

**AGRICULTURAL KNOWLEDGE PRODUCTION AND TRANSFERS:  
SOME CROSS-COUNTRY EVIDENCE**

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## **Agricultural Knowledge Production and Transfers: Some Cross-Country Evidence**

### **INTRODUCTION**

An increase in the pool of agricultural knowledge is the most immediate tangible result of agricultural research endeavors. Ultimately, this expanding knowledge base generates new process and product technologies which have agricultural productivity plus broader economic growth and income distribution consequences. There are a host of empirical studies which attempt to measure the economic impacts of agricultural research in both developed and developing countries<sup>1</sup>. For reasons largely concerned with empirical tractability, most analyses have directly related research expenditures to an observed or imputed supply shifting or output enhancing effect.<sup>2</sup> The decomposition of these macro relationships into their constituent knowledge generation, technology development, diffusion or transfer, and depreciation (plus obsolescence) components has had fairly limited systematic attention in the literature. This lack of attention can largely be attributed to the absence of suitable indices of knowledge output and the like, rather than to a disinterest by economists and others in understanding these subprocesses.

After briefly reviewing the problems associated with measuring agricultural research activity we then present a panel data set of publication-based indicators of agricultural research output for ten Latin American countries over the 1972-1982 period.<sup>3</sup> These indicators are used to characterize not only the cross-country, temporal differences in the region's agricultural research output portfolio, but also to highlight substantial differences in the institutional structures that contribute to this research effort.

A novel aspect of this study is its quantification of the cross-country flows of scientific knowledge among six of the "Southern Cone" countries, in particular, Argentina, Bolivia, Brazil, Chile, Paraguay and Uruguay. It aims to assess the nature and degree of scientific knowledge transfer -- undistorted by other transfers which accompany the process of technological change -- and so improve our understanding of the networks or "invisible colleges" which are an integral component of agricultural research.

These six countries were chosen because of their involvement in the CONOSUR project, initiated in 1978 and extended as the PROCISUR project in 1984.<sup>4</sup> One of the fundamental objectives of the project is to enhance the transfer of scientific information concerning corn, wheat, soybean, sorghum and beef cattle production across the six participating countries. Unfortunately, although much discussed, little quantitative evidence on the nature of such transfers is available. Here we experiment with the development of some unique indicators which measure the cross-country flow of scientific information and track changes in this transfer process for these six participating countries over the 1974-1984 period.

## **RESEARCH INDICATORS**

Quantitative indicators of scientific activity are difficult to obtain, especially within a developing country context. Scientific personnel and expenditure data have been commonly used to date.<sup>5</sup> The multiplicity of available data sources makes it difficult to achieve consistency in the scope and definitions of expenditure and personnel variables, not only between countries, but also within countries over time. It is not always clear if these variables relate solely to research activities directly under ministry auspices, or whether they also include universities and other parastatal organizations. Exchange rate distortions

and inappropriate research expenditure deflators add further to the problems associated with using research expenditure figures in a panel data context, especially for the hyperinflation periods of several Latin American countries in our sample.

The currently available personnel figures are equally fraught with problems. A major difficulty lies in controlling for large variations in human capital levels between and within countries over time. Even crude skill indicators, such as degree status, are difficult to obtain or standardize. The related issues of distinguishing research staff from support and administrative personnel, and controlling for official and "de facto" part-time appointments, also present substantial problems.<sup>6</sup>

Moreover, these research expenditure and personnel data measure inputs into the research process. Given the focus of this study on the production and use of scientific knowledge we require output rather than input indicators. When studying the non-agricultural (private) sector a popular research output measure has been patents, beginning on a systematic basis with the early work of Schmookler and recently, using more detailed data sets and refined analytical techniques, of Griliches.<sup>7</sup> Patent rights are an institutional mechanism which enable innovators to appropriate some of the returns to invention in a situation where generally the costs of replication are negligible compared with the costs of initial discovery.

For agricultural research performed in the public sector, publication-based indicators appear to be more appropriate, given the institutional and incentive structure under which public sector researchers operate. Publications afford researchers a means of establishing intellectual property rights over their work, which, at least in the developed countries, ultimately affects their salaries, promotion and professional standing. The National Science Foundation has for some time used publication-based indicators to make cross-country

comparisons of relative research performance.<sup>8</sup> Although Jimenez-Saa cautions that in some Latin American countries there may be a lack of motivation to publish research findings, the limited geographical scope of the countries included here confers a degree of homogeneity on the sample and facilitates a comparative assessment of the data which may not be possible in a broader study.<sup>9</sup>

The maintained hypothesis in the section to follow is that, at the aggregate level at least, there is a reasonably close association between gross additions to the stock of scientific knowledge and the amount of research captured by the publication-based indicators presented here.<sup>10</sup> Clearly a substantial amount of applied agricultural research also aims to generate information more specifically targeted to end users rather than to scientific audiences. For example, fertilizer trials concerned with application rates, timing, and placement aim to generate information which directly improves management practices rather than expand the scientific knowledge base. One could probably also capture much of this research by using a broader based publication indicator than the one used for this study.

## **CHARACTERIZATION OF AGRICULTURAL RESEARCH ACTIVITY<sup>11</sup>**

### *An Overview*

The cumulative publication output of the Brazilian system from 1973 to 1982 including both university and non-university research activity, is by far the largest in the region, accounting for 56.7% of the total output of the 10 country sample (Table 1). Argentina follows with a 13.6% share and Chile and Venezuela account for 8.8% and 8.1% respectively. The remaining systems are quite small with Bolivia, Ecuador and Paraguay

each accounting for less than 1% of the 24,653 agriculturally-related scientific publications produced by the region over this decade.

Comparing the distribution of publications across research areas indicates that for the region as a whole around 59.2% of the scientific activity is in the plant sciences, 33.8% in the animal sciences, and only 2.4% in the agriculturally-related social sciences. Table 1 also indicates that, averaging across all 10 countries, the measured scientific output increased by 37% over the period 1973-77 to 1978-82. However the increase was not evenly distributed across research areas. The data points to a 29% increase in plant science output, and a 49% increase in animal science output, suggesting that the scientific research portfolio of the region has become more animal science intensive over this period. There was also a dramatic 73% increase in social science output but this was from an extremely small base of research activity. In the latter part of the decade social science research still accounted for only 2.6% of total published output.

The cross-country pattern of growth in published research output was also quite variable. Bolivia, Brazil, and Uruguay experienced substantial growth, in excess of 50%, while Argentina and Ecuador showed a more modest increase of 25% and 33% respectively. Only minor increases of less than 20% were observed for Chile, Colombia, Paraguay, and Peru while the research output from Venezuela actually contracted by about 17%.<sup>12</sup> A cursory analysis of these growth profiles does not reveal any clearly discernable pattern. For instance, relative growth performance does not appear to be related, on average, to the size of the system.

Table 1: *Publication Output of Latin American NARS<sup>a</sup>*

| Country               | Period  | <u>Non-Social Sciences</u>  |                 | Social Sciences | Total Agricultural Sciences |       |
|-----------------------|---------|-----------------------------|-----------------|-----------------|-----------------------------|-------|
|                       |         | Plant Sciences              | Animal Sciences |                 |                             |       |
|                       |         | %                           | %               | %               | %                           | no.   |
| Argentina             | 1973-77 | 24.3                        | 18.4            | 1.4             | 44.4                        | 1489  |
|                       | 1978-82 | 24.6                        | 28.9            | 2.2             | 55.6                        | 1867  |
| Bolivia               | 1973-77 | 8.2                         | 14.7            | 0.5             | 23.4                        | 43    |
|                       | 1978-82 | 26.6                        | 44.6            | 5.4             | 76.7                        | 141   |
| Brazil                | 1973-77 | 25.8                        | 12.4            | 0.6             | 38.8                        | 5424  |
|                       | 1978-82 | 39.2                        | 21.1            | 0.8             | 61.2                        | 8556  |
| Chile                 | 1973-77 | 28.1                        | 17.5            | 0.6             | 46.3                        | 999   |
|                       | 1978-82 | 28.2                        | 24.2            | 1.3             | 53.8                        | 1161  |
| Colombia <sup>b</sup> | 1973-77 | 29.7                        | 15.0            | 1.9             | 46.7                        | 649   |
|                       | 1978-82 | 29.2                        | 20.5            | 3.5             | 53.3                        | 740   |
| Ecuador               | 1973-77 | 28.9                        | 13.4            | 0.7             | 43.0                        | 61    |
|                       | 1978-82 | 31.0                        | 20.4            | 5.6             | 57.0                        | 81    |
| Paraguay              | 1973-77 | 11.0                        | 35.2            | 0.7             | 46.9                        | 68    |
|                       | 1978-82 | 7.6                         | 43.4            | 2.1             | 53.1                        | 77    |
| Peru <sup>c</sup>     | 1973-77 | 35.5                        | 12.8            | 1.2             | 49.4                        | 471   |
|                       | 1978-82 | 32.5                        | 13.5            | 4.5             | 50.6                        | 482   |
| Uruguay               | 1973-77 | 11.3                        | 24.6            | 0.6             | 36.4                        | 129   |
|                       | 1978-82 | 34.7                        | 24.3            | 4.5             | 63.6                        | 225   |
| Venezuela             | 1973-77 | 24.9                        | 27.6            | 1.4             | 53.9                        | 1073  |
|                       | 1978-82 | 17.3                        | 27.9            | 0.9             | 46.1                        | 917   |
| 10 Country Total      | 1973-77 | 25.9<br>(6394) <sup>d</sup> | 15.4<br>(3800)  | 0.9<br>(212)    | 42.2                        | 10406 |
|                       | 1978-82 | 33.3<br>(8204)              | 23.0<br>(5673)  | 1.5<br>(366)    | 57.8                        | 14247 |

<sup>a</sup> All figures given as percentages of national 1973-82 totals.

<sup>b</sup> Represents national system only. Excludes output of International Center for Tropical Agriculture (CIAT) which published 554 scientific articles during the 1973-82 period.

<sup>c</sup> Represents national system only. Excludes output of International Potato Center (CIP) which published 91 scientific articles during the 1973-82 period.

<sup>d</sup> Figures in brackets are publication counts.

A finer breakdown of research activity for the commodities targeted by the CONOSUR project is given in Table 2. Here commodity specific scientific output is normalized with respect to the total published output of each NARS reported in Table 1. It gives an indication of the relative importance of each commodity group in domestic scientific research portfolios. The commodities in the CONOSUR project appear to account for a significant amount of local agricultural research activity except in the case of Bolivia where only 2.8% of the measured output occurs in CONOSUR-related commodities.

