helped to create the research capacity in agriculture will also stimulate the development of research capacity in forestry. Indeed, one of the reasons for compiling data of the type reported in this paper is to enable us to obtain a better understanding of the factors that influence both public agencies and private firms to invest in research and to seek productivity improvement.

The state of development of forestry research institutions in developing countries today is probably comparable to that existing for agriculture three or four decades ago. If the substantial expansion and development of agricultural research institutions in these countries is at all indicative of what may occur in forestry, it will be important that we obtain better data to

guide that development. Our present effort illustrates the disparities in research system development between agriculture and forestry and between developed and developing countries. International aid agencies may not be fully aware of the extent of these disparities.

We anticipate that in the future the building of research capacity in developing countries, and in the tropics generally, will take on more importance for many countries and in international agencies. Better data will aid the design and implementation of research programs. Forestry research programs will differ from agricultural research programs in many respects. Nonetheless, there are lessons in the agricultural research development experience. This is especially the case in the agroforestry field where, in spite of widespread concern by forestry scientists about the effects of the conversion of forest land to agricultural land, little investment in research has been made.

We offer these limited data in part to show that international comparisons are useful. Our broader purpose is to stimulate a process of improvements in the data base dealing with activities and institutions that are important to further development.

## FOOTNOTES

1. See Y. Kislev and R. E. Evenson, 1975, James K. Boyce and R. E. Evenson, 1975, and M. Ann Judd, James K. Boyce and R. E. Evenson, 1983.

2. The five country groups are (1) Industrialized countries - members of the Organization for Economic Cooperation and Development, except for Greece, Portugal, Spain and Turkey; (2) Planned Economies - Eastern Europe, USSR, and China; (3) Semi-industrialized countries - other countries with annual per capita income above \$1050; (4) Middle-income developing countries - other countries with annual per capita income between \$360 and \$1050; (5) Low-income developing countries - other countries with annual per capita income below \$360. See World Development Report (Washington, D. C., World Bank, 1980). p. viii. The term "developing countries" is used to refer to countries in the latter three groups.

3. Appendix Tables 1, 1A, 2, 2A and 3 report data on expenditure and manpower intensities and expenditures per SMY by country.

4. See Ruttan, 1984, for a survey of studies of returns to research in agriculture.

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International Forestry Research Survey: Questionnaire Returns

Africa

Congo:	Centre Technique Forestier Tropical, Pointe Noire
Ivory Coast:	Centre Technique Forestier Tropical, Abidjan
Kenya:	Forestry Research Department, Kikuyu
Malawi:	Forestry Research Institute of Malawi, Zomba
Nigeria:	Forestry Research Institute of Nigeria, Ibadan
South Africa:	South African Forestry Research Institute, Pretoria National Timber Research Institute, Pretoria Faculty of Forestry, University of Stellenbosch, Stellenbosch Wattle Research Institute, University of Natal, Pietermaritzburg
Sudan:	Silvicultural Research Section, ARC Ministry of Agriculture, Food and Natural Resources, Wad Medani

Asia

China:	Beijing College of Forestry, Beijing
Cyprus:	Department of Forests, Ministry of Agriculture and Natural Resources, Nicosia
India:	Conservator of Forests, Research and Development, Lucknow, Uttar Pradesh Kerala Forest Research Institute, Peechi, Kerala Forestry Department, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu Department of Forestry, Himachal Pradesh Agricultural University, Solan, Himachal Pradesh Department of Forestry, Punjab Agricultural University, Ludhiana, Punjab
Indonesia:	Forest Products Research and Development Center, Bogor SEAMEO-BIOTROP Regional Center for Tropical Biology, Bogor Forest Research Institute, Bogor
Iran:	Faculty of Natural Resources, Tehran University, Karadj
Israel:	Forestry Division, Agricultural Research Organization, Hasharon