For those countries with limited local scientific activity on a given commodity it is likely that the gains from networking would be minimal. The country in question, particularly if it's total research effort was limited, would have little local capacity to screen and respond to scientific inputs from other members of the network, nor the capacity to make substantive contributions to the rest of the network in return. Plucknett and Smith identify these as two critical factors which contribute to the success of a network.<sup>13</sup> In this particular case all 6 countries participating in the CONOSUR project would appear, *a priori*, to have the local capacity to participate successfully in a livestock network and, except for Bolivia, in a corn network. Bolivia and Paraguay's participation in a wheat network may be questioned as can Chile's participation in soybean and sorghum networks.

These figures at best raise questions about the likely structure and emphasis of the CONOSUR network and should not be overinterpreted. As indicated earlier the nature of the publications captured by this indicator suggest that they measure the domestic production of scientific rather than production-oriented knowledge. Thus a low publication count, say sorghum research in Chile, does not necessarily indicate that Chile has a relatively low level of research activity on sorghum. It may be that the research being performed is of a production not scientific orientation and therefore not captured in this

particular output indicator. If this is indeed the case it still raises questions about network participation, at least in terms of the nature of the network interactions which are likely to prove useful. Production oriented information would generally contain a higher site-specific component so that this type of information may be less suitable for broad dissemination within a network.

Table 2. *Commodity Specific Publication Output of the Southern Cone NARS: Commodity Specific Percentages<sup>a</sup>*

|           | Corn | Wheat | Soybean | Sorghum | "Plant<br>Sciences" | Livestock | CONOSUR<br>Total |
|-----------|------|-------|---------|---------|---------------------|-----------|------------------|
|           | (1)  | (2)   | (3)     | (4)     | (1+2+3+4)           | (5)       | (6)              |
| Argentina | 4.6  | 4.0   | 2.3     | 2.7     | 13.6                | 8.2       | 21.8             |
| Bolivia   | 0.5  | 0.5   | 0.5     | 0.0     | 1.5                 | 1.3       | 2.8              |
| Brazil    | 5.4  | 2.6   | 6.6     | 2.2     | 16.8                | 5.2       | 22.0             |
| Chile     | 1.7  | 8.6   | 0.8     | 0.3     | 11.4                | 5.1       | 16.5             |
| Colombia  | 6.5  | 0.8   | 2.9     | 1.2     | 11.3                | 11.4      | 22.7             |
| Ecuador   | 2.1  | 1.4   | 0.0     | 0.7     | 4.2                 | 9.1       | 13.3             |
| Paraguay  | 1.4  | 0.0   | 0.7     | 0.0     | 2.1                 | 9.7       | 11.8             |
| Peru      | 4.8  | 1.8   | 1.6     | 1.2     | 9.4                 | 5.6       | 15.0             |
| Uruguay   | 2.5  | 7.6   | 3.1     | 4.2     | 17.5                | 12.1      | 29.6             |
| Venezuela | 3.5  | 0.2   | 1.2     | 1.3     | 6.2                 | 12.7      | 18.9             |

<sup>a</sup> All figures are percentages of country-specific 1973-82 totals given in Table 1.

### *Role of the University Sector*

About 42% of the published agricultural research output of the region originated in the university sector. Once again, however, the data imply substantial differences in the institutional research structure across countries. Chile and Paraguay appear to be relatively university intensive systems with less than 35% of their published agricultural research output originating in the non-university sector. Argentina, Peru and Venezuela have relatively balanced structures with 45% to 55% of their research output originating in the non-university sector, while Brazil, Colombia, Ecuador, Uruguay and Bolivia are relatively non-university intensive systems, with greater than 55% of their published research output originating in the non-university sector. In fact, virtually all the published agricultural research in Bolivia, around 97%, originated outside the university structure.

Table 3. *Summary of Scientific Orientation and Institutional Structure of Latin America NARS*

| Principal Research Organization | Principal Orientation of Published Agricultural Research |                        |                |
|---------------------------------|----------------------------------------------------------|------------------------|----------------|
|                                 | Plant Science                                            | Plant/Animal Science   | Animal Science |
| Non-University                  | Brazil<br>Colombia<br>Ecuador                            | Uruguay                | Bolivia        |
| University/<br>Non-University   | Peru                                                     | Argentina<br>Venezuela |                |
| University                      | Chile                                                    |                        | Paraguay       |

Table 3 summarizes much of the discussion concerning both the scientific orientation of the published research output, and the principal organizations which sponsor the research. It indicates, for example, that Brazil's research is plant science oriented and performed principally in the non-university sector, while Paraguay focuses more on animal science research and conducts much of its scientific research within the university system.

## **QUANTIFYING CROSS-COUNTRY KNOWLEDGE TRANSFERS**

The seminal work of Griliches concerning the diffusion of hybrid corn technology in the U.S. showed that the rate of adoption of new technology was, *inter alia*, a function of the profitability of the innovation.<sup>14</sup> These early studies gave rise to further attempts to explicitly model the adoption process using economic concepts which are micro rather than macro in nature. Rather than view potential adopters as passive recipients of new technology these models saw them engaged in an active search and screening process where information was sought concerning the expected profitability of a particular innovation prior to its eventual adoption. Good overviews of this literature can be found in Lindner and with particular reference to developing countries in Feder, Just, and Zilberman.<sup>15</sup>

However, few of these studies focus on the international diffusion of innovations and, as Thirtle and Ruttan observe, do not really tackle the problem of the transmission of technology between countries.<sup>16</sup> In the case of agricultural technology this transfer process is complicated by location specificity issues, in which the value of biological techniques is often a function of ecological as well as economic and social conditions. For instance a study of the international transfer of new sugar cane, banana, and rice varieties by Evenson, Houck, and Ruttan stressed the role of climate and associated disease resistance factors.<sup>17</sup>

The recent study by Davis, Oram and Ryan, which builds on the earlier work of

Edwards and Freebairn, has shown that agricultural research performed on internationally traded commodities in one country may generate price "spillovers" in addition to the more commonly discussed technological spillovers.<sup>18</sup> Technological spillovers occur when research performed in one country is incorporated into the agricultural production processes of others. Price spillovers occur when research in a commodity for which the researching country is a significant world trader so shifts world supply schedules to affect directly world prices. An understanding of both spillover effects is necessary in order to measure the economic implications of these cross-country transfer effects.

However, these studies do not address issues concerning the more fundamental knowledge transfer process, particularly as it relates to the cross-country transfer of knowledge between public sector agricultural research agencies. While there has been increasing attention given to the concept of cross-country networking amongst agricultural scientists, most of the discussion has been quite selective and anecdotal in nature.<sup>19</sup> Comprehensive indicators of the nature and extent of this cross-country knowledge transfer process are virtually nonexistent.

The scientific knowledge base available to any particular country represents the sum of past and present contributions from national, regional and international sources. Here we estimate the relative importance of these various sources of agricultural knowledge for the current research effort of selected Latin American countries. Following a brief discussion of the data base used to measure cross-country knowledge transfers both the spatial and temporal dimensions of this transfer process are analyzed in some depth.

#### *Data Collection and Measurement*

To quantify the transfer of scientific knowledge amongst agricultural researchers from

countries participating in the CONOSUR network and between these researchers and the world's scientific community as a whole, we used the online database SCISEARCH, produced by the Institute for Scientific Information (ISI). While ISI's databases are the only ones available which give information on the documents cited by their source references their use presents some problems, particularly in a developing country context. The multidisciplinary SCISEARCH includes only a small fraction of the scientific journals published throughout the world, though at the same time it does include a very high percentage of the "important" and "significant" journals, as assessed on the basis of objective criteria, mainly involving citation ratings. It is claimed, however, and probably correctly, that among the journals and articles omitted, there is a very high percentage published in the developing countries. Therefore, we must bear in mind that the articles we identified as our source set represent the major research contributions from the CONOSUR countries to the international pool of agricultural knowledge.

We first obtained the total publication output of the six countries for the five commodity areas which are central to the CONOSUR project -- corn, wheat, sorghum, soybean, and livestock -- over a 14 year period between 1972 and 1984. These source references were found to represent 116 journals from 15 different countries. Two thirds of them were published in international journals originating in North America and Europe. The remaining one third were published in Latin American journals.<sup>20</sup> The table in Appendix II provides additional information on the subject characteristics of the references and the type of journal in which they were published. Around 70% of the source articles were published since 1980.

It is common to assess the impact or scientific quality of a set of articles by measuring their subsequent citation performance.<sup>21</sup> For this study, however, we were

interested in looking back rather than forward in time to the knowledge base which contributed to the current CONOSUR research activity. We took the material cited by the source references to be a proxy measure of the pool of knowledge upon which this current research activity drew. The 445 source references provided 7926 citations to the literature, an average of 17.8 citations per reference. Of the 7926 citations obtained, more than half were to items published before 1972, which for technical reasons had to be eliminated from the sample. It nevertheless seems reasonable to limit the cited material to fairly contemporary publications given that our purpose is to investigate the more recent transfer of agricultural knowledge between the countries. A total of 3415 post-1972 citations remained.

Given that a substantial number of authors publish in journals which do not originate in the country where the reported research was carried out, place of publication was rejected as a means of mapping knowledge transfers. A more representative measure of the flow of information into the CONOSUR countries from identifiable within and out-of-country sources was obtained by cross-matching the country affiliation of the source authors with the country affiliation of the principal cited authors.