- Japan:** Department of Forestry, Ehime University, Matsuyama  
 Department of Forestry, Miyazaki University, Miyazaki  
 Forestry and Forest Products Research Institute, Ibaraki  
 Department of Forestry, Tokyo University, Tokyo  
 Kyoto University Forest, Kyoto University, Kyoto  
 Oji Institute for Tree Improvement, Oji Paper Co., Ltd.,  
 Hokkaido  
 Department of Forestry, Yamagata University, Tsuruoka  
 Department of Forestry, Nagoya University, Nagoya  
 Department of Forestry, Kagoshima University, Kagoshima  
 Department of Forestry, Shinshu University, Nagano  
 Department of Forestry, Niigata University, Niigata  
 Department of Forestry, Gifu University, Gifu City  
 Department of Forestry, Tokyo University of Agriculture  
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 Department of Forestry, University of the Ryukyus, Okinawa
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 Department of Forestry, Seoul National University, Suwon
- Malaysia:** Forest Research Center, Sandakan, Sabah  
 Forest Department, Kuching, Sarawak  
 Faculty of Forestry, Universiti Pertanian Malaysia, Serdang,  
 Selangor
- Nepal:** Department of Forestry, Forest Survey and Research  
 Department, Kathmandu
- Philippines:** Forest Products Research and Development Institute, Laguna
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 Renovables, Bogotá  
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 de Colombia, Medellín  
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- Costa Rica:** Departamento de Ingeniería Forestal, Instituto Tecnológico  
 de Costa Rica, Cartago

Mexico: Institute Nacional de Investigaciones Forestales, Coyoacan

Paraguay: Carrera Ingenieria Forestal, Universidad Nacional de Asuncion, Asuncion

Peru: Programa Académico de Ingenieria Forestal, Universidad Nacional de la Amazonia Peruana, Iquitos

Suriname: Center for Agricultural Research in Suriname, Paramaribo

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Australia: Forestry Section, School of Agriculture and Forestry, University of Melbourne, Parkville, Victoria  
Forestry Commission of New South Wales, Sydney  
CSIRO Division of Forest Research, Canberra, A.C.T.  
Department of Forestry, Australian National University, Canberra, A.C.T.  
Tasmanian Forestry Commission, Hobart, Tasmania  
Department of Forestry, Brisbane, Queensland  
Woods and Forests Department, Mount Gambier, South Australia  
Forestry Commission of Victoria, Melbourne, Victoria  
A.P.M. Forests Proprietary Ltd., Morwell, Victoria  
Forests Department, Perth, Western Australia  
CSIRO Division of Building Research, Highett, Victoria  
Comalco Aluminum Ltd., Weipa, North Queensland

Canada: Canadian Forestry Service, Ste. Foy, Québec  
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Research Branch, Ministry of Forests, Victoria, British Columbia  
Forest Research Branch, Alberta Forest Service, Spruce Grove, Alberta  
Faculty of Forestry, University of British Columbia, Vancouver, British Columbia

New Zealand: Department of Scientific and Industrial Research, Physics and Engineering Laboratory, Lower Hutt  
New Zealand Forest Products, Ltd., Auckland  
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#### Europe

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Belgium: Station de Recherches des Eaux et Forêts, Hoeilaart  
Onderzoekscentrum voor Bosbouw, Gent  
Université de Liège, Service des Forêts et Jardins, Liège  
Centrum voor Bosbiologisch Onderzoek, Genk  
Centre de Recherche et de Promotion Forestières, Gembloux

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Arboretum of the Royal Veterinary and Agricultural University, Hoersholm  
Danish Land Development Service, Viborg
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Department of Logging and Utilization of Forest Products, University of Helsinki, Helsinki  
Forest Products Laboratory, Technical Research Centre of Finland, Espoo  
Forestry Department, Work Efficiency Association, Helsinki  
Metsäteho, Helsinki
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Centre Technique Du Bois et de L'Ameublement, Paris  
Laboratoire Botanique et Forestier, Université Paul Sabatier, Toulouse  
Association Forêt-Cellulose, Nangis
- Greece:** Forest Research Institute of Thessaloniki, Thessaloniki
- Hungary:** Forest Research Institute, Budapest
- Ireland:** Forest and Wildlife Service, Research Branch, Wicklow  
Forest Products Department, Institution for Industrial Research and Standards, Dublin
- Italy:** Istituto Sperimentale per la Selvicoltura, Arezzo  
Istituto di Selvicoltura, Firenze  
Societa Agricola e Forestale Per La Pianta Da Cellulosa e Da Carta, Roma  
Istituto per la Ricerca sul Legno, Firenze  
Istituto per la Tecnologia del Legno, Trento  
Centro di Studio per la Patologia Specie Legnose, Montane
- Netherlands:** Department of Forest Management, University of Wageningen, Wageningen  
Department of Silviculture, Agricultural University, Wageningen  
Forest Products Research Institute, Delft  
Research Institute for Plant Protection, Wageningen
- Norway:** Agricultural University of Norway, Institute of Forest Economics, Ås  
Norwegian Forest Research Institute, Bergen  
Department of Wood Technology, Agricultural University of Norway, Ås-NLH  
Norwegian Institute of Woodworking and Wood Technology, Oslo  
Norwegian Pulp and Paper Research Institute, Oslo