### *Spatial Dimension*

Table 4 summarizes the pattern of cross-country knowledge transfers obtained in this study. Looking first at the country averages for the 1974-84 period as a whole, around 72% of the cited knowledge base comes from international sources, with North American sources alone accounting for 42% of the scientific knowledge inflow. Approximately 24% of the transferred knowledge comes from domestic sources while an amazingly low 4% comes from regional, exclusive of within country, sources. Tracing the changes in these country totals

Table 4. *Cross-Country Agricultural Knowledge Transfers*

| Transfers from <sup>a</sup> /<br>Period <sup>c</sup> | Transfers To <sup>b</sup> |           |                                         |      |
|------------------------------------------------------|---------------------------|-----------|-----------------------------------------|------|
|                                                      | Brazil                    | Argentina | Other CONOSUR <sup>d</sup><br>Countries | All  |
|                                                      | %                         | %         | %                                       | %    |
| <b>National</b>                                      | 26.5 <sup>e</sup>         | 22.8      | 9.7                                     | 23.9 |
| <b>Regional</b>                                      | 3.3                       | 4.6       | 8.3                                     | 4.1  |
| <b>International</b>                                 | 70.2                      | 72.6      | 82.0                                    | 72.0 |
| North American                                       | 41.4                      | 41.2      | 47.8                                    | 42.0 |
| European                                             | 17.1                      | 20.2      | 24.5                                    | 18.6 |
| Other                                                | 11.7                      | 11.2      | 9.7                                     | 11.4 |
| <b>National</b>                                      |                           |           |                                         |      |
| 1974-78                                              | 19.8                      | 41.9      | 17.9                                    | 24.4 |
| 1979-81                                              | 30.2                      | 22.3      | 11.3                                    | 26.7 |
| 1982-84                                              | 24.3                      | 20.5      | 5.2                                     | 21.5 |
| <b>Regional</b>                                      |                           |           |                                         |      |
| 1974-78                                              | 6.6                       | 4.8       | 0.0                                     | 5.3  |
| 1979-81                                              | 2.1                       | 8.9       | 12.1                                    | 4.5  |
| 1982-84                                              | 3.7                       | 2.5       | 7.0                                     | 3.6  |
| <b>International</b>                                 |                           |           |                                         |      |
| 1974-78                                              | 73.6                      | 53.6      | 82.0                                    | 70.3 |
| 1979-81                                              | 67.6                      | 68.8      | 76.6                                    | 68.8 |
| 1982-84                                              | 72.0                      | 76.9      | 87.8                                    | 75.0 |

<sup>a</sup> Country location of cited principal author.

<sup>b</sup> Country location of citing principal author.

<sup>c</sup> Represents period in which citing article was published. Upper half of table indicates to all (citing) articles for the 1974-84 period.

<sup>d</sup> Includes Bolivia, Chile, Paraguay and Uruguay.

<sup>e</sup> Indicates, for example, that 26.5 percent of all the source material for Brazilian research published during 1974-84 was national in origin.

over time we observe only a slight increase in the relative importance of national plus regional sources vis a vis international sources during the 1974-81 period, with the combined national and regional knowledge base increasing slightly from 29.7% in the 1974-78 period to 31.2% in the 1979-81 period, only to decline in the more recent years to around 25%.

Of course these six-country averages mask quite a deal of variation in the country-specific figures, with the relative importance of national, regional and international sources varying quite markedly from country to country. Although regional sources constitute a relatively small percentage of the total knowledge base for all countries, they account on average for 8.3% of the total for Bolivia, Chile, Paraguay and Uruguay, which is around double the Argentine and Brazilian level.<sup>22</sup> Most significantly, in recent years regional sources of scientific knowledge have become relatively more important for the smaller systems but appear to have become less important for the larger countries (i.e., Brazil and Argentina).

Following the national level figures over time also reveals some interesting trends. They suggest a significant decline in the relative importance of national knowledge sources for both the smaller countries and Argentina over the 1974-84 period, although the pattern is quite different in each instance. The smaller countries exhibit an accelerating deterioration in this situation since 1974 with a decline in the relative importance of the national system over the 1974-1981 period of 36% and an even higher rate of decline in the 1981-84 period of 53%. This contrasts with the Argentine case in which the national system declined dramatically in relative importance during the 1974-81 period from 41.9% to 22.3%, with only a further slight decline through to 1984. Brazil on the other hand appears to have placed an increasing reliance on its national system as a source of knowledge to support its current research effort, although there are indications this trend has reversed

itself of late.

The pattern of knowledge transfers for these CONOSUR countries can be compared with related U.S. figures presented in Table 5. While the CONOSUR countries cited publications by domestic authors only 24% of the time, U.S. articles relating to the biological sciences (inclusive of agricultural, food and animal sciences) cited articles from the U.S. an average of 59% of the time. Although the U.S. is clearly more self-sufficient in terms of its knowledge base, this result serves to strengthen the positive relationship between the degree of self-sufficiency and the size of the domestic research system which is evident from the CONOSUR data. Parenthetically, the figures in Table 5 do suggest that the U.S. biological sciences are becoming increasingly reliant on input from non-domestic researchers. Whereas the rate of local citation by U.S. biological researchers was approximately 63% in 1973 this had steadily declined to around 56% by 1982.

Table 5: *Percentage of References in U.S. Articles to Articles from the U.S.*

| Field                | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
|----------------------|------|------|------|------|------|------|------|------|------|------|
| Biology <sup>a</sup> | 62.9 | 61.8 | 59.5 | 60.3 | 58.8 | 58.8 | 58.9 | 57.2 | 56.5 | 55.7 |
| All Fields           | 59.1 | 58.4 | 57.4 | 57.6 | 57.4 | 62.0 | 56.1 | 55.7 | 55.2 | 54.1 |

Source: Adapted from National Science Foundation. *Science Indicators: The 1985 Report*. Washington, D.C.: National Science Board, November 1985. Appendix Table 1-28.

<sup>a</sup> Includes Agricultural and Food Science, Dairy and Animal Science plus various other biological disciplines.

### *Temporal Dimension*

Using the source publications identified in the previous section as representative of the agricultural knowledge output of the CONOSUR countries we have quantified the degree of contemporaneity of the knowledge based on which it drew. For the source references in both the 1973-76 and 1980-83 periods we calculated the citation lag in years for all cited publications, some 5,650 articles. The number of cited publications exhibiting a particular lag was expressed as a cumulative percent of the total number of cited articles in each of the two periods, 1973-76 and 1980-83.

The results suggest a marked decline in the contemporaneity of the current research effort in all countries over the 1973-83 period. In Brazil for instance 50% of the cited articles have an average citation lag of 6.5 years or less in 1973-76, which increased by 29% to 8.5 years by 1980-83. The increase in the cumulative citation lag of the remaining CONOSUR countries is even more dramatic with Argentina's lag increasing by around 39% and the smaller CONOSUR countries, when taken as a group, by approximately 126%. Budgetary and foreign exchange controls appear to have inhibited the access of these research systems to non-local sources of knowledge either in a direct manner through restrictions on journal purchases, conference attendances or on-line literature searching, or indirectly through a decline in the number of researchers gaining access to these knowledge sources by undertaking studies in foreign research and educational institutions.

The contemporaneity indicator developed here measures an important quality dimension of local agricultural research programs. In a dynamic environment the comparative advantage of Southern Cone agriculture vis à vis its international competitors is, in part, a function of the speed with which their agricultural research systems can adapt new knowledge into technological packages which are appropriate for their particular

circumstances. These results have serious implications for the state of agriculture in these six countries. If their local agricultural research systems continue to draw on an aging knowledge base this will eventually lead to an erosion of their indigenous technological capacity relative to their international competitors.

## **SUMMARY**

While publication-based indicators of research activity are not without their problems, when used judiciously can yield quantitative insights not readily available by other means. Such indicators show that the scientific output of the 10 Latin American NARS studied here has grown quite markedly over the 1973-82 period, although there are some hints of a downturn for many systems in the more recent years. An overwhelming amount of scientific output is concentrated in the plant sciences -- around 59% -- while the animal sciences accounted for 38% of the region's total output. This mix was subject to substantial cross-country variation although social science research activity constituted a relatively minor component of total agricultural research output for all countries. The university sector accounts for a substantial amount of regional research activity in the agricultural sciences, somewhere around 42%, but again this was subject to significant cross-country variation.

The indicators of cross-country flows of scientific knowledge developed here were most informative. The region as a whole appears to rely heavily on international sources of knowledge in the agricultural sciences. Domestic sources are of importance, the more so for the larger countries, while the smaller countries of the region demonstrate a greater propensity to draw on regional (net of domestic) sources than the larger systems. It should be emphasized that this study mapped only scientific knowledge flows. These NARS no

doubt also produce knowledge which is oriented more directly to local end users and which could exhibit significantly different flow patterns -- particularly given the likelihood that this knowledge, by its nature, may have a higher site-specific characteristic.

Finally, we also developed a contemporaneity indicator which suggests that the region's agricultural research systems, particularly the smaller systems, may be falling behind to the extent that they appear to be drawing on an aging knowledge base.



## NOTES

1. See Vernon W. Ruttan, Agricultural Research Policy (Minneapolis, University of Minnesota Press, 1982) pp. 224-246 for a representative sample.
2. The output enhancing effect has been investigated using either a direct approach, in which research expenditures are incorporated into an aggregate production or supply function, or an indirect or residualist approach which decomposes output growth into measurable factor inputs and a technical change residual. George W. Norton and Jeffrey S. Davis, "Evaluating Returns to Agricultural Research: A Review," American Journal of Agricultural Economics 63 No. 4 (November, 1981): 658-699, provides a review of the former approach and Susan M. Capalbo and John M. Antle eds. Agricultural Productivity Measurement and Explanation (Washington, D.C: Resources for the Future, 1988), of the latter.
3. These 10 countries represent Iberic South America, exclusive of Central America. Public sector agricultural research in most of these countries is concentrated in the universities and national agricultural research institutes, most of which were formed in the later 1950's and early 1960's with strong financial and technical support from external donors, particularly the United States. The institutes that emerged included the National Institute of Agricultural Technology (INTA) of Argentina in 1957 (which since 1980 has been placed back under the direct control of the Ministry of Agriculture); the National Institute of Agricultural Research (INIAP) of Ecuador in 1950; the complex Consejo Nacional para el Fondo Nacional de Investigaciones Agropecuarias (CONIA-FONAIAP) in Venezuela, between 1959 and 1961; the Agricultural Research Promotional Service (SIPA) in Peru, which after successive modifications became the National Institute of Agricultural Research Promotion (INIPA) in 1984; the Colombian Agricultural Research Institute (ICA) in 1963; and the Agricultural Research Institute (INIA) of Chile in 1964. In the seventies the Bolivian Institute of Agricultural Technology (IBTA) and the Brazilian Agricultural Research Corporation (EMBRAPA) were also created. See Martin Pineiro and Eduardo J. Trigo, "Latin American Agricultural Research in the Public Sector: Problems and Prospectives," ISNAR Working Paper No. 1 (The Hague: International Service for National Agricultural Research, 1985) for more details.
4. A listing of additional agricultural research networks in the region can be found in Carlos Valverde, "Agricultural Research Networking: Development and Evaluation" ISNAR Staff Notes No. 88-26 (The Hague: International Service for National Agricultural Research, 1988).
5. Examples include James K. Boyce and Robert E. Evenson, Agricultural Research and Extension Programs (New York: Agricultural Development Council, 1975); Peter A. Oram and Vishva Bindlish, Resource Allocations to National Agricultural Research: Trends in the 1970's (The Hague and Washington D.C.: International Service for National Agricultural Research and International Food Policy Research Institute, November 1981); and Philip G. Pardey and Johannes Roseboom, "A Global Evaluation of National Agricultural Research Investments: 1960-1985" in Emil Javier and Ulf Renborg, eds. The Changing Dynamics of Global Agriculture, proceedings from a seminar on Research Policy Implications for National Agricultural Research Systems held in Feldafing, Germany, 22-28 September 1988.
6. See Philip G. Pardey and Johannes Roseboom, ISNAR Agricultural Research Indicator Series: A global data base on national agricultural research systems, (Cambridge: Cambridge University Press, 1989) for a detailed discussion of many of these issues.
7. See Jacob Schmookler, Invention and Economic Growth (Cambridge, Mass: Harvard University Press, 1966) and Zvi Griliches, R & D Patents and Productivity (Chicago: University of Chicago Press, 1984).
8. F. Narin and M. P. Carpenter, "National Publication and Citation Comparisons." Journal of the American Society for Information Sciences (March-April, 1975): 80-93, present results from NSF's early attempts to develop cross-country publication- and citation-based science indicators.

9. See H. Jimenez-Saa, Los investigadores agricolas latinoamericanos no divulgan la informacion que generan: breve analisis de la situacion, (Turriablba, Centro Agronomico Tropical de Investigacion y Esenanza, 1978).
10. Of course, a fundamental justification for the use of publication data as a scientific indicator is to simply rely on a law of large numbers argument. Namely, that although the publication performance of an individual researcher can appear somewhat capricious, non-trivial differences in the aggregate number of publications across countries or over time do convey relevant information about the underlying trends and fluctuations in scientific output. This point is often a source of some confusion for critics of publication and patent-based indicators of scientific activity (or more appropriately output), who question their validity on the grounds of spurious publication records of particular scientists, or narrowly defined groups of scientists or subject areas. G.N. Gilbert, "Measuring the Growth of Science: A Review of Indicators of Scientific Growth," Scientometrics 1 No. 1 (1978): 9-34 and J. D. Frame, "Measuring Scientific Activity in Lesser Developed Countries" Scientometrics 2 No. 2 (1980): 133-145, discuss some of the measurement issues involved while S. Arunachalam and S. Morkanday, "Science in the middle-level countries: a bibliometric analysis of scientific journals of Australia, Canada, India and Israel," Journal of Information Science 3, No. 1 (1981): 13-26, E. Garfield "Mapping Science in the Third World" Science and Public Policy 10, No. 3 (June, 1983): 112-127 and J. Irvine et al., "Charting the Decline of British Science" Nature 316 (15 August 1985): 587-590, are recent examples of the application of such methods.
11. The publication counts reported in this section were obtained from online Commonwealth Agricultural Bureau (CAB) sources. R.M.J. Longo and U.D. Machado, "Characterization of Data Bases in the Agricultural Sciences" Journal of the American Society for Information Sciences (March, 1981): 83-91, in a comparative study of 3 major agricultural data bases, AGRICOLA, AGRIS, and CAB, show that the CAB source is the most comprehensive and regionally representative bibliographic data base currently available covering the entire range of agricultural sciences. This source includes the Plant Breeding and Dairy Science Abstracts used by Boyce and Evenson, "Agricultural Research and Extension Programs" to construct an earlier publication series, plus entries from an additional 17 abstracting journals. Details of the methodology used to construct the series are available from the authors on request. The underlying publication counts are reported in Appendix I.
12. A close examination of the underlying count data suggests that comparing these five year averages obscures the fact that the published research output for many countries of the region peaked during the late 1970's. However, we should caution that the latest publication figures recorded here could be biased downward due to the lags in getting some journals published and incorporated into CAB data bases.
13. See D. L. Plucknett and J. J. H. Smith, "Networking in International Agricultural Research," Science 225 (September 1984): 989-993.
14. See Zvi Griliches, "Hybrid Corn: An Explanation in the Economics of Technological Change," Econometrica 25 No. 4 (1957): 501-522.
15. See Robert K. Lindner, Adoption as a Decision Theoretic Process unpublished Ph.D Thesis (St. Paul: University of Minnesota, 1981) and Gershan Feder, Richard Just and David Zilberman, "Adoption of Agricultural Innovations in Developing Countries: A Survey" World Bank Staff Working Paper No. 444, (Washington, D.C.: The World Bank, 1981).
16. See Colin G. Thirtle and Vernon W. Ruttan, The Role of Demand and Supply in the Generation and Diffusion of Technical Change. A volume in the Economics of Technical Change Section edited by F. M. Scherer (Chur: Harwood Academic Publishers, 1987).
17. See Robert E. Evenson, James P. Houck and Vernon W. Ruttan, "Technical Change and Agricultural Trade: Three Examples - Sugar Cane, Bananas and Rice" in R. Vernon, ed., The Technology Factor in International Trade (New York: National Bureau of Economic Research, 1970) pp. 415-180.

18. See Jeffrey S. Davis, Peter A. Oram and Jim G. Ryan, Assessment of Agricultural Research Priorities: An International Perspective ACIAR Monograph No. 4 (Canberra: Australian Center for International Agricultural Research, 1987) and Geoff W. Edwards and John W. Freebairn, Measuring a Country's Gains from Research: Theory and Application to Rural Research in Australia. A report to the Commonwealth Council for Rural Research and Extension (Canberra: Australian Government Publishing Service, 1981).
19. See Plucknett and Smith "Networking."
20. E. Garfield, "Latin American Research. Part I. Where Is it Published and How Often It is Cited" Current Content 19 (May 7, 1984): 1-8, noted that 42% of all 1972 Latin American science was published in U.S. journals. He also noted that around 80% of these articles were in English. Approximately 75% of our source articles are in English, 13% in Portuguese and 8% in Spanish. Thus even though Portuguese speaking Brazil is by far the largest regional publisher the overwhelming propensity to publish scientific articles in English suggests that language issues may not seriously distort the knowledge transfers being mapped here.
21. For example see Robert E. Evenson and Brian Wright, "An Evaluation of Methods for Examining the Quality of Agricultural Research" in An Assessment of the United States Food and Agricultural Research System Vol. II, Part C, (Washington, D.C.: Office of Technology Assessment, April 1982) and Philip G. Pardey, "The Agricultural Knowledge Production Function: An Empirical Look" The Review of Economics and Statistics Vol. 71 No. 33 (August 1989): 453-461.
22. The figures for the four smaller countries are in fact dominated by the Chilean numbers, especially in the earlier years. They were grouped to overcome small number problems, not on the supposition that the group figures necessarily represent the actual situation in each country.



# APPENDIX I: CAB PUBLICATION COUNTS

## COUNTRY: ARGENTINA

| YEAR | PLANT SCIENCE |          |         | NON-SOCIAL SCIENCES |          |         | ANIMAL SCIENCES |          |         | SOCIAL SCIENCES |          |         | GRAND TOTAL |          |
|------|---------------|----------|---------|---------------------|----------|---------|-----------------|----------|---------|-----------------|----------|---------|-------------|----------|
|      | CONOSUR       | UNI ONLY | NON UNI | CONOSUR             | UNI ONLY | NON UNI | CONOSUR         | UNI ONLY | NON UNI | CONOSUR         | UNI ONLY | NON UNI | EXCL UNI    | INCL UNI |
|      | TOTAL         | TOTAL    | TOTAL   | TOTAL               | TOTAL    | TOTAL   | TOTAL           | TOTAL    | TOTAL   | TOTAL           | TOTAL    | TOTAL   | TOTAL       | TOTAL    |
| 1972 | 34            | 110      | 115     | 225                 | 12       | 54      | 46              | 100      | 2       | 2               | 161      | 327     |             |          |
| 1973 | 28            | 60       | 105     | 165                 | 10       | 58      | 59              | 117      | 4       | 4               | 166      | 286     |             |          |
| 1974 | 28            | 86       | 78      | 164                 | 21       | 55      | 64              | 119      | 1       | 1               | 142      | 284     |             |          |
| 1975 | 34            | 96       | 86      | 182                 | 12       | 40      | 57              | 97       | 1       | 10              | 152      | 289     |             |          |
| 1976 | 16            | 48       | 82      | 130                 | 21       | 70      | 63              | 133      | 1       | 11              | 155      | 274     |             |          |
| 1977 | 33            | 83       | 98      | 182                 | 25       | 77      | 76              | 153      | 2       | 21              | 194      | 356     |             |          |
| 1978 | 55            | 49       | 125     | 174                 | 26       | 112     | 83              | 185      | 1       | 16              | 223      | 385     |             |          |
| 1979 | 32            | 60       | 64      | 124                 | 26       | 83      | 107             | 190      | 2       | 21              | 190      | 335     |             |          |
| 1980 | 48            | 98       | 90      | 188                 | 24       | 100     | 114             | 214      | 3       | 13              | 214      | 415     |             |          |
| 1981 | 49            | 78       | 86      | 164                 | 25       | 97      | 87              | 184      | 3       | 17              | 197      | 375     |             |          |
| 1982 | 41            | 66       | 109     | 175                 | 43       | 80      | 96              | 176      | 3       | 6               | 208      | 357     |             |          |
| 1983 | 59            | 104      | 115     | 219                 | 14       | 79      | 75              | 154      | 1       | 3               | 192      | 376     |             |          |
| 1984 | 35            | 49       | 62      | 111                 | 45       | 42      | 100             | 142      | 0       | 0               | 162      | 253     |             |          |