Poland: Institute of Dendrology, Kórnik

Portugal: Centro de Estudos Florestais, Lisboa

Romania: Universitatea din Brasov, Brasov

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Sweden: The Swedish University of Agricultural Sciences, Stockholm  
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Swedish Forest Products Research Laboratory, Stockholm  
The Institute for Forest Improvement, Uppsala

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Swiss Federal Institute of Snow and Avalanche Research,  
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United Kingdom: Department of the Environment, Building Research  
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Forest Service, Department of Agriculture, Belfast,  
Northern Ireland  
Forestry Commission, Northern Research Station, Roslin,  
Midlothian, Scotland  
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Department of Forestry and Natural Resources, University  
of Edinburgh, Edinburgh, Scotland  
Department of Forestry, University of Aberdeen, Aberdeen,  
Scotland  
Department of Forestry and Wood Science, University  
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West Germany: Federal Research Center for Forestry and Forest Products,  
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Forest Experiment Station of Lower Saxony, Göttingen  
Hessian Forest Search Station, Munich

Yugoslavia: Institute of Forestry and Wood Industry, Beograd

## Appendix

### I. Estimation Procedures

The questionnaire sent to over 400 forestry research institutions throughout the world asked for detailed information on budgets, personnel, areas of research, number and size of research stations, etc. In addition the respondent was asked to estimate the percentage of total national research accounted for by that particular institution. These percentages then formed a base from which to estimate total expenditures for the country. Occasionally, questionnaire returns from several institutions in the same country gave conflicting answers to this question, e.g., two institutions accounting for over 100% of a country's research and there being four or five other institutions in the country also engaged in research. In such cases it was necessary to revise the estimates of the percentage of national research accounted for by an institution before total expenditures for the country were estimated. In a few cases, secondary source data could be used to check the reasonableness of estimates.

All currencies were converted to U. S. dollars using I.M.F. exchange rates. The U.S. wholesale price index was used to obtain constant 1980 dollars.

Appendix Table 1

Country	Forestry Research Expenditures as a % of the Value of Total Forestry Production			Agricultural Research Expenditures as a % of the Value of Total Agricultural Production		
	1970	1975	1980	1970	1975	1980
Congo	.292	.341	.292	n.a.	n.a.	n.a.
Ghana	.326	.296	.301	.474	.431	1.013
Ivory Coast	.126	.098	.138	1.426	1.100	.780
Kenya	.023	.014	.015	.679	1.059	1.315
Malawi	.012	.013	.013	1.203	1.196	1.599
Nigeria	.016	.109	.103	.551	.540	1.517
South Africa	.176	.217	.257	1.028	1.012	1.096
Bangladesh	—	.072	.063	.067	.074	.718
Cyprus	.128	.150	.089	.498	.588	1.363
India	.027	.027	.024	.222	.218	.351
Indonesia	.007	.015	.011	.182	.151	.526
Iran	.428	.577	.113	.548	.707	.728
Japan	.107	.154	.196	2.994	3.164	3.341
Korea, South	.027	.032	.031	.583	.564	.433
Malaysia	.050	.086	.063	.526	.411	.845
Nepal	.013	.015	.012	n.a.	n.a.	n.a.
Philippines	.066	.066	.036	.158	.180	.204
Thailand	.019	.026	.023	.447	.361	.606
Brazil	.066	.049	.029	.604	.860	1.051
Colombia	.029	.023	.021	.835	.750	.599
Mexico	.063	.284	.363	.204	.273	.751
Paraguay	—	.012	.006	.212	.343	1.110
Suriname	2.215	.975	1.352	n.a.	n.a.	n.a.
Austria	.051	.087	.070	.505	.413	.608
Belgium	.099	.160	.189	.672	.913	1.079
Denmark	.506	.686	.595	.761	.725	.808
England	.781	.697	.776	1.254	1.274	1.823
Finland	.260	.177	.108	.415	.545	.785
France	.153	.221	.216	1.044	.964	.975
Greece	.877	.548	.610	.408	.393	.428
Hungary	.145	.106	.105	1.248	1.007	.893
Ireland	1.101	1.154	1.267	1.314	1.310	1.820
Italy	.252	.183	.165	.669	.683	.820
Netherlands	.689	1.210	.962	1.917	2.384	5.138
Norway	.296	.401	.388	2.596	2.959	3.793
Portugal	.100	.056	.025	1.735	1.894	2.010
Romania	.101	.039	.029	1.011	.944	.808
Spain	.294	.166	.107	.769	.540	.627
Sweden	.241	.361	.317	1.064	1.096	1.356
Switzerland	.579	1.106	.588	1.799	2.327	2.952
West Germany	.222	.303	.221	1.279	1.229	1.229
Yugoslavia	.256	.271	.293	.414	.441	.376
Australia	1.156	1.173	1.064	3.124	2.992	3.025
Canada	.563	.426	.364	2.674	2.363	2.220
Papua New Guinea	.403	.387	.371	n.a.	n.a.	n.a.
United States	.212	.223	.209	1.205	1.096	.977