## COUNTRY: BOLIVIA

| YEAR | PLANT SCIENCE |          |         | NON-SOCIAL SCIENCES |          |         | ANIMAL SCIENCES |          |         | SOCIAL SCIENCES |          |         | GRAND TOTAL |          |
|------|---------------|----------|---------|---------------------|----------|---------|-----------------|----------|---------|-----------------|----------|---------|-------------|----------|
|      | CONOSUR       | UNI ONLY | NON UNI | CONOSUR             | UNI ONLY | NON UNI | CONOSUR         | UNI ONLY | NON UNI | CONOSUR         | UNI ONLY | NON UNI | EXCL UNI    | INCL UNI |
|      | TOTAL         | TOTAL    | TOTAL   | TOTAL               | TOTAL    | TOTAL   | TOTAL           | TOTAL    | TOTAL   | TOTAL           | TOTAL    | TOTAL   | TOTAL       | TOTAL    |
| 1972 | 1             | 0        | 6       | 6                   | 1        | 0       | 2               | 2        | 0       | 0               | 8        | 8       |             |          |
| 1973 | 0             | 0        | 1       | 1                   | 2        | 0       | 2               | 2        | 0       | 0               | 3        | 3       |             |          |
| 1974 | 0             | 0        | 2       | 2                   | 1        | 0       | 2               | 2        | 0       | 0               | 4        | 4       |             |          |
| 1975 | 0             | 0        | 2       | 2                   | 0        | 0       | 3               | 3        | 0       | 0               | 5        | 5       |             |          |
| 1976 | 0             | 0        | 5       | 5                   | 1        | 0       | 8               | 8        | 0       | 0               | 13       | 13      |             |          |
| 1977 | 0             | 1        | 4       | 5                   | 0        | 1       | 11              | 12       | 0       | 1               | 16       | 18      |             |          |
| 1978 | 0             | 0        | 2       | 2                   | 0        | 0       | 17              | 17       | 0       | 3               | 22       | 22      |             |          |
| 1979 | 3             | 2        | 13      | 15                  | 6        | 0       | 12              | 12       | 1       | 1               | 26       | 28      |             |          |
| 1980 | 0             | 0        | 20      | 20                  | 1        | 8       | 9               | 9        | 0       | 5               | 33       | 34      |             |          |
| 1981 | 0             | 1        | 8       | 9                   | 3        | 0       | 20              | 20       | 0       | 1               | 29       | 30      |             |          |
| 1982 | 0             | 0        | 3       | 3                   | 4        | 0       | 24              | 24       | 0       | 0               | 27       | 27      |             |          |
| 1983 | 2             | 7        | 1       | 8                   | 1        | 0       | 13              | 13       | 0       | 0               | 14       | 21      |             |          |
| 1984 | 1             | 0        | 3       | 3                   | 2        | 0       | 10              | 10       | 0       | 0               | 13       | 13      |             |          |

## COUNTRY: BRAZIL

| YEAR | NON-SOCIAL SCIENCES |          |         |       | ANIMAL SCIENCES |          |         |       | SOCIAL SCIENCES |       |          |          | GRAND TOTAL |  |
|------|---------------------|----------|---------|-------|-----------------|----------|---------|-------|-----------------|-------|----------|----------|-------------|--|
|      | PLANT SCIENCE       |          |         |       |                 |          |         |       |                 |       |          |          |             |  |
|      | CONOSUR             | UNI ONLY | NON UNI | TOTAL | CONOSUR         | UNI ONLY | NON UNI | TOTAL | UNI ONLY        | TOTAL | EXCL UNI | INCL UNI |             |  |
| 1972 | 79                  | 140      | 341     | 481   | 24              | 145      | 103     | 248   | 0               | 7     | 451      | 736      |             |  |
| 1973 | 76                  | 125      | 338     | 463   | 30              | 163      | 101     | 264   | 4               | 16    | 451      | 743      |             |  |
| 1974 | 97                  | 149      | 415     | 564   | 46              | 165      | 138     | 303   | 3               | 19    | 569      | 886      |             |  |
| 1975 | 132                 | 207      | 452     | 659   | 52              | 174      | 127     | 301   | 7               | 16    | 588      | 976      |             |  |
| 1976 | 185                 | 317      | 641     | 958   | 49              | 267      | 170     | 437   | 7               | 14    | 818      | 1409     |             |  |
| 1977 | 170                 | 287      | 673     | 960   | 55              | 227      | 205     | 432   | 7               | 18    | 889      | 1410     |             |  |
| 1978 | 217                 | 369      | 636     | 1005  | 61              | 315      | 233     | 548   | 8               | 23    | 884      | 1576     |             |  |
| 1979 | 354                 | 375      | 757     | 1132  | 76              | 304      | 258     | 562   | 6               | 28    | 1037     | 1722     |             |  |
| 1980 | 378                 | 305      | 1012    | 1317  | 64              | 348      | 312     | 660   | 11              | 26    | 1339     | 2003     |             |  |
| 1981 | 218                 | 275      | 700     | 975   | 68              | 312      | 305     | 617   | 10              | 23    | 1018     | 1615     |             |  |
| 1982 | 252                 | 225      | 831     | 1056  | 78              | 286      | 280     | 566   | 8               | 18    | 1121     | 1640     |             |  |
| 1983 | 234                 | 187      | 594     | 781   | 79              | 245      | 231     | 476   | 2               | 6     | 829      | 1263     |             |  |
| 1984 | 86                  | 112      | 309     | 421   | 46              | 167      | 176     | 343   | 0               | 2     | 487      | 766      |             |  |

## COUNTRY: CHILE

| YEAR | NON-SOCIAL SCIENCES |          |         |       | ANIMAL SCIENCES |          |         |       | SOCIAL SCIENCES |       |          |          | GRAND TOTAL |  |
|------|---------------------|----------|---------|-------|-----------------|----------|---------|-------|-----------------|-------|----------|----------|-------------|--|
|      | PLANT SCIENCE       |          |         |       |                 |          |         |       |                 |       |          |          |             |  |
|      | CONOSUR             | UNI ONLY | NON UNI | TOTAL | CONOSUR         | UNI ONLY | NON UNI | TOTAL | UNI ONLY        | TOTAL | EXCL UNI | INCL UNI |             |  |
| 1972 | 16                  | 46       | 38      | 84    | 5               | 24       | 14      | 38    | 2               | 2     | 52       | 124      |             |  |
| 1973 | 21                  | 48       | 39      | 87    | 7               | 56       | 9       | 65    | 1               | 3     | 50       | 155      |             |  |
| 1974 | 21                  | 84       | 29      | 113   | 16              | 56       | 21      | 77    | 0               | 1     | 51       | 191      |             |  |
| 1975 | 22                  | 70       | 45      | 115   | 5               | 48       | 14      | 62    | 4               | 5     | 60       | 182      |             |  |
| 1976 | 54                  | 66       | 72      | 138   | 13              | 63       | 16      | 79    | 2               | 3     | 89       | 220      |             |  |
| 1977 | 22                  | 77       | 78      | 155   | 13              | 71       | 25      | 96    | 0               | 0     | 103      | 251      |             |  |
| 1978 | 14                  | 102      | 57      | 159   | 16              | 96       | 33      | 129   | 2               | 6     | 94       | 294      |             |  |
| 1979 | 17                  | 82       | 35      | 117   | 6               | 67       | 11      | 78    | 2               | 5     | 49       | 200      |             |  |
| 1980 | 29                  | 70       | 36      | 106   | 0               | 84       | 13      | 97    | 3               | 5     | 51       | 208      |             |  |
| 1981 | 25                  | 71       | 45      | 116   | 15              | 73       | 31      | 104   | 4               | 7     | 79       | 227      |             |  |
| 1982 | 21                  | 67       | 45      | 112   | 9               | 80       | 34      | 114   | 3               | 6     | 82       | 232      |             |  |
| 1983 | 24                  | 84       | 53      | 137   | 16              | 77       | 28      | 105   | 2               | 4     | 83       | 246      |             |  |
| 1984 | 17                  | 47       | 34      | 81    | 15              | 48       | 19      | 67    | 1               | 1     | 53       | 149      |             |  |

COUNTRY: COLUMBIA

| YEAR | PLANT SCIENCE |          |        |       |       | NON-SOCIAL SCIENCES |          |        |       |       | ANIMAL SCIENCES |          |        |       |  | SOCIAL SCIENCES |       |      |  |  | GRAND TOTAL |          |       |  |  |
|------|---------------|----------|--------|-------|-------|---------------------|----------|--------|-------|-------|-----------------|----------|--------|-------|--|-----------------|-------|------|--|--|-------------|----------|-------|--|--|
|      |               |          |        |       |       |                     |          |        |       |       |                 |          |        |       |  |                 |       |      |  |  |             |          |       |  |  |
|      |               |          |        |       |       |                     |          |        |       |       |                 |          |        |       |  |                 |       |      |  |  |             |          |       |  |  |
|      | CONOSUR       | UNI ONLY | NON UN | TOTAL |       | CONOSUR             | UNI ONLY | NON UN | TOTAL |       | CONOSUR         | UNI ONLY | NON UN | TOTAL |  | UNI ONLY        | TOTAL |      |  |  | EXCL UNI    | INCL UNI |       |  |  |
| 1972 | 2             | 17       | 40     | 57    | (64)  | 5                   | 15       | 9      | 24    | (24)  |                 |          |        |       |  | 2               | 3     | (3)  |  |  | 50          | 84       | (91)  |  |  |
| 1973 | 3             | 8        | 18     | 27    | (34)  | 6                   | 20       | 10     | 30    | (30)  |                 |          |        |       |  | 2               | 7     | (7)  |  |  | 33          | 64       | (71)  |  |  |
| 1974 | 15            | 29       | 61     | 90    | (114) | 8                   | 17       | 10     | 27    | (28)  |                 |          |        |       |  | 2               | 4     | (4)  |  |  | 73          | 121      | (146) |  |  |
| 1975 | 15            | 25       | 93     | 118   | (146) | 2                   | 8        | 16     | 24    | (31)  |                 |          |        |       |  | 2               | 3     | (4)  |  |  | 110         | 145      | (181) |  |  |
| 1976 | 7             | 22       | 58     | 80    | (128) | 0                   | 31       | 50     | 81    | (88)  |                 |          |        |       |  | 1               | 5     | (6)  |  |  | 112         | 166      | (222) |  |  |
| 1977 | 8             | 22       | 76     | 98    | (144) | 8                   | 23       | 24     | 47    | (56)  |                 |          |        |       |  | 1               | 8     | (9)  |  |  | 107         | 153      | (214) |  |  |
| 1978 | 18            | 26       | 118    | 144   | (222) | 39                  | 28       | 76     | 104   | (124) |                 |          |        |       |  | 3               | 8     | (10) |  |  | 199         | 256      | (356) |  |  |
| 1979 | 10            | 24       | 51     | 75    | (153) | 10                  | 25       | 37     | 62    | (69)  |                 |          |        |       |  | 3               | 15    | (15) |  |  | 100         | 152      | (237) |  |  |
| 1980 | 5             | 31       | 41     | 72    | (112) | 0                   | 10       | 18     | 28    | (32)  |                 |          |        |       |  | 2               | 11    | (12) |  |  | 69          | 112      | (156) |  |  |
| 1981 | 4             | 24       | 50     | 74    | (145) | 8                   | 25       | 35     | 60    | (63)  |                 |          |        |       |  | 2               | 6     | (6)  |  |  | 89          | 140      | (214) |  |  |
| 1982 | 5             | 12       | 29     | 41    | (104) | 1                   | 10       | 20     | 30    | (32)  |                 |          |        |       |  | 3               | 9     | (10) |  |  | 55          | 80       | (146) |  |  |
| 1983 | 8             | 8        | 38     | 47    | (96)  | 10                  | 13       | 28     | 41    | (46)  |                 |          |        |       |  | 0               | 2     | (3)  |  |  | 68          | 90       | (145) |  |  |
| 1984 | 2             | 9        | 10     | 19    | (70)  | 5                   | 14       | 15     | 29    | (32)  |                 |          |        |       |  | 0               | 0     | (1)  |  |  | 25          | 48       | (103) |  |  |

Figures in brackets are inclusive of CIAI.

COUNTRY: ECUADOR

| YEAR | PLANT SCIENCE |          |        |       |  | NON-SOCIAL SCIENCES |          |        |       |  | ANIMAL SCIENCES |          |        |       |  | SOCIAL SCIENCES |       |  |  |  | GRAND TOTAL |          |  |  |  |
|------|---------------|----------|--------|-------|--|---------------------|----------|--------|-------|--|-----------------|----------|--------|-------|--|-----------------|-------|--|--|--|-------------|----------|--|--|--|
|      |               |          |        |       |  |                     |          |        |       |  |                 |          |        |       |  |                 |       |  |  |  |             |          |  |  |  |
|      |               |          |        |       |  |                     |          |        |       |  |                 |          |        |       |  |                 |       |  |  |  |             |          |  |  |  |
|      | CONOSUR       | UNI ONLY | NON UN | TOTAL |  | CONOSUR             | UNI ONLY | NON UN | TOTAL |  | CONOSUR         | UNI ONLY | NON UN | TOTAL |  | UNI ONLY        | TOTAL |  |  |  | EXCL UNI    | INCL UNI |  |  |  |
| 1972 | 1             | 2        | 8      | 10    |  | 1                   | 1        | 0      | 1     |  |                 |          |        |       |  | 0               | 1     |  |  |  | 9           | 12       |  |  |  |
| 1973 | 0             | 1        | 1      | 2     |  | 0                   | 0        | 1      | 1     |  |                 |          |        |       |  | 0               | 0     |  |  |  | 2           | 3        |  |  |  |
| 1974 | 1             | 1        | 5      | 6     |  | 0                   | 1        | 1      | 2     |  |                 |          |        |       |  | 0               | 0     |  |  |  | 6           | 8        |  |  |  |
| 1975 | 1             | 1        | 6      | 7     |  | 0                   | 0        | 1      | 1     |  |                 |          |        |       |  | 0               | 0     |  |  |  | 7           | 8        |  |  |  |
| 1976 | 0             | 2        | 6      | 8     |  | 0                   | 4        | 2      | 6     |  |                 |          |        |       |  | 0               | 1     |  |  |  | 9           | 15       |  |  |  |
| 1977 | 1             | 4        | 14     | 18    |  | 0                   | 4        | 5      | 9     |  |                 |          |        |       |  | 0               | 0     |  |  |  | 19          | 27       |  |  |  |
| 1978 | 0             | 2        | 16     | 18    |  | 4                   | 1        | 8      | 9     |  |                 |          |        |       |  | 0               | 2     |  |  |  | 26          | 29       |  |  |  |
| 1979 | 0             | 1        | 9      | 10    |  | 4                   | 0        | 6      | 6     |  |                 |          |        |       |  | 2               | 2     |  |  |  | 15          | 18       |  |  |  |
| 1980 | 0             | 2        | 5      | 7     |  | 0                   | 0        | 3      | 3     |  |                 |          |        |       |  | 2               | 3     |  |  |  | 9           | 13       |  |  |  |
| 1981 | 1             | 1        | 3      | 4     |  | 1                   | 1        | 1      | 3     |  |                 |          |        |       |  | 0               | 0     |  |  |  | 6           | 8        |  |  |  |
| 1982 | 1             | 0        | 5      | 5     |  | 1                   | 1        | 1      | 6     |  |                 |          |        |       |  | 1               | 1     |  |  |  | 11          | 13       |  |  |  |
| 1983 | 1             | 1        | 9      | 10    |  | 1                   | 3        | 8      | 11    |  |                 |          |        |       |  | 0               | 2     |  |  |  | 19          | 23       |  |  |  |
| 1984 | 1             | 0        | 4      | 4     |  | 0                   | 0        | 2      | 2     |  |                 |          |        |       |  | 0               | 0     |  |  |  | 6           | 6        |  |  |  |

## COUNTRY: PARAGUAY

| YEAR | PLANT SCIENCE |          |       |       |       | NON-SOCIAL SCIENCES |          |       |       |       | ANIMAL SCIENCES |          |       |       |       | SOCIAL SCIENCES |       |       | GRAND TOTAL |       |       |
|------|---------------|----------|-------|-------|-------|---------------------|----------|-------|-------|-------|-----------------|----------|-------|-------|-------|-----------------|-------|-------|-------------|-------|-------|
|      | -----         |          |       |       |       | -----               |          |       |       |       | -----           |          |       |       |       | -----           |       |       | -----       |       |       |
|      | CONOSUR       | UNI ONLY | NON   | UN    | TOTAL | CONOSUR             | UNI ONLY | NON   | UN    | TOTAL | CONOSUR         | UNI ONLY | NON   | UN    | TOTAL | UNI ONLY        | TOTAL | EXCL  | UNI         | INCL  | UNI   |
|      | -----         | -----    | ----- | ----- | ----- | -----               | -----    | ----- | ----- | ----- | -----           | -----    | ----- | ----- | ----- | -----           | ----- | ----- | -----       | ----- | ----- |
| 1972 | 0             | 1        |       | 1     | 2     |                     | 0        |       | 1     | 0     |                 | 0        |       | 0     | 1     | 0               | 0     |       | 1           |       | 3     |
| 1973 | 0             | 1        | 0     | 0     | 1     | 1                   | 14       |       | 1     | 15    |                 |          |       |       |       | 0               | 0     |       | 1           |       | 16    |
| 1974 | 0             | 5        | 1     | 1     | 6     |                     | 3        |       | 0     | 3     |                 |          |       |       |       | 0               | 0     |       | 1           |       | 9     |
| 1975 | 0             | 0        | 3     | 0     | 3     | 1                   |          | 2     |       | 0     |                 |          |       |       | 2     | 0               | 0     |       | 3           |       | 5     |
| 1976 | 0             | 0        | 0     | 0     | 0     | 2                   | 17       |       | 2     | 19    |                 |          |       |       | 0     | 0               | 0     |       | 2           |       | 19    |
| 1977 | 0             | 3        | 3     | 3     | 6     | 1                   | 9        |       | 3     | 12    |                 |          |       |       | 0     | 0               | 1     |       | 7           |       | 19    |
| 1978 | 0             | 1        | 0     | 0     | 1     | 2                   | 13       |       | 2     | 15    |                 |          |       |       | 0     | 0               | 2     |       | 4           |       | 18    |
| 1979 | 2             | 4        | 1     | 1     | 5     |                     | 7        |       | 3     | 10    |                 |          |       |       | 0     | 0               | 0     |       | 4           |       | 15    |
| 1980 | 1             | 1        | 0     | 0     | 1     | 1                   | 14       |       | 3     | 17    |                 |          |       |       | 0     | 0               | 0     |       | 3           |       | 18    |
| 1981 | 0             | 0        | 3     | 3     | 3     | 2                   | 11       |       | 4     | 15    |                 |          |       |       | 0     | 1               | 1     |       | 8           |       | 19    |
| 1982 | 0             | 1        | 0     | 0     | 1     | 1                   | 5        |       | 1     | 6     |                 |          |       |       | 0     | 0               | 0     |       | 1           |       | 7     |
| 1983 | 0             | 0        | 2     | 2     | 2     | 0                   | 6        |       | 2     | 8     |                 |          |       |       | 0     | 0               | 0     |       | 4           |       | 10    |
| 1984 | 0             | 1        | 1     | 1     | 2     | 0                   | 7        |       | 2     | 9     |                 |          |       |       | 0     | 0               | 0     |       | 3           |       | 11    |

COUNTRY: URUGUAY

| YEAR | PLANT SCIENCE |       |          |       | NON-SOCIAL SCIENCES |       |          |       | ANIMAL SCIENCES |       |          |       | SOCIAL SCIENCES |       |       | GRAND TOTAL |          |
|------|---------------|-------|----------|-------|---------------------|-------|----------|-------|-----------------|-------|----------|-------|-----------------|-------|-------|-------------|----------|
|      | CONOSUR       |       | NON UN   |       | CONOSUR             |       | NON UN   |       | CONOSUR         |       | NON UN   |       | UNI ONLY        |       | TOTAL | EXCL UNI    | INCL UNI |
|      | UNI ONLY      | TOTAL | UNI ONLY | TOTAL | UNI ONLY            | TOTAL | UNI ONLY | TOTAL | UNI ONLY        | TOTAL | UNI ONLY | TOTAL | UNI ONLY        | TOTAL |       |             |          |
| 1972 | 1             | 5     | 4        |       | 0                   |       | 2        | 4     | 2               |       | 6        | 17    | 0               | 0     | 0     | 6           | 9        |
| 1973 | 1             | 2     | 1        |       | 0                   |       | 11       | 6     | 11              |       | 7        | 16    | 0               | 0     | 0     | 7           | 19       |
| 1974 | 8             | 17    | 15       |       | 1                   |       | 9        | 7     | 8               |       | 7        | 13    | 0               | 0     | 0     | 22          | 33       |
| 1975 | 1             | 5     | 1        |       | 2                   |       | 7        | 6     | 7               |       | 6        | 13    | 0               | 0     | 0     | 7           | 18       |
| 1976 | 2             | 8     | 5        |       | 3                   |       | 10       | 15    | 10              |       | 15       | 25    | 0               | 2     | 2     | 22          | 35       |
| 1977 | 2             | 8     | 6        |       | 5                   |       | 4        | 12    | 4               |       | 12       | 16    | 0               | 0     | 0     | 18          | 24       |
| 1978 | 11            | 34    | 31       |       | 2                   |       | 4        | 17    | 4               |       | 17       | 21    | 0               | 0     | 0     | 48          | 55       |
| 1979 | 7             | 15    | 11       |       | 5                   |       | 8        | 14    | 8               |       | 14       | 22    | 0               | 1     | 1     | 26          | 38       |
| 1980 | 3             | 24    | 23       |       | 3                   |       | 3        | 9     | 3               |       | 9        | 12    | 0               | 7     | 7     | 39          | 43       |
| 1981 | 7             | 32    | 26       |       | 3                   |       | 3        | 12    | 3               |       | 12       | 15    | 1               | 4     | 4     | 41          | 51       |
| 1982 | 8             | 18    | 16       |       | 4                   |       | 3        | 13    | 3               |       | 13       | 16    | 1               | 4     | 4     | 32          | 38       |
| 1983 | 1             | 5     | 4        |       | 3                   |       | 1        | 12    | 1               |       | 12       | 13    | 0               | 0     | 0     | 16          | 18       |
| 1984 | 0             | 1     | 1        |       | 3                   |       | 4        | 5     | 4               |       | 5        | 9     | 0               | 0     | 0     | 6           | 10       |