Appendix Table 1A

Country	Forestry Research Expenditures as a % of the Value of Total Forestry Production plus Imports			Agricultural Research Expenditures as a % of the Value of Total Agricultural Production plus Imports		
	1970	1975	1980	1970	1975	1980
Congo	.290	.339	.291	—	—	—
Ghana	.315	.284	.299	.417	.379	.895
Ivory Coast	.123	.095	.136	1.187	.851	.628
Kenya	.022	.014	.014	.614	.943	1.227
Malawi	.012	.013	.013	1.024	1.051	1.510
Nigeria	.016	.106	.100	.528	.506	1.277
South Africa	.151	.194	.238	.893	.867	.991
Bangladesh	—	.072	.063	.057	.058	.652
Cyprus	.044	.061	.028	.329	.258	.681
India	.027	.027	.024	.210	.207	.336
Indonesia	.007	.015	.011	.162	.124	.429
Iran	.383	.353	.089	.507	.601	.530
Japan	.092	.126	.152	1.966	1.662	1.764
Korea, South	.026	.029	.029	.461	.406	.295
Malaysia	.049	.083	.062	.413	.312	.637
Nepal	.013	.015	.012	—	—	—
Philippines	.065	.065	.035	.144	.161	.184
Thailand	.018	.025	.022	.416	.329	.536
Brazil	.065	.049	.029	.568	.775	.903
Colombia	.029	.023	.021	.793	.701	.553
Mexico	.056	.257	.327	.190	.242	.653
Paraguay	—	.012	.006	.162	.274	.872
Suriname	2.017	.806	1.151	—	—	—
Austria	.047	.078	.062	.342	.241	.331
Belgium	.062	.097	.098	.281	.307	.294
Denmark	.239	.287	.249	.546	.469	.490
England	.361	.308	.318	.560	.515	.756
Finland	.257	.172	.106	.311	.384	.529
France	.120	.174	.170	.725	.611	.576
Greece	.534	.351	.402	.328	.276	.301
Hungary	.093	.064	.077	1.051	.872	.755
Ireland	.495	.494	.358	1.003	.922	1.147
Italy	.175	.129	.102	.389	.315	.365
Netherlands	.326	.531	.363	.861	.854	1.605
Norway	.259	.345	.332	1.362	1.332	1.681
Portugal	.092	.052	.024	1.055	.822	.800
Romania	.099	.038	.028	.897	.855	.727
Spain	.244	.138	.089	.575	.400	.447
Sweden	.235	.349	.304	.638	.607	.736
Switzerland	.413	.809	.400	.837	.904	1.260
West Germany	.162	.224	.153	.700	.556	.540
Yugoslavia	.224	.244	.263	.368	.368	.320
Australia	.948	.906	.825	2.922	2.792	2.774
Canada	.554	.410	.356	1.983	1.623	1.548
Papua New Guinea	.393	.387	.371	—	—	—
United States	.198	.207	.192	1.026	.924	.828



Appendix Table 2

Country	SMY's per 10 Million Dollars of Forestry Production			SMY's per 10 Million Dollars of Agricultural Production		
	1970	1975	1980	1970	1975	1980
Congo	.383	.434	.528	—	—	—
Ghana	.381	.353	.413	1.009	2.285	2.817
Ivory Coast	.257	.102	.127	1.113	1.005	.709
Kenya	.034	.033	.031	1.840	2.198	2.315
Malawi	.172	.097	.072	2.434	7.240	7.799
Nigeria	.032	.055	.062	.440	4.24	1.350
South Africa	.239	.228	.304	1.971	2.118	2.296
Bangladesh	—	.289	.253	.427	.525	3.435
Cyprus	1.038	.849	.372	2.016	3.364	3.280
India	.082	.135	.100	.654	.702	.685
Indonesia	.009	.022	.025	.711	1.112	2.336
Iran	.122	.169	.056	1.284	1.193	.834
Japan	.294	.381	.282	7.130	7.246	7.652
Korea, South	.020	.040	.020	1.931	1.866	1.432
Malaysia	.009	.018	.017	.873	.534	1.073
Nepal	.017	.021	.016	—	—	—
Philippines	.029	.105	.063	1.724	1.630	1.368
Thailand	.030	.082	.071	2.284	2.280	3.548
Brazil	.028	.017	.011	1.415	1.500	1.773
Colombia	.005	.003	.024	2.193	2.083	1.637
Mexico	.007	.017	.030	.757	.848	1.143
Paraguay	—	.056	.035	.711	.928	1.305
Suriname	.878	.531	.643	—	—	—
Austria	.493	.322	.226	.537	.506	.744
Belgium	.238	.203	.194	2.242	2.499	2.955
Denmark	1.014	.842	.704	1.620	1.634	1.820
England	.955	.856	.774	2.520	2.758	4.234
Finland	.151	.129	.119	1.031	1.190	1.716
France	.175	.142	.144	.628	.593	.964
Greece	.788	.718	.920	1.411	1.639	1.783
Hungary	.366	.249	.267	2.903	2.188	1.940
Ireland	.438	.624	1.011	2.248	2.453	1.218
Italy	.180	.170	.159	.963	.975	.487
Netherlands	1.181	1.011	.913	2.355	2.452	3.189
Norway	.601	.396	.380	4.480	5.311	6.816
Portugal	.080	.055	.062	4.157	4.957	3.846
Romania	.466	.336	.302	3.711	3.659	3.133
Spain	.171	.130	.118	1.048	.676	1.033
Sweden	.348	.279	.311	.906	1.147	1.424
Switzerland	2.342	1.730	1.550	1.507	1.553	1.970
West Germany	.324	.227	.176	1.498	1.608	1.609
Yugoslavia	.364	.401	.275	2.777	2.526	2.154
Australia	.562	.672	.773	3.326	3.580	2.558
Canada	.692	.570	.405	1.651	1.567	1.689
Papua New Guinea	.164	.210	.111	—	—	—
United States	.248	.215	.194	.844	.783	.756