COUNTRY: VENEZUELA

| YEAR | PLANT SCIENCE |       |         |       | NON-SOCIAL SCIENCES |       |          |       | ANIMAL SCIENCES |       |          |       | SOCIAL SCIENCES |       |          |          | GRAND TOTAL |          |
|------|---------------|-------|---------|-------|---------------------|-------|----------|-------|-----------------|-------|----------|-------|-----------------|-------|----------|----------|-------------|----------|
|      | CONOSUR       |       | NON UN  |       | CONOSUR             |       | UNI ONLY |       | CONOSUR         |       | UNI ONLY |       | UNI ONLY        |       | TOTAL    |          | EXCL UNI    | INCL UNI |
|      | UNI ONLY      | TOTAL | CONOSUR | TOTAL | UNI ONLY            | TOTAL | CONOSUR  | TOTAL | UNI ONLY        | TOTAL | UNI ONLY | TOTAL | UNI ONLY        | TOTAL | EXCL UNI | INCL UNI |             |          |
| 1972 | 17            | 35    | 62      | 86    | 4                   | 30    | 26       | 56    | 0               | 0     | 0        | 0     | 0               | 0     | 89       | 154      |             |          |
| 1973 | 7             | 30    | 66      | 96    | 12                  | 52    | 35       | 87    | 5               | 7     | 103      | 190   |                 |       | 103      | 190      |             |          |
| 1974 | 10            | 45    | 60      | 105   | 20                  | 48    | 35       | 83    | 0               | 1     | 96       | 189   |                 |       | 96       | 189      |             |          |
| 1975 | 14            | 29    | 55      | 84    | 12                  | 26    | 50       | 76    | 2               | 8     | 111      | 168   |                 |       | 111      | 168      |             |          |
| 1976 | 13            | 31    | 63      | 84    | 0                   | 74    | 81       | 155   | 4               | 4     | 148      | 253   |                 |       | 148      | 253      |             |          |
| 1977 | 15            | 45    | 72      | 117   | 26                  | 88    | 61       | 149   | 1               | 7     | 139      | 273   |                 |       | 139      | 273      |             |          |
| 1978 | 18            | 49    | 56      | 105   | 42                  | 68    | 70       | 138   | 3               | 7     | 130      | 250   |                 |       | 130      | 250      |             |          |
| 1979 | 11            | 33    | 44      | 77    | 31                  | 83    | 65       | 148   | 2               | 3     | 110      | 228   |                 |       | 110      | 228      |             |          |
| 1980 | 11            | 18    | 43      | 61    | 0                   | 46    | 28       | 74    | 0               | 3     | 74       | 138   |                 |       | 74       | 138      |             |          |
| 1981 | 1             | 25    | 35      | 60    | 37                  | 71    | 46       | 117   | 3               | 3     | 81       | 180   |                 |       | 81       | 180      |             |          |
| 1982 | 4             | 17    | 25      | 42    | 9                   | 38    | 40       | 78    | 0               | 1     | 66       | 121   |                 |       | 66       | 121      |             |          |
| 1983 | 5             | 37    | 11      | 48    | 6                   | 43    | 32       | 75    | 0               | 0     | 43       | 123   |                 |       | 43       | 123      |             |          |
| 1984 | 2             | 13    | 15      | 28    | 15                  | 42    | 15       | 57    | 0               | 0     | 30       | 85    |                 |       | 30       | 85       |             |          |

Note: The online searches to construct these tables were carried out during October 1985. Due to lags in the publication processes, this means that the later figures (particularly 1984) may be biased downward.

APPENDIX II: COMMODITY LEVEL PUBLICATION COUNTS

COUNTRY: ARGENTINA

| YEARS | CORN | WHEAT | SOYBEAN | SORGHUM | TOTAL PLANTS | LIVESTOCK | TOTAL CONOSUR |
|-------|------|-------|---------|---------|--------------|-----------|---------------|
| 1972  | 21   | 5     | 1       | 10      | 37           | 14        | 51            |
| 1973  | 8    | 12    | 7       | 8       | 35           | 11        | 46            |
| 1974  | 9    | 14    | 3       | 10      | 36           | 24        | 60            |
| 1975  | 16   | 4     | 7       | 10      | 37           | 16        | 53            |
| 1976  | 9    | 8     | 1       | 2       | 20           | 23        | 43            |
| 1977  | 11   | 9     | 9       | 15      | 44           | 28        | 73            |
| 1978  | 29   | 23    | 9       | 5       | 66           | 34        | 100           |
| 1979  | 9    | 26    | 9       | 7       | 51           | 27        | 78            |
| 1980  | 17   | 13    | 14      | 16      | 60           | 30        | 90            |
| 1981  | 23   | 11    | 14      | 10      | 58           | 35        | 93            |
| 1982  | 22   | 13    | 5       | 7       | 47           | 45        | 92            |
| 1983  | 26   | 15    | 12      | 12      | 65           | 15        | 80            |
| 1984  | 0    |       |         |         |              |           |               |

COUNTRY: BOLIVIA

| YEARS | CORN | WHEAT | SOYBEAN | SORGHUM | TOTAL PLANTS | LIVESTOCK | TOTAL CONOSUR |
|-------|------|-------|---------|---------|--------------|-----------|---------------|
| 1972  | 1    | 0     | 0       | 0       | 1            | 1         | 2             |
| 1973  | 0    | 0     | 0       | 0       | 0            | 2         | 2             |
| 1974  | 0    | 0     | 0       | 0       | 0            | 1         | 1             |
| 1975  | 0    | 0     | 0       | 0       | 0            | 0         | 0             |
| 1976  | 0    | 0     | 0       | 0       | 0            | 1         | 1             |
| 1977  | 0    | 0     | 0       | 0       | 0            | 0         | 0             |
| 1978  | 0    | 0     | 0       | 0       | 0            | 0         | 0             |
| 1979  | 1    | 1     | 1       | 0       | 3            | 8         | 11            |
| 1980  | 0    | 0     | 0       | 0       | 0            | 1         | 1             |
| 1981  | 0    | 0     | 0       | 0       | 0            | 4         | 4             |
| 1982  | 0    | 0     | 0       | 0       | 0            | 7         | 7             |
| 1983  | 1    | 1     | 0       | 0       | 2            | 2         | 4             |
| 1984  | 0    | 0     | 0       | 0       | 0            | 0         | 0             |

COUNTRY: BRAZIL

| YEARS | CORN | WHEAT | SOYBEAN | SORGHUM | TOTAL PLANTS | LIVESTOCK | TOTAL CONOSUR |
|-------|------|-------|---------|---------|--------------|-----------|---------------|
| 1972  | 42   | 21    | 23      | 7       | 93           | 32        | 125           |
| 1973  | 27   | 16    | 40      | 7       | 90           | 43        | 133           |
| 1974  | 42   | 26    | 42      | 7       | 117          | 53        | 170           |
| 1975  | 48   | 23    | 44      | 26      | 141          | 66        | 207           |
| 1976  | 64   | 39    | 72      | 31      | 206          | 56        | 262           |
| 1977  | 78   | 31    | 56      | 37      | 202          | 70        | 272           |
| 1978  | 94   | 34    | 93      | 30      | 251          | 77        | 328           |
| 1979  | 110  | 25    | 188     | 56      | 380          | 98        | 478           |
| 1980  | 114  | 56    | 176     | 68      | 414          | 85        | 499           |
| 1981  | 79   | 62    | 83      | 34      | 258          | 82        | 340           |
| 1982  | 86   | 53    | 128     | 18      | 295          | 92        | 387           |
| 1983  | 74   | 67    | 100     | 26      | 267          | 93        | 360           |
| 1984  | 0    |       |         |         |              |           |               |

COUNTRY: CHILE

| YEARS | CORN | WHEAT | SOYBEAN | SORGHUM | TOTAL PLANTS | LIVESTOCK | TOTAL CONOSUR |
|-------|------|-------|---------|---------|--------------|-----------|---------------|
| 1972  | 8    | 4     | 4       | 1       | 17           | 7         | 24            |
| 1973  | 5    | 15    | 3       | 3       | 26           | 7         | 33            |
| 1974  | 8    | 14    | 1       | 2       | 25           | 20        | 45            |
| 1975  | 3    | 18    | 3       | 0       | 24           | 6         | 30            |
| 1976  | 9    | 44    | 2       | 0       | 55           | 14        | 69            |
| 1977  | 2    | 17    | 2       | 1       | 22           | 16        | 38            |
| 1978  | 0    | 0     | 0       | 0       | 0            | 0         | 0             |
| 1979  | 3    | 13    | 2       | 0       | 18           | 7         | 25            |
| 1980  | 3    | 26    | 0       | 0       | 29           | 13        | 42            |
| 1981  | 1    | 22    | 3       | 0       | 26           | 16        | 42            |
| 1982  | 2    | 17    | 2       | 1       | 22           | 11        | 33            |
| 1983  | 5    | 21    | 3       | 1       | 30           | 18        | 48            |
| 1984  | 0    | 0     | 0       | 0       | 0            | 0         | 0             |