Appendix Table 2A

Country	SMY's per 10 Million Dollars of Forestry Production plus Imports			SMY's per 10 Million Dollars of Agricultural Production plus Imports		
	1970	1975	1980	1970	1975	1980
Congo	.380	.432	.527	—	—	—
Ghana	.369	.339	.411	.889	2.010	2.488
Ivory Coast	.251	.099	.125	.927	.777	.571
Kenya	.033	.032	.030	1.663	1.957	2.162
Malawi	.171	.096	.071	2.072	6.362	7.366
Nigeria	.032	.054	.060	.422	.398	1.136
South Africa	.205	.204	.283	1.712	1.816	2.075
Bangladesh	—	.289	.252	.362	.412	3.116
Cyprus	.355	.346	.115	1.332	1.476	1.638
India	.082	.134	.100	.620	.666	.656
Indonesia	.009	.022	.025	.634	.914	1.905
Iran	.109	.104	.044	1.189	1.013	.608
Japan	.252	.312	.220	4.683	3.806	4.040
Korea, South	.019	.037	.019	1.526	1.344	.976
Malaysia	.008	.018	.017	.686	.406	.809
Nepal	.017	.021	.016	—	—	—
Philippines	.029	.104	.062	1.567	1.454	1.234
Thailand	.030	.080	.069	2.124	2.079	3.136
Brazil	.028	.017	.011	1.331	1.352	1.524
Colombia	.005	.003	.023	2.082	1.947	1.511
Mexico	.006	.015	.027	.705	.752	.993
Paraguay	—	.055	.035	.544	.742	1.026
Suriname	.799	.439	.548	—	—	—
Austria	.454	.290	.201	.364	.295	.405
Belgium	.150	.123	.101	.939	.840	.806
Denmark	.480	.353	.294	1.163	1.058	1.105
England	.442	.379	.317	1.124	1.116	1.756
Finland	.149	.125	.117	.772	.839	1.156
France	.137	.112	.113	.436	.376	.570
Greece	.480	.460	.606	1.134	1.148	1.254
Hungary	.233	.149	.197	2.446	1.895	1.641
Ireland	.197	.267	.286	1.717	1.727	.768
Italy	.125	.120	.098	.560	.450	.217
Netherlands	.560	.444	.345	1.058	.878	.996
Norway	.525	.341	.325	2.350	2.390	3.021
Portugal	.073	.052	.059	2.528	2.151	1.530
Romania	.456	.329	.299	3.292	3.315	2.818
Spain	.143	.109	.098	.783	.501	.737
Sweden	.340	.271	.299	.543	.635	.773
Switzerland	1.670	1.267	1.056	.701	.603	.841
West Germany	.237	.168	.122	.820	.728	.707
Yugoslavia	.319	.361	.247	2.468	2.109	1.833
Australia	.461	.519	.599	3.111	3.340	2.346
Canada	.681	.549	.397	1.224	1.076	1.178
Papua New Guinea	.160	.210	.111	—	—	—
United States	.231	.200	.178	.719	.659	.641

Appendix Table 3

Country	Expenditures per SMY (000 1980 U.S. Dollars) Forestry Research			Expenditures per SMY (000 1980 U.S. Dollars) Agricultural Research		
	1970	1975	1980	1970	1975	1980
Congo	76.320	78.514	55.211	—	—	—
Ghana	85.465	83.708	72.830	46.957	18.852	35.952
Ivory Coast	48.980	96.540	108.790	128.073	109.418	110.095
Kenya	67.600	42.330	46.970	36.895	48.186	56.780
Malawi	6.740	13.900	18.520	49.439	16.524	20.507
Nigeria	49.570	196.760	166.450	125.227	127.357	112.399
South Africa	73.820	95.215	84.331	52.178	47.758	47.756
Bangladesh	—	24.935	25.049	15.653	14.089	20.919
Cyprus	12.300	17.700	24.100	24.730	17.481	41.552
India	33.368	19.892	23.598	33.902	31.101	51.244
Indonesia	79.927	68.992	44.679	25.553	13.552	22.539
Iran	351.360	340.560	200.000	42.691	59.286	87.187
Japan	36.440	40.320	69.210	41.990	43.665	43.665
Korea, South	137.980	79.360	152.700	30.208	30.235	30.221
Malaysia	585.000	469.070	370.120	60.205	76.933	78.733
Nepal	78.100	70.150	72.230	12.799	12.114	11.655
Philippines	229.150	62.480	57.300	9.165	11.039	14.895
Thailand	61.860	31.917	31.795	19.567	15.811	17.089
Brazil	222.393	266.652	155.038	42.691	57.310	59.289
Colombia	580.900	759.600	90.064	38.079	36.010	36.585
Mexico	868.200	1,687.450	1,229.440	26.959	32.242	65.736
Paraguay	—	22.040	17.840	29.808	36.968	85.032
Suriname	252.360	183.440	210.100	—	—	—
Austria	10.316	26.888	30.778	93.918	81.627	81.799
Belgium	41.488	79.048	97.106	29.982	36.535	36.512
Denmark	49.933	81.441	84.472	46.960	44.348	44.384
England	81.770	81.439	100.311	49.771	46.171	43.068
Finland	172.141	137.373	90.936	40.298	45.785	45.766
France	87.406	155.256	150.101	166.230	162.533	101.136
Greece	111.265	76.423	66.317	28.898	24.005	24.021
Hungary	39.668	42.737	39.088	42.992	46.033	46.048
Ireland	251.140	185.040	125.250	58.422	53.410	149.413
Italy	139.840	107.660	103.410	69.436	70.045	168.220
Netherlands	58.280	119.660	105.370	81.378	97.255	161.115
Norway	49.350	101.190	102.120	57.954	55.717	55.654
Portugal	125.720	100.490	40.670	41.742	38.206	52.267
Romania	21.690	11.500	9.480	27.237	25.800	25.797
Spain	171.216	127.191	91.079	73.375	79.836	60.664
Sweden	69.322	129.088	101.935	117.400	95.517	95.273
Switzerland	24.709	63.924	37.921	119.390	149.889	149.816
West Germany	68.405	133.552	125.434	85.382	76.413	76.423
Yugoslavia	70.272	67.626	106.667	14.908	17.455	17.452
Australia	205.715	174.596	137.595	93.920	83.577	118.269
Canada	81.405	74.779	89.765	161.931	150.816	131.398
Papua New Guinea	245.420	184.350	334.130	—	—	—
United States	85.520	103.556	107.439	142.784	140.091	129.217

Appendix Table 4

<u>Country</u>	<u>Total Forestry</u>		
	<u>Publications 1971-1976</u>		<u>1977-82</u>
Afghanistan	1	0	1
Algeria	1	0	1
Argentina	116	10	104
Australia	1377	182	1155
Austria	398	62	318
Bangladesh	50	3	44
Belgium	317	63	247
Brazil	642	198	428
Bulgaria	535	31	497
Burma	0	0	0
Canada	3042	440	2492
Chile	131	29	98
Colombia	76	16	60
Costa Rica	42	8	31
Cuba	27	7	20
Czechoslovakia	477	134	336
Denmark	138	21	115
Egypt	32	3	29
Fiji	21	0	21
Finland	779	82	675
France	1509	235	1241
Germany, Fed. Rep.	2227	292	1860
Germany, Dem. Rep.	634	122	502
Ghana	46	20	25
Greece	70	19	49
Hungary	137	72	65
Iceland	5	0	5
Indonesia	150	15	133
India	1781	320	1421
Ireland	22	5	16
Iran	36	11	25
Iraq	24	6	18
Israel	120	17	101
Italy	751	162	578
Ivory Coast	13	2	11
Japan	1861	324	1487
Kenya	54	7	43
Korea, South	170	46	122
Mexico	293	69	218
Malawi	7	0	7
Malaysia	135	11	86
Nepal	13	3	7
Netherlands	843	202	618
New Zealand	930	126	784
Nigeria	153	32	118
Norway	271	43	223
Pakistan	161	35	126
Paraguay	0	0	0
Peru	35	22	13
Philippines	360	106	254

42  
Total Forestry  
Publications 1971-1976 1977-82

Country

Papua New Guinea	58	23	35
Poland	550	128	411
Portugal	39	13	26
People's Republic	200	15	178
Romania	38	7	31
Senegal	14	1	13
South Africa	519	50	457
Spain	160	31	128
Sri Lanka	41	17	24
Sudan	8	2	5
Sweden	1030	121	876
Switzerland	463	96	354
Taiwan	133	67	65
Thailand	121	66	43
Tanzania	39	0	38
Turkey	33	12	21
Uruguay	4	1	3
UK	2722	410	2178
USSR	3655	500	3098
USA	12476	1973	10048
Venezuela	79	33	36
Yugoslavia	158	54	103
Zimbabwe (Rhodesia)	45	4	37

Regions

Central America (inc. Costa Rica)	87	11	68
Tropical South America (inc. Peru)	58	30	27
North Africa (inc. Egypt, Sudan)	74	21	52
West Africa (inc. Ghana, Ivory Coast)	134	36	94
East Africa (inc. Tanzania)	114	13	98
South Africa (inc. Zimbabwe-Rhodesia)	51	5	42
Near East	32	3	28