## COUNTRY: COLOMBIA

| YEARS | CORN | WHEAT | SOYBEAN | SORGHUM | TOTAL<br>PLANTS | LIVESTOCK | TOTAL<br>CONOSUR |
|-------|------|-------|---------|---------|-----------------|-----------|------------------|
| 1972  | 3    | 0     | 1       | 1       | 5               | 6         | 11               |
| 1973  | 4    | 1     | 1       | 0       | 6               | 6         | 12               |
| 1974  | 8    | 0     | 7       | 8       | 23              | 12        | 35               |
| 1975  | 12   | 2     | 10      | 1       | 25              | 6         | 31               |
| 1976  | 7    | 0     | 4       | 0       | 11              | 29        | 40               |
| 1977  | 11   | 2     | 3       | 0       | 16              | 12        | 28               |
| 1978  | 22   | 4     | 6       | 4       | 36              | 53        | 89               |
| 1979  | 6    | 2     | 3       | 1       | 12              | 14        | 26               |
| 1980  | 6    | 0     | 1       | 1       | 8               | 4         | 12               |
| 1981  | 5    | 0     | 2       | 2       | 9               | 15        | 24               |
| 1982  | 8    | 0     | 3       | 0       | 11              | 8         | 19               |
| 1983  | 8    | 0     | 4       | 1       | 13              | 16        | 29               |
| 1984  | 0    | 0     | 0       | 0       | 0               | 0         | 0                |

## COUNTRY: ECUADOR

| YEARS | CORN | WHEAT | SOYBEAN | SORGHUM | TOTAL<br>PLANTS | LIVESTOCK | TOTAL<br>CONOSUR |
|-------|------|-------|---------|---------|-----------------|-----------|------------------|
| 1972  | 0    | 1     | 0       | 0       | 1               | 1         | 2                |
| 1973  | 0    | 0     | 0       | 0       | 0               | 0         | 0                |
| 1974  | 1    | 0     | 0       | 0       | 1               | 0         | 1                |
| 1975  | 0    | 0     | 0       | 1       | 1               | 0         | 1                |
| 1976  | 0    | 0     | 0       | 0       | 0               | 0         | 0                |
| 1977  | 1    | 0     | 0       | 0       | 1               | 0         | 1                |
| 1978  | 0    | 0     | 0       | 0       | 0               | 5         | 5                |
| 1979  | 0    | 0     | 0       | 0       | 0               | 5         | 5                |
| 1980  | 0    | 0     | 0       | 0       | 0               | 0         | 0                |
| 1981  | 1    | 1     | 0       | 0       | 2               | 1         | 3                |
| 1982  | 0    | 1     | 0       | 0       | 1               | 2         | 3                |
| 1983  | 0    | 1     | 0       | 0       | 1               | 1         | 2                |
| 1984  | 0    | 0     | 0       | 0       | 0               | 0         | 0                |

## COUNTRY: PARAGUAY

| YEARS | CORN | WHEAT | SOYBEAN | SORGHUM | TOTAL<br>PLANTS | LIVESTOCK | TOTAL<br>CONOSUR |
|-------|------|-------|---------|---------|-----------------|-----------|------------------|
| 1972  | 0    | 0     | 0       | 0       | 0               | 0         | 0                |
| 1973  | 0    | 0     | 0       | 0       | 0               | 1         | 1                |
| 1974  | 0    | 0     | 0       | 0       | 0               | 0         | 0                |
| 1975  | 0    | 0     | 0       | 0       | 0               | 1         | 1                |
| 1976  | 0    | 0     | 0       | 0       | 0               | 2         | 2                |
| 1977  | 0    | 0     | 0       | 0       | 0               | 2         | 2                |
| 1978  | 0    | 0     | 0       | 0       | 0               | 2         | 2                |
| 1979  | 1    | 0     | 1       | 0       | 2               | 0         | 2                |
| 1980  | 1    | 0     | 0       | 0       | 1               | 1         | 2                |
| 1981  | 0    | 0     | 0       | 0       | 0               | 4         | 4                |
| 1982  | 0    | 0     | 0       | 0       | 0               | 1         | 1                |
| 1983  | 0    | 0     | 0       | 0       | 0               | 0         | 0                |
| 1984  | 0    | 0     | 0       | 0       | 0               | 0         | 0                |

## COUNTRY: PERU

| YEARS | CORN | WHEAT | SOYBEAN | SORGHUM | TOTAL<br>PLANTS | LIVESTOCK | TOTAL<br>CONOSUR |
|-------|------|-------|---------|---------|-----------------|-----------|------------------|
| 1972  | 5    | 6     | 4       | 5       | 20              | 3         | 23               |
| 1973  | 7    | 5     | 1       | 0       | 13              | 6         | 19               |
| 1974  | 12   | 3     | 3       | 2       | 20              | 4         | 24               |
| 1975  | 8    | 1     | 3       | 6       | 18              | 4         | 22               |
| 1976  | 3    | 0     | 2       | 1       | 6               | 6         | 12               |
| 1977  | 2    | 3     | 1       | 0       | 6               | 3         | 9                |
| 1978  | 2    | 2     | 3       | 0       | 7               | 19        | 26               |
| 1979  | 2    | 0     | 2       | 0       | 4               | 4         | 8                |
| 1980  | 10   | 2     | 0       | 2       | 14              | 5         | 19               |
| 1981  | 0    | 0     | 0       | 0       | 0               | 2         | 2                |
| 1982  | 0    | 1     | 0       | 0       | 1               | 0         | 1                |
| 1983  | 0    | 0     | 0       | 0       | 0               | 1         | 1                |
| 1984  | 0    | 0     | 0       | 0       | 0               | 0         | 0                |

## COUNTRY: URUGUAY

| YEARS | CORN | WHEAT | SOYBEAN | SORGHUM | TOTAL<br>PLANTS | LIVESTOCK | TOTAL<br>CONOSUR |
|-------|------|-------|---------|---------|-----------------|-----------|------------------|
| 1972  | 0    | 1     | 0       | 0       | 1               | 1         | 2                |
| 1973  | 1    | 1     | 0       | 0       | 2               | 0         | 2                |
| 1974  | 2    | 5     | 0       | 3       | 10              | 1         | 11               |
| 1975  | 1    | 0     | 0       | 0       | 1               | 2         | 3                |
| 1976  | 2    | 1     | 2       | 3       | 8               | 5         | 13               |
| 1977  | 1    | 0     | 1       | 2       | 4               | 6         | 10               |
| 1978  | 1    | 3     | 2       | 5       | 11              | 7         | 18               |
| 1979  | 0    | 2     | 4       | 2       | 8               | 5         | 13               |
| 1980  | 0    | 3     | 0       | 0       | 3               | 9         | 12               |
| 1981  | 1    | 4     | 2       | 0       | 7               | 4         | 11               |
| 1982  | 0    | 8     | 0       | 0       | 8               | 4         | 12               |
| 1983  | 0    | 1     | 1       | 0       | 2               | 3         | 5                |
| 1984  | 0    | 0     | 0       | 0       | 0               | 0         | 0                |

## COUNTRY: VENEZUELA

| YEARS | CORN | WHEAT | SOYBEAN | SORGHUM | TOTAL<br>PLANTS | LIVESTOCK | TOTAL<br>CONOSUR |
|-------|------|-------|---------|---------|-----------------|-----------|------------------|
| 1972  | 13   | 0     | 2       | 2       | 17              | 4         | 21               |
| 1973  | 2    | 1     | 3       | 2       | 8               | 12        | 20               |
| 1974  | 8    | 0     | 2       | 1       | 11              | 20        | 31               |
| 1975  | 7    | 0     | 5       | 5       | 17              | 18        | 35               |
| 1976  | 12   | 1     | 1       | 0       | 14              | 38        | 52               |
| 1977  | 12   | 1     | 4       | 2       | 19              | 30        | 49               |
| 1978  | 12   | 0     | 1       | 6       | 19              | 44        | 63               |
| 1979  | 5    | 0     | 4       | 3       | 12              | 32        | 44               |
| 1980  | 9    | 0     | 2       | 4       | 15              | 11        | 26               |
| 1981  | 2    | 0     | 0       | 1       | 3               | 38        | 41               |
| 1982  | 1    | 1     | 1       | 1       | 4               | 10        | 14               |
| 1983  | 4    | 1     | 4       | 6       | 15              | 17        | 32               |
| 1984  | 0    | 0     | 0       | 0       | 0               | 0         | 0                |

## APPENDIX II: CHARACTERISTICS OF THE SOURCE SET OF REFERENCES

| Subject Area                          | Type of Journal <sup>a</sup> |              |               |            | Total No. of<br>References | Percentage of<br>Total References |
|---------------------------------------|------------------------------|--------------|---------------|------------|----------------------------|-----------------------------------|
|                                       | I                            | R            | N             | D          |                            |                                   |
| Agronomy                              | 38                           | 19           |               |            | 57                         | 12.81                             |
| Agricultural Engineering              | 8                            |              |               |            | 8                          | 1.80                              |
| Animal Production                     | 9                            | 7            |               |            | 16                         | 3.59                              |
| Biochemistry/Physiology               | 70                           |              | 4             |            | 74                         | 16.63                             |
| Chemistry                             | 3                            |              | 10            |            | 13                         | 2.92                              |
| Experimental Biology                  | 16                           | 11           |               |            | 27                         | 6.07                              |
| Economics                             | 1                            |              | 1             |            | 2                          | 0.45                              |
| Food Science and Technology           | 30                           |              |               |            | 30                         | 6.74                              |
| Genetics/Plant Breeding               | 13                           | 6            | 25            |            | 44                         | 9.89                              |
| General Science                       | 2                            | 1            |               |            | 3                          | 0.67                              |
| Medicine/Human Nutrition              | 24                           | 1            | 2             |            | 27                         | 6.07                              |
| Meteorology/Environmental<br>Sciences | 8                            |              |               |            | 8                          | 1.80                              |
| Plant Pathology                       | 41                           | 1            |               |            | 42                         | 9.44                              |
| Soil Science                          | 10                           |              |               |            | 10                         | 2.25                              |
| Veterinary Medicine                   | 22                           |              | 61            | 1          | 84                         | 18.87                             |
| Total                                 | 295<br>(66.3)                | 46<br>(10.3) | 103<br>(23.2) | 1<br>(0.2) | 445                        | 100.00                            |

<sup>a</sup> I = International; R = Regional; N = National; D = Other Developing Country.

Note: Bracketed Figures are percentages.



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